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Recovery Potential Indicator Summaries Table

Introduction

The following is a table of indicators usable in Recovery Potential Screening when suitable quality data are available and the indicator is relevant to the user's area and purpose for the screening assessment. For each indicator, the table provides a brief summary of why it is relevant to recovery potential, how it might be measured, and the potential data sources. These indicators are broadly defined, and many have several options for measurement. Because of the diversity of possible geographic settings, data sources and quality, and assessment goals, how best to measure a given indicator is a project-specific decision. This table is provided to help users consider a wide range of potentially relevant options as they select 5 to 10 suitable ecological, stressor and social context indicators for their screening project. Where marked, most of the indicators also have a link to an indicator reference document that provides greater detail about the indicator, including excerpts from technical literature that demonstrate its relevance to restorability.

See www.epa.gov/recoverypotential/ for more information.

Part 1: Ecological Indicator Summaries

Watershed natural structure

watershed % natural cover

Why relevant to recovery: Large-scale land use change often provides nonpoint pollution (e.g. from urban areas, agriculture, transportation, mining) as well as altering runoff and infiltration patterns in ways that can destabilize stream channels and flow regimes. The percent of watershed area that is not transformed to non-natural cover types is generally associated with runoff and flow dynamics within normal range of variability, as well as reduced opportunity for pollutant runoff. Natural cover categories from land cover mapping mainly include forest, shrubland, wetlands, grasslands and in some regions desert or barren land categories.

Data sources and measurement: Measured as total percent of land area (not including water area) in the watershed within several mapped natural land cover categories, as listed above. For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources. For 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.

watershed % forest (PDF) (4 pp, 57.7K)

Why relevant to recovery: More watershed forest cover reduces risk of numerous impairment types, thus lessening the relative complexity of restoration of impaired waters from forested watersheds. Mollifying effects on runoff and recharge, temperature, and overland pollutant transport are associated with more forested watersheds and help ensure that several primary natural processes are or can become functional once stresses are removed.

Data sources and measurement: Percent of the total land area of a watershed mapped with a land cover classification of "forest" (i.e. deciduous forest, evergreen forest, mixed forest). For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources. For 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. For relatively small study areas, it is possible to use aerial imagery to digitize the forest cover manually.

watershed % wetlands (PDF) (5 pp, 83.5K)

Why relevant to recovery: Wetlands are key features in watershed processing of nutrients in runoff, detention of excessive runoff during extreme weather events, and act as sinks for sediment and pollutants. In addition, wetlands provide vital recharge, detention and release in their role within groundwater/surface water interactions. Absence of wetlands degrades natural processing of the pollutants mentioned and results in greater direct transport to the receiving water body of the watershed, increasing or perpetuating impairment. Greater proportion of wetland area in the watershed positively influences recovery potential in that watersheds with more wetlands have greater resilience concerning the types of impairments mentioned.

Data sources and measurement: Percent wetland area within the selected watershed scale. Data sources may vary considerably in source, date and accuracy of wetland/upland delineation. For land cover data including generalized wetland categories, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources. NLCD or state land cover datasets are generally available but less accurate than wetland-specific mapping efforts such as National Wetlands Inventory (NWI) (see: http://www.fws.gov/wetlands/index.html). NWI data are partially available as digital coverage, are likely more accurately interpreted but may be out of date in selected areas. For 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.

watershed % woody vegetation (PDF) (2 pp, 16k)

Why relevant to recovery: This metric is relevant for reasons similar to watershed forest and watershed natural cover, and provides a more appropriate indicator choice in regions that are not naturally forested. More watershed forest and shrub cover reduces risk of numerous impairment types, thus lessening the relative complexity of restoration. Mollifying effects on runoff and recharge, temperature, and overland pollutant transport are associated with more naturally vegetated watersheds and help ensure that several primary natural processes are or can become functional once stresses are removed. Broad array of influences on capacity to recover including intercepting and moderating the timing of runoff, buffering temperature extremes (which can also reduce certain toxicities), filtering pollutants in surface or subsurface runoff, providing woody debris to stream channels that enhances aquatic food webs, and stabilizing excessive erosion.

Data sources and measurement: Land cover mapping typically contains forested and shrub categories, which are added to calculate this metric. For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources. For 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.

watershed topographic complexity (PDF) (2 pp, 43.1k)

Why relevant to recovery: Although likely not a strong causal influence on ecological condition, topographic complexity is associated with higher biodiversity, better water quality and reduced nutrient pollution in some studies. The metric may be indirectly related to limiting the extent of some forms of land use that may degrade aquatic condition, also associating it with greater recovery potential in general.

Data sources and measurement: Watershed elevation range, mean watershed slope and relief ratio are measurable from elevation datasets and are closely correlated with topographic complexity. The National Elevation Dataset (NED) (See: http://nhd.usgs.gov/index.html) is adequate for generalized differences in elevation. High resolution elevation data should be used for any assessment units at HUC12 level of smaller. The Elevation Derivatives for National Applications (EDNA) has been derived from the NED and is hydrologically conditioned to improve hydrologic flow representation (see: http://edna.usgs.gov/). NHD plus contains information on maximum and minimum elevation for each flowline (http://www.horizon-systems.com/nhdplus/).

watershed forest patch mean area

Why relevant to recovery: Patch size is a direct indicator of how fragmented a watershed's natural cover is. Larger average patch size is likely to be associated with less fragmentation in a watershed. Forest fragmentation and its land use causes are associated with runoff changes and potentially greater pollutant loading. Larger forest patches containing parts of the stream network are also more likely to harbor functionally intact waters.

Data sources and measurement: Calculated as the total forested land area of a watershed divided by forest patch count. For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources. For 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. For relatively small study areas, it is possible to use aerial imagery to digitize the forest cover manually.

watershed soil resilience (PDF) (6 pp, 131K)

Why relevant to recovery: Soil texture and slope characteristics affect the degree of nitrogen retention, bank stability, overland flow and erosion potential, and soil characteristics can even completely override land cover effects. Higher stream slopes increase soil erosion potential, and thus, Phosphorus transport potential in overland flow. Soil texture has been called the single most important watershed characteristic affecting water quality of the Great Lakes. Stream nutrients can be associated with soil properties, and fine-textured soils with higher runoff potentials appear to limit the transport of leached Nitrogen.

Data sources and measurement: Measured from mapped soil survey data within a selected corridor width, e.g. 30 meters, 90 meters. Based on selection of specific soil types documented as better for nitrogen processing, stability/erosion resistance, and other factors as appropriate to the study area. Assigning scores to different soil types based on the properties discussed should be done specifically for the area undergoing assessment, as national generalizations are limiting. Another option is to measure % area within the corridor that has soils with high resilience properties. Digital soil survey data varies from State to State in availability. States with fully digitized county soil survey-level information can use this metric most effectively. Physical and chemical properties of soils are available for most areas as part of the US General Soils Map through the NRCS Soil Data Mart (See: http://soildatamart.nrcs.usda.gov/).

watershed % streamlength unimpaired

Why relevant to recovery: From the standpoint of watershed-scale condition and functionality, the proportion of waterbodies reported as impaired is likely associated with the difficulty and complexity of a watershed-wide restoration. Functionally healthy stream reaches upstream of impairments may aid the recovery of impaired segments via dilution and through recruitment of aquatic biota. Caution should be taken that streams not reported as impaired aren't simply unassessed waters that could be impaired.

Data sources and measurement: Measured as a proportion of total stream length per watershed. Geospatial data on impaired waters reporting (CWA section 303(d) impaired waters listing) is available from states directly or from EPA national geospatial data downloads (http://www.epa.gov/waters/data/downloads.html), which are updated periodically with the most recent final spatial data from the states.

watershed shape (PDF) (1 pp, 36.9K)

Why relevant to recovery: A more circular watershed shape has been associated with degraded water quality primarily due to greater risk of a more frequently destabilized channel. Runoff from rounder watersheds tends to concentrate and reach the mouth more quickly and with greater erosive power and velocity. Further, the shortened channel length associated with rounder watersheds enables less travel time to naturally process excess nutrients. Elongate watersheds tend to lessen the effects described above, which would lower the risk of repeated destabilization during recovery efforts.

Data sources and measurement: Uses watershed boundary data. Watershed boundary datasets are available from the NRCS Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/GDGHome.aspx). Locate the watershed centroid, measure the axis (A) through the centroid most nearly parallel to the main channel, measure three additional axes (B, C, D) in 45 degree increments, then calculate the variability in length of these axes as A divided by the mean of the four axes. Nearly round watersheds approach a value of 1, elongate watersheds have higher values.

watershed size (PDF) (3 pp, 52.3K)

Why relevant to recovery: 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.

Data sources and measurement: Direct measurement of watershed area, with smaller size scoring higher. 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.

Corridor and shorelands stability

bank stability/soils (PDF) (8 pp, 174K)

Why relevant to recovery: Specifically at the banks of rivers and streams as well as lakes, soils that are unstable are prone to continual erosion and greater likelihood of excess sediment load. Destabilizing forces can include the absence of woody and/or herbaceous vegetation, an unstable channel form (e.g. cut banks), or the soil type itself may be erosion-prone. Continual erosion and excess sediment are often linked to instream habitat degradation and diminished spawning success of lithophilic spawners, and may also add to other impairments involving nutrients or water temperature.

Data sources and measurement: Metric reflects bank, not corridor, soil characteristics. Depending upon soil survey data available, specific soil types are rated as 'highly erosive'. This metric would be based on % of stream length passing through highly erosive soil types. Alternatively for lakes, use % of shoreline with highly erosive soil types. If a small buffer (e.g., 1 meter) is applied to the streams and lakes, then the measurement can be based on the % of area in the buffered corridor that contains highly erosive soil types yet still represent the land/water interface. Physical properties of soils are available for most areas as part of the US General Soils Map through the NRCS Soil Data Mart (See: http://soildatamart.nrcs.usda.gov/).

bank stability/woody vegetation (PDF) (4 pp, 72.8K)

Why relevant to recovery: Specifically at the banks of rivers and streams as well as lakes, areas that are unstable are prone to continual erosion and greater likelihood of a continuing excess sediment load. Destabilizing forces can include the absence of woody and/or herbaceous vegetation, an unstable channel form (e.g. cut banks), or the soil type itself may be erosion-prone. Continual erosion and excess sediment are often linked to instream habitat degradation and diminished spawning success of lithophilic spawners, and may also add to other impairments such as elevated nutrients or water temperature. River and stream banks without woody vegetative cover may be particularly prone to erosional damage during extreme high flow events and slower to recover in the aftermath. The prevalence of streambank stabilization projects involving woody plantings in restoration practice reflects the widespread opinion that the relative proportion of stable banks and woody vegetation needs to be high for the system to recover.

Data sources and measurement: Land cover datasets coarsely identify woody vegetation (e.g forest, shrub, forested wetland, shrub wetland) that can be assessed as % of bank length with woody cover along the reach being assessed, calculated for both banks: Lwoody / 2 Ltotal X 100. Making this a linear metric (i.e. length of woody cover actually in contact with both stream/river banks, as mapped) discerns this metric from the "Riparian % woody cover" which is areal and relates to additional recovery relevant factors. GIS algorithms may be used to set buffer = 0, or if a small buffer (e.g., 1 meter) is applied to the streams and lakes, then the measurement can be based on the % of area in the buffered corridor yet still represent the land/water interface. Land cover datasets are available through the National Land Cover Database (See: http://www.mrlc.gov/index.php). Land cover for coastal areas is available through NOAA's Coastal Change Analysis Program (See: http://www.csc.noaa.gov/digitalcoast/data/ccapregional/index.html) Orthophoto maps or remote imagery can be a good source for detailed local information. NHD Plus dataset contains flowline attributes on % for each land cover type from the National Land Cover Dataset (http://www.horizon-systems.com/nhdplus/index.php).

corridor % forest (PDF) (10 pp, 111K)

Why relevant to recovery: Broad array of influences on capacity to recover, including intercepting and moderating the timing of runoff, buffering water temperature extremes (which can also reduce certain toxicities), filtering pollutants in surface or subsurface runoff, providing woody debris to stream channels that enhances aquatic food webs, and stabilizing excessive erosion.

Data sources and measurement: Simplified calculation involves defining a standard corridor width on both sides of a watercourse (e.g. 30 meters, 90 meters) and calculating % area within the corridor. Also possible to calculate area within a variable-width corridor (e.g., an estimated flood return frequency zone). For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources.

corridor % woody veg (PDF) (4 pp, 65K)

Why relevant to recovery: Broad array of influences on capacity to recover, including intercepting and moderating the timing of runoff, buffering temperature extremes (which can also reduce certain toxicities), filtering pollutants in surface or subsurface runoff, providing woody debris to stream channels that enhances aquatic food webs, and stabilizing excessive erosion. See also corridor percent forest.

Data sources and measurement: Requires medium to high resolution land cover mapping with shrub and forested classes included. Simplified calculation involves defining a standard corridor width on both sides of a watercourse (e.g. 30 meters, 90 meters) and calculating % area total of forested and shrub categories within the corridor. Also possible to calculate area within a variable-width corridor (e.g., an estimated flood return frequency zone). Different results from forested % possible when land cover data include a shrub class as well. Land cover datasets are available through the National Land Cover Database (See: http://www.mrlc.gov/index.php). Land cover for coastal areas is available through NOAA's Coastal Change Analysis Program (See: http://www.csc.noaa.gov/digitalcoast/data/ccapregional/index.html) Orthophoto maps or remote imagery can be a good source for detailed local information.

corridor % wetlands

Why relevant to recovery: Wetlands are key features in watershed processing of nutrients in runoff, detention of excessive runoff during extreme weather events, and act as sinks for sediment and pollutants. In addition, wetlands provide vital recharge, detention and release in their role within groundwater/surface water interactions particularly in stream corridors. Absence of wetlands degrades natural processing of the pollutants mentioned and results in greater direct transport to the receiving water body, increasing or perpetuating impairment. Presence of wetlands in the corridor may imply a more functionally connected and active floodplain.

Data sources and measurement: Percent wetland area within the selected corridor width. Data sources may vary considerably in source, date and accuracy of wetland/upland delineation. For land cover data including generalized wetland categories, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources. NLCD or state land cover datasets are generally available but less accurate than wetland-specific mapping efforts such as National Wetlands Inventory (NWI) (see: http://www.fws.gov/wetlands/index.html). NWI data are partially available as digital coverage, are likely more accurately interpreted but may be out of date in selected areas.

corridor slope (PDF) (2 pp, 44.2K)

Why relevant to recovery: Mainly relevant as low-gradient land surfaces near waters tend to develop less gullying and destabilized floodplain features that may perpetuate some impairments or make restoration more difficult, complex or expensive. These low-slope areas may also have superior water retention and favor more stabilizing vegetative growth. Note that corridor slope and channel slope are different metrics that do not have identical implications for recovery potential.

Data sources and measurement: Digital elevation model (DEM) data or topographic data in many cases have already been mapped into slope classes, which can be merged with a selected corridor width to yield % in selected slope classes or a mean % slope for the corridor lands overall. Slope information can be obtained through the USGS Elevation Derivatives for National Applications (EDNA) (See: http://edna.usgs.gov/) For finer resolution, use local Digital Elevation Model (DEM) data.

corridor soil erosion potential

Why relevant to recovery: Soil types can vary substantially in erosion potential, with implications for the ease and frequency of siltation, as well as for delivery of associated pollutants. Corridor soils have potentially greater influence than erosive watershed soils in general due to proximity.

Data sources and measurement: Measured from mapped soil survey data within a selected corridor width, e.g. 30 meters, 90 meters. Assigning scores to different soil types based on the properties discussed should be done specifically for the area undergoing assessment, as national generalizations are limiting. Another option is to measure % area within the corridor that has soils with high resilience properties. Digital soil survey data varies from State to State in availability. States with fully digitized county soil survey-level information can use this metric most effectively. Physical and chemical properties of soils are available for most areas as part of the US General Soils Map through the NRCS Soil Data Mart (See: http://soildatamart.nrcs.usda.gov/).

corridor soil type

Why relevant to recovery: Soil texture and slope characteristics affect the degree of nitrogen retention, bank stability, overland flow and erosion potential, and soil characteristics can even completely over-ride land cover effects. Higher stream slopes increase soil erosion potential, and thus, Phosphorus transport potential in overland flow. Soil texture has been called the single most important watershed characteristic affecting water quality of the Great Lakes. Stream nutrients can be associated with soil properties, and fine-textured soils with higher runoff potentials appear to limit the transport of leached Nitrogen.

Data sources and measurement: Measured from mapped soil survey data within a selected corridor width, e.g. 30 meters, 90 meters. Based on selection of specific soil types documented as better for nitrogen processing, stability/erosion resistance, and other factors as appropriate to the study area. Assigning scores to different soil types based on the properties discussed should be done specifically for the area undergoing assessment, as national generalizations are limiting. Another option is to measure % area within the corridor that has soils with high resilience properties. Digital soil survey data varies from State to State in availability. States with fully digitized county soil survey-level information can use this metric most effectively. Physical and chemical properties of soils are available for most areas as part of the US General Soils Map through the NRCS Soil Data Mart (See: http://soildatamart.nrcs.usda.gov/).

shoreline % forested

Why relevant to recovery: Broad array of influences on capacity of lakes and reservoirs to recover, including intercepting and moderating the timing of runoff, buffering water temperature extremes (which can also reduce certain toxicities), filtering pollutants in surface or subsurface runoff, providing woody debris that enhances aquatic food webs, and stabilizing excessive erosion.

Data sources and measurement: Similar to corridor % forested measurement, but adapted for lakes and reservoirs to measure forested area within a shoreline buffer of specified width. For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources.

shoreline % woody veg

Why relevant to recovery: Broad array of influences on capacity of lakes and reservoirs to recover, including intercepting and moderating the timing of runoff, buffering water temperature extremes (which can also reduce certain toxicities), filtering pollutants in surface or subsurface runoff, providing woody debris that enhances aquatic food webs, and stabilizing excessive erosion.

Data sources and measurement: Similar to corridor % woody vegetation measurement, but adapted for lakes and reservoirs to measure wooded area within a shoreline buffer of specified width. For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources.

Flow and channel dynamics

natural channel form (PDF) (2 pp, 16.4K)

Why relevant to recovery: Retention of natural channel form is one of the most basic requirements for physical processes (e.g., flow regimes, sediment transport dynamics) to occur within a natural range of variability, and for biotic communities to become established. Although a wide variety of natural channel forms exist and some may be unstable or impaired for other reasons, the absence of any natural channel form (i.e. channelization) provides no generally preferred habitat as a starting point for biotic or natural fluvial process recovery. (see also Channelization under stressor indicators)

Data sources and measurement: Because channelization may occur in straight-line segments that join at angles, original detection is best done manually by visual ID on mapped or remote data (high resolution preferably). Once detected, the linear % of total reach length in natural channel form can be measured with common GIS software in a two-step process. Some monitoring programs note channel form among other field-gathered data, and this is occasionally adaptable to a metric. Data source – high resolution National Hydrography Dataset (See: http://nhd.usgs.gov/index.html), state/locally compiled channelization metrics from previous studies, or other digital source.

corridor groundwater level (PDF) (2 pp, 113K)

Why relevant to recovery: Potentially related in multiple ways to waterbody recovery. Shallower vadose zone depth is likely to be related to the retention of alternating influent and effluent reaches along stream corridors, implying greater likelihood that groundwater/surface water interactions and exchanges are functional rather than isolated and disconnected. Also related to the likelihood of successful reestablishment of riparian vegetation and the greater bank stabilization that is implied.

Data sources and measurement: Dependent upon data source; could be based on depth of water table as an average figure over a specific size area. Not often available as continuous landscape data, but localized sources of information may exist.

channel slope

Why relevant to recovery: Restoration practice implies that specific channel gradients are often more dynamically stable than others, and thus less prone to the instability that frequently causes channel restoration failure. Often, moderately sloped (e.g. 2 to 3%) channels are more stable than either lower or higher gradient channels. Note that corridor slope and channel slope are different metrics that do not have identical implications for recovery potential.

Data sources and measurement: Measured as change in elevation over channel length for a specified segment or interval; can be averaged for longer segments or watersheds. High-resolution data over longer horizontal distances will produce better results. Generalized slope information can be obtained through the USGS Elevation Derivatives for National Applications (EDNA) (See: http://edna.usgs.gov/) For finer resolution, use local Digital Elevation Model (DEM) data or LIDAR if available.

sinuosity

Why relevant to recovery: Highly sinuous channels generally are more prone to longer-term sediment problems if they are impaired by excessive sediment loads. On the other hand, sinuous channels may allow for more nutrient processing. Relevance to recovery can vary with the impairment type and whether the sinuosity is human-altered.

Data sources and measurement: Channel gradient can be field-measured very accurately at selected points. Topographic information or elevation datasets are less accurate but allow for coarse estimates of gradient anywhere. Sinuosity is better measured from high-resolution NHD or similar source than medium-resolution NHD. Expressed as channel segment length divided by straight line length between A and B, for a segment involving at least several meanders.

confinement ratio

Why relevant to recovery: Confinement indicates the relative narrowness of a stream valley in comparison to stream width; more confined channels (i.e., low confinement ratio) tend to be more highly sensitive and prone to high-energy bank erosion and channel destabilization. This sensitivity can make the banks of confined channels with sediment impairments more difficult to restore through establishment and management of vegetated buffers. Relevance to other impairment types is unknown.

Data sources and measurement: To calculate the confinement ratio, divide the valley floor width by the stream channel width. Very confined segments may have values around 1 to 2; very broad unconfined valley types with abandoned terraces may have a ratio of 10 or more. Measurement can require field work or be performed using aerial photography.

channel evolution status

Why relevant to recovery: Many stream channels evolve in form after a significant disturbance, and the stage of this evolutionary process is relevant to recovery potential. The tendency of rivers is to seek their own flow-related and sediment-related stability. Following disturbance, streams will try to reestablish the dimension, pattern, and profile of a pre-disturbance morphology. Channels in a highly destabilized state undergoing channel evolution may be more difficult to restore temporarily until approaching a more stable condition.

Data sources and measurement: The existing stream type must be compared to the potential stable form it is likely to take on in time. Widespread spatial data on this factor are not likely to be found, but helpful guidance on evaluating successional status is available at http://water.epa.gov/scitech/datait/tools/warsss/rrisc_box18.cfm

fine sediment transport capacity (PDF) (2 pp, 38.6K)

Why relevant to recovery: Moderate- to high-gradient streams and rivers are normally coarse-bedded and have aquatic communities adapted to coarse sediments. Fine sediment inputs commonly impair those communities. A system's capacity to move fine sediment and reestablish dynamic equilibrium affects how quickly it can recover from excess fine sediment loading.

Data sources and measurement: Channel gradient can be field-measured very accurately at selected points. Topographic information or elevation datasets are less accurate but allow for coarse estimates of gradient anywhere. Sinuosity is better measured from high-resolution NHD or similar source than medium-resolution NHD.

natural flow regime

Why relevant to recovery: Stream condition is largely dependent not only on 'enough' water but on naturally dynamic changes in the flow regime. Streamflow is strongly correlated with water temperature, channel form, and habitat, thus acting as a primary factor that determines their aquatic communities instream and affects numerous human uses near streams. Five components of the flow regime include magnitude, frequency, duration, timing, and rate of change; significant alteration of any of the five can affect stream ecosystem condition and strongly influence the potential for recovery from impairments of many kinds.

Data sources and measurement: Data on flow regime may be limited but are extremely valuable to recovery potential screening where available. Using specific measures of one or more of the five flow regime components is more feasible than a single metric to summarize flow regime overall.

median flow maintenance

Why relevant to recovery: See also natural flow regime. Depending on geographic region, median flow during specific times of the year influences stream and biological community condition. Surplus flows or deficits during crucial times of year may influence salmonid egg development, spawning, growth rates and survival, among many other effects. Although stream flow naturally varies, degree of departure from median flow on a monthly basis has been associated with significant biological impacts to current condition, and higher departure from expected flow range would likely work against recovery.

Data sources and measurement: Typically measured as the median monthly flow for a selected month throughout a period of record, and departure from median monthly flow is estimated with reference to natural streamflow regimes calculated from gauging stations in the area. Typically a departure threshold such as less than +/- 10% difference from reference flow can be considered maintenance within natural variability.

low-flow maintenance

Why relevant to recovery: See also natural flow regime. Seasonal low flow is a vulnerable time for stream communities due to greater risk of elevated water temperature, lower dissolved oxygen, predation, and more concentrated pollutants. As such, metrics that address the maintenance of low flows above harmful levels are useful in addressing whether flow volume might sustain or repeatedly interfere with stream recovery.

Data sources and measurement: A number of different metrics can address low flow. Annual 7-day minimum flow is a commonly used statistic in water monitoring. Also, the number of times and duration of each time that flows drop below a given threshold make useful measures from which to examine how well flow is maintained under low-flow scenarios.

Strahler stream order (PDF) (6 pp, 74.3K)

Why relevant to recovery: Stream size is strongly related to many condition-relevant attributes but the recovery potential of different stream sizes varies with the attribute. The smallest headwater streams appear to be most sensitive to riparian stresses, suggesting lower recovery potential, yet their small size and high disturbance regime may imply greater resiliency and more rapid recovery than larger orders, as well as less complex and expensive restoration needs. Generally higher biodiversity associated with small to moderate orders (2nd to 4th order) may imply a more complex and resilient biotic community structure that may respond well to restoration efforts. Another recovery factor favoring a focus on the recovery of smaller orders is their favorable downstream influence on the condition of larger order streams.

Data sources and measurement: Strahler stream order is manually calculable from topographic maps as well as available as a feature of the NHDplus value-added attributes data (see: http://www.horizon-systems.com/nhdplus/). NHDplus value-added attributes include stream order based on 1:100,000 NHD, which misses many finer order streams; thus orders may be lower than field-measured data, but may show relative rather than absolute differences in order adequately for general comparisons. Streams with Strahler stream order > 2 are compiled for the Mid-Atlantic region in the Mid-Atlantic Landscape Atlas (See: http://www.epa.gov/emap/html/cdrom/maia_dlg/). If high resolution DEM is available it is possible to use ArcGIS tools to derive the stream raster network and run “Stream Order” tool within Spatial Analyst toolbox to calculate Strahler Order for the network. Local datasets may also be available.

Biotic community integrity

biotic community integrity (PDF) (4 pp, 68.7K)

Why relevant to recovery: 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.

Data sources and measurement: 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).

rare taxa presence (PDF) (2 pp, 50.6K)

Why relevant to recovery: Rare taxa have repeatedly been associated with more diverse and functionally intact ecosystems, including aquatic ecosystems. Rare taxa are also often more sensitive to stressors, and their presence in an impaired water may imply that the impairment is not severe. Increased eligibility and options for protection or restoration, elevated public and scientific concern and motivation to act, and other social factors may also be associated with rare taxa. These reasons support a probable association of the presence of rare aquatic taxa with generally higher recovery potential.

Data sources and measurement: Species rarity has been organized and categorized for most major taxonomic groups as part of Natural Heritage Programs in most states and through NatureServe's conservation status assessment methodologies. National datasets can be found through the NatureServe Explorer (See: http://www.natureserve.org/explorer/) or the USDA Plants Database (See: http://plants.usda.gov/). In addition, USFWS runs the Critical Habitat Portal for obtaining GIS data for threatened and endangered species (http://criticalhabitat.fws.gov/crithab/). More detailed datasets can be found through Natural Heritage Programs available in most states. It is possible to score the presence/absence of rare taxa with corresponding values of 1 and 0.

trophic state

Why relevant to recovery: Trophic state is often associated with water body condition relative to nutrients, with highly eutrophic systems frequently considered nutrient-impaired. Beyond nutrients, trophic state also has implications for biological impairment, oxygen depletion, sediment, and other impairment types, the recovery from which can be hindered.

Data sources and measurement: Standard data sources usually do not exist unless compiled through state monitoring programs or special studies. Measurement can be categorical with weights assigned between eutrophic and oligotrophic extremes.

NFHAP fish habitat condition index

Why relevant to recovery: In a national assessment of fish habitat condition by the National Fish Habitat Action Partnership (NFHAP), 17 metrics related to fish habitat condition were calculated at the NHDplus catchment level. Better-scoring catchments with better habitats represent less of a departure from fully functional systems, generally implying greater likelihood of restorability.

Data sources and measurement: Data are publicly available for browsing and download through the NFHAP map viewer (see http://www.nbii.gov/far/nfhap/). Scores have been calculated at the watershed scale of NHDplus catchments, HUC12, and HUC8.

Aquatic connectivity

confluence density

Why relevant to recovery: For impairments affecting biological communities in streams, recruitment from tributaries, particularly those large enough to support similar species assemblages, is one factor influencing speed of recovery. Tributaries per linear mile of impaired stream represent possible recolonization sources. On a watershed basis, confluence density is a measurement of this property.

Data sources and measurement: Measured as the count of confluences per mile of watershed total stream length. Strahler Order if used is available from NHD plus (See: http://www.horizon-systems.com/nhdplus/). Confluence count can be manual or automated. Where available, dam locations can be used to further assess and verify accessibility. Note that NHDplus data are at 100K resolution, missing many finer order streams.

unimpaired confluences density

Why relevant to recovery: Impaired waters with unimpaired tributary confluences or bracketed by unimpaired upstream and downstream segments may be good prospects, as are listed waters where species of concern are reduced in number but not totally lost. In contrast, impaired waters isolated from similar systems may have poor prospects for recruitment or even be dependent on manmade reintroductions to recover fully, even if physical conditions have become suitable.

Data sources and measurement: Measured as the count of confluences (optionally within + or - 1 Strahler stream order) unimpaired channels per mile of impaired segment on a watershed basis (also counts both up and downstream of segments within longer watercourses). Impaired segment shapefiles are available from ATTAINS (See: http://www.epa.gov/waters/ir/) and can be measured for length. Strahler Order is available from NHDplus (See: http://www.horizon-systems.com/nhdplus/) for both impaired segments and their tributaries. Where available, dam locations should be used to further assess and verify accessibility. Note that both the ATTAINS dataset and NHDplus are at 100K resolution missing many finer order streams. When possible, high resolution data on Strahler order should be used.

watershed stream density

Why relevant to recovery: Stream density is a surrogate measurement related to opportunities for biotic recruitment from tributaries. For impairments affecting biological communities in streams, recruitment from tributaries, particularly those large enough to support similar species assemblages, is one factor influencing speed of recovery. Tributaries per linear mile of impaired stream represent possible recolonization sources.

Data sources and measurement: Measured as the total stream length per watershed total land area. Note that NHDplus data are at 100K resolution missing many finer order streams.

contiguity with green infrastructure corridor (PDF) (4 pp, 60K)

Why relevant to recovery: Based on extensive documentation of the importance of connectivity among suitable habitats and habitat size/extent supporting more diverse and resilient ecological communities. Corridors increase effective habitat size and access, afford migration and movement to avoid temporary stressors, and aid recruitment and recolonization of impaired areas. Basically, impaired water segments near, or hydrologically connected to, functionally intact waters identified as important corridors by a green infrastructure (GI) mapping effort have greater recovery potential than isolated impaired waters for the reasons above. Generally, GI corridors have relatively unimpaired aquatic systems and relatively uninterrupted, naturally vegetated riparian corridors.

Data sources and measurement: This factor can be measured on a watershed-specific basis as corridor length, but that does not address connectivity. Measured on a stream segment basis, one example system for scoring would be: 0) no surface hydrologic connection to green infrastructure corridor; 1) no proximity to green infrastructure corridor (e.g., connected hydrologically but >2 km from corridor terminus); 2) proximate to green infrastructure corridor (e.g., connected hydrologically and < 2 km from corridor terminus); 3) connected to green infrastructure corridor; 4) Connected to and bridging two or more green infrastructure corridors. Green Infrastructure (McMahon and others) mapping at statewide and other large scales has established criteria by which the more intact and ecologically functional stream corridors and larger natural habitat 'hubs' are identified. Examples of available state data include Maryland (See: http://www.dnr.state.md.us/greenways/gi/gi.html) or California (See: http://imaps.dfg.ca.gov/viewers/biospublic/app.asp?zoomtoBookmark=2335).

proximity to green infrastructure hub (PDF) (3 pp, 56.3K)

Why relevant to recovery: Based on extensive documentation of island biogeographic principles and the importance of habitat size/extent supporting more diverse and resilient ecological communities. Green hubs and connected corridors increase effective habitat size and access, afford migration and movement to avoid temporary stressors, and aid recruitment and recolonization of impaired areas. Basically, impaired water segments near, or hydrologically connected to, functionally intact waters identified as parts of hubs and important corridors by a green infrastructure (GI) mapping effort have greater recovery potential than isolated impaired waters for the reasons above. Generally GI hubs contain major or multiple unimpaired aquatic systems and constitute larger, relatively uninterrupted, naturally vegetated communities with connections to multiple, naturally vegetated riparian corridors.

Data sources and measurement: This factor can be measured on a watershed-specific basis as GI hub % of watershed, or measured on a stream segment basis. Green Infrastructure (McMahon and others) mapping at statewide and other large scales has established criteria by which the more intact and ecologically functional, larger natural habitat 'hubs' are identified. Examples of available state data include Maryland (See: http://www.dnr.state.md.us/greenways/gi/gi.html) or California (See: http://imaps.dfg.ca.gov/viewers/biospublic/app.asp?zoomtoBookmark=2335). Relative differences in this metric can be summarized as follows. If a categorical scheme is used, each impaired water segment could fall somewhere in the following classes (worst to best):0) no hydrologic or watershed connection to a GI hub; 1) limited proximity to GI hub (e.g., within GI watershed and connected hydrologically but > 2 km from GI hub); 2) proximate to GI hub (e.g., connected hydrologically and < 2 km from GI hub); 3) continuous with GI hub.

recolonization access (PDF) (7 pp, 159K)

Why relevant to recovery: Loss or degradation of aquatic life, usually affecting a more sensitive subset of the resident fish or stream invertebrates, is an impairment whose recovery can be highly influenced by access and proximity to the nearest appropriate source for recolonization after conditions improve. Same or similar-sized streams within the same drainage are more likely to support similar aquatic life and act as biotic refugia and recruitment sources for recolonizing the impaired segment. Most relevant where aquatic life use support is impaired (many, perhaps most listed waters). Impaired waters with unimpaired tributary confluences or bracketed by unimpaired upstream and downstream segments may be good prospects, as are listed waters where species of concern are reduced in number but not totally lost. In contrast, impaired waters isolated from similar systems may have poor prospects for recruitment or even be dependent on manmade reintroductions to recover fully, even if physical conditions have become suitable.

Data sources and measurement: Count # of confluences with + or - 1 Strahler stream order unimpaired channels per mile of impaired segment; impaired waters data from EPA/ATTAINS, stream order from NHDplus value-added attributes. Impaired segment shapefiles are available from ATTAINS (See: http://www.epa.gov/waters/ir/) and can be measured for length. Strahler Order is available from NHD plus (See: http://www.horizon-systems.com/nhdplus/) for both impaired segments and their tributaries. Confluence count can be manual or automated. Where available, dam locations should be used to further assess and verify accessibility. Note that both the ATTAINS dataset and NHD plus are at 100K resolution missing many finer order streams. When possible, high resolution data on Strahler order should be used.

Ecological history

maintenance of % natural cover

Why relevant to recovery: The relative proportion of land cover in a watershed that is not human-made (e.g., urban, agricultural, mining, or other altered cover types) influences watershed and water body condition in a number of ways. A high proportion of natural land cover is associated with better retention and infiltration of precipitation, less likelihood of damaging overland flow and erosion, and less transport of pollutants in runoff. This metric also incorporates the lack of rapid change in the proportion of natural cover, which generally implies low prospects for future loss of natural cover.

Data sources and measurement: Natural cover categories from land cover mapping mainly include forest, shrubland, wetlands, grasslands and in some regions desert or barren land categories. Maintenance of natural cover is measured as change in total percent of land area (not including water area) in the watershed within the total of these several mapped natural land cover categories. For land cover data, the National Land Cover Dataset (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; the NLCD has already made available a land cover change dataset that can be used to generate this indicator. Numerous statewide land cover mapping datasets are also available from state-specific sources, but would require equivalent classification categories for two different dates.

ratio current/historic % forest

Why relevant to recovery: It is possible to consider a watershed's estimated pre-settlement natural vegetation cover as the original baseline for its general land-water interactions. For naturally forested regions the pre-settlement percentage of watershed forest cover can be reasonably estimated based on general terrain characteristics, soils and geologic data. When the current land cover proportions closely approximate original land cover, there is less likelihood of altered recharge, runoff, and other land/water interactions that may impede recovery.

Data sources and measurement: For land cover data, the National Land Cover Dataset (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php. Studies of potential natural vegetation cover have been produced for most states, providing an approximation of pre-settlement vegetation types and distribution.

ratio current/historic % wetlands

Why relevant to recovery: It is possible to consider a watershed's estimated pre-settlement natural vegetation cover as the original baseline for its general land-water interactions, and the similarity of current to historic wetlands extent provides insight into current condition relative to watershed hydrologic processes. Wetlands are key features in watershed processing of nutrients in runoff, detention of excessive runoff during extreme weather events, and act as sinks for sediment and pollutants. In addition, wetlands provide vital recharge, detention and release in their role within groundwater/surface water interactions particularly in stream corridors. Absence of wetlands degrades natural processing of the pollutants mentioned and results in greater direct transport to the receiving water body, increasing or perpetuating impairment.

Data sources and measurement: Measure of the watershed's current percent wetland area divided by an estimated historic percent area, based on hydric soils with very low slope. Current data sources may vary considerably in source, date and accuracy of wetland/upland delineation. For land cover data including generalized wetland categories, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources. NLCD or state land cover datasets are generally available but less accurate than wetland-specific mapping efforts such as National Wetlands Inventory (NWI) (see: http://www.fws.gov/wetlands/index.html). NWI data are partially available as digital coverage, are likely more accurately interpreted but may be out of date in selected areas.

historical species occurrence (PDF) (2 pp, 27.9K)

Why relevant to recovery: Although single-species oriented, this metric is appropriate where a restoration target or even a water quality criterion directly addresses a species of concern (e.g., naturally reproducing salmon or trout populations), or indirectly alludes to an aquatic condition exemplified by a keystone species (e.g., Eastern Brook Trout exemplifying a coldwater biotic community target). Verified historical occurrence does not necessarily ensure recovery potential due to the many additional factors that may interfere, but should provide a starting point for comparative evaluations of numerous potential restorations involving that species as a target. Verified historical absence is valuable for avoiding inappropriate restoration investments due to low recovery potential.

Data sources and measurement: Limited to individual species of concern that have been researched sufficiently to establish historical presence/absence data. Assuming the probability that historical data are incomplete or imperfect, this metric at a minimum allows for the following three ranking categories (lowest to highest): 0) historically not found; 1) unknown historical occurrence; 2) known historical occurrence. Distributional information on historical presence/absence of the species of interest may not exist for many species. Threatened and Endangered Species Habitat can be found through the USFWS Critical Habitat Portal (See: http://criticalhabitat.fws.gov/). Historical information may be available through State Fish and Wildlife Service, as is the case in Oregon (See: http://www.fws.gov/oregonfwo/Species/Data/). Biodiversity organizations and state natural heritage programs may have data on other major aquatic taxa of interest.

species range (PDF) (2 pp, 40.1K)

Why relevant to recovery: Although single-species oriented, this metric is appropriate where a restoration target or even a water quality criterion directly addresses a species of concern (e.g., naturally reproducing salmon or trout populations), or indirectly alludes to an aquatic condition exemplified by a keystone species (e.g., Eastern Brook Trout exemplifying a coldwater biotic community target). The rationale regarding recovery is that a waterbody occurring in marginal habitat that approaches an extreme of species range generally represents greater stressors and higher risks to restoration efforts than non-marginal range locations. Marginality concepts may be numerous (e.g., northern or southern extremes; elevation; waterbody traits such as size, channel gradient, substrate; precipitation regime) and need to be selected appropriately for the species of interest. Climate change effects – both global processes and local, man-induced processes that approximate global effects (e.g. water temperature regime changes due to development and vegetation removal) – may act to make marginal range areas additionally unsuitable and difficult to restore.

Data sources and measurement: Dependent upon species range maps, which are often very generalized. Modification may be necessary by consulting with local experts on the species of concern. Threatened and Endangered Species Habitat can be found through the USFWS Critical Habitat Portal (See: http://criticalhabitat.fws.gov/). Historical information may be available through State Fish and Wildlife Service, as is the case in Oregon (See: http://www.fws.gov/oregonfwo/Species/Data/). Biodiversity organizations and state natural heritage programs may have data on other major aquatic taxa of interest.

Part 2: Stressor Indicator Summaries

Watershed-level disturbance

watershed % agriculture (PDF) (9 pp, 90.3K)

Why relevant to recovery: Croplands and pastures have been linked to a wide variety of water quality and biotic impacts on waters. Common effects seen at moderate to high agricultural proportions of total watershed land cover include less diverse and more intolerant macrobenthic communities, increased nutrient loading resulting in turbid water, overall homogenization of the fish fauna, accelerated erosion and bank destabilization, suspended sediment particles carrying pesticides, pathogens, and heavy metals, habitat degradation and reduced biodiversity, and increases in specific conductivity, DIN, DRP, and TP concentrations. See other highlights in literature excerpts, below. Although watershed agriculture is commonly linked to degraded aquatic conditions that may be difficult to reverse and quite persistent over time, it is important to note that some degree of recovery is rarely considered impossible.

Data sources and measurement: Calculated as % by area within watershed; often cropland and pasture are compiled as separate metrics. Land cover sources include the National Land Cover Data from 1992 (See: http://www.epa.gov/mrlc/nlcd.html), 2001 (See: http://www.epa.gov/mrlc/nlcd-2001.html), and 2006 (http://www.mrlc.gov/nlcd06_data.php) as well as various state sources. The USGS lists cropland by county since 1850 (See: http://landcover.usgs.gov/cropland/index.php). Approximate watershed boundaries can be constructed by aggregating small-scale catchments from the NHDplus datasets (See: http://www.horizon-systems.com/nhdplus/). If the user chooses to use this indicator for a specific crop relevant to the study area, USDA has developed a national GIS crop dataset that can be downloaded from Geospatial Data Gateway (See: http://datagateway.nrcs.usda.gov/GDGHome.aspx). In addition, where applicable, BLM data set on range allotments and pastures can be used (See: http://www.geocommunicator.gov/GeoComm/).

watershed % steep slope agriculture

Why relevant to recovery: See watershed % agriculture for rationale. Specifically on steep slopes, cropland is associated with higher erosion and overland transport of nutrients and other pollutants. Abundant steep-slope agriculture in a watershed may represent a significant difficulty to overcome in restoration efforts.

Data sources and measurement: : Calculated as % by area within watershed; land cover data and elevation data (preferably converted to slope map categories) are necessary to target the steep slope agriculture. Land cover sources include the National Land Cover Data from 1992 (See: http://www.epa.gov/mrlc/nlcd.html), 2001 (See: http://www.epa.gov/mrlc/nlcd-2001.html), and 2006 (http://www.mrlc.gov/nlcd06_data.php) as well as various state sources. If the user chooses to use this indicator for a specific crop relevant to the study area, USDA has developed a national GIS crop dataset that can be downloaded from Geospatial Data Gateway (See: http://datagateway.nrcs.usda.gov/GDGHome.aspx). The National Elevation Dataset (NED) (See: http://nhd.usgs.gov/index.html) is adequate for generalized differences in elevation. High resolution elevation data should be used for any assessment units at HUC12 level of smaller. The Elevation Derivatives for National Applications (EDNA) has been derived from the NED and is hydrologically conditioned to improve hydrologic flow representation (see: http://edna.usgs.gov/). NHD plus contains information on maximum and minimum elevation for each flowline (http://www.horizon-systems.com/nhdplus/).

watershed number of CAFOs

Why relevant to recovery: Confined animal feeding operations (CAFOs) are a spatially concentrated source of nutrients and pathogens that, although frequently managed or regulated, can episodically release pollutants that set back impaired waters recovery. Due to the high magnitude of pollutant loads associated with CAFOs, they can be considered a potential stressor that may reduce recovery potential in some areas.

Data sources and measurement: State records may identify or map CAFO locations and likely also the livestock species and numbers.

watershed number of septic systems

Why relevant to recovery: Although subject to regulations, private septic systems are in failure frequently enough that many watershed models routinely assume a "% septic failure" factor of 30% or more. Failed septics that reach waterways can increase nutrient and pathogen loadings, as well as deliver household toxins such as chlorine. Because of difficulty of detection, failed septic systems are also an obstacle to effective recovery and restoration targeting.

Data sources and measurement: Land cover maps overlaid with non-sewered area maps can help identify zones of potential septic usage and assumed partial failure rates. Some municipalities have individual septic records that can be summed by township or watershed. Local watershed studies and TMDLs may provide a source for septic failure coefficient assumed in the area.

watershed % impervious cover (PDF) (8 pp, 103K)

Why relevant to recovery: Impervious cover is an indicator of the impacts of urbanization and development on water resources. Impervious cover results in multiple stressors to a watershed, such as increased pollutant loads from stormwater runoff, altered stream flow, decreased bank stability, and increased water temperatures. The significance of this metric in reducing recovery potential is based on the multiple impacts to the watershed as well as the nearly irreversible nature of imperviousness at high levels.

Data sources and measurement: Multiply the watershed area classified as "urban" (i.e. low, medium, and high density residential; commercial; industrial; etc) by the appropriate impervious cover coefficient for each land use type. The percent impervious cover indicator is calculated by averaging the impervious cover areas across the total land area of the watershed. If possible, differentiating between impervious cover contiguous with or isolated from drainage should be done to estimate 'effective' impervious cover. The 2001 and 2006 National Land Cover Data contains information on impervious covers as well as urban land cover (See: http://www.epa.gov/mrlc/nlcd-2001.html and http://www.mrlc.gov/nlcd06_data.php). Approximate watershed boundaries can be constructed by aggregating small-scale catchments from the NHDplus datasets (See: http://www.horizon-systems.com/nhdplus/).

watershed % tile-drained cropland (PDF) (3 pp, 51.9K)

Why relevant to recovery: Tiles efficiently drain water from the soil saturated zones to streams, thereby reducing residence time in areas conducive to denitrification and increasing nitrogen export. Tile draining also has created concern for the delivery of sediment, sources of bacteria, contaminants, and suspended solids. Tile drains can selectively transport fine-grained sediment from soils to receiving freshwater, increase the size of the contributing area by hydraulically connecting remote areas of the catchment to the stream system, and circumvent management strategies such as buffer strips. Subsurface drain tiling that accompanies wetland drainage can lead to flashy hydrology that can decimate the stream biota. Most of the above effects are exacerbated by the way tiles extend the total area producing these negative impacts farther out into the watershed.

Data sources and measurement: Based on verifying the association of tile drain usage with specific hydric soil types that are being cropped. Basic information needs include three elements: locally gathered monitoring data on agricultural practices associated with specific hydric soil types and agricultural uses (e.g., NASS, NRI surveys by USDA), soil type mapping, and agricultural land cover mapping). Digital soil survey data varies from State to State in availability. States with fully digitized county soil survey-level information can use this metric most effectively. Physical and chemical properties of soils are available for most areas as part of the US General Soils Map through the NRCS Soil Data Mart (See: http://soildatamart.nrcs.usda.gov/). Land cover sources include the National Land Cover Data from 1992 (See: http://www.epa.gov/mrlc/nlcd.html), 2001 (See: http://www.epa.gov/mrlc/nlcd-2001.html), and 2006 (http://www.mrlc.gov/nlcd06_data.php), as well as various state sources. The USGS lists cropland by county since 1850 (See: http://landcover.usgs.gov/cropland/index.php). If the user chooses to use this indicator for a specific crop relevant to the study area, USDA has developed a national GIS crop dataset that can be downloaded from Geospatial Data Gateway (See: http://datagateway.nrcs.usda.gov/GDGHome.aspx).

watershed % U index (PDF) (2 pp, 33.4K)

Why relevant to recovery: Watershed-wide U-index (anthropogenic) land cover patterns are associated with benthic macroinvertebrate communities that are tolerant of stream degradation, indicating a lower level of aquatic ecological integrity and water quality. As the intensity of human activities increase there is a tendency that the biological integrity of the rivers decreases. Increasing substrate embeddedness and bank erosion have also been observed to increase in streams in developing areas. High U-index may indicate that, as widespread anthropogenic cover is unlikely to be reduced and is complex to remediate, U-index may be a strong determinant of poor recovery prospects.

Data sources and measurement: Extracted from land cover mapping within the watershed, and summarized as % anthropogenic cover types (e.g. developed, agricultural) by area. For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources.

watershed % urban (PDF) (30 pp, 311K)

Why relevant to recovery: Urbanization of a watershed results in multiple stressors to a watershed, such as increased pollutant loads from stormwater runoff, altered stream flow, decreased bank stability, and increased water temperatures. The significance of this metric in reducing recovery potential is based on the multiple impacts to the watershed as well as the nearly irreversible nature of imperviousness. (See also Watershed Impervious Cover under Stressor Exposure indicators.)

Data sources and measurement: Measured as a percent of the area of a watershed with a land use classification of "urban" (i.e. low, medium, and high density residential; commercial; industrial; etc). For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources.

watershed road density (PDF) (3 pp, 57.6K)

Why relevant to recovery: Storm drains and roads appeared to be important elements influencing the degradation of water quality with respect to the biota. Fish density, number of intolerant fish species, and invertebrate density are seen to change in association with more roads in watersheds. Studies of Middle Atlantic streams have linked greater road densities to increased conductivity and subsequent impacts on aquatic life. Roads also add to impervious cover and thereby contribute to many secondary effects on flashy flows and related destabilized channels, increased urban pollutant transport, and other effects.

Data sources and measurement: Mean road length per watershed square mile. Transportation GIS datasets are widely available and can be used in overlay with an impaired waters dataset where watershed boundaries have been delineated. National road and stream data is obtainable through the National Atlas (See: http://nationalatlas.gov/). Transportation GIS datasets are widely available and can be used in overlay with an impaired waters dataset where watershed boundaries have been delineated. ESRI offers a free roads dataset that can be opened in ArcMap (http://www.arcgis.com/home/item.html?id=3b93337983e9436f8db950e38a8629af).

other % watershed stressor

Why relevant to recovery: The indicators described in this table are not an exhaustive list of all the stressors that might play a highly significant role in the restorability of some watersheds. Surface mining, for example, is not among the indicators summarized but can play a major role in comparison of recovery potential of some watersheds. This metric is a simple placeholder for regionally-significant stressors in watersheds that are not captured in other indicators.

Data sources and measurement: As appropriate, depending upon data source.

Corridor and shorelands disturbance

corridor % impervious cover (PDF) (3 pp, 50.9K)

Why relevant to recovery: Impervious cover is an indicator of the impacts of urbanization and development on water resources. Some literature reveals greater impacts of corridor urbanization and imperviousness than the same activities across the watershed. Impervious cover results in multiple stressors to a watershed, such as increased pollutant loads from stormwater runoff, altered stream flow, decreased bank stability, and increased water temperatures. The significance of this metric in reducing recovery potential is based on the multiple secondary impacts to the corridor and water body as well as the nearly irreversible nature of imperviousness. (See also Watershed Percent Impervious.)

Data sources and measurement: Multiply the area classified as "urban" (i.e. low, medium, and high density residential; commercial; industrial; etc) within a defined corridor width (e.g. 90 meters per side) by the appropriate impervious cover coefficient for each land use type. The percent impervious cover indicator is calculated by averaging the impervious cover areas across the total land area of the corridor. If possible, differentiating between impervious cover contiguous with or isolated from drainage should be done to estimate 'effective' impervious cover. The 2001 and 2006 National Land Cover Data contains information on impervious covers as well as urban land cover (See: http://www.epa.gov/mrlc/nlcd-2001.html and http://www.mrlc.gov/nlcd06_data.php). Approximate watershed boundaries can be constructed by aggregating small-scale catchments from the NHDplus datasets (See: http://www.horizon-systems.com/nhdplus/).

corridor % tile-drained cropland

Why relevant to recovery: Tiles efficiently drain water from the soil saturated zones to streams, thereby reducing residence time in areas conducive to denitrification and increasing nitrogen export. Tile draining also has created concern for the delivery of sediment, sources of bacteria, contaminants, and suspended solids. Tile drains can selectively transport fine-grained sediment from soils to receiving freshwater, and increase the size of the contributing area, by hydraulically connecting remote areas of the catchment to the stream system, and (ii) circumvent management strategies such as buffer strips. Subsurface drain tiling that accompanied wetland drainage can lead to flashy hydrology that can decimate the stream biota.

Data sources and measurement: Based on verifying the association of tile drain usage with specific hydric soil types that are being cropped. Basic information needs include three elements: locally gathered monitoring data on agricultural practices associated with specific hydric soil types and agricultural uses (e.g., NASS, NRI surveys by USDA), soil type mapping, and agricultural land cover mapping). Digital soil survey data varies from State to State in availability. States with fully digitized county soil survey-level information can use this metric most effectively. Physical and chemical properties of soils are available for most areas as part of the US General Soils Map through the NRCS Soil Data Mart (See: http://soildatamart.nrcs.usda.gov/). Land cover sources include the National Land Cover Data from 1992 (See: http://www.epa.gov/mrlc/nlcd.html), 2001 (See: http://www.epa.gov/mrlc/nlcd-2001.html), and 2006 (http://www.mrlc.gov/nlcd06_data.php), as well as various state sources. The USGS lists cropland by county since 1850 (See: http://landcover.usgs.gov/cropland/index.php). If the user chooses to use this indicator for a specific crop relevant to the study area, USDA has developed a national GIS crop dataset that can be downloaded from Geospatial Data Gateway (See: http://datagateway.nrcs.usda.gov/GDGHome.aspx).

corridor % U-index (PDF) (2 pp, 42.2K)

Why relevant to recovery: Both riparian and watershed-wide U-index (anthropogenic) land cover patterns are associated with benthic macroinvertebrate communities that are tolerant of stream degradation, indicating a lower level of aquatic ecological integrity and water quality. As the intensity of human activities increase there is a tendency that the biological integrity of the rivers decreases. Increasing substrate embeddedness and bank erosion have also been observed to increase in streams in developing areas. High riparian U-index may indicate that, as widespread anthropogenic cover is unlikely to be reduced and is complex to remediate, U-index may be a strong determinant of poor recovery prospects.

Data sources and measurement: Extracted from land cover mapping within a set corridor width, and summarized as % anthropogenic cover types (e.g. developed, agricultural) by area within the corridor. For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources. This metric can also be measured with a narrow corridor width or as a linear feature to identify specifically the land-water interface proportions that are in human-altered cover types.

corridor % urban (PDF) (6 pp, 63.7K)

Why relevant to recovery: As the intensity of urbanization increases, biotic integrity tends to decrease. Developed land cover in riparian zones is associated with aquatic biota more tolerant of pollutants. Increasing substrate embeddedness and bank erosion have also been observed to increase in streams in developing areas. Significantly lower water quality is often found downstream of highly developed corridors where not attributable to treatment plant discharges. Human shoreline development may lead to loss of littoral habitats. Threshold responses to percentages of development found in corridors were not borne out also at the watershed scale, indicating potentially greater significance of corridor vs watershed effects from urbanization.

Data sources and measurement: Extracted from land cover mapping within a set corridor width, and summarized as % developed (e.g., residential, commercial, industrial, urban center, etc) by area within the corridor. For land cover data, the National Land Cover Database (NLCD) for 2006, 2001 and 1992 is accessible at http://www.mrlc.gov/finddata.php; numerous statewide land cover mapping datasets are also available from state-specific sources.

corridor % agriculture (PDF) (5 pp, 51.9K)

Why relevant to recovery: Croplands and pastures have been linked to a wide variety of water quality and biotic impacts on waters. Agriculture within stream corridors is sometimes more highly linked with several impairment types than agriculture generally distributed in the watershed, but often watershed percentage also appears to be a strong influence. Common effects seen at moderate to high agricultural proportions of land cover include less diverse and more intolerant macrobenthic communities, increased nutrient loading resulting in turbid water, overall homogenization of the fish fauna, accelerated erosion and bank destabilization, suspended sediment particles carrying pesticides, pathogens, and heavy metals, habitat degradation and reduced biodiversity, and increases in specific conductivity, DIN, DRP, and TP concentrations. Although agriculture is commonly linked to degraded aquatic conditions that may be difficult to reverse and quite persistent over time, it is important to note that some degree of recovery is rarely considered impossible; for example, livestock access to channels may be more influential than corridor agricultural use and is commonly feasible to reduce. However, some studies claim that agriculture on floodplains can constrain the benefits of restoring natural hydrologic processes.

Data sources and measurement: Calculated as % by area within a set corridor width (e.g., 30 M or 90 M on each side); often cropland and pasture are compiled as separate metrics. Land cover sources include the National Land Cover Data from 1992 (See: http://www.epa.gov/mrlc/nlcd.html), 2001 (See: http://www.epa.gov/mrlc/nlcd-2001.html), and 2006 (http://www.mrlc.gov/nlcd06_data.php) as well as various state sources. The USGS lists cropland by county since 1850 (See: http://landcover.usgs.gov/cropland/index.php). If the user chooses to use this indicator for a specific crop relevant to the study area, USDA has developed a national GIS crop dataset that can be downloaded from Geospatial Data Gateway (See: http://datagateway.nrcs.usda.gov/GDGHome.aspx). In addition, where applicable, BLM data set on range allotments and pastures can be used (See: http://www.geocommunicator.gov/GeoComm/).

linear % of channel through agriculture

Why relevant to recovery: Croplands and pastures have been linked to a wide variety of water quality and biotic impacts on waters (see watershed % agriculture, corridor % agriculture). The actual land/water interface along streams that pass through agricultural areas can vary substantially in its relevance to agriculture-related impairment; corridors or watersheds with high proportions of agriculture may still have well-vegetated buffers, or may be farmed or grazed all the way to the channel. Unbuffered shorelines are more erosion-prone, deliver more sediment and pollutants such as pesticides and fertilizers in runoff, can elevate water temperatures, and other impacts that hinder and complicate recovery.

Data sources and measurement: Overlaid stream hydrography and land cover enables quantifying this metric on a segment or watershed basis. Calculation can be performed as a linear measurement if the watershed contains only linear streams, but can also be approximated by calculating % area within a very narrow (e.g., 1 meter) buffer. An equivalent approach allows for lake shores to be characterized. Resolution of the land cover source should be considered, as thin buffers may not be detected or mapped. A slightly different way to quantify the agriculture/flowing water interface involves looking also at flow accumulation paths generated from digital elevation data. These 'low spots' may not have channels but where coinciding with agricultural lands they have some likelihood of transporting agricultural runoff to surface waters nearby.

corridor road crossings (PDF) (2 pp, 43.3K)

Why relevant to recovery: Road crossings are linked with degraded condition for several reasons, but because most crossings are likely permanent, their relevance to recovery potential is also linked to whether the degraded conditions can be managed or mitigated for. Road crossings are linked with channel destabilization, tree collapse, hanging tributary junctions as a result of variable incision rates, and erosion around artificial structures including bridges. Local scouring alters sedimentation and deposition processes, and more sediment and chemicals enter streams where a road crosses. Wetland road crossings often block drainage passages and groundwater flows, effectively raising the upslope water table and killing vegetation by root inundation, while lowering the downslope water table. Small road crossings for which the culverts do not allow upstream fish passage and constrict the available useful habitat for salmonids already vulnerable to other impacts.

Data sources and measurement: Measured as number of crossings per stream mile. Land cover or transportation GIS data are widely available. National road and stream data is obtainable through the National Atlas (See: http://nationalatlas.gov/). Landsat data is also often used for road and stream data and can be accessed through the USGS Earth Explorer (See: http://edcsns17.cr.usgs.gov/EarthExplorer/). ESRI offers a free roads dataset (http://www.arcgis.com/home/item.html?id=3b93337983e9436f8db950e38a8629af). Data on unimproved road crossings in remote parts of federal lands may need to be obtained through the land management agency.

corridor road density (PDF) (3 pp, 48.5K)

Why relevant to recovery: Riparian corridor roads can affect sedimentation and deposition processes, increase siltation to the detriment of aquatic biota, compact floodplain substrates and reduce recharge that would help maintain base flow, and increase pollutants such as road salts that raise conductivity and harm stream invertebrates and fish. Because most stream corridor roads are likely permanent, their relevance to recovery potential is also linked to whether the degraded conditions can be managed or mitigated for.

Data sources and measurement: Measured as mean road length per stream corridor area. Transportation GIS datasets are widely available and can be used in overlay with an impaired waters dataset with a corridor of set width (e.g., 30M, 90M per side) delineated. National road and stream data is obtainable through the National Atlas (See: http://nationalatlas.gov/). Transportation GIS datasets (e.g., ESRI transportation http://www.arcgis.com/home/item.html?id=3b93337983e9436f8db950e38a8629af) are widely available and can be used in overlay with an impaired waters dataset with a corridor of set width (e.g., 30M, 90M per side) delineated. 90M is preferable for this metric in order to ensure that roads that generally parallel the channel are detected and counted.

Hydrologic alteration

aquatic barriers (PDF) (14 pp, 215K)

Why relevant to recovery: This metric is often relevant to evaluating restoration prospects for bio-impairments. Barriers that fragment aquatic populations of marginal size may reduce the viability of each fragment. Barriers often also can prevent or delay recolonization of areas with diminished or absent populations. Barriers may be natural (waterfalls, major habitat changes) as well as artificial (perched culverts, buried streams, dams), and may be physico-chemical (temperature, toxicity) as well as structural. Unless species reintroduction is feasible to circumvent a problem that cannot be removed or modified, barriers are sometimes insurmountable obstacles to aquatic community recovery.

Data sources and measurement: Barrier influence is most easily measured as a count per watershed, but more meaningfully scored on the basis of relative isolation of specific segments from waters of similar (+ or – 1 Strahler order) size. Depending on motility of the species of interest, the height considered impassable and the barrier's upstream or downstream location may be considered. Where information on the dam types is limited, the metric can be measured in terms of barriers presence/absence. Aquatic barriers for fish passage are documented through the US Fish and Wildlife Fish Passage Decision Support System (See: http://fpdss.fws.gov/home). Major dams have been mapped through the US Army Corps of Engineers' National Inventory of Dams (See: http://www.usace.army.mil/Library/Maps/Pages/NationalInventoryofDams.aspx) but the large numbers of smaller dams on small to medium-scale streams and rivers are not uniformly documented. In addition, National Hydrography Dataset (NHD) contains data on dams and divergence structures (http://nhd.usgs.gov/). Some types of barrier information may be available from monitoring.

channelization (PDF) (4 pp, 126K)

Why relevant to recovery: Channelization is a major modification of natural form that results in habitat simplification and reduction in frequency of specific, life-supporting habitat types (e.g. pools, spawning gravels). The process also destabilizes erosion/deposition dynamics, shortens residence time during which excess nutrients may be processed, and increases risks of downstream erosion and channel destabilization with accompanying loss of use or property. Negative impacts on biological communities are well documented not only within channelized reaches but at substantial distances downstream. The significance of this metric in reducing recovery potential is based on multiple effects: degraded habitat, altered primary physical processes, destabilized instream conditions, persistence of negative effects for decades, and high expense of reengineering channel sinuosity.

Data sources and measurement: The simplest manner of measuring channelization is as the percent of total impaired segment length that is artificially straightened, as observable on imagery or mapped media. Straight channels are easily detected, but highly reduced sinuosity (which often has similar effects) is less easily identified unless factors such as valley slope and expected vs observed sinuosity are measured. Additional measurements may choose to consider the channelized length per watershed area, whether lined or armored banks or bed are present, and percent of channelized length weighted by Strahler stream order. A visual inspection of these data is the best way to identify presence/absence of channelization, after which measurement of length channelized and impaired 303(d) reach length can be carried out via GIS to obtain the % channelized and total channelized length. Except on very short reaches or the smallest channel orders, much channelization is visible on high resolution surface hydrography data such as data available through the National Hydrography Dataset (See: http://nhd.usgs.gov/data.html) or local resources. Manual visual interpretation from GIS hydrographic data, although somewhat laborious, is effective for identifying and measuring the length/percent of channelized reaches in each impaired waterbody segment. Channelization presence/absence is sometimes reported as a cause for 303(d) listing and available as attribute data from EPA's ATTAINS data system (See: http://www.epa.gov/waters/ir/)

hydrologic alteration (PDF) (26 pp, 304K)

Why relevant to recovery: Several different forms of hydrologic alteration (i.e., mainly timing, magnitude and influences of flow on other natural processes) have resulted in dramatic shifts in river flow regimes, sediment transport and deposition patterns, temperature, nutrients, fish assemblages, floodplain isolation, altered high and low flow, and floodplain land use. Numerous additional effects are noted in the literature excerpts below. Most U.S. river systems are hydrologically altered by dams, but water diversions or withdrawals, channelization and human-made disruptions of overland flow also produce hydrologic alteration. Significant departure of an impaired waterbody from its range of natural flow variability is the most common mechanism among these that negatively influences recovery potential. However, dam removal, adjusting flow regulation at dams or the changing the seasonality or timing of withdrawals is often possible and can bring about recovery in many flow-altered waters.

Data sources and measurement: A scoring process of waterbody segments downstream of dams or withdrawals can consider dam sizes, active status, role on flow alteration, and feasibility of flow management. Where information on the dam types is not available, the metric can be measured in terms of dam presence/absence. Aquatic barriers for fish passage (including culverts) are documented through the US Fish and Wildlife Fish Passage Decision Support System (See: http://fpdss.fws.gov/home). Major dams have been mapped through the US Army Corps of Engineers' National Inventory of Dams (See: http://www.usace.army.mil/Library/Maps/Pages/NationalInventoryofDams.aspx) but the large numbers of smaller dams on small to medium-scale streams and rivers are not uniformly documented. National Hydrography Dataset (NHD) contains data on dams and divergence structures (http://nhd.usgs.gov/). Data on water withdrawal locations may vary highly among states. An example of state withdrawal information can be found through the Michigan Department of Natural Resources and Environment (See: http://michigan.gov/deq/0,1607,7-135-3313_3677_3704-72931--,00.html).

relative net water demand

Why relevant to recovery: Stressors affecting the natural flow regime can have numerous secondary impacts. Ecological responses to flow alterations include loss of sensitive species, reduced diversity, altered assemblages and dominant taxa, reduced abundance, and increases in non-native species.

Human water use can affect the magnitude, frequency, and duration of streamflows. For this metric, ratios of impacted streamflow to natural streamflow are used as indices to describe the magnitude of hydrologic alteration. Specifically, in this USGS-developed metric annual withdrawal and discharge are averaged and disaggregated to a one-year time series of daily flow. Net daily water use is subtracted from natural streamflow to get impacted streamflow for the period of record.

Data sources and measurement: Flow information is usually limited, but gaging station records can sometimes be used to develop natural flow estimators and calculate this metric relative to natural flow.

water use intensity

Why relevant to recovery: Stressors affecting the natural flow regime can have numerous secondary impacts. Ecological responses to flow alterations include loss of sensitive species, reduced diversity, altered assemblages and dominant taxa, reduced abundance, and increases in non-native species. Human water use can affect the magnitude, frequency, and duration of streamflows. For this metric, ratios of impacted streamflow to natural streamflow are used as indices to describe the magnitude of hydrologic alteration. Specifically, this USGS-developed metric is a ratio defined as the sum of the absolute value of withdrawals and return flows relative to the long-term average unaltered streamflow from a watershed. The WUI indicator is used to identify "churned" basins, where human flows (withdrawals and return flows) are similar to each other but each individually is a large proportion of natural streamflow.

Data sources and measurement: Flow information is usually limited, but gaging station records can sometimes be used to develop natural flow estimators and calculate this metric relative to natural flow.

Biotic or climatic risks

elevation (PDF) (3 pp, x54.6K)

Why relevant to recovery: Specific to waters with bio-impairments involving coldwater fish populations. For a given state or sub-state region, the range of elevations among different bio-impaired waters may provide part of the basis for comparing the likelihood of reestablishing coldwater temperature regimes, all other factors aside. Lower elevations correlate with greater vulnerability of coldwater aquatic communities and difficulty in their restoration, especially in consideration of expected climate change. Secondarily, the warmer water temperature regimes can increase chemical pollutant availability or toxicity and oxygen depletion.

Data sources and measurement: Measured as mean elevation of the watershed or the specific stream/river segment. Field data or models may be usable to estimate elevation thresholds below which recovery of a coldwater system or species is unlikely. The National Elevation Dataset (NED) (http://nhd.usgs.gov/index.html) is adequate for arraying a set of waters into quantiles based on mean elevation. High resolution elevation data should be used for any assessment units at HUC12 level of smaller. The Elevation Derivatives for National Applications (EDNA) has been derived from the NED and is hydrologically conditioned to improve hydrologic flow representation (See: http://edna.usgs.gov/). NHD plus contains information on maximum and minimum elevation for each flowline (http://www.horizon-systems.com/nhdplus/).

invasive species risk (PDF) (5 pp, 77K)

Why relevant to recovery: Non-indigenous species (NIS) invasions are widely known to disrupt aquatic system function and inhibit recovery of altered systems. The rapid colonization typical of NIS may act to subvert expected succession pathways and thereby disrupt restoration planning. Altered structure due to aquatic or riparian NIS can reduce shade, inhibit native riparian vegetation cover, and increase sedimentation. Aquatic invaders may compete directly or prey upon key native species, reduce numbers or species diversity, and markedly alter food webs and ecological structure. Presence of NIS may actually be the impairment cause for listing, and recovery in such cases depends on eradication or control. Particularly relevant to recovery potential screening is the fact that some NIS, once established, cannot currently be controlled or eradicated by any known methods.

Data sources and measurement: In recovery potential screening, this metric may consider existing invasions or the risk of future invasions, or both. Many options for scoring can be developed, based on the state. An example quantile scoring process is: 0 – no established NIS of concern, no immediate risk; 1 – no established NIS of concern, risk due to proximity or other vulnerability; 2 -- established NIS of concern exists, control or eradication feasible; 3 – established NIS of concern exists, control or eradication infeasible.

This scoring approach can be customized for NIS species-specific rankings, direct influence on prospects of reattaining the unmet water quality standard, or to consider multiple NIS problems per waterbody. Data availability may be through waterbody-specific monitoring information on occurrence, such as the USGS Non-Indigenous Aquatic Species Information Resource (See: http://nas.er.usgs.gov/default.aspx) or through Non-Indigenous Species Database Network range maps by species (http://www.nisbase.org/nisbase/index.jsp) which include a variety of participating databases. The USDA National Invasive Species Information Center also contains links to several databases (See: http://www.invasivespeciesinfo.gov/resources/databases.shtml). Availability of either is highly variable and difficult to update under rapid changes.

Severity of pollutant loading

number of 303d listed causes (PDF) (1 pp, 11.9K)

Why relevant to recovery: The number of stressors affecting and impaired water body is generally a direct indication of the relative complexity, expense and difficulty of its restoration, according to many practitioners. More pollutants causing impairments frequently implies more numbers and diverse types of responsible sources. The number of listing causes also may be associated with greater magnitude of impairment due to cumulative effects.

Data sources and measurement: Number of pollutant causes per listed water body segment, or number of listed cause/waterbody segment combinations per watershed, which are both identifiable from EPA data systems available online. If the reporting unit contains more than one listed waterbody segment, the total number of pollutant causes per length of listed waterbodies can be measured. The Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/) contains information on 303d-listed waters by state and by semi-annual reporting cycle. States may also have more detailed information.

number of permits

Why relevant to recovery: Although point source discharge permits are a tool for pollution control, the abundance of permits in a given watershed can be associated with a number of secondary effects on restorability. Mainly, the occurrence of many permits correlates with high levels of commercial and industrial activity, all stressors from which may not necessarily be controlled by the permits. Legacy pollutants from these land uses may exist. Further, unless all permits were developed from a watershed basis, their collective loads may exceed what can be assimilated.

Data sources and measurement: Permit outfall and facility locations are available in GIS datasets on a national basis and in most states. EPA's national geospatial dataset on permits contains permit latitude-longitude point information for outfalls or secondarily for permitted facility locations.

CSO or MS4 areas

Why relevant to recovery: Public sewer systems are designed to handle stormwater runoff and its pollutants, up to a point. Exceeding the capacity of a system can result in an episodic increase in pollutant loadings and complicate efforts at restoration. Existence of CSO or MS4 areas in a watershed as well as the capacity of the systems can be a consideration when evaluating stressors that affect recovery.

Data sources and measurement: Generally these areas are available in mapped form at state or municipal level.

age of sewer infrastructure

Why relevant to recovery: Older sewerage infrastructure can be a more important stressor than new construction and thus affect recovery prospects in some watersheds. Pipe failures and leaks with age are more common in older systems.

Data sources and measurement: Generally the ages of infrastructure piping are available from municipalities, sometimes in mapped form.

severity of loading (PDF) (2 pp, 15K)

Why relevant to recovery: For impaired waters where needed load reductions have been calculated, the magnitude of necessary reductions compared with current loadings has been shown to relate to likelihood of successful restoration, although this metric is not necessarily a determinant of irreversible degradation. Case studies of restoration successes showed multiple cases where if needed load reductions were less than 50% of current levels, more restoration successes were achieved. The 50% figure is likely not a consistent threshold value and data of this sort are limited, thus the metric is best used to array a set of waters into quantiles based on expert judgment about % loading reduction.

Data sources and measurement: The measure compares the current loading estimates with the TMDL target loading calculation, in terms of the percent reduction needed. The Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/) contains information on 303(d)-listed waters by state and by semi-annual reporting cycle. Loading estimates generally need to come from completed TMDLs or watershed models. Most completed TMDLs are available online via state or EPA websites (see also http://www.epa.gov/waters/tmdl/expert_query.html).

stressor persistence (PDF) (2 pp, 97K)

Why relevant to recovery: Stressors causing impairment can vary considerably in their likelihood to persist over long periods, or to naturally dissipate or respond rapidly to controls. This can be due to the nature of the stressor itself (e.g., radionuclides), its source (e.g., unremediated acid mine drainage), or its setting (e.g., excess fine sediment persistence in lower gradient streams). Comparison of recovery potential across many watersheds can consider differences in persistence across different stressor types and settings.

Data sources and measurement: Methods for measurement would be project-specific, and differ with the stressors included. One option for developing persistence metrics involving different stressors and settings is to use high/medium/low categories specific to each stressor.

SPARROW nitrogen loading estimate

Why relevant to recovery: SPARROW is one of the most widely used geospatial models for estimating nutrient pollution on a watershed basis, and has been used to estimate nitrogen and phosphorus loads and yields over large areas at the HUC8 and HUC12 scales. These models identify urban and agricultural sources as major contributors of nutrients to streams and reveal local and regional differences in nutrient contributions from contrasting types of agricultural (farm fertilizers vs. animal manure) and urban (wastewater vs diffuse runoff from developed land) sources.

Data sources and measurement: The EPA's NPDAT website (see http://www.epa.gov/nutrientpollution/npdat/) provides an introductory website, geospatial viewer, and data downloads as well as associated water quality information. An online, interactive USGS **decision support system** also provides easy access to regional models describing how rivers receive and transport nutrients from natural and human sources to sensitive waters, such as the Gulf of Mexico.

SPARROW phosphorus loading estimate

Why relevant to recovery: SPARROW is one of the most widely used geospatial models for estimating nutrient pollution on a watershed basis, and has been used to estimate nitrogen and phosphorus loads and yields over large areas at the HUC8 and HUC12 scales. These models identify urban and agricultural sources as major contributors of nutrients to streams and reveal local and regional differences in nutrient contributions from contrasting types of agricultural (farm fertilizers vs. animal manure) and urban (wastewater vs diffuse runoff from developed land) sources.

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watershed stream miles impaired

Why relevant to recovery: Although state monitoring programs are generally unable to assess all of their waters in each integrated reporting cycle, the relative quantity of reported impairments provides an important insight into what is currently known. Larger quantities or proportions of impaired stream miles imply a likely more complex and extensive watershed restoration task, and also may be associated with additional unmonitored impairments within adjacent or connected streams and other water bodies.

Data sources and measurement: This metric can be used as a quantity (total impaired miles per watershed) or as a proportion (impaired miles per total stream miles in the watershed, impaired miles per total watershed miles assessed). A national geospatial impaired waters dataset is available through EPA's Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/). This source contains information on 303(d)-listed waters by state and by semi-annual reporting cycle.

watershed water body acres impaired

Why relevant to recovery: Although state monitoring programs are generally unable to assess all of their waters in each integrated reporting cycle, the relative quantity of reported impairments provides an important insight into what is currently known in each watershed. Larger quantities or proportions of impaired water body acres imply a likely more complex and extensive watershed restoration task, and also may be associated with additional unmonitored impairments within adjacent or connected streams and other water bodies.

Data sources and measurement: This metric can be used as a quantity (total impaired acres per watershed) or as a proportion (impaired acres per total water body acres in the watershed, impaired acres per total watershed acres assessed). A national geospatial impaired waters dataset is available through EPA's Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/). This source contains information on 303(d)-listed waters by state and by semi-annual reporting cycle.

modeled watershed aerial N deposition

Why relevant to recovery: Excessive N loadings to waters cause a number of adverse effects, whether from land-based sources or aerial deposition. Aerial deposition is worth separate consideration as a factor inhibiting recovery potential as the likelihood of successful control of the aerial sources is independent of the likelihood of controlling the within-watershed point or nonpoint sources of N. Where aerial sources continue to be the primary sources of N, watershed-based restoration efforts alone might be expected to have low recovery potential.

Data sources and measurement: Modeled N deposition across large regions may be available for selected areas at a resolution that enables aggregation into N deposition values at a given watershed scale, e.g., HUC12s. Likely that original model outputs are not on a watershed basis, but areal weighting methods allow for translating values to a watershed basis.

modeled watershed aerial Hg deposition

Why relevant to recovery: Over 8700 waterbodies in 43 States plus the District of Columbia and Puerto Rico are listed as impaired under section 303(d) of the Clean Water Act due to excessive amounts of mercury in fish tissue or in the water column. Atmospheric deposition is believed to be the dominant avenue by which mercury loads are delivered to most watersheds, although some waters have significant inputs from sources such as historic mine tailings and/or enriched minerals. A discussion of the adverse effects of mercury on human health, especially for unborn children, as well as ecological impacts can be found at http://www.epa.gov/mercury/about.htm.

Data sources and measurement: In order to support development and implementation of TMDLs for mercury in areas impacted by atmospheric deposition, EPA's Office of Water in cooperation with State and Regional partners has completed deposition modeling. The Regional Modeling System for Aerosols and Deposition (REMSAD) was the primary model relied upon in this analysis. The Community Multi-scale Air Quality Model (CMAQ) was also used to provide a "second opinion" of key REMSAD findings. In addition, three different global models were used in order to provide a range of likely impacts from foreign sources. The domain of this modeling was the lower continental US and the spatial resolution was a network of 12km by 12km grid cells throughout the domain (see http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/techsupp.cfm).

other stressor-specific severity factors

Why relevant to recovery: The broad variety of impairment causes that can affect degraded waters may vary substantially from one another in relative difficulty of restoration. A given area may, for example, find their urban runoff impairments far more difficult to remediate than their rural pathogen impairments. This metric relates to differentiating between specific stressors and their generalized differences in restorability as a recovery potential indicator concept. This concept can also be applied to develop single-stressor-based indicators that recognize recovery potential differences related to loading magnitude, frequency, duration, or association with other factors that influence restorability.

Data sources and measurement: Project-specific and stressor-specific measurement methods need to be developed to use this indicator.

Legacy of past, trajectory of future land use

land use change trajectory (PDF) (4 pp, 72.6K)

Why relevant to recovery: Human use effects in watersheds that influence recovery can be observed not just by current conditions, but also by recent changes in those conditions. Recent land cover trajectory studies may suggest the likely direction of continued pressures, such as continuing urbanization, deforestation, or agricultural expansion. Also, recent changes may not have fully produced impacts that can occur over several years. Some studies have suggested that decades-old land use history is sometimes more correlated with aquatic impairment than recent land use pattern.

Data sources and measurement: Land cover totals (%) for given watersheds can be contrasted for different past time periods. Buildout scenario projects may be sources of estimating future change trajectory, as are data sources that identify high-growth urban areas. Specific changes are more easily tracked than attempting to summarize all watershed change types in one metric – for example, one can separately estimate recent loss in % forest, gain in % urban, and gain in % agriculture in each watershed of interest. National Land Cover Data from 1992 (See: http://landcover.usgs.gov/natllandcover.php), 2001 (See: http://www.mrlc.gov/index.php), and 2006 (http://www.mrlc.gov/nlcd06_data.php) can be contrasted at the watershed level. MRLC provides calculated data on developed imperviousness change, as well as the change for all of the NLCD land use classes, between 2001 and 2006 (http://www.mrlc.gov/nlcd06_data.php). The USGS is a source for several land use change datasets, including the Land Cover Trends Project (See: http://landcovertrends.usgs.gov/download/overview.html) and the Temporal Urban Mapping project (See: http://landcover.usgs.gov/urban/umap/). State or local data on land cover change are not common and may present technical challenges to data comparability over time. The Historical Topographic Map Collection includes published U.S. maps of all scales and editions, and are offered as a georeferenced digital download or as a scanned print from the USGS Store (see http://nationalmap.gov/historical/).

legacy land uses (PDF) (6 pp, 80.9K)

Why relevant to recovery: A variety of impacts on waters are associated with agricultural uses in general, including increased loadings of nutrients, fine sediment, pesticides, herbicides, flow alteration, elevated water temperature, and others. A past history of agriculture in the watershed and/or riparian corridor can continue to account for adverse effects even after land use change (vegetational succession, transition to residential or other uses) has replaced the agriculture. Built-up nutrients and pesticides/herbicides in groundwater can continue to be discharged through influent groundwater connections for decades. Excess fine sediments and channel widening (which reduces channel habitat quality) caused during active agriculture can also persist for years to decades, as can channel destabilization and related erosion. Some studies suggest that a past history of agricultural use is more strongly correlated with impairment than current, other land use patterns.

Data sources and measurement: Although geospatial data on past agriculture is date-limited, one national digital source (LUDA/GIRAS) characterized agricultural usage in the 1970s at coarse resolution. Locally older data may be available in isolated areas, or where historical aerial analyses back to the 1930s may have been conducted using airphotos. Measurable with suitable data as percent by area within watershed or corridor. Historical land cover data is available through the USGS Land Cover Institute (See: http://landcover.usgs.gov/cropland/index.php). NLCD land cover data is available as far back as 1992 (http://landcover.usgs.gov/natllandcover.php). MRLC provides calculated data on the change for all of the NLCD land use classes between 2001 and 2006 (http://www.mrlc.gov/nlcd06_data.php). The Historical Topographic Map Collection includes published U.S. maps of all scales and editions, and are offered as a georeferenced digital download or as a scanned print from the USGS Store (see http://nationalmap.gov/historical/).

watershed % legacy agriculture (PDF) (5 pp, 69.5K)

Why relevant to recovery: A variety of impacts on waters are associated with agricultural uses in general, including increased loadings of nutrients, fine sediment, pesticides, herbicides, flow alteration, elevated water temperature, and others. A past history of agriculture in the watershed and/or riparian corridor can continue to account for adverse effects even after land use change (vegetational succession, transition to residential or other uses) has replaced the agriculture. Built-up nutrients and pesticides/herbicides in groundwater can continue to be discharged through influent groundwater connections for decades. Excess fine sediments and channel widening (which reduces channel habitat quality) caused during active agriculture can also persist for years to decades, as can channel destabilization and related erosion. Some studies suggest that a past history of agricultural use is more strongly correlated with impairment than current, other land use patterns.

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watershed % legacy urban (PDF) (2 pp, 54K)

Why relevant to recovery: The age of an urbanized area or specifics of its history may have implications for its legacy pollutants in groundwater that can affect recovery. Built-up urban and industrial pollutants in groundwater can continue to be discharged through influent groundwater connections for decades.

Data sources and measurement: Measured as % urban land cover categories from a historic source. Although geospatial data on past urban land is date-limited, one national digital source (LUDA/GIRAS) characterized urban usage in the 1970s at coarse resolution (10 acre mapping unit). Locally older data may be available in isolated areas, or where historical aerial analyses back to the 1930s may have been conducted using airphotos. Measurable with suitable data as percent by area within watershed or corridor. Historical land cover data is available through the USGS Land Cover Institute (See: http://landcover.usgs.gov/cropland/index.php). NLCD land cover data is available as far back as 1992 (http://landcover.usgs.gov/natllandcover.php). MRLC provides calculated data on the change for all of the NLCD land use classes between 2001 and 2006 (http://www.mrlc.gov/nlcd06_data.php). The Historical Topographic Map Collection includes published U.S. maps of all scales and editions, and are offered as a georeferenced digital download or as a scanned print from the USGS Store (see http://nationalmap.gov/historical/).

corridor % legacy agriculture (PDF) (5 pp, 71.9K)

Why relevant to recovery: A variety of impacts on waters are associated with agricultural uses in general, including increased loadings of nutrients, fine sediment, pesticides, herbicides, flow alteration, elevated water temperature, and others. A past history of agriculture in the watershed and/or riparian corridor can continue to account for adverse effects even after land use change (vegetational succession, transition to residential or other uses) has replaced the agriculture. Built-up nutrients and pesticides/herbicides in groundwater can continue to be discharged through influent groundwater connections for decades. Excess fine sediments and channel widening (which reduces channel habitat quality) caused during active agriculture can also persist for years to decades, as can channel destabilization and related erosion. Some studies suggest that a past history of agricultural use is more strongly correlated with impairment than current, other land use patterns.

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Why relevant to recovery: The age of an urbanized area or specifics of its history may have implications for its legacy pollutants in groundwater that can affect recovery. Built-up urban and industrial pollutants in groundwater can continue to be discharged through influent groundwater connections for decades.

Data sources and measurement: Measured as % urban land cover categories from a historic source. Although geospatial data on past urban land is date-limited, one national digital source (LUDA/GIRAS) characterized urban usage in the 1970s at coarse resolution (10 acre mapping unit). Locally older data may be available in isolated areas, or where historical aerial analyses back to the 1930s may have been conducted using airphotos. Measurable with suitable data as percent by area within watershed or corridor. Historical land cover data is available through the USGS Land Cover Institute (See: http://landcover.usgs.gov/cropland/index.php). NLCD land cover data is available as far back as 1992 (http://landcover.usgs.gov/natllandcover.php). MRLC provides calculated data on the change for all of the NLCD land use classes between 2001 and 2006 (http://www.mrlc.gov/nlcd06_data.php). The Historical Topographic Map Collection includes published U.S. maps of all scales and editions, and are offered as a georeferenced digital download or as a scanned print from the USGS Store (see http://nationalmap.gov/historical/).

Part 3: Social Indicator Summaries

Leadership, organization and engagement

watershed organizational leadership (PDF) (3 pp, 58.4K)

Why relevant to recovery: Organizations at the level of the specific watershed have been shown to have a key influence on restoration success through building legitimacy through local representation, fostering conflict resolution, and clarifying multiple interests and ideas. Some sources of restoration assistance will not generally implement restoration efforts without active groups that indicate community support and interest. Other related metrics associated with restoration success include organizational persistence, existence of a funded watershed leadership position, and individual leader performance.

Data sources and measurement: Measured as a numeric indicator of the number of watershed groups located within each 303(d) watershed. EPA provides an online database that catalogues watershed groups by 8-digit HUC (EPA-ADOPT). EPA's ADOPT database (See: http://cfpub.epa.gov/surf/locate/index.cfm) provides organization information for watersheds. Users can download the list of watershed groups and create a table that cross-references watershed groups by HUCs for use in GIS. Intersect the watershed coverage by the statewide HUC coverage and link the watershed groups to the corresponding watersheds.

watershed collaboration (PDF) (4 pp, 55.1K)

Why relevant to recovery: A metric of collaboration is related to a watershed organizational presence, but goes beyond in providing a measure of involvement and cooperation by diverse interests. As conflicting interests commonly are responsible for watershed restoration failures, successful bridging across differing interest groups is a positive indicator of prospects for success. This can be in the form of one organization but is dependent upon broad and inclusive membership and inclusive procedural rules for its legitimacy.

Data sources and measurement: Although some spatial data on watershed and landowner organizations may be available (e.g., the EPA ADOPT database, See: http://cfpub.epa.gov/surf/locate/index.cfm), complete spatial data on this metric is not likely to be available. Rather, other sources may be needed to verify collaboration through other information from watershed to watershed. Likely this metric needs to be scored as presence/absence of a multi-interest organization and/or process. If evaluation involves a small number of watersheds or the watersheds are all well-known, it may be possible for a group process to rank each as high/medium/low.

corridor owner-occupied residential

Why relevant to recovery: The degree of owner occupancy along stream frontage can influence the prospects of restoration in numerous ways, including positive and negative influences. As property owners and as residents, they may be motivated by the fact that restoration often improves property values and beneficial uses. In contrast, sensitivity about property rights and engaging in waterfront uses that contribute to impairment or interfere with restoration can lead some owners to oppose restoration efforts. In all cases this subset of landowners are important stakeholders whose positions are capable of influencing recovery.

Data sources and measurement: Data for determining ownership are likely to be found at local level but may not contain actual occupancy information; it may be possible to generalize this metric into high/medium/low categories based on the available information.

government agency involvement (PDF) (1 pp, 33.6K)

Why relevant to recovery: Government agency support in the form of funding, recognition, added expertise, regulatory backing, or an organizing/facilitating influence is cited as having a favorable effect on community and stakeholder buy-in on restoration efforts. Specifically in restoration efforts, other stakeholders have appeared less likely to participate and commit to restoration if government agencies aren't also participating actively in support.

Data sources and measurement: Examples of agency involvement often perceived as a positive effect by other stakeholders include watershed or restoration planning, research projects that may inform actions that can improve condition, recognition programs (e.g., wild, scenic and recreational rivers), and agency conservation funding incentives. Scoring this metric can be most simply done as 1/0 for presence/absence of any agency involvement. Other scoring alternatives include numeric counts of total agencies/programs involved, or weighting specific agency connections that appear to be particularly important.

participation rate in land conservation programs

Why relevant to recovery: Socially, landowners engaging in restoration activities tend to motivate other landowners to take part. This may be due to observation of the positive results from the projects or from the demonstration that participation is possible and available. Incentive-based agricultural conservation programs not only address common sources of pollutants but also are a possibility for financial gain to participants.

Data sources and measurement: Information on participation rates may exist on a mapped basis or be attributable to generalized watershed locations. State conservationists provide a state-specific source of this information concerning USDA conservation programs.

large watershed management potential (PDF) (3 pp, 85.8K)

Why relevant to recovery: State impaired waters programs are increasingly developing watershed plans and TMDLs on the basis of whole watersheds containing multiple impaired waters, rather than individual actions for specific impaired segments alone. EPA also promotes these 'watershed TMDLs' as an effective approach that employs many efficiencies and a 'critical mass' of effort. Frequently, watersheds at the 10- or 12-digit HUC scale contain several different impaired reaches or tributaries that are addressed in a single watershed plan or TMDL document. Moderate to large watersheds at the 8-digit HUC scale or larger have been successfully used to develop TMDLs and implement controls for 100 or more impaired segments. The approach has several procedural advantages for potential recovery. Primarily, there are efficiencies in modeling one larger system rather than constructing numerous models for smaller segments. Also regarding communications, one larger, coordinated effort can provide more consistent messages and thorough outreach to establish community support. Further, the interrelationship of numerous impaired segments in the same watershed through downstream effects, and indirectly through watershed protection decisions that may shift land use pressures to different sub-watersheds, argues for some restoration planning to be done at a broader watershed context.

Data sources and measurement: This metric may be used to compare segments or compare watersheds with multiple impaired segments within them. Individual, impaired segments are most easily compared on the basis of their co-location with other impaired waters within a standardized watershed unit (e.g. HUC12, HUC10, HUC8). The score can be based on a simple threshold (e.g. 5 or more) or can array the waters continuously based on total count. This metric may also be used to target less dense clusters that still offer the efficiencies of a watershed-based approach with greater likelihood that valuable ecological features remain and restoration can be achieved.

university proximity (PDF) (2 pp, 39.4K)

Why relevant to recovery: Universities provide persons with specialized knowledge that may advance a restoration effort in numerous ways. Experts from universities may be able to fill information gaps, or lead technically advanced modeling or calculations essential to complex restoration plans. They also may be less polarizing sources of key information for reconciling stakeholder conflicts than corporate or agency experts. Students from universities may provide low-cost labor through the learning experience of restoration projects managed and overseen by professionals. As students and faculty are typically busy and seldom highly paid, proximity to an impaired water very likely influences the likelihood that they will become involved.

Data sources and measurement: Statewide coverage of universities can be developed from online sources such as UnivSource EXIT Disclaimer or American Universities EXIT Disclaimer; the entries can be further refined by including only those colleges with environmental, hydrology, or civil engineering programs. Proximity can be estimated by buffering a selected distance (e.g., 50 miles) around either the impaired waters or the universities, then identifying the number of 'proximate' universities. Locations of state and private universities with environmental, hydrology, or civil engineering programs can generally be obtained from state websites. National lists of colleges and general information by state and city are found at University Source (See: http://www.univsource.com/region.htm) or at Global Computing (See: http://www.globalcomputing.com/CollegesContent.htm).

political support (PDF) (2 pp, 44.4K)

Why relevant to recovery: The support for specific actions or programs that carry out restoration can be an influence on likelihood of restoration success. This support can be demonstrated in public opinion, in public leaders' positions, or through both. Frequently the degree of community support and political support are in alignment. Thus political support for restoration actions can be an effective metric representing not only general likelihood of community backing but also the existence of influential backing from community leaders.

Data sources and measurement: Sources of this information are likely to vary from state to state.

Protective ownership or regulation

watershed % protected land (PDF) (2 pp, 39.6K)

Why relevant to recovery: Depending on the protections afforded among categories of protected land, this factor provides an indicator of the prospects for a given proportion of total watershed land area to remain in conditions desirable for water quality restoration and protection. Although this factor may not be relevant for sorting relative recovery potential among watersheds at low levels (e.g., less than 25% watershed area), impaired waters with a high proportion of protected drainage area arguably have more ecological functions remaining intact, or may take less effort to reestablish degraded functions.

Data sources and measurement: The Gap Analysis Program (GAP) of the US Fish and Wildlife Service has worked in most states to compile geo-spatial data on statewide land and water protection status for combination with species range datasets. GAP stewardship data identify four categories of land protection status, three of which are protected land. Categories 1 and 2 prohibit natural land cover conversion entirely, category 3 allows for small areas of intensive use or broad areas of low-intensity use. Category 4 is unprotected. Scoring to compare land protection by watershed can most simply be done by summing the percent area by watershed in categories 1 - 3. The Protected Areas Database (http://www.protectedlands.net/dataportal/find.php) contains the GIS information for GAP. Other forms of land protection may be available at the state level.

applicable regulation (PDF) (2 pp, 45.4K)

Why relevant to recovery: As many restoration actions are voluntary, particularly nonpoint source control actions, the applicability of a regulatory requirement that adds greater certainty to actions that may partially or fully restore an impairment increases the prospects of recovery. Formal enforceable mechanisms not only improve the likelihood of pollution reduction directly, but also may encourage restoration partners and other restoration efforts affecting the same waterbody, in the knowledge that at least some progress will be made. One easily assessed example includes point source permitting, but several other state or federal regulatory links may influence impaired waters.

Data sources and measurement: Data availability varies according to the regulation, but the link to enforceable point source controls is one well documented regulatory connection. Data available from the Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/) contains information on 303(d)-listed waters by state and by semi-annual reporting cycle. Online via state or EPA websites (see also http://www.epa.gov/waters/tmdl/expert_query.html) identify impaired waters and waters with completed TMDLs as point source only, nonpoint source only, or mixed. Assessing this metric may be done as simply as distinguishing impaired waters that are nonpoint only from waters with some or all point sources, and this can be drawn from available GIS coverage of listed waters or TMDLs. Specific states or areas may have other regulations (e.g. riparian zone protections, conservation zoning) that may be directly mapped or can be extracted through mapping. Coastal information is available through NOAA's Legislative Atlas (See: http://csc-s-maps-q.csc.noaa.gov/legislativeatlas/index.html). For further regulatory information, the EPA has compiled a list of regulations by environmental topic (See: http://www.epa.gov/regulations/envtopics/index.html). Zoning maps are typically available from county and state sources.

Level of information, certainty and planning

certainty of causal linkages (PDF) (3 pp, 53.4K)

Why relevant to recovery: Certainty in restoration is usually relative and rarely absolute. Nevertheless, a truly unknown cause is a major obstacle to restoration. Restoration prospects depend heavily on understanding the impairment, the stressors to which the system is exposed, and the sources and pathways along which such exposure occurs. Together these elements make up a causal pathway that, if uncertain, jeopardizes the progress of restoration. Action taken despite causal uncertainty can lead to targeting the wrong stressor or source, funding or requiring inappropriate control actions, under- or over-estimating controls needed, and related development of significant stakeholder conflicts or legal actions.

Data sources and measurement: With 303(d)-listed waters, some impairment causes (usually bioimpairments) are reported as 'Cause Unknown' when a pollutant cause for a verified impairment effect is not yet evident at the monitoring stage. Due to variable reporting among states, several other actual cause (i.e., pollutant) unknown listings also occur under categories such as low DO, degraded habitat, toxicity, and other terms not specific to one pollutant cause. One measurement approach is to sort waters using this metric by simple presence/absence of 'cause unknown' or similar listings. Another option is to measure the percent of waters with unknown causes of impairment out of the total length of impaired waters within each reporting unit. Cause information occurs in attribute tables that are linked to 303(d) shape files of each state's impaired waters. Data is available through the Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/).

% identified stressor sources

Why relevant to recovery: Taking action to restore an impaired waterbody not only requires understanding the stressors impacting it but also the sources of those stressors. An impasse can occur when information on sources is incomplete, as loading reductions allocated to other sources may be insufficient to achieve recovery. Sources are as crucial to understanding causal pathways as are the stressors themselves.

Data sources and measurement: State monitoring and integrated reporting sometimes identifies probable source information, but this is an optional reporting field and not consistently present among attributes available through the Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/). Other state sources may be available, or landscape models may allow for estimates of probable sources.

certainty of restoration practices (PDF) (2 pp, 42.1K)

Why relevant to recovery: The development of restoration techniques and the knowledge of their range of applicability are still incomplete. Waters whose restoration can be accomplished by known, tested techniques are stronger prospects for recovery potential than those facing uncertainty about technique applicability or effectiveness. As track records are still being developed for many techniques, and settings vary so widely, uncertainty about techniques is still common. Extensive familiarity with techniques and their applicability is needed for applying this metric.

Data sources and measurement: have experts estimate the availability of applicable restoration techniques using the following scoring: 0 – no restoration technique applicable; 1 – technique applicability uncertain; 2 – known technique moderately applicable and feasible; 3 – known technique highly applicable and feasible. Unlikely to be map-based information, but rather reliant on expert judgment of whether routine techniques for addressing specific impairments and settings are available. May be adapted to a geographic basis by first identifying waterbody type, size, and pollutant types from the 303(d) datasets, then having experts estimate the availability of applicable restoration techniques using the scoring described above. Various stream restoration techniques, searchable by region, are available through the National River Restoration Science Synthesis Database (See: http://nrrss.nbii.gov/) and other online sources.

TMDL or watershed plan (PDF) (3 pp, 51.2K)

Why relevant to recovery: Many different types of studies have observed that despite the potential for conflict about a plan's contents, a completed plan generally has a positive influence on community progress, understanding and acceptance of restoration efforts. Studies of success stories have noted that a sound plan was a major driving factor. A technical plan such as a TMDL provides a quantitative, scientific basis for guiding actions. Existing plans can also clarify misconceptions, increase recognition of common interests, indicate government support and service, and provide a basis for further collaborative planning or action.

Data sources and measurement: Impaired waters with available plans are best represented by completed TMDLs or, in the case on non-pollutant impairments, by CWA Section 319 watershed plans. A variety of other restoration or management plan types may be available in specific states or river basins. A national mapped dataset of waters with completed and approved TMDLs has been developed by EPA and is available through the Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/ and http://www.epa.gov/waters/data/downloads.html) or the Reach Address Database (RAD) (http://epamap32.epa.gov/radims/). EPA has also been collecting data on locations of section 319 projects since 2004 (see link to RAD above).

watershed education level (PDF) (2 pp, 28.2K)

Why relevant to recovery: Greater understanding of restoration activities and goals is generally

associated with greater community support of restoration. This support may be associated in turn with specialized efforts to inform stakeholders about the local restoration setting, with general ability to understand restoration techniques and goals, or with both. Communities with generally higher levels of education may more quickly understand the advanced and complex descriptions typical of a restoration project and the environmental processes it will address. This metric may provide insight about earlier communication opportunities for reaching stakeholders, but may not necessarily imply higher support ultimately.
Data sources and measurement: This metric requires proportionally merging county-level educational attainment data from the Census with the watersheds being assessed, where watersheds overlap with multiple counties. The metric is assigned a score per watershed. Data on educational attainment are available for the U.S., states, counties, and subcounty statistical areas (such as zip codes and block groups), from 1940 to 2010 (see http://www.census.gov/hhes/socdemo/education/data/index.html).

ratio #TMDLs/#impairments

Why relevant to recovery: This metric indicates how much restoration planning progress has been made relative to the known and reported amount of impairments overall. On the basis of this factor, watersheds ranking more highly are better documented and prepared for more rapid implementation of restoration practices and recovery.

Data sources and measurement: The calculation involves comparing the number of TMDLs (i.e., individual water body segment/pollutant combinations) finalized with the number of impairments (i.e., also individual water body segment/pollutant combinations) in the watershed. Both are available from EPA as national geospatial datasets online. Cause information is available in attribute tables that are linked to 303(d) shape files of each state's impaired waters, through the Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/ and http://www.epa.gov/waters/data/downloads.html). A national mapped dataset of waters with completed and approved TMDLs has been developed by EPA and is available through the Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/ and http://www.epa.gov/waters/data/downloads.html) or the Reach Address Database (RAD) (http://epamap32.epa.gov/radims/).

% of stream miles assessed

Why relevant to recovery: This metric provides one measure of how thoroughly understood each watershed's impairments are. More thoroughly assessed watersheds leave less to the unknown factors that may inhibit recovery.

Data sources and measurement: States vary in the format and detail in which they document what waters have been assessed, but useful data are available in many areas. An assessed waters GIS national dataset has been developed by EPA from state-specific information and is available through the Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/ and http://www.epa.gov/waters/data/downloads.html).

% of lake acres assessed

Why relevant to recovery: This metric provides one measure of how thoroughly understood each watershed's impairments are. More thoroughly assessed watersheds leave less to the unknown factors that may inhibit recovery.

Data sources and measurement: States vary in the format and detail in which they document what waters have been assessed, but useful data are available in many areas. An assessed waters GIS national dataset has been developed by EPA from state-specific information and is available through the Assessment TMDL Tracking and Implementation System (ATTAINS) (See: http://www.epa.gov/waters/ir/ and http://www.epa.gov/waters/data/downloads.html).

Restoration cost, difficulty, or complexity

estimated restoration cost (PDF) (3 pp, 23.6K)

Why relevant to recovery: The expense of restoration due to the numbers of impaired waters and the complexity of most restoration and remediation techniques is a well known, major factor influencing likelihood of success. Extreme expense may halt progress on a single restoration effort, either directly due to the unwanted financial burden or due to inability to compete with other, less expensive restoration sites as priorities are set. Prioritization often depends as much on economic issues as ecological concerns.

Data sources and measurement: Detailed estimates of full restoration cost are not likely to be available, nor necessary for a rough comparison. Expert judgment based on impairment type and number, system type and size may be used to assign high-medium-low expense categories to waters of interest. Not likely to be available in mapped form, although system size, impairment type and numbers from mapped 303(d) data may be used as surrogates for factors commonly affecting cost; cost for stream restoration projects is compiled in the National River Restoration Science Synthesis database (See: http://restoringrivers.org/newsite/nbii.html).

jurisdictional complexity (PDF) (2 pp, 39K)

Why relevant to recovery: The number of political jurisdictions within a watershed can negatively influence the speed and effectiveness of restoration activities. Watersheds with multiple political jurisdictions often require the establishment of a separate group to facilitate planning and consensus-building for environmental initiatives. Single-jurisdiction watersheds are usually less complicated in watershed planning interactions.

Data sources and measurement: Metric is total number of cities, counties, and towns wholly or partially within an impaired watershed. The measurement can involve counting a number of jurisdictions per reporting unit, and requires the City/County polygon shapefile (cnty.shp available from EPA-BASINS, See: http://www.epa.gov/waterscience/BASINS/b3webdwn.htm). ArcGIS online contains data on national administrative boundaries (See: http://www.arcgis.com/home/item.html?id=3b93337983e9436f8db950e38a8629af). If available, other jurisdictions may be added to the city/county dataset if these populated places typically become involved in land use decisions and restoration actions.

landownership complexity (PDF) (2 pp, 19.4K)

Why relevant to recovery: High amounts and high variety in types of private landownership in a watershed or stream corridor are likely to complicate efforts to restore an impaired water, and landownership pattern can rank among the highly influential factors. Negotiating management practices, easements or land purchases becomes complicated in fragmented ownership. Public lands often are the site of many restoration projects as a result. Single ownership-dominated watersheds, particularly where public land predominates, may optimize landownership pattern for likelihood of restoration success.

Data sources and measurement: Possible to measure on a watershed or corridor basis, as desired. Can be most simply applied as presence/absence of over half public landownership, or if data allow, as percents in public/private ownership. One reasonable surrogate for complexity in terms of numbers of owners/stakeholders is the number of low, medium and high-density urban land cover polygons per unit of area.

recovery time frame

Why relevant to recovery: Whereas the necessary time frame for recovery may not always directly relate to the difficulty of recovery, longer recovery times do bear the burden of needing sustained public and technical support over prolonged periods while usually being unable to provide short term evidence of success. This can be an added social burden beyond the usual complexity of developing long term recoveries.

Data sources and measurement: Although data specifically estimating recovery times is not common, several easily measured traits generally translate into longer recoveries. On the basic premise that larger ecosystems are more complex and slower to degrade and to recover, watershed size or waterbody size can be used as a surrogate for assumptions about recovery time frame. Type of impairments can vary in their implications for recovery time. If Watershed Boundary Dataset HUC12 units are used as the basis for watershed assessment, the number of upstream HUCs can be identified as another manner of determining larger watershed implications on recovery of a specific, drainage-based component.

Socio-economic considerations

Environmental Justice area of concern

Why relevant to recovery: EJ areas do not present a consistently positive or negative association with restorability, but can be a very important factor in either case. Highly populous urban EJ areas may have lower recovery potential associated with being densely populated watersheds, often with legacy land uses and pollutants, but may have eligibility for additional sources of restoration support not available to other watersheds. Rural EJ situations may share the eligibility advantage, plus sometimes have less intensive land use pressures and less pollutant loading. A wide range of restoration-relevant circumstances may exist in any given area.

Data sources and measurement: Development of EJ-related metrics is project-specific. It may not be feasible to develop an EJ metric that is directionally consistent in all cases. One option for using EJ information in recovery potential screening is as a subset of watersheds, in order to compare EJ areas only to one another on the basis of multiple restorability factors.

local socio-economic stress (PDF) (4 pp, 58.5K)

Why relevant to recovery: A community's socio-economic well-being or lack thereof can have mixed effects on community views about the prospects for restoration. A distressed rural area may be inclined to see restoration negatively if additional restrictions, expenses or loss of economic options are assumed. In contrast, restorations that may increase property value, provide restoration project jobs and an improved recreational economy may be welcomed. Generally, whereas perceptions in distressed areas provide an obstacle, the ultimate effects of a restoration often provide a welcome improvement. This metric can be used as a negative input to the overall social context score if it is based on perceptions of distressed communities, or as a positive input to the score if based on the potential economic benefits to distressed areas - thus a choice is necessary before each screening use.

Data sources and measurement: This metric is drawn directly from measures developed by the Sonoran Institute in 2005. Nine measures were originally published. These included high-distress interpretations of: 1. long-term employment change; 2. unemployment rate; 3. per capita income; 4. families living under poverty; 5. educational attainment, 6. housing affordability, 7. short-term employment change, 8. population change, and 9. natural disaster risk. The measures can be aggregated into a single value, used singly, or in other combinations. The aggregated index value is reported on county level, which then needs to be transposed to a watershed or stream corridor value by proportional averaging in order to relate it to impaired waters recovery potential screening. The primary data sources for the nine component metrics used by the Sonoran Institute study are all nationally available GIS datasets, available from the US Dept of Commerce Bureau of Economic Analysis (long and short term employment change, per capita income, housing affordability, See: http://www.bea.gov/), Bureau of Labor Statistics (unemployment rate, natural disaster risk, See: http://www.bls.gov/data/), and Census Bureau (population change, families living under poverty, educational attainment, See: http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml). Generally these are county-aggregated datasets although finer, census-tract data are available for the Census Bureau elements. NOAA has developed spatial trends in socioeconomics for coastal areas (See: http://www.csc.noaa.gov/digitalcoast/data/stics/index.html). ArcGIS online offers a number of compiled map services on socio-economic data that can be opened directly in ArcMap (http://www.arcgis.com/home/gallery.html).

Human health, beneficial uses, recognition and incentives

watershed population

Why relevant to recovery: Population density does have implications for recovery potential but they differ in directionality. More dense population is generally associated with multiple stressors of higher magnitude that are generally more difficult and expensive to remediate. On the other hand, higher populations are associated with better information flow and education, which are credited as background reasons why more highly populous areas often support restoration with greater interest. Project-specific consideration is recommended before using this metric.

Data sources and measurement: Census information can be adapted to a watershed basis or used in its original form as census tract or county information. See Census Bureau sources online (http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml).

recreational resource (PDF) (3 pp, 48.4K)

Why relevant to recovery: Public support of restoration funding uses is often strongly tied to expectations of access and outdoor recreational benefit from the restoration investment. In contrast, inaccessible and privately owned waters with impairment problems may struggle for restoration funding from public sources due to limited community support. An observable pattern of restoration projects largely on public and recreationally accessible lands is attributable largely to this factor.

Data sources and measurement: Scoring is based on water body location in relation to the recreational land category, as 0 = water passes through no recreational use lands; 1 = water is partially within recreational use lands; 2 = water is completely within recreational use lands. Statewide GIS shapefiles at a minimum should include State Conservation Areas, State Forests, State Fish and Wildlife Areas, and State Parks, and other recreational land types where available. The Protected Area Database contains nationwide information on recreation areas (See:

http://www.protectedlands.net/dataportal/find.php). ArcGIS online contains a number of mapping services of recreation areas nationwide (See: http://www.arcgis.com/home/search.html?q=recreation&t=content). Statewide GIS shapefiles at a minimum should include State Conservation Areas, State Forests, State Fish and Wildlife Areas, and State Parks, and other recreational land types where available.

watershed # drinking water intakes

Why relevant to recovery: Association with public drinking water is one of the most powerful traits a watershed can have, concerning the need to demonstrate public support for restoration. This metric can provide a count of surface water and groundwater resources in use for drinking water.

Data sources and measurement: Exact locations of most drinking water intakes are not publicly available for security reasons, but can usually be obtained as more generalized information on a small watershed basis or topographic quad basis. EPA has developed national data relating drinking water intakes to HUC12 watersheds.

watershed % source water protection area

Why relevant to recovery: Association with public drinking water is one of the most powerful traits a watershed can have, concerning the need to demonstrate public support for restoration. This metric can provide an area measurement associated with surface water and groundwater resources in use for drinking water.

Data sources and measurement: Exact locations may be security-limited but generalized areas associated with drinking water sources can be obtained. EPA has developed national data relating source water protection areas to HUC12 watersheds.

valued ecological attribute (PDF) (3 pp, 54.5K)

Why relevant to recovery: Community support for restoration is motivated by widely-shared recognition of a site's value, often in the form of natural aesthetics, biodiversity, rarity, charismatic species, outdoor sport e.g. fishing, or ecological goods and services. Formalized designation of a valued site not only reflects those original beliefs in the worth of an area but also reinforces the perception of its value with others, thereby strengthening the prospects for public support of its restoration.

Data sources and measurement: This metric is most easily based on formal recognition and designation by one of several programs that are generally aligned with protecting biodiversity, aesthetics, recreational sport, or other uses. The metric can be scored as a basic presence/absence metric, or high/medium/low/none rankings can be defined according to the available data. Geo-spatial data sources on rarity and biodiversity include NatureServe data systems (See: http://www.natureserve.org/explorer/) and state natural heritage databases (See: http://www.natureserve.org/getData/programData.jsp#A). Other designations with spatial data available include Wild, Scenic and Recreational Rivers (See: http://www.rivers.gov/maps.html), and Outstanding Natural Resource Waters under CWA. A number of cultural datasets can be obtained through ArcGIS online (See: http://www.arcgis.com/home/search.html?q=cultural&t=content). Fisheries programs at state and federal level may also have recognition categories such as 'blue ribbon' or Class A fisheries.

funding eligibility (PDF) (2 pp, 16.6K)

Why relevant to recovery: As adequate funding is widely recognized as a major driver of restoration success, eligibility for significant restoration sources is a strong influence on the social context for recovery potential. Waters without eligibility for restoration funding may have very limited opportunities especially if facing an expensive restoration effort. A major amount of restoration takes place through relatively few funding sources, thus eligibility for those sources can be crucial. Some major federal sources with limited eligibility include Clean Water Act Section 319 nonpoint source funds and State Revolving Funds; USDA agricultural programs such as WHIP, EQIP, CREP, CSP and WRP; and SMCRAA abandoned minelands remediation funds.

Data sources and measurement: Crosswalk watershed boundaries for impaired waters of interest with selected funding programs either by currently active project information, or by implied eligibility determined from existing spatial data (e.g. agricultural activities, abandoned minelands). Scoring can be done by presence/absence of eligibility for selected or any funding sources, or by total counts of eligible programs, by watershed.

human health and safety (PDF) (2 pp, 44.9K)

Why relevant to recovery: Among decision-makers and communities alike, the relevance to human health or safety has always been among the most powerful criteria for determining the importance of an activity. Some environmental restorations are needed in part because of health and safety hazards that accompany environmental degradation – for example, many abandoned mineland settings and hazardous waste remediation activities. When human health and safety risks are involved, the degree of support for a restoration effort is boosted above the support based on environmental factors alone, and the positive social context for recovery potential is increased.

Data sources and measurement: This metric generally relies upon site-specific monitoring data to verify the risk. Such data are available from hazardous waste, mining or other programs. Flooding or storm risks, where involved in a restoration action that will explicitly reduce those risks, may also be attributed to this metric. Scoring may be performed as simple presence/absence of risk or assigned a severity scale, depending on available data and its consistency. Some example sources include beach closing information (See: http://iaspub.epa.gov/waters10/beacon_national_page.main), searchable data as part of the Toxics Release Inventory (See: http://www.epa.gov/tri/tridata/index.htm) and hazardous waste geographical queries through the Resource Conservation and Recovery Act (See: http://www.epa.gov/enviro/html/rcris/rcris_query_java.html).

iconic value of resource (PDF) (3 pp, 53.1K)

Why relevant to recovery: A large number of communities grew around a well-known water body and identify heavily with it in their local culture and history. Others have come to recognize and appreciate the economic or recreational uses and positive impacts a prominent local water body may have on their community well-being and assets. In situations where the best-known and important water body has become impaired, this information can motivate communities very strongly to support restoration.

Data sources and measurement: There is no standard measure for how communities identify with specific water bodies, but it is easily recognized at local scales. Among the ways to address this factor are to recognize tributaries that can impact the iconic water body (such as, tributaries in the Chesapeake Bay drainage versus ones that are not) and raise their recovery potential scores.

303(d) schedule priority (PDF) (2 pp, 41.7K)

Why relevant to recovery: For pollutant-impaired waters that will undergo TMDL development en route to their restoration, Clean Water Act (CWA) regulations require states to prioritize the current 303(d) listed waters for TMDL development in a schedule. High priority waters on this schedule have the best chance of accelerated action toward their recovery. Faster, earlier restoration may also decrease the likelihood that continuing degradation will meanwhile progress further and lead to greater losses of ecological function and beneficial uses.

Data sources and measurement: High, medium and low priority categories are assigned by states to the 303(d)-listed waters they list each cycle, indicating relative priority for TMDL development. If the recovery potential screening involves only listed waters without TMDLs (e.g. the most recent listing cycle only, where prioritized schedule has been completed), this metric is appropriate for use. The metric is inappropriate for non-303(d) waters or for screening waters that already have TMDLs or watershed plans, or where the recovery potential screening is intended to provide the basis for 303(d) schedule priority-setting.