Recovery Potential Metrics Summary Form

Indicator Name: LAND USE CHANGE TRAJECTORY

Type: Stressor Exposure

Rationale/Relevance to Recovery Potential: Human use effects in watersheds that influence recovery can be observed not just by current conditions, but also by past or recent changes in those conditions. Some studies have suggested that decades-old land use history is at times more correlated with aquatic impairment than recent land use pattern. Recent land cover trajectory studies may also 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.

How Measured: Land cover totals (%) for given watersheds can be contrasted for different 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.

Geo-Spatial Data Source: 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/).

Indicator Status (check one or more)

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

Comments: Operational and widespread applicability. Users are cautioned to ensure change is based on the same areas and same classification categories from time one to time two.

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

- (Hillman and Brierley 2005) Unless we understand trajectory of change, placing reaches within their catchment context, we cannot establish programmes that focus on enhancing natural recovery mechanisms (Fryirs and Brierley, 2000; Brierley *et al.*, 2002).
- (Xian, Crane and Su 2007) Land use and land cover (LULC) change associated with urban development is considered one of the most disturbing processes because it causes dramatic changes in the natural energy and material cycles of ecosystems and influences mesoscale weather patterns, local climate conditions, biodiversity, and water

resources (Miller, 1981; Berry, 1990; Oke, 1989; Pielke et al., 1999; Kalnay and Cai, 2003).

- (Xian, Crane and Su 2007) The relationship between spatial patterns of urban land use, population distribution, and pollutant loadings in different sub-drainage basins is also investigated. Improved understanding of the relations among these factors will certainly help planning efforts for future water and ecosystem quality and natural resource distribution and management.
- (Xian, Crane and Su 2007) Accommodating the growing population of the region requires a heightened awareness of environmental conditions associated with urban growth trends. Although the effect of urbanization, population growth, and impervious surface cover on water quality and the health of watersheds has been generally studied over the decades (Slonecker et al., 2001), challenges exist in quantifying the detailed spatial extent and distribution of imperviousness.
- (Xian, Crane and Su 2007) Analysis results indicated that spatial extents of ISA (impervious surface area) in drainage basins were closely associated with annual non-point source pollutant loadings. However, from inspection of annual areal average loading rates, population density appeared to be a better indicator than ISA density for most non-point source pollutants….The results of this study demonstrate a useful tool for monitoring urban development and non-point source surface water loadings in the Tampa Bay watershed. It can be used to help urban planners, coastal managers, and decision makers to assess potential long-term influences of urbanization so that appropriate policies can be implemented to mitigate or minimize future impacts.
- (Ruiz and Domon 2009) The analysis shows that although the majority of lots were subjected to a homogenization of their landscape patterns since 1950, this trend is not entirely uniform and that since 2000 it occurs alongside trends towards diversification of certain landscape features on some lots. Furthermore, nearly a third of the lots are not following the main trajectories of change detected. Thus, the results suggest that extrinsic forces (policies, technologies) that are directing main changes in areas of intensive agricultural use toward uniformity could be modulated by internal forces (uses and values of the population). A better understanding of theses internal forces seems crucial to manage landscapes.
- (Ruiz and Domon 2009) Trajectories aim at identifying the paths by which landscapes change through time. By tying the history of change to a specific part of the territory, they not only allow the illustration of temporal patterns of change but also take into account their continuity and their direction. Thus, emphasizing change trajectories could be useful, such as for reconstructing past changes and understanding their main driving forces, or as for predicting the future changes of landscapes in the case of assumed constant political, economical and technological contexts (Domon and Bouchard 2007). This understanding is even more important because the past changes influence the current ecological characteristics of the various landscape elements, and thus the role that they can play within planning strategies (Haines-Young 2005).
- (Ruiz and Domon 2009) Thus, it appears that understanding past changes does not allow the prediction of all future changes, but within a given political, economic, technological and socio-cultural context it remains possible to reduce the uncertainty as to the principal future changes (Domon and Bouchard 2007). But above all, it seems crucial to acquire better knowledge about internal forces on which it could be possible to act for reintroducing the multifunctional character of landscapes in areas of intensive agriculture.
- (Haase 2009) The long-term observation of urban growth and sprawling land consumption has proven that it is the cumulative impact of land use change and surface sealing, rather than short-term consequences that is likely to impair the urban water balance. It highlights the problems that can arise in the long run due to this cumulative impact of land use change over time on the city or regional scale and thus gives an example of how severely urban growth on a city's fringes can affect environmental processes such as the water balance in quantitative terms (Gainsborough, 2002).

- (Haase 2009) Urban sprawl potentially leads to an increased flood risk produced by increasing direct runoff and a resulting higher release of water out of the urban system. This could restrict a city's chances for future development in that technical precautions necessary to mitigate these problems may become extremely expensive. However, it is fairly clear that the long-term effects of urban land uptake on the environment in general, and water balance in particular, not only depend on the amount but also the distribution of the land to be developed, or the spatial pattern of land conversion, as well as the previous quality of this land (Newman, 2000; Burchell andMukherji, 2003; Nuissl et al., 2008).
- (Ojeda-Revah, Bocco, Ezcurra and Espejel 2008) LUCC (Land Cover and Use Change) operates at the landscape level through ecosystem fragmentation, which disrupts environmental functions (Forman 1995; Mas et al. 2004). As semi-natural landscapes become predominant, knowledge of LUCC in human altered ecosystems will play a growing role in the conservation of natural resources (Noss 1996; Schwartz 1997).
- (Ojeda-Revah, Bocco, Ezcurra and Espejel 2008) In order to study LUCC patterns and processes, Bürgi et al. (2004) suggested the use of the driving forces concept, and identified five main types: natural, socioeconomic, policies, technology and cultural.
- (Ojeda-Revah, Bocco, Ezcurra and Espejel 2008) The study of LUCC patterns in watersheds is of particular relevance because it may affect erosion rates (Sah & Shimizu 1998), hydrologic cycles and water availability (Peters & Meybeck 2000).
- (Matthews and Endress 2010) The ability of restoration practitioners to accelerate succession through active manipulation may be contingent upon landscape context.
- (Matthews and Endress 2010) high soil fertility in agricultural wetlands may drive rapid succession to a relatively stable perennial community. Wetlands in agricultural settings often receive fertilizer runoff (Mitsch & Gosselink 2000; Jones et al. 2001) or may have high residual soil fertility before restoration because of an agricultural legacy. Higher growth rates owing to high fertility result in rapid dominance by fast-growing, nutrient-limited species (Grime 1977; Huston & Smith 1987; Tilman 1987; Prach et al. 2007a), and restored wetlands with high soil fertility often develop high cover by non-native, clonal species such as P. arundinacea within a few years following restoration (Matthews et al. 2009). The effect of surrounding land use on the rate of succession is a fruitful area for further research, and ecological restorations will provide valuable study locations.
- (Wicklein and Schiffer 2002) Changes in land use over time, due to land development, in the Reedy Creek watershed make predicting changes in hydrology and water quality difficult. Because of the natural variability of hydrologic and water-quality data, the spatial variability within watersheds, and the complexity of nutrient runoff and transport relations, it is difficult to relate specific watershed properties to conditions downstream unless the watershed is analyzed as a system. Watershed modeling can be used to better understand the relation of land use to hydrologic and water-quality processes occurring within a watershed. A continuous-simulation watershed model can provide the framework for understanding the relations among land use and water quantity and quality within the Reedy Creek watershed and the RCID.
- (Scott 2006) A linear combination of watershed-scale measures reflecting the extent contemporary forest cover, the trajectory of forest cover change over time, and building and road density were stronger predictors of fish assemblage composition than topographic features.
- (Scott 2006) Quantification of the homogenization process in response to urban development and other stressors is a promising avenue for proactive conservation, land use planning, and sustainable development efforts.
- (Scott 2006) Aquatic systems are integrated with surrounding terrestrial systems through the processes of runoff, sedimentation, and transport of chemical and biotic elements (Fisher, 1997). Conversion of landscapes from indigenous cover to urban and suburban uses disrupts those processes, altering hydrologic regimes, channel morphology, and water quality to the detriment of dependent biological communities (Paul and Meyer, 2001; Miltner et al., 2004)…. Complications arise, however, with the recognition that the

biota may reflect influences other than contemporary watershed disturbance. Faunal structure and organization may be more indicative of past rather than current conditions (Harding et al., 1998). Moreover, anthropogenic and natural topographic gradients often covary in the landscape, confounding empirical associations between land use and ecological response (Allan, 2004).

- (Scott 2006) Regeneration of forest cover across these landscapes was not a major factor influencing homogenization. Endemic fishes are not significant components of the assemblage in watersheds that have made large gains in forest cover over two decades, suggesting a lack of biological recovery in these systems. The evidence suggests two possible reasons. One is that some of the catchments that have recovered from past deforestation have concomitantly undergone exurban development. The impacts of ongoing development activities negate the aquatic habitat recovery presumably associated with reforestation. The other possibility is that the habitat impacts that are legacies of the old disturbance (fine sediments, lack of large woody debris) are still present, a situation termed the ‘‘ghost of land use past’’ by Harding et al. (1998). Long term monitoring of such systems is desirable to establish what the rates of recovery in the physical, chemical, and biological components of the aquatic ecosystem might be.