Recovery Potential Metrics Summary Form

Indicator Name: CORRIDOR PERCENT WOODY VEGETATION

Type: Ecological Capacity

Rationale/Relevance to Recovery Potential: Broad array of influences on capacity to recover (see notes below), 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 Percent Riparian Forest cites and examples.

How Measured: 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). Different results from forested % possible when land cover data include a shrub class as well.

Data Source: Land cover datasets are available through the National Land Cover Pattern 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.

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: Widespread applicability, even for riparian corridors in regions not naturally forested

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

- (ourso and frenzel 2002) Riparian buffer strips can successfully sustain many important aquatic habitat components (Schueler, 1995; Shaw & Bible, 1996).
- (parkyn et al 2003) Generally, streams within buffer zones showed rapid improvements in visual water clarity and channel stability, but nutrient and fecal contamination responses were variable. Significant changes in macroinvertebrate communities toward "clean water" or native forest communities did not occur at most of the study sites. Improvement in invertebrate communities appeared to be most strongly linked to decreases in water temperature, suggesting that restoration of in-stream communities would only be achieved after canopy closure, with long buffer lengths, and protection of headwater tributaries. Planting (or preserving) riparian buffer zones can be an effective means of reducing nutrient and sediment loads into streams (Barling & Moore 1994; Williamson et al. 1996; Fennesy & Cronk 1997; Martin et al. 1999). However, the extent to which buffers can restore riparian ecosystems in terms of ecological function and species composition is essentially unknown (Ebersole et al. 1997; Jorgensen et al. 2000).

- (parkyn et al 2003) Across the nine sites there were few consistent improvements in water quality and habitat and few changes in the invertebrate community to suggest that the [planted] patches of buffer zone had improved stream health.
- (parkyn et al 2003) In general, there was little evidence of the channel widening phenomenon expected after riparian shading of formerly pasture stream banks (Sweeney 1993; Davies-Colley 1997). Restoration of shade is expected to result in substantial losses of stored stream bank sediment as the armoring effect of riparian grasses is reduced, at least in upland catchments (Collier et al. 2001; Parkyn et al. 2001) Loss of in-stream nutrient processing is also associated with shade.
- (parkyn et al 2003) Modeling studies in New Zealand (Rutherford et al. 1999) indicated that the deeper and wider the stream, the longer the buffer will need to be to achieve reductions in temperature, for example, 1–5 km for first-order streams versus 10–20 km for fifth-order streams, with 75% shade, to achieve a 5C reduction in temperature.
- (Bernhardt and Palmer 2007) Moore & Palmer (2005) found that while the invertebrate diversity of headwater streams in suburban Maryland decreased with the proportion of impervious cover in the catchment, there was a positive effect of the extent of intact riparian vegetation on urban stream macroinvertebrate taxa richness (Fig. 4). Sudduth & Meyer (2006) found in both urban and urban restored streams that macroinvertebrate richness and biomass were strongly correlated with the per cent of streambanks covered with roots or wood, indicating that biological structures could improve habitat quality (741).
- (Bernhardt and Palmer 2007) However, the presence of riparian vegetation along urban streams is important regardless of the width of the buffer. Not only does it improve bank stability but the generally low aquatic biodiversity in urban streams may be enhanced in reaches where the riparian zone is intact (Moore & Palmer, 2005, but see Walsh, 2004, and Walsh et al., 2005a for a discussion of contrasting results) (746).
- (Bernhardt and Palmer 2007) In the Paint Branch catchment of heavily suburban Montgomery County in Maryland, progressive urban planning has led to purchase and preservation of large areas of riparian forest and used aggressive zoning laws to limit new development in the catchment. This approach has been successful at maintaining high water quality and supporting reproducing populations of trout despite very high impervious cover within the catchment (Montgomery County DEP, 2003) (747).
- (Andersen et al., 2007) Riparian forests and woodlands provide important ecosystem services through their high productivity and habitat values (Finch and Ruggiero 1993; Hughes 1994; Knopf and others 1988; Skagen and others 2005; Wright and Flecker 2004), the food and fiber they provide (Gregory and others 1991), and the organic matter they supply to aquatic ecosystems (Angradi 1994; Townsend-Small and others 2005) (453).
- (Poiani et al., 2000) The minimum dynamic area for the Yampa River riparian ecosystem must maintain recolonization sources for each internal patch type and provide room for the geomorphic processes that reshape the floodplain and create and destroy the complete array of patch types (143).
- (Poiani et al., 2000) Not only is riparian vegetation more vulnerable to widespread destruction by floods, but future sources of propagules for post-disturbance recovery may also be severely reduced as a result of a narrowed and fragmented riparian corridor (143).
- (Ekness and Randhir 2007) Lateral [riparian] and longitudinal [stream order] connectivity and flow regime are critical factors that influence watershed health. The latter can be impaired by land and water use practices that affect biotic diversity, water quality, esthetics and hydrology (Brooks et al., 1997) (1469).
- (Ekness and Randhir 2007) The riparian gradient is an important component of a watershed and maintenance of a ''natural'' gradient plays a vital role in protecting water quality (Corell, 1996; Novak et al., 2002), flood control, and ground-water recharge, and provides habitat for a variety of organisms (Naiman and Decamps, 1993). Riparian vegetation regulates hydrologic fluxes, light incidence, temperature, physical habitat, food

and energy, and nutrient flows (Gregory et al., 1991; Sweeney 1992) into and out of the riverine-riparian zones (Lynch et al., 2002). The riparian system contributes organic material in the form of woody debris and leaf litter to a riverine system (Gregory et al., 1991; Hubbard and Lowrance, 1997) and reduces bank erosion (Hubbard and Lowrance, 1997). This flow of energy between the terrestrial and aquatic ecosystems occurs from a more to a less productive habitat (Polis and Strong, 1996). Thus, riverine ecosystems in which the river inundates the riparian zone are more productive because they are acquiring organic maternal from the nearby terrestrial ecosystems. Riparian vegetation and litter that fall from upland environments are major sources of nutrients to streams (Oelbermann and Gordon, 2000). Minerals and oxygen levels are affected by riparian zones as well. McGlynn et al. (1999) observed that Ca concentrations increase with depth and DOC concentrations decrease with depth in riparian zones. The riparian zone was also found to effectively limit the movement of phosphorus enriched sediments (Novak et al., 2002) and assimilate NO3-N (Hubbard and Lowrance, 1997) (1469).

- (Poole and Downing 2004) Stream sites often had riparian zones dominated by agricultural use and were generally characterized by poor water quality (Table 2). Multiple regression showed that the fraction of remaining woodland in the riparian zone, and the fractions of fine sediment, sand, gravel, and cobble substrate were significantly (*p* , 0.05) positively related to DR (Table 3). Positive variable loadings in this context indicated smaller declines or improvements in biodiversity, so areas with more riparian woodlands and more nearly equal fractions of fine sediment, sand, gravel, and cobble substrates had the least severe rates of decline in mussel richness. Riparian woodlands had the strongest positive partial effect on change in mussel species richness (Table 3) in multiple regressions. The effect is illustrated as a bivariate plot (Fig. 4A) showing that only sites with .50% woodlands in the riparian zone occasionally lost no species or increased in species richness. The median rate of species loss only approached 0 in stream reaches with .80% wooded riparian zone. Riparian woodlands, previously the rule across this landscape (Andreas 1875), are of immense water-quality and biological benefit to stream animals (Karr and Schlosser 1978, Allan 1995), providing shading as well as water-quality protection (119-121).
- (Poole and Downing 2004) The combination of intense agricultural land use and low potential for water recharge (inferred by low fractions of Mississippian formations) results in suboptimal water quality and hydrologic conditions for mussels. The results of the watershed analysis underscored the positive influence of site-specific, nonagricultural, geomorphic features like wooded riparian zones (Table 3). Both results are consistent with other recent analyses (Hoggarth et al. 1995) in indicating that agricultural practices degrade mussel richness (122).
- (Poole and Downing 2004) Successful protection or restoration of mussels in regions that have undergone major alterations in land use over the past century must address the factors degrading stream conditions for the biota and the factors impeding recolonization. Restoration and long-term protection of mussel biodiversity should therefore address the restoration of riparian zones and the increased protection of streams from agricultural influences (124).
- (Dodds and Oakes 2008) Riparian land use may be particularly influential and, in some cases, a better predictor of in-stream water quality than land cover in the entire catchment (Johnson and others 1997; Osborne and Wiley 1988). Intact riparian zones provide water quality benefits and help preserve the biological integrity of watersheds (Gregory and others 1991) (368).
- (Dodds and Oakes 2008) Across all studied watersheds, riparian land cover was a significant predictor of among-site variation in water chemistry concentrations at the watershed and first-order streams scales, particularly for nutrients (Table 1) (371).
- (Ekness and Randhir 2007) Species richness has been shown to increase as vegetative density increases and with distance from developed areas (1470).
- (Barker et al., 2006) In October 1996, the Executive Council of the CBP established a goal of restoring riparian forest buffers on 2010 miles of streams in the Chesapeake Bay

watershed by 2010. Commitment to riparian restoration was continued in the 2000 Chesapeake Bay Agreement. These actions exemplified the widespread acceptance of riparian buffers as an important tool for the reduction of non-point-source pollution and enhancement of stream ecological condition (2).

- (Ekness and Randhir 2007) Identification of optimal riparian buffer width is an important policy issue in watershed conservation. Paine and Ribic (2002) evaluated how four types of managed buffer types influence water quality. The lowest impact was observed in woody buffer strips, rotationally grazed, and continuously grazed riparian areas that contain a greater number of plant species (1470).
- (Ducros and Joyce 2003) The three criteria that varied from the usual scoring range were the WFO agreement adopted, stream lower-bank stability, and vegetation type within the buffer zone. In the first exception, the WFO agreement, scores ranged from 15 to 40 with greater value placed on 20-year withdrawal and arable conversion agreements (Table 2). This scoring range recognized that the type of WFO agreement was potentially a particularly important influence on riparian condition in this study. It also reflects the long-term nature of environmental enhancement and the potential habitat and water quality benefits of converting arable cropland to more natural vegetation (Dosskey 2001, Kemp and Dodds 2001). Furthermore, it was recognized that all WFO agreements potentially have considerable environmental benefit, so the minimum score possible was raised to 15. The second exception to the normal range of scores was for stability of the lower bank of the buffered stream. This criterion featured a depressed maximum score of 25 (Table 2) as lower-bank stability is not a substantial contributor to environmental enhancement in riparian zones compared, for example, to upper-bank character (Cooper and others 1987). The final exception related to the physical type or structure of vegetation in the buffer zone, which was assessed by recording the percentage of different vegetation types in the field and allocating a score based on the proportion of each vegetation type present (Table 2). Thus, a buffer zone with 50% woodland cover and 50% open ground would score 50% of 30 points (15) for the woodland and 50% of 10 points (5) for the open ground, yielding a total of 20 points. The minimum score assigned to this criterion was 10, as even the lowest category of open vegetation, such as low grasses, represents valuable wildlife habitat and can contribute to effective buffer zone functioning (Lyons and others 2000) (255).
- (Ekness and Randhir 2007) Spatial variations created by different riparian distance, stream order, and land use affect the type and quality of habitat potential at a particular position within a watershed. The buffer is often critical in the flow of mass and energy into and out of water bodies. The longitudinal dimension reflects upstream-downstream linkages, which is a key factor in watershed ecology. Various land uses contribute to the type and level of disturbances in a watershed. The intensity and the extent of land disturbance affect the habitat potential of a watershed (1471-1472).
- (Ekness and Randhir 2007) In general, habitat potential decreases with respect to land disturbance for most vertebrates. It is highest for birds, mammals, and amphibians in undisturbed forested, nonforested wetland, woody perennial, or open water areas. Reptiles are exposed to higher disturbance in cropland and pastures, possibly because of a higher availability of prey. There was an increase in habitat potential for birds, mammals, and amphibians between disturbance values of 1 and 2. The transition between the forested and urban areas could explain this increase. This is consistent with the intermediate disturbance hypothesis, which proposes that disturbance at intermediate levels can contribute to moderate increase in species diversity at particular levels (Dial and Roughgarden, 1998). Habitat potential for all four vertebrate species declines with increases in disturbance except for the transition between disturbance Levels 1 and 2 mentioned before (1475-1476).