Functional Assessment Method for Riparian Ecosystems of Western Placer County, California

Prepared for:

Placer County Planning Department

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Summary

This report presents a Functional Assessment Method (FAM) for assessing the integrity and functions of riparian ecosystems that are associated with perennial and seasonal streams in western Placer County. It is intended to support conservation planning within the region, and together with assessment procedures for aquatic and upland ecosystems, to provide a basis for evaluating entire watersheds.

This FAM is an indicator-based approach for assessing the functions provided by riparian ecosystems and the effect of human alterations on those functions. Ecosystems provide functions, such as sustaining animal habitats and degrading pesticides. Measuring these functions directly can be costly or otherwise impracticable. Therefore, instead of measuring functions directly, indicator-based approaches use readily observed site attributes that provide information about the functions occurring at sites.

The FAM consists of three indicators of functional capacity and integrity. Functional capacity is the magnitude of the function being performed, such as the quantity of a pesticide degraded or the amount of sediment moved by a stream. Functional integrity is the resemblance of the current functional capacity to that observed under unaltered conditions. These indicators are:

- cover of natural vegetation on the floodplain and adjacent land,
- inundation of the floodplain, and
- quantity of rainfall infiltrating into (i.e., entering) floodplain soils.

Each of these indicators is a key variable for a category of riparian functions (e.g., biogeochemical and habitat functions). These key variables were selected because they strongly influence multiple functions within the category, and their measurement does not require extensive on-site data collection.

The FAM was restricted to a single indicator for each category of functions to avoid the problems associated with combining different types of variables (i.e., unrelated or disparate variables). For example, averaging unrelated variables, such as cover of nonnative plants and continuity with adjacent uplands, produces scores that are difficult to interpret. For this reason, the FAM also does not combine the scores for these three indicators into a single quantitative assessment score, but instead the value of each indicator is reported for all evaluated sites.

For each of these indicators, this report provides a rationale for their inclusion in the FAM, one or more methods for quantifying functional capacity and integrity for each indicator, and guidance regarding their interpretation. The appendices include detailed descriptions of how to calculate indicator scores, and they provide an example where the FAM is applied to three sites along Dry Creek in western Placer County.

Functional Assessment Method for Riparian Ecosystems of Western Placer County, California

Introduction

This report presents a Functional Assessment Method (FAM) for riparian ecosystems associated with perennial and seasonal streams in western Placer County. This FAM also can be applied to foothill streams elsewhere in the Central Valley. The rationale for the assessment's approach and indicators is provided along with the methodology and guidance for interpreting the results. This FAM is an indicator-based approach for assessing the functions provided by riparian ecosystems and the effects of human alterations on those functions. Indicator-based evaluations use readily measured attributes of riparian sites to indicate the amount of a function (i.e., the capacity) and the resemblance of this quantity to unaltered conditions (i.e., integrity). For example, conveyance of floodwaters is a function; the rate of flow, for a given discharge, is the capacity to provide this function, and its resemblance to the unaltered rate is the integrity of floodwater conveyance.

The FAM is intended to support conservation planning in Placer County and elsewhere within the Central Valley region, including identification of potential preservation and restoration sites, and evaluating the consequences of land use alternatives. Together with assessment procedures for aquatic and upland ecosystems, it also provides a basis for assessing whole watersheds.

Rationale for Assessment Approach

Riparian ecosystems are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes and biota, and they occur in areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands (Brinson et al. 2002). Riparian ecosystems provide a wide range of ecological functions (Table 1) that are major influences on terrestrial and aquatic animal habitats and stream water quality.

Table 1. Ecological Functions of Riparian Ecosystems

Hydrologic and Geomorphic Functions
Recharges ground water
Stores surface water
Conveys floodwaters and other overland flows
Transports sediment and organic matter
Transports dissolved molecules (e.g., ammonia, nitrates)
Stores sediment
Sustains channel and floodplain landforms
Biogeochemical Functions
Produces biomass (i.e., primary production)
Stores carbon in vegetation and soil
Cycles phosphorus
Cycles nitrogen
Cycles micronutrients
Adsorbs, stores and transforms non-nutrient metals (e.g., mercury)
Adsorbs, stores and degrades pesticides and hydrocarbons
Habitat Functions
Sustains characteristic native plant associations
Sustains aquatic animal habitats
Sustains terrestrial animal habitats

Note:
[1] Based on lists of functions in Keddy 2000 and Brinson et al. 2002.

Effective conservation planning requires the assessment of the quantity of functions provided by riparian ecosystems. The federal Clean Water Act mandates the conservation of riparian and wetland functions, and riparian ecosystems also provide habitat for a number of species that are protected by the California and Federal Endangered Species Acts, as well as other special-status species.

Conservation planning is typically conducted with limited funding on short timelines (i.e., rarely longer than several years), and it is often a contentious process that may include legal challenges. Therefore, a functional assessment of riparian habitats should be:

- Cost-effective;
- Comprehensive, consisting of one to several ratings that indicate capacity for numerous functions;

- Transparent (i.e., readily understood, interpreted and communicated);
- Flexible, and capable of supporting a variety of assessments based on varied data sources; and,
- Defensible, by making the best use of existing data.

Unfortunately, the different approaches to assessing functions involve trade-offs among these desired attributes (Table 2). The main approaches to assessing functions are: 1) direct measurement of functions, 2) process-based models, and 3) indicator-based evaluations.

Table 2. Attributes of Assessment Approaches

Approach	Examples	Cost	Breadth[1]	Transparency[2]	Flexibility[3]	Defensibility[4]
Direct Measurement	Species surveys, water quality monitoring	Moderate-High	Low-High[5]	High	Low	High
Process-based Modeling	SWAT, HEC	Moderate-High	Low-Moderate	Moderate	High	High
Indicator-based Assessment	HGM	Low	High	Low-Moderate	Moderate	Low

Notes:

[1] Breadth represents the variety of functions that can be assessed.

[2] Transparency represents the ease of communicating and interpreting assessment results.

[3] Flexibility refers to the variety of uses the assessment can be applied to (e.g., assessing current conditions, effects of management alternatives, etc.).

[4] Defensibility refers to the ability of assessment results to withstand scientific or legal challenges.

[5] For direct measurements, breadth depends on the particular combination of variables measured. For example, monitoring a single animal species would have less breadth than monitoring the structure of riparian vegetation.

Direct measurements of functions, such as monitoring of hydrology or site-specific surveys for species' presence, are readily understood and highly defensible. However, they have a moderate to high cost, are usually very time consuming, and have limited value for evaluating management alternatives.

Process-based modeling, such as using the SWAT model to simulate water quality (Neitsch et al. 2002), can be highly defensible as it uses mechanistic relationships and detailed site-specific information to make predictions, and its accuracy and precision have been evaluated in a variety of settings. However, applying such models is expensive and process-based models are not available for all riparian functions.

Evaluations based on indicators, such as the Hydrogeomorphic (HGM) Approach (Hauer et al. 2002) combine the values of several readily observed variables into a rating representing the amount of a function provided. These assessments are inexpensive, address numerous functions and are readily applied both to current

conditions and future scenarios. However, interpreting and communicating the indicator-based ratings can be difficult, and their accuracy and precision is unlikely to equal those of direct measurements or those derived from process-based models (Suter 1993).

Perhaps because of their cost-effectiveness, numerous indicator-based functional assessments have been developed, yet relatively few of these approaches have been evaluated to test the accuracy and precision of their results (Table 3). This limits the defensibility of indicator-based assessments, particularly when critics have pointed out a number of potential problems with indicator-based assessments. These potential problems include:

- **ambiguity**—it may not be clear why the rating is high or low because a particular assessment rating may be produced by several different combinations of variables;
- **eclipsing**—low values of one variable can be eclipsed by high values of others;
- **arbitrary combining functions**—the value of a rating may be sensitive to the combining functions, and the use of addition, multiplication, or some other mathematical operation may not be justified or give an interpretable result;
- **high variance**—the variances of assessment ratings may be high due to compounding of component variances;
- **unreality**—assessments based on combinations of heterogeneous variables may not measure any real-world property; and
- **nonsense results**—the rating may increase due to an undesirable property of one of the component variables (e.g., increase in a plant habitat rating due to an increase in the diversity of nonnative species) (Suter 1993).

These potential problems largely result from combining several disparate variables into a single number, a widespread practice among indicator-based assessments. For example, the assessments provided in Table 3 combine tree density and inundation frequency (Hauer et al. 2002), riparian vegetation area and continuity (Smith 2000), plant cover and soil texture (Findlay et al. 2002), patch connectivity and landform diversity (Stevens et al. 2002), density of snags and vegetation type interspersion (Hruby et al. 1999), interior area and presence of surface water (Sutter 2001), and bird species number and wetland area (Cable et al. 1989). Deriving a single number to represent the ecological functions of a complex ecosystem, such as a riparian area, is likely to result in the loss and distortion of information.

Therefore, in developing this FAM, we used data for species' presence and site attributes from our related study of Sacramento Valley riparian areas to assess the performance of current indicator-based methods and the utility of indicators typically included in these methods for assessing habitat functions (Jones & Stokes 2004; Hunter et al. 2004). For multiple taxonomic groups, we examined the correspondence of species richness (i.e., number of species observed) with

individual site attributes, combinations of multiple site attributes and the habitat function scores produced by several assessment methods (Hruby et al. 1999; Smith 2000; Stein et al. 2000).

Table 3. Evaluation of Habitat Functions by Representative Functional Assessment Methods

Assessment	Terrestrial Habitat Functions	Variables used to Assess Habitat Function	Tested[1]
Spatial Wetland Assessment for Management and Planning, SWAMP (Sutter 2001)	Terrestrial wildlife habitat	Area of interior habitat Heterogeneity of vegetation Presence of surface water	No
Assessment of riverine wetlands in Washington State (Hruby et al. 1999)	Bird, Mammal, Amphibian Habitat	Density and condition of snags Presence of special features Evidence of disturbance on adjacent land Interspersion of vegetation types	No
Hydrogeomorphic assessment (HGM) of riverine floodplains in the Northern Rocky Mountains (Hauer et al. 2002)	Characteristic vertebrate habitats	Cover in herb and shrub layers and of native species Tree density Inundation frequency Connectivity of vegetation types	No
Suggested revisions to BLM's Proper Functioning Condition assessment procedure (Stevens et al. 2002)	Fish and wildlife habitat	Canopy connectivity Vegetation patch density Fluvial landform diversity	No
Southern California Riparian Model (Stein et al. 2000)[2]	Condition units[2]	Cover of native plants Percent invasive species Vegetation structural diversity Riparian vegetation continuity Adjacent land cover	No
Bird Integrity Index (Bryce et al. 2002)	Overall riparian integrity including overall habitat integrity	Number or proportion of bird species (or of individuals) in selected guilds	Yes
Tidal freshwater wetlands along Hudson River (Findlay et al. 2002)	Breeding Bird, Muskrat and Waterfowl Habitat[3]	Cover or stem density of plant species Soil texture	No[3]
Wetland Assessment, WEA, for San Francisco Bay Region (Breaux and Martindale 2003)	Wildlife Utilization Rating	Guidelines for professional judgment	No
San Diego Creek Assessment (Smith 2000)	Riparian habitat integrity	Native riparian vegetation area Riparian corridor continuity Adjacent land use/land cover	No
Indicator Value Assessment, IVA (Hruby et al. 1995)	General waterfowl, General wildlife	Numerous (>60 indicators)	No
Wetland Habitat Assessment Technique, HAT (Cable et al. 1989)	Habitat quality	Bird species presence Wetland area	No

Notes:

1 Tested by comparison to direct measurements of species presence, abundance or demography. For assessments that used direct measures of animal species group (e.g., birds) presence to assess overall site condition or habitat quality, testing requires comparison to direct measurements of other animal groups.

2 Habitat function incorporated into overall rating (i.e., condition units), and only habitat variables are listed in this table

3 This study also included fish and aquatic invertebrate habitat functions that were tested by comparison to direct measurements.

In the Sacramento Valley data sets, most site attributes were unrelated to the richness of any taxonomic group, most relationships that did exist were weak and inconsistent among taxonomic groups (Jones & Stokes 2004). Thus, ratings produced by indicator-based assessments also were not related to the species richness of any taxonomic group (Figure 1) (Hunter et al. 2004). However, for several taxonomic groups, strong relationships existed between species richness and surrounding land cover (i.e., natural, agricultural and developed land cover types) at scales from 250 meters (m) to 5 kilometers (km) (Jones & Stokes 2004).

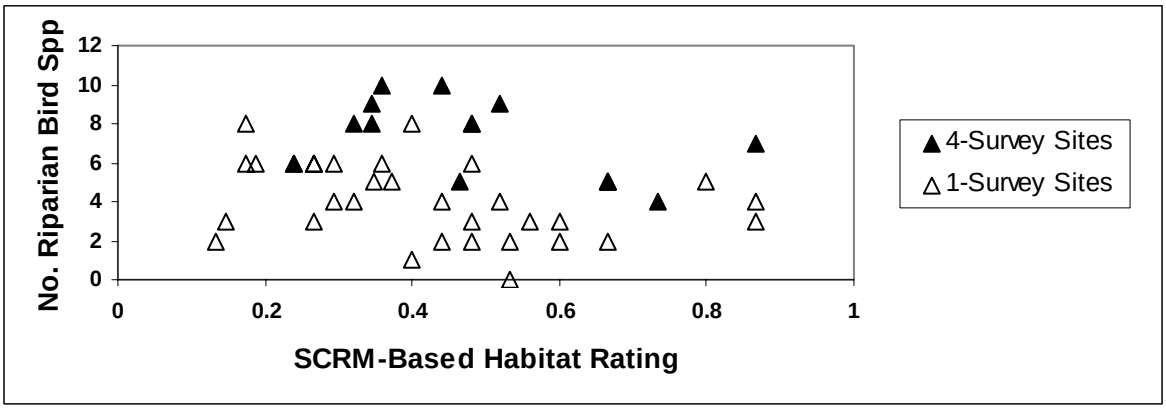

Figure 1. Relationship of Species Richness of Riparian-Associated Birds and Site Ratings Based on the Southern California Riparian Model (SCRM) (Stein et al. 2000)

These relationships indicate that: 1) a single important variable (e.g., proportion of surrounding land in natural vegetation) can indicate habitat functions, and 2) combining multiple variables through formulas that lack a mechanistic basis can lead to ratings that poorly predict biodiversity, particularly when relationships between the variables and the function under consideration are not strong and consistent, or have not been evaluated.

Therefore, formulas for calculating functional capacity (i.e., for assessing the quantity of function provided) should be consistent with, and based on, known mechanistic relationships, and variables should not be combined in an arbitrary manner. Unfortunately, most existing assessment methods often are not consistent with this guideline. Indicator-based assessments frequently incorporate averages and products of indicators into ratings of functional capacity, and often use categorical ratings (i.e., ordinal scales) for indicators. While this allows considerable flexibility for modeling the relationships between indicators and functional capacity, it also creates greater opportunity for distorting relationships. For example, there is little ecological or mathematical basis for believing that variables correlated with habitat will be more strongly correlated when their values are averaged. However, averaging indicator values is a widespread practice in assessment methods (e.g., Hruby et al. 1995, Smith 2000, Hauer et al. 2002). Similarly, while categorical ratings can be used to reflect non-linear relationships (e.g., the effects of an ecologically significant threshold), they cause some loss of precision when applied to a linear relationship and can cause inaccuracy if the categories are created without a

strong mechanistic or empirical basis. Yet, categorical scoring systems are used throughout some assessment systems (Smith 2000; Stein et al. 2000).

In the absence of strong mechanistic or empirical reasons to do otherwise, the number of indicator variables should be minimized. By minimizing the number of variables, the chances of including a variable weakly correlated with functional capacity are reduced. Costs also will be reduced and ease of interpretation and communication of assessment results will be increased as well.

Therefore, we applied the following three guidelines in developing the FAM for the riparian ecosystems of western Placer County by:

- Minimizing the number of variables used to assess a function;
- Not combining disparate variables (e.g., number of diversions and percent of reach with levees); and,
- Combining related variables in a manner consistent with known mechanistic relationships.

In following these guidelines, our general approach was to identify a single key variable as an indicator of capacity and integrity of each major group of ecological functions (i.e., hydrologic and geomorphic, biogeochemical, and habitat functions). These key indicators were selected as being strongly related to multiple functions and capable of being measured without time-intensive on-site measurements, and being applicable to single sites as well as entire watersheds. This approach avoids the major problems of combining disparate variables, maintains ease of interpretation, and results in a cost-effective and flexible FAM that can support varied conservation planning activities from local to regional scales.

FAM Indicators

The FAM consists of three indicators of functional capacity and integrity, each of which is a key variable for a category of riparian functions. These indicators are:

- For habitat functions, the cover of natural vegetation on the floodplain and adjacent land (measured as percent of total area);
- For hydrologic and geomorphic functions, the hydraulic connectivity of the floodplain and stream channel (measured as width of the inundated floodplain); and,
- For biogeochemical functions, the quantity of water infiltrating floodplain and adjacent soils during a moderately intense rainfall event (measured as inches of water per unit area).

These key variables were selected because they strongly influence multiple functions within the category, and their measurement does not require extensive on-site data collection. The FAM does not combine the scores for these three

indicators into a single quantitative assessment score, but instead each indicator's value is reported for all evaluated sites.

For each indicator, the following sections present a rationale and methodology. The rationales describe the relationships between the indicator variable and riparian functions, and other factors considered in the variable's selection for the FAM. The methodology for each indicator provides one or more methods for quantifying functional capacity and integrity.

Indicator for Habitat Functions—Cover of Natural Vegetation

Rationale

The cover of natural vegetation on the floodplain and adjacent upland was selected as the indicator of habitat functions because it is the most significant single variable and is readily measured. It is most significant because loss of riparian vegetation is a major factor contributing to population declines of riparian-associated species, and the extent of riparian vegetation is related to other landscape variables affecting habitat functions (e.g., patch size and connectivity, extent of forest interior habitats). Although habitat value for a species or guild may be more closely related to a combination of vegetation and landscape variables, these relationships vary among species and guilds and in general are not well documented. In addition, measuring such variables is more costly than measuring the area of vegetation.

Throughout the Central Valley and adjacent foothills, riparian vegetation has been significantly reduced by stream channelization, riprapping of streambanks, altered hydraulics, livestock grazing, and by loss to agriculture and urban development (The Bay Institute 1998; Riparian Habitat Joint Venture 2000; CALFED Bay-Delta Program 2000). Estimates place the loss of woody riparian vegetation in the Central Valley at 92–97%, and the remaining riparian forests are frequently fragmented and in relatively poor condition (Hunter et al. 1999; Jones & Stokes 2002). This loss of riparian vegetation has contributed to the declines and endangerment of numerous terrestrial vertebrates, invertebrates, and plants (U.S. Fish and Wildlife Service 1984; U.S. Fish and Wildlife Service 1997; Riparian Habitat Joint Venture 2000; California Natural Diversity Database 2004).

The area of natural vegetation remaining in riparian corridors is related to the quantity and quality of habitat. The quantity of resources available, and thus potential population size, varies with patch area, as does connectivity and the area of patch interior habitats (Belovsky 1987; Forman 1999). While continuous corridors of riparian vegetation represent large patches, discontinuous corridors of riparian vegetation may function as a series of much smaller patches, and thus have a lower habitat value. From the edge to the interior of forest habitats, there are climatic gradients, changes in light levels and plant species composition, and

gradients in predation and parasitism (Foreman 1999; Riparian Habitat Joint Venture 2000). Consequently, many species are associated primarily with either edges or interior of forest patches. Larger and wider patches provide habitat for both groups and greater overall habitat value than narrower patches. Furthermore, greater cover of natural vegetation corresponds to lesser cover of developed and agricultural lands, which are negatively associated with the species richness of some vertebrate groups in the Sacramento Valley and elsewhere (Findlay and Houlahan 1996; Forman and Alexander 1998; Miller et al. 2003; Jones & Stokes 2004).

In the Central Valley, riparian vegetation provides habitat for over 170 vertebrate, innumerable invertebrate and numerous plant species. These species represent multiple guilds with distinct habitat requirements (Table 4) (Mayer and Landenslayer 1988; Riparian Habitat Joint Venture 2000). Thus, overall habitat values may be comparable under many different combinations of vegetation and landscape structure. Different vegetation types and aspects of vegetation structure are important for several of these guilds such as marsh-nesting birds and neotropical migrant birds. For many invertebrate species, such as valley elderberry long-horn beetle and many butterflies, habitat requirements include specific host plants (U.S. Fish and Wildlife Service 1984). In addition, for some species, habitat value also can vary with landscape attributes. For example, surrounding land uses and patch attributes affect parasitism of riparian birds by brown-headed cowbird (*Molothrus ater*), which is a major stressor affecting these species (Harris 1991; Laymon 1987; Larison et al. 1998). Because of these substantial differences in habitat requirements, and many habitat relationships being poorly documented, a single indicator for habitat functions based on multiple vegetation and landscape variables would be difficult to develop, defend and interpret, and costly and time-consuming to apply. In contrast, the area of natural vegetation provides a simple, measurable indicator for habitat functions.

Methodology

For this indicator, functional capacity is measured as the acreage of natural vegetation on the floodplain and adjacent land. For this FAM, floodplain is defined as the area with alluvial soils, as mapped in the local soil survey or during a field survey of the site being assessed. The adjacent land is the area within 100 m of the floodplain. This width of adjacent land is included because it provides important habitat for riparian-associated species in Placer County (Jones & Stokes 2005). For lengths of stream lacking mapped floodplain soils, a 200 m minimum width along the stream (i.e., 100 m on each side) is still included as adjacent land.

The area of natural vegetation could be expressed in acres or as acres per stream mile. For assessments of sites of different lengths, expressing the area as acres per stream mile (by dividing the acreage by the corresponding stream length) would facilitate comparisons among sites.

For this indicator, integrity is measured as the percent of the floodplain and adjacent land that is in natural vegetation.

Table 4. Representative Guilds of Riparian and Wetland Habitat-Dependent Species in California's Central Valley

Guild[1]	Definition of Guild	Habitat Requirements	Habitat Attributes	Indicator Species
Riparian forest-dependent neotropic migrant birds	Neotropical migrant bird species that breed or forage in riparian forest	Riparian forest	Large patches Structural diversity Species diversity Elderberry, grape Moist soil	Yellow-billed Cuckoo, Ash-throated Flycatcher, Lazuli Bunting, Pacific-slope Flycatcher, Yellow Warbler, Black-headed Grosbeak
Riparian scrub dependent neotropic migrant birds	Neotropical migrant bird species that breed or forage in riparian scrub	Riparian scrub	Herbaceous understory, moist soil	Yellow Warbler, Spotted Towhee
Raptors	Raptors that breed and forage in riparian areas	Mature riparian forest	Tall trees Foraging habitat	Swainson's Hawk, Red-shouldered Hawk, Cooper's Hawk, White-tailed Kite, Great Horned Owl
Cavity nesters	Birds that nest in tree cavities	Mature riparian forest Open water (bats)	Snags Tall trees	Downy Woodpecker, Hairy Woodpecker, Northern Flicker), Western Screech-owl, Wood Duck
Marsh-nesting birds	Birds that nest in marsh, wintering and nesting waterfowl	Emergent marsh	Large patches	Tricolored Blackbird, Short-eared Owl, Shorebirds, Waterfowl, Virginia Rail, Sora
Long-legged waders	Tall wading birds that nest in riparian trees	Riparian forest	Tall trees	Great Egret, Snowy Egret, Great Blue Heron, Black-crowned Night-heron
Mammalian herbivores	Mammalian herbivores that utilize riparian forest and scrub	Riparian forest and shrub	Diverse canopy structure Dense understory	Riparian Brush Rabbit, Riparian Woodrat, Black-tailed Deer, Muskrat, Beaver
Bats	Bats that roost and/or forage in riparian areas	Riparian forest	Tall trees for roosting Open water areas for foraging and drinking	Hoary Bat, Western Yellow Bat, Silver-haired Bat, Pallid Bat, California Myotis, Yuma Myotis, Red Bat
Mammalian carnivores and omnivores	Mammalian carnivores that utilize riparian forest and scrub	Riparian forest and shrub	Diverse canopy structure	River Otter, Gray Fox, Raccoon
Native herpetofauna	Native reptiles and amphibians that are wetland or riparian habitat dependent	Emergent marsh, seasonal wetland, riparian forest and scrub	Slow-moving and stagnant water	Giant Garter Snake, Western Spade Foot Toad, Western Pond Turtle, Chorus Frog
Oak mast species	Species that forage on acorns	Valley oak woodland, oak riparian forest	Mature valley oaks	Acorn Woodpecker, Western Gray Squirrel, Yellow-billed Magpie

Note:

[1] Guild: A group of species that use similar habitats, or habitat features, that are not necessarily taxonomically related.

Indicator for Hydrologic and Geomorphic Functions—Hydraulic Connectivity

Rationale

Of the hydrologic and geomorphic functions provided by riparian ecosystems, conveyance of floodwaters distinguishes riparian ecosystems from other terrestrial ecosystems. Floodwaters sustain riparian vegetation, and are an important influence on aquatic ecosystems. For these reasons, we –identified hydraulic connectivity of the floodplain to its associated stream as an indicator of hydrologic and geomorphic functions.

An extensive body of literature documents the central role of hydrology in the ecology of woody riparian vegetation (e.g., Hupp and Osterkamp 1985; Mahoney and Rood 1998; Scott et al. 1999; Shafroth et al. 1998, 2000; Scott et al. 2000). Temporary floodplain inundation saturates soil, transports seeds and nutrients, and deposits bare sediment that facilitates seed germination and seedling establishment. Periodic inundation of floodplains therefore increases the area and quality of wetland and riparian vegetation. Riparian vegetation and the physical processes that maintain its development are critical for supporting populations of animal species that are seasonally dependent upon floodplain riparian habitats for foraging substrate, nest sites, and cover from predators (Riparian Habitat Joint Venture 2000).

Riparian vegetation filters sediments, provides inputs of woody debris and organic matter, modifies channel pattern and geometry, creates shaded riverine aquatic (SRA) cover, and provides habitat for invertebrates eaten by fish including salmonids. Woody material is important because it provides the hydraulic diversity necessary for selection of suitable velocities, access to drifting food, and escape cover from predatory fish (Peters et al. 1998). Additionally, the input of large woody material from the floodplain into the river system increases the complexity of habitat and fosters the creation of pools and cover for juvenile salmon during high flow events (Keller and Swanson 1979; Larson 1999; Macklin and Plumb 1999). Shade from riparian vegetation reduces daily water temperature variability and maximum temperature, maintains dissolved oxygen, and may help maintain base flows during dry seasons (CALFED Bay-Delta Program 2000; Haberstock 1999; Slaney and Zaldokas 1997; Whitting 1998). SRA cover is important to juvenile Chinook salmon and steelhead, as well as other fish, because it provides high-value resting and feeding areas, and protection from predators. In studies comparing riprapped and non-riprapped banks, juvenile Chinook salmon were shown to prefer non-riprapped areas (Shaffter et al. 1983; Peters et al. 1998; Michny and Deibel 1986).

Many native fish species are dependent on or benefit from inundated floodplain habitat including Chinook salmon and splittail. Sacramento splittail spawn in shallow areas, and deposit adhesive eggs over flooded streambanks and aquatic vegetation (Moyle 2002; Wang 1986). Juvenile Chinook salmon also rear on

inundated floodplain where they have increased growth and survival rates (Sommer et al. 2001a, b). Inundated floodplains functions as nursery areas, refuges from low water temperatures in early spring and winter, and from high water velocity (Turner et al. 1994). For example, low splittail abundance has been attributed to drought conditions resulting in a minimal area of shallow inundated floodplain area (Sommer et al. 1997; Baxter 2000). To various degrees, floodplain also provides habitat for other native fish species. Moyle et al. (2000) found that permanent floodplain ponds and sloughs are dominated by resident non-native fish species. However, seasonally inundated floodplain, though providing habitat for both native and non-native fish species, was particularly important to native species.

These effects on riparian vegetation, aquatic ecosystems and fish habitat occur during inundation of riparian areas. Thus, riparian areas that are more frequently inundated would affect riparian vegetation, aquatic ecosystems, and fish habitat more than infrequently inundated areas. Therefore, we assessed hydraulic connectivity of the floodplain through an indicator based on inundated width weighted by frequency of inundation.

Methodology

There are several ways that the hydraulic connectivity of the floodplain to the stream can be quantified. These include::

- width of the undeveloped, active floodplain,
- width of undeveloped floodplain inundated by a flow of a selected recurrence interval (e.g., a 10 year flood), or
- mean width of undeveloped floodplain inundated per year.

For all of these approaches, developed lands (i.e., infrastructure and residential, commercial and industrial land-cover) are excluded from hydraulically connected areas because they do not provide a significant quantity of many of the functions supported by overbank flows and sediment deposition (e.g., habitat functions). Similarly, for this indicator, mine tailings and other heavily disturbed areas also are not included in inundated floodplain area.

The area of undeveloped, active floodplain (i.e., natural vegetation and agricultural land) can be mapped from aerial photographs and site visits. Aerial photographs can be used to map development and areas isolated from the stream by structures (e.g., diversion dams and levees). Field surveys of the entire floodplain being assessed or of representative sites can be used to document evidence of overbank flows (e.g., sediment and debris on tree trunks) and map the width of the active floodplain. For this FAM, floodplain is defined as the area with alluvial soils, as mapped in the local soil survey or during a field survey of the site being assessed.

Measuring hydraulic connectivity on the basis of the width of undeveloped active floodplain requires only a minimal amount of information. However, it may not

fully reflect changes in the frequency of inundation due to flow alterations or channel incision.

Measuring hydraulic connectivity based either on floodplain width inundated by a flow of selected recurrence or on mean floodplain width inundated per year is more accurate and precise than using just active floodplain width. However, determining these inundated widths requires more supporting information and analysis than estimating active floodplain width from field observations.

Mean floodplain width inundated per year can be calculated as:

$$\frac{1}{L}\sum_{i=1}^{i=n}\frac{1}{RI_i}Area_i \text{, where} \qquad \text{(Equation 1)}$$

L = study site length;
i = zone of floodplain with relatively uniform frequency of inundation;
RI_i = recurrence interval (in years) for inundation of zone i; and
$Area_i$ = area (in acres) of undeveloped land in zone i.

The width of floodplain inundated by flows can be determined from stage-discharge relationships based on direct observations or from hydraulic modeling. The width of floodplain inundated by particular discharges also can be approximated at representative cross-sections by the slope-area method that is commonly used to estimate discharge (Gordon et al. 1992; Chin 2000). Appendix A describes how this method could be used to estimate inundated widths in western Placer County.

For this indicator, functional capacity is either the width of the undeveloped, active floodplain, the undeveloped floodplain width inundated by a selected recurrence flood, or the floodplain's mean inundated width per year (i.e., the result of Equation 1), depending on the basis of the assessment.

For this indicator, integrity is the degree to which floodplain inundation approximates unaltered conditions (i.e., natural land cover, no barriers to inundation of floodplain, flow unaltered and channel not incised).

$$100\left(\frac{Current_{FI}}{Historical_{FI}}\right)\text{, where} \qquad \text{(Equation 2)}$$

$Current_{FI}$ = current floodplain inundated width; and
$Historical_{FI}$ = historical floodplain inundated width.

The availability of historical or long-term flow and cross-section data allows the calculation of integrity based on any of the measures of hydraulic connectivity described in this report.

In the absence of long-term flow and cross-section data, integrity would be calculated, as in Equation 2, using the width of the active floodplain (for

Current$_{FI}$) and the width of alluvial soils, or historical alluvial landforms (for *Historical*$_{FI}$), based on mapped soils or field observations. (Historical flows could be estimated and historical cross-sections reconstructed to allow the calculation of inundated widths, but this would be more time consuming and potentially very inaccurate.)

Indicator for Biogeochemical Functions—Infiltration

Rationale

The biogeochemical functions of riparian ecosystems are particularly significant for stream water quality. When water passes through a riparian area en route to a stream, dissolved and suspended materials may be removed or transformed, including sediment, nutrients, pesticides and metals.

Most chemicals are transported in water both dissolved in solution and adsorbed to entrained particles of soil and organic matter. Nutrients also are transported as constituents of organic matter.

Suspended sediment and particles of organic matter are transported through overland flow. Vegetation has resistance to this flow, and thus slows it and promotes deposition of sediment and sediment-bound chemicals. There is also filtration of particles by vegetation and litter from overland flow and adsorption of particles, bacteria, and dissolved chemicals to plant and litter surfaces (Brinson et al. 2002).

Adsorption to clay and organic matter traps a larger fraction of dissolved particles with positive charges such as metals and phosphorus (in the form of orthophosphate) and some pesticides (Neitsch et al. 2002). This adsorption occurs primarily when water enters the soil (i.e., during infiltration).

Within riparian areas, microbes degrade synthetic organic compounds (including hydrocarbons and most pesticides) primarily within soil, and also in standing water (NRCS 2000; Brock and Madigan 1991). Similarly, nutrient transformations such as denitrification (i.e., the conversion of nitrate to nitrogen gas by microbes that derive energy from the process) also occur primarily in soil or in some cases in standing water.

Therefore, decreases in infiltration (i.e., increases in runoff) within the riparian zone correspond to a general decrease in the removal and degradation of dissolved and suspended materials. Thus, this hydrologic variable is an effective indicator of the riparian functions affecting stream water quality.

Methodology

This indicator estimates infiltration in the riparian zone during a moderately intense rainfall event. The riparian zone is defined as areas with floodplain soils and immediately adjacent land (i.e., land within 100 m). For lengths of stream lacking mapped floodplain soils, a 200 m minimum width along the stream is included as adjacent land. Mean infiltration per unit area is estimated through the formula:

$$\frac{\sum_{LC=1}^{LC=n}(R-Q_{LC})A_{LC}}{A_{LC}}\text{, where} \qquad \text{(Equation 3)}$$

R = daily rainfall in cm;
Q_{LC} = runoff (i.e., overland flow) per unit area (in cm) of a land-cover type; and
A_{LC} = land-cover type area.

The estimate of Q_{LC} is based on the curve number equation developed by the Soil Conservation Service (1972). The procedure for calculating Q_{LC} is described in detail in Appendix B.

Functional capacity is mean infiltration per unit area, as calculated in Equation 3.

Integrity is the magnitude of current floodplain infiltration to floodplain runoff under natural vegetation. This is expressed as a percentage that is calculated as:

$$100\left(\frac{R-Q_{Est}}{R-Q_{Min}}\right)\text{, where} \qquad \text{(Equation 4)}$$

R = daily rainfall;
Q_{Est} = runoff estimate for entire floodplain under current land cover (result of Equation 6); and
Q_{Min} = runoff estimate for entire floodplain assigned *CN* value for riparian vegetation.

FAM Application and Interpretation

Application

The previous sections of this document described a riparian FAM based on three indicators:

- cover of natural vegetation as an indicator of habitat functions,

- hydraulic connectivity (i.e., active floodplain or inundated floodplain width) as an indicator of hydrologic and geomorphic functions, and
- infiltration as an indicator of biogeochemical functions.

Calculating these indicators requires digital aerial photographs, and geographic information systems (GIS) data layers of stream courses, soils, and land cover data. For western Placer County, this information is readily available and has been previously used by the Placer County Planning Department for regional conservation planning.

However, the assessment will be more informative if also based on field observations of active floodplain width, flow data, and representative stream cross-sections, as described for the hydraulic connectivity indicator and in Appendix A. For western Placer County, this information is currently limited. While field observations of active floodplain width could be inexpensive, collecting and analyzing cross-section data would be more expensive, and the collection of additional flow data may be impractical.

Calculation of functional assessment results for functional capacity and integrity involves three steps:

1. Delineation of study sites. The GIS data layers of stream courses, and of either soils or floodplains are used to define the polygons representing study sites. These polygons do not have a predetermined length, but generally should extend from the stream course to the floodplain's edge. The length of the polygons depends upon the assessment's purpose (e.g., evaluating specific potential conservation sites versus a regional evaluation of all riparian areas).

2. Compilation of data for study sites. This involves using aerial photographs and land cover maps (or on-site measurements) to create GIS data layers representing the floodplain and adjacent areas in: a) natural vegetation, b) developed or disturbed land-cover types, or hydraulically isolated from streams by structures, and c) the NRCS land-cover types representing different curve numbers for infiltration. These GIS layers could be readily created from recent aerial photography and the SSURGO *(don't find this acro mentioned before…)*GIS data layer of western Placer County's soils (NRCS 1998).

In addition, if incorporated into the analysis, representative cross-sections and flow data would be used to estimate the historic and current mean inundated width of undeveloped areas not isolated by structures, as described in the section regarding hydraulic connectivity. The GIS data layer described under 2b above would subsequently be modified to incorporate this information.

3. Calculation of functional capacity and integrity for each indicator. For each site, functional capacity and integrity are calculated from the compiled data using the methods described in the preceding sections of this document.

Interpretation

In interpreting FAM scores, the three indicator scores for integrity could be averaged into a single rating of overall riparian ecosystem integrity. However, this overall rating may provide less guidance for conservation and restoration planning than would interpretation of the three separate scores individually. The three indicators together represent a continuum from riparian areas with intact physical processes and little alteration of land-cover or human use, to riparian areas with disrupted physical processes, extensive alteration of land-cover and intensive human use.

High integrity of hydraulic connectivity indicates that the physical processes that sustain riparian vegetation are largely intact. Sites with both a high integrity of hydraulic connectivity, and a high cover of natural vegetation, will also have a high integrity of infiltration flow. These represent unaltered sites, and their conservation may be important. Sites with a high integrity of hydraulic connectivity, but low habitat integrity, may represent opportunities for restoration.

Low integrity of hydraulic connectivity indicates riparian areas that are isolated from the stream's aquatic ecosystems and from the physical processes that sustain riparian vegetation. Even without hydraulic connectivity, riparian areas still provide considerable habitat functions if remaining in natural land-cover. However, the lack of floodwaters has led or will lead to detrimental changes in vegetation structure and habitat attributes. Restoration of these sites may be problematic because it would require changes to channel form, flow regime or existing structures.

Among sites with low integrity of hydrologic, geomorphic and habitat functions (i.e., hydraulically isolated sites with little natural vegetation), integrity of infiltration can vary widely depending on the extent of impermeable surfaces. Low integrity of infiltration indicates extremely modified riparian areas that may detrimentally affect aquatic ecosystems. Because of intensive human use, these sites are not suitable for restoration or preservation.

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Appendix A. Estimation of Inundated Width Using the Slope-Area Method

This appendix describes the slope-area method that is commonly used to estimate discharge (Gordon et al. 1992; Chin 2000). Through this method discharge is estimated as:

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}\text{, where} \qquad \text{(Equation A1)}$$

Q = discharge (in $m^3 sec^{-1}$),
n = Manning's roughness coefficient,
A = cross-sectional area of flow,
R = hydraulic radius, and
S = energy slope.

This equation can be rearranged to solve for cross-sectional area instead of discharge. It then is:

$$A = \frac{nQ}{R^{2/3} S^{1/2}} \qquad \text{(Equation A2)}$$

For representative cross-sections, the widths associated with the areas for a series of discharges could then be determined, and these widths then used to divide the floodplain into zones based on their frequency of inundation.

If flow data are lacking for particular streams, the flow regime can be roughly estimated from flow data for a similar nearby stream by adjusting for the difference in the area of their catchments (Gordon et al. 1992). This would be calculated as:

$$Q_{UG} = Q_G \left(\frac{A_{UG}}{A_G} \right) \qquad \text{(Equation A3)}$$

For the purpose of this assessment, approximate values for flows of different recurrence intervals are adequate, particularly when evaluating integrity, which is based on the change in area inundated by the estimated flows due to alterations such as incision, structures and land cover changes.

Appendix B. Using the Curve Number Equation to Estimate Infiltration

This appendix describes application of the curve number equation to estimate infiltration and runoff. For the FAM, this equation is:

$$Q = \frac{(R - 0.2S)^2}{(R + 0.8S)}, \text{ where} \qquad \text{(Equation B1)}$$

S = the retention parameter (in cm).

As daily rainfall, a value of 2.54 cm (i.e., 1 inch) is used to represent a moderately intense rainfall event for this assessment. The retention parameter is defined as:

$$S = 2.54\left(\frac{1000}{CN} - 10\right), \text{ where} \qquad \text{(Equation B2)}$$

CN = curve number.

The value of *CN* varies with land cover, initial moisture content, soil type and slope. Consequently, the estimates of infiltration and runoff also vary with these factors. Table 5 contains the values of *CN* for different land cover types. These values are for saturated soil conditions, Soil Hydrologic Group B and slopes of less than 5%.

Table B-1. Curve Number (CN) Values for Different Land Cover Types[1]

Land Cover Type	CN Value
Agricultural Land	89
Grassland, Oak Woodland	77
Urban Parks, Golf Courses	85
Brush	85
Riparian Forest and Riparian Scrub	79
Conifer Forest	77
Developed—Commercial	97
Developed—Industrial	95
Developed—Residential 1/8 acre lots	94
Developed—Residential 1/4 acre lots	89
Developed—Residential 1/2 acre lots	86
Developed—Residential 1 acre lots	84
Developed—Residential > 1 acre lots	82
Developed—Road	96
Developed—Other impervious surfaces	99

Note:

Based on values for Hydrologic Soil Group B, saturated soils and < 5% slopes (Soil Conservation Service 1972).

Rainfall events will wet floodplain soils directly and through below- and above-ground flows. Due to the low levels of evapotranspiration during late-fall and winter, floodplain soils will remain wet for prolonged periods of time and are likely to be saturated for much of the winter. Thus, *CN* values for saturated soils were considered most appropriate for estimating infiltration.

Soil Hydrologic Group B consists of moderately well-drained soils that have moderately fine to moderately coarse textures (Natural Resources Conservation Service 1996). Though Sacramento Valley and Sierra Foothill floodplains also contain excessively-drained gravels and poorly-drained clays, the intermediate values of coefficients for moderately well-drained soils are most applicable in the absence of site-specific soil information. However, where soil information is available, *CN* values can be selected based on the floodplain's soils (Neitsch et al. 2002; Soil Conservation Service 1972).

Because floodplains are relatively flat, the *CN* coefficients for less than 5% slopes were considered representative of most riparian zones. However, narrower riparian zones in the Sierra foothills may have steeper slopes particularly for the adjacent land included in the assessment. For assessments focused on such sites, the *CN* values can be adjusted for slope using the equation (Williams 1995):

$$CN_{MII,S} = \frac{\left(CN_{MIII} - CN_{MII}\right)}{3}\left[1 - 2e^{-13.86Slp}\right] + CN_{MII}$$ (Equation B3), where:

$CN_{MII,S}$ = *CN* value for moist soil on slopes > 5% (soil assumed not saturated on slopes);

CN_{MIII} = *CN* value for saturated soil conditions;

CN_{MII} = *CN* value for moist soil conditions; and

Slp = slope as a decimal percentage (e.g., 100% = 45°).

Appendix C. Application of FAM to Dry Creek Sites

In 2004, Jones & Stokes staff used the FAM to assess three sites along a reach of Dry Creek in Roseville. The results of this pilot application are presented in Figure C-1, which is a reproduction of a poster presented at the 2004 CALFED Science Conference (Hunter and Beedy 2004). This poster describes the FAM and presents the results of the pilot application.

Two significant outcomes of the pilot application were not included in this poster presentation, however. The first was the time required to apply the FAM, which was about 5 hours per site (with easy site access and small site size). Most of this time was spent collecting and analyzing information for the hydraulic connectivity indicator, which was calculated both from an estimate of the active floodplain's width and from a HEC-RAS analysis of U.S. Geological Survey gauging station data (Brunner 2002).

The other significant outcome not included in the poster was that field observations of the active floodplain's width and the HEC-RAS analysis of floodplain inundation resulted in very similar hydraulic connectivity scores. This occurred because incision of Dry Creek's channel restricts flood flows to a small portion of the historical floodplain, and this was apparent from visual observations without the additional data and analysis of the HEC-RAS modeling. This demonstrates that observations of active floodplain width, which are cost-effective and practicable, can be an effective measure of hydraulic connectivity in western Placer County.

A Functional Assessment Methodology for Central Valley Riparian Areas

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ABSTRACT

Indicator-based assessments of the functions provided by wetlands are a cost-effective tool for conservation planning, and are becoming widely used. However, most of these methods produce ratings by combining numerous, disparate variables (i.e., indicators) using rules or equations that may lack a mechanistic basis. Consequently, communicating, interpreting, and defending the results of these assessments can be problematic.

To avoid these potential problems, we have designed an assessment methodology for Western Placer County's riparian areas that consists of a single key indicator for each category of functions. These key variables were selected as being strongly related to multiple functions, and not requiring intensive on-site measurements. For habitat functions, this variable is cover of natural vegetation on the floodplain and adjacent land. For hydrologic and geomorphic functions, the variable is the hydraulic connectivity of the floodplain and stream channel. For biogeochemical functions, the variable is quantity of runoff from the floodplain and adjacent land. These three variables are used as indicators of functional capacity (i.e., the amount of function provided) and integrity (i.e., resemblance to unaltered conditions). In this functional assessment methodology, the scores for these three indicators are not combined into a single quantitative assessment score, but instead each indicator's value is reported for all evaluated sites.

The results produced by this assessment method are readily communicated and interpreted, and can contribute to conservation and restoration planning at site, watershed and regional scales. Though this approach was developed for Western Placer County, it or a comparable methodology would be applicable throughout the Central Valley and adjacent foothills.

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Table 1. Ecological Functions of Riparian Ecosystems

Hydrologic and Geomorphic Functions
- Recharges ground water
- Stores surface water
- Conveys floodwaters and other overland flows
- Transports sediment
- Stores sediment

Biogeochemical Functions
- Produces biomass (i.e., primary production)
- Stores carbon in vegetation and soil
- Cycles phosphorus
- Cycles nitrogen
- Cycles micronutrient
- Adsorbs,storesandtransformsnon-nutrientmetals(e.g.,mercury)
- Adsorbs, stores and degrades pesticides and hydrocarbons

Habitat Functions
- Sustains characteristic plant associations
- Sustains aquatic animal habitats
- Sustains terrestrial animal habitats

Notes: 1–Based on lists of functions in Keddy 2000 and Brinson et al. 2002.

INTRODUCTION

Effective conservation planning requires assessment of functions provided by riparian ecosystems. These functions sustain terrestrial and aquatic ecosystems, and provide important services to society (Table 1).

Because conservation planning is a contentious process conducted with limited funding, a functional assessment should be:

- **Cost-effective**;
- **Comprehensive**, consisting of one to several ratings that indicate capacity for numerous functions;
- **Transparent**, in other words, readily understood, interpreted and communicated;
- **Flexible**, and thus capable of supporting a variety of assessments based on varied data sources; and
- **Defensible**, by making the best use of existing data.

Perhaps because of their cost-effectiveness, numerous indicator-based functional assessments have been developed. Evaluations based on indicators, such as the Hydrogeomorphic (HGM) Approach (Hauer et al. 2002) combine the values of several readily observed variables (i.e., indicators) into a rating representing the amount of functions (i.e., functional capacity) or their integrity (i.e., amount relative to unaltered conditions). These assessments are inexpensive, address numerous functions and are readily applied both to current conditions and future scenarios.

However, critics have pointed out a number of potential problems with indicator-based assessments including:

- **Ambiguous basis for ratings** - it may not be clear why the rating is high or low because a particular assessment rating may be produced by several different combinations of variables, and combinations of indicators may not correspond to any real-world property;
- **Non-mechanistic combining functions** - rating values are sensitive to the functions used to combine variables, and the use of addition, multiplication, or some other operation may distort the relationship between indicators and functions;
- **High variability** - the correspondence of ratings and functions may be weak due to low correlations between indicators and functions or to propagation of error when indicators are combined, and
- **No explicit guidance for management** - the effect of potential management actions on the rating may not be apparent and thus it can be difficult to apply ratings to guide management. (Suter 1993, Hunter et al. 2004)

These potential problems can prevent indicator-based functions from providing all of the desired attributes of a functional assessment. These problems largely result from combining several disparate variables into a single number, which is a widespread practice among indicator-based assessments. For example, in assessing habitat functions, current assessments combine tree density and inundation frequency (Hauer et al. 2002), riparian vegetation area and continuity (Smith 2000), plant cover and soil texture (Findlay et al. 2002), patch connectivity and landform diversity (Stevens et al. 2002), density of snags and vegetation type interspersion (Hruby et al. 1999), interior area and presence of surface water (Sutter 2001), and bird species number and wetland area (Cable et al. 1989).

EXAMPLE APPLICATION OF OUR ASSESSMENT METHODOLOGY

Figure 1. Example Sites along Dry Creek, Placer County. Each site is a 100 m by 100 m plot beginning at the streambank at approximately the location indicated by the arrows. Of Site B, 60% is filled, graded, and dominated by non-native, weeds vegetation, as is 20% of Site C.

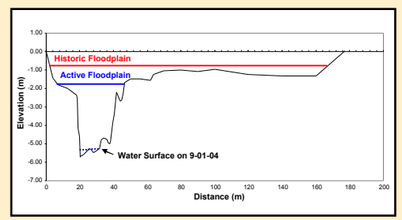

Figure 2. Cross-section at Site B. This cross-section indicates the extent of the historical and currently active floodplain. The width of the historical floodplain was based on soils, landforms and vegetation. The width of the active floodplain was also based on an analysis of USGS gauging station data.

Figure 3. View along Dry Creek from Site A towards Sites B and C

Table 2. Rating of Functional Integrity for Example Sites

Site	Overall Rating	Habitat Integrity (%)	Hydrologic and Geomorphic Integrity (%)	Biogeochemical Integrity (%)
Site A	Low	25	25	29
Site B	Low-Moderate	40	25	72
Site C	Moderate	80	25	91

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APPROACH

Our approach was to identify a single key variable as an indicator of capacity and integrity for each major group of ecological functions (i.e., hydrologic and geomorphic, biogeochemical, and habitat functions). These key indicators were selected as being strongly related to multiple functions and capable of being measured without time-intensive on-site measurements, and being applicable to single sites as well as entire watersheds. This approach avoids the major problems of combining disparate variables, maintains ease of interpretation, and results in a cost-effective and flexible assessment that can support varied conservation planning activities from local to regional scales.

FUNCTIONAL ASSESSMENT INDICATORS

Indicator for Habitat Functions: Cover of Natural Vegetation

The cover of natural vegetation on the floodplain and adjacent upland was selected as the indicator of habitat functions because it is the most significant single variable and is readily measured. It is most significant because loss of riparian vegetation is a major factor contributing to population declines of riparian-associated species, and the extent of riparian vegetation is related to other landscape variables affecting habitat functions (e.g., patch size and connectivity, extent of forest interior habitats).

For this indicator, functional capacity is measured as the acreage (per stream mile) of natural vegetation on the floodplain and adjacent land (within 30 m).

For this indicator, functional integrity is measured as the percent of the historical floodplain and adjacent land that is still in natural vegetation.

Indicator for Hydrologic and Geomorphic Functions: Hydraulic Connectivity

The hydraulic connectivity of the floodplain to its associated stream was selected as the indicator of hydrologic and geomorphic functions because conveyance of floodwaters distinguishes riparian ecosystems from other terrestrial ecosystems and floodwaters sustain riparian vegetation, and are an important influence on aquatic ecosystems.

For this indicator, functional capacity is measured as the floodplain's mean inundated width or the width inundated by the floodflow of a specific recurrence interval (e.g., a 10 year flood). These represent the width of the active floodplain.

Integrity is the degree to which floodplain inundation approximates unaltered conditions (i.e., natural land cover, no barriers to inundation of floodplain, flow unaltered and channel not incised). It is the percent of the historical floodplain that remains in the active floodplain.

Depending on data availability and an assessment's budget, any of several different approaches could be taken for quantifying this indicator.

Indicator for Biogeochemical Functions: Infiltration

The infiltration of precipitation into riparian soils was selected as the indicator for biogeochemical functions because the removal and transformation of materials dissolved or suspended in water entering a riparian area occurs primarily within soil. Thus, the amount of infiltration (or conversely the amount of runoff) has a substantial influence on several biogeochemical functions related to water quality.

For these functions, functional capacity is mean infiltration per unit area for a moderately intense rainfall event (25.4 mm of rainfall). This is estimated from land-cover using the NRCS Curve Number Model.

For these functions, integrity is the magnitude of current floodplain infiltration to floodplain runoff under natural vegetation.

INTERPRETATION OF ASSESSMENT

In interpreting assessment scores, the three indicators together represent a continuum from riparian areas with intact physical processes and little alteration of land-cover or human use, to riparian areas with disrupted physical processes, extensive alteration of land-cover and intensive human use. Providing a verbal overall rating (e.g., high, moderate, low) and the value of each indicator separately, gives both an overall rating and the basis for it.