New Mexico Rapid Assessment Method

Montane Riverine Wetlands

2011

NMRAM

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New Mexico Rapid Assessment Method: Montane Riverine Wetlands

Manual

(Version 1.1)

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AA	assessment area
cfs	cubic feet per second
cm	centimeters
CRAM	California Rapid Assessment Method
CT	community type
dbh	diameter at breast height
EIA	Ecological Integrity Assessment
EPA	U.S. Environmental Protection Agency
GIS	geographic information system
ha	hectare
HGM	hydrogeomorphic
HUC	Hydrologic Unit Code
km	kilometer
km^2	square kilometer
LUc	land use coefficient
LUI	land use index
m	meter
NHNM	Natural Heritage New Mexico
NMED	New Mexico Environment Department
NMRAM	New Mexico Rapid Assessment Method
NMWRAD	New Mexico Rapid Assessment Database
NRC	National Research Council
NRCS	Natural Resources Conservation Service
PC	percent of adjacent area in the land use type
ORAM	Ohio Rapid Assessment Method
RWSI	Relative Wetland Size Index
Sc	current (wetland) size
Sh	historic (wetland) size
SWCA	SWCA Environmental Consultants
SWQB	Surface Water Quality Bureau
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WOI	wetland of interest
Wt	weighted
WY	water year

CHAPTER 1
INTRODUCTION

NEW MEXICO RAPID ASSESSMENT METHOD

The New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) Wetlands Program has initiated the development and use of a rapid assessment framework to evaluate the ecological status of riverine wetlands and riparian areas throughout New Mexico. The New Mexico Rapid Assessment Method Version 1.1 (hereafter referred to as the NMRAM) was developed as part of the SWQB Wetlands Program's on-going efforts to promote effective management and protection of the state's wetland resources. The overarching goal is to provide the necessary information to help prevent the continued loss and decline of New Mexico's scarce and important wetland resources.

In support of this goal, the intent of the NMRAM is to provide a cost-effective yet consistent and meaningful tool for the assessment of wetland condition. Accordingly, it uses a select set of observable and relatively easy to measure landscape and field indicators (metrics) to express the relative condition of a particular wetland site. NMRAM metrics have been developed in the context of a "reference set" of wetlands that vary along an anthropogenic-disturbance gradient. The underlying premise is that wetland condition among similar wetlands will vary along this disturbance gradient, from high quality and functionality with low disturbance to the most degraded with high disturbance. Based on this, the ecological condition of a particular site is then evaluated and ranked based on a preponderance of evidence from a suite of landscape, biological, and abiotic attributes that are sensitive to the gradient. The outcome is that wetlands can be compared equitably across many scales and jurisdictions, and in a variety of project contexts.

To aid in the application of the NMRAM, we have developed an assessment package that includes this manual, which provides the details on the method and underlying rationale; a Field Guide with associated worksheets to ensure efficient and accurate data collection; an NMRAM Rank Calculator in spreadsheet form to make data summarizing and reporting easier; and other supporting materials. Using the package, the NMRAM can be implemented efficiently by minimizing training, execution, and reporting requirements. The target is to be able to conduct an assessment from start to finish over the course of one to two days using two people, depending on the complexity of the wetland.

Which rapid assessment metrics are used and how they are measured can vary with wetland type. For consistency, the SWQB Wetlands Program classifies wetlands into classes and regional wetland subclasses based on the hydrogeomorphic (HGM) factors identified by Brinson (1993) and other factors of regional importance. The objective of this classification is to identify groups of wetlands that are relatively homogeneous in terms of structure, process, and function. A regional wetland subclass is a subdivision of a larger wetland class and is defined by sharing similar characteristics such as stream discharge, slope, physical setting, geology, climate, and vegetation. NMRAM metrics are tailored to any given subclass to reflect only within-subclass variability to provide a more reliable indicator of wetland condition. Based on the SWQB Wetlands Program's needs and program objectives, this first version of NMRAM was developed for the Riverine Class (Brinson 1993) of wetlands and tested for a subclass that is defined as Montane Riverine Wetlands. In future years, the NMRAM will be expanded to encompass all the major wetland subclasses of the state.

Purpose of the NMRAM

Water resources assessments and management have become a priority since the 1948 Federal Water Pollution Control Act and the 1972 amendments contained in the Federal Water Pollution Control Act. As the third-driest state in the U.S., water issues in New Mexico are significant. Wetlands, as waters of the state, have been largely overlooked as a resource that needs to be monitored and managed on a statewide scale to prevent pollution and degradation and to protect the many benefits and ecosystem services that wetlands resources provide. The continued loss of wetlands resources will result in both direct and indirect negative effects on environmental quality and human health and welfare. The NMRAM will provide informative and defensible evaluations of wetland condition, status, and health quickly and accurately by utilizing a cost-effective approach. The NMRAM will inform ecosystem management and guide wetland conservation aimed at minimizing loss and protecting wetland acreage, quality, and function.

This version of the NMRAM is focused on riverine wetlands, possibly the most abundant type of wetland in New Mexico and the most impacted. Significant time and funding is expended each year restoring and protecting New Mexico's river systems and associated wetland and riparian areas. Riverine wetlands and riparian areas are the focus of many of these projects because they provide important functions that also maintain water quality in adjacent stream systems. Some of the important functions that riverine wetlands and riparian areas provide include sediment filtering, flood sequestration and reduction, erosion control, aquifer recharge, maintenance of stream temperature and stream flow, nutrient transformation and recycling, hyporheic interchange, and provision of habitat and maintenance of characteristic native populations. Riverine wetlands help maintain bank stability through the extremely dense and resilient fibrous root systems of typical wetland plants. Riverine wetlands also provide nutrients and detritus that maintain the food chain in adjacent rivers and streams, and provide habitat for beaver and other species that maintain the ecological integrity of stream systems.

The NMRAM is designed to describe the reference set of conditions and stressors that affect similar wetlands—that is, the range from the natural condition to the most impacted condition within a reference domain. From these assessment data, a broad range of applications are available for management and protection of wetland resources. These applications include:

1. prioritization of wetlands and riparian areas for restoration and protection,
2. identification and location of high-quality wetlands in need of protection,
3. identification of suites of wetlands that are particularly impacted,
4. focus on the causes (or stressors) that result in wetlands resources decline,
5. provision of profile data to facilitate restoration design standards,

6. development of restoration and mitigation performance standards, and
7. utilization as an iterative monitoring tool for wetlands.

DEVELOPMENT OF THE NEW MEXICO WETLAND RAPID ASSESSMENT METHOD

Rapid bioassessments (e.g., Barbour et al. 1999) have become standard approaches to evaluate the quality and biotic health of bodies of water and wetlands, and HGM assessments (e.g., Brinson et al. 1995) have become important tools for determining the hydrologic function of water bodies and wetlands. Wetland rapid assessment methods have evolved to combine aspects of both bioassessments and HGM assessments. Rapid assessment methods are based upon three basic principles: 1) assessments are relative to current conditions; 2) the method is rapid such that two people can complete the field assessment and data analysis for the assessment in one day; and 3) the assessment is based primarily on observed field conditions (Fennessy et al. 2004, 2007).

Wetland rapid assessment methods are being developed simultaneously in different parts of the United States by agencies and institutions using varying approaches and levels of intensity, and with slightly different goals and objectives (for example, see Ohio Rapid Assessment Method [Mack 2001], Colorado Vegetation Index of Biotic Integrity [Rocchio 2007], or HGM assessments [Hauer et al. 2002; Klimas et al. 2004]). Two of the most advanced wetland rapid assessment methods to date are the California Rapid Assessment Method (CRAM) (Collins et al. 2008) and NatureServe's national "Ecological Performance Standards for Wetland Mitigation: An Approach Based on Ecological Integrity Assessments" (Faber-Langendoen et al. 2008a). The NMRAM is based largely on methods and protocols that were adopted and modified from CRAM and NatureServe's Ecological Integrity Assessment (EIA) method (and in some places the HGM methods of Hauer et al. 2002). The specific goals of CRAM and the NatureServe approach differ in several respects. CRAM was developed primarily to assess the status and trends in condition of classes of wetlands throughout the state of California and focuses on ecological processes and services that wetlands provide to society. The goals of the NatureServe EIA approach were to develop stronger ecological performance standards to guide the wetland conservation, restoration, and mitigation. Performance standards include a range of structural and functional ecological attributes, including hydrology, vegetation, soils, and landscape context. As part of the NMRAM development, metrics and methods from all of these approaches were evaluated and tested and a unique suite of measurements were selected that best reflects the important attributes of New Mexico's riverine wetlands and serves the goals and needs of New Mexico.

Overall, the NMRAM is primarily focused on evaluating wetland condition both as a measure of ecological integrity and, by inference, the functional capacity of a wetland. In other words, if a wetland is in good condition, then it is assumed that the wetland is functioning at reference standard levels[1]. Ecological *integrity* is the "ability of a system to support and maintain a balanced, integrated, adaptive community of organisms having species

[1] Reference standard levels or reference standard conditions are "conditions of unimpaired or minimally impaired water bodies characteristic of a water body type in a region" (EPA 2010).

composition, diversity, and functional organization comparable to the natural habitat of the region" (Fennessy et al. 2007; U.S. Environmental Protection Agency [EPA] 2010). Ecological *condition* could then be defined as the "ability of a wetland to support and maintain its complexity and capacity of self-organization with respect to species composition, physico-chemical characteristics, and functional process as *compared to wetlands of a similar type without human alterations*" (Fennessy et al. 2007, emphasis added). The assessment of wetland condition thus describes the departure from the reference standard condition, or the condition of full ecological integrity in a defined subclass or geographical region.

Ecological assessments can be performed at multiple scales and there are generally three levels of measurement effort that have been defined (EPA 2006). Level 1 assessment involves mapping, classifying, and evaluating wetlands using different land-feature and land-use maps (typically using geographic information system [GIS] data). Level 2 assessment is a field-based rapid assessment, where surveyors visit sites and quickly collect data using simple field metrics and stressor checklists to evaluate the condition of the wetland. Level 3 involves more direct, detailed, and time-intensive field surveys and detailed measurements, and is beyond the scope of Level 2 rapid assessments. The NMRAM uses Level 1 and 2 methods to integrate both higher-level mapping metrics with field-based measurements.

To evaluate the sensitivity and practicality of the suite of Level 1 and 2 metrics chosen for the NMRAM and to set the range of possible assessment scores, a field study was conducted within a reference domain (a specified geographic area) that contained numerous examples of the mid-elevation montane riverine wetlands subclass (the reference domain is described in detail in Chapter 2). In total, 31 sites were sampled across a disturbance gradient from those highly impacted by urban development to sites on the edge of the forest wilderness. Based on the field study, measurement techniques were modified and metrics were dropped that were difficult to measure or were ambiguous, or simply were insensitive to changes along the disturbance gradient. The outcome is the NMRAM Version 1.1 with 15 field-tested metrics designed to evaluate mid-elevation montane riverine wetlands throughout the state.

ORGANIZATION AND COORDINATION

The NMRAM is organized to provide the user with a brief overview of rapid assessment and purpose of the NMRAM and definitions and descriptions of the wetland class, subclass, and geographic domain for which the NMRAM is intended. The NMRAM then presents detailed assessment metrics: 1) Landscape Context; 2) Size; 3) Biotic metrics; and 4) Abiotic metrics followed by a brief overview of stressor checklists. Finally, the NMRAM addresses guidelines for rating metrics and provides a scoring rollup worksheet. A Field Guide, prepared as a stand-alone document, provides detailed field protocols, worksheets, and scoring rollup worksheet.

The NMRAM is funded by the EPA Region 6 Wetlands Program Development Grants, awarded to the SWQB Wetlands Program. The principal contract for the NMRAM was awarded to Natural Heritage New Mexico (University of New Mexico) (NHNM), with a subcontract awarded to SWCA Environmental Consultants (SWCA), Albuquerque, New

Mexico. The NMRAM was developed by an assessment team (Table 1.1), field tested by a field team (Table 1.2), guided by a team of wetland experts (Advisory Team) (Table 1.3), and reviewed by independent reviewers (Table 1.4).

Table 1.1. Assessment Team

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CHAPTER 2
SUBCLASS DESCRIPTION AND REFERENCE DOMAIN

The NMRAM Version 1.1 was designed for Montane Riverine Wetlands, a subclass of the HGM Riverine Class (Brinson 1993), and in turn calibrated against a set of representative reference sites within a specific geographic area or reference domain. The Riverine Class is broadly defined as wetlands of floodplains and riparian corridors where there is a predominance of overbank flow from fluvial channels as a water source, and unidirectional surface flow (Brinson 1993). The Montane Riverine Wetland subclass includes unconfined streams and wetlands that are associated with mid-elevations between the confluence with the main stem lowland rivers and streams of subalpine and alpine elevations. Streams in confined valleys are excluded from the subclass.

The reference domain for calibration of the subclass metrics represents a relatively homogeneous region in terms of the climate, geology, and physiography that influence its wetlands. In this case, the Upper Rio Grande Montane Riverine Reference Domain definition is inclusive of most streams that drain the western slope of the Sangre de Cristo Mountains into the Rio Grande, plus the Rio Tusas and Rio Vallecitos west of the Rio Grande that drain into the Chama River just north of its confluence with the Rio Grande. This reference domain as defined here does not include the entire geographic area in which the regional wetland subclass occurs, but reflects the limits of the sampling and calibration area for the current NMRAM version. It is anticipated that the NMRAM will be applicable to Montane Riverine Wetlands in other watersheds throughout New Mexico pending further validation.

Below is a description of the subclass and an overview of the reference domain characteristics.

MONTANE RIVERINE WETLANDS

RIVERINE CLASS DESCRIPTION

Rivers can be considered conveyer belts of water and sediment. The amount and periodicity of water and quantity and character of sediment are a function of a river's climatic and geologic context, which is manifested in a range of river forms. In turn, it is these attributes of water and sediment, such as channel shape and pattern, that make a classification system possible (Leopold 1994). The HGM approach to classification is based on geomorphic setting, water source, and hydrodynamics (Hauer et al. 2002). This approach defines the riverine wetland class as those systems that

> occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional water sources may be interflow or occasional overland flow from adjacent uplands, tributary flow and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In the headwaters, riverine wetlands often intergrade with slope or depressional wetlands as the

> channel (bed) and banks disappear or may intergrade with poorly drained flats or uplands. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel after rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwood floodplains are a common example of riverine wetlands. (Hauer et al. 2002:6)

The NMRAM builds upon the HGM definition to classify riverine wetlands within the Upper Rio Grande watershed. A riverine wetland will include the active channel and its floodplain, which are connected by the lateral flow of water during periods of high water, overland flow, and inundation. The active channel and its floodplain are linked not only hydrologically but also ecologically (Rheinhardt et al. 2007); the alteration of one affects the other (National Research Council [NRC] 2002) and as such warrants an inclusive definition of this system. Finally, the HGM definition acknowledges inputs coming from beyond the immediate stream channel and riparian zone. For this reason, the broader landscape context, such as adjacent uplands, tributary flow, and precipitation, is also an important part of the riverine class definition. This definition departs from Cowardin et al. (1979), which defines riverine systems as including "all wetlands and deepwater habitats contained within a channel." For the purpose of the NMRAM, the riverine class includes the palustrine areas (i.e., habitats that are temporarily flooded) as defined by Cowardin et al. (1979) (Figure 2.1) and includes portions of riparian systems as defined by the U.S. Fish and Wildlife Service (USFWS 2009)[2]. The critical element of riparian areas that distinguishes them from adjacent uplands is the connection to surface or subsurface water.

MONTANE RIVERINE WETLANDS SUBCLASS

For the long-term purposes of the NMRAM, it was important to differentiate among riverine wetland subclasses. This allows for 1) potential users to conceptualize and identify those study reaches for analysis, 2) a more accurate delineation of the assessment area (AA) and associated landscape context, and 3) the development of effective assessment methods pertinent to specific characteristics of the subclass to assess the condition of wetlands and response to stressors. While the target subclass for this version of the NMRAM was the Montane Riverine Wetlands, others exist within the sampling domain of Upper Rio Grande (e.g., Lowland Riverine Wetlands or Montane Canyon Riverine Wetlands—see Other Riverine Subclasses below).

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[2] The USFWS (2009) defines riparian as transitional interfaces between terrestrial and aquatic ecosystems and recognizes surface and subsurface hydrology as a factor that influences woody and emergent vegetation patterns.

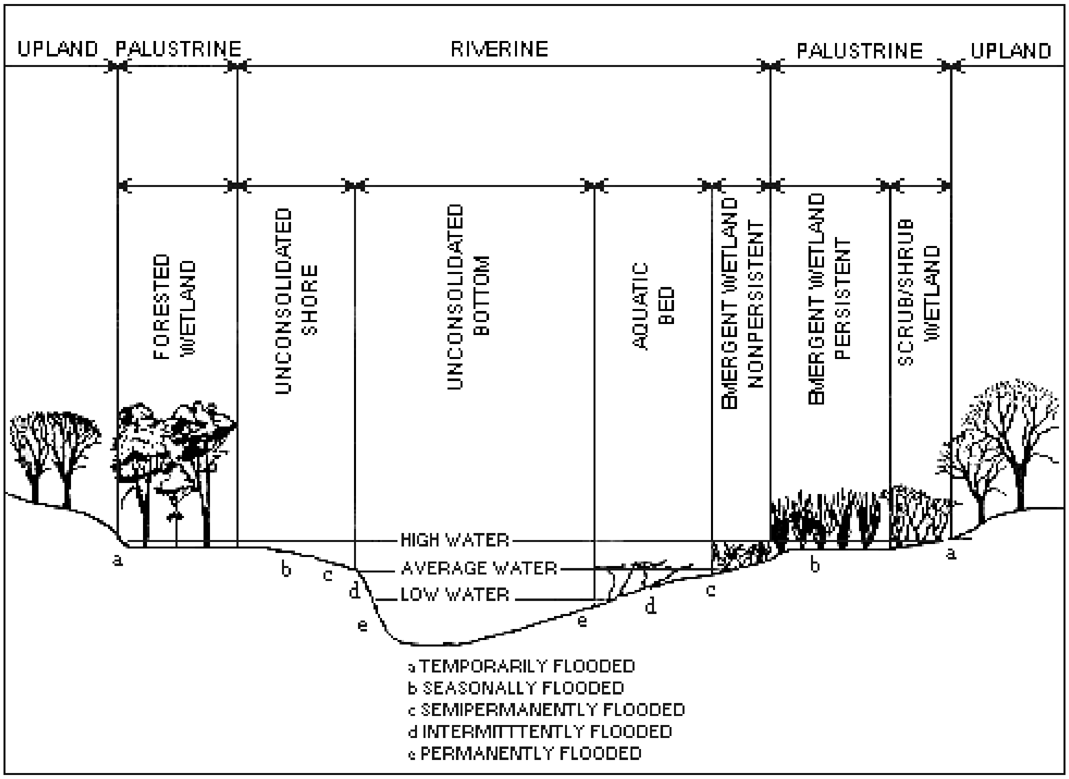

Figure 2.1. Habitat characteristics of the Riverine System (from Cowardin et al. 1979). The NMRAM riverine class differs from Cowardin et al. (1979) in that it includes areas that are seasonally or temporarily flooded, such as those identified as "Palustrine" as well as those areas identified as "Riverine" or those areas that are semi-permanently, intermittently, or permanently flooded.

ABIOTIC CONDITIONS

CHANNEL CHARACTERISTICS AND GEOMORPHOLOGY

The Montane Riverine Wetlands subclass of the Upper Rio Grande watershed occurs between subalpine watersheds and the lowland mainstem of the Rio Grande (Figure 2.2). The subclass includes mid-elevation, second- to fourth-order stream segments with moderate drainage areas feeding the streams ranging from 18 to 800 km^2 (7–309 square miles). Streams may be perennial or intermittent, have annual overbank flow (defined bed and bank), and support a riparian zone (see Figure 2.1 above). Gravel and cobble dominate beds and banks, but sand and silt may be present in the banks and often form a floodplain surface. These wadeable channels have a low degree of confinement and are found on developed floodplains with room for lateral movement. Valley widths generally exceed 80 m (262 feet). Channels have moderate slopes on the order of 1% to 4% and have a channel width ranging from 2 to 10 m (6.6–33 feet). Channel features may include point bars, runs, riffles, pools, and backwaters. Characteristic stream types are typical of Rosgen "C" channels or Rosgen "E" channels. These channel types are typically found in broad, alluvial valleys, have moderate sinuosity, have an entrenchment ratio exceeding 2.2, and a width- to-depth ratio greater than 12. Representative stream types are illustrated in Figure 2.3.

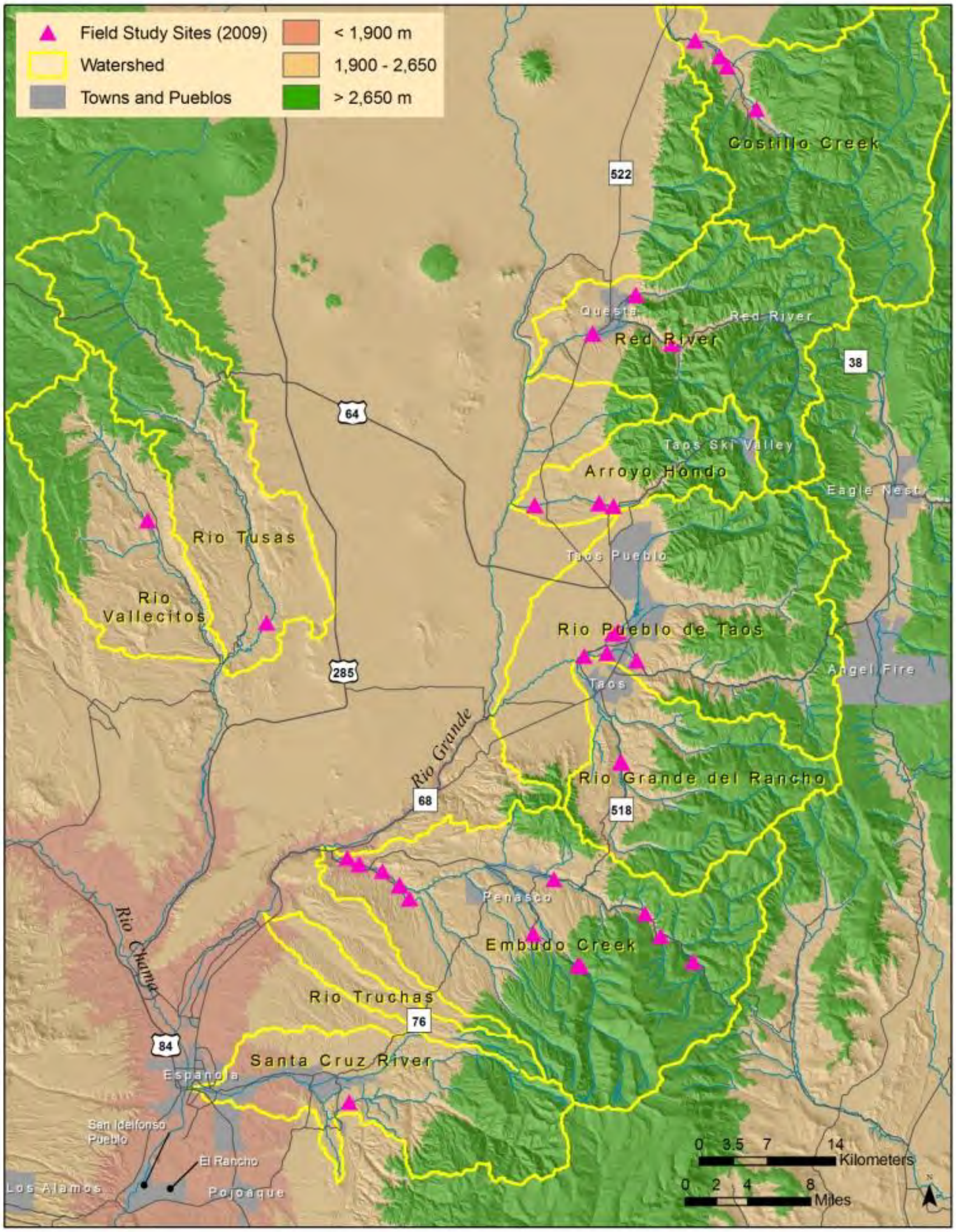

Figure 2.2. Montane Riverine Wetlands subclass location showing the geographical relationship and watershed boundaries (Natural Resources Conservation Service 2005) of the subclass. The 2009 field study sites illustrate the upper and lower limits of the subclass.

Figure 2.3. Representative stream types. Left is Rio Pueblo de Taos, right is Red River.

CLIMATE

The climate of the Montane Riverine Wetlands is semiarid with a bi-seasonal precipitation regime of distinct precipitation peaks in both the winter and summer months (Table 2.1). Winter precipitation (October through March) accounts for about 40% of annual precipitation and is delivered principally as snow by low-pressure systems that sweep from west to east across the Southwest, coalescing with moisture from the Pacific Ocean or the Gulf of Mexico. Winter precipitation is generally followed by a seasonal dry period during the months of May and June. This dry period is defined as much by increased potential evapotranspiration that accompanies increased day length, solar radiation, and temperatures, as by decreased precipitation. The spring dry period is usually relieved by the onset of the Mexican monsoon; this weather pattern typically delivers at least 40% of the annual precipitation during the months July through September, and is associated mostly with short-duration, high-intensity thunderstorms. Each summer, as high pressure becomes entrenched off the coast of Baja California, low pressure in the Southwest feeds Pacific moisture across the region, fueling the development of afternoon thunderstorms. The magnitude, frequency, and tracking of individual large, intense thunderstorm cells during this period can account for large year-to-year variability in annual rainfall and between local areas (Jacobs et al. 2002).

Table 2.1. Summary Climate Data for the Upper Rio Grande Montane Riverine Reference Domain

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temp Max (°C)	4.3	6.4	10.0	15.3	20.3	25.7	27.8	26.4	23.5	17.6	10.1	5.0	16.0
Temp Min (°C)	-12.0	-9.4	-6.4	-2.4	1.9	6.3	9.3	8.7	5.2	-0.2	-6.6	-11.0	-1.4
Temp Mean (°C)	-3.7	-1.1	2.3	6.4	11.0	16.1	18.5	17.6	14.4	8.7	1.7	-2.9	7.4
Precip. (cm)	2.0	2.0	2.6	2.7	3.1	2.5	5.1	5.9	3.7	3.1	2.1	2.0	36.7

Data based on Cerro, El Rito, Red River, Taos, and Truchas stations (Western Regional Climate Center 2010).

Hydrology

The hydrological regime of this subclass is characterized by peak flows in April through June driven by snowmelt runoff, followed by extended periods of low to moderate base flows (Figure 2.4). Rain events associated with large summer monsoon events may result in flow spikes of short duration during the summer and fall months. By and large, there are no major impoundments with controls that alter the flow regime significantly, but there are small irrigation dams along most reaches that can result in significant diversions during the summer months. The degree of actual use and return flows is unknown.

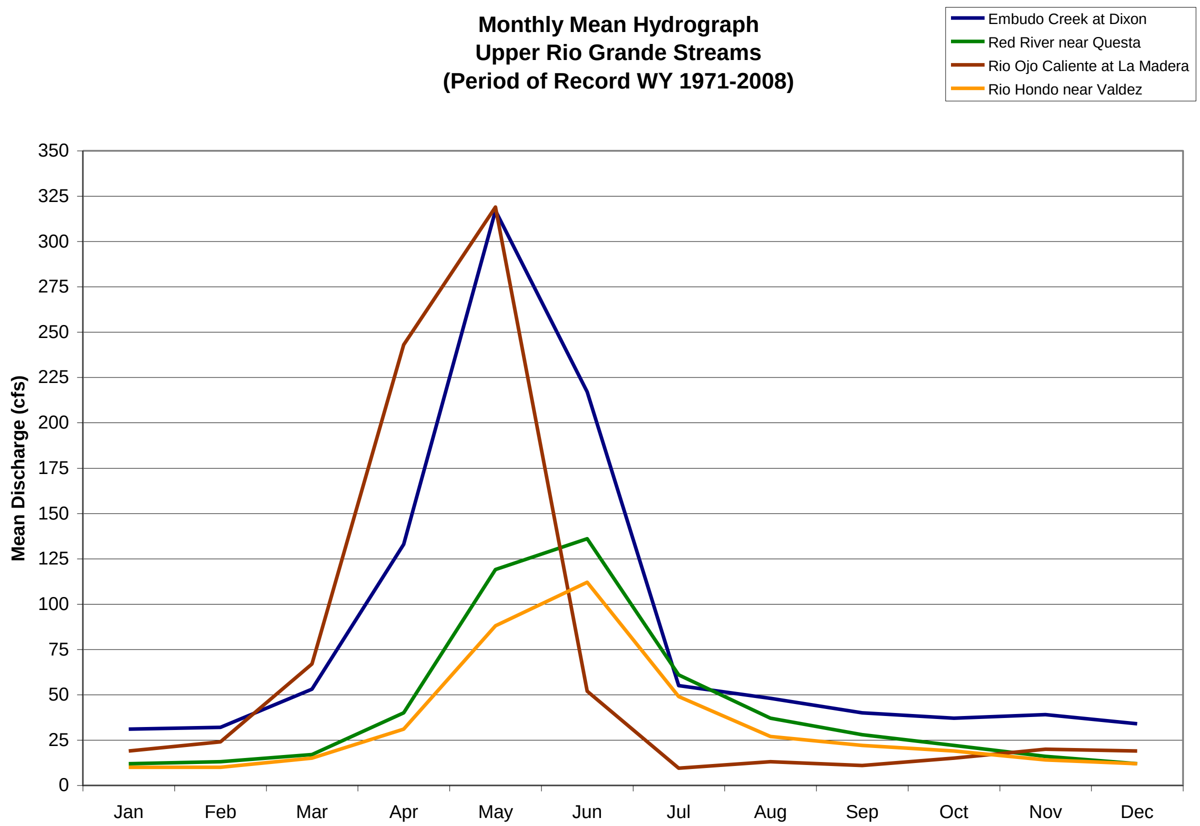

Figure 2.4. Monthly mean hydrograph for the four gaged streams 1971 through 2008 for four watersheds within the Upper Rio Grande Montane Riverine Reference Domain is calculated using mean monthly discharge values from 1971 to 2008. Source: U.S. Geological Survey (2010).

Flood frequency and size is a critical feature of riverine ecosystems. The flood frequency curves for the four selected gages in the Upper Rio Grande domain show similar curve shapes although amounts vary depending on watershed size (Figure 2.5) (U.S. Geological Survey [USGS] 2010). The Embudo Creek at Dixon and Rio Ojo Caliente at La Madera are predicted to experience floods close to or greater than 1,000 cubic feet per second (cfs) at the five-year return interval (see Figure 2.5). However, the predicted return interval for 1,000 cfs floods for Red River near Questa and Rio Hondo near Valdez is 200 years. The drainage areas for the Embudo Creek at Dixon and Rio Ojo Caliente at La Madera are considerably larger than the Red River and Rio Hondo gages. As a result, the former watersheds are able to transport larger volumes of water during any given precipitation event. Because impoundments are minimal in the domain, even high-volume floods are expected to occur more or less as predicted (the flood frequency curves do not arbitrarily flatten at a given discharge level). Overbank flooding plays a major role in developing and sustaining complex floodplains composed of point bars, terraces, and back-water channels. Channel modifications and stabilization do occur that can restrict overbank flooding, particularly in urban areas and in the larger agricultural areas, and hence lead to substantial changes in floodplain geomorphology.

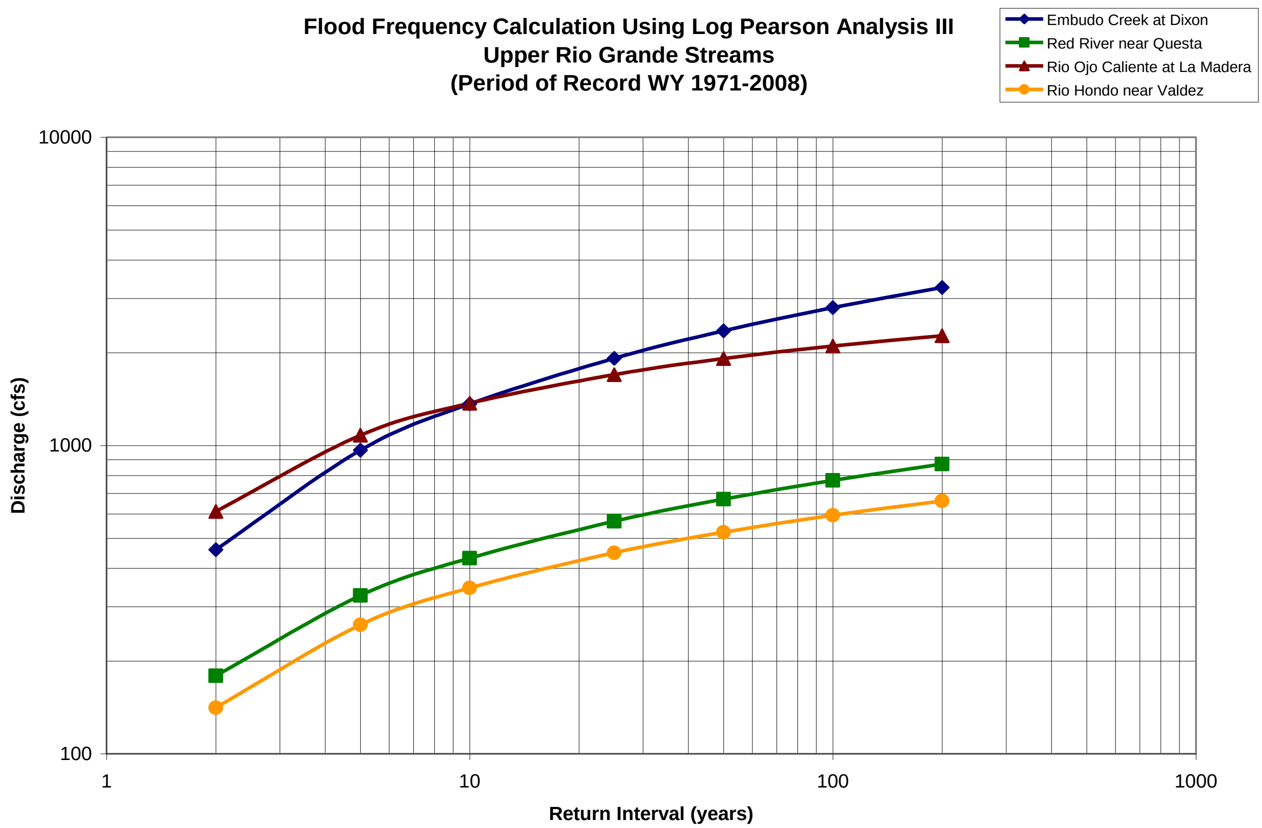

Figure 2.5. Flood frequency calculation using Log Pearson Analysis III for the four streams within the reference domain, water years 1971–2008. Source: USGS (2010).

BIOTIC COMPOSITION

VEGETATION

The vegetation of Montane Riverine Wetlands subclass can be broadly characterized as a complex of montane riparian forests, shrublands, and emergent herbaceous wetlands. Following the National Vegetation Classification System (Federal Geographic Data Committee 2008), these communities can be classified at the group level as Rocky Mountain and Great Basin Montane Riparian Forest, Rocky Mountain and Great Basin Montane

Riparian and Seep Shrubland, and Western North American Temperate Interior Freshwater Marsh, respectively (Faber-Langendoen, personal communication, 2010).

The groups are characterized by a suite of plant associations defined by dominant and/or diagnostic species (e.g., see Muldavin et al. 2000 riparian/wetland classification for New Mexico). Briefly, Rocky Mountain and Great Basin Montane Riparian Forest (Figure 2.6) is dominated by a mix of obligate or facultative wetland trees that include narrowleaf cottonwood (*Populus angustifolia*), boxelder (*Acer negundo*), peachleaf willow (*Salix amygdaloides*), and blue spruce (*Picea pungens*). Plains cottonwood (*P. deltoids*) can enter the stands at lower elevations. Exotic tree species can also be found as co-dominants, especially at lower elevations. Russian olive (*Elaeagnus angustifolia*) is the most common exotic, but both Siberian elm (*Ulmus pumila*) and tree of heaven (*Ailanthus altissima*) are becoming more common within the reference domain. The understories of these woodlands vary, but wetland shrubs can be important, along with a diverse herbaceous layer of graminoids and forbs. At the other extreme, understories can be essentially barren.

Figure 2.6. An example of Rocky Mountain and Great Basin Montane Riparian Forest dominated by narrowleaf cottonwood along the lower reach the Rio Embudo (photo: Y. Chauvin).

Rocky Mountain and Great Basin Montane Riparian and Seep Shrubland (Figure 2.7) is typically composed of dense, pure or mixed stands of obligate or facultative wetland shrubs that include bluestem willow (*Salix irrorata*), coyote willow (*S. exigua*), water birch (*Betula occidentalis*), thinleaf alder (*Alnus incana*), New Mexico olive (*Forestiera pubescens*), or chokecherry (*Prunus virginiana*). Saltcedar (*Tamarix chinensis*) is a common exotic in many stands. Generally, these stands are 2 to 3 m (6.6–10 ft) in height and may include reproduction of overstory trees. Ground cover can vary from dense graminoid cover to barren.

Figure 2.7. An example of Rocky Mountain and Great Basin Montane Riparian and Seep Shrubland dominated by coyote willow along the Rio Tusas (photo: Y. Chauvin).

Western North American Temperate Interior Freshwater Marsh (Figure 2.8) is a broadly defined group, but within the reference domain stands are typically dominated by obligate and facultative graminoids that include Baltic rush (*Juncus balticus*), beaked sedge (*Carex rostrata*), broadleaf cattail (*Typha latifolia*), common spikerush (*Eleocharis palustris*), reed canarygrass (*Phalaris arundinacea*), softstem bulrush (*Scirpus tabernaemontani*), threesquare bulrush (*Scirpus pungens*), and water sedge (*Carex aquatilis*) (Muldavin et al. 2000). Frequent flooding on a seasonal basis is the norm, but at somewhat higher sites, wet meadows can also occur where mesic grasses and forbs predominate (e.g., bluegrass [*Poa pratensis*]).

Figure 2.8. An example of Western North American Temperate Interior Freshwater Marsh along the upper reaches of the Rio Santa Barbara. Obligate wetland sedges typically dominate along with a variety of grasses and forbs (photo: Y. Chauvin).

From the perspective of the NMRAM, the expectation is that all three major groups together will form riparian complexes of intermixed patches across the floodplains of the reference domain. This perspective that riverine floodplains are made up of a complex mosaics of vegetation communities, in combination with intact hydrological regimes, is central to the underlying concept of ecological integrity in this subclass.

WILDLIFE

Many native wildlife species use habitats associated with this subclass, and those habitats are essential to many of those species. Large mammals, such as Rocky Mountain elk (*Cervus elaphus nelsoni*), mule deer (*Odocoileus hemionus*), black bear (*Ursus americanus*), and mountain lion (*Puma concolor*), use the rivers and riparian habitats for water and foraging. Medium-sized and small mammals, such as skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), beaver (*Castor canadensis*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), and small mammals, such as squirrels (*Spermophilus* sp.), mice, voles, and gophers (*Thomomys* sp.), all utilize the riparian habitats and streams for food, water, and shelter. The riparian corridors are very important to many species of birds, providing unique habitats and food resources. Many species of amphibians, reptiles, and invertebrates also rely on these riverine environments for habitat and food resources (Fennessy et al. 2004).

Some important engineering animal species, such as beaver, not only require riverine habitats to live in, but also modify the physical structure of those environments for other species by building structures such as dams and burrows in river banks. In this way, these engineering animals are keystone species that alter the environment in such a way as to create new environments for many other species of animals and plants. Other species that may have significant impacts on vegetation and soils, such as Rocky Mountain elk, may also act as stressors to riverine wetland environments if densities become high. Beaver may remove a considerable number of trees, and elk grazing and trampling may affect shrubby and herbaceous vegetation and soils.

OTHER RIVERINE SUBCLASSES

Three other subclasses have been identified that can occur near or adjacent to Montane Riverine Wetlands. The Montane Canyon Riverine Wetlands subclass (Figure 2.9) is typically found along confined stream reaches in the same elevation zone and intermixed with Montane Riverine Wetlands. This subclass is characterized by steep stream systems confined by the underlying bedrock, with channel substrates dominated by boulders and cobbles. These streams typically have a narrow riparian zone and may lack a distinct floodplain.

Figure 2.9. Example of Montane Canyon Riverine Wetlands subclass where the stream is confined by bedrock and there is little or no floodplain.

The Subalpine-Alpine Riverine Wetland subclass occurs at the upper reaches of watersheds where the catchments are significantly reduced (less than tens of square kilometers). These first- and second-order streams are dominated by snowmelt runoff and have low gradients and associated stream beds dominated by fine sediments. Typically, they meander through broad valleys with large floodplains and have near-surface groundwater that can support herbaceous wetland vegetation and shrub willow communities.

At lower elevations, the Montane Riverine Wetlands grade to Lowland Riverine Wetlands (Figure 2.10). This subclass is associated with high-volume river systems with large drainage areas capable of moving various sediment size classes to create complex fluvial terrains made up of large mid-channel (uncommon in the other subclasses) and point bars, as well multiple terraces and back channels. Floodplains can be more than 0.4 km (0.25 mile) wide, and the alluvial valley may store large quantities of fine sediments. These channels have a low degree of confinement and low slopes (<2%) and are often associated with broad alluvial valleys with extensive lateral movement. Typical vegetation includes Rio Grande cottonwood *(Populus deltoids* ssp. *wizlenii*) and coyote willow while alder and high-elevation willow species are typically absent. Non-native dominants include saltcedar and Russian olive (Muldavin et al. 2000).

Figure 2.10. Example of Lowland Riverine Wetlands along the Rio Grande in Albuquerque.

APPLICABILITY TO OTHER WATERSHEDS

The NMRAM Version 1.1 is expected to be applicable to unconfined, mid-elevation montane stream systems with stream orders ranging from 2 to 4 in other watersheds throughout New Mexico. There are similar streams and rivers found in the Sangre de Cristo, Jemez, Sacramento, Zuni, Chuska, and Mogollon (Gila) mountains, etc. At lower latitudes, the suite of plant species may change, but the structure and complexity should be similar. Future versions of NMRAM will refine these differences. The NMRAM is not applicable to desert, lowland systems, large, main stem rivers, or high-elevation (headwater, subalpine) systems, nor is the NMRAM applicable in steep-gradient, confined valleys where the river's ability to migrate is confined by geology. Future versions of the NMRAM will address those systems.

UPPER RIO GRANDE MONTANE RIVERINE REFERENCE DOMAIN

The Upper Rio Grande watershed was selected as the reference domain to design and calibrate the NMRAM because of its proximity and watershed characteristics. In developing the NMRAM, it was important to test the metrics within an area of similar environmental characteristics (reference domain) in order to minimize random environmental variation and hone in on the effect of stressors on wetland condition (see Figure 2.2 above).

GEOGRAPHIC SETTING OF THE REFERENCE DOMAIN

The Upper Rio Grande Montane Riverine reference domain (Figure 2.11) is located at the transition of the Southern Rockies (Ecoregion 21) and the Arizona/New Mexico Plateau (Ecoregion 22) Level III ecoregions of Griffith et al. (2006). The Southern Rockies ecoregion is composed of high-elevation, steep, rugged mountains. At lower elevations, the upland slopes tend to be lower and unconfined river valleys have formed. In general, at high elevations this ecoregion is dominated by coniferous forests with spruce-fir forests consisting of white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*) Engelmann's spruce (*Picea engelmannii*), and blue spruce (*Picea pungens*). The middle elevations grade through forests dominated by Douglas-fir (*Pseudotsuga menziesii*) down to ponderosa pine (*Pinus ponderosa*) forests, and then into low-statured woodlands dominated by one-seed juniper (*Juniperus monosperma*), Rocky Mountain juniper (*J. scopulorum*), Gambel oak (*Quercus gambelii*), and piñon pine (*Pinus edulis*) at lower elevations (Muldavin et al. 2000; Griffith et al. 2006).

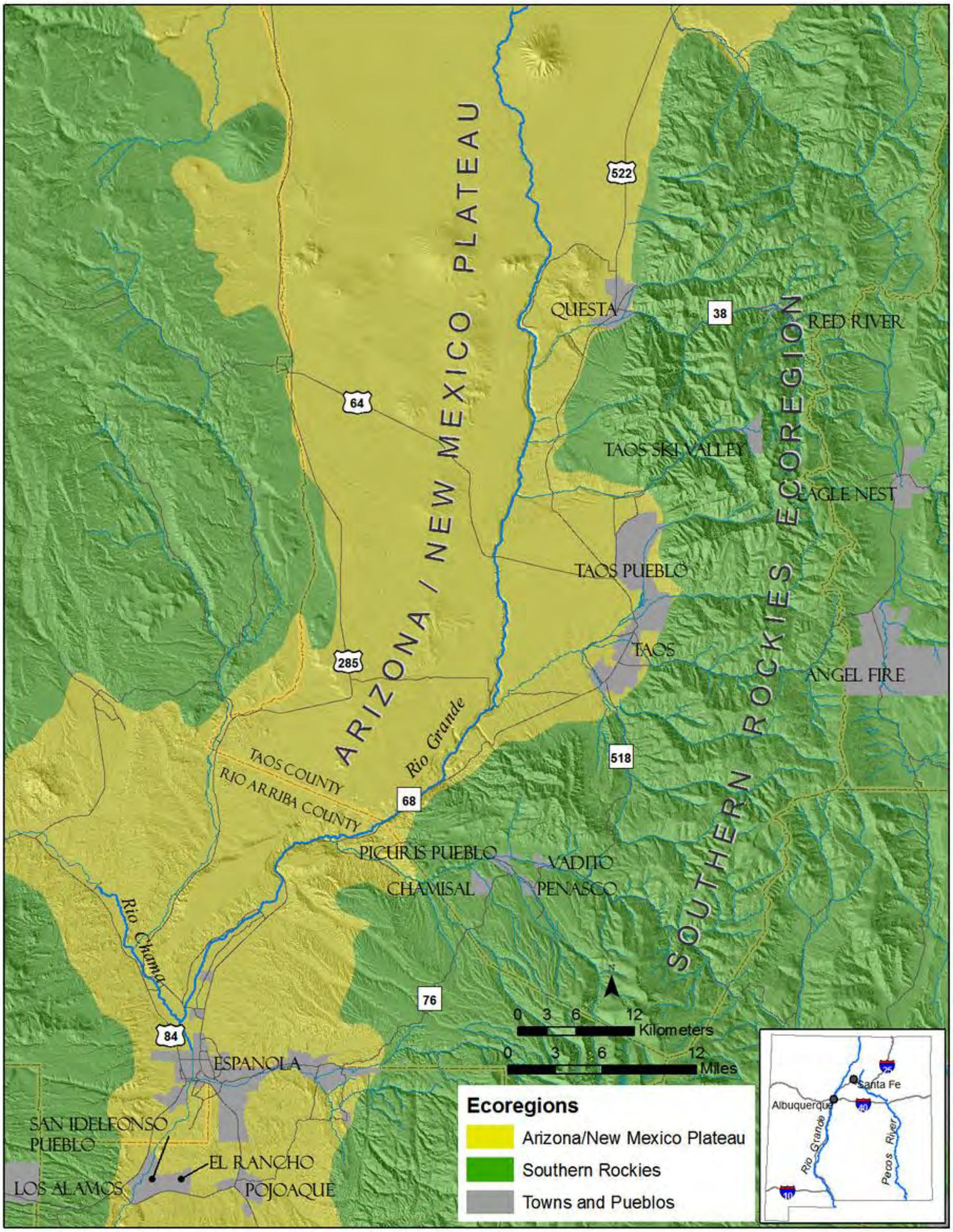

Figure 2.11. Level III Ecoregions representing the Upper Rio Grande Montane Riverine Reference Domain. Source: Griffith et al. (2006).

Within the Southern Rockies, Griffith et al. (2006) further describe four zones at mid-elevations: Crystalline Mid-Elevation Forests (21c), Foothill Woodlands and Shrublands (21d), Sedimentary Mid-Elevation Forests (21f), and Volcanic Mid-Elevation Forests (21h). The Foothill Woodlands and Shrublands found at the lowest elevations along the boundary with the Arizona/New Mexico Plateau Ecoregion (1,829–2,438 m [6,000–8,000 feet]). This is a semiarid region of rolling hills, ridges, and footslopes with a variety of rock and soil types, dominated primarily by piñon-juniper woodlands. Streams and rivers in this zone range from perennial to ephemeral and have moderate to high gradients with cobble, gravel, and sandy substrates.

The Sedimentary (limestone and sandstone), Crystalline (granitic) and Volcanic (basalts and pumice) Mid-Elevation forest zones are dominated by ponderosa pine, Douglas-fir, white fir (*Abies concolor*) and limber pine (*Pinus flexilis*) and range from about 2,438 to 3,048 m (8,000–10,000 feet). They are found on low mountain ridges, slopes, and outwash fans. Soils derived from sedimentary and volcanic substrates are generally finer textured than those derived from granitic substrates. The streams are generally perennial with moderate to high gradients.

The Arizona/New Mexico Plateau Ecoregion occurs across most of northwestern New Mexico and parts of northern Arizona, extending into the upper Rio Grande between the Sangre de Cristo Mountains on the east and the Tusas and Jemez mountains on the west. It is characterized by shrublands dominated by big sagebrush (*Artemisia tridentata*), rabbitbrush (*Ericameria* and *Chrysothamnus* spp.), and winterfat (*Krascheninnikovia lanata*) and blue grama (*Bouteloua gracilis*) and galleta (*Pleuraphis jamesii*)-dominated grasslands. This ecoregion is a relatively minor element within the reference domain, with the Taos Plateau (22f) as the most significant zone. It is composed of mostly Pliocene basaltic lavas, including cones of composite volcanoes, with only one major dissection, the Rio Grande Gorge cutting through the basalt caprock. Streams are mostly ephemeral or intermittent, but include some perennial streams from nearby mountains.

WATERSHED ATTRIBUTES AND LAND USE

The reference domain includes 10 principal watersheds from which rapid assessment reference sites have been selected (Figure 2.12). The majority of these watersheds are on the east side of the reference domain and drain westward out of the Sangre de Cristo Mountains into the Rio Grande. Only two of the study watersheds are on the west side of the reference domain: the Rio Tusas and Rio Vallecitos. These watersheds were included to test the limits of the subclass. Both are part of the larger Rio Chama watershed, a tributary of the Rio Grande that drains southerly from the San Juan Mountains to the north; both occur within Ecoregion 21, but do not directly drain from the Sangre de Cristo Mountains.

The watersheds differ in size, ranging from 8,696 to 82,981 ha (21,488–205,046 acres) (Table 2.2). Embudo Creek is the largest watershed, with Rio Pueblo de Taos a close second. Both are watersheds made up of multiple steams and drainages. The Rio Grande del Rancho watershed actually drains into the Rio Pueblo de Taos before it drains into the Rio Grande and, if combined, they would become the largest watershed in the study area. However, as all the study sites are above the confluence of the Rio Grande, watersheds are kept separate based on their Hydrologic Unit Code (HUC) 10 boundaries (Natural Resources Conservation Service [NRCS] 2009) (see Figure 2.12). The smallest watershed is the Rio Truchas, which consists of one stream with no major tributaries.

All of the study watersheds are subject to some level of agricultural use and development. For the watersheds from Rio Pueblo de Taos south, human settlement and agricultural use have a long history, extending to pre-Columbian times. Following the arrival of Spanish settlers to the area in the eighteenth century, irrigated (acequia) agriculture was extended to most of the foothills and lower montane valleys within the study area and continues today. Most of the study area is subject to some level of grazing, both on public lands and within privately owned pastures.

Within the reference domain multiple small towns, pueblos, and one city have impacted streams through urban and suburban development. These watersheds include the Rio Pueblo de Taos, Rio Grande del Rancho, the greater Embudo Creek, Red River, and Arroyo Hondo watersheds. There are also developed ski areas in the Arroyo Hondo, Costilla Creek, Rio Pueblo de Taos, and Red River watersheds. Mining is a significant activity within the Red River watershed and is present to a lesser degree in some of the other watersheds within the study area. Land ownership is summarized in Figure 2.12.

While most study watershed boundaries and names are based on their HUC 10 designations, there are three exceptions. The Costillo Creek watershed was slightly modified by the removal of the Costillo Creek-Eastdale Creek HUC 12 subunit, which was outside the study subclass. The Arroyo Hondo watershed, consisting of two HUC 12 units, was separated from the larger Rio Pueblo de Taos–Rio Grande HUC 10 watershed. The Rio Truchas watershed is actually a HUC 12 subunit of the larger Rio Chama–Rio Grande HUC 10 watershed.

Table 2.2. Summary of Watershed Area

Watershed	Acres	Hectares
Costillo Creek	139,041	56,269
Red River	121,272	49,078
Arroyo Hondo	45,748	18,514
Rio Pueblo de Taos	174,564	70,645
Rio Grande del Rancho	94,204	38,124
Embudo Creek	205,046	82,981
Rio Truchas	21,488	8,696
Santa Cruz River	92,724	37525
Rio Tusas	126,518	51,201
Rio Vallecitos	90,703	36,707

Adapted from NRCS (2009).

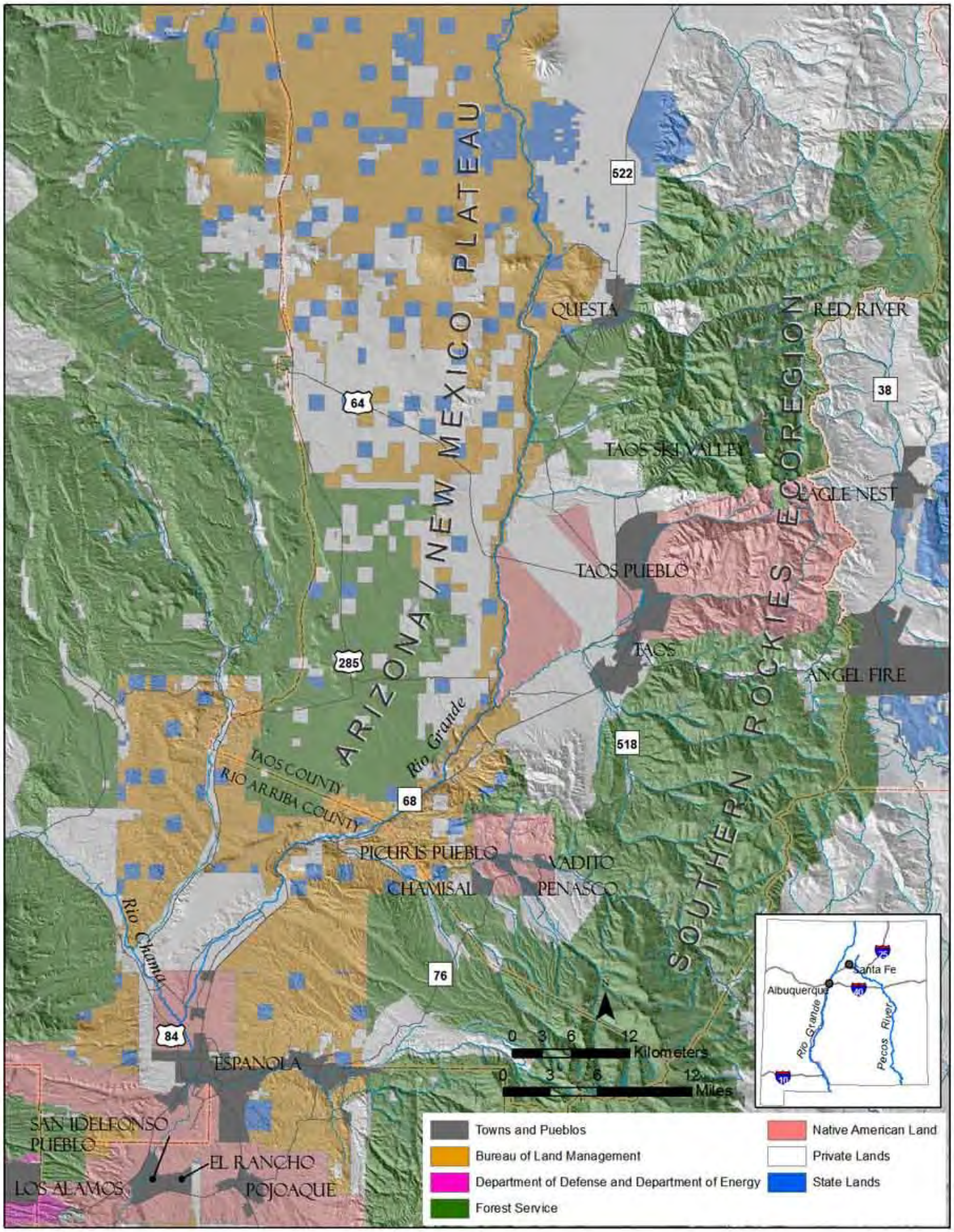

Figure 2.12. Land ownership within the reference domain (Bureau of Land Management 2007).

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CHAPTER 3
THE ASSESSMENT PROCESS

Conducting a wetland assessment using the NMRAM is a multi-step process that begins with determining and mapping the target Wetland of Interest (WOI). Then, an AA or multiple AAs are delineated within the WOI that are representative samples of the wetland complex being evaluated. Within and around an AA, a suite of 15 metrics representing various landscape, size, biotic, and abiotic attribute groups are measured and rated. Ratings have values from one (poor condition) to four (excellent condition), relative to the range of conditions found within the reference domain for a given metric. To arrive at an overall rating for an AA, individual metric ratings are weighted and rolled up by attribute group into a final summary assessment score (this also ranges between 1.0 and 4.0). Lastly, for the WOI as a whole, all AA scores are averaged and a categorical wetland condition rank of A, B, C, or D (reflecting Excellent, Good, Fair, or Poor condition, respectively) is assigned based on the average.

To aid in this process, we provide below an overview of the assessment procedures followed by a section containing individual metric descriptions with details on the rationale underlying their use, along with specific protocols for their measurement and rating (Section 5). In Section 6, we provide the details for the calculation of a final wetland condition rank and include a wetland rank calculator in paper and digital spreadsheet form that has been developed to simplify rank calculation and reporting. It is designed to be compatible with a web-based New Mexico Wetlands Database that is currently under construction.

In an accompanying NMRAM Montane Riverine Wetlands Field Guide (available at http://www.nmenv.state.nm.us/swqb and http://nhnm.unm.edu) with associated appendices, we have condensed the information from this manual and provide a suite of worksheets to ensure efficient and accurate data gathering, and the tracking of pre-field, field, and post-field tasks.

DETERMINING AND MAPPING THE WETLAND OF INTEREST

Determining the boundary WOI is the first and necessary step in the NMRAM process, but how that determination is made may vary depending on user needs and objectives. The NMRAM requires no specific criteria, but as a minimum, the "natural rule" is suggested where **a wetland delineated in a mapping process should be at least 0.5 ha (1.2 acres) in size** and be composed of continuous natural wetland vegetation unbroken by major anthropogenic-disturbance patches (e.g., roads, urban development over 10 m [33 feet] wide). The wetland may be a complex of one or more natural vegetation types, but all of them should be part of the same wetland subclass (Montane Riverine). The key is the lack of significant internal fragmentation caused by direct human disturbance and clear separation from other wetlands or wetland types. Figure 3.1 provides an example of a WOI delineation where the boundary follows this natural rule. While this natural rule is by default an approximation, it provides an operational guideline designed to meet the immediate needs of a rapid assessment when other procedures are not required or desired (e.g., jurisdictional wetland delineation). As necessary, the boundary may be modified based on the field reconnaissance or requirements at a project level. Regardless of how the boundary is determined, the designation of the WOI provides the foundation for delineation of the AAs and subsequent metric measurements.

DEFINING AND DESCRIBING THE ASSESSMENT AREA

An AA is a focus sampling area unit within the WOI where the suite of assessment metrics is evaluated. While an AA may be placed randomly, given the limitation of time and personnel resources that often occurs, it can be placed so as to best capture the range of variation of vegetation patches within the WOI. At a minimum, there is one AA per WOI, but for large WOIs two or more AAs may be required to capture the range of variation (particularly if randomization is used). In addition, an AA may be constrained by logistical considerations such as ownership and access.

Following the guidelines below, a provisional AA is identified prior to going into the field and then modified as needed based on field indicators and constraints. The delineation of AAs should be done with care, and decision rules documented because they are the context for most of the metric measurements.

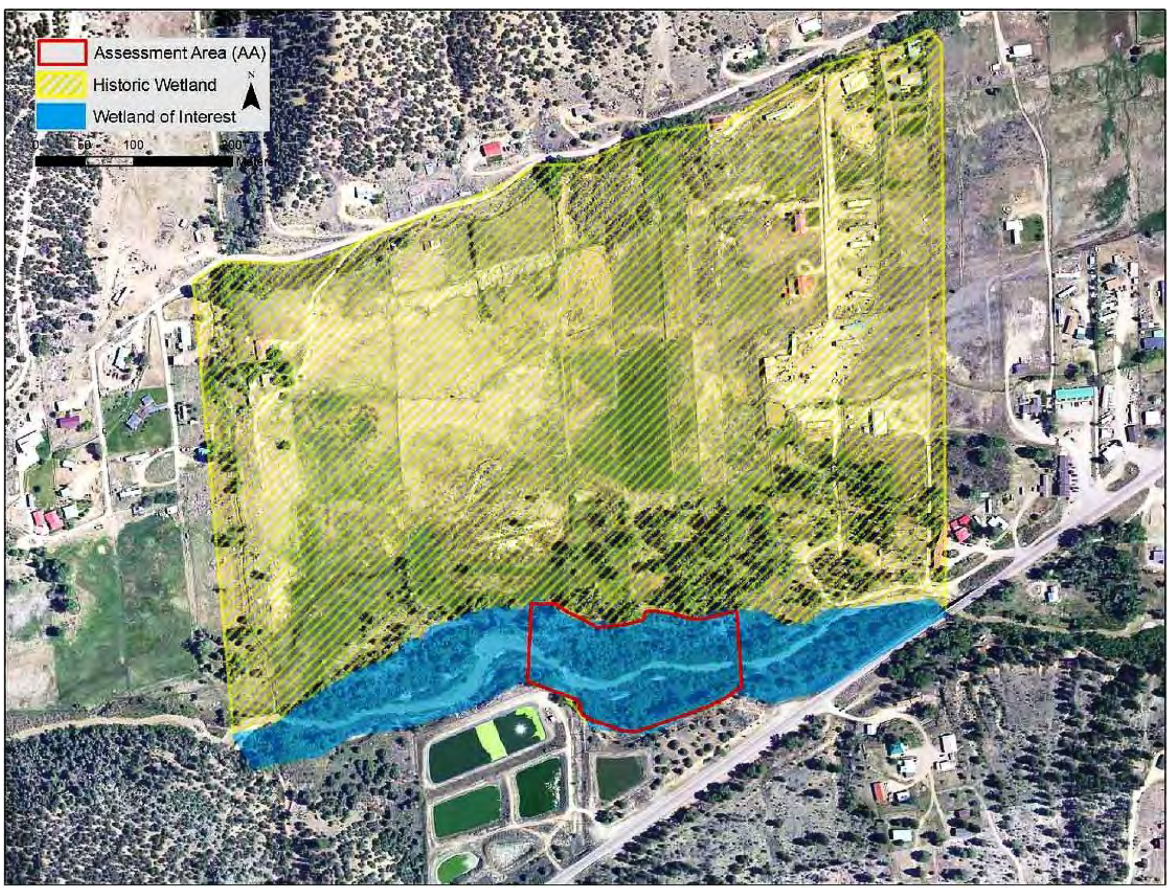

Figure 3.1. Delineation of the WOI relative to the historic wetland and the placement of an AA that is representative of the WOI.

LATERAL EXTENT OF THE AA

For the purposes of the NMRAM, the lateral extent of the AA within the WOI is defined as that area that influences the stream channel through allochthonous input; is influenced by active hydrological processes such as flooding, sediment deposition, scour, and groundwater recharge; and is characterized by wetland vegetation communities. Although this area may not correspond directly to the maximum area that may be flooded, for simplicity this lateral extent is referred to as the flood-prone width. By defining the lateral extent this way, the NMRAM uses a qualitative measure of physical or fluvial geomorphic processes to define the AA. Indicators of these processes include, but are not limited to:

- deposition of sand, gravel, and silt;
- flat surfaces or terracing;
- recent flood deposits or racking;
- disturbance caused by water;
- changes in soil type or vegetation communities (note that the transition from hydrophytic to upland vegetation is a surrogate measure of hydrology and fluvial processes); and
- hydrological modifications that restrict flooding, such as berms or levees.

For practical purposes of rapid field sampling, the lateral extent is limited to 100 m (328 feet) (or 50 m [164 feet] on each side of the center of the stream) or less, based on these parameters.

It is also important to note that the flood-prone width should not be defined by land use. Hydrological modifications that restrict flooding, such as a berm, could result in an artificially narrow flood-prone width.

LINEAR EXTENT OF THE AA

The NMRAM adopts a modification of the CRAM (Collins et al. 2008) approach for determining the linear extent of the AA. The linear extent should be roughly 10 times the channel width but at least 100 m (328 feet) and encompass at least two meander bends of the stream channel. Optimally, the extent should not exceed 200 m (656 feet) to support rapid assessment, but may be longer to ensure the incorporation of two meander bends (if this is impractical, then the number of subsequent cross-section measurements will be reduced). In addition, the AA should not cross hydrologic boundaries that affect flow volume or channel morphology. Changes in land use are not sufficient to delineate the AA boundary unless a notable change in hydrological conditions is evident. Examples of features that should be used to delineate AA boundaries include:

- acequias and other diversion structures and ditches;
- end of large pipe discharges;

- grade control or water elevation control structures;
- weirs, culverts, dams, levees, and other flow control structures;
- major changes in riverine confinement, entrenchment, degradation, aggradation, slope, or bed form;
- tributary or channel confluences;
- waterfalls; and
- transitions between wetland types, such as beaver ponds, spring or seep-fed adjacent wetlands, or change in subclass.

The linear extent of each AA is delineated in the GIS using aerial imagery interpretation and then verified in the field. For the calculation of the extent as 10 times the stream width, the stream width is determined as the distance between the greenlines—the line of perennial terrestrial vegetation closest to the barren shoreline, parallel to each shoreline. A series of three to five stream-width measurements should be made on either side of the center point of the location to be assessed and averaged for use in the calculation.

RAPID ASSESSMENT METRIC MEASUREMENTS

The rapid assessment of an AA within a WOI and has two levels of investigation:

- Level 1. Metrics that are usually measured remotely using maps and aerial imagery, and typically using a GIS (with field validation as needed). These are relatively coarse-scale metrics that are focused on the condition of the landscape surrounding an AA.
- Level 2. Metrics that require on-the-ground measurements as part of a field reconnaissance survey of the AA. These are finer-scale, semi-quantitative metrics focused on biotic and abiotic attributes within an AA.

Some assessment methods include a third level of intensive quantitative measurements at the plot level, but these are typically outside the scope of a rapid assessment approach (although they can be useful for Level 2 validation).

ASSESSING LEVEL 1 METRICS

Level 1 metrics include measurement of the WOI current size and four Landscape Context metrics (Buffer Integrity Index, Riparian Corridor Connectivity, Relative Wetland Size, and Surrounding Land Use) that are measured in the context of an AA. While Level 1 metrics can be evaluated manually using topographic maps and aerial photographs, they are most easily measured using a GIS. The basic layers needed are:

1. Recent ortho-rectified aerial photography or satellite imagery with a minimum resolution (pixel size) of 1 m (3 feet), preferably less;
2. Roads and trails;

3. Ownership;
4. Topographic maps or digital elevation models.

Sources for geospatial data include New Mexico Resource Geographic Information System (http://rgis.unm.edu/browsedata), BING, and Google Earth, among others.

The metrics are measured using the protocols described below, and while not typically field based (except for validation), they are also included in the NMRAM Montane Riverine Wetlands Field Guide along with associated worksheets as an aid to efficient and accurate data recording and subsequent site ranking.

Assessing Level 2 Metrics

Level 2 assessment includes five Biotic and five Abiotic metrics that are measured as part of the field survey of the AA. The field survey has two components:

1. A reconnaissance of the AA to map the major vegetation communities, evaluate the Biotic metrics, and validate targeted Level 1 metrics as needed;
2. A channel and floodplain survey that focuses on the evaluation of the Abiotic metrics related to the hydrology, geomorphology, and soils of the AA.

The survey team is preferably composed of three members, with one individual responsible for evaluating the Biotic metrics and verifying the Landscape Context and Size metrics, while the other individuals evaluate the Abiotic metrics. The team member responsible for the Biotic reconnaissance should have a basic understanding of the local flora, particularly common dominant trees and shrubs and whether they are native or introduced (exotic). In addition, they should be familiar with state-listed noxious weeds that may occur in the area. For the channel and floodplain survey, team members should have basic training in measuring hydrological characteristics and recognizing floodplain geomorphic characteristics (Rosgen Applied Fluvial Geomorphology training is a plus). A three-member team should divide the work as follows:

1. All team members conduct the reconnaissance survey;
2. The Biotic team member completes the Biotic assessment, verifies the Landscape Context and Size metrics, and completes the Biotic stressor checklist;
3. The two Abiotic team members take channel measurements and complete the Abiotic assessment and the Hydrology and Physical Structure Stressor checklists;
4. The entire team collaborates to complete the Land Use stressor checklist.

Note, if only two team members are available, they both work on the channel measurements and then split the mapping and metric measurement tasks as appropriate. The intent is that a team should be able to complete the field survey in four to six hours, depending on the complexity of the site and personnel resources.

THE RECONNAISSANCE AND VEGETATION MAPPING

The first task for a given AA is to confirm the location and configuration of the AA before proceeding with the remainder of the metric evaluations. While the AA is initially mapped in the office prior to heading out into the field, it is not always possible to identify hydrologic breaks such as irrigation diversion structures, irrigation returns, or landownership changes, all of which may affect the AA configuration. Therefore, it is good practice to first check if the AA length meets the specifications outlined above, as well as any lateral constraints not detected in the imagery. The AA can be shifted or the configuration changed in the field as necessary to accommodate the specifications (e.g., two meander bends) or constraints (e.g., unforeseen ownership restrictions).

As the foundation for evaluating the five Biotic metrics, a walkthrough of the AA is then conducted whereby vegetation communities are mapped by strata dominance (tall and short, woody and herbaceous). A mapping procedure is followed because it makes fewer demands on the practitioner to know all plant species at a site (i.e., it requires only a basic knowledge of the major dominants in an area and limits the need for later identification when a given dominant species is not known).

While a draft of the vegetation community map may be prepared in a GIS prior to the field survey, it will need to be field verified. Hence, the simplest approach can be to chart the vegetation on a hardcopy aerial photograph map of the AA as part of the walkthrough of the AA. Polygons of individual patches of homogeneous vegetation are delineated that are not less than a 0.1 ha [0.25 acre] (i.e., the minimum mapping unit polygon size). Each polygon is labeled with a number, recorded on a polygon list, and then evaluated with respect to **Vegetation Vertical Structure, Native Riparian Tree Regeneration, and Invasive Exotic Plant Species Cover** metrics (see Biotic Protocols below and the NMRAM Montane Riverine Wetlands Field Guide). Polygons are also assigned to a running list of community types (CTs) based on the top two dominants in each strata. The CT list is used to evaluate **Relative Native Plant Community Composition**. To help later interpretations and scoring, documentary photographs representative of each CT are recommended. When the species identification of a stratum dominant is uncertain, collect and press a voucher specimen for later confirmation.

The reconnaissance also involves evaluating the **Buffer Condition submetric** along the perimeter of the AA using the buffer lines as a guide to verify the **Buffer Percent** and **Buffer Width**, as well as Buffer Condition of the Buffer Integrity Index (See Landscape Context Protocols below and the NMRAM Montane Riverine Wetlands Field Guide). In addition, other Level 1 elements may need to be confirmed at the same time, as needed. Lastly, a **Vegetation (Biotic Condition) Impacts Stressor Checklist** is completed as part of the walkthrough to aid in interpretation of conditions, along with a narrative description of AA conditions and impacts.

THE CHANNEL AND FLOODPLAIN SURVEY

A channel and floodplain survey is conducted by two team members to evaluate five Abiotic metrics (See Abiotic Protocols below and the NMRAM Montane Riverine Wetlands Field Guide). The channel and floodplain survey team should scope out where cross-sections for the **Hydrologic Connectivity** measurements will be placed during the initial site reconnaissance. The stream reach is divided into three, more-or-less equal segments (upper, middle, and lower). Each segment should encompass at least one meander bend with a riffle zone where **Hydrologic Connectivity** can be measured using stream cross-sections. The cross-section measurements require two people for holding tapes and rods to measure entrenchment variables. In addition, photographs of the banks are taken in each direction on the cross-section, upstream and downstream, preferably at the mid-point of the channel. Photo-points are logged. **Channel Stability** and **Stream Bank Stability** are evaluated in each segment along the channel using field indicator checklists.

Macrotopographic Complexity and **Soil Surface Condition** also use checklists by segment but are evaluated as part of a walkthrough of the flood-prone width (a sketch map of major features of the floodplain is encouraged as an aid to filling out the checklist and for later interpretation). The field indicator checklists are designed to guide and remind surveyors in identifying important parameters and characteristics, but surveyors can add other indicators that are deemed important in a given AA. In addition to the field indicator checklists, there are Hydrologic and Physical Structure (soil/substrate) **stressor checklists** to assess impacts caused by human disturbances that are used to aid interpretation of channel and floodplain conditions.

BEST MANAGEMENT PRACTICES

To prevent the spread of aquatic diseases and nuisance species, it is imperative that field staff follow procedures to clean and sterilize field equipment. Outside the wetland at the staging area before the wetland is entered and upon leaving the wetland, boots, waders, and field equipment (e.g., stadia rods, etc.) that come in contact with surface waters must be hosed or washed off away from wetlands and surface waters. All porous material (including felt-soled boots, which are not recommended due to didymo concerns) must be immersed in a 2% bleach solution for five minutes or until thoroughly soaked, then rinsed or dried thoroughly. Any remaining solution must be poured away from vegetation.

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CHAPTER 4
METRIC DESCRIPTIONS, MEASUREMENTS, AND RATINGS

LANDSCAPE CONTEXT METRICS

Four Landscape Context metrics are designed to measure the condition of the landscape surrounding the AA. These metrics are based on the concept that significant anthropogenic modification of a landscape and degraded condition around the wetland can influence biotic and abiotic conditions within the wetland itself. The expectation is that those impacts immediately adjacent to the AA will have the most effect on wetland conditions and these are measured using the Buffer Integrity Index and Riparian Corridor Connectivity. As distance increases from the AA, the effect of disturbance declines, but may still be a factor. Surrounding Land Use and Relative Wetland Size are designed to measure this broader scale impacts.

BUFFER INTEGRITY INDEX

Assessment Level: This metric has three submetrics, two of which are Level 1 (Buffer Percent and Buffer Width) and one is Level 2 field verified (Buffer Condition).

Definition: The Buffer Integrity Index is a measure of the overall area and condition of the buffer, the zone of transition between the AA and its surrounding environment (Collins et al. 2008). For the purposes of the NMRAM, the buffer includes the area immediately adjacent to the AA that is in a natural or semi-natural state, and that provides the functions and services associated with natural buffers, including reducing erosion and sedimentation, reducing nutrient loading, reducing pollutant contamination, and providing contiguous natural habitat to the wetland AA. Accordingly, a set of buffer and non-buffer land-cover elements is defined for evaluating Buffer Integrity (Table 4.1).

Table 4.1. AA Buffer Checklist of Land Cover Elements

	Included Buffer Land Cover Elements		Excluded Non-buffer Land Cover Elements
☐	Natural wetland vegetation patches	☐	Commercial developments
☐	Swales and ditches	☐	Residential developments
☐	Nature or wildland parks	☐	Urbanized parks with active recreation
☐	Old fields, unmaintained	☐	Lawns, golf courses, sports fields
☐	Open range land	☐	Developed pedestrian/bike trails
☐	Unpaved roads not hazardous to wildlife (e.g., two-track roads)	☐	Intensive livestock areas (horse paddocks, feedlots, turkey ranches, etc.)
☐	Foot trails, horse trails, unpaved bike trails (low intensity)	☐	Intensive agriculture (row crops, orchards, and vineyards lacking ground cover)
☐	Non-channel open water	☐	Paved roads or developed second order unpaved but graded gravel roads
☐	Maintained pastures and hay fields	☐	Railroads
☐	Vegetated levees	☐	Parking lots

Land cover elements are categorized as either allowed in riverine buffers or excluded and considered non-buffer that disrupt ecosystem connectivity.

The Buffer Integrity Index is composed of three submetrics:

- *Buffer Percent*: the percentage of the perimeter surrounding a wetland AA that is considered natural or semi-natural buffer;
- *Buffer Width*: the average width of the extant buffer;
- *Buffer Condition*: the extent and quality of vegetation cover and the overall condition of substrate in the extant buffer.

Background: The Buffer Integrity Index is originally a non-riverine metric rating developed by McIntyre and Hobbs (1999); the riverine version is adapted from CRAM 5.0.2 (Collins et al. 2008) and its modifications (Faber-Langendoen et al. 2008a, 2008b, 2009).

Confidence Value: High. The metric has been field tested and exhibits a good range of scores across the reference domain.

Rationale:

OVERALL

Buffers are important components of the wetland in that they enhance function and protect the wetland from anthropogenic environmental stressors. The NMRAM adopts the buffer concept as described in Collins et al. (2008) and Faber-Langendoen (2008a). Buffers are transitional zones between the margins of a wetland and its surrounding environment that are in a natural or relatively natural state and not greatly impacted by anthropogenic stressors or disturbances. The buffer can protect wetlands from anthropogenic stressors by filtering pollutants, reducing nutrient loads, reducing erosion and stream sedimentation, providing habitat and/or corridors for wetland wildlife, and acting as barriers to disruptive anthropogenic incursions. Buffers can also reduce the risk of invasion by non-native plants and animals by either obstructing terrestrial corridors of invasion or by helping to maintain the integrity and therefore the resistance of wetland communities to invasion.

Buffer Percent

Natural or semi-natural buffers that surround a high percentage of a wetland perimeter perform more and offer better buffer services than those that do not. Collins et al. (2008) state,

> the ability of buffers to protect a wetland increases with buffer extent along the wetland perimeter. For some kinds of stress, such as predation by feral pets or disruption of plant communities by cattle, small breaks in buffers may be adequate to nullify the benefits of an existing buffer. However, for most stressors, small breaks in buffers caused by such features as trails and small, unpaved roadways probably do not significantly disrupt the buffer functions (Collins et al. 2008:47).

Buffer Width

Wider buffers perform more and offer better buffer services than narrow buffers. According to Collins et al. (2008),

> a wider buffer has a greater capacity to serve as habitat for wetland edge-dependent species, to reduce the inputs of non-point source contaminants, to control erosion, and to generally protect the wetland from human activities (Collins et al. 2008:50).

Buffer Condition

The better the condition of the buffer, the better the buffer performs buffer services. Furthermore,

> the condition or composition of the buffer, in addition to its width and extent around a wetland, determines the overall capacity of the buffer to perform its critical functions (Collins et al. 2008:52).

Seasonality: This metric is not sensitive to seasonality.

Assessment Protocol: The metric is modified from Collins et al. (2006), who provide an equation to integrate the three measures into an overall index.

The buffer percent and buffer width submetrics can be evaluated using a spatial analysis via GIS or in the field, but buffer condition is field based only. A GIS assessment should be conducted by visually estimating the percentage of the AA that is adjacent to buffer areas (Figure 4.1). Buffer areas must be at least 5 m (16 feet) wide and no more than 250 m (820 feet) away from the AA and must extend along the perimeter of the AA for at least 5 m (16 feet). Large bodies of open water, such as lakes that are 30 m (98 feet) or wider and adjoin the AA, are not considered part of the buffer. Bodies of water that are within 250 m (820 feet) of the AA, but not adjoining the AA are considered as part of the buffer.

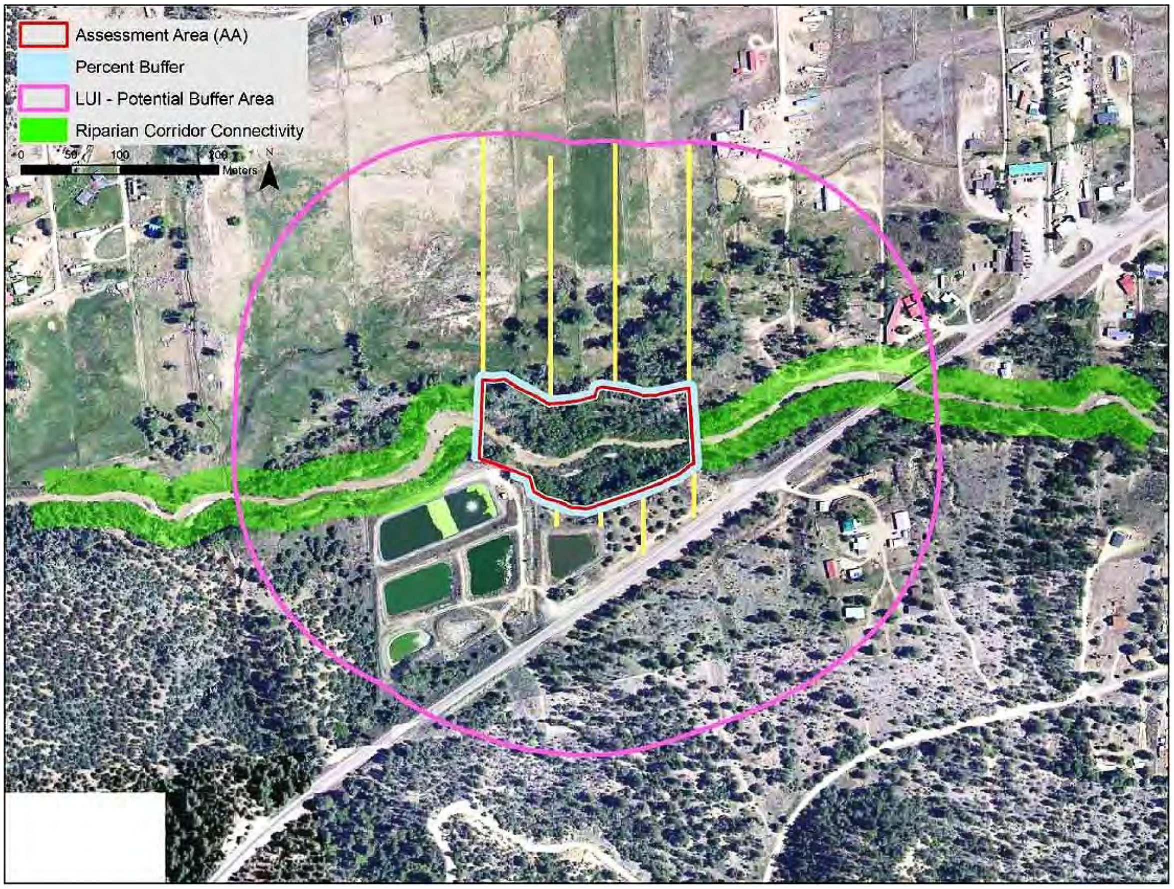

Figure 4.1. Buffer Integrity and Riparian Corridor delineation and measurement. The Buffer Percent and Buffer Condition submetrics are evaluated along the perimeter of the AA. Sample lines are extended out from the AA boundary to a maximum of 250 m (820 feet) to measure the Buffer Width submetric. Riparian Corridor Connectivity is evaluated 500 m (1,640 feet) upstream and downstream on both banks.

Buffer Percent is assessed using the following protocols:

- Using aerial photography or field reconnaissance, delineate the outer boundary of the AA buffer based on *allowed* buffer elements (Table 4.1);
- Check off buffer elements that occur on the worksheet. The maximum width of the buffer from the AA boundary is 250 m (820 feet);
- Do not include any areas less than the minimum buffer width of 5 m (16 feet;
- Estimate the percentage of the AA perimeter that is flanked by "included" buffer elements and then score the AA using Table 4.2 below.

Table 4.2. **Buffer Percent Rating Table**

Rating	States
4	Buffer is 75%–100% of occurrence perimeter
3	Buffer is 50%–74% of occurrence perimeter
2	Buffer is 25%–49% of occurrence perimeter
1	Buffer is < 25% of occurrence perimeter

Source: Collins et al. (2008); Faber-Langendoen (2008a).

Buffer width is measured in meters (feet) using the following steps (modified from Collins et al. 2008):

1. Identify areas in which open water is within 5 m (16 feet) of the AA. These areas are excluded from buffer calculations;
2. Draw a series of 8 lines perpendicular to the perimeter of the AA at even intervals around the AA extending to the buffer boundary or a non-buffer element as defined in Table 4.1 under **Buffer Percent**. Label the lines A through H. No lines should extend upstream or downstream or parallel to the river channel (Refer to Figure 4.1 above for an example). Enter the Universal Transverse Mercator [UTM] location of the buffer lines along the perimeter from the GIS to aid locating them in the field;
3. Measure the length of each of the lines;
4. Calculate the average buffer width among the measured lines (Table 4.3).

Table 4.3. **Buffer Width Rating Table**

Rating	States
4	Average buffer width is > 200 m (656 feet)
3	Average buffer width is 100–199 m (328–653 feet)
2	Average buffer width is 50–99 m (164–325 feet)
1	Average buffer width is < 50 m (164 feet)

Source: Collins et al. (2008); Faber-Langendoen (2008a).

Buffer Condition is measured as follows:

1. As part of the field reconnaissance, the buffer condition along the perimeter of the AA is evaluated. Estimate the percentage of non-native vegetation cover in the buffer and qualitatively assess the degree of soil disturbance within the last three years, trash or refuse accumulation, and human visitation and/or recreation intensity using Table 4.4.

Table 4.4. Buffer Condition Rating Table

Rating	States
4	Buffer for occurrence is characterized by abundant (>95%) cover of native vegetation and little to no (<5%) cover of non-native plants, with intact soils and little or no trash or refuse.
3	Buffer for occurrence is characterized by substantial (75%–95%) cover of native vegetation, low (5%–25%) cover of non-native plants, intact or moderately disrupted soils, moderate or lesser amounts of trash or refuse, and minor intensity of human visitation or recreation.
2	Buffer for occurrence is characterized by a moderate (50%–75%) cover of native plants and either moderate or extensive soil disruption, moderate or greater amounts of trash or refuse, and moderate intensity of human visitation or recreation.
1	Buffer for occurrence is dominated by non-native plant cover (>50%) characterized by barren ground and highly compacted or otherwise disrupted soils, with moderate or greater amounts of trash or refuse, and moderate or greater intensity of human visitation or recreation, or there is no buffer present.

Source: Faber-Langendoen et al. (2009).

Rating: Each submetric is rated independently per Table 4.2 through Table 4.4 above and summarized in Table 4.5.

Table 4.5. Buffer Integrity Summary

Submetric	Rating	Comments
Buffer Percent:		
Buffer Width Average:		
Buffer Condition Average:		

An index score that weights buffer condition over buffer percent and width is then computed based on the following formula derived from Collins et al. (2008):

$$\text{Buffer Integrity Index (BI)} = [\text{Buffer Condition} \times (\text{Buffer Percent} \times \text{Buffer Width})^{1/2}]^{1/2}$$

The overall summary rating is provided in Table 4.6.

Table 4.6. Overall Summary Rating Table for the Buffer Integrity Index

Rating	Description
4	Buffer Integrity Index Score > 3.5
3	Buffer Integrity Index Score = 2.5–3.4
2	Buffer Integrity Index Score = 1.5–2.4
1	Buffer Integrity Index Score < 1.5

Scaling Rationale: Based on the results of the field study, Buffer Integrity is a robust metric. With respect to buffer percent, the greater the proportion of the wetland perimeter that is surrounded by buffer, the greater the overall Buffer Integrity (see Collins et al. 2006; Faber-

Langendoen et al. 2008a). There is abundant evidence on the value of buffer widths. Even narrow buffers between 10 and 50 m (33–164 feet) (Environmental Law Institute 2008) provide protection. Buffer condition is weighted heavier that buffer percent or buffer width. Buffer condition is expected to be sensitive to anthropogenic disturbances within the acceptable buffer elements for the AA, suggesting that while buffer zones around sites may be composed of acceptable buffer elements, human use impacts may affect the overall function and purpose of the buffer. The field study indicated that buffer condition scores were sensitive to anthropogenic impacts, and that these tend to be moderately impacted by human use.

Riparian Corridor Connectivity

Assessment Level: Riparian Corridor Connectivity is a Level 1 and Level 2 metric. This metric is assessed initially as Level 1 and field verified.

Definition: Riparian Corridor Connectivity measures connectivity versus fragmentation among natural systems (riverine types) upstream and downstream from the AA, with an emphasis on detecting intervening obstructions that might inhibit wildlife movement, fragment plant populations, or disrupt ecosystem processes. In a riverine system, connectivity is measured as the percentage of anthropogenically altered length upstream and downstream of the AA within 25 m (82 feet) of either side of the channel.

Background: Riparian Corridor Connectivity is derived from Landscape Connectivity, originally a non-riverine metric rating developed by McIntyre and Hobbs (1999); the riverine version is adapted from CRAM 5.0.2 (Collins et al. 2008) and its modifications (Faber-Langendoen et al. 2008a, 2008b, 2009).

Confidence Value: Moderate. The metric has been revised and needs further testing.

Rationale: Faber-Langendoen et al. (2008b) state that riverine areas are typically composed of a continuous corridor of intact natural riparian vegetation made up of forested, shrub, and herbaceous wetlands along the stream channel and floodplain (Muldavin et al. 2000; Smith 2000). These corridors allow uninterrupted movement of animals throughout the riparian zone as well as access to adjacent uplands (Gregory et al. 1991). These corridors also allow for unimpeded movement of surface and overbank flow, which is critical for the distribution of sediments and nutrients as well as the recharging of local alluvial aquifers. Hence, connectivity among riparian wetlands in a corridor is key to the function and integrity of a riverine riparian ecosystem. Collins et al. (2008) state that

> wetlands that are close together without hydrological or ecological barriers between them are better able to provide refuge and alternative habitat patches for metapopulations of wildlife, support transient or migratory wildlife species, and function as sources of colonists for primary or secondary succession of newly created or restored wetlands. In general, good landscape connectivity exists only where neighboring wetlands or other habitats do not have intervening obstructions that could inhibit the movements of wildlife (Collins et al. 2008:44).

Fragmentation and the breaking of connectivity of the riverine corridor can be caused by human alterations, such as roads, power line and pipeline corridors, agriculture activities, and urban/industrial development (Smith 2000). Fragmentation and associated habitat loss can have synergistic, cumulative impacts to remaining natural areas. As more habitat is altered and converted by anthropogenic disturbance, remaining fragments become more important to remaining wildlife populations and, at the same time, also more likely to be isolated and have disruptions to structure, biotic composition, ecosystem functions, and natural disturbance regimes such as floods (Faber-Langendoen et al. 2008b).

Seasonality: This metric is not sensitive to seasonality.

Assessment Protocol: This metric can be evaluated using a spatial analysis in a GIS (Level 1) assessment or during field reconnaissance (Level 2).

Modified from Collins et al. (2008), this metric is assessed as the total length of non-connectivity land-cover elements that interrupt the riparian corridor within 500 m (1,640 feet) upstream or downstream of the AA (see Table 4.1). For this metric, a break in the riparian corridor is defined as any non-connectivity land-cover element that comes within 25 m (82 feet) of the active channel bank and extends for 10 m (33 feet) or more. Unlike the CRAM (Collins et al. 2008), areas of non-natural vegetation, unpaved roads, and vegetated levees are considered interruptions of connectivity.

The guidelines for assessing Riparian Corridor Connectivity are:

1. Assume a minimum riparian width of 25 m (82 feet) from each river bank upstream and downstream of the AA for a total corridor width of 50 m (82 feet) plus the width of the stream;
2. Assume that open water areas serve as connectivity;
3. Limit the minimum length for any non-connectivity land cover patches (measured parallel to the channel) to at least 10 m (33 feet). Assign all roads a minimum width of 10 m (33 feet);
4. For wadeable systems or GIS-determined evaluations, assess both sides of the channel upstream and downstream of the AA;
5. For systems that cannot be waded, only assess the accessible side of the channel, upstream and downstream of the AA.

The procedural steps for assessing Riparian Corridor Connectivity are:

1. Extend 500 m (1,640 feet) upstream and downstream along both river banks from the AA boundaries;
2. Using the site imagery or field reconnaissance, check off and measure the length of all non-connectivity land cover patches (Table 4.7) that interrupt the riparian area on at least one side of the channel over the 500-m (1,640-foot) length and that are within 25 m (82 feet) of the active river channel and at least 10 m (33 feet) long. Do not

consider open water as an interruption. Record lengths by segment and bank (L = left bank or R = right bank facing downstream) in the respective map or field columns on Table 4.8.

Table 4.7. Riparian Corridor Connectivity Checklist of Land Cover Elements

Included riparian corridor land cover elements		Excluded non-buffer riparian corridor land cover elements	
☐	Natural wetland/riparian vegetation patches	☐	Invasive species vegetation patches, such as tamarisk or Russian olive (field verified)
☐	Swales and ditches	☐	Commercial developments
☐	Nature or wildland parks	☐	Residential developments
☐	Old fields, unmaintained	☐	Urbanized parks with active recreation
☐	Open range land	☐	Lawns, golf courses, sports fields
☐	Unpaved roads not hazardous to wildlife (e.g., two-track roads)	☐	Pedestrian/bike trails (i.e., nearly constant traffic)
☐	Foot trails, horse trails, unpaved bike trails (low intensity)	☐	Intensive livestock areas (horse paddocks, feedlots, turkey ranches, etc.)
☐	Non-channel open water	☐	Intensive agriculture (row crops, orchards, and vineyards lacking ground cover and other best management practices
		☐	Paved roads or developed second order unpaved but graded gravel roads
		☐	Railroads
		☐	Parking lots
		☐	Maintained pastures and hay fields
		☐	Vegetated levees

Modified from Collins et al. (2008)

Table 4.8. Riparian Corridor Non-connectivity Elements Length

Segment	Upstream		Downstream		Comments
	Bank 1 (L)	Bank 2 (R)	Bank 1 (L)	Bank 2 (R)	
0–100 m					
100–200 m					
200–300 m					
300–400 m					
400–500 m					
Total Bank (m)					
Total Segment (m)					
Segment Non-buffer %					
Segment Sub-score					

Rating: Riparian Corridor Connectivity rating is based on the total length of non-connectivity segments in the riverine corridor 500 m (1,640 feet) upstream and downstream of the AA. When both sides of the stream are considered, this results in 1,000 m (3,281 feet) upstream and downstream that are evaluated for a total of 2,000 m (6,562 feet). Riparian Corridor Connectivity is focused on the ability of a riverine ecosystem to maintain essential functions, maintain native vegetation, and provide habitat for wildlife. Good connectivity on both sides of an AA is most desirable; however, having very good connectivity (<5% disruption) on one side with poor connectivity on the other is more desirable than having connectivity moderately to severely disturbed (>20%) on both sides.

The procedural steps for rating Riparian Corridor Connectivity are:

1. Sum the length of non-connectivity patches identified in the upstream and downstream segments;
2. Calculate the percentage of non-connectivity for the upstream and downstream segments by dividing by 500 m [1,640 feet] if only one side of the channel was measured or by 1,000 m [3,281 feet] if both sides were measured (Table 4.8);
3. Use Table 4.9 to assign sub-scores for the upstream and downstream segments based on the percentage non-connectivity;
4. Add the sub-scores together for the upstream and downstream lengths, which will provide the raw metric score. Enter on Table 4.10. Convert the raw score to a final rating score for Riparian Corridor Connectivity using Table 4.11 or the Rank Calculator Worksheet.

Table 4.9. Riparian Corridor Connectivity Sub-score Assignments Based on Upstream and Downstream Segments Percent Fragmentation

Percent Fragmented	Sub-score
≤ 5%	16
> 5 and ≤ 10	15
> 10 and ≤ 15	14
> 15 and ≤ 20	12
> 20 and ≤ 25%	9
> 25 and ≤ 30%	8
> 30 and ≤40%	6
>40%	4

Table 4.10. Riparian Corridor Connectivity Score Calculation

Upstream Segment Sub-score		Downstream Segment Sub-score
	+	

Table 4.11. Overall Summary Rating Table for Riparian Corridor Connectivity

Rating Score	Raw Score (sum of sub-scores)
4	>28
3	20–27
2	12–19
1	<12

Scaling Rationale: The effects of fragmentation within a riparian corridor are not likely to be linear and it is suggested that disruptions may reach a threshold of dysfunction for a corridor at around 40% fragmentation. This is built into the sub-score weighting in Table 4.9 and rating score distribution in Table 4.10. Table 4.11 produces a spread of scores such that most sites with less than 15% connectivity disruption will score in the "4" or Excellent range, while the majority of sites with greater than 40% disruption will end up scoring in the "1" or Poor range.

RELATIVE WETLAND SIZE

Assessment Level: This is a Level 1 assessment completed in the office prior to fieldwork.

Definition: An index of reduction of the current wetland relative to its estimated historical size.

Background: This metric is derived from the Patch Size Condition metric of NatureServe's Ecological Integrity Assessment methodology (Faber-Langendoen et al. 2008a).

Confidence Value: Moderate. This is a new metric that requires further testing.

Rationale: Relative size is a measure of the degree of a wetland's alteration from its historical natural size (and condition) (see Figure 3.1 above) as a function of human-induced disturbances, particularly land-use conversions and major hydrological modifications. This metric assumes that large reductions of area indicate alteration to hydrology or ecosystem processes and may indicate ecological instability, reduced viability, and tendency to lose diversity in the future. As such, relative size is an indicator of potential stress on the remaining extant wetland, but it can also be used as a measure of wetland area potentially available for restoration.

Seasonality: This metric can be evaluated during any season. However, if measuring this metric solely at Level 1, the use of growing-season imagery with adequate "green-up" can improve accuracy.

Assessment Protocol: Determining the historical size of riverine wetlands can be problematic given their potential for extended linear distribution upstream and downstream, plus the difficulty in ascertaining the limits of the lateral extent of the historic active floodplain. Accordingly, the NMRAM takes a proximal, pragmatic index approach that can provide a first approximation of wetland size reduction. The steps for determining historical size are:

1. Using the mapped WOI, extend lines laterally (perpendicular to the channel) from the upstream and downstream ends of the current WOI polygon in both directions to the edge of the floodplain within the drainage. Exclude ancient alluvial terraces, e.g., several thousand years old or more and that appear to support upland type vegetation

2. Connect the lateral lines along the upland on both sides of the channel to create a single polygon (see Figure 4.1 above) and calculate or estimate the area.

The outcome is an estimate of potential maximum size of the riverine wetland constrained proximally by the current WOI extent upstream and downstream. Hence, the metric is an index rather than absolute determination of historical wetland size. The Relative Wetland Size Index (RWSI) metric is computed as the percent reduction from historical size:

$$RWSI = (1-(S_c / S_h)) *100$$

Where: S_c = current size and S_h = historical size.

Rating: The Relative Wetland Size metric rating (Table 4.12) is based on ranges of the RWSI.

Table 4.12. Relative Wetland Size Rating Based on the Ratio of Current Size to Historical Size

Rating	Description
4	RWSI <10%. Wetland is at, or only minimally reduced from, its full original, natural extent and has not been artificially reduced in size.
3	RWSI between 10% and 39% wetland reduction.
2	RWSI between 40% and 79% wetland reduction.
1	RWSI ≥80% wetland reduction from its original, natural extent.

Scaling Rationale: Scaling criteria are derived from Rondeau (2001) and the NatureServe Ecological Integrity Assessment Working Group (Faber-Langendoen et al. 2008a) but have been modified to reflect a different measurement technique and the range of variation found in this domain.

SURROUNDING LAND USE

Assessment Level: This metric is assessed initially as Level 1 and field verified.

Definition: This metric addresses the extent and intensity of human-dominated land in the floodplain adjacent to the AA. Each land-use type occurring in the landscape area is assigned a coefficient indicating its relative impact on ecosystem patterns and processes (from 0.0 indicating no impact to 1.0 high impact), and then scaled by the extent of the impact in the surrounding area.

Background: Surrounding Land Use is based on Hauer et al. (2002) as developed in Faber-Langendoen et al. (2008a). See also Mack (2006) for a related version of this metric.

Confidence Value: High. This metric has been field tested.

Rationale: The intensity of human activity in the landscape has a proportionate impact to the ecological processes of natural ecosystems. Assessing land use incorporates both the aspect of "habitat destruction" and "habitat modification" (McIntyre and Hobbs 1999), at least for the non-natural habitats. That is, in addition to the effect of converting natural habitat to agricultural, urban, and other land use modifications, there is the additional aspect of the intensity of that land use reflected in the coefficients.

Assessment Protocol: This metric is measured by documenting land-use types and their relative amount in the an area that represents the potential buffer area, that is the area extending from the boundary of the AA out 250 m (820 feet) (see Figure 4.1 above), along with the AA and that portion of the riparian corridor within 250 m (820 feet) of the AA. This is primarily a Level 1 metric whereby, using current aerial photography and/or GIS data, a Land Use Index (LUI) is calculated based on estimating the percent cover across the target area of each land use type (Table 4.13). The assessor should indicate if the area estimate is map or field based. A spreadsheet calculator for the metric has been provided to simplify the scoring process. If the spreadsheet is not available, the LUI can be calculated by hand using the formula:

$$\text{Land Use Index (LUI)} = \sum \text{LU Coefficient x Percent of Buffer Area}$$

Where: LU Coefficient= Land Use Coefficient for a land use type (Table 3.12); Percent of Buffer= percentage of the buffer for a land use type.

For example, if 30% of the adjacent area is old fields (0.3 * 0.5 = 0.15), 10% composed of unpaved roads (0.1 * 0.1 = 0.01), and 40% of natural area (e.g., no human land use) (1.0 * 0.4 = 0.4), the total land use score would equal 0.56 as the sum of 0.15 + 0.01 + 0.40. The total percentage cover cannot exceed 100% and the index itself cannot exceed 1.0.

Table 4.13. Land Use Types and Corresponding Weighting Coefficients for the Calculation of the LUI

Land Use Element	Coefficient	Percent of Buffer Area	LUI Score[1]
Paved roads/parking lots/domestic or commercially developed buildings/mining (gravel pit, quarry, open pit, strip mining)	0.0		
Unpaved roads (e.g., driveway, tractor trail, unpaved parking lots)	0.1		
Dredging, borrow pits, abandoned mines, water-filled artificial impoundments (ponds and reservoirs)	0.1		
Filling or dumping of sediment or soils	0.1		
Intense recreation (all-terrain vehicle use/camping/popular fishing spot, etc.)	0.3		
Rip-rapped channel (highly modified channel with severely limited vegetation zone that is altered by human activities but not a completely concrete channel [that goes under paved roads]), junkyards, trash dumps, disturbed ground (not including roads	0.3		
Ski area	0.4		
Dam sites and flood-disturbed shorelines around water storage reservoirs	0.5		
Abandoned artificial impoundments (ponds and reservoirs) and associated disturbed flood zones	0.5		
Artificial/Constructed wetlands, irrigation ditches	0.7		
Developed/Managed trail system (high use trail)	0.8		
Paddock, dirt lot	0.1		
Agriculture – active tilled crop production	0.2		
Agriculture – permanent crop (vineyards, orchards, nurseries, berry production)	0.3		
Manicured lawns, sport fields, and golf courses	0.3		
Old fields and other disturbed fallow lands dominated by ruderal and/or exotic species (e.g., kochia, Russian thistle, mustards, annual vegetation)	0.5		
Mature old fields and other fallow lands with natural composition, introduced hay field and pastures (e.g., perennial vegetation cover)	0.7		
Restoration areas in process to natural conditions (re-conversion in process)	0.8		
Haying of native grassland (e.g., no tillage, haying and baling only)	0.9		
Woodland/Shrub vegetation conversion (chaining, cabling, rotochopping)	0.3		
Heavy logging or tree removal with >50% of large trees (e.g., >30 cm diameter at breast height) removed	0.3		
Commercial tree plantation/Christmas tree farms	0.6		
Selective logging or tree removal with <50% of large trees (e.g., >30 cm diameter at breast height) removed	0.8		
Mature restoration areas returned to natural conditions (re-converted)	0.9		
Natural area/land managed for native vegetation – No agriculture/logging/development	1.0		
[1] Element Score= Coefficient * % Area	Sum	100%	

Adapted from Hauer et al. (2002).

Rating: Using the LUI values, the Surrounding Land Use metric is rated using the scale provided in Table 4.14.

Table 4.14. Ratings for Surrounding Land Use Based on the Ranges of LUI Scores

Rating	Land Use Index Score
4	95–100
3	80–94
2	40–79
1	< 40

Scaling Rationale: Land uses have differing degrees of potential impact on ecological patterns and processes. Some land uses have minimal impact, such as simply altering the integrity of native vegetation (e.g., recreation and grazing), while other activities (e.g., hay production and agriculture) may replace native vegetation with non-native or cultural vegetation yet still provide potential cover for species movement. Intensive land uses (i.e., urban development, roads, mining, etc.) may completely destroy vegetation and drastically alter ecological processes. The coefficients were assigned according to best scientific judgment regarding each land use's potential impact (Hauer et al. 2002; Mack 2006; NatureServe and Network ecology staff, personal communication, 2008).

Size Metric

Absolute Wetland Size

Because of the intrinsic importance of size in assessments, whether they are for restoration, conservation, or mitigation, etc., the Size metric has been made a standalone metric within a size attribute category at the same level as Landscape Context, Biotic, and Abiotic attribute groups.

Assessment Level: This is a Level 1 assessment completed in the office prior to fieldwork.

Definition: An assessment of current size (ha/acres) of a WOI relative to reference conditions of known and historic occurrences or the presence of area-sensitive indicator species.

Background: The metric rating is derived from the Patch Size metric of NatureServe's Ecological Integrity Assessment methodology (Faber-Langendoen et al. 2008a).

Alternatives: HGM V_{TRACT} – Size of the AA and all contiguous wetland areas (Klimas et al. 2006).

Confidence Value: Moderate. This metric requires further testing.

Rationale: The role of Absolute Wetland Size in assessing ecological integrity and function is complex (Faber-Langendoen et al. 2008a). Size can be important for maintaining plant and animal populations and the overall biodiversity of a wetland. That is, there can be minimum dynamic and resource area requirements for supporting a full suite of biota. Larger wetlands tend to support more diverse mosaics of vegetation communities and micro-habitat features. Larger wetlands are likely to be more resistant to hydrologic stressors and land-use impacts from the surrounding landscape. Thus, size can serve as a readily measured proxy for some ecological processes and the diversity of interdependent assemblages of plants and animals.

Yet, higher ratings for size may not always indicate increased integrity, per se. Absolute size within the same wetland type can vary widely for entirely natural reasons (e.g., valley confinement may naturally restrict the size of a functioning floodplain wetland). This is compensated by the Relative Wetland Size metric under Landscape Context and by taking into account to some degree of minimum functionality when setting the lower limits of size in the ratings table.

In addition, size can overlap with other Landscape Context elements such as Riparian Corridor Connectivity and Buffer Integrity. Both Size and Landscape Context metrics deal with spatial aspects of the occurrence. However, very large matrix wetland occurrences can essentially define Landscape Context and outweigh other factors. For example, a wetland of 1,000 ha (2,471 acres) may dominate a landscape while landscape connectivity or buffers are assessed perhaps for only the 15 ha (37 acres) or so area around an AA that all lies within the larger, intact wetland. Accordingly, large wetlands may need multiple AAs to evaluate context, particularly at the edges of the occurrence.

Overall, size has traditionally played an important role in assessing conservation value, restoration potential, and mitigation issues. For example, NatureServe's methodology for assigning an "Element Occurrence Rank" integrates integrity and conservation values and, with respect to size, larger element occurrences are generally presumed to be more valuable for conservation purposes, as they provide a better representation of the type being conserved. Larger wetlands may also afford more opportunities for restoration (larger source populations, room for manipulation, and buffering against immediate impacts). Because of its importance for assessing conservation and restoration values, as well as mitigation, the NMRAM follows NatureServe here and keeps the Absolute Size metric separate within a Size Rank attribute alongside Landscape Context, Biotic and Abiotic attributes, and their corresponding metrics.

Seasonality: This metric can be evaluated during any season. However, the use of growing-season imagery with adequate "green-up" can improve accuracy.

Assessment Protocol: Absolute Wetland Size is the size of the WOI as determined from existing maps or through a custom-mapping process in a GIS following the "natural rule" or other methods described above under the WOI determination above (pp. 25–26). Once a wetland area site has been delineated, the total area is then calculated using either a GIS or manually estimated using a dot-grid or similar manual area estimator.

Rating: Absolute Wetland Size rating is based on the area calculation using Table 4.15.

Table 4.15. Ratings for Wetland Size

Rating	Size	Description
4	> 10 ha (>25 acres)	Wetland size is very large compared to other examples of the same type and potentially capable of supporting a wealth of biodiversity in functional sustaining ecosystem
3	> 5 and ≤ 10 ha (>12 and ≤25 acres	Wetland size is large compared to other examples of the same type (e.g., within 10%–30%, based on known and historic occurrences
2	>2 and ≤ 5 ha (>5 and ≤ 12 acres)	Wetland size is moderate compared to other examples of the same type (e.g., within 30%–70% of known or historic sizes)
1	≤ 2 ha (≤ 5 acres	Wetland size is too small to sustain full diversity and full function of the type (e.g., less than 30% of known or historic occurrences)

Scaling Rationale: The rating scale for absolute size is dependent on the known natural range of variation and the intrinsic characteristic or functional scale of a wetland within the target subclass. None of the sites in the NMRAM sample set of wetlands for this subclass exceeded 25 ha (62 acres), but there were likely larger wetlands not available for sampling, and there is evidence that historically there were much larger riverine wetlands in the lower-elevation, wide-valley floodplains. When current sites in this sample were compared to the potential historical sizes in the wide floodplain, wetlands 150 to 1,000 ha (371–2,471 acres) or larger were certainly possible. But wetlands of this size are not currently known to exist in this domain. In contrast, at higher elevations a wetland of 5 ha (12 acres) or less might fill an entire valley floor and appear to be diverse and functional. Hence, the rating here is tempered by extant reference conditions and a considered evaluation of what constitutes a functional wetland from the perspective of process and biodiversity. While the needs of keystone and area-sensitive species such as beaver should be considered, the data on wetland size requirements for population sustainability for such species are elusive. Accordingly, size requirements are conservative and the ratings are scaled based on the distribution of sizes within the sampling framework, i.e., contiguous montane riverine wetlands in New Mexico that exceed 10 ha (25 acres) are considered sufficient to support a diverse biota component in conjunction with a complex mosaic of habitats. In contrast, when wetland size falls below 2 ha (5 acres), species richness is likely to be compromised along with wetland function.

BIOTIC METRICS

There are five Biotic metrics within this group designed to measure key biological attributes within a wetland that reflect ecosystem health. These include measures of vegetation native community composition and diversity; vegetation patch diversity, both across the wetland and with respect to vertical structure; the degree of non-native and invasive species incursion into a wetland; and the presence of key riparian tree regeneration.

RELATIVE NATIVE PLANT COMMUNITY COMPOSITION

Assessment Level: This metric is Level 1 and Level 2. Initial vegetation CT mapping may occur in the office followed by field verification and mapping.

Definition: A measure of the abundance of native wetland vegetation communities versus exotic-dominated communities.

Background: This is a new metric, derived from greenline and related monitoring techniques of Winward (2000) and the Relative Total Cover of Native Plant Species metric of Faber-Langendoen et al. (2008a).

Alternatives: "Vegetation Composition" in Faber-Langendoen et al. (2008a) is a summary of overall vegetation diversity based on a reconnaissance survey or plot data on the abundance of dominants by strata with the expectation that is usually only one plant community present. The rating is based on a semi-quantitative comparison of species composition and structure to a reference standard. The Faber-Langendoen et al. (2008a) "Relative Total Cover of Native Plant Species" uses the same data approach as above where overall native species abundance is estimated and rated at the same time. The Plant Community metric of Collins et al. (2008) is based on the *number* of strata layers and dominant/co-dominant species plus the percent invasives.

Confidence Value: Moderate to high. The metric is new and has received limited field testing. Further testing could result in adjustment to the rating scale.

Rationale: Faber-Langendoen et al. (2008a) suggest that those systems that are dominated by native species reflect high ecological integrity. Collins et al. (2008:75) state,

> the functions of whole-wetland systems are optimized when a rich native flora dominates the plant community, and when the botanical structure of the wetland is complex in 3-dimensional space, due to species diversity and recruitment, and resulting in suitable habitat for multiple animal species. Much of the natural microbial, invertebrate, and vertebrate communities of wetlands are adjusted to the architectural forms, phenologies, detrital materials, and chemistry of the native vegetation. Furthermore, the physical form of wetlands is partly the result of interactions between plants and physical processes, especially hydrology. A sudden change in the dominant species, such as results

from plant invasions, can have cascading effects on whole-system form, structure, and function.

High native plant species diversity generally indicates overall high biotic diversity, stability of wetland biotic communities, increased wildlife habitat and species diversity, and overall higher resilience and resistance to environmental disturbance. In contrast, high numbers of exotic plant species indicate degraded or disturbed wetlands.

Seasonality: This metric should be assessed during the growing season when dominant species can be easily recognized.

Assessment Protocol: This metric is based on the vegetation map described above in which each polygon is assigned to CTs during the reconnaissance and, in turn, the CTs are evaluated with respect to native species composition and their relative abundance. The polygon assignment to CTs is an iterative process whereby the first polygon visited is described with respect to the two top dominant species by height strata. There are three strata: a Tall Woody Stratum composed of trees and shrubs greater than 5 m tall (15 feet); a Short Woody Stratum of trees and shrubs under 5 m (15 feet), and a Herbaceous Strata made up of graminoids (grasses and grass-like plants) and forbs. For each of the tall and short wood strata, total stratum vegetative canopy cover must exceed 10% before a species is recorded; for the herbaceous stratum, total cover must be greater than 5%. The species are recorded in the order of their relative abundance by stratum, and a species can only appear once within a CT designation (if a species occurs in two strata, it is assigned to the strata it is most abundant in). The next polygon visited is either assigned to the same CT if it has the same composition and structure or, if not, a new CT is designated and the polygon assigned to it. This process is continued for all polygons mapped in the AA. Documentary photos of the various CTs are recommended.

Once the CT list has been compiled and the polygons assigned, the relative abundance of each CT is estimated as a percentage of entire AA. This can be done in the GIS or visually estimated. For each mapped CT, a Raw Community Type Native Score is assigned based on native versus exotic composition of the dominants in each strata following the guidelines in Table 4.16. This value is multiplied by the % AA decimal value to arrive at an area-weighted score. The weighted scores are summed to give the Final Weighted CT Native Composition Score for the AA, and this, in turn, is used to rate the Relative Native Plant Community Composition metric using Table 4.16. An example of how the Relative Native Community Type Composition score is calculated is presented in Appendix A.

Table 4.16. CT Native Composition Scoring,

CT Score	Tree Stratum (>10% Cover)	Shrub Stratum (>10% Cover)	Herbaceous Stratum (>5% Cover)
Forested Wetland			
0.00	E	E or absent	E or absent
0.25	E	E or absent	N/E or unknown
0.50	E	E or absent	N
0.75	E	N/E or unknown	E or absent
1.00	E	N/E or unknown	N/E or unknown
1.15	E	N/E or unknown	N
1.30	E	N	E or absent
1.40	E	N	N/E or unknown
1.50	E	N	N
1.60	N/E or unknown	E	E
1.70	N/E or unknown	E	N/E or absent or unknown
1.80	N/E or unknown	E	N
1.90	N/E or unknown	N/E or unknown or absent	E
2.00	N/E or unknown	N/E or unknown or absent	N/E or unknown or absent
2.10	N/E or unknown	N/E or unknown or absent	N
2.20	N/E or unknown	N	E
2.30	N/E or unknown	N	N/E or absent or unknown
2.40	N/E or unknown	N	N
2.50	N	E	E
2.60	N	E	N/E or unknown
2.70	N	E	N or absent
2.85	N	N/E or unknown	E
3.00	N	N/E or unknown	N/E or unknown
3.25	N	N/E or unknown	N or absent
3.50	N	N or absent	E
3.75	N	N or absent	N/E or unknown
4.00	N	N or absent	N or absent
Shrub Wetland			
0.00		E	E or absent
0.50		E	N/E or unknown
1.00		E	N
1.50		N/E or unknown	E
2.00		N/E or unknown	N/E or unknown or absent
2.50		N/E or unknown	N
3.00		Native	E
3.50		Native	N/E or unknown
4.00		Native	N or absent
Herbaceous Wetland			
0.00			E
2.00			N/E or unknown
4.00			N
Sparsely Vegetated			
0.00			Human-disturbed ground (e.g., roads, cleared areas)
2.00			Mixed natural/human-disturbed ground
4.00			Natural disturbed ground (e.g., sand bars, side channels)

E = exotic-dominated CT strata; N/E = mixed exotic native CT strata; N = native-dominated CT strata or strata naturally absent.

Ratings: Relative Native Community Type Composition ratings are calculated based on the distribution of the summary Site CT Native Score using Table 4.17.

Table 4.17. Relative Native Plant Community Composition Rating

Rating	Site CT Native Score
4	≥ 3.5 (≈ <10% non-native)
3	≥ 2.75 and <3.5 (≈ 10%–20% non-native)
2	≥ 2.0 and <2.75 (≈ 20%–50% non-native)
1	<2.0 (≈ <50% non-native)

Sites are rated into classes based on the range of the Site CT Native Score.

Scaling Rationale: Rating classes were based on preliminary field assessments conducted in 2009. In general, when evaluating exotic species incursions into native communities, even low amounts have been considered highly detrimental to the overall biodiversity values and integrity of a wetland. For example, Faber-Langendoen et al. (2008a) present a five-level scale[3] wherein the "A" score exotics cannot exceed 1% relative cover; "B" = 1%–5%, "C" = 5%–20% "D" = 20%–50%, and E > 50% exotic-dominated. While the NMRAM scale still favors natives, it is less demanding, e.g., a site rated as a 2 ("C" score) essentially states that a site is still dominated by natives, but exotics are estimated to comprise approximately between 20% and 50% of the community composition, sites rated as a 3 ("B" score), 10% to 20% exotics, and sites rated as a 4 ("A" score) 0% to 10%.

VEGETATION HORIZONTAL PATCH STRUCTURE

Assessment Level: Vegetation Horizontal Patch Structure is a Level 1 and Level 2 metric. Initial mapping of vegetation patch structure in the office is followed by field verification and mapping.

Definition: The Vegetation Horizontal Patch Structure metric is an assessment of general vegetation patch diversity and complexity of the patch pattern (interspersion among vegetation patch types) within an AA.

Background: The Vegetation Horizontal Patch Structure metric is derived from CRAM 5.0.2, Horizontal Interspersion and Zonation (of Biotic Structure) (Collins et al. 2008).

Alternatives: A more detailed vegetation cross-section composition alternative can be found in Winward (2000).

Confidence Value: High. The metric has been field tested and is sensitive to the range of condition within the reference domain.

Rationale: Multiple horizontal plant patches across the AA indicate high biotic diversity, diverse habitat structure for wildlife, and predictable ecosystem processes.

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[3] Faber-Langendoen et al. (2008a) use a scoring system of A, B, C, D, and E. In the NMRAM rating system A = 4; B = 3; C = 2; and D = 1. An "E" score is not recognized in the NMRAM.

Seasonality: Maps should date from the growing period, but analysis can happen at any time.

Assessment Protocol: Using the vegetation patch map developed as part of the reconnaissance survey, Vegetation Horizontal Patch Structure is rated using modal pattern diagrams for the subclass (Figure 4.2). The mapped patch pattern is matched as closely as possible to one of the example diagrams and then the rating value assigned per Table 4.18.

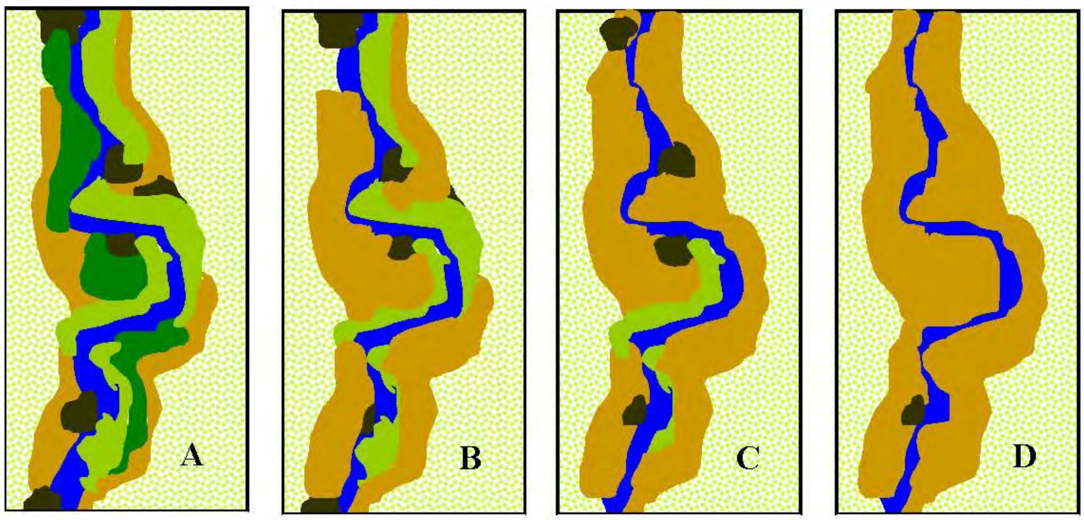

Figure 4.2. Schematic diagrams illustrating varying degrees of interspersion of plant zones for riverine wetlands. Each zone comprises at least 5% of the AA (from Collins et al. 2008).

Rating: Overall Vegetation Horizontal Patch Structure ratings are provided in Table 4.18 (from Collins et al. 2008).

Table 4.18. Ratings for Overall Vegetation Horizontal Patch Structure

Rating	Alternative States
4	AA has a diverse patch structure (>4 patch types) and complexity. A dominant patch type would be difficult to determine.
3	AA has a moderate degree of patch diversity (3 patch types present) and complexity. A single, dominate patch type may be present, although the other patch types would be well represented and have more than one occurrence in the AA.
2	AA has a low degree of patch diversity and complexity. Two or three patch types may be present; however, a single, dominant patch type exists with the others occupying a small portion of the AA.
1	AA has essentially little to no patch diversity or complexity. The AA is dominated by a single patch type. Other patch types, if present, occur infrequently and occupy a small portion of the floodplain.

Scaling Rationale: High interspersion (high patch diversity and patch number) suggest high function in riverine wetlands. In a GIS, this can be calculated numerically in terms of the number of patch types and the number of patches. When this is done, the above qualitative scale exhibits a more or less linear trend across scalar values. In addition, within the target domain, scores have been well distributed among scalar classes.

VEGETATION VERTICAL STRUCTURE

Assessment Level: Vegetation Vertical Structure is a field-based, Level 2 metric.

Definition: An assessment of the overall vertical structural complexity of the vegetation canopy layers across the AA, including presence of multiple strata and age/size classes.

Background: The concept of Vegetation Vertical Structure is derived from CRAM 5.0.2, Vertical Biotic Structure (Collins et al. 2008). However, the potential vertical structure class types used here are based on a riparian vegetation structural type classifications developed by Hink and Ohmart (1984) and Callahan and White (2004) for the Rio Grande of New Mexico. This system was originally formulated to characterize stand structure of dominant woody species for vegetation mapping and biotic inventory, but it has since been adapted to many uses within the Rio Grande, including wildlife habitat potential. Their structural type categories and map units can be directly cross-referenced with USFWS Resource Category ranks 1–4 and the 36 Middle Rio Grande USFWS vegetation CTs (USACE et al. 2007).

Alternatives: Alternatives include CRAM 5.0.2 Vertical Biotic Structure (Collins et al. 2008) and Vegetation Structure (Faber-Langendoen et al. 2008a).

Confidence Value: To be determined. The metric has been revised with limited field testing. Similar approaches used elsewhere suggest that this should be a robust metric.

Rationale: Vegetation Vertical Structure is an integral part of habitat structure and associated processes. Collins et al. (2008) state wetland vertical vegetation structure is correlated with overall biodiversity and can positively affect hydrological functions through rainfall interception and reduction of evaporation. Increased vertical structure indicates multiple plant life forms, more habitat complexity for wildlife, and higher overall biotic diversity for the AA. Structure is thought to be a particularly important component of bird habitat (Wilson 1974; Rotenberry and Wiems 1980). Although Hink and Ohmart (1984) vegetation structural classifications were developed for riparian communities along the Middle Rio Grande, the same structural class types are appropriate for this Upper Rio Grande riverine subclass.

Seasonality: This metric is best assessed in late spring to early fall when vegetation foliage is present.

Assessment Protocol: Vegetation Vertical Structure is evaluated during reconnaissance and mapping. Each mapped patch is assigned one of the six vertical structure classes that best matches the model, with the most common condition for the polygon as defined by Hink and Ohmart (1984).

VEGETATION VERTICAL STRUCTURE TYPE DEFINITIONS (FROM CALLAHAN AND WHITE 2004)

1. Multiple Story Communities (Woodlands/Forests)

Type 1 – Tall trees with a well-developed understory.

Tall or mature to mixed-aged trees (>12 m [40 feet]) with canopy covering >25% of the area of the community (polygon) and understory layer (0–4.6 m [0–15 feet]) covering >25% of the area of the community (polygon). Substantial foliage is in all height layers. Photograph from Callahan and White (2004).

Type 2 – Tall trees with little or no understory.

Tall or mature to mixed–aged trees (>12 m [40 feet]) with canopy covering >25% of the area of the community (polygon) and understory layer (0–4.6 m [0–15 feet]) covering <25% of the area of the community (polygon). Majority of foliage is over 9 m (30 feet) above the ground. Photograph from Callahan and White (2004).

Type 3 – Intermediate-sized trees with dense understory.

Intermediate sized trees (6–12 m [20–40 feet]) with canopy covering >25% of the area of the community (polygon) and understory layer (0–4.6 m [0–15 feet]) covering >25% of the area of the community (polygon). Majority of foliage is between 0 and 9 m (0–30 feet) above the ground. Photograph from Callahan and White (2004).

Type 4 – Intermediate-sized trees with little or no understory.

Intermediate-sized trees (6–12 m [20–40 feet]) with canopy covering >25% of the area of the community (polygon) and understory layer (0–4.6 m [0–15 feet]) covering <25% of the area of the community (polygon). Majority of foliage is between 4.6 and 9 m (15–30 feet) above the ground. Photograph from Callahan and White (2004).

2. Single-story Communities (Shrublands and Herbaceous)

Type 5 – Stands with dense shrubby growth.

Young tree and shrub layer only (1.5–6 m [5–20 feet]) covering >25% of is the area of the community (polygon). The majority of vegetation is between 0 and 4.6 m (0–15 feet] and may include herbaceous vegetation underneath the woody vegetation. Photograph from Callahan and White (2004).

Type 6 – Very young, low growth, and herbaceous.

Young understory layer (0–1.5 m [0–5 feet]) or herbaceous vegetation covering >25% of the area of the community (polygon). Majority of foliage is between 0 and 1.5 m (0–5 feet). Photograph upper Rio Santa Barbara by Y. Chauvin (2009).

Scoring: The diversity of vertical vegetation structural types present at an AA will determine the rating. Using the data gathered during the reconnaissance survey, the AA is scored based on the structural richness provided by both the individual structural types and the mosaic of structural types within the AA. Because some structural types provide more overall vertical structure than others, the six structure types are grouped and weighted differently. Types 1 and 3 are grouped into the High Structure Forest class. Types 2 and 4 are the Low Structure Forest class. Type 5 is the Shrubland class, and Type 6 is the Herbaceous class. High Structure Forests provide more vertical structure than any other type individually, and thus are weighted more heavily in the scoring (Table 4.19). Low Structure Forests, with more structure than Shrublands or Herbaceous, are weighted intermediately, while Shrublands and Herbaceous are given the lowest weight individually. The most complex vertical structure is attained by sites that combined a number of different structure types in proximity to one another. Thus, for all structure types, higher scores are obtained in combination with another structure class (see Table 4.19).

Rating: Vegetation Vertical Structure ratings for the AA are based on various combinations of the structure type classes. The more structural types that are present, the higher the rating.

Table 4.19. Ratings for Vegetation Vertical Structure

Rating	Alternative States
4	High structure forest (Type 1 or 3) **plus** shrubland (Type 5) **and/or** herbaceous (Type 6) or Low structure forest (Type 2 or 4) **plus** shrubland (Type 5) **and** herbaceous (Type 6)
3	High structure forest (Type 1 or 3) alone or High structure forest (Type 1 or 3) **plus** only low structure forest (Type 2 or 4) or Low structure forest (Type 2 or 4) **plus** shrubland (Type 5) **or** herbaceous (Type 6)
2	Low structure forest (Type 2 or 4) alone or Shrubland (Type 5) **and** herbaceous (Type 6)
1	Shrubland (Type 5) alone or Herbaceous (Type 6) alone

Scaling Rationale: Qualitative assessment of Vegetation Vertical Structure represents the range in variability in vertical complexity of the wetlands vegetation and ecological diversity. High scores represent highly complex and tall vertical structure, which should support a higher diversity of wildlife species than low stature, low vertical complexity vegetation. Different species of wildlife and wetland plants have different structural needs. Weighting Vertical Vegetation Structure scores for a complexity of vertical structure across vegetation patches within the AA, as well within patch structural complexity, accounts for this aspect of vertical vegetation complexity.

NATIVE RIPARIAN TREE REGENERATION

Assessment Level: Native Riparian Tree Regeneration is a Level 2, field-based metric.

Definition: This metric assesses the abundance and spatial distribution of riparian tree reproduction across the AA (tree seedling, saplings, and poles under 12.7 cm (5 inches) diameter at breast height (dbh).

Background: The Native Riparian Tree Regeneration metric is derived from Winward (2000) and Burton et al. (2008), modified for canopy cover young-aged trees rather than stem counts by size classes.

Alternatives: Winward (2000) and Burton et al. (2008) provide alternatives that approach Level 3 metrics because of the intensity of stem-count measurements within plots and across stands.

Confidence Value: Low to moderate.

Rationale: Healthy functioning riverine wetlands should consist of a mosaic of woody vegetation stands that include stands of both mature and young regeneration trees. Absence of young trees may indicate ecological dysfunction. Generally, native riparian trees reproduce in patches on disturbed, usually recently flooded ground. Because reproduction is closely tied to natural disturbance cycles (Crawford et al. 1993), the presence of numerous patches of differently aged native tree species acts as a surrogate measure for a functional natural-disturbance regime that includes flooding and sediment transport. Hence, the limited presence or absence of patches of young trees within a riverine wetland system is of particular concern. Within this subclass, the tree species for which this metric is applicable are narrowleaf cottonwood, Rio Grande cottonwood, lanceleaf cottonwood (*Populus acuminata*), peachleaf willow, Goodding's willow (*Salix gooddingii*), thinleaf alder, and water birch.

Seasonality: This metric can be measured year-round.

Assessment Protocol: During the reconnaissance survey, estimate percent cover of native tree reproduction. Reproduction includes seedlings (<5 cm [2 inches] diameter at breast height [dbh]; <1.5 m [5 feet] height), saplings (<5 cm [2 inches] dbh; > 1.5 m [5 feet] height), and poles (5–13 cm [2–6 inches dbh). Estimate the percent cover by vegetation patch or mapped polygon in the AA.

Rating: The Native Riparian Tree Regeneration rating based on the estimated cover and patch density as provided in Table 4.20.

Table 4.20. Native Riparian Tree Regeneration Rating

Score	Native Riparian/Wetland Tree Seedling and Saplings Regeneration
4	Native poles, sapling, and seedlings trees well represented; obvious regeneration, many patches or polygons with >5% cover; typically multiple size (age) classes
3	Native poles, saplings and/or seedlings common; scattered patches or polygons with 1%–5% cover; size (ages) classes few.
2	Native poles, saplings and/or seedlings present but uncommon; restricted to one or two patches or polygons with, typically <1% cover); little size (age) class differentiation.
1	Native poles, saplings, and/or seedlings absent (0% cover).

Source: Lemly and Rocchio (2009).

Scaling Rationale: Healthy and regenerating riparian woodlands should have a relatively large proportion of young trees or of stands of young trees. Based on expert knowledge, reproduction that exceeds 15% cover of an AA would be exceptional in Southwest riparian ecosystems.

Invasive Exotic Plant Species Cover

Assessment Level: Invasive Exotic Plant Species Cover is a Level 2, field-based metric.

Definition: The Invasive Exotic Plant Species Cover is a measure of the total percent cover of a set of exotic plant species that are considered invasive based on the New Mexico list of noxious weeds (NRCS 1999). This includes Class C weeds such as saltcedar, Russian olive, and Siberian elm that are considered invasive and widespread. Species of specific concern for a given project or those that are not yet on the New Mexico list of noxious weeds could be included in this measure on a project-specific basis.

Background: The Invasive Exotic Plant Species Cover metric is derived from NatureServe's EIA Working Group, based in part on work by Tierney et al. (2008) and Miller et al. (2006).

Confidence Value: Moderate.

Rationale: Invasive, non-native species can have a significant impact on community diversity and function. High levels of invasive exotic species within a riparian plant community are a direct threat to maintaining wetland function and biodiversity (Stenquist 2000; Bailey et al. 2001). While the mechanisms underlying the "invasive" character of some species is an active area of research, there are indications that riparian sites that have been altered or significantly impacted by human activity may be more prone to invasion. Invasive exotic species tend to thrive in riparian systems when natural hydrologic and geomorphic functions have been disturbed, particularly where the hydrological regime has been altered and is controlled. Thus, this metric is both a measure of current vegetation condition and but also an indicator of the status of the hydrological regime.

Seasonality: Exotic cover is best assessed from summer to early fall.

Assessment Protocol: The metric is modified from Faber-Langendoen et al. (2008a, 2008b, 2009). Protocols involve field qualitative and quantitative sampling, and photo documentation. Using the New Mexico Noxious Weed list (Appendix B), record the invasive species found in the AA during the reconnaissance survey and estimate the cover invasive species in each mapped patch type, noting roughly the percentage cover for each mapped patch type within the AA and listing them in the comments field.

After completing the reconnaissance survey, estimate the total percentage cover of invasive exotic species for the AA based on patch values, being particularly mindful of the percentage break points used for rating this metric (Table 4.21). If the invasive exotic species of particular interest at a given site are woody (e.g., saltcedar), it may be possible to assess this metric in GIS using fine-scaled satellite imagery or aerial photographs, if there is good ground control. However, there are a number of invasive exotic species that are herbaceous and require on the ground survey of the site (Figure 4.3).

Figure 4.3. Stand dominated by Canada thistle (*Cirsium arvense* – Class A noxious weed) and Baltic rush (photo: Y. Chauvin).

Rating: Invasive Exotic Plant Species Cover Ratings are based on estimated percent cover across the AA (Table 4.21).

Table 4.21. Ratings for Invasive Exotic Plant Species Cover Based on Estimated Percent Cover across the AA

Rating	Relative Cover of Invasive Exotic Plant Species
4	Key invasive species <1% cover
3	Key invasive species 1%–5%
2	Key invasive species 5%–10%
1	Key invasive species >10%

Modified from Faber-Langendoen et al. (2008a).

Scaling Rationale: The scaling rationale follows Faber-Langendoen et al. (2008a, 2008b and 2009). The ratings include non-native invasive species and do not include native invasive species or exotic species, which are not considered invasive.

ABIOTIC METRICS

There are five Abiotic condition metrics that reflect the functional status of a wetland, three of which focus on the factors affecting the hydrology at a site and its ensuing effects on biodiversity and ecosystem services (Hydrologic Connectivity, Channel Stability, and Macrotopographic Complexity). These metrics provide a three-dimensional view of geomorphic processes that influence wetland function and condition. Two are soil factors that reflect direct disturbance impacts within the AA such as livestock grazing, roads, and other anthropogenic disturbances (Steam Bank Stability and Cover and Soil Surface Condition).

HYDROLOGIC CONNECTIVITY

Assessment Level: This is a Level 2 metric and is measured in the field.

Definition: Hydrologic Connectivity is an assessment of the ability of the water to flow into or out of the wetland or to inundate adjacent areas.

Background: This metric is derived from CRAM (Collins et al. 2008). An alternative to Hydrologic Connectivity is frequency of surface flooding in Hauer et al. (2002), a regional guidebook for applying the HGM approach to assessing wetland functions of riverine floodplains in the northern Rocky Mountains.

Confidence Value: High. The metric has been field tested and is sensitive to the range of condition in the reference domain, adopted from Collins et al. (2008) where it has been used extensively.

Rationale: Hydrologic Connectivity is an assessment of the relationship of the river channel to its floodplain at the bankfull stage. The adjoining floodplain is constructed by the river in the present climate and overflowed at times of high discharge (Dunne and Leopold 1978). The Hydrologic Connectivity between the river and riverine wetlands formed on its floodplain supports ecologic function and plant and wildlife habitat diversity by promoting exchange of water, sediment, nutrients, and organic carbon (Collins et al. 2008).

Seasonality: This metric can be evaluated during any season when the river is below the bankfull stage. Flood stage above bankfull makes it dangerous or difficult to identify the bankfull depth and score.

Assessment Protocol: Hydrologic Connectivity is assessed based on the degree of channel entrenchment (Leopold et al. 1964; Rosgen 1996). Entrenchment is a field measurement calculated as the flood-prone width divided by the bankfull width; bankfull width is the channel width at the height of bankfull flow, and flood-prone channel width is measured at the elevation of twice the maximum bankfull depth.

Hydrologic Connectivity should be assessed at three typical cross-sections, one each in the upper, middle, and lower segments of the reach, depending on the linear extent of the AA. The measurements should be made within each riffle section, the straight section, or inflection point between two meander curves (Figure 4.4). Measurements should not be made in meander bends or in pools where the increased depth will not provide a representative channel depth and thus overestimate the entrenchment ratio. Similarly, measurements should not be made where deflectors, such as rocks or logs, make the stream especially narrow or create exceptionally wide backwater conditions, in areas affected by beaver activity, or in areas where management/manipulation confounds the presence of appropriate bankfull indicators. Ideally, the linear extent of the AA will contain two meander bends, allowing for the establishment of three transects. In the event that this condition is not met, the number of transects should be reduced to two to avoid pseudo-sampling (e.g., taking two samples in one riffle section) or sampling in meander bends or pools. In step-pool systems, transects should be located in the rapids between the pools (Figure 4.5).

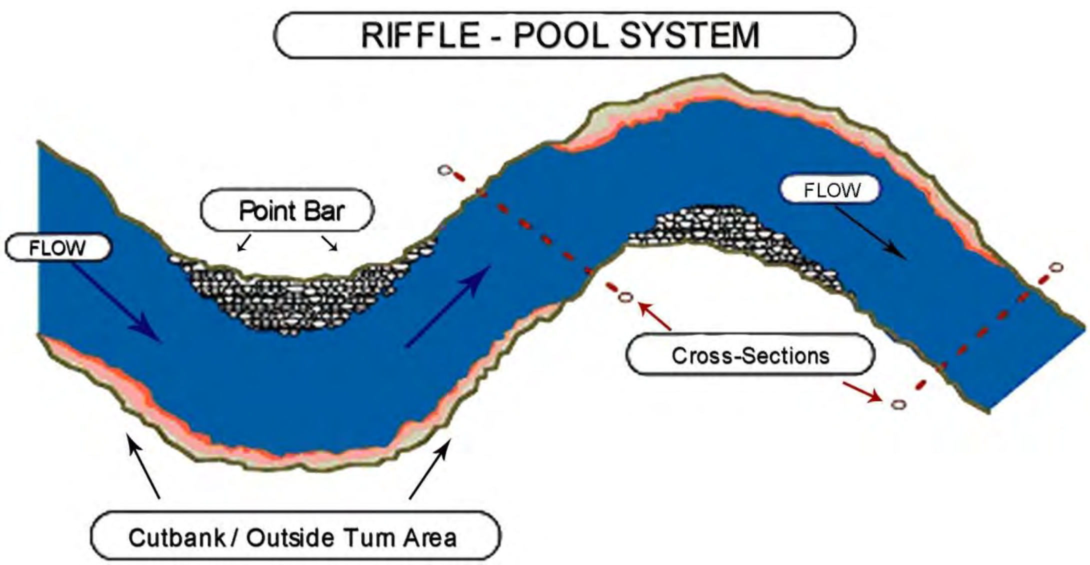

Figure 4.4. Cross-section locations for riffle-pool systems (reproduced from EPA 2011 after Silvey in Rosgen 1996).

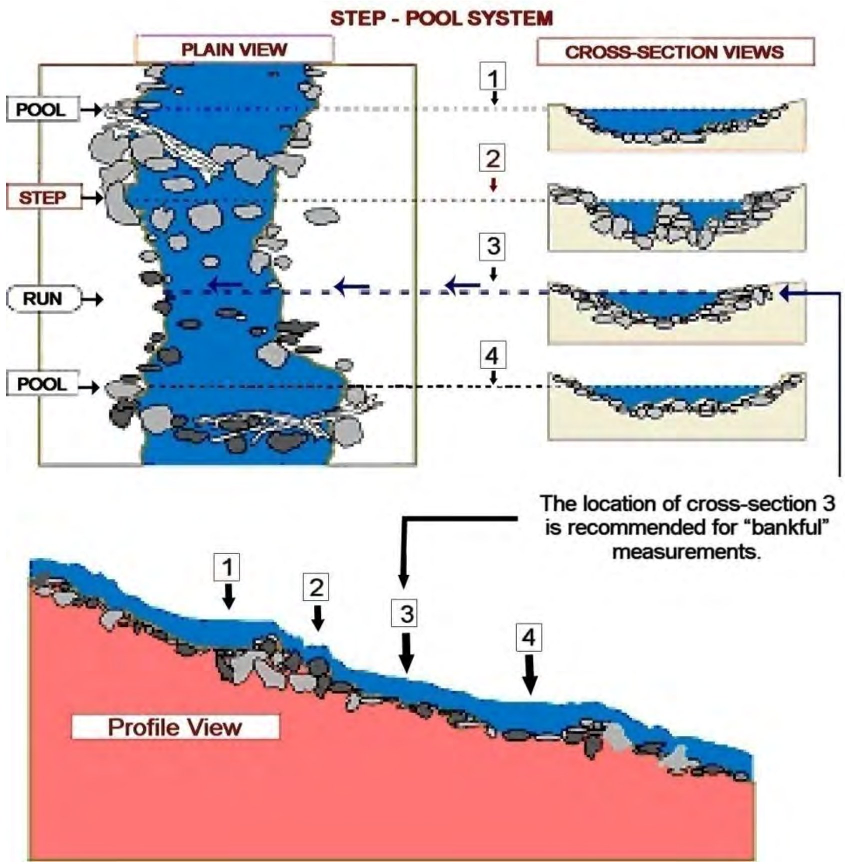

Figure 4.5. Cross-section locations for step-pool systems (reproduced from EPA 2011 after Silvey in Rosgen 1996).

The procedural steps, modified from Collins et al. 2008, for assessing Hydrologic Connectivity are:

1. Measure bankfull width using field indicators to identify the bankfull elevation;
2. Measure bankfull depth (maximum depth below the bankfull indicators at the bankfull width, used to estimate the flood-prone width) (Figure 4.6);
3. Calculate flood-prone depth (flood-prone depth = 2 × bankfull depth, used to estimate flood-prone width);
4. Measure the flood-prone width from bank to bank at height of the flood-prone depth.
5. Calculate entrenchment ratio (entrenchment ratio = flood-prone width/bankfull width). For example 24/15 = 1.6;
6. Repeat at two additional cross-sections and calculate the mean entrenchment ratio across three sites.

The key measurement is determining the bankfull width. The bankfull stage is the determination of the level of the floodplain and corresponds to the discharge at which channel maintenance is most effective (Dunne and Leopold 1978). Bankfull discharge, which occurs every one to two years in New Mexico (Moody et al. 2003), is the discharge whereby sediments are most effectively moved to form or remove bars, form meanders and bends, and shape the average geomorphic characteristics of the channel. In the field, evidence of the bankfull elevation[4] includes:

- changes in bank slope, such as from a steep bank to a more gentle slope or a change from a vertical bank to a flat floodplain;
- changes in sediment texture of deposited material from clay to sand, sand to pebbles, or boulders to pebbles;
- vegetation limits or changes in vegetation;
- consistent alluvial depositional features, such as flood-deposited silt;
- scour lines; and
- elevation of point bars and other floodplain features.

When assessing the bankfull elevation, it is important to look for consistent and corroborating bankfull indicators. The presence of high-water marks, such as wrack lines or debris hanging in trees or on brush or vegetation that has recently colonized within the boundaries of the bankfull channel (Rosgen 1996), may be deceiving. These indicators may be the result of high flows or may be deposited at a higher elevation than the mean water surface of the flow that deposited it. Conversely, vegetation can encroach within the channel below bankfull during periods of drought or low flow.

In smaller streams, such as those predominantly found in the Mid-montane subclass, a measuring tape, stadia rod (for measuring depth), rebar, and clamps and pin flags (to indicate the bankfull elevation) are all that is required to measure Hydrologic Connectivity. In areas where there is a very wide, flat floodplain or in areas dominated by dense vegetation, a quality hand level and stadia rod are recommended additions to the basic equipment list.

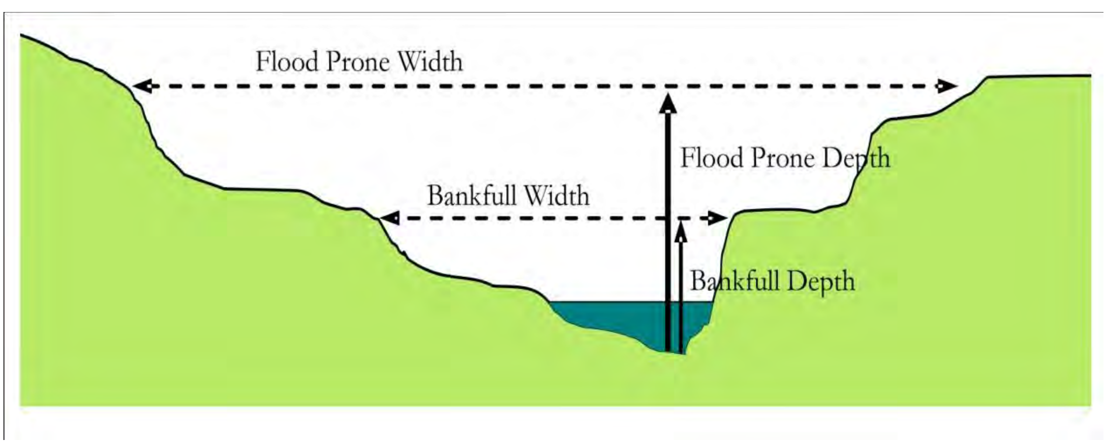

Figure 4.6. Parameters used to calculate channel entrenchment (from Collins et al. 2008).

[4] Users may find the U.S. Forest Service video "A Guide for Field Identification of Bankfull Stage in the Western United States" helpful for identifying bankfull indictors. This video can be viewed online at: http://www.stream.fs.fed.us/publications/videos.html

Rating: The overall ratings for Hydrologic Connectivity are outlined in Table 4.22.

Table 4.22. Ratings for Overall Hydrologic Connectivity

Rating	Alternative States
4	Average entrenchment ratio is > 2.2;
3	Average entrenchment ratio is 1.9 to 2.2
2	Average entrenchment ratio is 1.5 to 1.8
1	Average entrenchment ratio is < 1.5

The NMRAM recommends using the narrative approach (Table 4.23) when beaver ponds inundate the entire, normally active floodplain or preclude identification of the bankfull discharge or floodplain width, when users cannot determine bankfull discharge, or if the bankfull discharge extends beyond what can be accurately measured with the equipment at hand. The narrative approach assesses the connectivity of the stream to its floodplain, but is not based on channel entrenchment.

Table 4.23. Narrative Rating Approach for Hydrologic Connectivity

Rating	Description
4	Fully connected to the natural floodplain. Broad floodplain except where naturally constricted by valley. Stream provides adequate hydrology to utilize floodplain. Indicators of bankfull discharge are at the bank/floodplain transition, with over-bankfull flows likely to inundate a broad area of floodplain. Floodplain supports riparian vegetation and shows signs of overbank sediment deposition. Beaver ponds inundate the entire, normally active floodplain and preclude the identification of bankfull indicators and the active floodplain width.
3	Access to the floodplain not limited or moderately limited by incision, channelization, etc., but less frequent inundation than fully connected streams described above (as noted by bankfull indicators below floodplain). Floodplain supports a riparian overstory, but some understory plants may be upland. An inset floodplain supporting riparian vegetation may also be present.
2	Somewhat incised channelized or modified, but with an inset floodplain formed, which is regularly inundated and supports appropriate vegetation and sediment regimes. The stream has no access to the natural floodplain due to incision, channelization, or flow modification, and the natural floodplain does not support riparian vegetation expect for relatively long-lived phreatophytes (e.g., cottonwood, saltcedar, etc).
1	Fully disconnected from floodplain, either through incision (no inset floodplain), bank modification/channelization, or hydrologic modification (i.e., abandonment of floodplain due to decreased peak flows). Indicators may include upland vegetation, lack of fresh sediment deposits, etc.

Scaling Rationale: Streams within the subclass are characterized as “C” or “E” streams using the Rosgen (1996) stream classification. These streams are characterized as having entrenchment ratios greater than 2.2. Decreases from this typical state are indicative of disconnection of the stream from its floodplain (i.e., less frequent floodplain inundation). Greater departures from typical entrenchment ratios are reflective of less hydrological connectivity.

MACROTOPOGRAPHIC COMPLEXITY

Assessment Level: This is a Level 2, and is field-based.

Definition: This metric describes the structural complexity of riverine wetlands based on the richness of indicators that demonstrate connectivity between the main channel, side channels, floodplain scour pools, and other floodplain features. Macrotopographic complexity represents a plan view of the AA. This metric focuses on hydrologic and physical features and looks for evidence of fluvial processes

Background: Macrotopographic Complexity is derived from Hauer et al. (2002), a regional guidebook for applying the HGM approach to assessing wetland functions of riverine floodplains in the northern Rocky Mountains. The NMRAM adds additional indicators representative of this subclass based on findings from reference site visits and those included in CRAM (Collins et al. (2008).

Alternatives: An alternative is structural patch richness, from Collins et al. (2008). CRAM treats this metric as an assessment of actual to potential patch types found within an AA, i.e., patch richness. Patches include examples of physical and biological structure or habitats. However, the Macrotopographic Complexity metric focuses on hydrologic and physical features and looks for evidence of fluvial processes, whereas structural patch richness also includes indicators of wildlife activity (e.g., animal mounds and burrows) or potential wildlife habitats.

Confidence Value: High. Metric has been field tested and is sensitive to the range of condition in the reference domain.

Rationale: Rivers act as conveyor belts of both water and sediment, the movement of which occurs linearly in the direction of flow and horizontally as rivers periodically overflow their banks and spill onto the floodplain. This interaction between channel and floodplain is indicative of a "natural" hydrograph and is manifested by structural complexity, including a main channel, side channels, floodplain scour pools, and other floodplain features. Assessing the distribution, age, connectivity, and abundance of these features is a surrogate for a Tier 3 hydrologic study using historic stream gage data among other sources.

Seasonality: This metric can be evaluated during any season.

Assessment Protocol: This protocol is field based and qualitative. As part of the a reconnaissance survey, assessors should walk the length and width of the AA to familiarize themselves with the abiotic conditions by checking off Macrotopographic Indicators (Table 4.24Table 4.24) in the upper, middle, and lower segments of the AA and creating a sketch map of these features to guide the rating.

Table 4.24. Macrotopographic Complexity Checklist

Upper Segment	Middle Segment	Lower Segment	Field Indicators (check all existing conditions)
☐	☐	☐	Side channels
☐	☐	☐	Backwater
☐	☐	☐	Pool riffle complex
☐	☐	☐	Runs
☐	☐	☐	New depositional area
☐	☐	☐	Oxbow lakes
☐	☐	☐	Point or in-channel bars
☐	☐	☐	Terraces
☐	☐	☐	Deep pools
☐	☐	☐	Beaver ponds
☐	☐	☐	Depressional features on floodplains
☐	☐	☐	Debris jams
☐	☐	☐	Wrack lines
☐	☐	☐	Other

Fluvial geomorphic features created by the movement of water and sediment include:

- Tributaries or swales – While perennial tributaries serve as a way to demarcate the linear extent of an AA, intermittent tributaries or swales (that lack a defined bed and bank and) that convey seasonal runoff to the main channel act as zones of infiltration and groundwater recharge should be identified.
- Backwaters – Backwaters or large still eddies that provide fish spawning habitat outside the main current of the stream. These features may be disconnected at low water and open-access during high water.
- Side channels – Secondary channels or swales parallel to the existing channel that may carry water at times of high flow.
- Riffle pool complex – A feature of channel bed topography in which alternating deep (pools) and shallow (riffles) reaches form through a combination of scour and deposition at higher flows and are maintained at lower flows. Riffles result in a turbulent surface and high dissolved oxygen levels in the water. Pools are characterized by a slower stream velocity, a smooth surface, and a finer substrate.
- Oxbow lakes – Permanent off-channel ponded areas.
- New depositional areas – Evidence of sediment transport. Areas of transient bedload that may not form into bars.
- Point or in-channel bars – Depositional areas on the inside bend in a stream or within a straight channel.
- Terraces – An abandoned floodplain.

- Deep pools – Areas in the fluvial channel that retain water during low flow and are generally too deep to support emergent vegetation. Can be considered a separate indicator if riffle pool complexes are not present.
- Beaver ponds – Shallow, palustrine wetlands occupying all or some of the channel, converting it from a lotic to lentic aquatic system.
- Depressional features on floodplains – Shallow, seasonally inundated depressions composed of very fine depositional sediments that may have concentric rings of vegetation.
- Debris jams – Accumulation of large, woody debris in channel that partially obstructs water flow.
- Wrack lines – Accumulation of natural and non-natural debris at the high water line.

Rating: The overall Macrotopographic Complexity ratings are found in Table 4.25, which is used to select the description most applicable to conditions within the AA.

Table 4.25. Ratings for Overall Macrotopographic Complexity

Rating	Description
4	Multiple side and/or backwater channels and a mix of and new depositional surfaces are present in the channel and on the floodplain, e.g., point bars and wrack lines, respectively. Oxbows may also be present within an active floodplain. The channel includes pool/riffle complexes with limited or no runs, especially at lower water. Additional indicators outside the channel and may include terraces, tributaries, and swales. Eight or more indicators from the checklist present, although this varies depending on their size and watershed location.
3	One side and/or backwater channel is present with some evidence of active floodplain development. Floodplain surfaces exhibit some new depositional areas. Channels include at least one pool/riffle complex. AAs dominated by beaver ponds receive a 3 rating. Six to eight indicators from the checklist present.
2	Side and backwater channels are few, obscure, and very old. No new or recently inundated channels are present. Floodplain surfaces are generally old and no active deposition occurs on these surfaces. The floodplain and associated side channels are only inundated during the very highest flood events, >10 years. Limited deposition in the form of point bars is apparent. Channels lack a diverse pool/riffle complex interspersed with runs although one of these features may be present. Three to five indicators from the checklist present, although this varies depending on their size and watershed location.
1	No side and backwater channels are present on the floodplain surface. The channel is dominated by runs and lack pool/riffle complexes. The channel is almost devoid of complexity and habitat variability. Two or less indicators from the checklist present, although this varies depending on their size and watershed location.

Scaling Rationale: Scaling is based on the richness of features that indicate the presence of overbank inundation. Multiple indicators assume fluvial processes are present to maintain riverine wetlands and their ecological condition. Absence of these features indicates impairment of the fluvial process and corresponding ecological condition.

CHANNEL STABILITY

Assessment Level: Channel Stability is a field-based, Level 2 metric.

Definition: Channel Stability is the assessment of the degree of channel aggradation or degradation resulting from the characteristic flow patterns within a river system. Channel stability is indicative of the equilibrium between water and sediment supply. Stable channels or those in "dynamic equilibrium" condition do not exhibit progressive, rapid changes in slope, shape, or dimensions in response to changes in water and sediment. Degrading channels exhibit downcutting of a stream into its bed materials, often leading to channel entrenchment and eroding banks. Aggrading channels result from the accumulation of bed materials resulting in an increase in the bed elevation and changes in slope (Gordon et al. 2004).

Background: The Channel Stability metric is derived from CRAM (Collins et al. 2008).

Confidence Value: High. Metric has been field tested and is sensitive to the range of condition in the reference domain.

Rationale: Riverine systems are driven by the long-term trends in peak flow, base flow, and average flows and the types and kinds of sediment deposits that form the floodplain and control ecological functions. Changing patterns associated with climate, seasonal variations in rainfall, diversions, releases from dams, and land use determine the timing and duration of flow patterns and sediment availability. Large, persistent changes to the flow or sediment regime caused by upstream land-use changes, alterations of the drainage network, or climatic changes tend to destabilize the channel and cause it to change form (Collins et al. 2008). Channel Stability can be assessed based on field indicators of channel equilibrium, degradation, and aggradation.

Seasonality: CRAM (Collins et al. 2008; Collins, personal communication, 2009) assesses hydrological parameters, including water source, during the dry season. It is during this period that it is possible to assess the site safely, which corresponds with the period in which impacts on vegetation can be assessed. The assessment could be conducted anytime when evidence of overbank inundation may be present. In New Mexico, water diversions should be most evident during the irrigation season.

Assessment Protocol: The assessment consists of evaluating field indicators of channel equilibrium, aggradation, or degradation throughout the AA. Site-scale field indicators caused by beaver activity should *not* be considered in assessing channel conditions, as they are indicative of a local disturbance rather than overall channel and watershed processes. For example, headcutting after a breach in a dam can be a natural process by which the stream returns to equilibrium as it degrades through sediments deposited in the impoundment area. To ensure that the entire AA is considered, it is recommended that the field indicator checklist be completed for the upper, middle, and lower parts of the reach (Table 4.26).

Table 4.26. Channel Condition Field Indicators

Condition	Upper Segment	Middle Segment	Lower Segment	Field Indicators (check all existing conditions)
Indicators of Channel Equilibrium	☐	☐	☐	The channel has a well-defined bankfull contour that clearly demarcates an obvious active floodplain in the cross-sectional profile of the channel throughout most of the AA.
	☐	☐	☐	Perennial riparian vegetation is abundant and well established along the bankfull contour, but not below it.
	☐	☐	☐	There is leaf litter, thatch, or wrack in most pools.
	☐	☐	☐	The channel contains embedded woody debris of the size and amount consistent with what is naturally available in the riparian area.
	☐	☐	☐	There is little or no active undercutting or burial of riparian vegetation.
	☐	☐	☐	There are no bars that are densely vegetated with perennial vegetation (neither mid-channel bars or point bars).
	☐	☐	☐	Channel bars consist of well-sorted bed material.
	☐	☐	☐	There are channel pools, the bed is not planar, and the spacing between pools tends to be regular.
Indicators of Active Degradation	☐	☐	☐	The channel is characterized by deeply undercut banks with exposed living roots of trees or shrubs.
	☐	☐	☐	There are abundant bank slides or slumps, or the lower banks are uniformly scoured and not vegetated.
	☐	☐	☐	Riparian vegetation is declining in stature or vigor, or many riparian trees and shrubs along the banks are leaning or falling into the channel.
	☐	☐	☐	Channel bed is highly armored; it is scoured to large cobbles or boulders.
	☐	☐	☐	An obvious historical floodplain has recently been abandoned, as indicated by the age structure of its riparian vegetation.
Indicators of Active Aggradation	☐	☐	☐	There is an active floodplain with fresh splays of coarse sediment.
	☐	☐	☐	There are partially buried living tree trunks or shrubs along the banks.
	☐	☐	☐	The bed is planar overall. The stream lacks well-defined channel pools, or pools are uncommon and irregularly spaced.
	☐	☐	☐	There are partially buried or sediment-choked culverts.
	☐	☐	☐	Perennial terrestrial or riparian vegetation is encroaching into the channel or onto channel bars below the bankfull contour.
	☐	☐	☐	There are avulsion channels on the floodplain or adjacent valley floor.

Modified from Collins et al. (2008).
Field indicators should be evaluated by walking the AA and looking for indicators in the upper, middle, and lower segments.

Rating: Overall Channel Stability ratings are provided in Table 4.27. The ratings reflect channel conditions throughout the entire assessment reach and should consider the condition of the upper, middle, and lower segments of the reach.

Table 4.27. Ratings for Overall Channel Stability

Rating	Description
4	Most of the channel throughout the AA is in equilibrium condition with little evidence of aggradation or degradation based on the field indicators checklist.
3	There is some evidence of aggradation or degradation; the channel throughout the AA seems to approach an equilibrium condition. Circle primary process: aggradation or degradation
2	There is evidence of severe aggradation or degradation throughout most of the channel through the AA. Circle primary process: aggradation or degradation
1	The channel is artificially hardened, channelized, or concrete throughout most of the AA.

Scaling Rationale: Channel Stability assesses the degree of departure from channels that are considered to be in an equilibrium condition. Departures from the expected dynamic equilibrium are indicators of alterations in the sediment supply and/or flow regime. Unlike some other metrics' scaling, the rating for Channel Stability may not be indicative of restoration potential. The user is encouraged to consider the causes of any disequilibrium at a local and watershed scale prior to considering restoration actions.

STREAM BANK STABILITY AND COVER

Assessment Level: Stream Bank Stability and Cover is a Level 2, field-based metric.

Definition: This metric involves a classification of stream bank soil/substrate stability and perennial vegetation cover, leading to an assessment of the stream bank stability. More stable stream banks and banks with little potential for erosion generally indicate less anthropogenic disturbance.

Background: The Stream Bank Stability and Cover metric is derived from Burton et al. (2008). The metric has been modified to incorporate additional measurements of bank soil stability and erosion potential loosely following the U.S. Forest Service's General Aquatic Wildlife Survey.

Alternatives: See Winward's (2000) "Greenline" method, which accounts for the ability of different vegetation communities to stabilize the stream bank.

Confidence Value: Moderate.

Rationale: The resistance of a stream bank to erosion is important to the integrity and stability of associated riverine wetlands. This metric provides a classification and ranking of stream bank stability. Stable stream banks should support more perennial vegetation (greenline) and more stable and healthy wetland communities. Unstable stream banks and those with the potential for erosion are likely suitable candidates for restoration.

Seasonality: This metric is not sensitive to seasonality.

Assessment Protocol: The assessment method relies on visual estimation of two measures of bank condition – bank soil stability and stream bank erosion potential. The entire reach should be walked for this assessment, noting the condition of the two measures in the upper, middle, and lower segment of the AA. Assessments of the bank condition should extend a minimum of 25 m (82 feet) upstream and downstream of Hydrologic Connectivity transect location on both sides of the stream, excluding meander curves, cut-banks, or point bars. The condition is noted by checking the field indicators in Table 4.28 for the upper, middle, and lower segments that best describes bank soil stability and stream bank erosion potential.

Table 4.28. Bank Soil Stability and Erosion Potential Checklist

Condition	Upper Segment	Middle Segment	Lower Segment	Field Indicators
Indicators of Bank Soil Stability	☐	☐	☐	Infrequent raw banks, less than 10% of stream bank under stress or eroding.
	☐	☐	☐	Raw banks intermittently at outcurves and 10%–25% of stream bank under stress or eroding.
	☐	☐	☐	Significant raw banks, 25%–50% of stream bank under stress or eroding.
	☐	☐	☐	Raw banks almost continuous with greater than 50% of stream bank under stress or eroding, or channel is artificially hardened or concrete along most of its length.
Indicators of Stream Bank Erosion Potential	☐	☐	☐	Over 80% of the stream bank surfaces are covered by vegetation in vigorous condition with dense root mass or by boulders and large cobbles. If the stream bank is not covered by vegetation, it is protected by materials that do not allow bank erosion.
	☐	☐	☐	50%–80% of the stream bank surfaces are covered by vegetation in vigorous condition with dense root mass or by cobble or larger material. Those areas not covered by vegetation are protected by materials that allow only minor erosion.
	☐	☐	☐	25%–49% of the stream bank surfaces are covered by vegetation in vigorous condition with dense root mass or by gravel or larger material. Those areas not covered by vegetation are covered by materials that give limited protection.
	☐	☐	☐	Less than 25% of the stream bank surfaces are covered by vegetation in vigorous condition with dense root mass or by gravel or larger material. The area not covered by vegetation provides little or no control over erosion and the banks are susceptible to erosion each year by high water flows.

Note: Check the indicator that best describes the condition upstream and downstream of the Hydrologic Connectivity transects.

Bank soil stability and stream bank erosion potential are assessed vertically from the channel bottom up to the bankfull elevation. However, the effects of vegetation cover and root mass on stream erosion potential should include vegetation growing up to the flood-prone elevation (Figure 4.7).

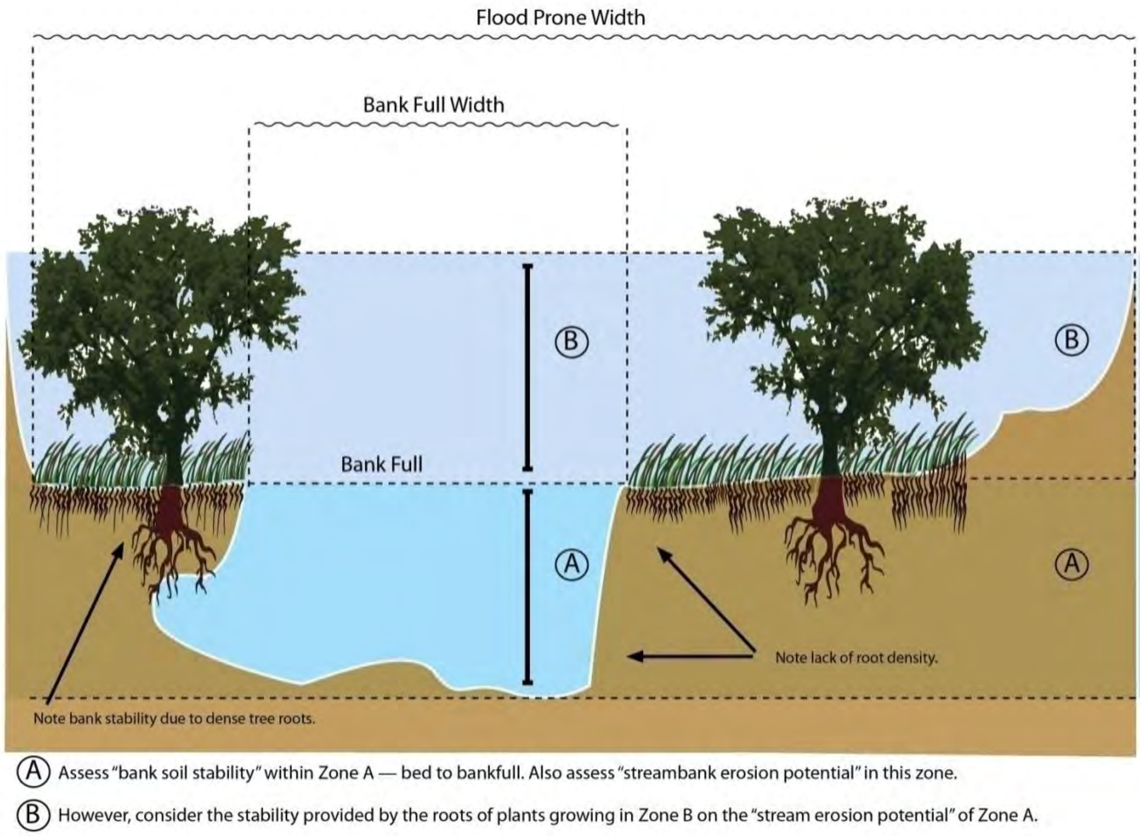

Figure 4.7. Stream Bank Stability and Cover metric assessment zones.

Under all circumstances, the area between the channel bed and the bankfull elevation should be assessed. If a floodplain is present directly above the bankfull elevation (as shown in Figure 4.7, above), the assessment of bank soil stability should be limited to the "bed to bankfull zone" (Zone A in Figure 4.7 above).

However, if the channel bank continues (vertically) uninterrupted by the floodplain above the bankfull elevation, then the upper banks are also capable of contributing sediment to the stream. In these cases, the assessor should extend the survey to cover the entire area between the channel bed and the flood-prone elevation (or top of the bank below whatever floodplain is present).

Rating: This method has two qualitative measures of bank condition, bank soil stability and stream bank erosion potential. The former is a measure of active, ongoing erosion and consists of an estimation of the percentage of the bank that is stable. The latter relates to the stability generated by vegetative cover and large bank material capable of limiting bank erosion as a measure of erosion potential. Both are scaled from 1 to 4, using the ratings shown in Table 4.29 and Table 4.30.

Table 4.29. Bank Soil Stability Ratings for Assessment

Rating	Description
4	Infrequent raw banks, less than 10% of stream bank under stress or eroding.
3	Raw banks intermittently at outcurves and 10%–25% of stream bank under stress or eroding.
2	Significant raw banks, 25%–50% of stream bank under stress or eroding.
1	Raw banks almost continuous with greater than 50% of stream bank under stress or eroding, or channel is artificially hardened or concrete along most of its length.

Note: Minor typical scour near the base of banks associated with normal conditions can be ignored unless it appears to be producing instability in the upper banks.

Table 4.30. Stream Bank Erosion Potential

Rating	Description
4	Over 80% of the stream bank surfaces are covered by vegetation in vigorous condition with dense root mass or by boulders and large cobbles. If the stream bank is not covered by vegetation, it is protected by materials that do not allow bank erosion.
3	50%–80% of the stream bank surfaces are covered by vegetation in vigorous condition with dense root mass or by cobble or larger material. Those areas not covered by vegetation are protected by materials that allow only minor erosion.
2	25%–49% of the stream bank surfaces are covered by vegetation in vigorous condition with dense root mass or by gravel or larger material. Those areas not covered by vegetation are covered by materials that give limited protection.
1	Less than 25% of the stream bank surfaces are covered by vegetation in vigorous condition with dense root mass or by gravel or larger material. The area not covered by vegetation provides little or no control over erosion and the banks are susceptible to erosion each year by high water flows.

Note: Minor typical scour near the base of banks associated with normal conditions can be ignored unless it appears to be producing instability in the upper banks.

Upon completion of the visual estimations, all six scores (bank soil stability and stream bank erosion potential for the upper, middle, and lower segments in the reach) are averaged to compute the overall bank stability rating using the rating Table 4.31.

Table 4.31. Stream Bank Stability and Cover Rating Table

Rating	Stream Bank Stability and Cover Average Score*
4	4.0–3.5
3	3.4–2.5
2	2.4–1.5
1	1.4–1.0

* Average of bank soil stability and stream bank erosion potential along the upper, middle, and lower segments of the assessment reach (six estimates total).

Scaling Rationale: Classification scores are ranked from most stable to most unstable.

SOIL SURFACE CONDITION

Assessment Level: Soil Surface Condition is a Level 2, field-based metric.

Definition: The Soil Surface Condition metric is a measure of anthropogenic disturbance to wetland and riparian soils that results in modification of soil characteristics and/or sedimentation of riverine wetlands. The metric is assessed by evaluating the intensity of human-dominated land uses, such as all-terrain vehicle use or grazing, or indicators of natural processes exacerbated by surrounding land uses, e.g., increased soil salinity or rill development.

Background: The Soil Surface Condition metric is derived from NatureServe (Faber-Langendoen et al. 2008a). It has been modified to document impervious surfaces and potential modification to soil chemistry such as changes in salinity. In addition, Soil Surface Condition differs from the NatureServe metric in that it does not ask assessors to predict restoration potential or site recovery.

Confidence Value: Moderate. The assessment of Soil Surface Condition can be sensitive to recent disturbances, which may obscure soil surface indicators of ecological function and process.

Rationale: Soil Surface Condition can be an indicator of degradation to the soil ecosystem characterized by nutrient cycling, soil moisture, soil chemistry, soil biodiversity, and soil structure. This metric evaluates disturbance to the soil and surface substrates that affects biological, physical, and chemical processes that ultimately define broader wetland ecological condition such as plant establishment and vegetation CT. In this capacity the understanding of soil condition whether natural or modified via land use is critical to setting restoration goals and developing restoration strategies. Examples of soil surface disturbance include filling and grading, plowing, livestock disturbance, vehicle use (motorbikes, off-road vehicles, and construction vehicles), sedimentation, dredging, and other mechanical disturbances to the surface substrates or soils.

Seasonality: This metric may be conducted at any season when the soil surface is visible or disturbance is evident.

Assessment Protocol: Soil Surface Condition is based on a visual assessment of anthropogenic soil disturbance indicators and a semi-quantitative estimate of the percentage of soil disturbance relative to the total area of the AA. This protocol has a GIS-based component, but is primarily field-based and semi-quantitative. As part of the reconnaissance survey, assessors should walk the length and width of the AA to familiarize themselves with the Biotic and Abiotic conditions. Assessors may choose to use the vegetation patch map and associated data table to record disturbance pattern by polygon, or alternatively keep a running checklist of features identified in the rating table. Either way, the final rating requires an estimate of total percent area of the AA that has anthropogenic soil disturbance. The detailed steps of the assessment protocol are:

1. Using available aerial imagery, identify roads and other soil surface disturbances within the AA and surrounding landscape area. Mark disturbed areas on aerial photographs to take in the field.

2. Conduct soil surface assessment as part of the general reconnaissance in order to ground-truth work completed in Step 1. Limit assessment outside the AA to a buffer of 30.5 m (100 feet).
3. Calculate the area of soil surface disturbance within the AA as a percentage of the total area of the AA.
4. Record disturbance to the landscape surrounding the AA in the stressor checklist.

The following are general guidelines for assessing Soil Surface Condition in riverine floodplain wetlands:

- Assume that there are zones of active, naturally occurring erosion and deposition within the active floodplain of the AA. Portions of the AA may be natural sources and sinks for sediment.
- Differentiate, to the extent possible, anthropogenic soil disturbance that could contribute to degradation of the riverine wetland.
- Within the broader context of wetland restoration, consider those conditions that can limit restoration potential such as salinity or impervious surfaces and/or be priorities for restoration such as erosion or discharge of fill material.
- For wadeable systems, assess both sides of the AA and buffer area.
- For systems that cannot be waded, only assess the accessible side of the AA and buffer area.

Rating: The Soil Surface Condition rating is based on the degree to which anthropogenic disturbances are present in the AA as identified in Table 4.32.

Table 4.32. Soil Surface Condition Rating Table

Rating	Description
4	Bare soil areas are limited to naturally occurring disturbances such as flood deposition, e.g., sand and gravel and/or low-density wildlife trails. Plant density may be naturally low because of soil type. No human-caused impervious surfaces are found within the AA. Total disturbance, including erosion, impervious surfaces, fill, mining, or other anthropogenic degradation to the soil surface is between 0% and 2% of the AA.
3	Some amount of bare soil from human causes is present but the extent is minimal. The depth of disturbance is limited to the soil surface and does not show evidence of ponding or channeling water. Very few imperious surfaces are present. Total disturbance, including erosion, impervious surfaces, fill, mining, or other anthropogenic degradation to the soil surface is between 2% and 5% of the AA.
2	Bare soils from human causes are common. These may include dense livestock trails, off-road vehicle tracks, other mechanical rutting, or irrigation driven salinity. Soil disturbance is limited to specific areas and not found across the majority of the AA. Total disturbance, including erosion, impervious surfaces, fill, mining, or other anthropogenic degradation to the soil surface is between 5% and 10% of the AA.
1	Bare soil areas substantially degrade most of the site because of altered hydrology or other long-lasting impacts. Deep ruts from off-road vehicles or machinery are present. Livestock disturbance or trails are widespread and several inches deep. Water is channeled into rills or ponded with no connection to groundwater. Additional human-caused impervious surfaces or other forms of soil stabilization are present. Total disturbance, including erosion, impervious surfaces, fill, mining, or other anthropogenic degradation, to the soil surface is greater than 10% of the AA.

Scaling Rationale: NatureServe (Faber-Langendoen et al. 2008a) scales Soil Surface Condition on a qualitative continuum from undisturbed to highly disturbed. Relative to restoration potential these different ratings range from natural recovery over short periods of time to no recovery (or recovery over long periods of time) without restoration. Ratings used the NMRAM include more detailed descriptions of anthropogenic disturbance as well as a semi-quantitative estimate of the area of disturbance. These area estimates are conservative in that, sites scoring a "4" have no degradation, i.e., 0% to 2%, while as little as 10% disturbance will result in a score of "1."

STRESSOR CHECKLISTS

Stressor checklists are designed to assess the intensity of stressors that occur within the AA the buffer. Stressors are anthropogenic disturbances that would be expected to have a negative effect on the condition of the WOI. Stressor checklists are grouped into four categories: 1) Landscape Context Stressors (Table 4.33), 2) Vegetation Stressors (Table 4.34), 3) Hydrologic Stressors (

Table 4.35), and 4) Physical Structure Stressors (Table 4.36). Stressor checklists identify stressors that occur within the AA and the buffer. The purpose of the stressor checklists is to provide additional information that furthers the understanding of the current wetland condition. Therefore, they are not used in scoring or ranking the condition of the wetland. To complete the stressor checklist,

1. Record negative, non-significant (<10% of the area) and negative significant (>10% of the area) for all occurrences that occur in the buffer and the AA.

The results are summarized for each attribute by totaling the number of stressors that are negative, non-significant (<10% of the area) and negative, significant (>10% of the area) for the buffer and AA, respectively (Table 4.37).

To complete the stressor checklists, the assessor will record negative, non-significant (<10% of the area) and negative, significant (>10% of the area) for all occurrences that occur in the upper, middle, and lower AA segments during the field reconnaissance. The absence of these indicators indicates that disturbances are naturally occurring (e.g., flood deposition or low-density wildlife trails.

Table 4.33. Landscape Context Stressors Checklist

Landscape Context	Buffer <10%	Buffer >10%	Assessment Area <10%	Assessment Area >10%
Urban residential				
Industrial/commercial				
Military training/air traffic				
Transportation corridor				
Sports fields and urban parklands (golf courses, soccer fields, etc.)				
Intensive row-crop agriculture				
Orchards/Nurseries				
Dryland farming				
Commercial feedlots				
Dairies				
Ranching – moderate(enclosed livestock grazing or horse paddock)				
Ranching – low intensity (livestock rangeland)				
Passive recreation (bird-watching, hiking, etc.)				
Active recreation (off-road vehicles, mountain biking, hunting, fishing)				
Physical resource extraction, mining, quarrying (rock, sediment, oil/gas)				
Biological resource extraction (aquaculture, commercial fisheries, horticultural and medical plant collecting)				
Comments:				

Table 4.34. Biotic Condition Stressor Checklist

Vegetation (Biotic Condition)	Buffer <10%	Buffer >10%	Assessment Area <10%	Assessment Area >10%
Mowing, grazing, excessive herbivory (within occurrence)				
Excessive human visitation				
Predation and habitat destruction by non-native vertebrates, including feral introduced naturalized species (domestic livestock, exotic game animals, and pet predators)				
Tree/Sapling or shrub removal (cutting, chaining, cabling, herbiciding)				
Removal of woody debris				
Treatment of non-native and nuisance plant species				
Presence of exotic plant species				
Pesticide application or vector control				
Biological resource extraction or stocking (various)				
Excessive organic debris (for recently logged sites)				
Lack of vegetation management to conserve natural resources				
Comments:				

Table 4.35. Hydrologic Condition Stressor Worksheet

Hydrologic Condition	Buffer		Assessment Area	
	<10%	>10%	<10%	>10%
Point source discharges, other non-storm water discharge)				
Non-point source discharges (urban runoff, farm drainage)				
Flow diversions or unnatural inflows (restrictions and augmentations)				
Dams (reservoirs, detention basins, recharge basins)				
Flow obstructions (culverts, paved stream crossings)				
Weir/Drop structure, tide gates				
Dredged inlet/channel				
Engineered channel (riprap, armored channel bank, bed)				
Dike/Levees				
Groundwater extraction				
Ditches (borrow, agricultural drainage, mosquito control, etc.)				
Actively managed hydrology (e.g., lake levels controlled)				
Comments:				

Table 4.36. Physical Structures Stressor Worksheet

Physical Structure (Soil/Substrate)	Buffer		Assessment Area	
	<10%	>10%	<10%	>10%
Filling or dumping of sediment or soils **(N/A for restoration areas)**				
Grading/Compaction **(N/A for restoration areas)**				
Plowing/Discing **(N/A for restoration areas)**				
Resource extraction (sediment, gravel, oil and/or gas)				
Vegetation management as negative impact (terracing, root plowing, pitting, drilling seed, or other practices that disturb soil surface)				
Disruption of leaf litter/humus, or peat/organic layer, or biological soil crust				
Excessive sediment or organic debris (e.g. excessive erosion, gullying, slope failure)				
Pesticides or trace organics impaired (point source or non-point source pollution)				
Trash or refuse				
Comments:				

Table 4.37. Stressor Checklist Summary

Stressor Summary	Buffer		Assessment Area	
	<10%	> 10%	<10%	> 10%
Total # Landscape Context Stressors				
Total # Vegetation (Biotic) Stressors				
Total # Hydrologic Condition Stressors				
Total # Physical Structure Stressors				
Total # Stressors				

CHAPTER 5
WETLAND SCORING AND REPORTING

WETLAND CONDITION SCORING AND RANKING

One of the fundamental goals of the NMRAM is to provide a mechanism for efficient, trackable summarization of wetland status that allows for consistent comparison of sites across spatial domains and wetland classes. While the NMRAM metrics can be evaluated on an individual basis by a user and ad-hoc summaries developed for a given site, this can be time consuming and may lead to ambiguity when making comparisons across a broad array of sites. Alternatively, because the NMRAM metrics are hierarchically structured by major attributes (Landscape Context, Size, Biotic, and Abiotic), they can be systematically summarized at higher levels, and ultimately rolled up into single **Wetland Condition Score** and categorical **Wetland Condition Rank** for a given wetland. Such scores then allow simple, consistent comparisons and prioritization among sites in planning, mitigation, and other management activities. While overall scores can mask important details, if the scoring process is transparent and well structured, then the underlying values can easily be accessed as necessary for further consideration.

To arrive at a final Wetland Condition Score and Wetland Condition Rank for an WOI, a **Rank Calculator** has been developed as a worksheet and companion spreadsheet calculator (see Field Guide and associated appendices and electronic addendum).The Rank Calculator is hierarchically structured by major attribute categories with associated metrics and provides for weighting each metric and attribute class. Weighting of metrics has been applied to varying degrees among many rapid assessment methodologies across the country (e.g., Collins et al. 2008) and the rationale underpinning the weighting is described in detail below. The NMRAM metric and attribute weighting structure is built into the calculator such that individual and attribute category weighted scores can be calculated easily and then rolled up into a final numeric Wetland Condition Score between 1.0 and 4.0. Separate Wetland Condition scores are calculated for each AA within a WOI, and a site is assigned a final categorical Wetland Condition Rank (A = Excellent, B = Good, C = Fair, and D = Poor) based on the average score (see Table 5.3).

A wetland in **excellent condition** (A) would be expected to have intact wetland functions and processes, diverse vegetative communities with no exotic weeds, and a large size relative to other wetlands and its historical size. These wetlands are undisturbed and would be considered reference communities.

A wetland that is in **good condition** (B) exhibits degradation in condition in response to an environmental stressor. These wetlands may have disrupted hydrological regimes, on-site anthropogenic disturbances, a reduction of vegetative community and structural diversity with the presence of exotic weeds, and a reduced size. Oftentimes, these wetlands would benefit from restoration. Wetlands in good condition may be the best available.

A wetland in **fair condition** (C) is heavily degraded in response to environmental stressors. These wetlands often exhibit disrupted hydrology, have a degraded vegetative condition marked by monotypic community types often with exotic and noxious weeds, and are small in size relative to other wetlands and its historical size. These wetlands may have some potential for restoration, depending on the stressor that is affecting the wetland condition and the nature of the existing wetland condition. Restoration efforts would likely be very costly.

Wetlands in **poor condition** (D) are not considered functioning wetlands. They are heavily degraded with a disrupted hydrology, poor vegetative composition and diversity often dominated by exotic and noxious weeds, and may be extremely small. These wetlands generally would not be considered candidates for restoration.

While some rapid assessment protocols further weight ranks by specifying differential ranges of scores per rank category (e.g., NatureServe EIA restricts the range of A rank scores and expands the range of Ds), for the NMRAM the rank categories are equally weighted with equal ranges of condition scores. Given the many programmatic applications that are possible with the NMRAM, an un-weighted final condition rank is considered the least biased approach.

The final scores and ranks for all AAs and the WOI as whole are entered on the WOI Cover Worksheet (see Field Guide). The final step is to complete a narrative **Assessment Summary** based on the condition ratings and stressor information from all AAs. The Assessment Summary provides a descriptive and analytical overview of wetland condition, as well as an opportunity for comments on wetland condition that may not have been captured by the metrics or a means to address specific effects of stressors based on the stressor checklists.

WEIGHTING RATIONALE

METRIC WEIGHTING

Not all metrics contribute equally to the understanding of ecosystem structure and function at a wetland site. For example, one could argue that the degree of invasive species incursion is more important than the extent of riparian tree reproduction, or that Soil Surface Condition, while still important, has a less impact on ecosystem function than Hydrologic Connectivity. Hence, the score calculator metrics are weighted within major attributes based on the best understanding of wetland ecological processes within the wetland subclass (Table 5.1a). In addition, in a hierarchical model such as this, the major attributes can be weighted prior to the Wetland Condition Score computation (Table 5.1b). The weighting structure presented here represents the target wetland subclass but may vary among subclasses as they are evaluated in the future.

Of the four metrics making up the Landscape Context attribute, Riparian Corridor Connectivity and Buffer Integrity are the two metrics that measure conditions within a limited buffer area directly adjacent to the AA. Hence, these metrics are given more weight (collectively 60% of the score) than the more broadly applied Relative Wetland Size and Surrounding Land Use metrics, each of which account for 20% of the Landscape Context Attribute score. The latter are measures of conditions across the entire floodplain, and because the expectation is that the impacts of anthropogenic modification diminish with distance from the wetland, these metrics should contribute less to the overall Landscape Context attribute.

With respect to Biotic metrics, because of the concern for significant impacts to ecosystem function and biodiversity by non-native and invasive plant species, the Relative Native Plant Community Composition and Invasive Exotic Plant Species Cover metrics collectively account for 50% of the Biotic score (30% and 20%, respectively). Native Riparian Tree Regeneration is downplayed (only 10% of the score) because regeneration can be patchy and not easily detected, but when it does occur, it is a significant positive attribute of a riparian wetland ecosystem to be accounted for. Horizontal Patch Structure and Vertical Vegetation Patch Structure comprise 20% of the score because the role that vegetation structure plays in determining the quality and availability of wildlife habitat.

Similarly, Abiotic metrics are considered relative to one another in terms of how they characterize riverine processes over time and the extent to which they apply to the entire AA. For example Hydrologic Connectivity, or the interaction of the river with its floodplain, is a fundamental process that affects both current condition and restoration potential. It accounts for 30% of the Abiotic score. Macrotopographic Complexity, Bank Stability, and Channel Stability collectively make up 60% of the Abiotic score (20% each). Each of these metrics, while an important component of condition, may be a relic of past processes or only apply to a portion of the AA. Finally, Soil Surface Condition is weighted 10% of the total Abiotic score because it may reflect stressors such as grazing or all-terrain vehicle use rather than process and may depict disturbance at a shorter temporal scale relative to the other metrics.

Table 5.1. Proportional Weighting of NMRAM Metric Scores: a) Weights Applied to Individual Metric Scores within Major Attribute Class

Metric		Weight
Landscape Context		
	Riparian Corridor Connectivity	0.3
	Buffer Integrity	0.3
	Relative Wetland Size	0.2
	Surrounding Land Use	0.2
Size		
	Absolute Wetland Size	1
Biotic		
	Vegetation Horizontal Patch Structure (Interspersion)	0.2
	Vegetation Vertical Structure	0.2
	Relative Native Plant Community Composition	0.3
	Invasive Exotic Plant Species Cover	0.2
	Native Riparian Tree Regeneration	0.1
Abiotic		
	Channel Stability	0.2
	Hydrologic Connectivity	0.3
	Macrotopographic Complexity	0.2
	Stream Bank Stability and Cover	0.2
	Soil Surface Condition	0.1

Table 5.2 Proportional Weighting of NMRAM Metric Scores: b) Weights Applied to Major Attribute Class Scores

Major Attribute		Weight
	Landscape Context	0.25
	Size	0.15
	Biotic	0.3
	Abiotic	0.3

Table 5.3. Wetland Condition Rank Ratings Table

Wetland Condition Rank	Wetland Condition Score	Description
A	3.25–4.0	Excellent condition
B	2.5–3.25	Good condition
C	1.75–2.5	Fair condition
D	1.0–1.75	Poor condition

Note: Final wetland ranks are assigned based on the specified ranges of the Final Wetland Condition Score (derived from the calculator spreadsheet or forms).

ATTRIBUTE WEIGHTING

A secondary weighting is also applied by major attribute class where Biotic and Abiotic scores equally account for 60% of the overall wetland score because these metrics represent the intrinsic value of the wetland. Landscape Context still matters (25%), particularly with respect to the stress and threats that surrounding land use and fragmentation can have on a target wetland. Lastly, Size is important because the larger the wetland, the greater the expectation that it can sustain functionality and composition over the long term. As the default, Size accounts for 15% of the overall score, but where surrounding landscape is significantly impacted (e.g., Landscape Context scores less than <1.5), then Size receives 25% of the overall score and Landscape Context only 15%. This emphasizes the potential role of size in restoration planning because even large sites that are severely impacted or surrounded by significant impacts have a greater potential rehabilitation.

REPORTING AND THE NEW MEXICO WETLANDS DATABASE

The worksheets, the ratings from the Rank Calculator, maps, and photographs together make up the **NMRAM Assessment Package,** which can be used in various ways as a reporting tool. Any of the package components can be used individually in project-level reports, but the package is also designed to aid direct entry into the New Mexico Rapid Assessment Database (NMWRAD). This database is intended as a comprehensive, central clearing house for information on New Mexico's wetlands. The database is currently under construction. When completed, the web interface will provide various reporting tools to facilitate the analysis of single and comparison of multiple sites from around the state. An update regarding the development of this database can be found on either the Natural Heritage New Mexico or NMED SWQB website along with the NMRAM Manual and Field Guide.

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APPENDIX A
RELATIVE NATIVE COMMUNITY TYPE COMPOSITION EXAMPLE

Below is an example of the calculation of the Relative Native Plant Community Composition score using actual field data from a site along the lower Rio Embudo (Table A.1and Table A.2). Using the field map, polygons were assigned to various community types (CT) in Table A.1 based on the dominant species in each strata—tall woody, short woody, and herbaceous. Each strata species was entered using the USDA PLANTS database symbol and the origin of the species, native or exotic, determined (Table A.3). A species can only be represented once per CT.

Each CT is then scored with respect the native versus exotic composition of each stratum using. For example, community type A fell under "Forested Wetland" in Table A.3 because it had a tall woody stratum, and it received a raw score of 3.50 because it has fully native tall woody and short woody strata, but the herbaceous layer is dominated by exotics. Community type B had the same exotic structure in the lower strata as CT A, but it received a lower raw score of 2.2 because it had a mixed native/ exotic tall woody stratum. Similarly, CT C received a raw score of 0.0 because all strata present were fully exotic; the absence of the short woody stratum does not affect the score. Community type D lacked a tall woody stratum, and hence was scored using the "Shrub Wetland" scoring structure in Table A.3. Because it was fully native in the remaining strata, it received a raw score of 4.0.

If the raw scores were simply averaged, the final score for the AA would have been 2.4. But because there was significant difference in the area contribution of each CT within the AA, the scores were weighted by the estimated percentage of the AA they comprised based on the map (represented as a decimal fraction). The sum of the weighted scores gives a value between 0.0 and 4.0 that is then used to assign the final rating value using Table A.4. In this case, the dominance of a predominantly native forested wetland (CT A) within the AA raised the overall score from 2.4 to 2.8 and changed its rating value from 2 to 3, that is, from "fair" to "good" condition, respectively.

Table A.1 Community type composition within the 28Embudo003.3 AA.

CT	Polygon Nos.	Tall Woody Strata [1]		Short Woody Strata [,2,3]		Herbaceous Strata		CT Score		
		T_Spp_1	T_Spp_2	S_Spp_1	S_Spp_2	H_Spp_1	H_Spp_2	Raw Score	% AA	Wt Score
A	1	PODEW	JUSC2	FOPU2	CLLI2	BRIN2	FEAR3	3.5	.55	1.9
B	1,2,3	POAN3	ELAN	SAEX	SALI	FEAR3	AGGI2	2.2	.30	0.7
C	1	ELAN				BRIN2	POPR	0	.10	0
D	1			FAPA	SAEX	SPCR	DACA	4	.05	.2
Final score								2.4	1.0	2.8

1) Trees and shrubs > 5 m (15 feet) and > 10% cover; 2) Trees and shrubs <5m (15 feet) and > 5% cover; 3) A species can only occur once on the list; 4) Raw Score is from Table; % AA Is the percentage of the AA area as a decimal number; Wt. Score is the product of the Raw Score X % AA .

Table A.2 Relative Native Plant Community Composition Rating.

Rating	Site CT Native Score
4	≥ 3.5 (≈ <10% non-native)
3	≥ 2.75 and <3.5 (≈ 10%–20% non-native)
2	≥ 2.0 and <2.75 (≈ 20%–50% non-native)
1	<2.0 (≈ <50% non-native)

Table A.3 PLANTS code, species names, and origin (E= Exotic, N=Native,) for species listed on Table A1.

Type	PLANTS Symbol	Species name	Origin
Woody	ELAN	Elaeagnus angustifolia	E
	JUSC2	Juniperus scopulorum	N
	POAN3	Populus angustifolia	N
	PODEW	Populus deltoides ssp. wislizeni	N
	CLLI2	Clematis ligusticifolia	N
	FAPA	Fallugia paradoxa	N
	FOPU2	Forestiera pubescens	N
	SAEX	Salix exigua	N
	SALI	Salix ligulifolia	N
Herbaceous	BRIN2	Bromus inermis	E
	AGGI2	Agrostis gigantea	E
	FEAR3	Festuca arundinacea	E
	SPCR	Sporobolus cryptandrus	N
	POPR	Poa pratensis	E
	DACA7	Dalea candida	N

Table A.4 CT Native Composition Scoring

CT Score	Trees (>10% Cover)	Shrubs (>10% Cover)	Herbs (>5% Cover)
Forested Wetland			
0.00	E	E or absent	E or absent
0.25	E	E or absent	N/E or unknown
0.50	E	E or absent	N
0.75	E	N/E or unknown	E or absent
1.00	E	N/E or unknown	N/E or unknown
1.15	E	N/E or unknown	N
1.30	E	N	E or absent
1.40	E	N	N/E or unknown
1.50	E	N	N
1.60	N/E or unknown	E	E
1.70	N/E or unknown	E	N/E or absent or unknown
1.80	N/E or unknown	E	N
1.90	N/E or unknown	N/E or unknown or absent	E
2.00	N/E or unknown	N/E or unknown or absent	N/E or unknown or absent
2.10	N/E or unknown	N/E or unknown or absent	N
2.20	N/E or unknown	N	E
2.30	N/E or unknown	N	N/E or absent or unknown
2.40	N/E or unknown	N	N
2.50	N	E	E
2.60	N	E	N/E or unknown
2.70	N	E	N or absent
2.85	N	N/E or unknown	E
3.00	N	N/E or unknown	N/E or unknown
3.25	N	N/E or unknown	N or absent
3.50	N	N or absent	E
3.75	N	N or absent	N/E or unknown
4.00	N	N or absent	N or absent
Shrub Wetland			
0.00		E	E or absent
0.50		E	N/E or unknown
1.00		E	N
1.50		N/E or unknown	E
2.00		N/E or unknown	N/E or unknown or absent
2.50		N/E or unknown	N
3.00		Native	E
3.50		Native	N/E or unknown
4.00		Native	N or absent
Herbaceous Wetland			
0.00			E
2.00			N/E or unknown
4.00			N
Sparsely Vegetated			
0.00			Human-disturbed ground (e.g., roads, cleared areas)
2.00			Mixed natural/human-disturbed ground
4.00			Natural disturbed ground (e.g., sand bars, side channels)

APPENDIX B
NEW MEXICO NOXIOUS WEED LIST

New Mexico Weed Class	Common Name	Scientific Name	USDA (NRCS) Plants Database Symbol	Family
Trees				
B	tree of heaven	*Ailanthus altissima*	AIAL	Simaroubaceae
C	Russian olive	*Elaeagnus angustifolia*	ELAN	Elaeagnaceae
C	saltcedar	*Tamarix spp.*	TAMAR2	Tamaricaceae
C	Siberian elm	*Ulmus pumila*	ULPU	Ulmaceae
Shrubs				
A	camelthorn	*Alhagi maurorum*	ALMA12	Fabaceae
Graminoids				
A	ravennagrass	*Saccharum ravennae*	SARA3	Poaceae
C	cheatgrass	*Bromus tectorum*	BRTE	Poaceae
C	jointed goatgrass	*Aegilops cylindrica*	AECY	Poaceae
W	crimson fountaingrass	*Pennisetum setaceum*	PESE3	Poaceae
W	giant reed	*Arundo donax*	ARDO4	Poaceae
W	quackgrass	*Elymus repens*	ELRE4	Poaceae
W	Uruguayan pampas grass	*Cortaderia selloana*	COSE4	Poaceae
Forbs				
A	black henbane	*Hyoscyamus niger*	HYNI	Solanaceae
A	butter and eggs, or yellow toadflax	*Linaria vulgaris*	LIVU2	Scrophulariaceae
A	Canada thistle	*Cirsium arvense*	CIAR4	Asteraceae
A	Dalmation toadflax	*Linaria dalmatica*	LIDA	Scrophulariaceae
A	diffuse knapweed	*Centaurea diffusa*	CEDI3	Asteraceae
A	Dyer's woad	*Isatis tinctoria*	ISTI	Brassicaceae
A	Eurasian watermilfoil	*Myriophyllum spicatum*	MYSP2	Haloragaceae
A	giant salvinia	*Salvinia molesta*	SAMO5	Salviniaceae
A	hoary cress	*Cardaria draba*	CADR	Brassicaceae
A	leafy spurge	*Euphorbia esula*	EUES	Euphorbiaceae
A	oxeye daisy	*Leucanthemum vulgare*	LEVU	Asteraceae
A	parrot feather watermilfoil	*Myriophyllum aquaticum*	MYAQ2	Haloragaceae
A	purple loosestrife	*Lythrum salicaria*	LYSA2	Lamiaceae
A	purple starthistle	*Centaurea calcitrapa*	CECA2	Asteraceae
A	sandwort drymary or alformbrilla	*Drymaria arenarioides*	DRAR7	Caryophyllaceae
A	Scotch thistle	*Onopordum acanthium*	ONAC	Asteraceae
A	spotted knapweed	*Centaurea stoebe ssp. micranthos*	CESTM	Asteraceae
A	waterthyme, or hydrilla	*Hydrilla verticillata*	HYVE3	Hydrocharitaceae
A	yellow starthistle	*Centaurea solstitialis*	CESO3	Asteraceae
B	African rue	*Peganum harmala*	PEHA	Zygophyllaceae
B	chicory	*Cichorium intybus*	CIIN	Asteraceae
B	Fuller's teasel	*Dipsacus fullonum*	DIFU2	Dipsacaceae
B	Malta starthistle	*Centaurea melitensis*	CEME2	Asteraceae
B	nodding plumeless thistle or musk thistle	*Carduus nutans*	CANU4	Asteraceae
B	perennial pepperweed	*Lepidium latifolium*	LELA2	Brassicaceae
B	poison hemlock	*Conium maculatum*	COMA2	Apiaceae
B	Russian knapweed	*Acroptilon repens*	ACRE3	Asteraceae
B	saltlover, or halogeton	*Halogeton glomeratus*	HAGL	Chenopodiaceae
C	bull thistle	*Cirsium vulgare*	CIVU	Asteraceae
W	Asian mustard	*Brassica tournefortii*	BRTO	Brassicaceae
W	perennial wallrocket	*Diplotaxis tenuifolia*	DITE4	Brassicaceae
W	spiny cockleburr	*Xanthium spinosum*	XASP2	Asteraceae
W	Tyrol knapweed	*Centaurea nigrescens*	CENI3	Asteraceae

USDA (NRCS) = U.S. Department of Agriculture (Natural Resources Conservation Service); A = Species with limited distribution; B = Species limited to portions of the state; C = Species that are wide spread; W = Watch list.