Klamath River Estuary

Wetlands Restoration Prioritization Plan

Version 1.0

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1.0 Introduction

As growth and infrastructure development in Del Norte County increasingly impacts formerly rural areas around the Lower Klamath River, the impacts to valuable wetland areas in the lower basin have increased. The affects of wetland degradation surrounding the Klamath River Estuary (KRE) have been strongly felt by the Yurok Tribe, particularly the fishery, but also are felt locally, and regionally.

Beyond providing open space and aesthetic appreciation by providing areas for hunting, gathering, fishing, hiking, and bird watching, wetlands also serve many critical functional roles as well. Floods are controlled by the hydrologic absorption and storage capacity of wetlands. Wetlands provide protection of subsurface water resources and provision for valuable watersheds and recharging of ground water supplies. Wetlands offer erosion control by serving as sedimentation areas and filtering basins, absorbing silt and organic matter and protecting channels and the estuary.

Wetlands remediate pollution by serving as biological and chemical oxidation basins. Importantly, wetlands offer future generations readily accessible outdoor biological-physical laboratories, living classrooms and vast training and educational resources. Wetland habitats provide the necessary conditions for the growth of culturally significant plant species and regionally important species as well. Willows *(Salix spp.)* and ferns *(Pteridophyta)* are both common species used in making Yurok basketry and regalia, and important medicinal plants used by Yurok people in healing and ceremony. The Federally endangered Western Lily *(Lilium Occidentale)* inhabits wetlands surrounding the KRE.

Wetlands serve as vital habitat to an array of migrating and resident waterfowl. The surrounding Klamath and Siskiyou mountains make coastal wetlands an integral part of the pacific flyway. Wetland habitats located in or near the KRE are considered regionally important. The endangered Willow Flycatcher is one of many bird species that inhabit the KRE wetlands. Wetlands located near the KRE are the only documented breeding sites for wood ducks within Redwood National and State Parks (RNSP 2004). The Great Blue Heron bones and Mallard feathers are traditionally used in Yurok ceremony, and these species are regarded with high cultural significance. Waterfowl have forever been a supplemental food source for the Yurok People. Waterfowl also provide the public recreational values such as hunting and bird watching

In addition, the health of the Klamath River fishery is vital to the survival of the Yurok People and their way of life. Since time immemorial, the Yurok People have subsisted on the resources readily available in the Klamath River Basin. The primary protein source for Yurok people is fish, which formerly filled the river during regular seasonal runs. Anthropogenic activities over the past century have resulted in substantial declines to Klamath River fish runs and drastically altered or degraded associated habitats. Man-made dams and water diversions in the upper basin and diversions in several major tributaries have significantly reduced Klamath River flows and drastically altered its natural hydrograph. The combination of altered flows, increased sediment delivery rates, and a reduction in quantity and quality of tributary, off-estuary wetlands, and slough habitats, has greatly impacted the productivity of the KRE.

The KRE is located in Southern Del Norte County. The Klamath River is within the Columbian province which extends along the Northern Pacific coast from Cape Mendocino to Vancouver Island. Mountainous shorelines with rocky foreshores are prevalent. Estuaries in this province are strongly influenced by freshwater runoff and the tidal range varies from large to moderate. The KRE is short and small even though the Klamath Basin is the second largest drainage in California (Bricker, 2007). The estuary provides habitat and passage way for anadromous fishes but lacks extensive tidal flats and tidal marshes which normally occur in larger estuaries (Wallace 1991). Due to size constraints resulting from the local topology, the productivity and function of the KRE and associated off-estuary wetlands play an increasingly significant role.

The KRE serves as a vital nursery and staging area for spring and fall-run chinook salmon, coho salmon, steelhead trout, coastal cutthroat trout, sturgeon, eulachon, flounder, and lamprey (Wallace 1995, Wallace 1998). It is likely that tens of millions of juvenile salmonids migrate through the KRE every year on their way to the ocean (Wallace 1995). Estuary rearing allows juvenile fish to physiologically adapt for ocean survival and to amass growth prior to ocean entry. Studies conducted in Oregon suggest ocean survival of juvenile chinook salmon was greatly increased when fish entered the ocean at larger sizes (120-160 mm) (Nicholas and Hankin 1989

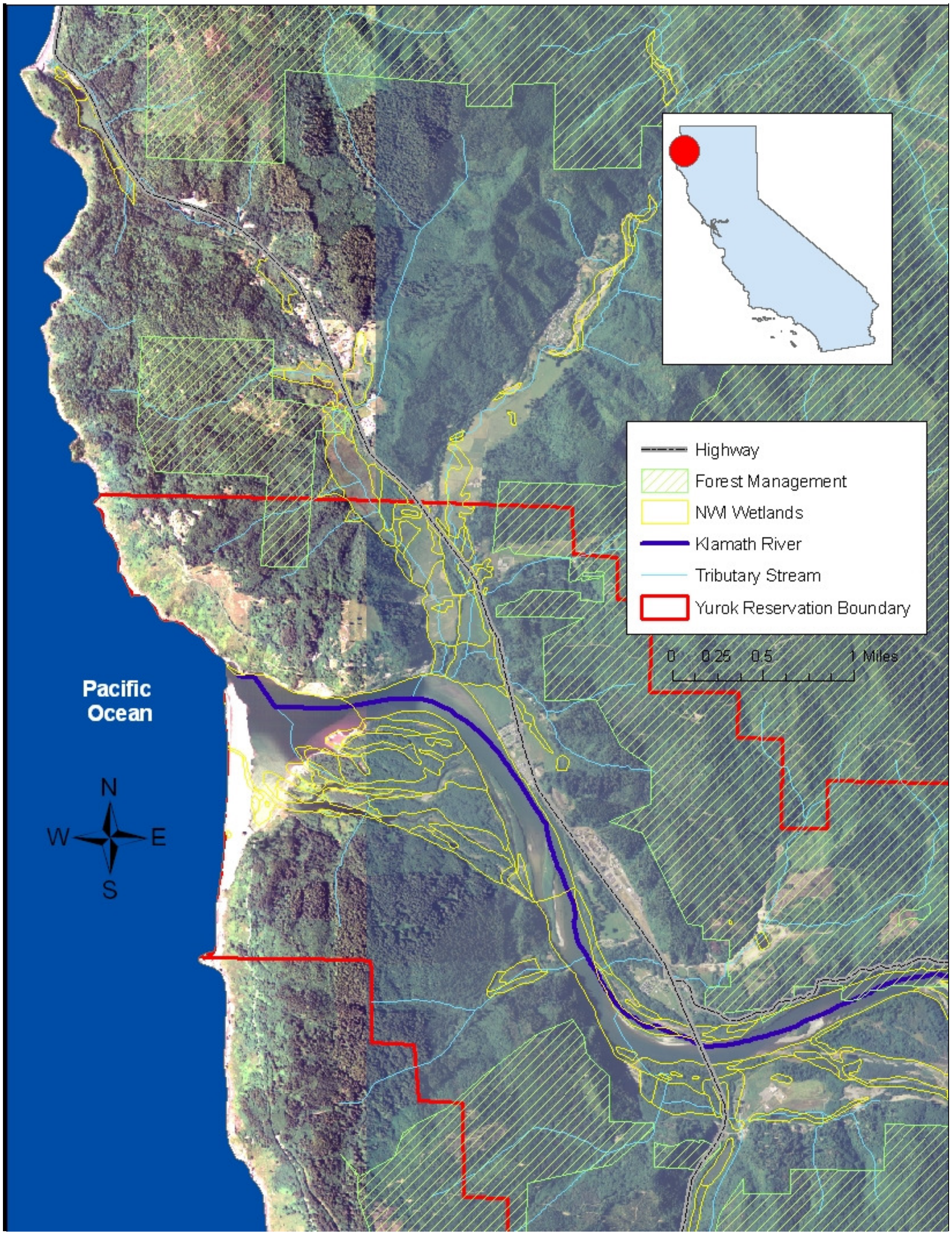

Figure 1: Project area map depicting wetland areas according to the National Wetland Inventory (NWI) and surrounding land use activities. Base image: portions of 2005 NAIP imagery, 1 meter resolution.

Studies conducted in the KRE indicate that estuary rearing of juvenile chinook tends to be brief, with mean residency time ranging from 8.7 - 16.2 days (Wallace 2000). Results from water quality and food availability studies suggest that water management activities, seasonal high water temperatures and a lack of preferred prey items play a role in the limited estuary residency of juvenile chinook (Wallace 1995, Wallace 1998, Hiner and Brown 2004). These limiting conditions present a juvenile salmonid with the option to enter the ocean at a sub-optimal size or find better quality rearing habitat.

Given the importance of off-estuary tributary and wetland habitats to Klamath Basin fish populations and the health of the Yurok Tribe, the YTFP and Fiori Geosciences (FGS) initiated historic and baseline hydrologic and geomorphic assessments to characterize conditions limiting salmonid populations in these critical habitats. Fisheries investigations conducted in off-estuary tributaries and wetlands of the Klamath River have documented consistent use of these habitats by juvenile and adult salmonids (Wallace 2001, Hiner and Brown 2004, Beesley and Fiori 2004, Beesley and Fiori 2007). In addition to providing high quality habitat for Tribal Trust fish and wildlife populations, off-estuary wetlands serve as critical water storage areas during flood events and greatly influence sediment retention and delivery rates in the lower river. Unfortunately, a majority of coastal wetlands in the Klamath River have been lost or severely degraded from land and water management activities (Hiner and Brown 2004, Beesley and Fiori 2004, Beesley and Fiori 2008).

2.0 Background

In 2007, the Yurok Tribe Environmental Program (YTEP) began identifying and assessing wetlands in the lower YIR. Under the Yurok Tribe Wetlands Compensatory Mitigation Enhancement Program (YTWCMEP) [an EPA approved Quality Assurance Project Plan (QAPP)] YTEP collected sound scientific data regarding the current location and condition of wetlands surrounding the KRE. Recent orthorectified aerial imagery (2005) and wetland inventory data was acquired to assist in the ground-truthing of wetland areas. An inventory map of wetland areas (Figure 1) was digitally created using ArcGIS 9.2 to direct wetland assessment activities and to compare to historical wetland loss. The development of GIS applications and wetland inventory has lead to an increased understanding of wetland loss that has occurred over time, and has in turn enhanced our knowledge of impacts and restoration needs of the KRE wetlands.

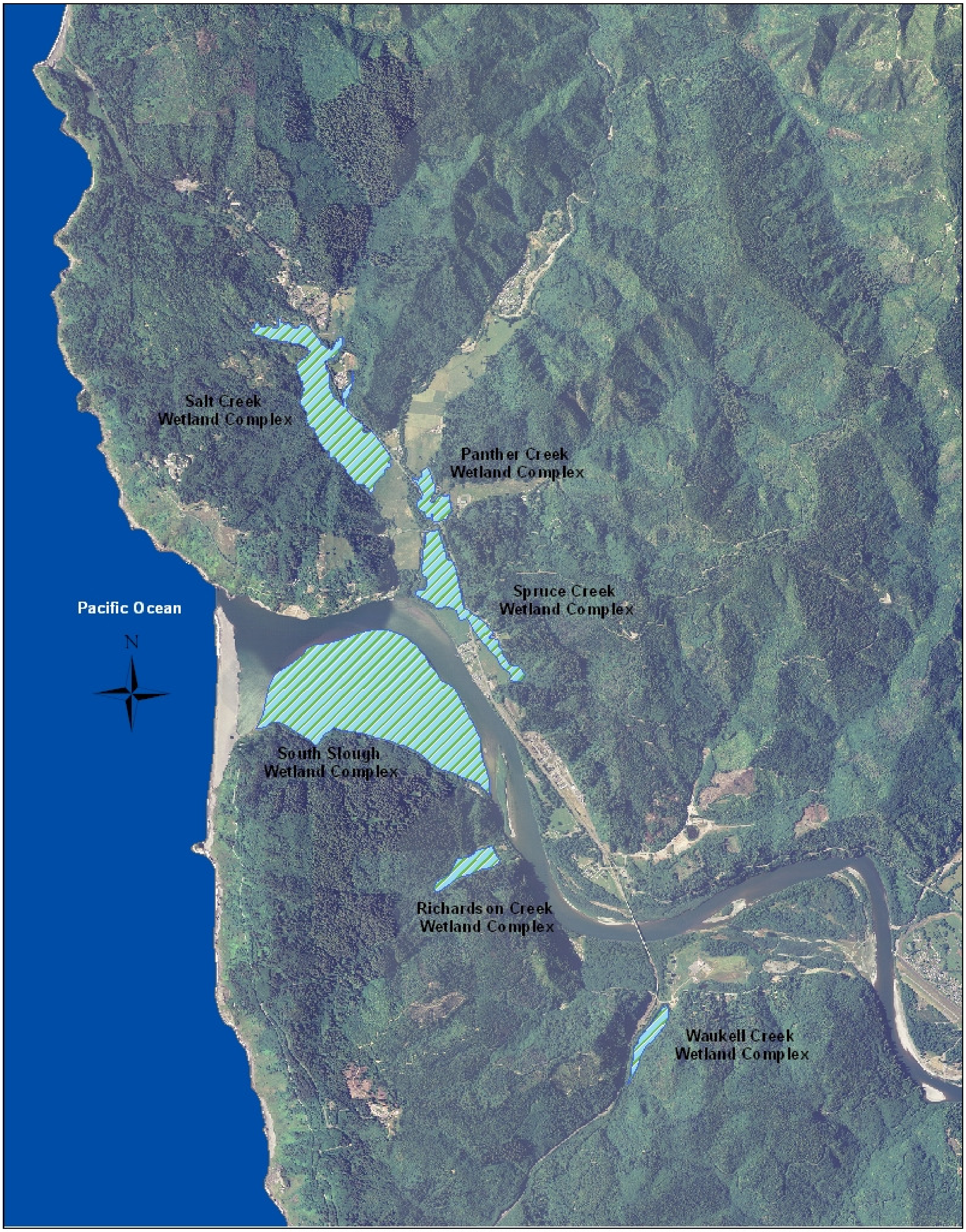

Figure 2: Map depicting wetlands inventoried for wetland assessments. Base image: portions of 2005 NAIP imagery, 1 meter resolution.

Previous road projects in the area have lacked mitigation guidance. In 2005 Caltrans performed a grade raise of highway 101 near the KRE in which critical wetland habitat was lost. Required wetland mitigation was performed in Crescent City, without addressing the restoration needs on site.

At the present time, the California Department of Transportation (Caltrans) is proposing the replacement of a 2 major bridges along US Highway 101, a large culvert replacement and raising the grade of the road up to five feet in some areas. The project will take place within the Reservation which will impact known wetlands. Caltrans is working to identify mitigation projects without the guidance offered by a restoration plan, and the Yurok Tribe is working to assist them in that process, which would be greatly eased by the establishment of such a plan. Known as the Klamath grade raise (KGR), the project will impact critical wetland habitat and for which mitigation will need to be identified prior to project approval.

2.1 Contributing Factors in the Decline of Wetland Function

Much of the historical wetland acreage surrounding the KRE has been lost due to land use changes beginning with the arrival of settlers in the mid 1800’s (Beesley and Fiori 2008). Remaining wetlands are severely impacted by anthropogenic stressors. Summaries of the predominant stressors can be found in the following sections.

2.1.1 Agriculture

Many of the historical wetlands occupied on the north side of the estuary have been degraded due to unregulated land use and alterations. Large wetlands have been converted into grass pastures for cattle or sewn for hay. The process in which wetlands have been converted has involved channelizing and rerouting of streams, ditching, building dikes and levees to control flood flows, and filling and grading. Much of the natural sinuosity and meander of tributaries to the estuary have been altered. The ability for streams to breach their banks and access the flood plain has been minimized. All of the tributaries to the estuary have had some form of these conversions (Gale 2000). Currently, cattle grazing takes place on the north side of the estuary in former highly functioning wetlands that have been converted. Much of the pasture land available to cattle is not completely dry but still maintains wet characteristics.

Historically, agriculture has been the major factor in freshwater and Estuarine wetland loss and degradation. Although the passage of the Food Security Act of 1985 "Swampbuster" provision prevented the conversion of wetlands to agricultural production, certain exempted activities performed in wetlands can degrade wetlands:

- harvesting food, fiber, or forest products;
- minor drainage;
- maintenance of drainage ditches;
- construction and maintenance of irrigation ditches;
- construction and maintenance of farm or forest roads;
- maintenance of dams, dikes, and levees;
- direct and aerial application of damaging pesticides (herbicides, fungicides, insecticides, fumigants); and
- ground water withdrawals.

These activities can alter a wetland's hydrology, water quality, and species composition. Excessive amounts of fertilizers and animal waste reaching wetlands in runoff from agricultural operations, including confined animal facilities, can cause eutrophication (Osmond D.L. et al 1995).

The following are potential wetland stressors from cattle grazing:

• Degradation, reduction or elimination of riparian vegetation. Livestock grazing can alter or eliminate riparian areas through direct grazing of riparian vegetation, trampling of stream banks, stream channel widening and aggradation, degradation and compaction of stream bank soil, and lowering of the water table (Fleischner 1994; Platts 1990, 1991). Livestock more typically graze riparian areas than upland zones due to flatter terrain, availability of water and shade, and presence of more succulent vegetation (Fleischner 1994; Platts 1991).

• Stream channel and bank degradation. Livestock grazing in and/or adjacent to stream channels can negatively impact salmonid habitat through increased sedimentation, stream bank trampling, reduction in stream shading and instream cover, channel widening and aggradation, and reduction in instream habitat diversity (Fleischner 1994; Platts 1990, 1991).

• Reduction in Water Quality. Livestock grazing can negatively impact stream water quality by increasing water temperature, decreasing dissolved oxygen levels, altering nutrient and suspended sediment levels, and increasing bacterial populations (Fleischner 1994; Platts 1990, 1991).

2.1.2 Road Construction

Roads and bridges are frequently constructed across wetlands since wetlands have low land value. It is often considered to be more cost effective to build roads or bridges across wetlands than around them (Winter 1988). Roads often act as an impoundment in a wetland, even if culverts are installed. Such inadvertent impoundment and hydrologic alteration can change the functions of the wetland (Winter 1988). Road and bridge construction activities can also increase sediment loading to wetlands (Mitsch and Gosselink 1993).

US Highway 101 is the largest road system located in the vicinity of the KRE. The highway passes through or borders approximately 3 miles of valuable off estuary wetland habitat. In addition to the direct loss caused by the road footprint, the hydrologic connectivity of off estuary wetlands located in the vicinity of the highway has been altered. Dikes and levees were created along this route to ease transportation construction. This altered hydrology has affected the wetlands ability to function during storm events. Much of the system’s ability to convey high flows without damage to the main stream channels has been lost. Many of the tributaries have experienced downcut, further separating the streambed from the flood plain. Smaller roads have the same effect but to a smaller extent.

2.1.3 Urban Development

Urbanization is a major cause of wetland impairment and direct loss of wetland acreage (USEPA 1994b). Wetland degradation results in changes in water quality, quantity, and flow rates; increases in pollutant inputs; and changes in species composition causes by the introduction of non-native species and ecosystem disturbance. The major pollutants associated with urbanization are sediment, nutrients, oxygen-demanding substances, road salts, heavy metals, hydrocarbons, bacteria, and viruses (USEPA 1994b). These pollutants may enter wetlands from point sources or from nonpoint sources. Construction activities are a major source of suspended sediments that enter wetlands through urban runoff.

2.1.3.1 Impervious Surfaces

As roads, buildings, and parking lots are constructed, the amount of impervious surface increases. Impervious surfaces prevent rainfall from percolating into the soil. Rainfall and snowmelt carry sediments; organic matter; animal- wastes; pesticides and fertilizers from lawns, gardens, and golf courses; heavy metals; hydrocarbons; road salts; and debris into urban streams and wetlands (USEPA 1993a; USEPA 1993c). Increased salinity, turbidity, and toxicity; and decreased dissolved oxygen, all affect aquatic life and, therefore, the food web (Crance 1988). Excessive inputs of nutrients can lead to eutrophication or result in the release of pollutants from a wetland into adjacent water resources (USEPA 1993a).

As runoff moves over warmed impervious surfaces, the water temperature rises and dissolved oxygen content of the runoff water decreases (USEPA 1993c). Increased water temperature, as well as the lower dissolved oxygen levels, can cause stress or mortality of aquatic organisms. Rising water temperatures can also trigger a release of nutrients from wetland sediment (Taylor et al. 1990). For example, as temperature rises, sediments release phosphorus at an exponential rate and can easily result in eutrophication.

Impervious surfaces decrease ground water recharge within a watershed and can reduce water flow into wetlands (USEPA 1993c). Significant increases in stormwater peak flow rates, and longer-term changes in wetland hydrology, as a result of stormwater discharge, can cause erosion and channelization in wetlands, as well as alteration of species composition and decreased pollutant removal efficiency (USEPA 1993a; USEPA 1993c). Changes in frequency, duration, and timing of the wetland hydroperiod may adversely affect reproduction, migration, species composition, and thus impact the food web in a given wetland and food webs of associated ecosystems (Crance 1988; USEPA 1993c).

2.1.3.2 Hydrologic Alterations

Wetland impacts often result in habitat fragmentation and , may result in changes in species composition as wetlands species are replaced by upland species; loss of large, wide-ranging species; loss of genetic integrity when isolated habitats are too small to support viable populations; reduced populations of interior species that can only reproduce in large tracts; and increased numbers of competitor, predator, and parasite species tolerant of disturbed environments (Harris 1988; Fleming e t al. 1994)

Wetlands areas have been drained and filled to offer suitable sites for homes, businesses and infrastructure. Some ditching and building of levees has occurred in this regard.
Water diversion structures, such as canals (channels), ditches, and levees have been used to modify wetlands to achieve flood control, drainage, mosquito control, irrigation, timber harvest, navigation, transportation, and industrial activity (Mitsch and Gosselink 1993). Canals and channelization change the hydrology of wetlands and increase the speed with which water moves into and through wetlands. As a result, patterns of sedimentation are altered and wetland functions and values that depend on the normal slow flow of water through a wetland can be affected. High sediment loads entering wetlands through channels, irrigation ditches and drainage ditches can smother aquatic vegetation, shellfish beds and tidal flats, fill in riffles and pools, and contribute to increased turbidity (USEPA 1993a). However, normal sedimentation rates in coastal wetlands are necessary to reduce land subsidence. Channelization and channel modification alter instream water temperature and diminish habitat suitable for fish and wildlife (USEPA 1993a). Normal sheet flow through wetlands is inhibited by the spoil banks that line a canal and by road embankments. Spoil banks and embankments also increase water stagnation. Channels often connect low-salinity areas to high-salinity areas, resulting in saltwater intrusion upstream, and causing species change and mortality of salt-intolerant vegetation.

2.1.3.3 Groundwater Extraction

The frequent or prolonged presence of water at or near the soil (hydrology) is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands can be identified by the presence of those plants (hydrophytes) that are adapted to life in the soils that form under flooded or saturated conditions (hydric soils) characteristic of all wetlands (Mitsch and Gosselink 1993). Thus alteration of wetland hydrology can change the soil chemistry and the plant and animal community. Alteration which reduces or increases the natural amount of water entering a wetland or the period of saturation and inundation can, in time, cause the ecosystem to change to an upland system or, conversely, to a Riverine or Lacustrine system.

Established domestic water systems are currently withdrawing water from the following tributaries, which feed wetland complexes: Salt (well), High Prairie (well), Hunter (well), Spruce Creeks (well), Minot (well) Waukell (well). Potential impacts associated with domestic water withdrawal include lowering of the water table and reduced stream flows (Gale 2000). Additional groundwater extraction takes place in the Klamath town site on Hoppow Creek (well).

2.1.4 Historical Floods

Natural flooding has occurred in the past with negative effects. In 1955 and again in 1964 the Klamath River suffered catastrophic floods in which altered the present day condition of the estuary. Following the 1964 flood event, much of the present day Klamath town site (located within historical flood plains) was created through filling wetlands, rip- rapping the river banks for flood protection. Stream courses have been altered to route water around property holdings further affecting the natural hydrology of the system. The inability of the river to inundate its flood plain has resulted in hydrologic and topographic changes in the estuary. Islands in the estuary once located on the north side no longer exist. The mouth of the river now exits the north side of the estuary instead of naturally moving south from year to year. The depth of the estuary has decreased drastically. The south side of the estuary now contains a slough complex, created through the natural process of the river adjusting to its banks (Hiner and Brown 2004). Extreme sedimentation occurred in some of the tributaries causing channel aggradation and subsequent loss of function (Beesley and Fiori 2007). The high flows scour out many of the existing vegetation communities and complex topography, making areas susceptible to invasive species which prefer disturbed areas to colonize.

2.1.5 Invasive Species

As a result of disturbance and habitat degradation, wetlands can be invaded by aggressive, highly-tolerant, non-native vegetation, such as reed canary grass *(Philaris Urundinacea),* purple loosestrife *(Lythrum salicaria)*, water hyacinth *(Eichornia crassipes)*, and salvinia *(Salvinia molesta*), or can be dominated by a monoculture of cattails *(Typha spp.)* or common reed *(Phragmites spp.)* (McColligan and Kraus 1988; Weller 1981; Mitsch and Gosselink 1993). Particularly in constructed wetlands, including restored wetlands, non-native and tolerant native species may outcompete other species leading to a reduction in species diversity.

Invasive species within KRE wetlands appear to be out-competing the native vegetation and cause a loss of wetland function and habitat. Increased sedimentation from floods and runoff from land use practices such as logging, disturbed soils from development, and land and hydrology alterations, have created a soil disturbance niches for invasive species to thrive. The spreading of invasive species occurs through the natural process such as dispersal of seeds or plants by water (carried downstream), by wind, and animals. Anthropogenic activities often results in the propagation and spreading of invasive species via improper management of invasive plants, transport to new areas via roadways and vehicles, and intentional planting as ornamental landscaping. All of the KRE wetland complexes contain invasive species. The most prevalent invasive species encountered during YTEP's wetland assessments were Reed Canary Grass *(Philaris urundinacea)*, Himalayan Blackberry *(Rubus procerns),* Common Reed *(Phragmites australis*), and the Yellow Pond lily *(Nuphar lutea)*.

Reed Canary Grass (RCG) is a species of special concern for its ability to choke out side-channels and smaller tributaries, colonize and clog streams and wetland complexes (Beesley and Fiori 2008). RCG greatly reduces botanical and biological diversity by homogenizing habitat structure and environmental variability (both of which correlate with species richness), alters hydrology by trapping silt and constricting waterways, and limits tree regeneration in riparian forests by shading and crowding out seedlings. RCG also decreases retention time of nutrients and carbon stored in wetlands, thus accelerating turnover cycles and reducing carbon sequestion capabilities characteristic of diverse plant communities (Wisconsin Reed Canary Grass Management Working Group, 2009).

2.1.6 Forest Management

85% of the Yurok Indian Reservation is comprised of timber harvest lands. Intensive forest management has taken place in the area surrounding the Lower Klamath River for over 100 years. The largest impacts come indirectly in the form of increased sedimentation to the watershed caused by runoff from roads, failed stream crossings, and landslides. Timber harvest activities currently account for the greatest percentage of erosion-related problems within the Lower Klamath Sub-basin. According to Balance Hydrologics, Inc. (1995), "erosion related to poorly designed, abandoned or poorly maintained logging roads may be equal to or greater than the all sum of natural erosion processes occurring elsewhere in the basin." Analysis of sediment sources and sinks in Salt High Prairie Creeks indicated that modern erosion and sedimentation rates were 1.5 to 13 times greater than the long term geologic rate (Beesley and Fiori 2007).

Logging practices such as drainage, clearing, haul road construction, rutting, and ditching of forested wetlands, likely result in negative impacts, although the impacts may only be temporary. Since timber removal generally occurs in 20-50 year rotations, careful harvest may not be a permanent threat to wetlands. Adverse timber harvest impacts can include a rise in water table due to a decrease in transpiration, soil disturbance and compaction by heavy equipment, sedimentation and erosion from logging decks, skid trails, roads, and ditches, and drainage and altered hydrology from ditching, draining, and road construction (Shepard 1994). Higher water tables may increase surface water duration and velocity which results in increased sediment transport. By utilizing best management practices, hydrology and biogeochemical processes of wetlands may be altered for only one to three years following timber harvest (Shepard 1994)

Several abandoned mill ponds exist on the YIR. They were created by the excavation of small tributary flood plains and damming the stream. Some of the hydrologic connectivity within the estuary has been lost due to levees and perched culverts created by logging mills, causing barriers to fish passage and eliminating tidal influence. Hydrologic impoundments resulting from intensive forest management have also increased the amount of sedimentation deposited in the wetlands and the Klamath River. Hydrologic impoundments alter the natural hydrology of a wetland and decreases water circulation. Decreased water circulation causes increased water temperatures, lower dissolved oxygen levels, changes salinity and pH; prevents nutrient outflow; and increases sedimentation (USEPA 1993a).

Sedimentation reduces water storage capacity, smothers vegetation of a given wetland, and reduces light penetration; reduces oxygen content; and affects ecosystem richness, diversity, and productivity. Toxic substances, adhering to sediments, may accumulate in impoundments as a result of decreased water circulation and bioaccumulation of contaminants by wetland biota may occur. These impacted wetlands may also contain remnant pollutants such as dioxins and tend to support invasive species.

2.1.7 Beaver Population Decline

Beaver dams measurably affect groundwater recharge rates and retention, increase summer flows, and elevate local water tables allowing riparian and wetland vegetation to expand. Beaver dams may retain enough sediment to cause substantial changes to the valley floor morphology. In general salmonid productivity has been found to be higher, especially for coho salmon, in reaches upstream of beaver dams, relative to habitats were beaver dams were not present (Pollock 2003, Beesley and Fiori 2007). Beginning with the onset of white settlers in the area, the beaver population was progressively curtailed due to massive trapping and shooting. Beaver dams were consequently destroyed. The main focus at the time was acquiring beaver pelts and the development of pasture land for agricultural purposes. Beaver populations are responsible for providing outstanding fisheries and waterfowl habitat by creating wetlands through dam building and maintenance activities. The beaver dams allow wetland conditions to persist during the summer, and store water year round. Currently, beaver dams exist in the KRE wetlands and the beaver population seems to be on the rebound (Beesley and Fiori 2007).

3.0 Goals and Objectives

A primary goal is to develop a large-scale restoration prioritization plan for the KRE and its off-estuary tributary, wetland, and slough habitats. Restoration objectives include enhancing coastal wetland and riparian forest habitats, increasing juvenile salmonid rearing capacity, and improving hydrologic function of the KRE and coastal tributaries.

Conducting estuary and coastal habitat restoration in a prioritized and steady manner will have long-term benefits including improved estuary and near-estuary wetland function. Through the development of a prioritized list of potential compensatory mitigation project sites and methods for wetlands assessment and monitoring.

KRE Wetlands Restoration Prioritization Plan (KREWRPP) will provide guidance to project proponents critical to meeting the needs and standards of the Yurok Tribe in wetlands conservation, mitigation, and restoration planning efforts. It is the goal of the Yurok Tribe to restore wetlands of the KRE to a level that focuses on the needs of Tribal trust fish and wildlife, and at the same time consider the many additional valuable functions that wetlands perform. These goals will be accomplished through restoration activities comprehensively outlined and through interaction with public and private landowners to implement long-term land management practices. The Yurok Tribe will rely on sound scientific methods and principles to plan, implement, and monitor all wetland restoration activities. By adhering to this scientific approach, the restoration needs of the KRE wetlands will be addressed in a credible, prioritized manner. Only through such a systematic approach will the resource needs of the area be identified and in turn the restoration goals are met. Implementing an adaptive management strategy will help to ensure long term success in the development restoration goals, as new information becomes available.

3.1 Objectives

- Identify and assess off-estuary wetlands using an acceptable wetland assessment method
- Develop a wetland restoration site prioritization method to rank wetlands for future restoration projects
- Score and rank wetlands based on the prioritization method

4.0 Methods

YTEP has an EPA approved Quality Assurance Project Plan (QAPP) for collecting wetland assessment data. The QAPP is titled the YUROK Tribe Wetlands Compensatory Mitigation Enhancement Project. The plan outlines specific protocols in order to collect legally defensible, sound data. The plan has been in use since it's' finalization in 2008.

4.1 Current Wetland Condition

YTEP has outlined in the YTWCMEP its method for assessing wetland condition. The California Rapid Assessment Method (CRAM) (Collins and others 2008) has been employed to assess wetlands in order to provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands. The CRAM assessments will result in an overall numerical score for each site assessed, based on a 50-100 scale, with low scores reflecting poor wetland condition. Scoring will allow for a basis of ranking wetland condition and prioritizing restoration. The score is based on analyzing 4 attributes of a wetland including; 1-Landscape Connectivity, 2-Hydrology, 3-Biotic Structure, and 4-Physical Structure. Within each attribute there are a number of metrics or defining characteristics (Table 1). This systematic breakdown of wetland function not only leads to accurate assessment of a wetland, but allows for the specific targeting of degraded wetland characteristics. Prioritizing future wetland restoration projects will depend largely on a relative comparison of wetlands attributes and metric scores. CRAM scores can also serve as baseline data used in long-term monitoring and to evaluate the effectiveness of restoration projects. Identifying and understanding past and present wetland impacts and threats is critical in developing appropriate and effective restoration strategies.

Table 1: CRAM Attributes and Metrics (Adapted from Collins and others 2008).

Attributes		Metrics
Buffer and Landscape Context		Landscape Connectivity
		Buffer:
		Percent of AA with Buffer
		Average Buffer Width
		Buffer Condition
Hydrology		Water Source
		Hydroperiod or Channel Stability
		Hydrologic Connectivity
Structure	Physical	Structural Patch Richness
		Topographic Complexity
	Biotic	Plant Community:
		Number of Plant Layers Present or Native Species Richness (vernal pools only)
		Number of Co-dominant Species
		Percent Invasion
		Horizontal Interspersion and Zonation
		Vertical Biotic Structure

It should be recognized that due to the vast size of the wetlands and limited staff and time, representative wetland assessment sites have been established to address the overall wetland condition in distinct wetland systems. Satellite imagery (NAIP 2005) was used to identify potential assessment areas (AA) based on consideration of vegetation, physical, and hydrologic signatures. Also factoring into assessment area designation were accessibility, landowner consent, and data observed while initially ground-truthing wetland boundaries.

Previous and on-going history of land management activities within KRE wetlands plays a major role in formulating and prioritizing meaningful restoration prescriptions. The Yurok Tribal Fisheries Program (YTFP) has compiled and analyzed a significant amount of information (Beesley and Fiori 2004, Beesley and Fiori 2007, Hiner and Brown 2004) Aerial photos dating back to the 1920s have been used to get an idea of topographic changes that have occurred over the years in relationship to land use changes and natural flooding of the river. Historical survey records, road planning documents and personal interviews have also been used.

4.1.1 Wetland Assessment Method

CRAM (Collins and others 2008) is a scientifically accepted method for assessing ambient wetland condition. Developed in recent years to meet the needs of limited staff and funding, and has gone through a rigorous QA/QC process. The YTEP elected to use CRAM for its rapid assessment component and applicability to the area. YTEP staff has been trained on the use of this method at the "practitioner" level by members of the CRAM development team. Additionally, YTEP has completed an EPA approved QAPP, "*Yurok Tribe Wetlands Compensatory Mitigation Enhancement Program*", thus ensuring CRAM data is collected in a valid and defensible fashion.

CRAM was designed to provide a measure of ambient wetland condition in numerical form. The condition of a wetland is determined by interactions among internal and external hydrologic, biologic (biotic), and physical (abiotic) processes (Brinson 1993). CRAM is based on a series of assumptions about how these processes interact through space and over time. First, CRAM assumes that the condition of a wetland is mainly determined by the quantities and qualities of water and sediment (both mineral and organic) that are either processed on-site or that are exchanged between the site and its immediate surroundings. Second, the supplies of water and sediment are ultimately controlled by climate, geology, and land use. Third, geology and climate govern natural disturbance, whereas land use accounts for anthropogenic stress. Fourth, biota (especially vegetation) tends to mediate the effects of climate, geology, and land use on the quantity and quality of water and sediment (Figure 3). For example, vegetation can stabilize stream banks and hillsides, entrap sediment, filter pollutants, provide shade that lowers temperatures, reduce winds, etc. Fifth, stress usually originates outside the wetland, in the surrounding landscape or encompassing watershed. Sixth, buffers around the wetland can intercept and otherwise mediate stress (Collins and others 2008) (Figure 4).

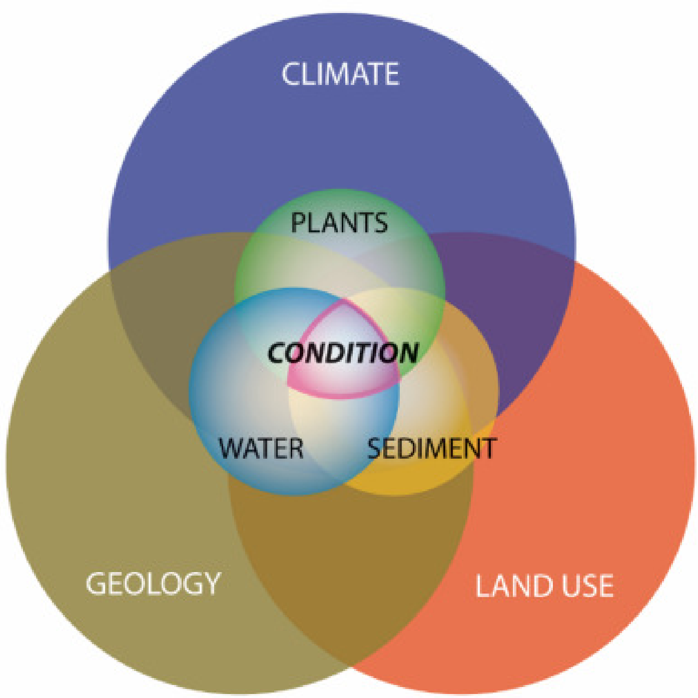

Figure 3: Spatial hierarchy of factors that control wetland conditions, which are ultimately controlled by climate, geology, and land use (Adapted from Collins and others 2008).

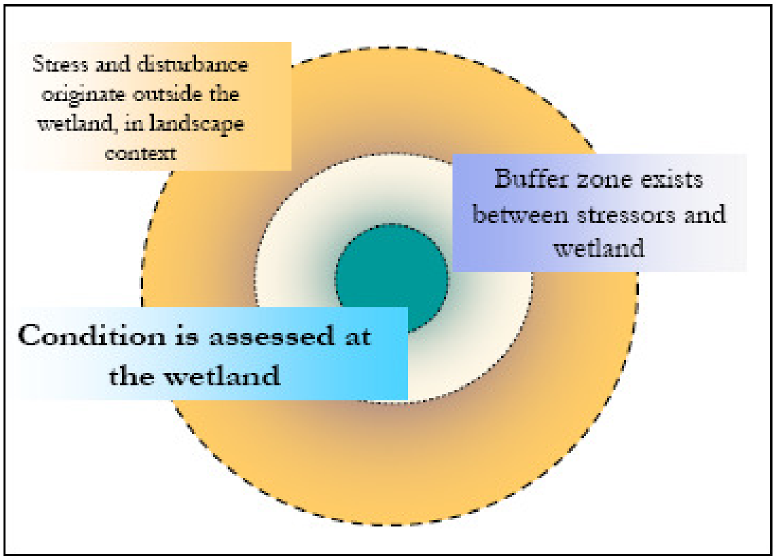

Figure 4: Spatial hierarchy of stressors, buffers, and wetland condition. Most stressors originate outside the wetland. The buffer exists between the wetland and the sources of stress, and serves to mediate the stress (Adapted from Collins and others 2008).

Three major assumptions govern how wetlands are scored using CRAM. First, it is assumed that the societal value of a wetland (i.e., its ecological service to people) matters more than whatever intrinsic value it might have in the absence of people. This assumption does not preclude the fact that the support of biological diversity is a service to society. Second, it is assumed that the value depends more on the diversity of services than the level of any one service. Third, it is assumed that the diversity of services increases with structural complexity and size. CRAM therefore favors large, structurally complex examples of each type of wetland (Collins and others 2008).

Table 2: Expected relationships among CRAM attributes, metrics, and key services (Adapted from Collins and others 2008).

KEY SERVICES	Buffer and Landscape Context	Hydrology			Physical Structure		Biotic Structure				
	Buffer and Landscape Connectivity Metrics	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Structural Patch Richness	Topographic Complexity	Number of Plant Layers	Number of Co-dominant Species and Native Species Richness	Percent Invasion	Horizontal Interspersion and Zonation	Vertical Biotic Structure
Short- or long-term surface water storage	X		X	X	X	X				X	X
Subsurface water storage		X	X	X		X					
Moderation of groundwater flow or discharge	X	X									
Dissipation of energy					X	X	X			X	X
Cycling of nutrients	X		X	X	X	X	X	X	X		X
Removal of elements and compounds	X		X	X		X	X			X	
Retention of particulates			X	X	X	X	X	X		X	
Export of organic carbon			X	X			X		X	X	X
Maintenance of plant and animal communities	X		X	X	X	X	X	X	X	X	X

Average numerical CRAM scores will be utilized to rank and prioritize wetlands for future restoration. CRAM scores range between 50 and 100. CRAM scores are based on 4 attributes of a wetland including Buffer and Landscape Connectivity, Hydrology, Biotic Structure, and Physical Structure. Each attribute contains a number of metrics that are scored based on the best fitting alternatives to each (Table 1). Each score for a metric has four alternative options: A=12, B=9, C=6, D=3.The sum of all metrics within an attribute will provide a score for that attribute. The sums of all attribute scores are converted into a percentage to reach an overall CRAM score for the assessment area.

CRAM scores of AAs within a wetland complex will be averaged to calculate overall CRAM scores for that wetland complex. Averages will help identify cumulative impacts on wetland condition within each complex and allow for comparison between wetland complexes. A CRAM score is a way to summarize the condition (health) of a wetland or riparian area, relative to its maximum achievable condition. The use of a standardized method allows for comparability between sites and the guidance needed in identifying restoration sites along with the possible need of higher level of assessment within those areas (Collins and others 2008).It should be recognized that CRAM scores do not address all aspects of functionality of a wetland. Certain functionality of a wetland is implied through a measure of ambient condition of a wetland (Table 2). Aspects of wetland function such as use by salmonids, waterfowl and wildlife are very important to consider. These can only truly be assessed through a higher level study. Additional functions of wetlands such as protection against floods, bio-remediation are also important aspects to consider, but would require extensive survey and photograph interpretation.

4.1.2. Attribute 1-Buffer and Landscape Connectivity

For the purposes of CRAM, a buffer is a zone of transition between the immediate margins of a wetland and its surrounding environment that is likely to help protect the wetland from anthropogenic stress (Figure 4). Areas adjoining wetlands that probably do not provide protection are not considered buffers (Collins and others, 2008). Buffers can protect wetlands by filtering pollutants, providing refuge for wetland wildlife during times of high water levels, acting as barriers to disruptive incursions by people and pets into wetlands, and moderating predation by ground-dwelling terrestrial predators. 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 invasions (Collins and others, 2008).

Because regulation and protection of wetlands historically did not extend to adjacent uplands, these areas in some cases have been converted to recreational, agricultural, or other human land uses and might no longer provide their critical buffer functions for wetlands. CRAM includes two metrics to assess the buffer and landscape context attribute of wetlands: the Landscape Connectivity metric and the Buffer metric. The buffer metric is composed of three sub-metrics: (1) percentage of the AA perimeter that has a buffer; (2) the average buffer width; and (3) the condition or quality of the buffer (Collins and others, 2008) (Table 1).

4.1.2.1 Landscape Connectivity Metric

The landscape connectivity of an AA is assessed in terms of its spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. It is assumed that wetlands close to each other have a greater potential to interact ecologically and hydrologically, and that such interactions are generally beneficial (Collins and others, 2008).

Wetlands are often important components of local mosaics of multiple types of habitat. The components of such mosaics tend to be inter-connected by the flow of water and movements of wildlife, such that they have additive influences on the timing and extent of many landscape-level processes, including flooding, filtration of pesticides and other contaminants, and wildlife support. In turn, these processes can strongly influence the form and function of wetlands. The functional capacity of a wetland is therefore determined not only by its intrinsic properties, but by its relationship to other habitats across the landscape. For example, Frissell and others (1986) concluded that the structure and dynamics of stream habitats are determined by the surrounding watershed. Several researchers have concluded that landscape-scale variables are often better predictors of stream and wetland integrity than localized variables (Roth et al. 1996; Scott et al. 2002). 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, to support transient or migratory wildlife species, and to 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 and others, 2008).

For the purposes of CRAM, 500 meters has been surmised as the maximum distance between wetlands and other water-dependent habitats that does not by itself function as a barrier to the easy regular movements of small mammals, birds, amphibians, or reptiles. Greater distances between the wetland of interest and neighboring habitats are considered breaks in landscape connectivity. Similarly, any permanent physical alteration of the landscape surrounding the wetland that would preclude the movements of wildlife between habitat types or patches, or that would substantially impound or divert surface water flow between the wetland of interest and other water-dependent habitats are also considered to be breaks in connectivity (Collins and others, 2008).

On aerial photos containing the assessment area, lines representative of 500 meters are drawn in each of the cardinal directions. The average percentage of the transects that is wetland habitat is used to determine the rating for the metric (Table 3).

Table 3: Rating for landscape connectivity for all wetlands except Riverine (Adapted from Collins and others 2008).

Rating	Alternative States
A	An average of 76 – 100 % of the transects is wetland habitat of any kind.
B	An average of 51 – 75 % of the transects is wetland habitat of any kind.
C	An average of 26 – 50 % of the transects is wetland habitat of any kind.
D	An average of 0 – 25 % of the transects is wetland habitat of any kind.

Riverine wetlands: For Riverine wetlands, landscape connectivity is assessed as the continuity of the riparian corridor over a distance of about 500 meters upstream and 500 meters downstream of the AA (Table 4). Of special concern is the ability of wildlife to enter the riparian area from outside of it at any place within 500 meters of the AA, and to move easily through adequate cover along the riparian corridor through the AA from upstream and downstream. The landscape connectivity of Riverine wetlands is assessed as the total amount of non-buffer land cover (as defined in Table 3) that interrupts the riparian corridor within 500 meters upstream or downstream of the AA. Non-buffer land covers less than 10meters wide are disregarded in this metric. Note that, for Riverine wetlands, this metric considers areas of open water to provide landscape connectivity. For the purpose of assessing buffers, open water is considered a non-buffer land cover. But for the purpose of assessing landscape connectivity for Riverine wetlands, open water is considered part of the riparian corridor. This acknowledges the role that riparian corridors have in linking together aquatic habitats and in providing habitat for anadromous fish and other wildlife.

Table 4: Rating for Landscape Connectivity for Riverine wetlands (Adapted from Collins and others 2008).

Rating	For Distance of 500 m Upstream of AA:	For Distance of 500 m Downstream of AA:
A	The combined total length of all non-buffer segments is less than 100 m for wadeable systems ("2-sided" AAs); 50 m for non-wadeable systems ("1-sided" AAs).	The combined total length of all non-buffer segments is less than 100 m for wadeable systems ("2-sided" AAs); 50 m for non-wadeable systems ("1-sided" AAs).
B	The combined total length of all non-buffer segments is less than 100 m for "2-sided" AAs; 50 m for "1-sided" AAs.	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.
OR		
B	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.	The combined total length of all non-buffer segments is less than 100 m for "2-sided" AAs; is less than 50 m for "1-sided" AAs.
C	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.	The combined total length of all non-buffer segments is between 100 m and 200 m for "2-sided" AAs; 50 m and 100 m for "1-sided" AAs.
D	The combined total length of non-buffer segments is greater than 200 m for "2-sided" AAs; greater than 100 m for "1-sided" AAs.	any condition
OR		
D	any condition	The combined total length of non-buffer segments is greater than 200 m for "2-sided" AAs; greater than 100 m for "1-sided" AAs.

4.1.2.2 Percent Buffer Metric

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 and others, 2008).

This metric is assessed by visually estimating the total percentage of the perimeter of the AA that adjoins land cover types that usually provide buffer functions (Table 5) (Table 6). To be considered as buffer, a suitable land cover type must be at least 5 m wide and extend along the perimeter of the AA for at least 5 m. The maximum width of the buffer is 250 m. At distances beyond 250 m from the AA, the buffer becomes part of the landscape context of the AA. Any area of open water at least 30 m wide that is adjoining the AA, such as a lake, large river, or large slough, is not considered in the assessment of the buffer. Such open water is considered to be neutral, neither part of the wetland nor part of the buffer. There are three reasons for excluding large areas of open water (i.e., more than 30 m wide) from AAs and their buffers. First, assessments of buffer extent and buffer width are inflated by including open water as a part of the buffer. Second, while there may be positive correlations between wetland stressors and the quality of open water, quantifying water quality generally requires laboratory analyses beyond the scope of rapid assessment. Third, open water can be a direct source of stress (i.e., water pollution, waves, boat wakes) or an indirect source of stress (i.e., promotes human visitation, encourages intensive use by livestock looking for water, provides dispersal for non-native plant species), or it can be a source of benefits to a wetland (e.g., nutrients, propagules of native plant species, water that is essential to maintain wetland hydroperiods, etc.). However, any area of open water at least 30 m wide that is within 250 m of the AA but is not adjoining the AA is considered part of the buffer (Collins and others, 2008).

Table 5: Guidelines for identifying wetland buffers and breaks in buffers (Adapted from Collins and others 2008).

Examples of Land Covers Included in Buffers	**Examples of Land Covers Excluded from Buffers** Notes: Buffers do not cross these land covers; areas of open water adjacent to the AA are not included in the assessment of the AA or its buffer.
☐ bike trails	☐ commercial developments
☐ dry-land farming areas	☐ fences that interfere with the movements of wildlife
☐ foot trails	☐ intensive agriculture (row crops, orchards and vineyards lacking ground cover and other BMPs)
☐ horse trails	☐ paved roads (two lanes plus a turning lane or larger)
☐ links or target golf courses	☐ lawns
☐ natural upland habitats	☐ parking lots
☐ nature or wildland parks	☐ horse paddocks, feedlots, turkey ranches, etc.
☐ open range land	☐ residential developments
☐ railroads	☐ sound walls
☐ roads not hazardous to wildlife	☐ sports fields
☐ swales and ditches	☐ traditional (intensely manicured) golf courses
☐ vegetated levees	☐ urbanized parks with active recreation
	☐ pedestrian/bike trails (i.e., nearly constant traffic)

On aerial photos containing the assessment area, the perimeter containing buffer is measured. The percentage of perimeter containing buffer is used to rate the buffer metric.

Table 6: Rating for Percent of AA with Buffer (Adapted from Collins and others 2008).

Rating	Alternative States (not including open-water areas)
A	Buffer is 75 - 100% of AA perimeter.
B	Buffer is 50 – 74% of AA perimeter.
C	Buffer is 25 – 49% of AA perimeter.
D	Buffer is 0 – 24% of AA perimeter.

4.1.2.3 Buffer Width Metric

The average width of the buffer adjoining the AA is estimated by averaging the lengths of straight lines drawn at regular intervals around the AA from its perimeter outward to the nearest non-buffer land cover at least 10 m wide, or to a maximum distance of 250 m, whichever is first encountered (Table 7). The maximum buffer width is 250 m. The minimum buffer width is 5 m, and the minimum buffer length along the AA perimeter is also 5 m. Any area that is less than 5 m wide and 5 m long is assumed to be too small to provide buffer functions.

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.

Table 7: Rating for Average Buffer Width (Adapted from Collins and others 2008).

Rating	Alternative States
A	Average buffer width is 190 – 250 m.
B	Average buffer width 130 – 189 m.
C	Average buffer width is 65 – 129 m.
D	Average buffer width is 0 – 64 m.

4.1.2.4 Buffer Condition Metric

The condition of a buffer is assessed according to the extent and quality of its vegetation cover and the overall condition of its substrate (Table 8). Evidence of direct impacts by people are excluded from this metric and included in the Stressor Checklist. Buffer conditions are assessed only for the portion of the wetland border that has already been identified or defined as buffer. 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.

Table 8: Rating for Buffer Condition (Adapted from Collins and others 2008).

Rating	Alternative States
A	Buffer for AA is dominated by native vegetation, has undisturbed soils, and is apparently subject to little or no human visitation.
B	Buffer is characterized by an intermediate mix of native and non-native vegetation, but mostly undisturbed soils and is apparently subject to little or no human visitation.
C	Buffer is characterized by substantial amounts of non-native vegetation AND there is at least a moderate degree of soil disturbance/compaction, and/or there is evidence of at least moderate intensity of human visitation.
D	Buffer is characterized by barren ground and/or highly compacted or otherwise disturbed soils, and/or there is evidence of very intense human visitation.

4.1.3 Attribute 2- Hydrology

Hydrology includes the sources, quantities, and movements of water, plus the quantities, transport, and fates of water-borne materials, particularly sediment as bed load and suspended load. Hydrology is the most important direct determinant of wetland functions (Mitch and Gosselink 1993). The physical structure of a wetland is largely determined by the magnitude, duration, and intensity of water movement. For example, substrate grain size, depth of wetland sediments, and total organic carbon in sediments tend to be inversely correlated to duration of inundation in a Lacustrine wetland. (Collins and others, 2008)The hydrology of a wetland directly affects many physical processes, including nutrient cycling, sediment entrapment, and pollution filtration (Collins and others, 2008). For example, Odum and Heywood (1978) found that leaves in freshwater Depressional wetlands decomposed more rapidly when submerged. The hydrology of a wetland constitutes a dynamic habitat template for wetland plants and animals. For example, Richards and others. 2002 concluded that meandering and braiding in Riverine systems control habitat patch dynamics and ecosystem turnover. The spatial distribution of plants and animals in a tidal marsh closely correspond to patterns of tidal inundation or exposure (Sanderson and others 2000).

4.1.3.1 Water Source Metric

Water sources directly affect the extent, duration, and frequency of saturated or ponded conditions within an AA. Water Sources include inputs of water into the AA as well as any diversions of water from the AA. Diversions are considered a water source because they affect the ability of the AA to function as a source of water for other habitats while also directly affecting the hydrology of the AA. Inputs of water affecting conditions during the dry season are especially important because they strongly influence the structure and composition of wetland plant and animal communities. The water source metric therefore focuses on conditions that affect dry season hydrology.

Wetlands depend on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate (National Research Council 2001). Consistent, natural inflows of water to a wetland are important to their ability to perform and maintain most of their intrinsic ecological, hydrological, and societal functions and services. The flow of water into a wetland also affects its sedimentary processes, geo-chemistry, and basic physical structure (Collins and others, 2008). Sudol and Ambrose (2002) found that one of the greatest causes of failed wetland mitigation or restoration projects is inadequate or inappropriate hydrology.

The assessment of this metric is the same for all wetland types. It can be assessed initially in the office using the site imaging, and then revised based on the field visit (Table 9). For all wetlands, this metric focuses on *direct* sources of non-tidal water as defined above. The natural sources will tend to be more obvious than the unnatural sources. Evaluation of this metric should therefore emphasize the identification of the unnatural sources or diversions that directly affect the dry season conditions of the AA. The office work should initially focus on the immediate margin of the AA and its wetland, and then expand to include the smallest watershed or storm drain system that directly contributes to the AA or its immediate environment, such as another part of the same wetland or adjacent reach of the same Riverine system within about 2 kilometers upstream of the AA. Landscape indicators of unnatural water sources include adjacent intensive development, irrigated agriculture, and wastewater treatment discharge (Collins and others, 2008).

Table 9: Rating for Water Source (Adapted from Collins and others 2008).

Rating	Alternative States
A	Freshwater sources that affect the dry season condition of the AA, such as its flow characteristics, hydroperiod, or salinity regime, are precipitation, groundwater, and/or natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the dry season. There is no indication that dry season conditions are substantially controlled by artificial water sources.
B	Freshwater sources that affect the dry season condition of the AA are mostly natural, but also obviously include occasional or small effects of modified hydrology. Indications of such anthropogenic inputs include developed land or irrigated agricultural land that comprises less than 20% of the immediate drainage basin within about 2 km upstream of the AA, or that is characterized by the presence of a few small stormdrains or scattered homes with septic systems. No large point sources or dams control the overall hydrology of the AA.
C	Freshwater sources that affect the dry season conditions of the AA are primarily urban runoff, direct irrigation, pumped water, artificially impounded water, water remaining after diversions, regulated releases of water through a dam, or other artificial hydrology. Indications of substantial artificial hydrology include developed or irrigated agricultural land that comprises more than 20% of the immediate drainage basin within about 2 km upstream of the AA, or the presence of major point source discharges that obviously control the hydrology of the AA. OR Freshwater sources that affect the dry season conditions of the AA are substantially controlled by known diversions of water or other withdrawals directly from the AA, its encompassing wetland, or from its drainage basin within 2 km of the AA.
D	Natural, freshwater sources that affect the dry season conditions of the AA have been eliminated based on the following indicators: impoundment of all possible wet season inflows, diversion of all dry-season inflow, predominance of xeric vegetation, etc.

4.1.3.2 Hydroperiod or Channel Stability Metric

Hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. The natural hydroperiod for Estuarine wetlands is governed by the tides, and includes predictable variations in inundation regimes over days, weeks, months, and seasons. Depressional, Lacustrine, playas, and Riverine wetlands typically have daily variations in water height that are governed by diurnal increases in evapotranspiration and seasonal cycles that are governed by rainfall and runoff. Seeps and springs that depend on groundwater may have relatively slight seasonal variations in hydroperiod. Channel stability only pertains to Riverine wetlands. It's assessed as the degree of channel aggradation (i.e. net accumulation of sediment on the channel bed causing it to rise over time), or degradation (i.e. net loss of sediment from the bed causing it to be lower over time). There is much interest in channel entrenchment (i.e. the inability of flows in a channel to exceed the channel banks) and this is addressed in the Hydrologic Connectivity metric (Collins and others, 2008).

For all wetlands except Riverine wetlands, hydroperiod is the dominant aspect of hydrology. The pattern and balance of inflows and outflows is a major determinant of wetland functions (Mitch and Gosselink 1993). The patterns of import, storage, and export of sediment and other water-borne materials are functions of the hydroperiod. In most wetlands, plant recruitment and maintenance are dependent on hydroperiod. The interactions of hydroperiod and topography are major determinants of the distribution and abundance of native wetland plants and animals (Collins and others, 2008). Natural hydroperiods are key attributes of successful wetland projects (National Research Council 2001).

For Riverine systems, the patterns of increasing and decreasing flows that are associated with storms, releases of water from dams, seasonal variations in rainfall, or longer term trends in peak flow, base flow, and average flow are more important than hydroperiod. The patterns of flow, in conjunction with the kinds and amounts of sediment that the flow carries or deposits, largely determine the form of Riverine systems, including their floodplains, and thus also control their ecological functions. Under natural conditions, the opposing tendencies for sediment to stop moving and for flow to move the sediment tend toward a dynamic equilibrium, such that the form of the channel in cross-section, plan view, and longitudinal profile remains relatively constant over time (Leopold 1994). Large and persistent changes in either the flow regime or the sediment regime tend to destabilize the channel and cause it to change form. Such regime changes are associated with upstream land use changes, alterations of the drainage network, and climatic changes. A Riverine channel is an almost infinitely adjustable complex of interrelations between flow, width, depth, bed resistance, sediment transport, and riparian vegetation. Change in any of these factors will be countered by adjustments in the others. The degree of channel stability can be assessed based on field indicators (Collins and others, 2008).

This metric evaluates recent changes in the hydroperiod, flow regime, or sediment regime of a wetland and the degree to which these changes affect the structure and composition of the wetland plant community or, in the case of Riverine wetlands, the stability of the Riverine channel (Table 10). Common indicators are presented for the different wetland types. This metric focuses on changes that have occurred in the last 2-3 years.

Table 10: Rating of Hydroperiod for Depressional, Lacustrine, Playas, and Slope wetlands (Adapted from Collins and others 2008).

Rating	Alternative States (based on Table 4.10 above)
A	Hydroperiod of the AA is characterized by natural patterns of filling or inundation and drying or drawdown.
B	The filling or inundation patterns in the AA are of greater magnitude or duration than would be expected under natural conditions, but thereafter, the AA is subject to natural drawdown or drying.
C	Hydroperiod of the AA is characterized by natural patterns of filling or inundation, but thereafter, is subject to more rapid or extreme drawdown or drying, as compared to more natural wetlands. OR The filling or inundation patterns in the AA are of substantially lower magnitude or duration than would be expected under natural conditions, but thereafter, the AA is subject to natural drawdown or drying.
D	Both the inundation and drawdown of the AA deviate from natural conditions (either increased or decreased in magnitude and/or duration).

Perennial Estuarine: The volume of water that flows into and out of an Estuarine wetland is termed the “tidal prism.”The tidal prism consists of inputs from both tidal (i.e., marine or Estuarine) and non-tidal (e.g., fluvial or upland) sources. The timing, duration, and frequency of inundation of the wetland by these waters are collectively referred to as the tidal hydroperiod. Under natural conditions, increases in tidal prism tend to cause increases in inorganic sedimentation, which raises the tidal elevation of the wetland and thus reduces its hydroperiod. If the sediment supply is adequate, Estuarine marshes tend to build upward in quasi-equilibrium with sea level rise. A change in the hydroperiod of an Estuarine wetland (i.e., a change in the tidal prism) can be inferred from changes in channel morphology, drainage network density, and the relative abundance of plants indicative of either high or low tidal marsh (Table 11). A preponderance of shrink-swell cracks or dried pannes on the wetland plain is indicative of decreased hydroperiod. In addition, inadequate tidal flushing may be indicated by algal blooms or by encroachment of freshwater vegetation. Dikes, levees, ponds, or ditches are indicators of an altered hydroperiod resulting from management for flood control, salt production, waterfowl hunting, mosquito control, etc (Collins and others, 2008).

Seasonal Estuarine: The hydroperiod of a seasonal Estuarine wetland can be highly variable due to inter-annual variations in freshwater inputs and occasional breaching of the tidal barrier. Assessing hydroperiod for seasonal estuaries requires knowing its recent history of inlet closure and opening (Table 12). Hydroperiod alteration can be inferred from atypical wetting and drying patterns along the shoreline (i.e. a preponderance of shrink-swell cracks or dried pannes). Inadequate tidal flushing, or, in arid systems, excessive freshwater input during the dry season may be indicated by algal blooms or by encroachment of freshwater vegetation. Dikes, levees, ponds, ditches, and tide-control structures are indicators of an altered hydroperiod resulting from management for flood control, salt production, waterfowl hunting, mosquito control, boating, etc.(Collins and others 2008).

Table 11: Rating of Hydroperiod for Perennial Estuarine wetlands (Adapted from Collins and others 2008).

Rating	Alternative States
A	AA is subject to the full tidal prism, with two daily tidal minima and maxima.
B	AA is subject to reduced, or muted, tidal prism, although two daily minima and maxima are observed.
C	AA is subject to muted tidal prism, with tidal fluctuations evident only in relation to extreme daily highs or spring tides.
D	AA is subject to muted tidal prism, plus there is inadequate drainage, such that the marsh plain tends to remain flooded during low tide.

Table 12: Rating of Hydroperiod for Seasonal Estuarine wetlands (Adapted from Collins and others 2008).

Rating	Alternative States
A	AA is subject to natural inter-annual tidal fluctuations (range may be severely muted or vary seasonally), and episodically has tidal inputs by natural breaching due to either fluvial flooding or storm surge.
B	AA is subject to tidal inputs more often than would be expected under natural circumstances, because of artificial breaching of the tidal inlet.
C	AA is subject to tidal inputs less often than would be expected under natural circumstances due to management of the inlet to prevent its opening.
D	AA is rarely subject to natural tidal inputs.

Riverine: The hydroperiod of a Riverine wetland can be assessed based on a variety of statistical parameters, including the frequency and duration of flooding (as indicated by the local relationship between stream depth and time spent at depth over a prescribed period), and flood frequency (i.e. how often a flood of a certain height is likely to occur). These characteristics, plus channel form in cross section and plan view, steepness of the channel bed, material composition of the bed, sediment loads, and the amount of woody material entering the channel all interact to create the physical structure and form of the channel at any given time. The data needed to calculate hydroperiod is not available for most Riverine systems in California. Rapid assessment must therefore rely on field indicators of hydroperiod. For a broad spectral diagnosis of overall

Riverine wetland condition, the physical stability or instability of the system is especially important. Whether a Riverine system is stable (i.e., sediment supplies and water supplies are in dynamic equilibrium with each other and with the stabilizing qualities of riparian vegetation), or if it is degrading (i.e., subject to chronic incision of the channel bed), or aggrading (i.e., the bed is being elevated due to in-channel storage of excess sediment) can have large effects on downstream flooding, contaminant transport, riparian vegetation structure and composition, and wildlife support. CRAM therefore translates the concept of Riverine wetland hydroperiod into Riverine system physical stability. Every stable Riverine channel tends to have a particular form in cross section, profile, and plan view that is in dynamic equilibrium with the inputs of water and sediment. If these supplies change enough, the channel will tend to adjust toward a new equilibrium form. An increase in the supply of sediment can cause a channel to aggrade. Aggradation might simply increase the duration of inundation for existing wetlands, or might cause complex changes in channel location and morphology through braiding, avulsion, burial of wetlands, creation of new wetlands, sediment splays and fan development, etc. An increase in discharge might cause a channel to incise (i.e., cut-down), leading to bank erosion, headward erosion of the channel bed, floodplain abandonment, and dewatering of riparian areas (Collins and others 2008).

There are many well-known field indicators of equilibrium conditions for assessing the degree to which a channel is stable enough to sustain existing wetlands. To score this metric, visually survey of the assessment area for field indicators of aggradation or degradation The worksheet (Table 13) is a guide to be used the determination of a rating (Table 14)(Collins and others 2008).

Table 13: Worksheet for Assessing Hydroperiod for Riverine Wetlands (Adapted from Collins and others 2008).

Condition	Field Indicators (check all existing conditions)
Indicators of Channel Equilibrium	☐ The channel (or multiple channels in braided systems) 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 mid-channel bars and/or point bars densely vegetated with perennial vegetation. ☐ 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. ☐ The larger bed material supports abundant mosses or periphyton.
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. ☐ An obvious historical floodplain has recently been abandoned, as indicated by the age structure of its riparian vegetation. ☐ The channel bed appears scoured to bedrock or dense clay. ☐ Recently active flow pathways appear to have coalesced into one channel (i.e. a previously braided system is no longer braided). ☐ The channel has one or more nick points indicating headward erosion of the bed.
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; it lacks well-defined channel pools, or they 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.

Table 14: Rating for Riverine Channel Stability (Adapted from Collins and others 2008).

Rating	Alternative State (based on worksheet above)
A	Most of the channel through the AA is characterized by equilibrium conditions, with little evidence of aggradation or degradation (based on the field indicators listed in worksheet).
B	Most of the channel through the AA is characterized by some aggradation or degradation, none of which is severe, and the channel seems to be approaching an equilibrium form (based on the field indicators listed in worksheet).
C	There is evidence of severe aggradation or degradation of most of the channel through the AA (based on the field indicators listed in worksheet), or the channel is artificially hardened through less than half of the AA.
D	The channel is concrete or otherwise artificially hardened through most of AA.

4.1.3.3 Hydrologic Connectivity Metric

Hydrologic connectivity describes the ability of water to flow into or out of the wetland, or to accommodate rising flood waters without persistent changes in water level that can result in stress to wetland plants and animals. This metric pertains only to Riverine, Estuarine, vernal pool systems, individual vernal pools, Depressional wetlands, and playas (Collins and others, 2008).

Hydrologic connectivity between wetlands and adjacent uplands promotes the exchange of water, sediment, nutrients, and organic carbon. Inputs of organic carbon are of great importance to ecosystem function. Litter and allochthanous input from adjacent uplands provides energy that subsidizes the aquatic food web (Roth 1966). Connection with adjacent water bodies promotes the import and export of water-borne materials, including nutrients. Hydrologic connections with shallow aquifers and hyporheic zones influence most wetland functions. Plant diversity tends to be positively correlated with connectivity between wetlands and natural uplands, and negatively correlated with increasing inter-wetland distances (Lopez *et al.* 2002). Amphibian diversity is directly correlated with connectivity between streams and their floodplains (Amoros and Bornette 2002). Linkages between aquatic and terrestrial habitats allow wetland-dependent species to move between habitats to complete life cycle requirements. This metric is scored by assessing the degree to which the lateral movement of flood waters or the associated upland transition zone of the AA and its encompassing wetland is restricted by unnatural features such as levees, sea walls, or road grades (Table 18)(Collins and others, 2008).

Riverine: For Riverine wetlands, hydrologic connectivity is assessed based on the degree of channel entrenchment (Table 16) (Table 17) (Leopold *et al*. 1964, Rosgen 1996, Montgomery and MacDonald 2002). Entrenchment calculated as the flood-prone width divided by the bankfull width (Table 15). The flood-prone width is measured at the elevation equal to twice the maximum bankfull depth; maximum bankfull depth is the height of bankfull flow above the thalweg (Figure 5). The process for estimating entrenchment is outlined below.

Table 15: Worksheet for Riverine Wetland Entrenchment Ratio Calculation (Adapted from Collins and others 2008).

The following 5 steps should be conducted for each of 3 cross-sections located in the AA at the approximate mid-points along straight riffles or glides, away from deep pools or meander bends.				
Steps	**Replicate Cross-sections** →	**1**	**2**	**3**
1 Estimate bankfull width.	This is a critical step requiring familiarity with field indicators of the bankfull contour. Estimate or measure the distance between the right and left bankfull contours.			
2: Estimate max. bankfull depth.	Imagine a level line between the right and left bankfull contours; estimate or measure the height of the line above the thalweg (the deepest part of the channel).			
3: Estimate flood prone depth.	Double the estimate of maximum bankfull depth from Step 2.			
4: Estimate flood prone width.	Imagine a level line having a height equal to the flood prone depth from Step 3; note where the line intercepts the right and left banks; estimate or measure the length of this line.			
5: Calculate entrenchment.	Divide the flood prone width (Step 4) by the bankfull width (Step 1).			
6: Calculate average entrenchment.	Calculate the average results for Step 5 for all 3 replicate cross-sections. Enter the average result here and use it in Tables 4.15 a, b.			

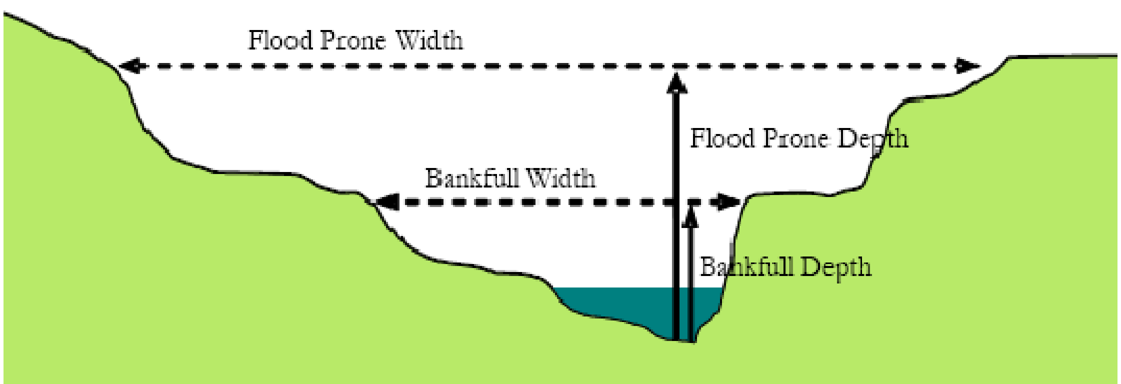

Figure 5: Parameters of Channel entrenchment. Flood prone depth is twice maximum bankfull depth. Entrenchment equals flood prone width divided by bankfull width (Adapted from Collins and others 2008).

Table 16: Rating of Hydrologic Connectivity for Non-confined Riverine wetlands (Adapted from Collins and others 2008).

Rating	Alternative States (based on the entrenchment ratio calculation worksheet above)
A	Entrenchment ratio is > 2.2.
B	Entrenchment ratio is 1.9 to 2.2.
C	Entrenchment ratio is 1.5 to 1.8.
D	Entrenchment ratio is <1.5.

Table 17: Rating of Hydrologic Connectivity for Confined Riverine wetlands (Adapted from Collins and others 2008).

Rating	Alternative States (based on the entrenchment ratio calculation worksheet above)
A	Entrenchment ratio is > 2.0.
B	Entrenchment ratio is 1.6 to 2.0.
C	Entrenchment ratio is 1.2 to 1.5.
D	Entrenchment ratio is < 1.2.

Table 18: Rating of Hydrologic Connectivity for Estuarine, Depressional, Lacustrine, and Slope wetlands, Playas, Individual Vernal Pools, and Vernal Pool Systems (Adapted from Collins and others 2008).

Rating	Alternative States
A	Rising water in the AA has unrestricted access to adjacent areas, without levees or other obstructions to the lateral movement of flood waters.
B	There are unnatural features such as levees or road grades that limit the amount of adjacent transition zone or the lateral movement of flood waters, relative to what is expected for the setting. But, the limitations exist for less than 50% of the boundary of AA. Restrictions may be intermittent along margins of the AA, or they may occur only along one bank or shore of the AA. Flood flows may exceed the obstructions, but drainage out of the AA is probably obstructed.
C	The amount of adjacent transition zone or the lateral movement of flood waters to and from the AA is limited, relative to what is expected for the setting, by unnatural features, such as levees or road grades, for 50-90% of the boundary of the AA. Flood flows may exceed the obstructions, but drainage out of the AA is probably obstructed.
D	The amount of adjacent transition zone or the lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features, such as levees or road grades, for more than 90% of the boundary of the AA.

4.1.4 Attribute 3 - Physical Structure

Physical structure is defined as the spatial organization of living and non-living surfaces that provide habitat for biota (Maddock 1999). For example, the distribution and abundance of organisms in Riverine systems are largely controlled by physical processes and the resulting physical characteristics of habitats (e.g., Frissell and others 1986). Metrics of the Physical Structure attribute in CRAM therefore focus on physical conditions that are indicative of the capacity of a wetland to support characteristic flora and fauna (Collins and others, 2008).

4.1.4.1 Structural Patch Richness Metric

Patch richness is the number of different obvious types of physical surfaces or features that may provide habitat for aquatic, wetland, or riparian species. This metric is different from topographic complexity in that it addresses the number of different patch types, whereas topographic complexity evaluates the spatial arrangement and interspersion of the types. Physical patches can be natural or unnatural (Collins and others, 2008).

The richness of physical, structural surfaces and features in a wetland reflects the diversity of physical processes, such as energy dissipation, water storage, and groundwater exchange, which strongly affect the potential ecological complexity of the wetland. The basic assumption is that natural physical complexity promotes natural ecological complexity, which in turn generally increases ecological functions, beneficial uses, and the overall condition of a wetland. For each wetland type, there are visible patches of physical structure that typically occur at multiple points along the hydrologic/moisture gradient. But not all patch types will occur in all wetland types. Therefore, the rating is based on the percent of total expected patch types for a given type of wetland (Collins and others, 2008).

The metric rating is determined by the number of observed patch types compared to what can be expected for a wetland type (Table 20). The following worksheet (Table 19) is a guide to which types can be expected for each wetland type. (Note: a 1 represents that the patch type can be expected, a zero represents it's typical absence for that wetland type).

Table 19: Worksheet for structural patch types for all wetland types, except vernal pool systems (Adapted from Collins and others 2008).Note: a 1 represents that the patch type is expected in a given wetland type, a 0 represents it is not expected.

STRUCTURAL PATCH TYPE (check for presence)	Riverine (Non-confined)	Riverine (Confined)	All Estuarine	Depressional	Slope Wetlands	Lacustrine	Individual Vernal Pools	Playas
Minimum Patch Size	3 m^2	3 m^2	3 m^2	3 m^2	1 m^2	3 m^2	1 m^2	3 m^2
Secondary channels on floodplains or along shorelines	1	0	1	0	1	1	0	1
Swales on floodplain or along shoreline	1	0	0	1	1	1	1	1
Pannes or pools on floodplain	1	0	1	0	1	1	1	1
Vegetated islands (mostly above high-water)	1	0	0	1	0	0	1	1
Pools or depressions in channels (wet or dry channels)	1	1	1	0	0	0	0	0
Riffles or rapids (wet channel) or planar bed (dry channel)	1	1	0	0	0	0	0	0
Non-vegetated flats or bare ground (sandflats, mudflats, gravel flats, etc.)	0	0	1	1	1	1	1	1
Point bars and in-channel bars	1	1	1	0	0	0	0	0
Debris jams	1	1	1	0	0	1	0	0
Abundant wrackline or organic debris in channel, on floodplain, or across depressional wetland plain	1	1	1	1	0	1	0	0
Plant hummocks and/or sediment mounds	1	1	1	1	1	1	1	1
Bank slumps or undercut banks in channels or along shoreline	1	1	1	1	0	1	0	0
Variegated, convoluted, or crenulated foreshore (instead of broadly arcuate or mostly straight)	1	1	0	1	0	1	0	0
Animal mounds and burrows	0	0	1	1	1	0	1	1
Standing snags (at least 3 m tall)	1	1	1	1	1	1	0	0
Filamentous macroalgae or algal mats	1	1	1	1	1	1	1	1
Shellfish beds	0	0	1	0	0	1	0	0
Concentric or parallel high water marks	0	0	0	1	1	1	1	1
Soil cracks	0	0	1	1	0	1	1	1
Cobble and/or Boulders	1	1	0	0	1	1	1	0
Submerged vegetation	1	0	1	1	0	1	0	0
Total Possible	16	11	15	13	10	16	10	10
No. Observed Patch Types(enter here and use in Table 4.16 below)								

Table 20: Rating of Structural Patch Richness (based on results from worksheet in table 19 (Adapted from Collins and others 2008).

Rating	Confined Riverine, Playas, Springs & Seeps, Individual Vernal Pools	Vernal Pool Systems and Depressional	Estuarine	Non-confined Riverine, Lacustrine
A	≥ 8	≥ 11	≥ 9	≥ 12
B	6 – 7	8 – 10	6 – 8	9 – 11
C	4 – 5	5 – 7	3 – 5	6 – 8
D	≤ 3	≤ 4	≤ 2	≤ 5

4.1.4.2 Topographic Complexity Metric

Topographic complexity refers to the micro- and macro-topographic relief within a wetland due to physical, abiotic features and elevations gradients. Topographic complexity promotes variable hydroperiods and concomitant moisture gradients that, in turn, promote ecological complexity by increasing the spatial and temporal variability in energy dissipation, surface water storage, groundwater recharge, particulate matter detention, cycling of elements and compounds, and habitat dynamics. Areas that are aerated due to flow across complex surfaces may promote volatilization of compounds, or re-suspension and export of water-borne material (Collins and others, 2008).

Topographic complexity is assessed by noting the overall variability in physical patches and topographic features (Table 21 and Figure 6). Care must be taken to distinguish indicators of topographic complexity or habitat features within a wetland from different kinds of wetlands. For each type of wetland, topographic complexity can be evaluated by observing the number of elevational features that affect moisture gradients or that influence the path of water flow along a transect across the AA, and the amount of micro-topographic relief along the gradients or flow paths. Topographic gradients may be indicated by plant assemblages with different inundation/saturation or salinity tolerances. Tables 21-24 provide narratives for rating Topographic Complexity for all wetland types.

Table 21: Typical indicators of Macro- and Micro-topographic Complexity for each wetland type (Adapted from Collins and others 2008).

Type	Examples of Topographic Features
Depressional and Playas	pools, islands, bars, mounds or hummocks, variegated shorelines, soil cracks, partially buried debris, plant hummocks, livestock tracks
Estuarine	channels large and small, islands, bars, pannes, potholes, natural levees, shellfish beds, hummocks, slump blocks, first-order tidal creeks, soil cracks, partially buried debris, plant hummocks
Lacustrine	islands, bars, boulders, cliffs, benches, variegated shorelines, cobble, boulders, partially buried debris, plant hummocks
Riverine	pools, runs, glides, pits, ponds, hummocks, bars, debris jams, cobble, boulders, slump blocks, tree-fall holes, plant hummocks
Slope Wetlands	pools, runnels, plant hummocks, burrows, plant hummocks, cobbles, boulders, partially buried debris, cattle or sheep tracks
Vernal Pools and Pool Systems	soil cracks, "mima-mounds," rivulets between pools or along swales, cobble, plant hummocks, cattle or sheep tracks

Figure 6: Scale independent schematic profiles of topographic complexity (Adapted from Collins and others 2008).

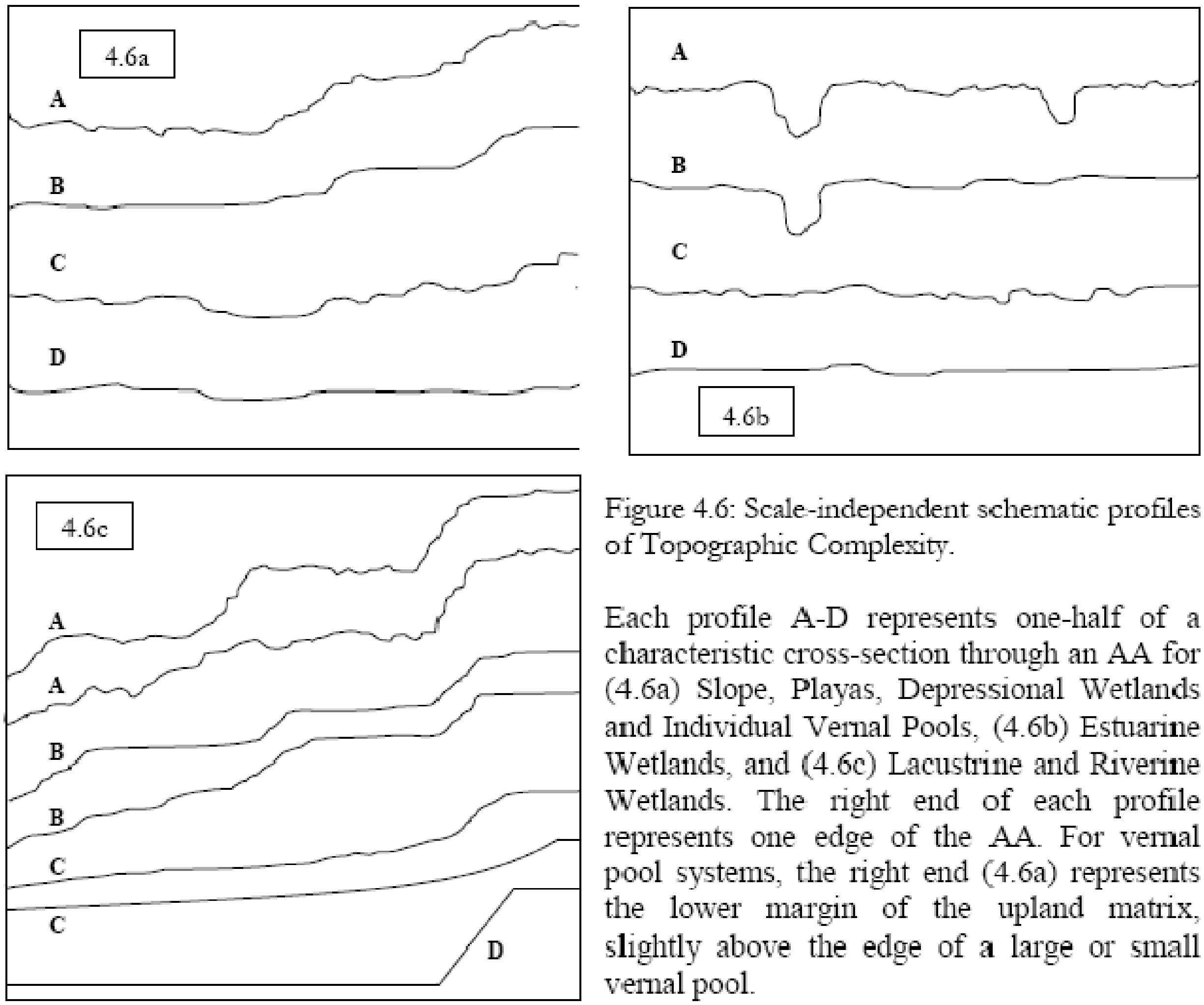

Figure 4.6: Scale-independent schematic profiles of Topographic Complexity.

Each profile A-D represents one-half of a characteristic cross-section through an AA for (4.6a) Slope, Playas, Depressional Wetlands and Individual Vernal Pools, (4.6b) Estuarine Wetlands, and (4.6c) Lacustrine and Riverine Wetlands. The right end of each profile represents one edge of the AA. For vernal pool systems, the right end (4.6a) represents the lower margin of the upland matrix, slightly above the edge of a large or small vernal pool.

Table 22: Rating of topographic complexity for Depressional wetlands, playas, individual vernal pools, and slope wetlands (Adapted from Collins and others 2008).

Rating	Alternative States (based on diagrams in Figure 4.6 above)
A	AA as viewed along a typical cross-section has at least two benches or breaks in slope, and each of these benches, plus the slopes between them contain physical patch types or features that contribute to abundant micro-topographic relief or variability as illustrated in profile A of Figure 4.6a.
B	AA has at least two benches or breaks in slope above the middle area or bottom zone of the AA, but these benches and slopes mostly lack abundant micro-topographic relief. The AA resembles profile B of Figure 4.6a.
C	AA lacks any obvious break in slope or bench, and is best characterized has a single slope that has at least a moderate amount of micro-topographic complexity, as illustrated in profile C of Figure 4.6a.
D	AA has a single, uniform slope with little or no micro-topographic complexity, as illustrated in profile D of Figure 4.6a.

Table 23: Rating of topographic complexity for all Estuarine wetlands (Adapted from Collins and others 2008).

Rating	Alternative States (based on diagrams in Figure 4.6 above)
A	The vegetated plain of the AA in cross-section has a variety of micro-topographic features created by plants, animal tracks, cracks, partially buried debris, retrogressing channels (i.e., channels filling-in with sediment and plants), natural levees along channels, potholes and pannes that together comprise a complex array of ups and downs resembling diagram A in Figure 4.6b.
B	The vegetated plain of the AA has a variety of micro-topographic features as described above for "A" but they are less abundant and/or they comprise less variability in elevation overall, as illustrated in diagram B of Figure 4.6b.
C	The vegetated plain of the AA has a variety of micro-topographic features as described above for "A" but lacks well-formed tidal channels that are well-drained during ebb tide. If channels exist, they mostly do not drain well or are filling-in with sediment. The plain overall resembles diagram C of Figure 4.6b.
D	The vegetated plain of the AA has little or no micro-topographic relief and few or no well-formed channels. The plain resembles diagram D of Figure 4.6b.

Table 24: Rating of topographic complexity for all Riverine wetlands (Adapted from Collins and others 2008).

Rating	Alternative States (based on diagrams in Figure 4.6 above)
A	AA as viewed along a typical cross-section has at least two benches or breaks in slope, including the riparian area of the AA, above the channel bottom, not including the thalweg. Each of these benches, plus the slopes between the benches, as well as the channel bottom area contain physical patch types or features such as boulders or cobbles, animal burrows, partially buried debris, slump blocks, furrows or runnels that contribute to abundant micro-topographic relief as illustrated in profile A of Figure 4.6c.
B	AA has at least two benches or breaks in slope above the channel bottom area of the AA, but these benches and slopes mostly lack abundant micro-topographic complexity. The AA resembles profile B of Figure 4.6c.
C	AA has a single bench or obvious break in slope that may or may not have abundant micro-topographic complexity, as illustrated in profile C of Figure 4.6c.
D	AA as viewed along a typical cross-section lacks any obvious break in slope or bench. The cross-section is best characterized as a single, uniform slope with or without micro-topographic complexity, as illustrated in profile D of Figure 4.6c (includes concrete channels).

4.1.5 Attribute 4 - Biotic Structure

The biotic structure of a wetland includes all of its organic matter that contributes to its material structure and architecture. Living vegetation and coarse detritus are examples of biotic structure. Plants strongly influence the quantity, quality, and spatial distribution of water and sediment within wetlands. For example, in many wetlands, including bogs and tidal marshes, much of the sediment pile is organic. Vascular plants in Estuarine and Riverine wetlands entrap suspended sediment. Plants reduce wave energies and decrease the velocity of water flowing through wetlands. Plant detritus is a main source of essential nutrients. Vascular plants and large patches of macroalgae function as habitat for wetland wildlife (Collins and others, 2008).

4.1.4.1 Plant Community Metric

The Plant Community Metric is composed of three submetrics for each wetland type. Two of these sub-metrics, Number of Co-dominant Plants and Percent Invasion, are common to all wetland types. For all wetlands except Vernal Pools and Vernal Pool Systems, the Number of Plant Layers as defined for CRAM is also assessed. A thorough reconnaissance of an AA is required to assess its condition using these submetrics. The assessment for each submetric is

guided by a set of Plant Community Worksheets. The Plant Community metric is calculated based on these worksheets (Table 26).
A "plant" is defined as an individual of any species of tree, shrub, herb/forbs, moss, fern, emergent, submerged, submergent or floating macrophyte, including non-native (exotic) plant species. For the purposes of CRAM, a plant "layer" is a stratum of vegetation indicated by a discreet canopy at a specified height that comprises at least 5% of the area of the AA where the layer is expected to occur. Non-native species owe their occurrence in California to the actions of people ever since shortly before Euro American contact. "Invasive" species are non-native species that tend to dominate one or more plant layers within an AA. CRAM uses the California Invasive Plant Council (Cal- IPC) list to determine the invasive status of plants, with augmentation by regional experts (Collins and others, 2008).

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 (Collins and others, 2008).

The plant community metric is assessed in terms of the similarity between the dominant species composition of the plant community and what is expected based on CRAM verification and validation studies, regional botanical surveys, and historical resources. This metric requires the ability to recognize the most common and abundant plants species of wetlands (Collins and others, 2008). Much of the plant identification was completed using voucher specimens and the Jepson manual, Western Wetland Flora, Calflora online, and Cal - IPC online because YTEP lacked a professional botanist.

4.1.5.1A Number of Plant Layers Present Metric

This submetric does not pertain to vernal pools or playas. Plant layers play a large role in the assessment of the biotic structure attribute. They are distinguished from one another by the differences in average maximum heights of their co-dominant plant species. For the Other Depressional wetlands, plus Estuarine, Lacustrine, and non-confined Riverine wetlands a maximum of five plant layers are recognized by CRAM (Table 25). For slope wetlands and confined Riverine wetlands, a maximum of four layers are recognized. To be counted in CRAM, a layer must cover at least 5% of the portion of the AA that is suitable for the layer. This would be the littoral zone of lakes and Depressional wetlands for the one aquatic layer, called "floating." The "short," "medium," and "tall" layers might be found throughout the non-aquatic areas of each wetland class, except in areas of exposed bedrock, mudflat, beaches, active point bars, etc. The "very tall" layer is usually expected to occur along the backshore, except in forested wetlands (Collins and others 2008).

It is essential that the layers be identified by the actual plant heights (i.e. the approximate maximum heights) of plant species in the AA, regardless of the growth potential of the species. For example, in a Riverine system a young sapling redwood between 0.5 m and 0.75 m tall would belong to the "medium" layer, even though in the future the same individual redwood might belong to the "very tall" layer. Some species might belong to multiple plant layers. For example, groves of red alders of all different ages and heights might collectively represent all four non-aquatic layers in a Riverine AA. Riparian vines, such as wild grape, might also dominate all of the non-aquatic layers. Standing (upright) dead or senescent vegetation from the previous growing season can be used in addition to live vegetation to assess the number of plant layers present. However, the lengths of prostrate stems or shoots are disregarded. In other words, fallen vegetation should not be "held up" to determine the plant layer to which it belongs. The number of plant layers must be determined based on the way the vegetation presents itself in the field (Collins and others 2008). The following are general descriptions of each plant layer:

Aquatic Layer. This layer includes rooted aquatic macrophytes such as *Ruppia cirrhosa* (ditchgrass), *Ranunculus aquatilis* (water buttercup), and *Potamogeton foliosus* (leafy pondweed) that create floating or buoyant canopies at or near the water surface that shade the water column. This layer also includes non-rooted aquatic plants such as *Lemna* spp. (duckweed) and *Eichhornia crassipes* (water hyacinth) that form floating canopies (Collins and others 2008).

Short Vegetation. This layer varies in maximum height among the wetland types, but is never taller than 50 cm. It includes small emergent vegetation and plants. It can include young forms of species that grow taller. Vegetation that is naturally short in its mature stage includes *Rorippa nasturtium aquaticum* (watercress), small Isoetes (quillworts*), Distichlis spicata* (saltgrass), *Jaumea carnosa* (jaumea), *Ranunculus flamula* (creeping buttercup), *Alisma* spp. (water plantain), *Sparganium* (burweeds), and *Sagitaria* spp. (arrowhead) (Collins and others 2008).

Medium Vegetation. This layer never exceeds 75 cm in height. It commonly includes emergent vegetation such *Salicornia virginica* (pickleweed), *Atriplex* spp. (saltbush), rushes (*Juncus* spp.), and *Rumex crispus* (curly dock) (Collins and others 2008).

Tall Vegetation. This layer never exceeds 1.5 m in height. It usually includes the tallest emergent vegetation and the larger shrubs. Examples include *Typha latifolia* (broad-leaved cattail), *Scirpus californicus* (bulrush), *Rubus ursinus* (California blackberry), and *Baccharis piluaris* (coyote brush) (Collins and others 2008).

Very tall Vegetation. This layer is reserved for shrubs, vines, and trees that are taller than 1.5 m. Examples include *Plantanus racemosa* (western sycamore), *Populus fremontii* (Fremont cottonwood), *Alnus rubra* (red alder), *Sambucus mexicanus* (Blue elderberry), and *Corylus californicus* (hazelnut) (Collins and others 2008).

Table 25; Worksheet for plant layer heights for all wetland types (Adapted from Collins and others 2008).

Wetland Type	Plant Layers				
	Aquatic	Semi-aquatic and Riparian			
	Floating	Short	Medium	Tall	Very Tall
Perennial Saline Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Perennial Non-saline Estuarine, Seasonal Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Lacustrine, Depressional and Non-confined Riverine	On Water Surface	<0.5 m	0.5 – 1.5 m	1.5 - 3.0 m	>3.0 m
Slope	NA	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Confined Riverine	NA	<0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	>3.0 m

4.1.5.1B Number of Co-Dominant Species

The second submetric, Number of Co-dominant Species, deals directly with dominant plant species richness in each plant layer and for the AA as a whole. For each plant layer in the AA, all species represented by living vegetation that comprises at least 10% relative cover within the layer are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded (Collins and others, 2008).

The investigator lists the names of all co-dominant plant species in each layer. The list is used to determine the total number of co-dominant species for all the layers that are represented in the AA. Some species, such as Himalayan Blackberry and Reed Canary Grass, can dominate multiple layers. Even though such plants have functional differences between layers, they should only be counted once when calculating the Number of Co-dominant Species for the AA. No matter how many layers a given species dominates, it should only be counted once as a co-dominant (Collins and others, 2008).

4.1.5.1C Percent Invasion

For the third submetric, Percent Invasion, the number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for many

California wetland and riparian plant species was based on the Cal-IPC list. However, the best professional judgment of local experts may be used instead to determine whether or not a co-dominant species is invasive. (Collins and others, 2008).Reed canary Grass has been determined to be an invasive species with the KRE wetlands. This judgment is based on the professional opinion of YTFP Biologists working in these wetlands for many years. The YTEP staff have concurred with this judgment after observing the aggressive spread of the species over several years. The plant is rhizomatic, and very hard to eradicate. The effects on wetland function caused by RCG infestations are negative and numerous.

Table 26: Ratings for submetrics of Plant Community Metric (Adapted from Collins and others 2008).

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
Perennial Saline Wetlands			
A	4 – 5	≥ 5	0 – 15%
B	2 – 3	4	16 – 30%
C	1	2 – 3	31 – 45%
D	0	0 – 1	46 – 100%
Perennial Non-Saline and Seasonal Estuarine Wetlands			
A	4 – 5	≥ 7	0 – 20%
B	3	5 – 6	21 – 35%
C	1 – 2	3 – 4	36 – 60%
D	0	0 – 2	61 – 100%
Lacustrine, Depressional and Non-confined Riverine Wetlands			
A	4 – 5	≥ 12	0 – 15%
B	3	9 – 11	16 – 30%
C	1 – 2	6 – 8	31 – 45%
D	0	0 – 5	46 – 100%
Slope Wetlands			
A	4	≥ 7	0 – 20%
B	3	5 – 6	21 – 35%
C	1 – 2	3 – 4	36 – 60%
D	0	0 – 2	61 – 100%
Confined Riverine Wetlands			
A	4	≥ 11	0 – 15%
B	3	8 – 10	16 – 30%
C	1 – 2	5 – 7	31 – 45%
D	0	0 – 4	46 – 100%

4.1.5.2 Horizontal Interspersion and Zonation Metric

Horizontal biotic structure refers to the variety and interspersion of plant "zones." Plant zones are plant monocultures or obvious multi-species associations that are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in plan view. Interspersion is essentially a measure of the number of distinct plant zones and the amount of edge between them. The existence of multiple horizontal plant zones indicates a well-developed plant community and predictable sedimentary and bio-chemical processes. The amount of interspersion among these plant zones is indicative of the spatial heterogeneity of these processes. Richer native communities of plants and animals tend to be associated with greater zonation and more interspersion of the plant zones (Collins and others 2008).

The distribution and abundance of horizontal plant zones, plus their interspersion, are combined into a single indicator. For large wetlands, the prominent zonation is evident in aerial photographs of scale 1:24,000 or smaller. For small wetlands, the zonation is apparent only in the field. The zones may be discontinuous and they can vary in number within a wetland. Plant zones often consist of more than one plant species, but some zones may be mono-specific. In some cases, one or two plant species dominates each zone. In order to score this metric, the practitioner must evaluate the wetland from a "plan view," i.e., as if the observer was hovering above the wetland in the air and looking down upon it. Figure 7 through 9 can aid evaluating the degree of horizontal interspersion (adapted from Mack 2001), which is rated using Table 27-28 (Collins and others, 2008).

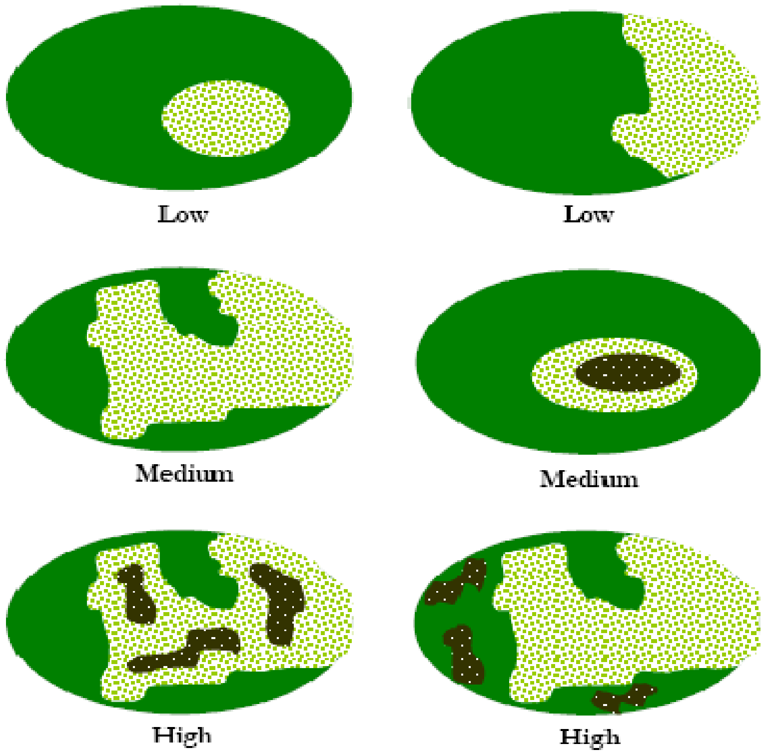

Figure 7: Diagram of the degrees of interspersion of plant zones for Lacustrine, Depressional, Playas, and Slope wetlands. Hatching patterns represent plant zones (adapted from Mack 2001).Each zone must comprise at least 5% of the AA (Adapted from Collins and others 2008).

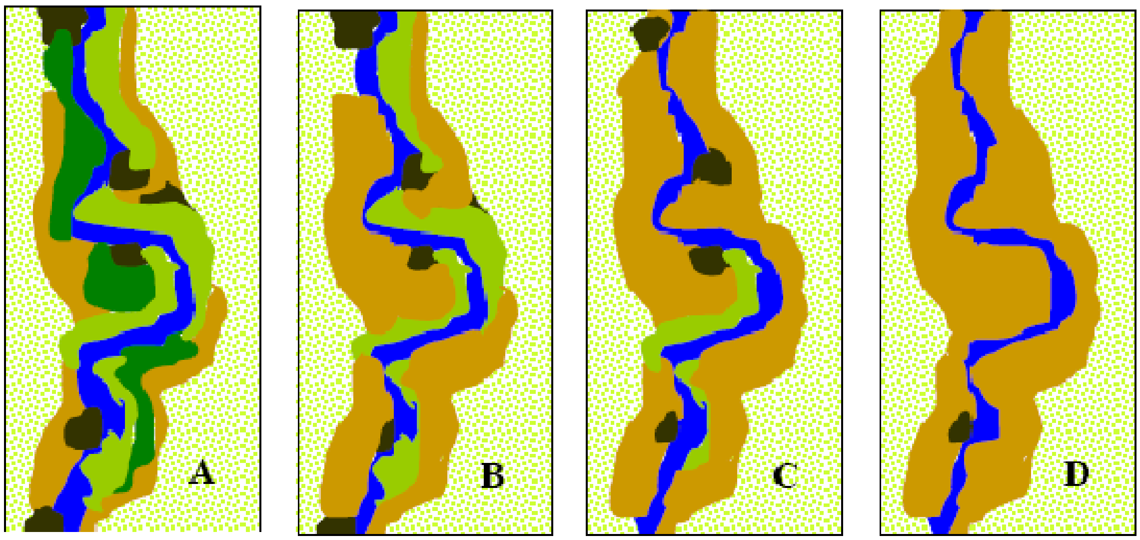

Figure 8: Schematic diagrams illustrating varying degrees of interspersion of plant zones for all Riverine wetlands (Adapted from Collins and others 2008).

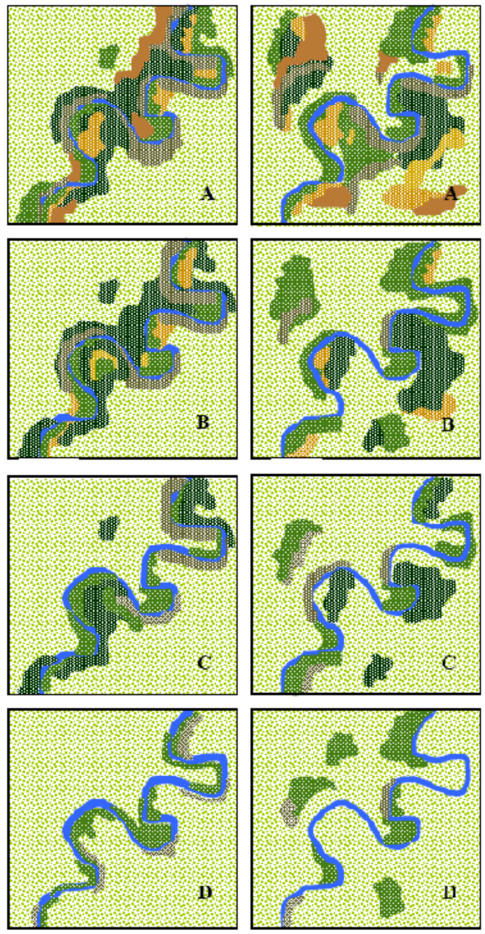

Figure 9: Schematic diagrams of varying degrees of interspersion of plant zones and patches for Perennial Saline, Non-saline, and Seasonal Estuarine wetlands. In these diagrams, each plant zone or patch type has a unique color and comprises at least 5% of the AA. There are two examples for each condition A-D. The left-side example in each pair shows zones or patches organized around a tidal channel, and the right-side example in each pair shows patches or zones that are more broadly distributed across the wetland plain (Adapted from Collins and others 2008).

Table 27: Rating of Horizontal Interspersion of plant zones for all AAs except Riverine and Vernal Pool systems (Adapted from Collins and others 2008)

Rating	Alternative States (based on Figures 4.7, 4.8, and 4.10)
A	AA has a high degree of plan-view interspersion.
B	AA has a moderate degree of plan-view interspersion.
C	AA has a low degree of plan-view interspersion.
D	AA has essentially no plan-view interspersion.

Table 28: Rating of Horizontal Interspersion of plant zones for Riverine AAs (Adapted from Collins and others 2008).

Rating	Alternative States (based on Figure 4.9)
A	AA has a high degree of plan-view interspersion.
B	AA has a moderate degree of plan-view interspersion.
C	AA has a low degree of plan-view interspersion.
D	AA has essentially no plan-view interspersion.

4.1.5.3 Vertical Biotic Structure Metric

The vertical component of biotic structure assesses the degree of overlap among plant layers. The same plant layers used to assess the Plant Community Composition metrics (see Section 4.4.2) are used to assess Vertical Biotic Structure. To be counted in CRAM, a layer must cover at least 5% of the portion of the AA that is suitable for the layer. This metric does not pertain to Vernal Pools, Vernal Pool Systems, or Playas (Collins and others, 2008).

The overall ecological diversity of a wetland tends to correlate with the vertical complexity of the wetland's vegetation. For many types of wetlands in California, overlapping layers of vegetation above or below the water surface contribute to vertical gradients in light and temperature that result in greater species diversity of macroinvertebrates, fish, amphibians, and birds. In riparian areas, the species richness of birds and small mammals tends to increase with the density and number of well-developed, overlapping plant layers. Many species of birds that nest near the ground or water surface in wetlands commonly require a cover of vegetation at their nest sites. Multiple layers of vegetation also enhance hydrological functions, including rainfall interception, reduced evaporation from soils, and enhanced filtration of floodwaters. In many Depressional wetlands and some wet meadows, the detritus of above-ground growth of low and medium layers of herbaceous plants and emergent monocots tends to get entrained within the layers as an internal canopy below the maximum height of the upper plant layer. These “entrained canopies” serve as cover for many wildlife species. In Estuarine wetlands, the entrained canopies entrap debris including coarse plant litter that is lifted into the canopies by rising tides. As the tide goes out, the material is left hanging in the plant cover. Over time, these entrained canopies can gain enough density and thickness to provide important shelter for many species of birds and small mammals that inhabit Estuarine wetlands. Most passerine birds and rails that nest in Estuarine wetlands choose to nest below an entrained canopy because it protects them from avian predators, including owls and harriers (Collins and others, 2008).

Vertical structure must be assessed in the field. The vertical component of biotic structure is commonly recognized as the overall number of plant layers, their spatial extent, and their vertical overlap relative to the expected conditions (Figure 10) (Figure 11) (Table 29) (Table 30) (Collins and others, 2008).

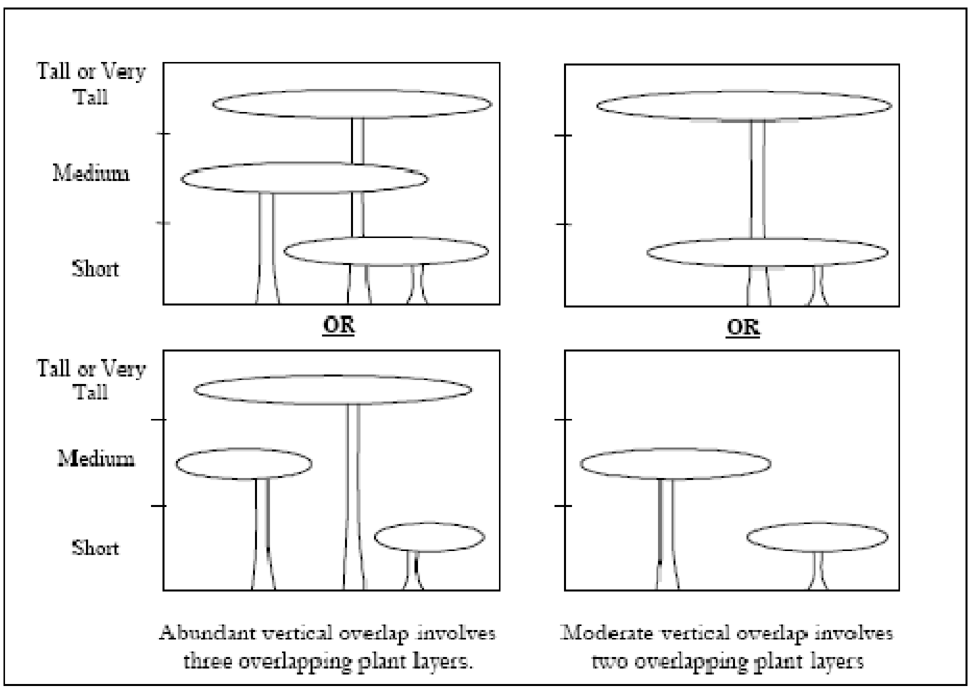

Figure 10: Schematic diagrams of vertical interspersion of plant layers for Riverine wetlands for Depressional and Lacustrine wetlands having tall or very tall plant layers (Adapted from Collins and others 2008).

Table 29: Rating of vertical biotic structure for Riverine AAs and for Lacustrine and Depressional AAs supporting tall or very tall plant layers (Adapted from Collins and others 2008).

Rating	Alternative States
A	More than 50% of the vegetated area of the AA supports abundant overlap of plant layers (see Figures 4.11).
B	More than 50% of the area supports at least moderate overlap of plant layers.
C	25–50% of the vegetated AA supports at least moderate overlap of plant layers, or three plant layers are well represented in the AA but there is little to no overlap.
D	Less than 25% of the vegetated AA supports moderate overlap of plant layers, or two layers are well represented with little overlap, or AA is sparsely vegetated overall.

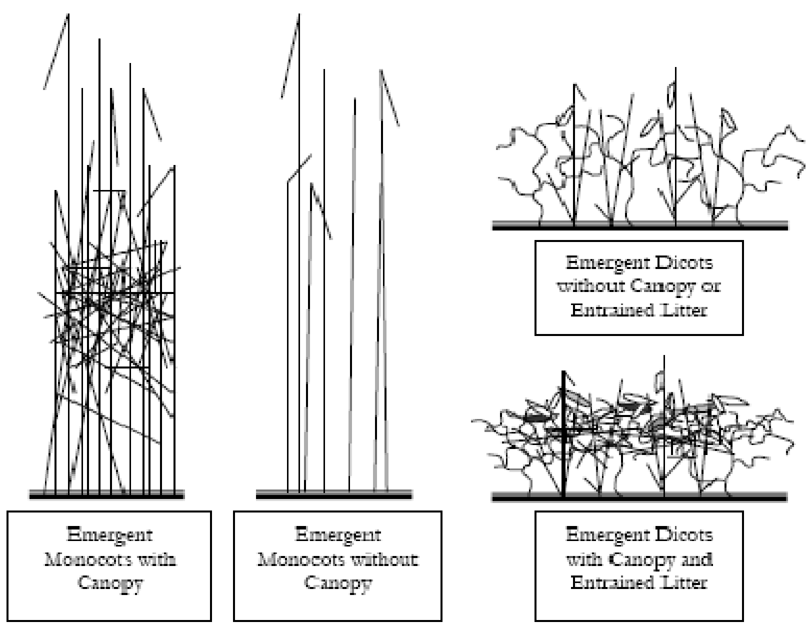

Figure 11: Schematic diagrams of entrained plant canopies as an important aspect of vertical biotic structure in all Estuarine wetlands, or in Depressional and Lacustrine wetlands dominated by emergent monocots or lacking tall and very tall plant layers. In Estuarine wetlands, the ability to conceal a hand or foot beneath the canopy is a key indicator of its density (Adapted from Collins and others 2008).

Table 30: Rating of Vertical Biotic Structure for wetlands dominated by emergent monocots or lacking tall and very tall plant layers, especially Estuarine saline wetlands (Adapted from Collins and others 2008).

Rating	Alternative States
A	Most of the vegetated plain of the AA has a dense canopy of living vegetation or entrained litter or detritus forming an entrained canopy that shades the soil surface and provides abundant cover for wildlife, such as small mammals and ground-dwelling birds.
B	Less than half of the vegetated plain of the AA has a dense entrained canopy as described in "A" above; OR Most of the vegetated plain has a dense entrained canopy but it is too close to the soil surface to provide cover for wildlife.
C	Less than half of the vegetated plain of the AA has a dense canopy of vegetation or entrained litter AND the canopy is too close to the soil surface to provide cover for wildlife.
D	Most of the AA lacks a dense entrained canopy of vegetation or litter.

5.0 Results

CRAM assessment data was collected at a number of assessment areas from within distinct wetland complexes. Maps depicting each assessment area link tabular data for each attribute and metrics to a location. The boundaries for each AA have been generalized for ease of viewing. The data from each AA is broken down by attributes revealing scores for each metric. Sub sequential breakdowns are given for each attribute. By breaking down attribute scores by metric it is possible to see why certain AAs scored lower than others and provided an explanation for low attribute scores for each wetland complex. It was also possible to assess the range of scores within a wetland complex. Averages of tabular data have been added for relative comparisons. Average metric scores for a wetland complex area can be compared, as well as average attribute scores for each wetland complex. Additionally, metric scores for each AA can be compared to overall complex averages.

5.1 South Slough Wetland Complex – Klamath River Estuary

The South side of the KRE comprises a very large wetland complex known as the South Slough. The wetlands are by bordered Redwood National Park to the south and the Klamath River to the northwest. Created by deposits of gravel and sediment, the large island type of land contains several large channels and many smaller branching arms. Much of the channels are under tidal influence while higher elevated wetlands are subject to seasonally flooding of the Klamath River.

(See Figure 12)) Classifying these wetlands has unique challenges. Salt tolerant species are not the overwhelming vegetation found here as in most Estuarine wetlands. The most prevalent species here are found throughout the freshwater (Riverine) reaches of the river as well. In general the KRE lacks tidal flats; this point serves to show the KRE is geographically constrained. For this study the wetland type to best characterize the South Slough was chosen due to the boundaries of the KRE. The estuary boundaries are based on salt water intrusion, which consistently reaches the highway 101 bridge. The CRAM wetland typing flow chart was also used to type these wetlands.

Figure 12: Photographs depicting varying channel sizes and vegetation in the South Slough (July 2008).

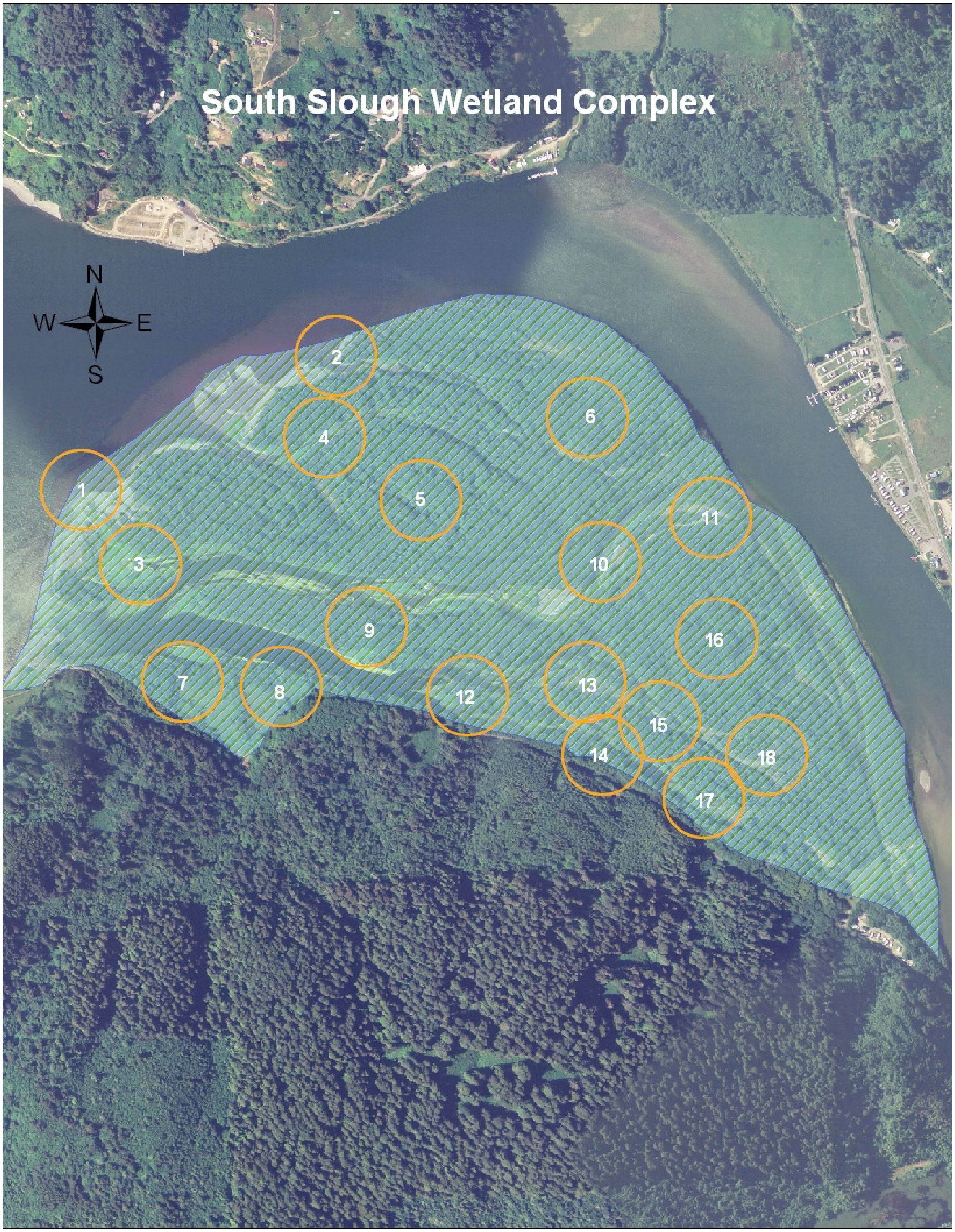

Figure 13: Assessment Areas (AA) in the South Slough Wetland Complex. Each AA is assigned a number and is linked to tabular data. See tables 31-35. Base image: portions of 2005 NAIP imagery, 1 meter resolution.

Table 31: South Slough Buffer and Landscape Context Attribute scoring breakdown by metric.

Assessment Area	Landscape Connectivity	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	Raw Score	Final Attribute score
1	12	6	12	12	22	92
2	12	12	12	9	22	92
3	12	12	9	9	22	92
4	12	12	12	12	24	100
5	12	12	12	12	24	100
6	12	12	9	12	23	96
7	12	12	9	12	23	96
8	12	12	9	9	22	92
9	12	12	12	9	22	92
10	12	12	12	9	22	92
11	12	12	12	9	22	92
12	12	6	9	12	21	88
13	12	12	12	9	22	92
14	12	12	12	9	22	92
15	12	12	12	9	22	92
16	12	12	12	9	22	92
17	12	12	12	9	22	92
18	12	12	9	9	22	92
Average	**12.00**	**11.33**	**11.00**	**10.00**	**22.28**	**93.11**

Table 32: South Slough Hydrology Attribute scoring breakdown by metric.

Assessment Area	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Score	Final Attribute Score
1	12	12	12	36	100
2	12	12	12	36	100
3	12	12	12	36	100
4	12	12	12	36	100
5	12	3	12	27	75
6	12	3	12	27	75
7	12	6	12	30	83
8	12	6	9	27	75
9	12	12	12	36	100
10	12	9	12	33	92
11	12	9	12	33	92
12	12	12	12	36	100
13	12	9	12	33	92
14	12	9	9	30	83
15	12	6	9	27	75
16	12	3	12	27	75
17	12	12	9	33	92
18	12	6	9	27	75
Average	**12.00**	**8.50**	**11.17**	**31.67**	**88.00**

Table 33: South Slough Physical Structure Attribute scoring breakdown by metric.

Assessment Area	Structural Patch Richness	Topographic Complexity	Raw Score	Final Attribute Score
1	9	9	18	75
2	6	9	15	63
3	6	9	15	63
4	6	9	15	63
5	3	9	12	50
6	6	6	12	50
7	6	9	15	63
8	6	9	15	63
9	6	9	15	63
10	6	12	18	75
11	9	9	18	75
12	9	9	18	75
13	3	9	12	50
14	9	6	15	63
15	9	9	18	75
16	6	12	18	75
17	6	9	15	63
18	9	9	18	75
Average	**6.67**	**9**	**15.67**	**65.5**

Table 34: South Slough Biotic Structure Attribute scoring breakdown by metric.

Assessment Area	Number of Plant Layers	Number of Co-Dominant species	Percent Invasion	Horizontal interspersion and Zonation	Vertical Biotic Structure	Raw Score	Final Attribute Score
1	9	12	6	6	3	26	72
2	12	12	9	9	9	29	81
3	12	12	9	6	6	23	64
4	12	12	9	6	9	29	81
5	9	9	12	6	9	25	69
6	12	12	9	9	6	26	72
7	6	12	9	6	9	24	67
8	6	12	9	9	9	27	75
9	12	12	9	6	6	23	64
10	9	12	9	9	6	25	69
11	12	12	9	9	6	26	72
12	9	12	9	6	6	22	61
13	9	12	9	6	9	25	69
14	12	12	9	9	9	29	81
15	12	12	6	9	6	25	69
16	6	12	9	6	6	21	58
17	9	9	9	9	9	27	75
18	12	12	12	9	9	30	83
Average	**10**	**11.66**	**9.00**	**7.50**	**7.33**	**25.67**	**71.22**

Table 35: South Slough Overall CRAM score breakdown by Attribute.

Assessment Area	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure	Overall AA score
1	92	100	75	50	79
2	92	100	63	81	84
3	92	100	63	64	80
4	100	100	63	81	84
5	100	75	50	69	74
6	96	75	50	72	73
7	96	83	63	67	77
8	92	75	63	75	76
9	92	100	63	64	80
10	92	92	75	69	82
11	92	92	75	72	83
12	88	100	75	61	81
13	92	92	50	69	76
14	92	83	63	81	80
15	92	75	75	69	78
16	92	75	75	58	75
17	92	92	63	75	81
18	92	75	75	83	81
Average	**93.11**	**88.00**	**65.50**	**71.22**	**79.29**

5.1.1 Summary of South Slough data

A total of 18 AA's were completed in the South Slough wetland complex during the growing seasons of 2008 and 2009. Overall CRAM scores averaged 79.29, which was the highest out of any of the wetland complexes. Buffer and Landscape Connectivity attribute scores averaged 93.18, the highest among wetland complexes, largely due to the lack of roads and human development on the south side of the KRE. Hydrology attribute scores averaged 88.76, again the highest among all wetland complexes. Hydrology within the South Slough is largely controlled by seasonal river flows and the tidal influence of the ocean. Both directly influence the estuary's water level fluctuations. Both of these hydrologic inputs are more difficult to manipulate compared to the hydrology of smaller off estuary tributaries, leading to high scores for South Slough's Hydrology attribute score. Physical Structure attribute scores averaged 65.65, second among wetland complexes. Physical Structure attribute scores were relatively higher in the South Slough due to the natural hydrologic processes occurring that help to create and maintain and wider variety of patch types, and more topographically complex channels and flood plains. Biotic Structure attribute scores averaged 71.22, the highest among wetland complexes, largely due to the wide variety of plant species present, and the number of plant layers.

5.2 Richardson Creek Wetland Complex

Also along the south side of the Estuary is the wetland complex known as Richardson Creek. The wetland complex is comprised of an abandoned mill pond known as Marshall Pond. The wetland is elevated from the Klamath River by a road prism and a perched culvert, making tidal influence impossible. Richardson creek was once connected to the estuary and experienced tidal influence, but now the lower portion is best classified as a Depressional wetland according to CRAM wetland typing guidelines. The wetland complex lies within Redwood National Park boundaries.

Figure 14: Richardson Creek wetland complex (August 2009).

Figure 15: Assessment Areas (AAs) located in the Richardson Creek Wetland Complex. Each AA is assigned a number and is linked to tabular data. See tables 36-40. Base image: portions of 2005 NAIP imagery, 1 meter resolution.

Table 36: Richardson Creek Buffer and Landscape Context Attribute scoring breakdown by metric.

Assessment Area	Landscape Connectivity	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	Raw Score	Final Attribute score
1	9	12	12	9	19	79
2	12	9	9	9	21	88
3	12	12	9	12	23	96
Average	**11**	**11**	**10**	**10**	**21**	**87.67**

Table 37: Richardson Creek Hydrology Attribute scoring breakdown by metric.

Assessment Area	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Score	Final Attribute Score
1	12	9	6	27	75
2	12	6	3	21	58
3	12	9	12	33	92
Average	**12**	**8**	**7**	**27**	**75**

Table 38: Richardson Creek Physical Structure Attribute scoring breakdown by metric.

Assessment Area	Structural Patch Richness	Topographic Complexity	Raw Score	Final Attribute Score
1	6	6	12	50
2	9	9	18	75
3	12	12	24	100
Average	**9**	**9**	**18**	**75**

Table 39: Richardson Creek Biotic Structure Attribute scoring breakdown by metric.

Assessment Area	Number of Plant Layers	Number of Co-Dominant species	Percent Invasion	Horizontal interspersion and Zonation	Vertical Biotic Structure	Raw Score	Final Attribute Score
1	12	9	9	6	3	19	53
2	9	9	9	6	6	21	58
3	9	3	12	9	6	23	64
Average	**10**	**7**	**10**	**7**	**5**	**21**	**58.33**

Table 40: Richardson Creek Overall CRAM score breakdown by attribute.

Assessment Area	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure	Overall AA score
1	79	75	50	53	64
2	88	58	75	58	70
3	96	92	100	64	88
Average	**87.67**	**75**	**75**	**58.33**	**74**

5.2.1 Summary of Richardson Creek data

A total of three AA's were completed at the Richardson Creek wetland complex during the wetland growing seasons of 2008. Richardson Creek wetland complex had an overall CRAM score average of 75.00. This was the second highest overall CRAM score average of the wetland complexes assessed. Buffer and Landscape Connectivity attribute scores averaged 87.67, third overall in wetland complexes. Although located in the Redwood National Park, and little human development is present there, a small presence of roads, a parking lot, homes, and slightly decreased buffer condition, have slightly lowered this attribute score. Hydrology attribute scores averaged 75.00, the second highest among all wetland complexes. Although a portion of the wetland complex scores low in the Hydrology attribute due to the presence of an abandoned mill pond levee, the upper wetland scored among the highest of any individual AA assessed throughout all the wetland complexes combined. Physical Structure attribute scores averaged 75.00 as well. A broad range of Physical Structure attribute scores was found between the AA's. Decreases to the Physical Structure attribute scores can be largely attributed to the presence of the abandoned mill pond, levee, and landscape changes made to accommodate the mill. Biotic Structure attribute scores averaged 58.33, second lowest of all wetland complexes. AA scores for the Biotic Structure attribute were within a smaller range than the other attributes, and were typified by poor vertical biotic structure and a lack of interspersion and zonation.

5.3 Waukell Creek Wetland Complex

Waukell Creek joins the KRE on the south side approximately 3 miles from the Pacific Ocean.Shortly upstream of the confluence was the location of a logging mill which operated in the 1960's.The natural hydrology of the creek has been significantly altered, causing entrapment of sediment, aggradation, invasive species colonization, and loss of fish habitat and passage. A portion of the creek upstream of its mouth resembles a Depressional wetland, which is a remnant logging pond that had been converted through excavation of the natural stream channel and flood plain and impounded by a levee. Above the log pond the creek resembles a forested Depressional wetland containing anastomizing channels. Further up the creek forms a typical channel which has been excluded from this study. According to CRAM typing guidelines the wetland is classified as a Depressional wetland. The Creek is bordered by highway 101 to the west, timber land to the east, and Resighini Rancheria to the north. The portion of the wetland complex assessed lies within the California Department of Fish and Game Wild life Management Area.

Figure 16: Waukell Creek Wetland Complex at the abandoned mill pond. Notice the wetland is dominated by Reed Canary Grass *(Philaris Urundinacea*) (June 2008).


Figure 17: Waukell Creek Wetland Complex upstream from the abandoned mill pond. Notice the wetland is densely vegetated and lacking a typical stream channel (June 2008).

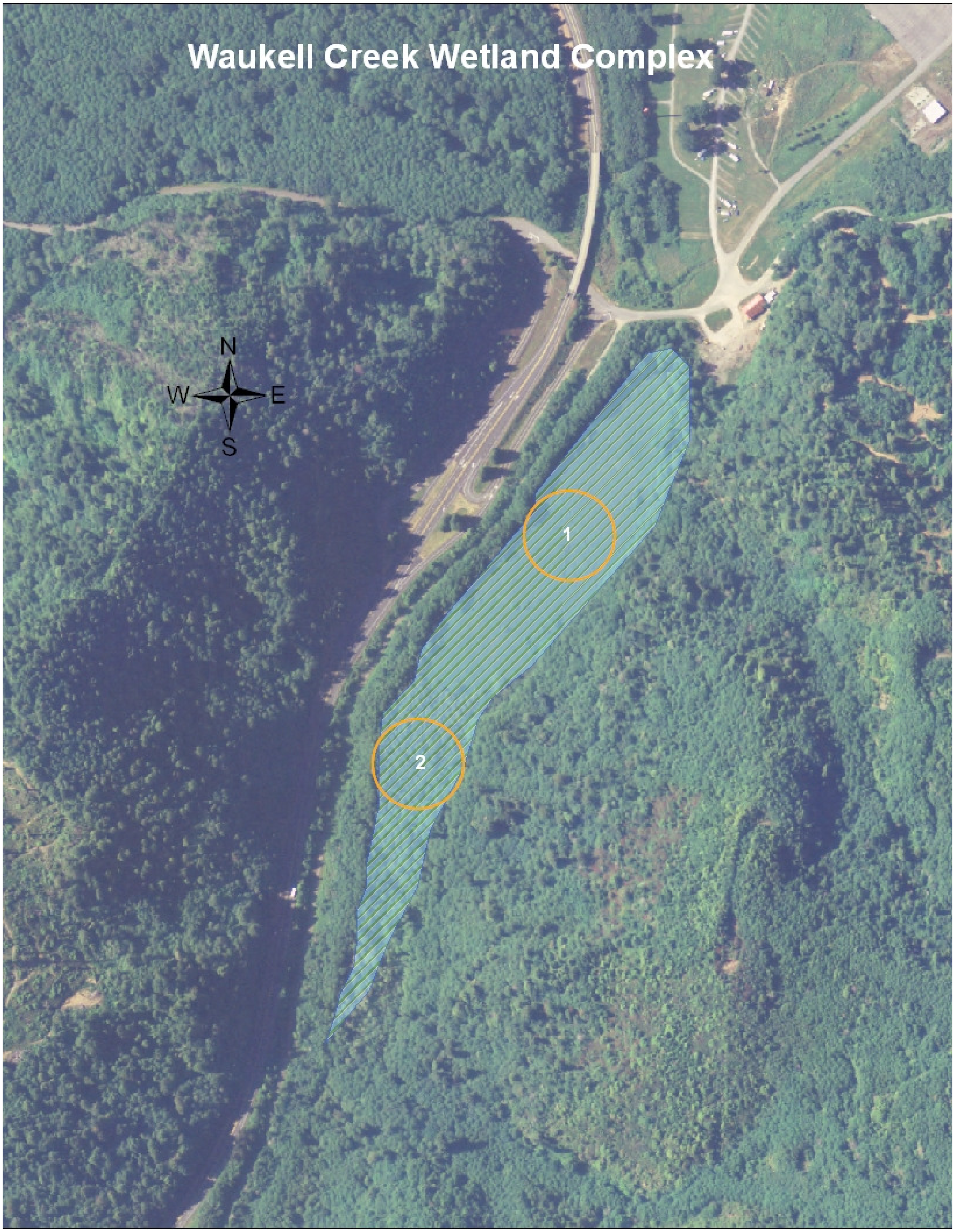

Figure 18: Assessment Areas (AA) located in the Waukell Creek Wetland Complex. Each AA is assigned a number and is linked to tabular data. See tables 41-45. Base image: portions of 2005 NAIP imagery, 1 meter resolution.

Table 41: Waukell Creek Buffer and Landscape Context Attribute scoring breakdown by metric.

Assessment Area	Landscape Connectivity	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	Raw Score	Final Attribute score
1	12	12	9	9	22	92
2	12	12	9	6	20	83
Average	**12**	**12**	**9**	**7.5**	**21**	**87.5**

Table 42: Waukell Creek Hydrology Attribute scoring breakdown by metric.

Assessment Area	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Score	Final Attribute Score
1	9	6	12	27	75
2	9	9	12	30	83
Average	**9**	**7.5**	**12**	**28.5**	**79**

Table 43: Waukell Creek Physical Structure Attribute scoring breakdown by metric.

Assessment Area	Structural Patch Richness	Topographic Complexity	Raw Score	Final Attribute Score
1	3	6	9	38
2	6	6	12	50
Average	**4.5**	**6**	**10.5**	**44**

Table 44: Waukell Creek Biotic Structure Attribute scoring breakdown by metric.

Assessment Area	Number of Plant Layers	Number of Co-Dominant species	Percent Invasion	Horizontal interspersion and Zonation	Vertical Biotic Structure	Raw Score	Final Attribute Score
1	6	3	12	3	3	13	36
2	9	3	9	9	9	25	69
Average	**7.5**	**3.0**	**10.5**	**6.0**	**6.0**	**19.0**	**52.5**

Table 45: Waukell Creek Overall CRAM score breakdown by attribute.

Assessment Area	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure	Overall AA score
1	92	75	38	36	60
2	83	83	50	69	71
Average	**87.5**	**79**	**44**	**52.5**	**65.5**

5.3.1 Summary of Waukell Creek data

A total of two AAs were completed at Waukell Creek wetland complex during the growing season of 2008. Overall CRAM scores averaged 65.50, the lowest among wetland complexes. Low CRAM scores were largely related to poor Physical Structure and Biotic Structure attribute scores. Physical Structure attribute scores averaged 44.0, the lowest among all wetland complexes. Biotic structure attribute scores were also the lowest among wetland complexes averaging 52.50. The area of Waukell Creek wetland complex that was assessed is at the site of an abandoned mill pond. The landscape has been significantly altered from its natural state and resembles a wet meadow completely colonized by an invasive species monoculture, RCG. There is virtually no topographic complexity in the lower reaches of the wetland complex. Conditions improve upstream, however areas that have a typical stream channel networks have been left out of this study. Buffer and Landscape Connectivity attribute scores averaged 87.5, third among wetland complexes. The area is a close distance to Highway 101, but has a small amount of upland buffering this stressor. Timber lands surround the wetland complex to the East, limiting human development and roads. The wetland is within wildlife management area boundaries, further protecting it from outside stressors. Hydrology attribute scores averaged 79.00, second among all wetland complexes. Hydrologic connectivity boosted the score for this attribute. The high degree of hydrologic Connectivity was due mainly to the wetland system's ability to breach its banks and access flood plains.

5.4 Salt Creek Wetland Complex

As the closest tributary to the mouth of the Klamath River, Salt Creek is tidally influenced in the lower reach. The wetlands located in the upper reaches of the creek are freshwater and are not tidally influenced, but do experience frequent back water flooding events when the Klamath River is high (Beesley and Fiori 2007). Agricultural landowners began converting complex off-estuary wetlands of lower salt creek in the mid to late 1800's (Beesley and Fiori 2007). Subsequently, Salt Creek was relocated to the western edge of the valley (Beesley and Fiori, 2007). The ability of the stream to access flood plains has been severely reduced in lower Salt creek. However, in the upper reaches of Salt Creek some hydrologic connectivity appears to have been marginally reestablished through natural processes over the last fifty years. The wetlands have been classified as Depressional according to the CRAM typing guidelines. These wetlands border forested hills to the west and Highway 101 to the east. Cattle ranching is occurring in and surrounding these wetlands. The Salt Creek wetland complex is entirely privately owned.

Figure 19: Photographs of wetlands found in the Salt Creek complex (August 2009).

Figure 20: A beaver dam located in the Salt Creek wetland complex (August 2009). Note the RCG behind the dam.

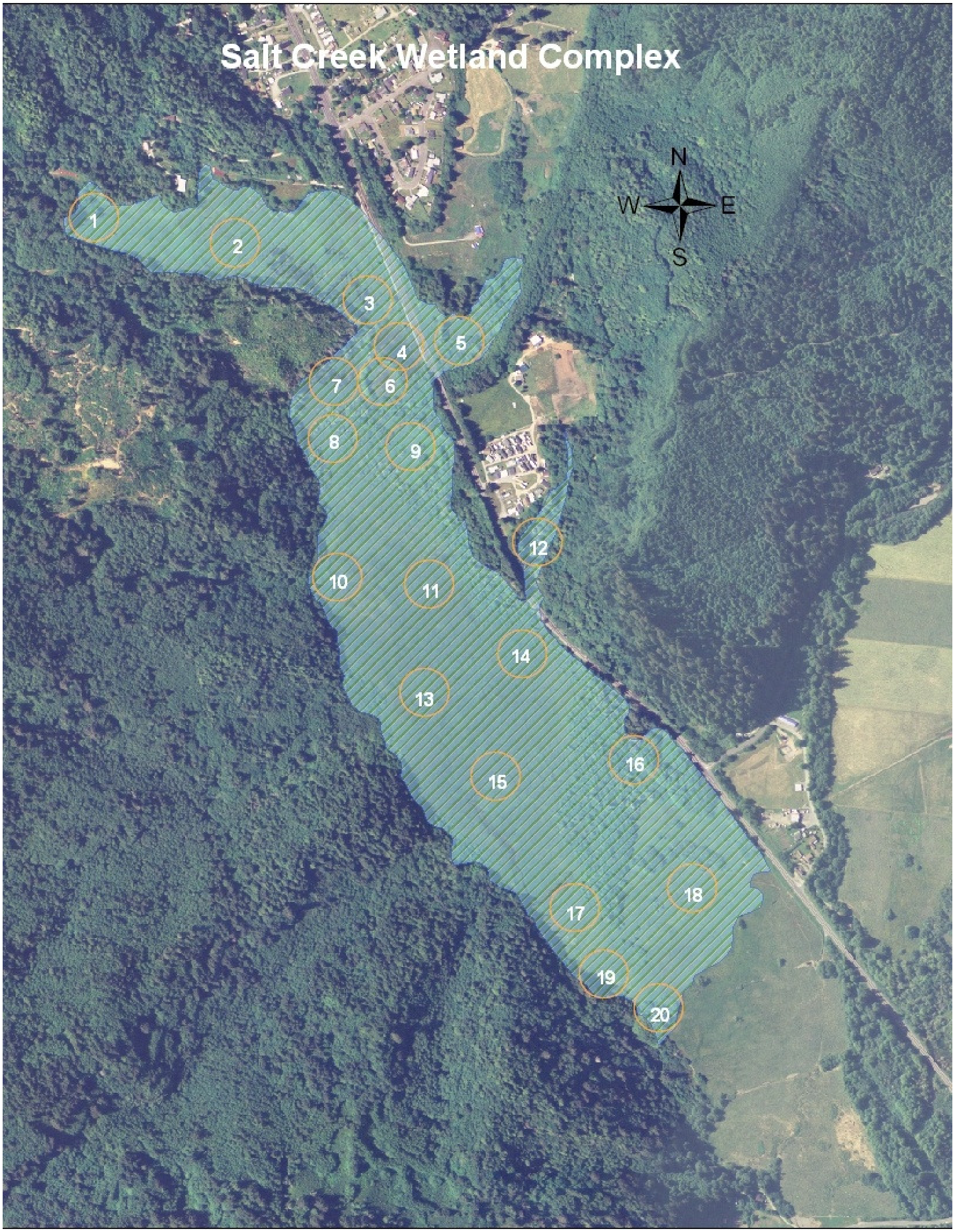

Figure 21: Assessment Areas (AA) locations in the Salt Creek Wetland Complex. Each AA is assigned a number and is linked to tabular data. See tables 46-50. Base image: portions of 2005 NAIP imagery, 1 meter resolution.

Table 46: Salt Creek Buffer and Landscape Context Attribute scoring breakdown by metric

Assessment Area	Landscape Connectivity	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	Raw Score	Final Attribute score
1	9	12	12	9	19	79
2	12	12	12	9	22	92
3	9	9	12	9	19	79
4	6	9	12	9	16	67
5	9	9	9	9	18	75
6	9	12	12	9	19	79
7	9	12	12	9	19	79
8	9	12	12	9	19	79
9	9	12	9	9	19	79
10	12	12	12	9	22	92
11	9	12	2	9	19	79
12	12	12	9	9	22	92
13	12	12	12	9	22	92
14	9	12	12	9	19	79
15	12	2	12	9	22	92
16	9	12	9	9	19	79
17	9	12	12	9	19	79
18	9	12	12	6	17	71
19	12	12	12	6	20	83
20	9	12	12	9	17	71
Average	**9.75**	**11.05**	**10.90**	**8.70**	**19.40**	**80.85**

Table 47: Salt Creek Hydrology Attribute scoring breakdown by metric.

Assessment Area	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Score	Final Attribute Score
1	12	9	9	30	83
2	9	9	9	27	75
3	12	9	9	30	83
4	9	6	3	18	50
5	9	6	6	21	58
6	9	6	3	18	50
7	9	9	9	27	75
8	9	6	9	24	67
9	9	6	9	24	67
10	9	9	9	27	75
11	9	9	9	27	75
12	9	9	9	27	75
13	9	9	9	27	75
14	9	6	9	24	67
15	9	9	9	27	75
16	9	6	9	24	67
17	9	6	9	24	67
18	9	6	9	24	67
19	9	6	9	24	67
20	9	6	9	24	67
Average	**9.30**	**7.35**	**8.25**	**24.90**	**69.25**

Table 48: Salt Creek Physical Structure Attribute scoring breakdown by metric.

Assessment Area	Structural Patch Richness	Topographic Complexity	Raw Score	Final Attribute Score
1	3	9	12	50
2	6	6	12	50
3	6	6	12	50
4	3	6	9	38
5	9	6	15	63
6	3	3	6	25
7	9	6	15	63
8	6	6	12	50
9	6	6	12	50
10	9	9	18	75
11	9	6	15	63
12	9	6	15	63
13	6	6	12	50
14	9	9	18	75
15	6	6	12	50
16	6	12	18	75
17	6	6	12	50
18	3	6	9	38
19	3	6	9	38
20	6	6	12	50
Average	**6.15**	**6.60**	**12.75**	**53.30**

Table 49: Salt Creek Biotic Structure Attribute scoring breakdown by metric

Assessment Area	Number of Plant Layers	Number of Co-Dominant species	Percent Invasion	Horizontal interspersion and Zonation	Vertical Biotic Structure	Raw Score	Final Attribute Score
1	6	6	6	6	9	21	58
2	6	3	9	9	9	24	67
3	6	3	6	6	9	20	56
4	9	6	9	6	6	20	56
5	9	6	12	9	6	24	67
6	9	6	9	9	6	23	64
7	9	6	9	9	6	23	64
8	9	6	9	9	12	29	81
9	9	6	9	9	9	26	72
10	6	3	9	9	9	24	67
11	9	6	9	9	6	23	64
12	12	12	12	12	12	36	100
13	6	3	3	6	9	19	53
14	6	6	12	9	9	26	72
15	9	6	6	9	9	25	69
16	12	9	12	9	9	29	81
17	6	6	6	9	12	27	75
18	6	9	3	6	6	18	50
19	9	12	6	6	3	18	50
20	12	9	12	9	12	32	89
Average	**8.25**	**6.45**	**8.40**	**8.25**	**8.40**	**24.35**	**67.75**

Table 50: Salt Creek overall CRAM score breakdown by attribute.

Assessment Area	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure	Overall AA score
1	79	83	50	58	68
2	92	75	50	67	71
3	79	83	50	56	67
4	67	50	38	56	53
5	75	58	63	67	66
6	79	50	25	64	55
7	79	75	63	64	70
8	79	67	50	81	69
9	79	67	50	72	67
10	92	75	75	67	77
11	79	75	63	64	70
12	92	75	63	100	83
13	92	75	50	53	68
14	79	67	75	72	73
15	92	75	50	69	72
16	79	67	75	81	76
17	79	67	50	75	68
18	71	67	50	50	57
19	83	67	38	50	60
20	71	67	50	89	69
Average	**80.85**	**69.25**	**53.30**	**67.75**	**67.95**

5.4.1 Summary of Salt Creek data

Salt creek wetland complex is the largest wetland complex and had a total of 20 AAs completed during the growing seasons of 2008 and 2009. Overall CRAM scores averaged 67.95, ranking fourth out of the six wetland complexes. Low scores were predominately due to the Physical Structure attribute which averaged 53.3, third lowest among wetland complexes. The physical Structure attribute scores had some variation between AA's but were best typified by a wet meadow containing anastomizing channels, lacking topographic complexity, and a variety of structural patch types. Biotic structure attribute scores averaged 67.75, and were a factor in lowering the overall CRAM score. Salt Creek wetland complex biota can be characterized by large emergent monocultures of mostly same height; this is evident in the number of co-dominant species metric (table 49). There is also an intermediate infestation of RCG present throughout the complex. Hydrology attribute scores averaged 69.25, lowest among all wetland complexes. There have been significant alterations to the hydrology of the complex, including the Highway 101 road prism, levees created for a now defunct waste water treatment facility, and streambed alterations to allow for agricultural activities. There are a considerable number of homes on septic systems in the upper reaches of the complex, contributing to artificial inputs of hydrology. There are also a number of wells located throughout the complex, further altering hydrologic inputs. The Buffer and Landscape Connectivity attribute scores averaged 80.85, fourth out of all wetland complexes. There is an intermediate amount of development surrounding the upper reaches of the complex, but this attribute was mostly compromised by the existence of Highway 101which resulted in lower landscape connectivity metric scores, and has lower buffer condition scores.

5.5 Panther Creek Wetland Complex

Panther Creek is located on the north side of the estuary adjacent to Highway 101. Panther Creek actually resembles a pond and marsh complex and contains a small portion of defined stream channel upstream of its confluence with Hunter Creek. Panther Creek has been believed to be spring fed and has had some hydrologic alterations from beaver dams. Panther Creek is hydrologically connected to Hunter Creek and provides habitat for non-natal salmonids, especially coho salmon (YTFP unpublished data). The wetland AAs have been classified as Depressional according to the CRAM wetland typing guidelines. The wetland complex is bordered by multiple residential and agricultural landowners, with some timber lands bordering to the east. This wetland complex is located on lands that are privately owned.

Figure 22: Photographs of the Panther Creek Wetland Complex (August 2009).

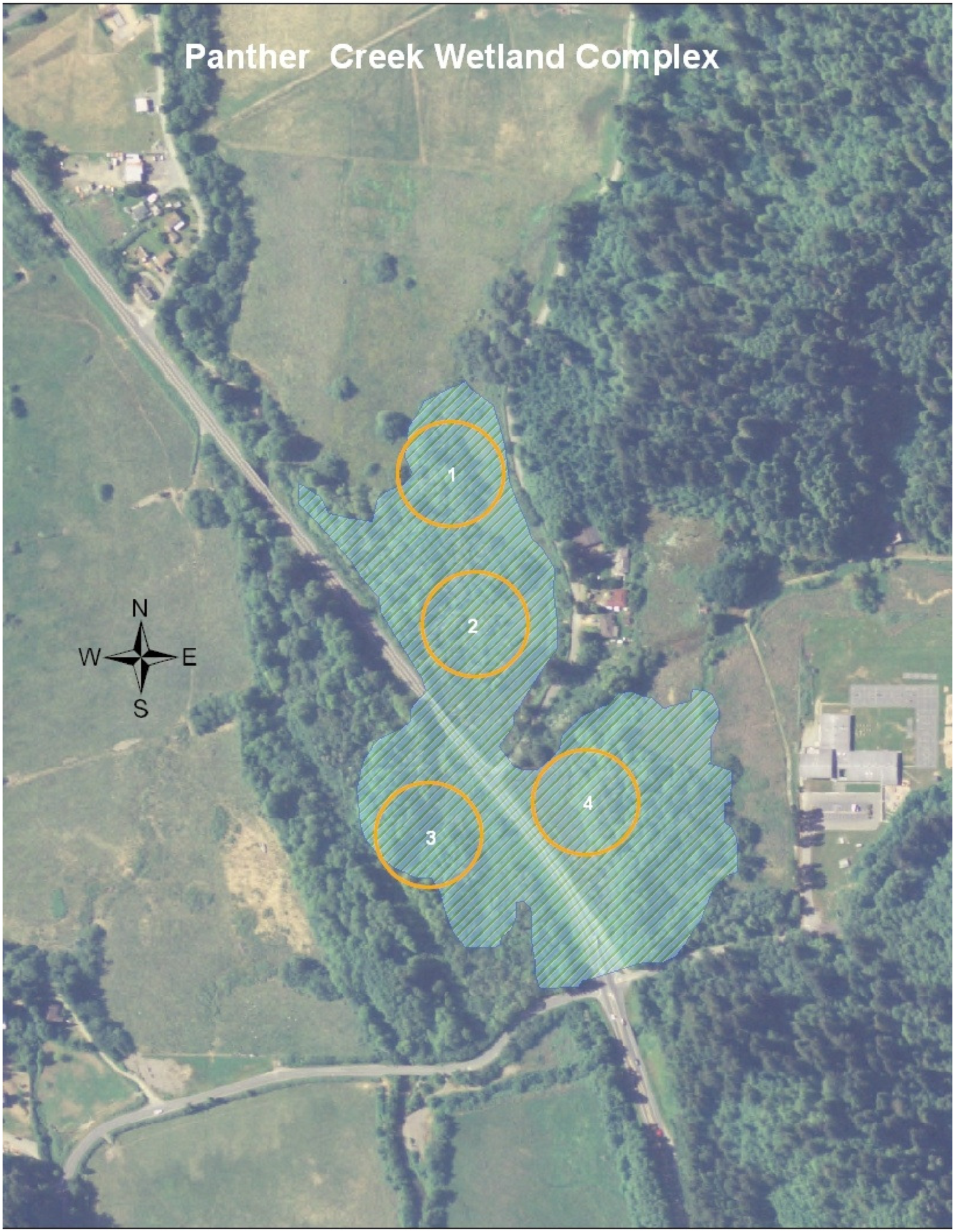

Figure 23: Assessment Areas (AA) locations in the Panther Creek Wetland Complex. Each AA is assigned a number and is linked to tabular data. See tables 51-55. Base image: portions of 2005 NAIP imagery, 1 meter resolution.

Table 51: Panther Creek Buffer and Landscape Context Attribute scoring breakdown by metric.

Assessment Area	Landscape Connectivity	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	Raw Score	Final Attribute score
1	12	9	9	6	19	79
2	9	6	9	6	16	67
3	12	6	12	9	19	79
4	6	9	6	9	14	58
Average	**9.75**	**7.5**	**9**	**7.5**	**17**	**70.75**

Table 52: Panther Creek Hydrology Attribute scoring breakdown by metric.

Assessment Area	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Score	Final Attribute Score
1	9	9	9	27	75
2	9	9	9	27	75
3	9	9	6	24	67
4	9	9	6	24	67
Average	**9**	**9**	**7.5**	**25.5**	**71**

Table 53: Panther Creek Physical Structure Attribute scoring breakdown by metric.

Assessment Area	Structural Patch Richness	Topographic Complexity	Raw Score	Final Attribute Score
1	6	6	12	50
2	9	6	15	63
3	6	9	15	63
4	6	6	12	50
Average	**6.75**	**6.75**	**13.5**	**56.5**

Table 54: Panther Creek Biotic Structure Attribute scoring breakdown by metric.

Assessment Area	Number of Plant Layers	Number of Co-Dominant species	Percent Invasion	Horizontal interspersion and Zonation	Vertical Biotic Structure	Raw Score	Final Attribute Score
1	12	12	9	9	6	26	72
2	12	12	9	9	6	26	72
3	9	9	9	9	9	27	75
4	9	6	12	9	9	27	75
Average	**10.5**	**9.75**	**9.75**	**9**	**7.5**	**26.5**	**73.5**

Table 55: Panther Creek Overall CRAM score breakdown by attribute.

Assessment Area	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure	Overall AA score
1	79	75	50	72	69
2	67	75	63	72	69
3	79	67	63	75	71
4	58	67	50	75	63
Average	**70.75**	**71**	**56.5**	**73.5**	**68**

5.5.1 Summary of Panther Creek data

A total of 4 AAs were completed at the Panther Creek wetland complex during the growing season of 2009. Overall CRAM scores averaged 68.00, fourth highest out of all wetland complexes. The predominant cause of overall CRAM score decline were Physical Structure attribute scores, averaging 56.50, fourth out of all wetland complexes. Structural patch richness and topographic complexity are lacking within this attribute. It is believed Panther Creek was created by excavation in order to provide fill for highway 101, therefore lacking the Physical Structure more common of natural systems. Because the system is mostly fed by groundwater, it lacks the surface flow characteristics that create and maintain physical structure patch types and topographic complexity. This complex is surrounded by cattle ranching, and attempts have been made to alter the landscape to create more pasture. Hydrology attribute scores averaged 71.00, second lowest of all wetland complexes. The hydrology is altered by the highway 101 road prism and is also influenced by septic and well systems. Buffer and Landscape Connectivity attribute scores averaged 70.75, the lowest among all wetland complexes. The wetland is characterized as having lower than average percent of buffer, due to the proximity of highway 101, roads, and several homes. Additionally, poor buffer condition is present due to the stress caused by cattle grazing, such as soil disturbance, removal of riparian vegetation, and the promotion of invasive species. Biotic structure scores average 73.50, the highest among all wetland complexes, and surprisingly proved to be a strong point for the complex. There is a large number of co-dominant species present comprising a variety of layers and are well interspersed. There is a relatively low amount of invasive species present. Higher Biotic Structure scores may be due to the nature of the hydrology of the complex. Calmer water flows may lead to more stable colonization of native plant species, and less dispersion of invasive plant species; as opposed to high flows which cause scouring and soil disturbance, and predispose areas to colonization by invasive species.

5.6 Spruce Creek Wetland Complex

Just south of Panther Creek, the Spruce Creek wetland complex is located. Hydrologic alterations have occurred in the past including streambed alterations and the building of the highway 101 road prism. The portion of the creek east of Highway 101 resembles a Depressional wetland, due to the complete loss of channel form. Beaver dams seem to have a large influence on the hydrology of this wetland complex, as does the highway 101 road prism. Prior to the flood of 1964, Mynot Creek flowed into Spruce Creek just west of highway 101. However Mynot Creek was realigned to join Hunter Creek as part of the post-flood road rehabilitation. The wetland AAs in this complex have been best classified as Depressional according to the CRAM wetland typing guidelines. The wetland complex is owned entirely by private landowners in the business of cattle ranching.

Figure 24: A beaver dam located on the Spruce Creek wetland complex (June 2008).

Figure 25: Photograph of a wetlands upstream from a beaver dam in the Spruce Creek wetland complex (May 2008).

Figure 26: Flooded pastureland in the Spruce Creek wetland complex (May 2008).

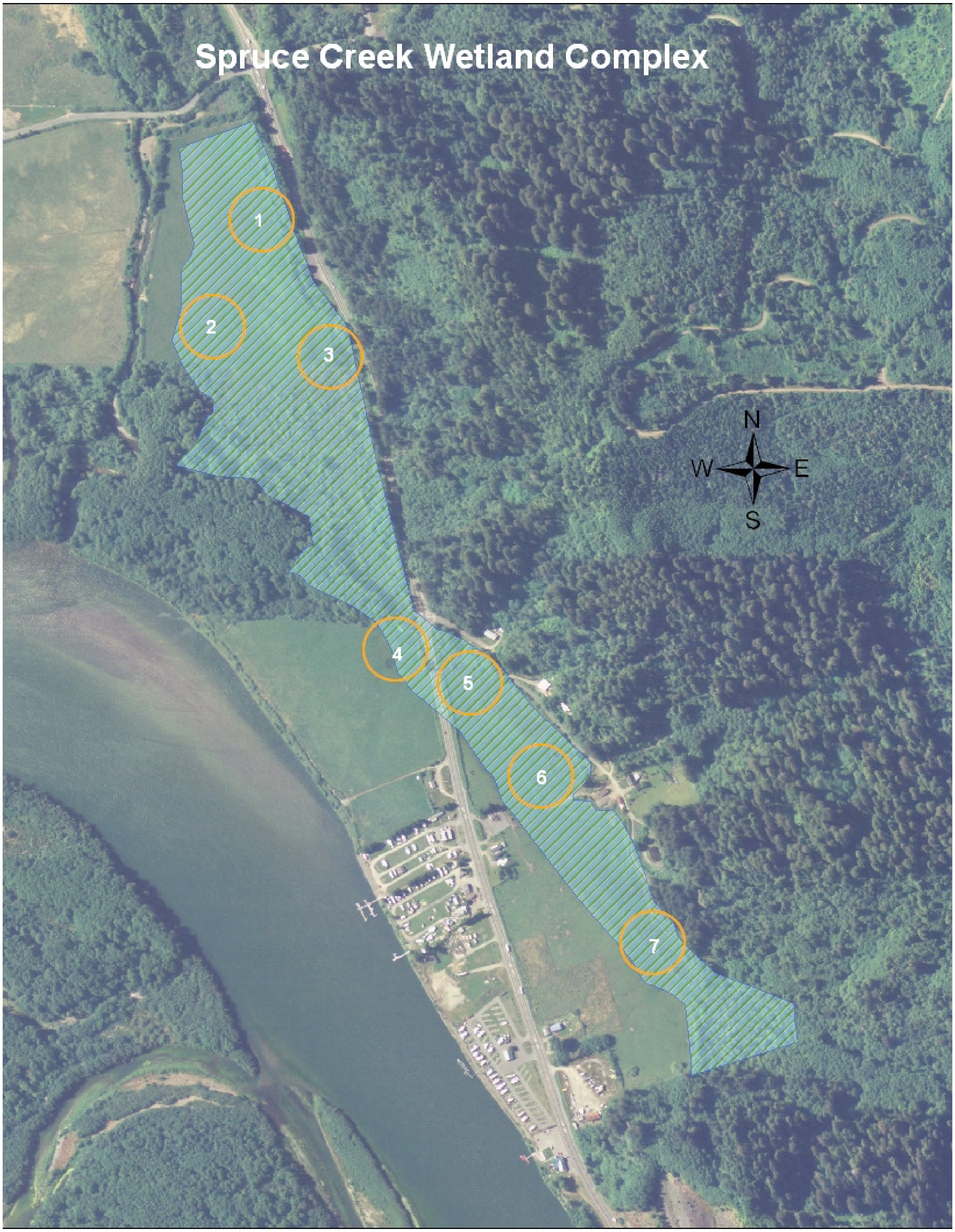

Figure 27: Assessment Areas (AA) locations in the Spruce Creek Wetland Complex. Each AA is assigned a number and is linked to tabular data. See tables 56-60. Base image: portions of 2005 NAIP imagery, 1 meter resolution.

Table 56: Spruce Creek Buffer and Landscape Context Attribute scoring breakdown by metric.

Assessment Area	Landscape Connectivity	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	Raw Score	Final Attribute score
1	12	12	9	6	20	83
2	12	12	12	9	22	92
3	12	12	9	6	20	83
4	12	9	12	6	20	83
5	12	6	12	3	17	71
6	9	9	12	6	17	71
7	12	12	9	6	20	83
Average	**11.57**	**10.29**	**10.71**	**6.00**	**19.43**	**80.86**

Table 57: Spruce Creek Hydrology Attribute scoring breakdown by metric.

Assessment Area	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Score	Final Attribute Score
1	12	6	9	27	75
2	12	6	12	30	83
3	12	6	12	30	83
4	9	6	9	24	67
5	9	9	6	24	67
6	12	9	6	27	75
7	12	6	9	27	75
Average	**11.14**	**6.86**	**9.00**	**27.00**	**75.00**

Table 58: Spruce Creek Physical Structure Attribute scoring breakdown by metric.

Assessment Area	Structural Patch Richness	Topographic Complexity	Raw Score	Final Attribute Score
1	3	6	9	38
2	6	6	12	50
3	3	6	9	38
4	6	6	12	50
5	3	6	9	38
6	6	6	12	50
7	6	6	12	50
Average	**4.71**	**6.00**	**10.71**	**44.86**

Table 59: Spruce Creek Biotic Structure Attribute scoring breakdown by metric.

Assessment Area	Number of Plant Layers	Number of Co-Dominant species	Percent Invasion	Horizontal interspersion and Zonation	Vertical Biotic Structure	Raw Score	Final Attribute Score
1	12	12	6	6	6	22	61
2	12	12	9	6	6	23	64
3	12	12	9	6	6	23	64
4	12	9	6	6	6	21	58
5	9	6	9	9	6	23	64
6	9	6	9	9	6	23	64
7	9	3	12	9	9	26	72
Average	**10.71**	**8.57**	**8.57**	**7.29**	**6.43**	**23.00**	**63.86**

Table 60: Spruce Creek overall CRAM score breakdown by attribute.

Assessment Area	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure	Overall AA score
1	83	75	38	61	64
2	92	83	50	64	72
3	83	83	38	64	67
4	83	67	50	58	65
5	71	67	38	64	60
6	71	75	50	64	65
7	83	75	50	72	70
Average	**80.86**	**75.00**	**44.86**	**63.86**	**66.14**

5.6.1 Summary of Spruce Creek data

A total of seven AAs were completed in Spruce Creek wetland complex during the growing seasons of 2008 and 2009. A middle portion of the Spruce Creek wetland complex not assessed due to lack of landowners access permission (between AAs 3 and 4 in figure 27).Overall CRAM scores averaged 66.14, second lowest of all wetland complexes. Average Physical Structure attribute scores averaged 44.86, second lowest of all wetland complexes, and were the predominant cause of overall CRAM score decline within this complex. Cattle ranching is a direct stressor to this attribute as numerous landscape alterations have been implemented to increase pasture land and allow for highway infrastructure. Streambed alterations have created a loss of complex meandering channel networks and the wetland complex now resembles a Depressional wetland, lacking topographic complexity and structural patch types created and maintained by fluctuating surface flows. Biotic Structure attribute scores averaged 63.86, the third lowest among wetland complexes. The vertical biotic structure metric was the lowest scoring metric for this attribute, and interspersion and zonation of plant layers is lacking within this complex, as well. It is very evident that cattle grazing is limiting species colonization, causes soil disturbance, and is the predominant stressor to the health of this wetland complex. Hydrology attribute scores averaged 75.00, third lowest of all wetland complexes. The hydroperiod and channel stability metric was a primary cause for decline in CRAM score for this attribute. The alterations made to the drainage network within this wetland complex have significantly affected the inundation and drawdown regime of the complex. Buffer and Landscape connectivity attribute scores averaged 80.86, fourth highest among wetland complexes. The predominant cause for decline in this attribute is due to poor buffer condition. The buffer consists largely of cattle pastures which suffer from a high degree of soil disturbance, dominance by invasive species, and compromised riparian vegetation.

5.7 Wetland Rankings

The following table is a ranking of wetlands that begins with the most degraded wetlands. The basis for the rankings is based upon average overall CRAM scores for each wetland complex. Average scores were calculated by scoring a number of AA assessment areas representative of the conditions existing in a wetland complex. The list can be used to identify wetland complexes that were in the least favorable condition at the time of the assessments. The list cannot be used to assume wetland function is directly related to condition, but rather can lead the way for higher level studies of wetland function.

Table 61: Wetland Degradation Rankings by overall CRAM score.

Ranking	Wetland Complex	Average Buffer and Landscape Context Score	Average Hydrology Score	Average Physical Structure Score	Average Biotic Structure Score	Average Overall Score
1	Waukell Creek	87.5	79.00	44.00	52.50	**65.50**
2	Spruce Creek	80.86	75.00	44.86	63.86	**66.14**
3	Salt Creek	80.85	69.25	56.50	67.75	**67.95**
4	Panther Creek	70.75	71.00	56.50	73.50	**68.00**
5	Richardson Creek	87.67	75.00	75.00	58.33	**74.00**
6	South Slough	93.11	88.00	65.50	71.22	**79.29**
Average		**83.45**	**76.21**	**56.06**	**64.52**	**70.14**

5.7.1 Overall Summary

Overall CRAM scores have been used to identify the wetland complex with the lowest condition (highest degradation). Table 61 shows overall CRAM scores for each wetland complex and the corresponding associated attribute scores. By averaging all wetland complex attributes it is reasonable to conclude that Physical Structure attribute scores are the predominant cause of declining overall CRAM scores, followed by Biotic Structure attribute scores. Past and present day land use, predominantly agricultural and infrastructure development are stressors having direct and indirect effects on the decline of these two attributes. Hydrology attribute scores tended to be slightly above the average overall scores. Buffer and Landscape Connectivity attribute scores were by far the strongest attribute of all wetland complexes. This is due to the small amount of human development, roads, and infrastructure within the area, and above average buffer conditions due to large amounts of park land and forest surrounding the KRE. The relationship between overall CRAM scores and any one attribute score was indiscernible. There is no single attribute when compared to other attributes that was consistently within close enough range of the overall CRAM score to be labeled an indicator of overall health.

6.0 Summary and Conclusion

CRAM assessment data has allowed for a better understanding of the condition of wetlands surrounding the KRE. The usefulness of the data is invaluable in determining locations for wetland restoration projects required through compensatory mitigation. Compliance with the Clean Water Act (CWA) section 404 regulations is usually initiated by the development of environmental documents under the National Environmental Protection Act (NEPA) and the California Environmental Quality Act (CEQA) pertaining to road development and/or land development. However, YTEP encourages the use of the data for use by private landowners, and agencies that have an interest in wetland conservation and wetland restoration projects. Examples of possible uses for the data include compensatory mitigation planning, fish and wildlife habitat restoration and enhancement projects, mitigation banking planning, conservation easement planning, wetland parcel acquisition and preservation planning, and land development planning.

YTEP supports the traditional three step process of mitigation set forth by the Environmental Protection Agency (EPA) and the US Army Core of Engineers, which is to 1- avoid, 2-minimize and 3-mitigate losses of aquatic resources. This document and the data within it should not be used to minimize the importance of avoiding and minimizing the loss of wetlands and aquatic resources.

6.1 Wetland Restoration Site Prioritization

A goal of this project was to develop guidance for prioritizing wetland restoration projects required through compensatory mitigation. The guidance will result in restoration that aims to achieve the resource needs of the Yurok People and local community. YTEP has taken the approach that the most degraded wetland complexes should be given the highest priority for restoration. Furthermore wetlands should be identified by complex with average CRAM scores used for the rankings and prioritization. Specific locations of restoration sites should be based upon the best available data and may require additional data collection regarding wetland function and potential benefits.

However, it is important to consider what is feasible within the context of wetlands restoration. A cost versus benefit analysis is necessary to fully understand the improvements that wetland restoration may have and the monetary value of such actions. In general, larger wetlands such as the Salt Creek complex and South Slough would require extensive amounts of restoration before average overall CRAM scores would significantly change. On the other hand, smaller wetlands such as the Waukell, Panther, and Spruce Creek complexes would obtain significantly higher CRAM scores with relatively smaller amounts of restoration.

It should also be noted that improving certain attributes of a CRAM score is not entirely feasible in a wetlands restoration context. Specifically, attempting to restore the Landscape Connectivity for wetlands would require removing significant amounts of human development and infrastructure within 500 meters of a wetland. Likewise improving wetland buffer condition would require extensive amounts of invasive species removal and/ or changes in land use management. Improving hydrology scores for a wetland would be slightly less intensive but would still require the removal of many septic systems, and wells, and US Highway 101.

The predominant cause in decline of overall CRAM scores is a lack of Physical Structure, and Biotic Structure (see averages table 61). In a wetland restoration context, these attributes are the most feasible to improve through restoration due to lower impacts to human infrastructure and landowners and reduced cost. Therefore, in the development of a wetland restoration site prioritization plan the focus has been put on these two attributes as determining factors. In the case where restoration of Buffer and Landscape Context and Hydrology attributes is feasible and the area is associated with low scores, restoration will be prioritized in these areas. However, as stated before, due to impacts on human infrastructure the economy, cost, and willing landowners, these attributes are being considered un-restorable.

Combing Physical and Biotic Structure attribute scores results a numerical value for “restorable” attributes. When wetland complexes are ranked by this value, the rankings are the same as when based on overall CRAM score. (See table 61and 62)

Table 62: Combined Physical Structure and Biotic Structure Attribute scores for each wetland complex

Ranking	Wetland complex	Physical Structure	Biotic Structure	Combined Restorable Attributes
1	Waukell Creek	44.00	52.50	96.5
2	Spruce Creek	44.86	63.86	108.72
3	Salt Creek	53.71	66.38	120.09
4	Panther Creek	56.50	73.50	130.00
5	Richardson Creek	75.00	58.33	133.33
6	South Slough	65.65	69.71	135.36

Restoration Potential:

A goal of prioritizing wetland restoration is to establish a means of maximizing restoration success. This can be accomplished by determining the amount of potential a given wetland complex has. For example, the possibility exists that wetland restoration focused on Physical Structure and Biotic Structure attributes, may not be successful if the wetland is limited by low scoring Buffer and Landscape Context and Hydrology attributes. Proper hydrology is repeatedly outlined as a major component in successful wetland restoration projects of many mitigation and restoration plans. So in addition to how the wetland complex ranked in restorable attributes what is equally important is how well the wetland complex scored in un-restorable attributes (see table 63). Thus, the wetland complex that scores the lowest in restorable attributes (Physical Structure and Biotic Structure), and also scores the highest in un-restorable attributes (Buffer and Landscape Context and Hydrology), is the wetland complex that should be given restoration priority .The difference between restorable attributes and un-restorable attributes is a numerical way to assign restoration potential to each wetland complex (see table 64).

Table 63: Combined Buffer and Landscape Context and Hydrology Attribute scores for each wetland complex

Ranking	Wetland Complex	Buffer and Landscape Context	Hydrology	Combined Un-Restorable Attributes
1	Waukell Creek	87.70	79.00	141.75
2	Spruce Creek	80.86	75.00	152.52
3	Salt Creek	83.38	69.14	155.86
4	Panther Creek	70.75	71.00	162.67
5	Richardson Creek	87.67	75.00	166.70
6	South Slough	93.18	88.76	181.94

Using the data from tables 62 and 63 it is possible to calculate the restoration potential for each wetland complex using the following:

Restoration Potential = (Un-Restorable Attributes) – (Restorable Attributes)

Table 64: Wetland Restoration Prioritization based on Restoration Potential

Wetland Complex	Combined Buffer and Landscape Context & Hydrology Attributes	Combined Physical Structure & Biotic Structure Attributes	Restoration Potential	Priority
Waukell Creek	166.70	96.50	70.20	1
Spruce Creek	155.86	108.72	47.14	2
South Slough	181.94	135.36	46.58	3
Salt Creek	152.52	120.93	31.59	4
Richardson Creek	162.67	133.33	29.34	5
Panther Creek	141.75	130.00	11.75	6

From table 64 we can see that accounting for restoration potential resulted in a slight change in the initial rankings. Waukell Creek and Spruce Creek remain at the top of the list for receiving restoration. However, the South Slough has jumped from last to third in the rankings due to its high scoring Buffer and Landscape Connectivity and Hydrology attributes. Panther Creek, formerly fourth in the rankings dropped to last due to having the poorest Buffer and Landscape Context and Hydrology attributes. Salt Creek dropped one spot in the rankings while Richardson Creek maintained the second to last position. (See Tables 61 and 64 for comparison)

Table 64 should provide a guideline for prioritizing restoration and mitigation in these wetland complexes. The data from each AA can be used to help identify attributes that can be targeted for restoration. However, assessment areas are only assumed to be representative of the entire complex and exact locations and the type of work cannot be completely deducted from the CRAM data. More information is needed to accurately define restoration actions pertaining to the function of a wetland. Table 64 is meant to be used in an adaptive strategy allowing for a baseline of wetland condition to be updated and as further information becomes available. The prioritization plan is not meant to restrict restoration activities of willing landowners whose wetland property is not at the top of the list, rather the data can be used to help guide future data collection, restoration planning, and development purposes.

6.1.1 Exceptions

In the case that large wetland mitigation projects involve creation of wetlands, priority should be given to those former wetlands that have been altered from their natural state to such a degree that they no longer maintain the parameters required to pass a jurisdictional delineation. Such former wetlands exist on the north side of the KRE, and were not included in this study because they lacked the necessary wetland characteristics.

6.2 Considerations / Data gaps

To further validate wetland restoration site prioritization YTEP identified the need to build the relationship between wetland condition and wetland function. CRAM scores are a measure of wetland condition where wetland function is implied. For example, the higher the CRAM score, the more services the wetland has to offer. Is this always true? Wetland functions such as fish habitat and improved water quality are very important resource needs of the KRE. Wetland restoration projects have yet to be implemented in the KRE for several reasons, mainly the lack of funding for such projects and willing landowners. To maximize the effectiveness of future wetland restoration projects and address the aquatic resource needs of the KRE the identified data gaps should be considered. The CRAM data presented in this plan can be used as a baseline for building relationships between important wetland functions and wetland conditions, which can lead to updates of this prioritization plan.

6.2.1 Fisheries

One of the most important roles of KRE wetlands is as fisheries habitat. The KRE wetlands serve as vital overwintering habitat for juvenile salmonids, including threatened coho salmon. YTFP has documented extensive off-channel habitat use in the Lower Klamath by non-natal juvenile coho salmon. Fish are migrating from main stem habitats into off-estuary sloughs, tributaries and wetlands beginning with the onset of the first fall freshets. The most used habitats appear to be beaver ponds or similar open water wetlands. Juvenile coho rear in these types of open water ponds throughout the winter and spring or early summer. Growth rates of coho rearing in these habitats are substantially greater than those of fish sampled over the same time frame in free flowing tributary habitats, revealing the rearing advantage these still water habitats have over winter habitat conditions in natal streams. To date PIT-tagged coho from throughout the basin are consistently captured in these off-channel habitats, indicating that off- channel wetlands are playing a key role in the growth and survival of coho salmon from throughout the Klamath basin (Hiner 2009).

Fisheries benefits should be a factor when prioritizing wetland restoration projects. CRAM scores are only indicators of wetland condition and wetland function is implied. The question arises, is there a relationship between CRAM scores and ecosystem services to salmonids? Currently there is not enough data to answer this question. Severely degraded wetlands may be functioning as outstanding fisheries habitat, and high CRAM scoring wetlands actually do not provide ecosystem services to salmonids at all. YTEP has identified the need that additional studies should be performed to answer this question in order to adequately address the aquatic resource needs of Klamath Basin coho salmon, other native salmonids, and the Yurok People's culture and livelihood.

YTEP has recent involvement in compensatory mitigation planning related to a Caltrans road rehabilitation and bridge replacement project. Caltrans, YTFP, and YTEP have been involved in developing a mitigation strategy to compensate for losses of wetlands and take of coho salmon. It is reasonable to consider combining these mitigations for several reasons. Wetlands are a critical component of salmon habitat, and the two mitigation projects may be very similar. Also, there are constraints on where wetland restoration can occur, due to parcel ownership, landowner willingness, and cost. To ensure the success of wetlands and fisheries mitigation in the same project, mitigation should be prioritized using wetland assessment data in this plan, but should also be based on salmonid habitat function.

6.2.2. Water Quality

The CRAM does not have an attribute to assess water quality within the assessment. YTEP and YTFP feels that water quality may play a role in how wetlands are functioning as fisheries habitat. It is also unknown whether or not wetland condition (CRAM scores) is related to water quality. Are high scoring wetlands related to better water quality? If so, are the benefits to salmonids higher in these areas? YTEP and YTFP have an extensive amount of experience in monitoring water quality in the Klamath River and tributaries. Expanding water quality data collection into wetlands, combined with YTFP's expanded efforts in collecting fisheries population data in wetlands, may provide some insight into how wetland condition (CRAM scores) are related to wetland function (water quality, fish habitat) on a local scale.

7.0 Limitations

YTEP has performed this study in general accordance with the scope and limitations. This plan was conducted on a budget at time scale that was feasible for the area that was included. Within the limitations of scope schedule and budget, our study has been executed in accordance with the general accepted practices for the CRAM for the time frame that the study was implemented. CRAM wetland assessment modules are continually being refined and updated for accuracy by regional CRAM development teams. No warranty or other conditions, expressed or implied, should be understood.

This plan was developed for the exclusive use of the Yurok Tribe, while cooperating with outside agencies. No other party may rely on the product of this study without advance agreement with the Yurok Tribe. Any alteration, deletion, or editing of this document without explicit written permission from the Yurok Tribe is strictly prohibited. Any unauthorized use of this document is prohibited. This document is intended to be used in its entirety. If an excerpt is quoted or paraphrased, it must be properly referenced.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and /or figure), if provided and any attachments are only a copy of the original document. The original document is stored by YTEP and will serve as the official document. It is anticipated that this document will be updated continually with a finalized version released September 30th 2011.

8.0 References

Amoros, C. and G. Bornette. 2002. Connectivity and Bio-complexity in Water bodies of Riverine Floodplains. Freshwater Biology 47:761-776.

Balance Hydrologic, Inc. 1995.Background report and strategic work plan for watershed restoration planning: lower Klamath River, California. Report Prepared for State of California, Coastal Conservancy, Oakland, CA.

Beesley, S. and Fiori, R. 2008.Cooperative Restoration of Tribal Trust Fish and Wildlife Habitat in Lower Klamath River Tributaries. Yurok Tribal Fisheries Program, Klamath, CA.

Beesley, S. and Fiori, R. 2007. Geomorphic and Hydrologic Assessment and Restoration Planning in the Salt Creek Watershed, Lower Klamath River Sub-Basin, California. Yurok Tribal Fisheries Program, Klamath, CA.

Beesley, S. and R.A. Fiori. 2004. Habitat Assessment and Restoration Planning in the Salt Creek Watershed, Lower Klamath River Sub-Basin, CA. Yurok Tribal Fisheries Program, Klamath, CA.

Bricker, S. 2007. Effect of Nutrient Enrichment in the Nations Estuaries: A Decade of Change. NOAA Coastal Ocean Program Decision Analysis Series No. 26. National centers for Coastal Ocean Science, Silver Spring, MD.

Collins, J.N., E.D. Stein, M. Sutula, R. Clark, A.E. Fetscher, L. Grenier, C. Grosso, and A. Wiskind. 2008. California Rapid Assessment Method (CRAM) for Wetlands. Version 5.0.2. 151 pp)

Crance J.H. 1988. Relationships between Palustrine Wetlands of Forested Riparian Floodplains and Fishery Resources: A Review US. Fish Wildlife Surveys. Biol. Rep. Vol.88 (32) 27pp.

Gale, Dan. 2009. Coho Salmon Use of Off- Channel Habitat in the Lower Klamath River. Coho Use of Off-Channel Habitat Workshop. Salmonid Restoration Federation 27th Salmonid Restoration Conference. Elements of Watershed Restoration.

Fleishner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8:629-644.

Fleming, Wolff, W.F., D.L. DeAngelis. 1994. Importance of Landscape Heterogeneity to Wood Storks in the Florida Everglades. Environ Manag. Vol. 18(5):743-758.

Frissell, C.A., W.J. Liss, C.E. Warren, and M.C. Hurley. 1986. A Hierarchical Framework for Stream Habitat Classification: Viewing Streams in a Watershed Context. Environmental Management Vol.10 (2): 199-214.

Harris, L.D. 1988. The Nature of Cumulative Impacts on Biotic Diversity of Wetland Vertebrates. Environ. Manag. Vol. 12(5):675-693.

Hickman, J.C., ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley.

Hiner, M. and Brown, A. 2004. Monitoring and Evaluation of Current and Historical Physical Habitat Conditions, Water Quality, and Juvenile Salmonid Use of the KRE. Yurok Tribe Fisheries Program, Klamath, CA.

Hiner, M. 2009. Juvenile coho salmon use of off-channel habitat in the Lower Klamath River. American Fisheries Society Cal/Neva Conference. April 2nd, 2009. Santa Rosa, CA.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial Processes in Geomorphology.

Lopez, R.D., C.B. Davis, and M.S. Fennessy. 2002. Ecological Relationships Between Landscape Change and Plant Guilds in Depressional Wetlands. Landscape Ecology 17(1): 43-56.

Maddock, I. 1999. The Importance of Physical Habitat Assessment for Evaluating River Health. Freshwater Biology 41:373-391.

McColligan, E.T., M.L. Kraus. 1988. Exotic Plants that Occur in New Jersey Wetlands. In. Kusler et al. 1988, Proceedings of the National Wetland Symposium. Urban Wetlands. June 26-29, 1988. Oakland California. Association of Wetland Managers: Berne, NY. p. 31.

Mitsch, W.J., Gosselink J.G.. 1993. Wetlands. 2nd Edition. Van Nostrand Reinhold: NY, NY.

Montgomery, D.R. and L.H. MacDonald. 2002. Diagnostic Approach to Stream Channel Assessment and Monitoring. JAWRA 38(1): 1-16.

National Research Council. 2001. Compensating for Wetland Losses under the Clean Water Act. Washington, DC, National Academy of Sciences: 322.

Nicholas, J.W. and D.G. Hankin. 1989. Chinook salmon populations in Oregon coastal river basins: descriptions of life histories and assessment of recent trends in run strengths. Oregon Department of Fish and Wildlife. No. EM 8402, March 1989. Oregon State University Extension Service, Corvallis, Oregon.

Odum, W.E., and M.A. Heywood. 1978. Decomposition of intertidal freshwater marsh plants. p. 89–97. In R.E. Good et al. (ed.) Fresh-water wetlands: Ecological processes and management potential. Academic Press, New York.

Osmond, D.L., D.E. Line, J.A. Gale, R.W. Gannon, C.B. Knott, K.A. Bartenhagen, M.H. Turner, S.W. Coffey, J. Spooner, J. Wells, J.C. Walker, L.L. Hargrove, M.A. Foster, P.D. Robillard, and D.W. Lehning. 1995. WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System.

Platts, W.S. 1990. Managing Fisheries and Wildlife on Rangelands Grazed by Livestock. A guidance and reference document for biologists. Nevada Department of Wildlife, Carson City Nevada.

Platts, W.S. 1991. Livestock Grazing. American Fisheries Society Special Publication 19: 389-423.

Pollock, M.M., M. Heim, and D. Werner. 2003. Hydrologic and geomorphic effects of beaver dams and their influences of fishes. In: Gregory S., K. Boyer, and A. Gurnell (Editors). The ecology and management of wood in world rivers.American Fisheries Society, Symposium 37. Bethesda, Maryland.

Richards, K., J. Brasington, and F. Hughes. 2002. Geomorphic dynamics of floodplains: ecological implications and a potential modeling strategy. Freshwater Biology Vol.47(4):559-579.

RNSP, (Redwood National and State Parks) 2004. Wetland Statement of Findings. Rehabilitate Alder Camp Road Project.

Roth, N.E., J.D. Allen, and D.L. Erickson. 1996. Landscape Influences on Stream Biotic Integrity Assessed at Multiple Spatial Scales. Landscape Ecology Vol.11(3): 141-156.

Rosgen, D. 1996. Applied river morphology. Wildlife Hydrology, Pagosa Springs, CO

Sanderson, E.W., S.L. Ustin, and T.C. Foin. 2000. The Influence of Tidal Channels on the Distribution of Salt Marsh Plant Species in Petaluma Marsh, CA, USA. Plant Ecology 146:29-41.

Shepard, J.P. 1994. Effects of Forest Management on Surface Water Quality in Wetland Forests. Vol. 14(1):18-26.

Sudol, M.F. and R.F. Ambrose. 2002. The U.S. Clean Water Act and Habitat Replacement: Evaluation of Mitigation Sites in Orange County, California, USA. Environmental Management Vol.30 (5): 727-734.

Taylor, J.R. M.A. Cardamone, W.J. Mitsch. 1990. Bottomland Hardwood Forests: their functions and values, Ch 2 in Gosselink et al. 1990. Ecological Processes and Cumulative Impacts. Lewis Publishers: Chelsea, MI.

USEPA. U.S. Environmental Protection Agency. 1994b. National Water Quality Inventory. 1992 Report to Congress. EPA 841-R-94-001. EPA: Washington, D.C.

USEPA. U.S. Environmental Protection Agency. 1993a. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA: Washington D.C.

USEPA. U.S. Environmental Protection Agency. 1993c. Natural Wetlands and Urban Stormwater: Potential Impacts and Management. EPA: Washington D.C.

Wallace, M. 1995. The emigration timing of juvenile salmonids through the Klamath River estuary. In T.J. Hassler (Editor). Proceedings of the Klamath Basin Fisheries Symposium. March 23-24, 1994. Eureka, CA.

Wallace, M. 1998. Seasonal water quality monitoring in the KRE, 1991-1994. Administrative Report No. 98-9, Inland Fisheries Division, California Department of Fish and Game, Arcata, California.

Weller, M.W. 1981. Freshwater Marshes, University of Minnesota Press: Minneapolis, Minn.

Winter, T.C. 1988. A Conceptual Framework for Assessing Cumulative Impacts on the Hydrology of Nontidal Wetlands. Environ Manag. Vol. 12(5): 605

Wisconsin Reed Canary Grass Working Group,2009. Reed Canary Grass *(Philaris Arundinacea)* Management Guide: Recommendations for Landowners and Restoration Professionals

Yurok Tribe Environmental Program. 2006. Healthy River, Healthy People: Tribal Member Traditional Foods Survey. On File in the Yurok Tribe Environmental Program, Klamath, CA.

- 2008 Environmental Justice and Yurok Beneficial Uses Survey. On File at the Yurok Tribe Environmental Program, Klamath, CA.

- 2009 Yurok Beneficial Uses Survey. On File at the Yurok Tribe Environmental Program, Klamath, CA.