

**PROPOSAL: Assessing the Effects of USDA Conservation Practices on Wetland  
Ecosystem Services California's Central Valley**

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**Introduction**

The U. S. Department of Agriculture, Natural Resource Conservation Service (USDA-NRCS) administers a variety of programs intended to assist farmers and ranchers in addressing their natural resource concerns on private lands. Among these programs is the Wetland Reserve Program (WRP), created as part of the 1990 Farm Bill (Gray 2005). The WRP program focuses on restoring degraded wetlands or those that have been converted to agricultural production. In California, NRCS has focused their WRP activities on restoring freshwater wetlands that have seasonal or semi-permanent water regimes. Vernal pools, riparian wetlands and tidally-influenced wetlands have received less attention. During 2000 – 2006, USDA-NRCS restored more than 15,000 ha of freshwater wetlands in two areas of California, the Central Valley (CCV) and Upper Klamath River Basin (UKB).

Although the WRP program in California is widely viewed as benefiting ecological functions, there has been little or no evaluation or quantification of the ecological services provided to society from this program. Evaluation of conservation programs is important because of federal regulations requiring that programs demonstrate their effectiveness in

providing intended results and because program evaluations can guide future implementation of conservation programs.

The goal of this proposed research is to quantify ecological services derived from WRP program wetland restoration in the CCV and UKRB. This research will develop wetland functional condition indicator models. These models will be applied to estimate ecosystem service benefits that may be expected from continued implementation conservation practices or from expanding the program.

### **Approach and Objectives**

This study will quantify selected ecosystem services provided by WRP wetlands in the CCV. The approach will be to address two objectives. The **first** objective will be to evaluate ecosystem services provided by palustrine emergent wetlands restored by USDA-NRCS in the CCV. This category of wetlands is the focus of the WRP program in the CCV.

The **second** objective will be to evaluate ecosystem services provided by USDA-NRCS restoration of different types of wetlands. To meet this objective we will sample 36 seasonal, semi-permanent and riparian wetlands in the Sacramento and upper Klamath basins and the inter-mountain region of California. Key elements of this study will include; (1) sampling across different wetland types to compare ecosystem services provided by each and (2) sampling across different physiographic provinces.

**Objective 1:** Evaluate ecosystem services provided by USDA-NRCS restoration of palustrine emergent wetlands in the CCV.

To meet this objective we will survey 150 seasonal and semi-permanent wetlands in the Tulare, San Joaquin and Sacramento basins (Table 1). Key elements of this survey include; (1) sampling across a gradient of management intensity, (2) sampling across a gradient in wetland restoration age and (3) sampling across a gradient of precipitation from the arid Tulare Basin to the more temperate Sacramento Basin (Figure 1).

Data collection will begin in September 2007 and be completed by June 2009. Wetlands will be stratified along age of restoration ranging from croplands not yet restored (0 years) to restored <5 years and >5 years ago and management activity (unmanaged, little management and intensive management). Each wetland will be sampled one time. Data collected during the

survey will focus on easily measured edaphic, vegetation, and morphological variables that can be used in various combinations to directly or indirectly quantify the ecological services identified in the objective (Appendices A and B). These indicator variables will be used in various combinations to directly or indirectly quantify the following ecological services: biodiversity and habitat, soil erosion and sediment reduction, nutrient loading, floodwater storage, and soil carbon sequestration. The primary focus will be to characterize wetlands restored as part of USDA-NRCS programs using metrics that can be readily acquired to facilitate future evaluations. In addition, functional attributes of wetlands restored on WRP lands will be compared among age and management categories to identify the impact of federal restoration programs relative to existing agricultural practices and determine if ecological services of restored wetlands change temporally.

Table 1. Allocation of sampling effort (number of wetlands) among sub-basins and management regimes within the CCV.

Management Regime	Time Restored	Sacramento	San Joaquin	Tulare
Not restored		5	5	5
Low	< 5 yr	5	5	5
Low	> 10 yr	5	5	5
Intermediate	< 5 yr	5	5	5
Intermediate	> 5 yr	5	5	5
Active	< 5 yr	5	5	5
Active	> 5 yr	5	5	5
Active	Reference	5	5	5

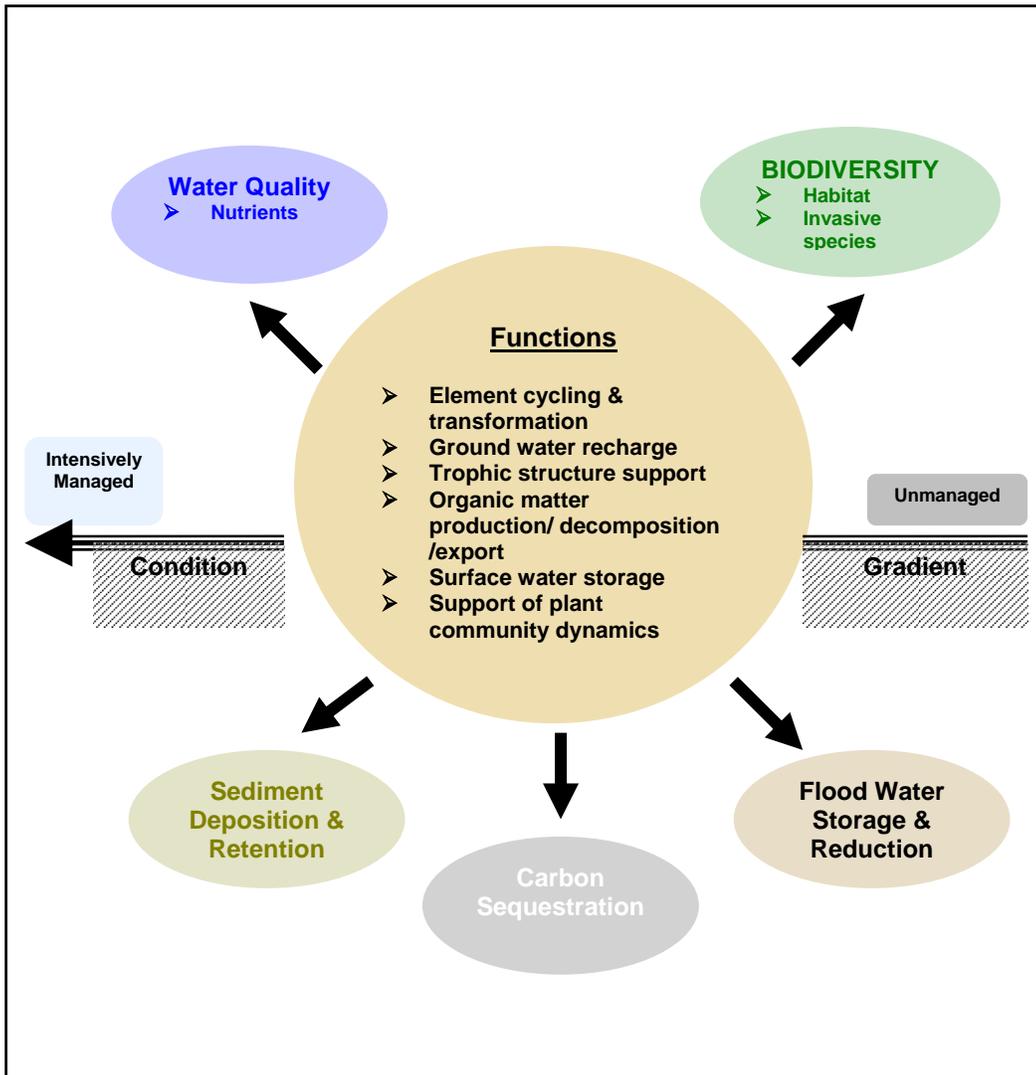


Figure 2. Wetland functions and ecological services expected to change along a condition gradient.

**Objective 2:** Evaluate ecosystem services provided by USDA-NRCS restoration of different types of wetlands.

To meet this objective we will sample 36 temporary, seasonal, semi-permanent and riparian wetlands in the Sacramento and upper Klamath basins and the inter-mountain region of California (Table 2). Key elements of this study will include; (1) sampling across different wetland types to compare ecosystem services provided by each and (2) sampling across different physiographic provinces.

Data collection will begin in September 2007 and be completed by June 2009. Because of the limited numbers of riparian and temporary wetlands that have been restored in California, we will select sample wetlands of similar age (<5 or 5-10 years) since restoration. Emphasis will be placed on sampling to compare ecosystem services provided by different types of USDA-NRCS restored wetlands. Data collected during the survey will include repeated sampling of biota, but will also include single measurements of easily measured edaphic, and morphological variables that can be used in various combinations to directly or indirectly quantify the ecological services. These variables will also be used in various combinations to directly or indirectly quantify the following ecological services: biodiversity and habitat, soil erosion and sediment reduction, nutrient loading, floodwater storage, and soil carbon sequestration. The primary focus will be to characterize ecosystem services provided by different categories of wetlands restored as part of USDA-NRCS programs using metrics that can be readily acquired to facilitate future evaluations.

Table 2. Allocation of sampling effort (number of wetlands) among sub-basins and wetland types.

Wetland type	Basin			
	Sacramento	Klamath	Inter-Mountain	Reference
Emergent Marsh	5	5		2
Riparian	5	5		2
Temporary			10	2

## Study Area

The primary study area will be the Tulare, San Joaquin, and Sacramento Basins of the CCV (Figure 2). The Central Valley is an elongated sedimentary basin about 650 km long, 120 km wide, covering an area of 108,800 km<sup>2</sup> (Schoenherr 1992). It is often subdivided into the Sacramento River Valley in the north and San Joaquin and Tulare Valleys in the south.

Topography is relatively flat throughout the valley, with elevation ranging from 120 m in the north and south to below sea level near San Francisco Bay (Schoenherr 1992). Boundaries of the valley are not precisely defined since valley grasslands grade into oak – grassland savannas of the foothills everywhere except the south where desert conditions exist. Climate of the valley is Mediterranean with warm, dry summers and mild, wet winters. Air temperatures varies little throughout the valley with average July highs being 37.1 °C in both Bakersfield and Redding, while average December lows in Bakersfield (2.9 °C) and are only slightly warmer than in Redding (2.7 °C). Annual precipitation, however, exhibits a distinct gradient and ranges from 16 cm in Bakersfield, to 46 cm in Sacramento to 100 cm in Redding. Throughout the valley, more than 90% of annual precipitation falls as rain during November – May. Native vegetation in the Central Valley was predominantly grasslands dominated by bunchgrasses, with extensive riparian forests and freshwater marshes. Freshwater marshes, fed by winter precipitation and snowmelt runoff, formerly covered about 1,638,000 ha of the valley. The largest freshwater wetland area in California was associated with Tulare, Buena Vista and Kern Lakes. These lakes contained as much as 3,360 km of freshwater marsh habitats along their shorelines, although the amount would vary naturally.

Today, most of the wetlands in the CCV, 94%, have been lost. Area of wetland habitats in the CCV prior to 1900 was estimated to be 1.6-2.0 million ha (Hartman and Goldstein 1994). Wetland area in the CCV had been reduced to 153,000 ha. Since the 1980's, however, restoration programs have increased wetland coverage in the CCV to over 200,000 ha (Dahl 2006, Central Valley Joint Venture 2006). Human activities leading to wetland loss in the CCV are varied, but agricultural development and urbanization are chief among them.

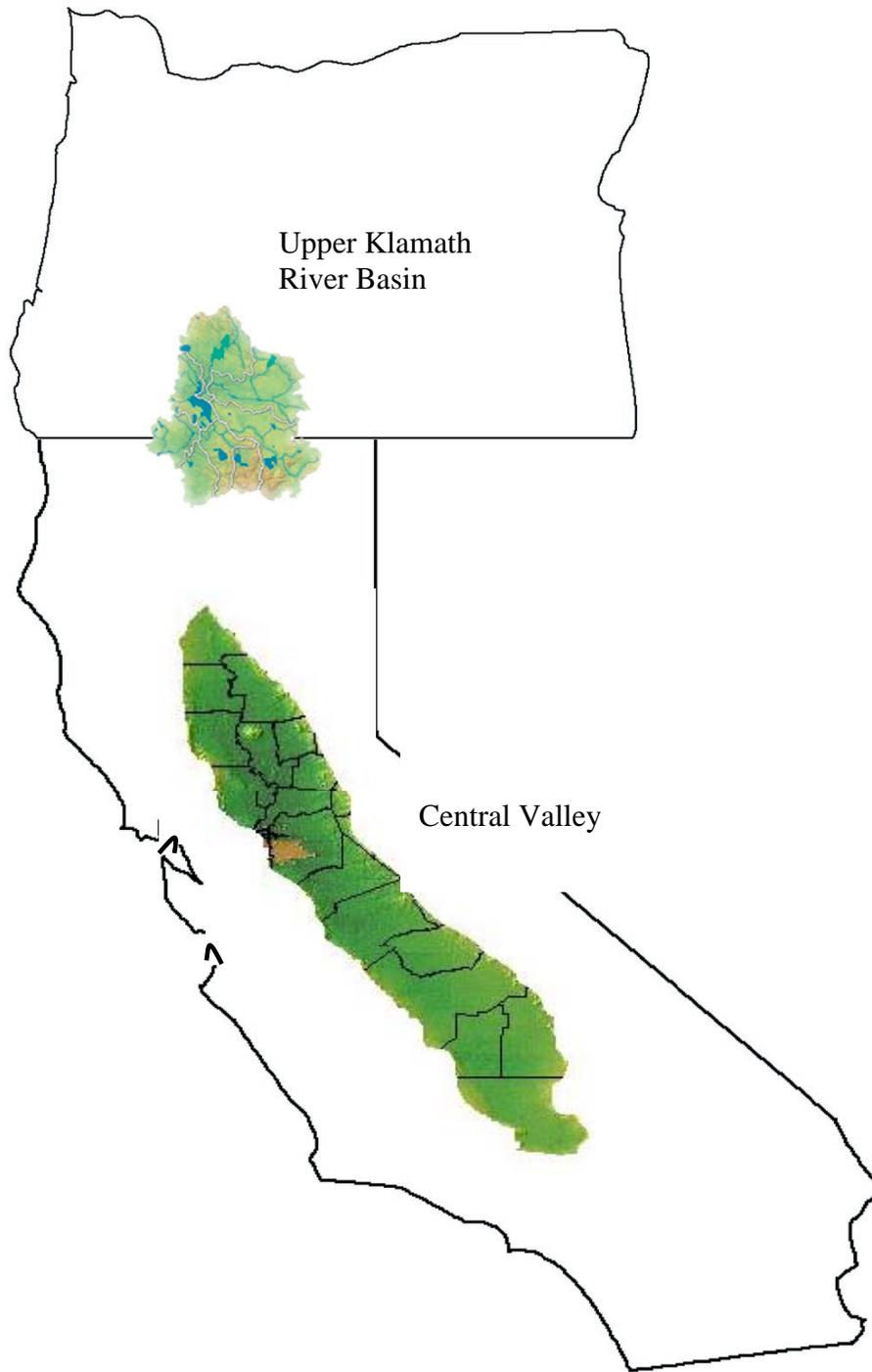


Figure 2. Map of California and Oregon showing the Central Valley and upper Klamath River basin.

Secondary sampling areas will include the Upper Klamath River Basin (UKRB) and inter-mountain region of California. The UKRB encompasses an area of 20,720 km<sup>2</sup> in northern California and southern Oregon. Palustrine emergent wetlands once covered expansive areas in the UKRB, but most have been converted to agricultural lands. The UKRB and inter-mountain region are located within the southern Cascade physiographic region. Soils of the UKRB are of volcanic, alluvial and wetland or lake bed origin. Climate of the area grades from Mediterranean to undifferentiated upland. Summers are hot and winters short but cold. Soils of the inter-mountain region are volcanic in origin while climate is undifferentiated upland. Wetlands of the inter-mountain region are primarily temporary emergent palustrine wetlands.

### **Data Collection**

Data collected at each site selected for each study will range from numerous landscape measures to *in situ* abiotic and biotic data for wetland basins. Collectively, this information will be used to assess differences in ecological services along gradients of management intensity and age, as well as among wetland classes and physiographic provinces. Data types are described below and a composite list of variables and their definitions are provided in Appendix A and B, respectively.

*Land-Use History Survey*: Information collected will vary by wetland category, but will include restoration age, cropping history, drainage or conversion date, and type of conservation plan. This information will be collected from a variety of sources including landowners, collaborators (e.g., USDA, FWS), and field surveys.

*Climate*: Information will be obtained from the National Oceanic and Atmospheric Administration's National Climatic Data Center and the National Weather Service's Climate Prediction Center. Data will include temperature, relative humidity, precipitation, solar radiation, evaporation, and wind speed. Additional data will be gathered from USGS gauging stations, including stream flow, channel discharge, and ground water levels.

*Landscape Features and Wetland Inventories*: We will determine land-use (%), wetland density (number/km<sup>2</sup>) and area (ha), and category of all wetlands at 4 landscape scales (500m, 1km, 2km and 4km) surrounding study wetlands. Information will be obtained using aerial photography supplied by NRCS and digital data from the following sources: National Wetlands Inventory (NWI) and USDA CRP and WRP land units. Other digital data that may be used,

including USDA major land resource areas (MLRAs), management districts (county, state, federal) and management areas (federal or state management areas), hydrologic units, physiographic regions, USGS level IV ecoregions, soils, and public land survey areas. In addition to estimating landscape features at multiple scales surrounding study wetlands, these databases will be blended as needed to generate estimates of wetland areas by hydrogeomorphic boundaries (e.g., ecoregions, MLRAs, and watersheds), conservation programs (e.g., CRP and WRP), and other resource areas.

*Morphometry:* Wetland basins will be surveyed using a GPS total station. Other features surveyed will include secondary surface outlets and inlets, surface water elevation, transect locations including quadrat and soil sample locations, and upland/wetland transition zones (see *Vegetation* and *Soils* sections). Estimates of wetland morphometry, including area (ha), volume ( $m^3$ ), maximum depth (m), and perimeter (m) will be based on outlet elevations. Estimates of the surrounding 4 km radius will include total area (ha), area comprised of major vegetation types (ha, e.g. grasslands, row crops, orchards) and average slope (%).

*Vegetation:* Estimates derived for each wetland basin will include the area covered by open water and emergent vegetation (%), cover/water interspersion (categorical ranking), and type of land use (%) in the surrounding 4 km radius. In addition, we will gather detailed vegetation information similar to procedures developed by USGS-Northern Prairie Wildlife Research Center (Kantrud and Newton 1996). We will establish 4 equally spaced transects that radiate out from the wetland center to the wetland boundary. The width (m) of all wetland vegetation zones, as delineated by plant species composition, bisected by transects will be estimated and average water depth (cm) recorded. Within each of these zones, a 1- $m^2$  quadrat will be randomly sited along each transect. Within each quadrat, vegetation cover (%) by taxon (Daubenmire 1959), litter depth (cm), and visual obstruction at plot center (Robel 1970) will be estimated and any plant taxa not encountered within quadrats will be recorded. Estimates of aboveground vegetation biomass also will be collected from all quadrats along one transect by placing a 0.25- $m^2$  quadrat in the center of the 1- $m^2$  quadrat and clipping all above ground biomass (live and dead). Biomass samples will be stored in paper bags until returned to the laboratory at Humboldt State University for determination of dry mass. Following dry mass determination, samples will be shipped to the Colorado State University Soil-Water-Plant

Testing Laboratory for determination of total phosphorus (TP), total nitrogen (TN) total carbon (TC) and inorganic carbon (TIC) following standard methods (Klute 1986, Page et al. 1982).

Soils: Following vegetation surveys, soil samples will be collected at depths of 0–15 cm ( $n = 2$ ) from each quadrat used to survey vegetation. Samples will be aggregated and a single sub-sample will be submitted to the Colorado State University Soil-Water-Plant Testing Laboratory for determination of TP, TN, TC and TIC using standard methods (Klute 1986, Page et al. 1982).

Fauna: Pollinators: We will census bee (Hymenoptera) pollinators using WRP wetlands. Inventory methods use pap traps as suggested by Le Buhn et al. (2003). Two 50 m long inventory plots will be established in each wetland. To allow correlation of pollinators with plant types, plots will be selected after vegetation surveys are completed and will, if possible, be located in distinctive vegetation habitats. Fifteen pans (Solo brand PB6-0099 6 oz bowls) will be placed in each plot, spaced at 5 m intervals. Five pans will be painted fluorescent yellow, 5 will be painted fluorescent blue and 5 will be unpainted white. Pans will be filled with a solution of 1 Tsp of Dawn brand blue soap per gallon of water and left in place for 24 hr, after which bees will be collected and returned to the laboratory for identification. We will send reference specimens to the USDA-ARS Bee Biology and Systematics Lab in Logan, Utah, for confirmation of taxonomic identification.

Fauna: Amphibians: We will census amphibians in each WRP wetland. The census will be conducted using funnel trapping, as this method has been recommended as having the least sampling bias and provides information on the entire anuran breeding assemblage (U. S. EPA 2002). Ten funnel traps will be placed in each wetland in the afternoon and retrieved the following morning. Traps will be distributed randomly in distinct wetlands zones, if zones exist, or placed randomly throughout the wetland. Amphibians encountered while conducting plant transects or other sampling will also be recorded. Animals collected will be identified in the field using keys to tadpoles (Altig et al. 2007) and adults available at CaliforniaHerps.com.

Fauna: Birds: A census of birds using WRP wetlands will be conducted prior to measuring abiotic characteristics. Each census will be completed in the morning, before 100 hr. Designated observers will walk or slowly drive the wetland perimeter and record all birds observed. Other species encountered by designated observers and crew members collecting abiotic information also will be recorded. However, this information should provide insight

regarding the types of fauna that use wetlands in different land use and age categories and facilitate efforts to quantify these values in the future.

We will also use radiotelemetry data collected on key waterfowl species during 1987-2000 and waterfowl aerial survey data collected during 1970-2000 to study impacts of USDA programs on waterfowl distribution, movements, and habitat use. The Central Valley of California is one of the most important waterfowl wintering areas in the world. Half or more of the northern pintails (*Anas acuta*) and a significant portion of numerous other waterfowl species in North America migrate to and winter in California, arriving as early as the first week of August and remaining through March. USDA programs such as the Wetlands Reserve Program (WRP) have restored significant amounts of waterfowl habitat in the Central Valley but response of wintering waterfowl to these programs have not been determined. We will determine the use of WRP wetlands by individually radio tagged waterfowl. These data will provide information on the importance of WRP wetlands to waterfowl during feeding, loafing, and resting.

*Special Case: Fish Fauna*

Wetland support high rates of invertebrate production and provide complex habitat, characteristics that are important to the growth and survival of fish. However, the distribution of fish in wetlands is uneven, largely due to their requirements for dependable water of relatively good quality and access to permanent water bodies. Thus, fish will not occur in many of the wetlands selected for our sampling to quantify ecosystem services. Nevertheless, fish production in wetlands is an important ecosystem service.

We will sample fish using restored riparian wetlands in the Sacramento Valley of the CCV and in the upper Klamath Basin. Sampling will be directed toward estimating diversity, abundance, growth and production of juvenile fishes using riparian wetlands. This will require repeated sampling (4 – 5 events) over the period when fish are using wetlands, usually early spring through mid-summer. Sampling gear will be selected based on the density of emergent vegetation and flow characteristics within the wetland. However, we anticipate that either “throw nets”, “pop-nets”, traps or some combination of these gear will be effective in sampling fish in riparian wetlands.

## Data Analysis

We will analyze data with the intent of explaining the response of ecosystem services to selected gradients. We will use an information theory approach popularized by Burnham and Anderson (2002). This approach emphasizes using the investigators biological or ecological knowledge to build a suite of models that include realistic subsets of independent variables (e.g. wetland area within 4 km, period of flooding) that best explain the behavior of the response variable. Information theory is then employed to select, from a suite of models, a single or limited number of models that are most parsimonious in explaining an ecosystem service response. We will likely use general linear modeling or multiple linear regression to construct models.

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Appendix A. Complete list of extensive variables.

Category	Variable
History	Date of wetland conversion
	Age of restoration (years)
	Year enrolled (WRP)
	Crop history (wetland)
	Management intensity
Morphology	Area (wetland, zones) (ha)
	Shoreline length (m)
	Elevations (vegetation zones, spill, etc.) (m)
	Volumes (ha-m)
	GPS location, lat/long
Vegetation	Number of vegetation zones
	Width of vegetation zones (m)
	% open water
	Water Depth (m)
	Floristic composition
	Cover estimates (%)
	Litter depth (m) and dry mass (g)
Robel readings and dry mass (g)	
Soils	Organic carbon
	Inorganic carbon
	Total nitrogen
	Total phosphorus
	Buried horizons
Hydrology	Water depth (actual and maximum) (m)
	Natural outlet and inlets
	Wetland type
	Period of flooding

## Appendix B. Detailed Description of Variables.

### Land Use History Survey:

- **Date of Conversion:** Will be used to determine the length of time a wetland was drained. Information will be primarily based on landowner knowledge; however, some information may be available from USDA field offices. Availability and quality of this information is expected to vary because exact drainage dates often not documented.
- **Restoration Age:** Length of time a wetland has been restored. This information will be collected for restored wetlands. Information will be determined from conservation plan documents provided by collaborators (e.g., USDA and FWS documents).
- **Cropping History:** Refers to type of cropping that has occurred within the wetland basin. We will seek this information from USDA and collaborators for all wetlands with a farmed history.
- **Date of Conversion:** Will be used to determine the length of time a wetland was drained. This information will be collected for drained cropland and hydrologically restored wetlands. Information will be primarily based on landowner knowledge; however, some information may be available from USDA field offices. Availability and quality of this information is expected to vary because exact drainage dates are rarely documented. For example, a landowner may only recall that a wetland was drained during a particular decade (e.g., 1930s, 1940s, etc.) rather than providing a specific date.
- **Management intensity:** Will be treated as a categorical variable. Management will be either active (managed throughout year), intermediate (water managed during waterfowl season only) or unmanaged (no water or vegetation management).

### Vegetation:

#### *Wetland Basin and Catchment Scale Estimates:*

- **Number of vegetation zone:** a count of distinct vegetation zones present.
- **Percent open water:** Visual estimate of the percent open water.
- **% cover:** Proportion of wetland cover types (e.g. emergent, scrub/shrub, forest).
- **Percent land use:** Visual estimate of wetland basin and catchment landuse (e.g., grazed, hayed, idle, small grains, row crop, other).

*Transect / Quadrat Data:*

- Number of vegetative zones: Vegetative zones (e.g., wet-meadow, shallow-marsh, deep-marsh) will be determined using the classification system of Stewart and Kantrud (1971).
- Visual Obstruction: Visual obstruction measurements will be collected following procedures described by Robel et al. (1970).
- Cover estimates: Daubenmire (1959) cover classes of each taxon within quadrat.
- Litter thickness: Measurement (cm) of O' horizon within quadrat.
- Water depth: Depth (cm) of water within quadrats.
- Species list: Plant species nomenclature will follow Hickman (1993). Species level data will be used to summarize floristic quality and physiognomy (native, introduced, perennial, annual, biennial) characteristics of each vegetative zone.
- Width of vegetative zones: Width (m) of the each vegetative zone bisected by transects. This will be measured directly in the field, but area (ha) and average width of each zone also will be estimated using the data from the topographic survey.

*Vegetation Biomass:*

- Total biomass: Dry weight (g) per 0.25 m<sup>2</sup>.
- Total carbon: Percent carbon.
- Total nitrogen: Percent nitrogen.
- Phosphorous: phosphorous (µg/g).

Soils:

*Physical and Chemical Characterization of Soil Samples:*

- Total carbon: percent organic carbon.
- Organic carbon: percent organic carbon.
- Inorganic carbon: percent inorganic carbon.
- Phosphorus: phosphorous (µg/g).
- Total nitrogen: percent nitrogen.

Morphometry:

- Wetland areas: Area (ha) of wetland based on hydric soil, hydric vegetation, and natural outlet elevational boundaries/transitions.

- Wetland volumes: Basin volume ( $\text{ha m}^{-1}$ ) as demarcated by the hydric soil, hydric vegetation, and natural outlet boundaries.
- Perimeter length(s): Perimeter (m) of wetland area based on hydric soil, hydric vegetation, and natural outlet boundaries, and each vegetative zone (e.g., wet-meadow, shallow-marsh, deep-marsh).
- Maximum water depth: Maximum potential water depth (m) of the wetland basin as demarcated by the natural or artificial outlet/spill point.
- Period of flooding: Time during year that water is held on the wetland.
- Average percent slope: Average percent slope of the land within a 2 km radius.
- Average slope length: Average length (m) of slope of the land within a 2 km radius.
- Elevation of water control features: This may include elevation of dams, spillways, drains, and various other water control features.
- Surface water elevation: Elevation of water.

#### Spatial Climate Data:

- Air temperature: °C
- Relative humidity: percent
- Precipitation: cm
- Evaporation: mm/day
- Wind speed: miles per hour
- Stream flow: meters/second
- Channel discharge: cubic meters/second
- Ground water levels: meters

#### Landscape Features and Wetland Inventories:

- Perimeter of wetland: meters
- Proportion dominant land covers within landscape: percent
- Wetland density or nearest neighbor wetlands: wetlands/ha, meters
- Road length or density: meters/ha
- Number/area/density of wetlands: number/ha per buffer zone

#### Fauna

Fauna Species: List of all bees, amphibians, fish and birds recorded in wetlands.