DEVELOPMENT OF A FRAMEWORK APPLICABLE FOR MANAGED WETLANDS: STATE-AND-TRANSITION MODELS FOR WETLAND HABITAT ASSESSMENT AND MANAGEMENT

PROCEDURES MANUAL

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1st edition
July 2014

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INTRODUCTION

This manual is intended to assist participants in understanding the purpose of this study as well as provide information and rationale behind the techniques employed. We understand that this manual cannot be comprehensive, but hope that it will serve as a useful guide. If you find areas of the manual confusing, don't hesitate to ask for an explanation. Comments and constructive criticism regarding the manual are welcomed. To help prepare this manual, we "borrowed liberally" from the Prairie Habitat Joint Venture Assessment Program: Procedures Manual, 7th edition (Institute for Wetland and Waterfowl Research, Ducks Unlimited Canada, Stonewall, Manitoba, Canada).

Background

Intermountain West wetlands provide important habitat for migratory birds and other wetland-dependent wildlife. Similar to wetland habitats in other regions of North America, agriculture and urban development have resulted in the loss of approximately 57% of Intermountain West wetlands to drainage (Ratti and Kadlec 1992). The significance of this loss is magnified due to the region's largely arid landscape. Moreover, anthropogenic modification of wetlands has altered historical wetland function; however the extent and degree of altered functions has not been quantified. Wetland loss and degradation, and the importance of these wetland resources to migratory birds, has led to the establishment and active management of some of the Intermountain West's largest wetland complexes, such as National Wildlife Refuges (NWRs) (e.g., Alamosa-Monte Vista, Malheur, Red Rock Lakes, and Ruby Lake), state Wildlife Management Areas (WMAs) (e.g., Farmington Bay, Market Lake), and private duck clubs (e.g., Ambassador Duck Club, Newstate Duck Club).

Objectives for managing wetland habitat for migratory birds and other wetland-dependent wildlife within the Intermountain West typically fall into two classes: wetland function based on a desired plant community, or habitat for a specified population size and/or life-history requirements of a focal wildlife species or suite of species. In the former case, a wetland is commonly managed to maintain a desired reference submerged aquatic vegetation (SAV) community based on 1) historical accounts of SAV community composition, and/or 2) relative quality of SAV species necessary for migratory birds (commonly waterfowl). For the latter scenario, habitat objectives for SAV could be based upon bioenergetics models defining the necessary biomass of species or communities of SAV providing forage to support population objective(s) of migratory birds (again, commonly waterfowl).

Building a common management framework encompassing these, and other, types of wetland objectives is challenging and has not been accomplished to date. Much of the difficulty lies in incorporating ecological processes that define a potential range of states of a wetland considering management, i.e., fitting the objective within a site's potential. A wetland will have multiple potential states whose expression can be influenced by management. Therefore, it is essential to 1) determine the potential range of states a wetland can express, 2) define which species or group of species and associated life cycles are to be managed for, and 3) link 1 and 2 as a basis to determine management prescriptions that provide the preferred state within dynamic and productive wetland cycles for the target species or group of species.

Wetland management actions largely center on mimicking natural disturbance processes to maintain ecological function of managed wetlands in the Intermountain West. The primary process of management interest is the dynamic wet/dry hydrological cycle, which is a key driver of wetland productivity and vegetation community structure (see reviews in Murkin et al. 1997, Mitsch and Gosselink 2007). The ability to manipulate the timing and duration of flooding in managed wetlands permits controlling, to some degree, the primary wetland disturbance regime. Water-level manipulations can be considered a perturbation, where the ability to predict the outcome of such manipulations varies dependent upon the knowledge of the system being manipulated. Importantly, ecological systems (including wetlands) commonly respond to perturbations in a non-linear fashion with multiple states possible (Drake 1990, van der Valk 1981, Zweig and Kitchens 2009, Smith 2012). This can be contrasted with linear succession to a climax seral community as initially espoused by Clements (1936). Application of linear climax theory to management has proven largely unfruitful (Stringham et al. 2003), and led to the development of non-linear state and transition models (Westoby et al. 1989).

State and transition models (STMs) provide a framework to address the needs described above. An STM depicts the current knowledge of ecological dynamics on a site, identifying the range of potential vegetation communities, i.e., states, which could exist. The STM also identifies the conditions, disturbances, and management actions that may cause a site to transition among states (e.g., from submerged aquatic vegetation to emergent vegetation in a wetland) or simply shift among phases of a state (e.g., from milfoil-dominated to pondweed-dominated within the submerged aquatic vegetation state). Therefore, STMs can assist in making management decisions by identifying actions to maintain a current state, or those that would likely result in a transition to a more preferred state.

We have developed a draft STM for semi-permanently flooded wetlands in the Intermountain West (Fig. 1). It is based on conceptual ecological models that include drivers, stressors, and effects on performance measures (Busch and Trexler 2003). Conceptual models will assist in another important step – identifying possible ecological, utility, and decision thresholds (Martin et al. 2009). Ecological thresholds are commonly defined as a point or zone along a continuum of a system variable (or suite of variables); when it is crossed, there is a sudden transition in the system state (Huggett 2005, Bennetts et al. 2007). Utility thresholds are values of system state or key drivers of system state at which small changes result in significant response in the management outcome (Martin et al. 2009).

A multi-region FWS working group is also currently developing a bottom-up, empirically-driven STM using data from two distinct sites: Lower Red Rock and Malheur lakes. The working group believes that these 2 approaches to STMs will provide 1) a more universally-applicable framework to apply across stations, WMAs, and regions, 2) a more comprehensive understanding of the process of STM development, and 3) a broader tool-set of analyses useful for creating and validating STMs for individual stations. A top-down development of a wetland STM will help elucidate common ecological drivers and processes that influence the expression of wetland plants.

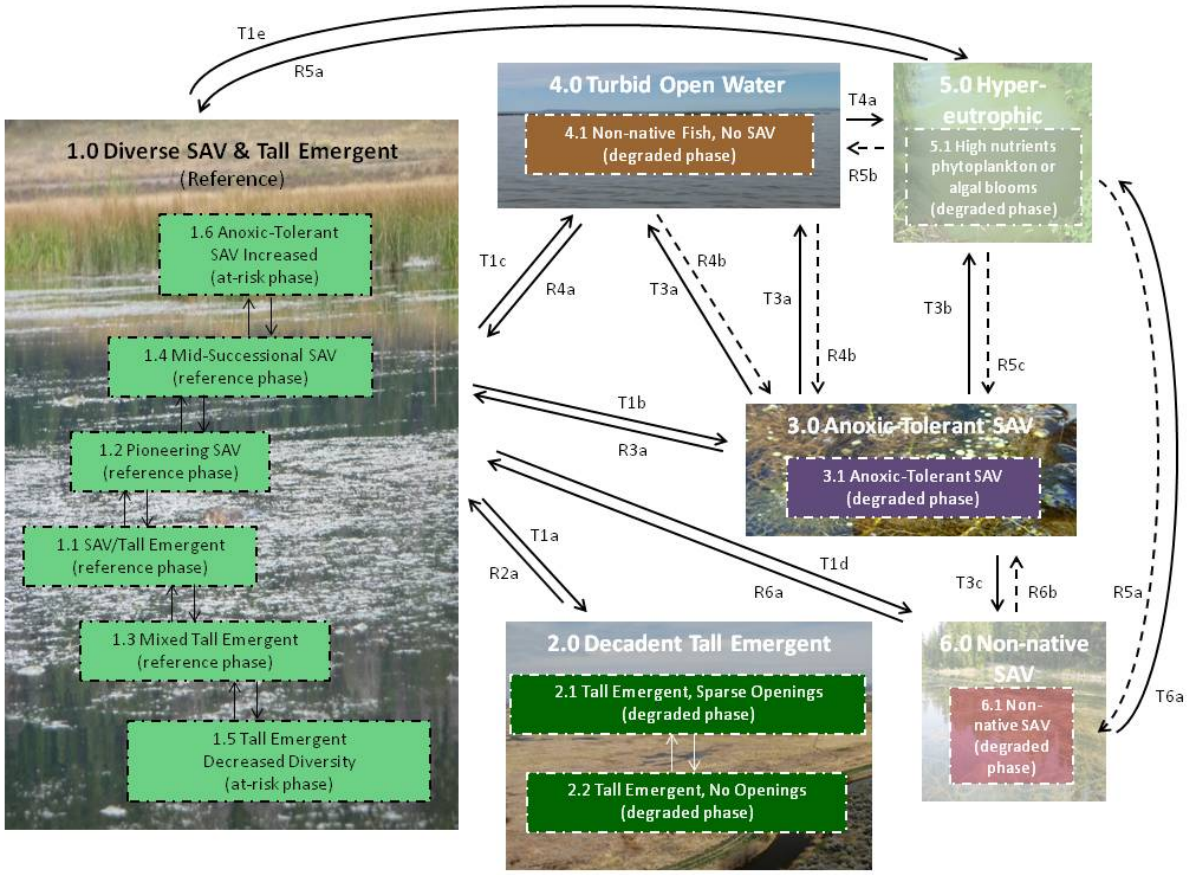

Figure 1. Draft state-and-transition model (STM) for semi-permanently flooded wetlands. Six states are defined in the STM, with state 1.0 Diverse SAV & Tall Emergent the reference state. Within the reference state six vegetation community phases exist. Arrows between states represent transition ('Txx') and restoration ('Rxx') pathways. Dashed lines represent 1) unintended outcomes of restoration efforts, i.e., restoration pathways to altered states that could result from management actions intended to return a wetland to the reference state, or 2) partial restorations, e.g., removing artificial nutrient inputs, but not restoring hydrology. Bestelmeyer et al. (2010) is an excellent resource for clarification on the concepts and terminology of STMs.

Objectives

The objectives of the pilot work to be conducted in 2014 are:

- Conduct an inventory of vegetation, hydrologic conditions, and water quality within semi-permanently flooded wetland habitats on priority units of participating stations.

- Field test methodologies for collecting consistent wetland vegetation data for characterizing a wetland's current condition across diverse landscapes in the Intermountain West and western Prairie Pothole Region.

- Describe, qualitatively and quantitatively, the ecological and abiotic conditions of wetland states and vegetation community phases to inform future management actions and the current draft state-and-transition model at multiple scales.

- Identify preliminary indicator species and abiotic variables for states and phases for streamlining future monitoring efforts to quantify wetland status and assess response to management actions.

Study Area

The 2014 field work will be conducted across nine NWRs within USFWS regions one and six. Participating stations include: Bear Lake NWR, Bowdoin NWR, Camas NWR, Fish Springs NWR, Grays Lake NWR, Lee Metcalf NWR, Malheur NWR, Medicine Lake NWR, and Red Rock Lakes NWR. Each station selected priority management units for sampling.

CHAPTER 1

GENERAL INFORMATION

Safety

Watercraft will be used frequently during fieldwork. Personal flotation devices (PFDs) **MUST BE WORN AT ALL TIMES WHILE IN A WATERCRAFT.** All other FWS field and safety protocols should be strictly followed.

Training

It is very important for training to take place prior to field sampling to 1) maximize the repeatability of field data collection, i.e., minimize among-observer variation, 2) ensure consistent data collection among participating stations, and 3) make field data collection as efficient as possible. The two most common sources of observer error in a project such as this are 1) mis-identification of wetland plants and 2) differences in ocular estimates of percent cover. An investment in training before going to the field can greatly reduce both these types of errors. Stations are generally far from the next nearest station participating in this project, so it will be rare that training will occur with staff from multiple stations. We have tried to provide detailed instructions for training so that training occurs similarly across participating stations. We have also tried to make the training as efficient and effective as possible.

Plant Identification—It will be imperative to spend time reviewing common wetland species you expect to encounter on your unit(s). Local knowledge of wetland plant communities is very helpful; if you are new to an area it will be worth spending time looking at plant inventories available in vegetation maps, reports, plans (e.g., Comprehensive Conservation Plans), theses, etc. If you've sampled wetlands on your station previously you may already have a list of common species for the area. The Consortium of Pacific Northwest Herbaria (http://www.pnwherbaria.org/) is also a useful resource for species lists in your county (and adjacent counties). These resources will be very helpful when keying out wetland plants, but don't try too hard to make an unknown plant key out to one on your list (many of us have made that mistake before!). When keying out plants there are numerous manuals to choose from; a brief list is provided below. Some of the manuals listed are not current with plant scientific names. The Integrated Taxonomic Information System (http://www.itis.gov/) should be used for accepted common and scientific names; the US Department of Agriculture's PLANTS database (http://plants.usda.gov/java/) is the source for standardized plant species symbols used on field data forms (e.g., Northwest Territory sedge, *Carex utriculata*, CAUT). The codes for bare ground/open water (BASU) and residual vegetation (RESID) are included on the datasheet. Lastly, if you can't identify a plant while in the field collect a specimen for later identification (specimens should be placed in a small sealable plastic bag with a small amount of water; try to collect a full plant, i.e., roots or rhizomes should be included).

Useful identification manuals for wetland vegetation in western North America:

Chadde, S. W. 2012. Wetland plants of the Northern Great Plains: a complete guide to the wetland and aquatic plants of North and South Dakota, Nebraska, eastern Montana, and eastern Wyoming. CreateSpace Independent Publishing Platform. (Update to Larson 1993.)

DiTomaso and Healy 2003. Aquatic and riparian weeds of the West. University of California

Fassett, N. C. 1957. A manual of aquatic plants. University of Wisconsin Press, Madison, Wisconsin.

Guard, B. J. 1995. Wetland plants of Oregon and Washington. Lone Pine Publishing, Auburn, Washington.

Hamel, K., J. Parsons, M. Boule, S. Feldman, I. Wertz, and L. Zempke. 2001. An aquatic plant identification manual for Washington's freshwater plants. Washington Department of Ecology Publication No. 01-10-032. http://www.ecy.wa.gov/PROGRAMS/wq/plants/plantid2/index.html

Hitchcock and Cronquist 1973. Flora of the Pacific Northwest: an illustrated manual. University of Washington Press, Seattle, Washington.

Hotchkiss, N. 1972. Common marsh plants of the United States and Canada. Dover Publications, Inc. New York, New York.

Hurd, E. G., S. Goodrich, and N. L. Shaw. 1994. Field guide to intermountain rushes. US Department of Agriculture Forest Service General Technical Report INT-306. http://www.treesearch.fs.fed.us/pubs/24234

Hurd, E. G., N. L. Shaw, J. Mastrogiuseppe, L. C. Smithman, and S. Goodrich. 1994. Field guide to intermountain sedges. US Department of Agriculture Forest Service General Technical Report RMRS-GTR-10. http://www.fs.fed.us/rm/pubs/rmrs_gtr010/rmrs_gtr010_01intro.pdf

Larson, G. E. 1993. Aquatic and wetland vascular plants of the northern Great Plains. US Department of Agriculture Forest Service General Technical Report RM-238. http://www.treesearch.fs.fed.us/pubs/30420

Lesica, P., and P. Husby. 2001. Field guide to Montana's wetland vascular plants. A non-technical key to the genera with keys to the species of sedges and rushes. Montana Wetlands Trust, Helena, Montana.

Also, a great reference for relationships among some abiotic conditions and wetland plants based largely on data from the Midwest, but applicable to this project, is the US Geological Survey Scientific Investigations Report 'Literature review and database of relations between salinity and

aquatic biota: applications to Bowdoin National Wildlife Refuge, Montana', which is available at http://pubs.usgs.gov/sir/2009/5098/pdf/sir2009-5098.pdf.

If you need references for assistance with plant terminology the following may help:

Beentje, H. J. 2010. The Kew plant glossary: an illustrated dictionary of plant terms. Royal Botanic Gardens, Kew, U.K.

Harris, J. G., and M. W. Harris. 2001. Plant identification terminology: an illustrated glossary. Springer Lake Pub.

Ocular Cover Estimation—'Training' your eye to consistently estimate percent canopy cover of a species in a quadrat is an important step in preparing for field data collection. This can be done with simple cutouts in various shapes and sizes of a known area. Preparing a set of cutouts can be done with cardboard, card stock, construction paper, etc., and the cutouts can be saved for training in subsequent years. Start by cutting out the shapes listed in Table 1 and labeling them as one of five species. You could simply use 'Spp. 1', 'Spp. 2', etc., or you could pick five species you expect to find and label the cutouts using actual species names. Next, print out several data sheets to record estimates on. Place a PVC plot frame (see Appendix II for instructions to build a frame) on the ground and have someone put a series of cutouts in the quadrat for each person to record. Have everyone participating record their observations on a data sheet following the protocol described in the Vegetation Surveys section of chapter two. Compare everyone's results with the 'truth' and discuss differences among observers. Repeat this with different combinations of cutouts until the observers have 'repeatable' results across a broad diversity of cutout combinations.

Table 1. Inventory of cutouts to be used for training observers for ocular estimation of percent canopy cover prior to field data collection.

Shape	Size	Area (m^2)	Dimensions[a] (cm)	No. of Cutouts
Circle	Large	0.126	20	5[b]
Circle	Medium	0.031	10	11[c]
Circle	Small	0.005	4	12[d]
Rectangle	Extra Large	0.780	100 × 78	1
Rectangle	Large	0.550	100 × 55	1
Rectangle	Medium	0.360	90 × 40	2
Rectangle	Small	0.05	25 × 20	5[b]
Square	Large	0.640	80 × 80	1
Square	Medium	0.410	64 × 64	3
Square	Small	0.090	30 × 30	5[b]

[a]Radius provided for circles.
[b]Labelled such that one species has two cutouts, three species have one.
[c]Labelled such that one species has five cutouts, one species has three, and three species have one.
[d]Labelled such that one species has five circles, one species has four circles, and three species have one circle.

After the observers are trained using the known percent cover cutouts, practice cover estimates in the field. Have the cutouts available to discuss discrepancies among observers.

GPS— Please spend some time familiarizing yourself with the GPS unit you'll be using. It will be necessary to quickly and efficiently navigate to sampling points using a GPS unit while in the field. If you do not have experience navigating to points, or want a refresher, work with other staff at the station to practice finding points. For example, one person can mark the location of an object (e.g., a beach ball) in tall emergent vegetation and the other person can locate it using the GPS unit. It is important that you set your GPS unit to the same datum of the GRTS sample points (see Chapter 2), which is **WGS 1984**. You should have been provided a .csv file that contains location data for each GRTS sample point by sampling unit. If you need assistance importing that data into your GPS unit you can contact Jenny Barnett (jenny_barnett@fws.gov; 509.380.6479) or Jeff Warren (jeffrey_warren@fws.gov; 406.276.3536 ext. 304).

Abiotic Variables; Water Quality—It is important to be familiar with your water quality meter and to calibrate it following the manufacturer's recommendations. Calibration buffer (pH and conductivity) will be needed, so plan ahead and make certain you have those on hand prior to calibrating your unit for sampling. Instructions for calibrating a YSI 63 meter, a common meter used for collecting water quality data, are provided in Appendix III. Note that pH should be calibrated at least each year, while specific conductivity will rarely need recalibrated. Follow calibration and storage instructions for your meter and sensors. The complete operations manual for a YSI 63 can be downloaded at http://www.ysi.com/media/pdfs/031178-YSI-Model-63-Operations-Manual-RevC.pdf. The water quality meter and other equipment should be cleaned between units and/or stations.

Preparations to be Made Before Going Afield

The bulleted list below is intended to help you get ready for going into the field to collect data. There are a few items that will need to be purchased if you don't already have them on hand, e.g., a water quality meter. If you need to borrow equipment for sampling this year call Jeff because there are some items on the list below that are available for loaning out to stations.

- Plant identification training
- Ocular cover estimation training
- GPS training
- Create and print maps of GRTS points (datum WGS 1984)
- Print data forms (Appendix I)
- Build PVC plot frame for sampling vegetation (Appendix II)
- Calibrate water quality meter (Appendix IV for model YSI 63)
- Attach secchi disc to 5–30 m fiberglass tape (attach end of tape using eyebolt on disc)
- Build rake sampler (see Figs. X and X; text pg X)
- Build/purchase aqua-viewer (http://www.wildco.com/Fieldmaster-Aquavue.html)

- Purchase soil corer (http://www.forestry-suppliers.com/product_pages/Products.asp?mi=31233&title=Oakfield+Model+L+Tube+Sampler+Soil+Probe&itemnum=77117)
- Organize PPE (e.g., PFDs, polarized glasses, sun block, radio, etc.)

Equipment to be Taken Afield

- Maps
- Data forms
- Vegetation manuals
- Hand lens
- GPS and spare batteries
- PVC plot frame
- Water quality meter
- Secchi disc with fiberglass tape
- Rake sampler
- Aqua-viewer
- Soil corer
- Plastic bags to collect unidentified species samples
- Pencils
- Permanent marker (for labeling vegetation sample, soil sample bags, etc)
- Compass
- Field notebook
- PPE (e.g., PFDs, polarized glasses, sun block, insect repellant, radio, etc.)

WE MAY SEEM OVERLY CONCERNED WITH HOW THINGS GET DONE. HOWEVER, THIS IS NECESSARY BECAUSE MANY DIFFERENT PEOPLE WILL CONTRIBUTE TO THE PROJECT OVER MANY YEARS. WE MUST ACHIEVE CONSISTENT DATA COLLECTION TO ACHIEVE COMPARABLE RESULTS.

CHAPTER 2

SURVEYS AND MONITORING

Sampling Design

Our sampling frame is the **entire collection of geographic areas across all stations classified as potential semi-permanently flooded wetland.** Each station can be considered a distinct geographic "strata." Within each station we have multiple delineated areas (hereafter, "unit" = primary sampling unit), and within each area we will have plots where vegetation and covariates are measured (hereafter, "points" = secondary sampling units). As the units were not selected randomly from a list of possible units in 2014, we can think of this design as a nested stratified design with strata1 = stations and strata 2 = units that are nested within strata 1 or stations.

A generalized random tessellation stratified **(GRTS)** sample of points was created for each unit identified as a sampling priority by a station. The GRTS algorithm provides a spatially-balanced random sample of ordered points to be visited for data collection. We used the `grts()` function within the `spsurvey` R package (Kincaid 2013). Sampling intensity, defined as points per acre × 100% (e.g., 30 points/100 acres × 100% = 30% sampling intensity), was specified at 30% within most units (i.e., those 100–300 acres in area) with a minimum of 30 points for smaller units (20–100 acres), 90 points for units between 300 and 500 acres, and a maximum of 120 points for larger units (>500 Acres). Units within a station were stratified to produce an independent GRTS sample for each unit within each station.

The output of the GRTS sample was saved as a .csv file with GRTS point locations ("xcoord" and "ycoord") provided in decimal degrees, datum **WGS 1984**. The first column, **GRTS_ID**, is a concatenation of several pieces of information found in the .csv file. The first 3 letters are a literal for your station (e.g., LMC for Lee Metcalf), followed by an abbreviation for the unit (e.g., PO10 for Pond 10), the panel (i.e, PO for PanelOne or OS for OverSamp), and finally a consecutive numbering of points for each panel. The highest point number within a panel for a unit is the total number of suggested survey points. The **panel** column will be either PanelOne or OverSamp; the former comprises the primary set of GRTS points for sampling and the latter are replacement points if a PanelOne point needs to be excluded from the sample (see ***Dropping Points*** below). The .csv file therefore contains *twice* as many GRTS points as necessary if all of the PanelOne points are sampled. The **siteID** column in these files has a consecutive numbering of points across the entire station. The unit name is listed in the **stratum** column with the station literal preceding it (e.g., LMC – Pond 10).

Order of GRTS Points

As mentioned above, the GRTS sample is a spatially-balanced random sample of *ordered* points. If you can sample the complete set of PanelOne GRTS points in a unit the ordering is not relevant to your field effort. However, if you determine that you can only sample a subset of GRTS points, it is important to select an ordered subset for sampling. For example, if you have 30 GRTS points for a unit, but determine *a priori* that you only have time to sample 20, your

subset should be 1–20 (or some similarly ordered subset). This will maintain the spatially-balanced nature of the sampling, minimizing over- or under-sampling areas of the unit. Once you determine the ordered subset of GRTS points to be sampled in a unit, the actual order in which points are visited in the field is irrelevant and should be organized for efficiency. If PanelOne points need to be dropped from the sample (see ***Dropping Points*** below) you will need to sample OverSamp points, also in order. For example, if you dropped three PanelOne points (*any* three) you would use OverSamp points 1–3 as replacements. If one of the first three OverSamp points needed to be dropped, you would continue in order, i.e., move to point 4. Replacement points will likely not be close to the dropped points due to the spatial balance of the sampling design.

During this pilot year of data collection, we want stations to focus on complete sampling of priority units. For example, if a station has 6 units with 50 points each, and you only have time to sample 150 points, please sample 50 points at the 3 highest priority units rather than 25 points at 6 units.

Dropping Points

It is important to keep good records of each point, identifying if the point was surveyed or not and if not surveyed, recording the reason. This record keeping for both the PanelOne and OverSample points is critical for adjustment to the design-weights after field surveys are conducted.

There are several reasons why data may not be collected at a point sampled but most likely because the point was not in the appropriate habitat type (see below) or it was logistically inaccessible. If a point was visited and deemed non-target (e.g., point fell within uplands) or in the office it was deemed non-target, it needs to be denoted as such on the data sheet (see header). No vegetation data will be recorded for that point. Standard codes are: TS = target and sampled, NT = non-target, IN = inaccessible, Turbid = too turbid to see the bottom substrate due to localized and presumably ephemeral turbidity (see *Ocular observations* below), and NotEval = not evaluated. Within the EvalReason column denote why a point was deemed non-target (NT) or inaccessible (IN). EvalReason codes include:

UPL (upland e.g., sagebrush, lodgepole pine) note habitat type

TF (temporarily flooded, e.g., tufted hairgrass) note dominant vegetation

SF (seasonally flooded, e.g., Baltic rush, sedge) note dominant vegetation

PF (deep > 3 m permanently flooded)

IN (inaccessible) note why a point was inaccessible

OTHER please explain (e.g., muskrat house, swan nest platform, vegetation uprooted by foraging)

NOTE: A semi-permanently flooded area that is dry at the time of sampling **IS** a target point and **SHOULD** be sampled.

If you are not familiar with vegetation types in wetlands with different flooding regimes, work with station staff to identify these habitat types at the station. A great reference for plant species as indicators of wetland permanency class is Stewart and Kantrud (1971), Classification of Natural Ponds and Lakes in the Glaciated Prairie Region. Appendix A has a list of characteristic plants species in prairie wetlands. A web-version of this resource publication is available online at http://www.npwrc.usgs.gov/resource/wetlands/pondlake/index.htm.

An example of an SOP that sampled using GRTS that might be useful:
Yeo, J.J., T.J. Rodhouse, G.H. Dicus, K.M. Irvine, L.K. Garrett. 2009. 1 Upper Columbia Basin Network sagebrush steppe vegetation monitoring protocol: Standard operating procedures version 1.0. Natural Resource Report NPS/UCBN/NRR---2009/142. National Park Service, Fort Collins, Colorado.

Timing of Surveys

When surveys should be conducted is as important as *where* they are conducted, the latter discussed in detail above. When surveys should be conducted can be considered at two temporal scales, 1) season within a year, and 2) period within a season. First, the season within a year that sampling should occur is during peak growing season for wetland vegetation. This allows species with varying phenology to reach their full growth potential, as well as ensure seeds, or other characteristic reproductive parts, are present to assist with species identification. For most stations participating in this project this will be late July through August, with lower elevation/warmer sites having an earlier phenology than higher elevation/cooler sites. The phenology at a station among years may also vary; a warm, dry spring may result in peak growing season occurring several weeks earlier than a cool, wet spring. When to conduct sampling within the growing season is driven by local conditions that may influence your ability to detect aquatic species. For example, heavy thunderstorms could result in localized and short-term turbid conditions on a unit to be sampled. Postponing sampling a few days to let the turbidity settle out would be warranted in this situation.

Vegetation Surveys

Vegetation surveys will consist of 1 × 1 m quadrats positioned such that the GRTS point location demarcates the northwest corner of the quadrat. To not bias placement of the plot, do not look at the vegetation before placing the plot. For surveys conducted from a boat the quadrat is placed on the east side of the boat (Fig. 2) and ocular estimates of percent cover will be recorded for each species (see *Ocular observations* below). If the water in a unit is too turbid to see the bottom of the quadrat, rake subsamples will be taken to characterize SAV. These subsamples comprise three juxtaposed 1 × 0.35 m rake samples collected within a 1 × 1 m quadrat (Fig. 3; see *Rake observations* below) (Yin et al. 2000).

All surveys should be conducted with 1 observer and 1 recorder. The observer may sit in the bow or stern of the boat, and will locate each GRTS point. The boat should be oriented with the stern due south of the bow. The boat should be steadied either with an anchor at each end, or, in shallow water when using a canoe, paddles pushed into the substrate will often suffice to hold position.

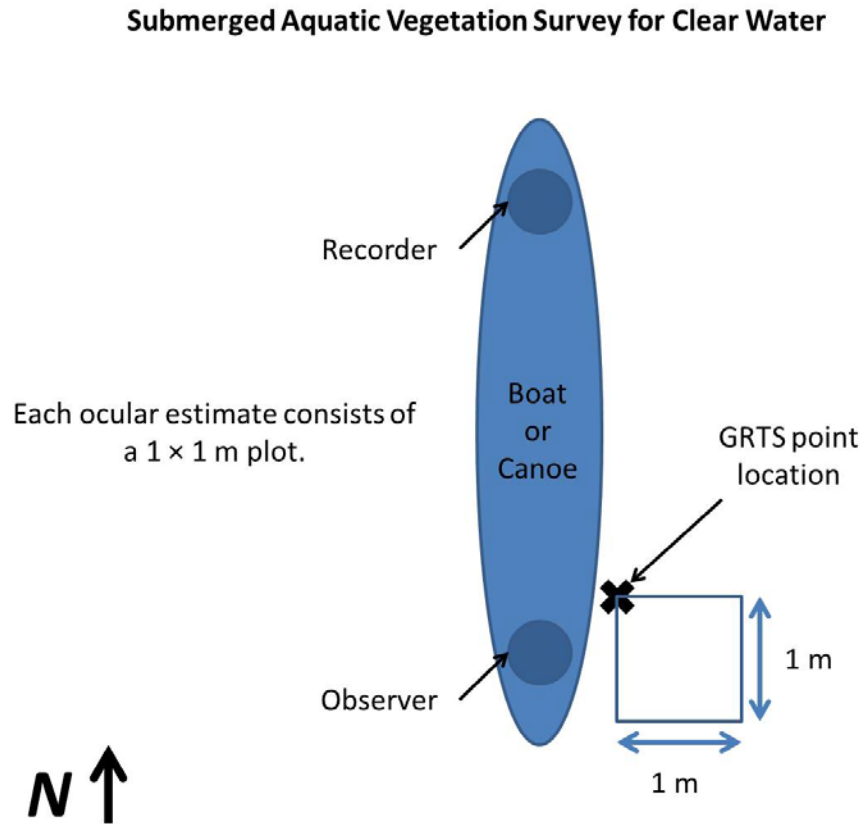

Figure 2. Placement of submerged aquatic vegetation survey quadrat in relation to the GRTS point and canoe or boat.

Aquatic Vegetation

Ocular observations—For each quadrat, percent canopy cover will be recorded for each species present. Quadrats will be surveyed from canoe or boat when possible, or on foot in areas of low water and/or high density emergent vegetation. Ocular estimates should be collected first after arriving at a sample point in order to reduce the potential of stirring up bottom sediment that can obscure vegetation.

Once the boat is positioned and steadied, the observer should assess the canopy cover of **each species, residual vegetation (i.e., last year's standing dead vegetation; record species in comments if identifiable), and bare substrate** in the quadrat. It is imperative that the observer uses polarized glasses at this step to maximize visibility into the water column. An aqua viewer

should also be used to view SAV and ensure that all vegetation species within the plot are recorded (http://www.wildco.com/Fieldmaster-Aquavue.html; they can also be relatively easily built). Slowly sweep the aqua viewer through the water to examine the vegetation present, careful not to disturb vegetation and bottom sediment. Start with species that occur as a single plant in the plot and work up to the species that dominate the quadrat, recording the percent of the plot that is bare substrate last. **For every species present, percent cover should be estimated to the nearest 5%, or nearest 1% if total cover is < 5%.** Species that occur as a single plant should be recorded as having at least 1% canopy cover; they could have more than that, but not less (i.e., it is o.k. to record 3% canopy cover for a single plant, but not 0.5%). When you have recorded the percent canopy cover for all species present and bare substrate **be sure to check that the total sums to *roughly* 100% (i.e., a few percentage points in difference is o.k., but ~10% or greater differences from 100% should be corrected).**

Localized turbidity may preclude you from observing submerged vegetation at some points in a unit that has otherwise clear water. This should be obvious when you first arrive at a point, i.e., if you can't see the bottom substrate due to turbidity. In this situation the point will not be sampled and an OverSample point should be selected as a replacement. The header of the data sheet should be completed and the EvalStatus 'Turbid' circled. No other data needs to be recorded at a turbid site.

Floating-leaved species (e.g., duckweed (*Lemna* spp.), floating pondweed (*Potamogeton natans*), bladderwort (*Utricularia* spp.)) and algae may obscure the observers ability to see submerged species in the water column. Observers should record aerial coverage of each species as it looks from above, even though the floating-leaved species and/or algae are obscuring other species. Once canopy cover has been estimated, please record obscured species in the notes for that point (you do *not* need to record canopy cover of the obscured species, simply their presence).

You will also likely encounter floating plant parts from current year growth in your frame during surveys, often the result of grazing by waterbirds. These species should ***not*** be included in your estimate of aerial cover in your frame; remove them if necessary to get a clear view of the frame. Be certain that you do not exclude non-rooted species such as coon's tail (*Ceratophyllum demersum*) or common bladderwort (*Utricularia macrorhiza*) as floating plant parts.

Waterlily (*Nuphar* spp.) presents a unique issue for sampling due to the growth form of this genus. If waterlily is present, ocular estimates will be made for 2 strata: 1) vegetation at or above the surface of the water, and 2) vegetation within the water column, including all species (SAV, waterlily stems, etc). For the total cover, do not include the ocular estimate of waterlily above the water column.

Any unidentified species should be collected and placed in a labeled plastic bag with a small amount of water for keying out after the survey.

Rake observations—In units where water turbidity precludes obtaining ocular estimates of canopy cover it will be necessary to collect rake samples to characterize aquatic vegetation. We assume the decision regarding whether rake sampling is necessary can be made 1) at the unit scale, and 2) prior to sampling. Localized turbidity in units that are otherwise clear water will be handled differently (see *Ocular observations* above). Canopy cover of visible SAV, emergent,

and floating-leaved species should be estimated and recorded similar to ocular observation surveys before rake samples are collected. The rake sampler is the same as that described by Yin et al. (2000), which is modified from Jessen and Lound (1962) and Deppe and Lathrop (1992). The rake sampler comprises two square-headed garden rakes welded (or bolted, Fig. 4) together such that the teeth of each faces out. Rake heads should be 35 cm in width with 14 5-cm long teeth. Teeth are marked in 20% increments for estimating total plant density for each sample (Fig. 5). For species that occur as one plant in the rake sample, record the plant density as a 1 (Fig. 5).

Prior to sampling the gunwale of the boat should be marked at the 1) ends of the 1 × 1 m quadrat edges, and 2) center of each 1 × 0.35 m subsample (Fig. 3).

Rake subplot sampling should start with R1 and proceed from north to south until all three subplots are sampled (Fig. 3). Extend the rake out from the boat to the bottom of the wetland at the outer boundary of the imaginary 1 × 0.35 m rectangle within the 1 × 1 m quadrat. Drag the rake along the bottom for 1 m. Twist the rake 180° as it is lifted off of the bottom to bring the vegetation into the boat. Twisting minimizes the loss of plants from the rake; twisting more than 180° could cause plants to fall off. Plants hanging off of the rake head should be added to the teeth and those hanging from the handle should be ignored (Yin et al. 2000). Gently sweep the rake head in the water using a figure eight motion to compact and rinse vegetation. Rate the total density of plants on the rake head according to the rake density categories in Table 2, then record the density of **each species** such that it sums to the total plant density recorded. Repeat these steps for rake subplots R2 and R3 (Fig. 3). To identity all the species in the rake sample, this may require poking through the rake sample with your fingers to better see plants present. Deppe and Lathrop (1992) state that separation of plants to assess individual coverage on the rake may be necessary, particularly when plants are entwined with each other.

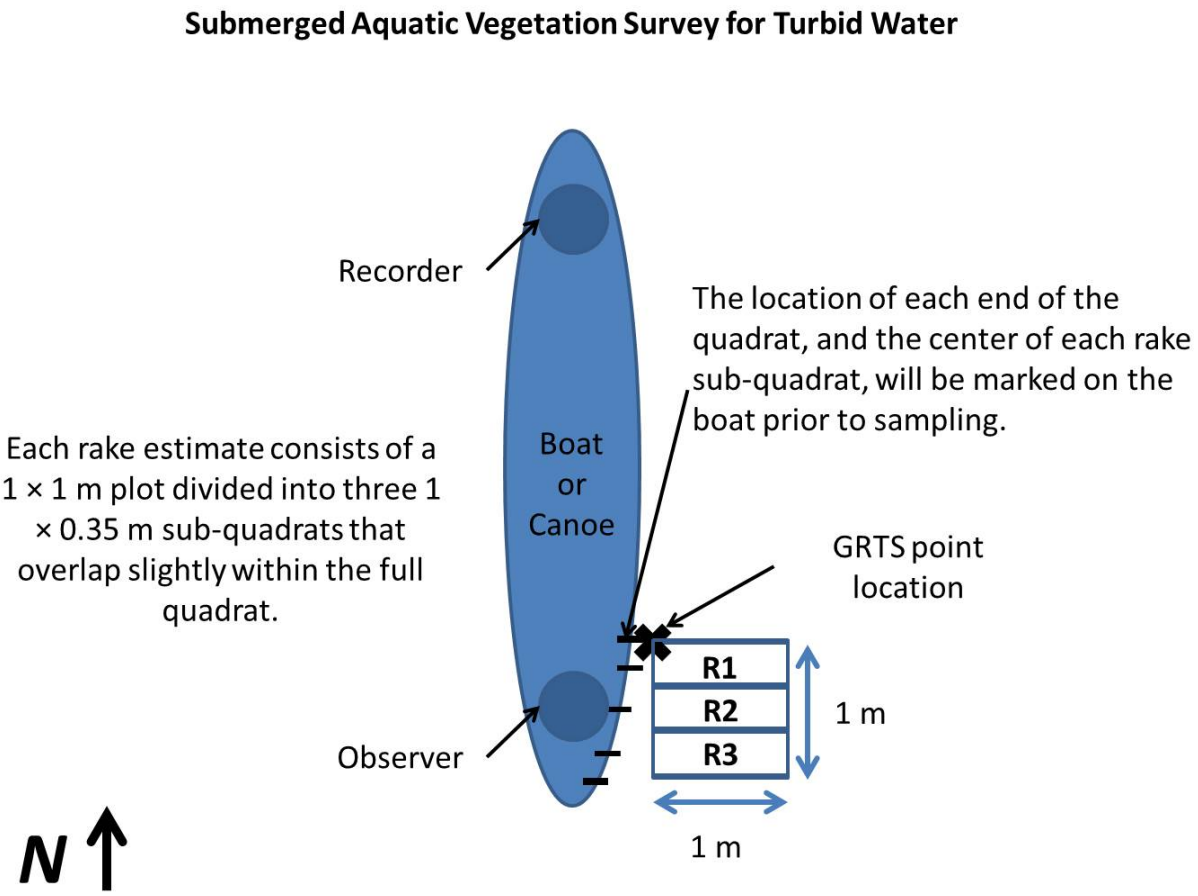

Figure 3. Placement of the three rake sub-samples in relation to the GRTS point and canoe or boat.

Table 2. Rake density plant rating categories.

Density Rating	Percent Rake Teeth Filled
1	1% (i.e., a single plant)
2	1–20%
3	21–40%
4	41–60%
5	61–80%
6	81–100%
7	>100%

Any unidentified species should be collected and placed in a labeled plastic bag with a small amount of water for keying out after the survey.

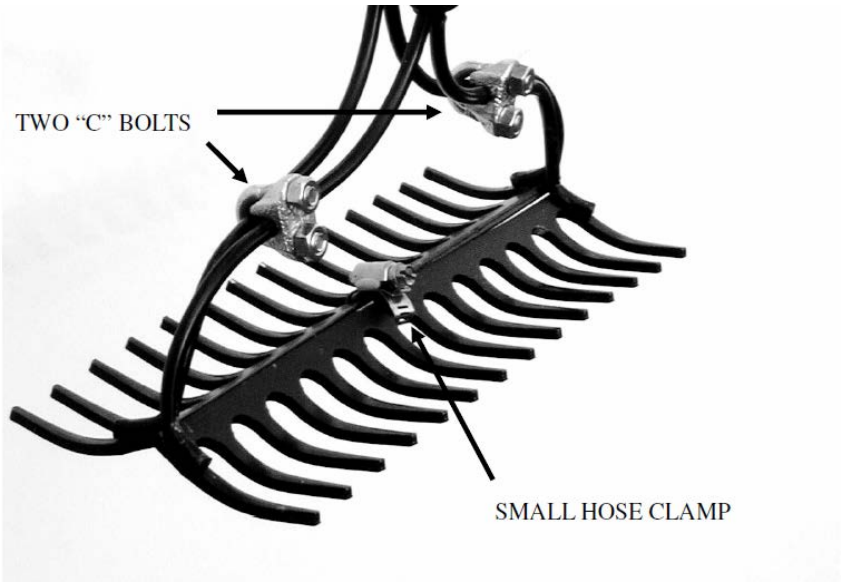

Figure 4. Rake samplers can be made from two square-headed garden rakes that are 35cm wide with 14 5-cm long teeth. Rake heads can be welded or clamped together.

Figure 5. Rake sampler used to sample aquatic vegetation in turbid-water units (photo from Yen and Kreiling 2011). Arrows show the lines used to indicate increments used to estimate total plant density. Vegetation hanging from the rake teeth would be added to the rake before estimating total SAV density.

Abiotic Variables

Abiotic characteristics known to influence wetland plant communities will be recorded during vegetation surveys. The method of survey (boat or foot), water depth (± 1 cm), Secchi disc depth (± 1 cm), temperature (± 0.1˚ C), pH (± 0.01 units), salinity (± 0.1 ppt), relative conductivity (± 1 µS/cm), and soil texture (Table 3) will be measured at each GRTS point after vegetation data are recorded.

Survey method—Record how the survey was conducted, i.e., from a boat (B) or on foot (F).

Water depth—Lower the Secchi disc attached to the fiberglass tape to the bottom of the wetland. If dense vegetation prevents the disc from reaching the bottom, gently separate the vegetation to allow the Secchi disc to sit flat on the substrate. If you are still unable to get the Secchi disc to the substrate use a steel tape measure. In wetlands with unconsolidated bottoms it may be hard to determine where the water column ends and the substrate begins, but do your best. Measure water depth to the nearest 1 cm. If the site is dry a water depth of '0' should be recorded. Circle 'Other' in the Depth section of the data form if you used something other than a Secchi disc for measuring depth.

Secchi disc depth—While the disc is on the bottom of the wetland look to see if it is visible. If it is, the Secchi disc depth should be recorded the same as the water depth. If it is not visible, slowly raise it until it is visible. Move the disc up and down to determine the point at which it disappears from view. Record the depth at which that occurs (± 1 cm) as the Secchi disc depth.

Temperature, pH, salinity, and specific conductivity—Using a water quality meter (e.g., YSI 63) with the probe at the mid-point of the water column, record water temperature (±0.1°C), pH, salinity (±0.1 ppt), and specific conductivity (±1 µS cm^{-1}).

Soil texture—Soil texture by feel will be recorded for each plot. Use a soil corer to collect soil (~ 25 grams, slightly larger than a ping-pong ball) from the top 4 inches of the substrate. Use the flow chart in Figure 6 to determine the soil texture and record the appropriate code from Table 3 on the datasheet.

Soil chemical and physical characteristics—**Optional for 2014.** Soil samples will be collected, air-dried, and ground to pass through a 2 mm sieve and then sent to a lab for analyses (see Appendix IV). No funding from I&M is available, so if stations have funding available and are interested in analysis of soil samples, see Appendix IV for variables and estimated cost (based on prices from Utah State University Analytic Lab).

Because soils need to be air dried within 24 hours for accurate nutrient analyses, we recommend going back to collect soil samples at a unit after all the vegetation and other abiotic information is collected.

Soils should be collected from the first 10 (or 20) GRTS points in each habitat type (e.g., tall emergent, SAV). Approximately 2 cups of soil will be needed for a lab to analyze all the parameters in Appendix IV. Soil from the top 6 inches of the core should be placed in a plastic bag. After sampling, immediately take the soils to an area (no direct sunlight) where they can be spread out on plastic tray to air dry. Fans can be used to increase air circulation drying speed, but ensure that fans to not blow away fine soils or light organic matter. If soils are collected at a plot, circle "yes" for soil sample collected on the vegetation data sheet.

Soil moisture and temperature—**Optional for 2014**. For plots with no standing water, measure soil moisture and temperature at two locations in the soil profile: 1) in the top 3 cm of the soil surface and 2) at 12 inches below the soil surface. Measure soil temperature to the nearest 1 ^{o}C

using with a soil thermometer (e.g., http://www.forestry-suppliers.com/product_pages/Products.asp?mi=64641&title=Soil+Thermometer&itemnum=89027).

Due to the high clay and organic matter likely present in most sampling unit, volumetric water content will be calculated from permittivity values measured by a soil moisture meter such as the Campbell Scientific H2S (http://www.campbellsci.com/hs2-overview). For each sampling unit where soil moisture is collected, a linear relationship between permittivity and volumetric water content will have to be developed. We are currently working on this methodology. If you are interested in collecting data on soil moisture during 2014, contact Adonia Henry (adoniarhenry@gmail.com).

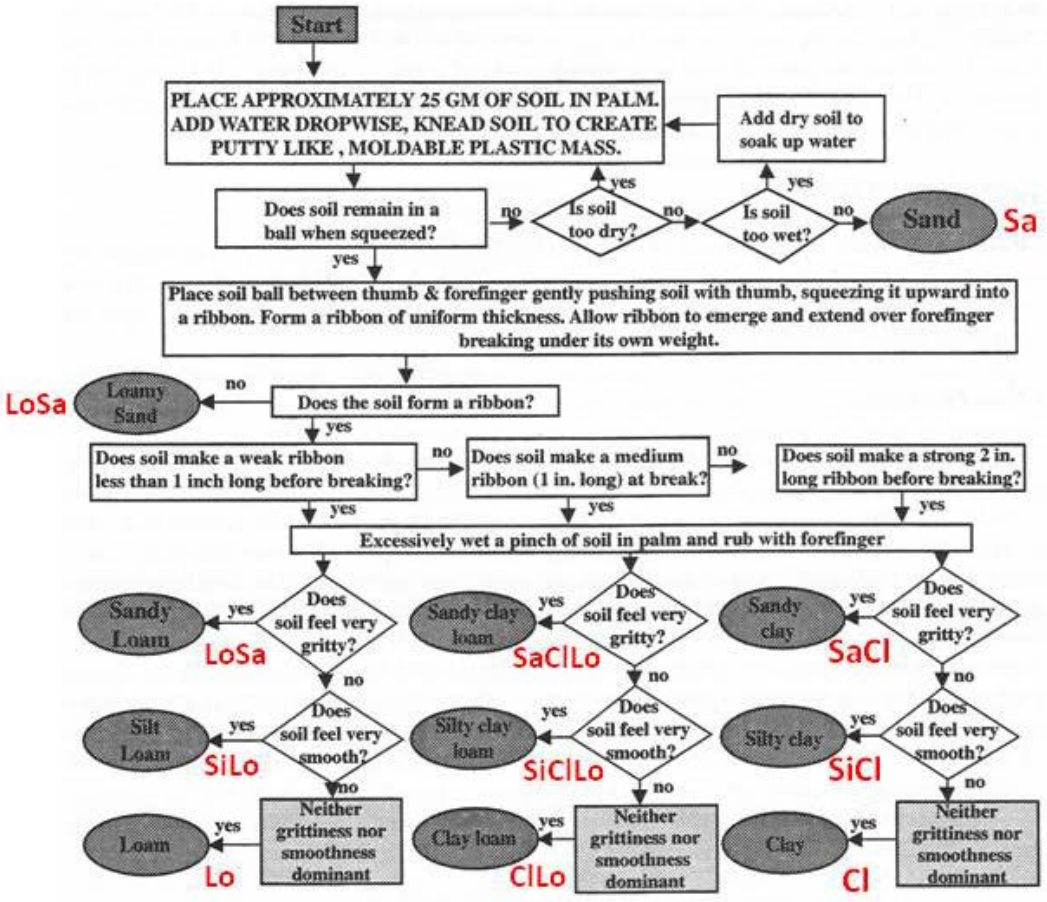

Figure 6. Flow chart for estimating soil texture by feel. Note that most soils collected during the vegetation sampling will be wet. If the soil is too wet and puddles, let the water drain off. There is no silt in this diagram but pure silt is uncommon and the difference between silt and silt loam is inconsequential in most routine wetland work (adapted from Thein 1979 by Richardson and Vepraskas 2001). Soil codes from Table 3 included in red.

Table 3. Soil texture classes.

Class	Code	Characteristics[a]
Organic (peat, mucky peat, or muck)	Org	Does not feel gritty or sticky, is easily compressed, has no internal strength, almost always black
Mineral		Feel gritty or sticky, resists compression, usually brown, red, yellow, or gray
Sand	Sa	So not remain in a ball when squeezed
Loamy sand	LoSa	Remains in a ball when squeezed but does not form a ribbon
Sandy loam	SaLo	
Silt loam	SiLo	
Loam	Lo	
Sandy clay loam	SaClLo	
Silty clay loam	SiClLo	
Clay loam	ClLo	
Sandy clay	SaCl	
Silty clay	SiCl	
Clay	Cl	

[a]See Figure 6 for detailed characteristics of measuring soil texture in the field

Wetland Hydrology

Depth and duration of flooding---A staff gauge or water level data-logger should be installed in each sampling unit if not already present. Water levels should be recorded at least weekly following ice-out through the end of October. Water levels at the staff gauge (or data-logger) should also be recorded on each day vegetation sampling is completed within that unit.

CHAPTER 3

DATA MANAGEMENT

Data Forms and Data Storage:

Most of the data you collect will be recorded on data forms (Appendix I). Please record all data in pencil. Complete data forms following the instructions provided. If you are unsure about how you should record something, spell it out in sufficient detail so that there can be no doubt about what you mean. Then contact one of the project leads for an explanation as soon as possible.

A database will be provided to you for entering data collected in the field.

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APPENDIX I

DATA FORMS

SAV/TALL EMERGENT WETLAND VEGETATION SAMPLING DATA SHEET

OCCULAR SURVEY

Date ____/____/____ (mm/dd/yy) | Observer _____ Recorder_____ Time: Start _____

Station:_____ | Unit Name_____ End _____

Point (SiteID) _____ | **EvalStatus:** TS NT IN Turbid NotEval (circle)

Survey Method: B F (circle) | **EvalReason:** (**if** IN or NT) UPL TF SF PF IN* OTHER* (circle)

Explain* (IN or Other):_____

OCULAR VEGETATION SURVEY (1m × 1m plot)						ABIOTIC
Spp Code	**% Cover**	**Comments[a]**	**Spp Code**	**% Cover**	**Comments[a]**	**Depth (cm)**
BASU						Water Depth _____
RESID						Secchi Depth _____
						Other
						Water Chemsitry
						pH _____
						Sp. Cond _____
						Salinity _____
						Temp _____
						Soil Characteristics
						Texture _____
						(texture by feel)
						Soil Sample Collected
Total Cover			Total Cover			Y N (circle)

[a]Waterlily canopy cover should be recorded for both vegetation at or above the surface of the water and within the water column; record ABOVE or WITHIN in the comments for this genus.

Comments:_____

_____

Time: Start _____ End _____

Point (SiteID) _____ | **EvalStatus:** TS NT IN Turbid NotEval (circle)

Survey Method: B F (circle) | **EvalReason:** (**if** IN or NT) UPL TF SF PF IN* OTHER* (circle)

Explain* (IN or Other):_____

OCULAR VEGETATION SURVEY (1m × 1m plot)						ABIOTIC
Spp Code	**% Cover**	**Comments[a]**	**Spp Code**	**% Cover**	**Comments[a]**	**Depth (cm)**
BASU						Water Depth _____
RESID						Secchi Depth _____
						Other
						Water Chemsitry
						pH _____
						Sp. Cond _____
						Salinity _____
						Temp _____
						Soil Characteristics
						Texture _____
						(texture by feel)
						Soil Sample Collected
Total Cover			Total Cover			Y N (circle)

Comments:_____

_____

SAV/TALL EMERGENT WETLAND VEGETATION SAMPLING DATA SHEET

RAKE AND OCCULAR SURVEY

Date ____/____/____ (mm/dd/yy) | Observer _____ Recorder_____ | Time: Start _____

Station:_____ | Unit Name_____ | End _____

Point (SiteID) _____ | **EvalStatus:** TS NT IN Turbid NotEval (circle)

Survey Method: B F (circle) | **EvalReason:** (**if** IN or NT) UPL TF SF PF IN* OTHER* (circle)

Explain* (IN or Other):_____

OCULAR VEGETATION SURVEY (1m × 1m plot)						ABIOTIC
Spp Code	**% Cover**	**Comments[a]**	**Spp Code**	**% Cover**	**Comments[a]**	**Depth (cm)**
BASU						Water Depth _____
RESID						Secchi Depth _____
						Other
						Water Chemsitry
						pH _____
						Sp. Cond _____
						Salinity _____
						Temp _____
						Soil Characteristics
						Texture _____
						(texture by feel)
						Soil Sample Collected
Total Cover			Total Cover			Y N (circle)

[a]Waterlily canopy cover should be recorded for both vegetation at or above the surface of the water and within the water column; record ABOVE or WITHIN in the comments for this genus.

Comments:_____

_____

RAKE VEGETATION SURVEY (1m × 0.35m sub-plots)						Rake Density Categories	
R1		**R2**		**R3**			
Spp Code	**Density**	**Spp Code**	**Density**	**Spp Code**	**Density**	Density	%Filled
Total		***Total***		***Total***		1	1% (single plant)
						2	1–20%
						3	21–40%
						4	41–60%
						5	61–80%
						6	81–100%
						7	>100%

Comments:_____

_____

APPENDIX II

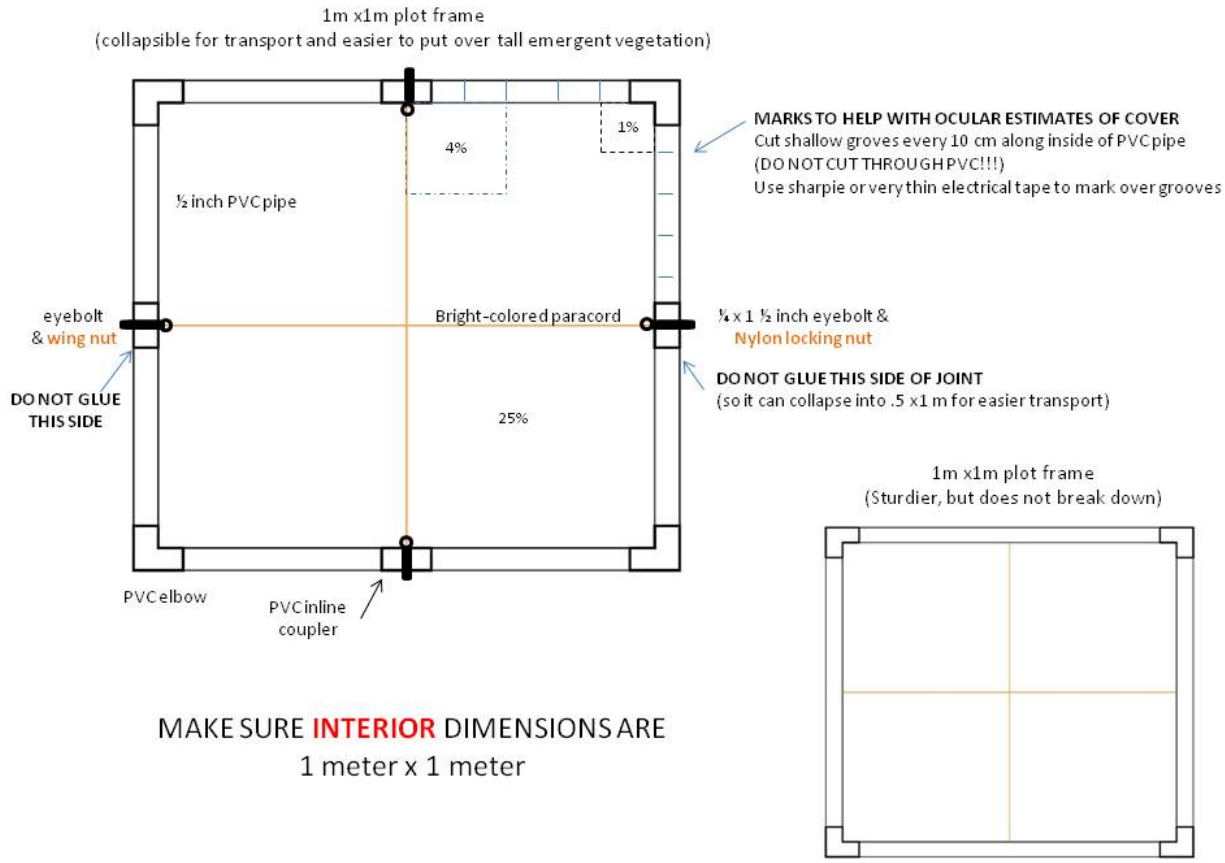
HOW TO BUILD A 1M × 1M PVC PLOT FRAME

Supplies

¾ inch PVC pipe (cut to desired lengths)
4 PVC elbows
2 or 4 PVC in-line couplers
4 eyebolts (¼ x 1 ½ inch)
2 wing nuts
2 nylon locking washers
PVC primer
PVC cement
Silicone or expansive foam
Sharpie or electrical tape (cut thin)
Bright-colored paracord
Drill and hacksaw

Cut and assemble plot frame using PVC pipe, elbows, and in-line couplers as shown below. The plot frame can be made with 0, 2, or 4 in-line couplers, depending on how small you want it to be able to break down for easy transport. We suggest that it should at least split in half (e.g., using 2 couplers) to facilitate putting the frame over tall emergent vegetation. Using 4 couplers will allow it to break down further, but the more joints that are not glued, the less sturdy it will be in the field. Seal inside of PVC pipe, couplers, and elbows with silicone or expansive foam to ensure water does not get into the PVC. PVC joints should be glued with PVC primer and cement (follow instructions on the cans). All elbow joints should be glued!!

Note: Larger diameter PVC may be used to build a sturdier frame. Ensure that the eye-bolts are long enough to go through the size PVC you use.



Characteristics of all plot frames (regardless of the number of glued joints):

1. Seal inside of PVC pipe, couplers, and elbows with silicone or expansive foam to ensure water does not get into the PVC.
2. **Interior** dimensions of 1 meter x 1 meter. PVC elbows will overlap 1 inch of the PVC pipe, but may not be exactly the same. THEREFORE IT IS NECESSARY TO MEASURE WITH THE PARTS YOU ARE USING.
3. Marks every 10 cm along the frame (measured along the inside of the frame) to facilitate accurate and consistent estimates of percent cover.
4. One end of bright-colored paracord should be permanently tied to the eye bolt with the nylon locking nut. The other end should be attached to a wing nut that can be secured onto the eyebolt on the opposite side of the frame once the frame is placed at sample points in tall emergent and floating leaved vegetation. Note: both ends of the paracord can stay permanently attached to the frame when in SAV/open water.

APPENDIX III

CALIBRATING A YSI 63 PORTABLE WATER METER

4.2 pH Calibration

The YSI Model 63 *MUST* be calibrated before making pH measurements. Calibration may be performed at 1, 2 or 3-points (at pH 7, 4 and 10, or at pH 6.86, 4.01 and 9.18). Perform a 1-point calibration (at pH 7 or at pH 6.86) *ONLY* if a previous 2 or 3-point calibration has been performed recently. In most cases, a 2-point pH calibration will be sufficient for accurate pH measurements, but if the general range of pH in the sample is not known, a 3-point calibration may be necessary. 3-point calibration assures accurate pH readings regardless of the pH value of the sample. See *9.1 pH* for more details.

WARNING: **Calibration reagents may be hazardous to your health. Refer to *Appendix B - Health and Safety* for more information.**

Before calibrating the YSI Model 63, complete the procedures discussed in the *Preparing the Meter* and *Preparing the Probe* chapters of this manual.

The user can choose from two sets of pH buffer values for 3-point calibration. The first set consists of the standard YSI pH buffer values of pH 7 (YSI 3822), pH 4 (YSI 3821) and pH 10 (YSI 3823). The second set available is the NIST pH 6.86, 4.01 and 9.18. **Note that the first calibration point must be either pH 7 or pH 6.86.** Calibration is performed as follows:

1. Turn the instrument on by pressing the **ON/OFF** key. Press the **MODE** key until pH is displayed.

2. Rinse the probe with deionized or distilled water, then carefully dry the probe (or rinse it with some of the pH buffer solution to be used for calibration).

3. Place 30 to 35 mL of the pH buffer you have chosen to calibrate the system with (pH 7 or 6.86) in the 100 mL graduated cylinder. The graduated cylinder minimizes the amount of solution needed. Immerse the probe making sure that both the pH and temperature sensors are covered by the solution (see *Figure 5* on the following page).

For best results:

- Calibrate as close as possible to the sample temperature.
- After storage in pH 4 buffer/KCl solution, place the pH sensor in pH 7 (6.86) buffer and allow to acclimate before calibrating (5 to 10 minutes).
- Always give the pH and temperature sensors enough time to equilibrate with the temperature of the buffer.

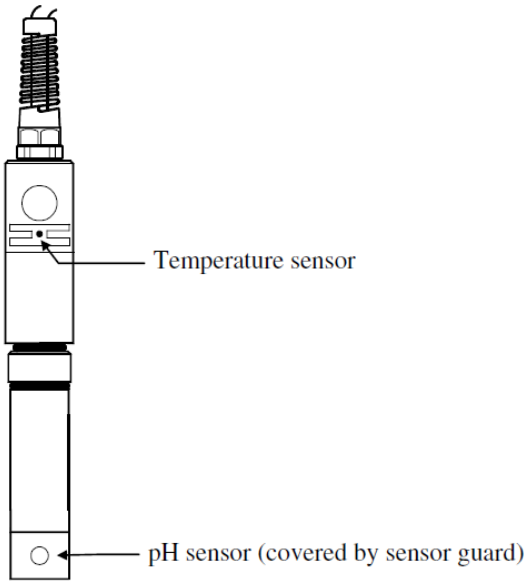
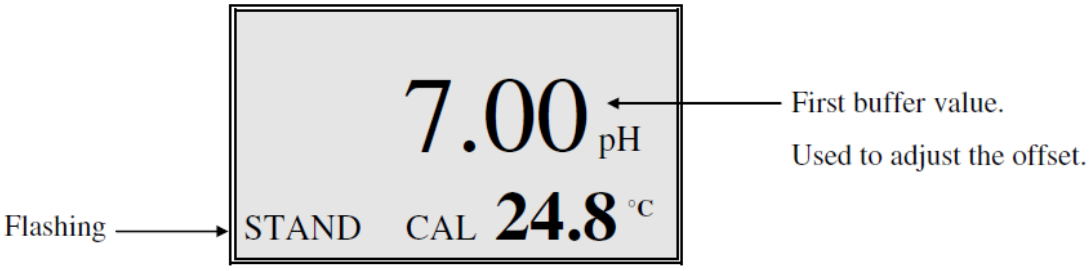


Figure 5

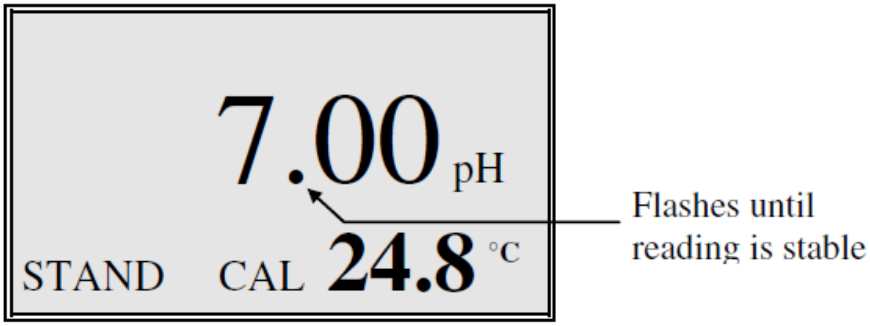
4. To enter the calibration menu, use two fingers to press and release both the **UP ARROW** and **DOWN ARROW** keys at the same time. The Model 63 display will show **CAL** at the bottom, **STAND** will be flashing and the pH reading will show **7.00** (the buffer to be used to adjust the offset).



NOTE: If you will be calibrating with pH buffers of 6.86, 4.01 and 9.18 (instead of 7, 4 and 10), press both the **UP ARROW** and **DOWN ARROW** keys again. The display will change to 6.86.

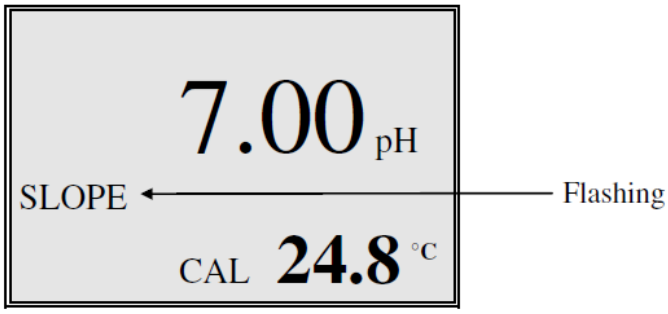
NOTE: The Model 63 automatically accounts for the fact that the true pH of the buffers changes with temperature, therefore, the pH values displayed during calibration will vary with temperature. For example, pH 7 buffer at 20°C (rather than 25°C) has an actual pH of 7.02 and this number (rather than 7.00) will appear on the display when the probe is placed in the solution. See *Appendix C - pH Buffer Values*.

5. Press the **ENTER** key. The Model 63 display will show **CAL** at the bottom, **STAND** will stop flashing and the pH calibration value is shown with the middle decimal point flashing.



6. When the reading is stable (does not change by 0.01 pH in 10 seconds), the decimal point will stop flashing. Press and hold the **ENTER** key to save the calibration point. The Model 63 will flash **SAVE** on the display along with **OFS** to indicate that the offset value has been saved.

7. **SLOPE** will now appear on the display and be flashing. This indicates that the slope is ready to be set using a second pH buffer. The system is now calibrated at a single point. If you are only performing a single point calibration, press the **MODE** key to return to normal operation.

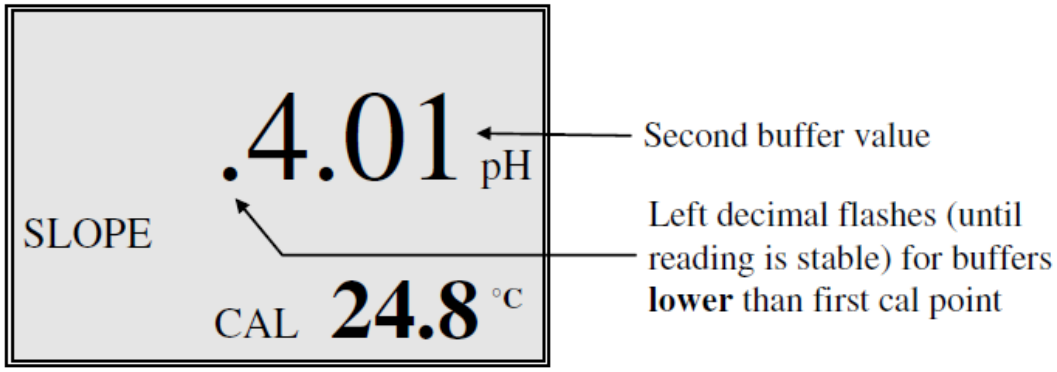


8. Rinse the probe with deionized or distilled water, then carefully dry the probe.

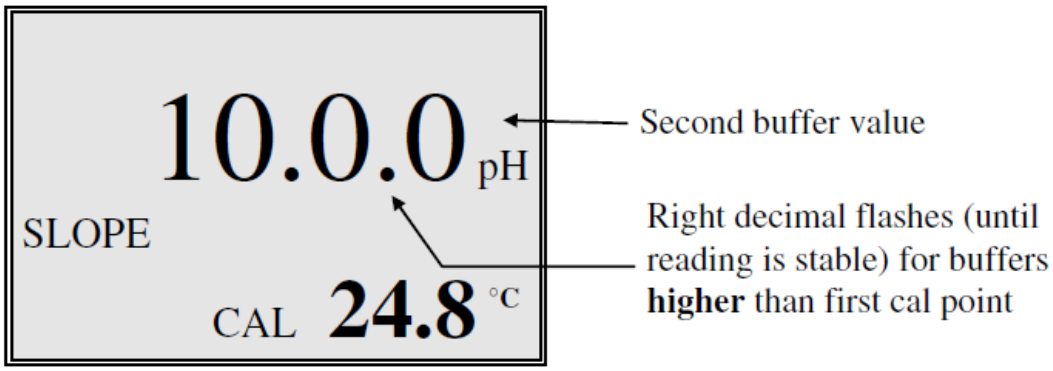
STOP HERE IF PERFORMING A 1-POINT CALIBRATION.

9. If you are performing a 2-point or 3-point calibration, fill a clean container with the second value pH buffer (pH 4 or 10, or pH 4.01 or 9.18) and immerse the probe into the solution. Make sure that the temperature sensor is immersed.

10. Press the **ENTER** key. The Model 63 should now show **CAL** at the bottom, **SLOPE** will stop flashing and the pH calibration value (automatically sensed by the instrument) is shown with one of the decimal points flashing.

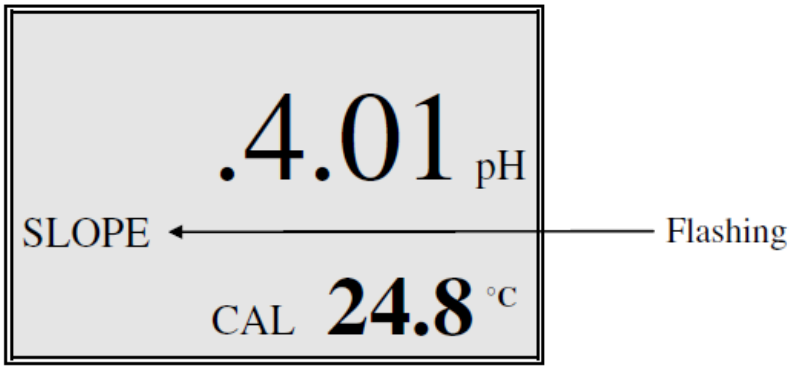


If the second pH buffer is less than the first buffer (which was used to adjust the offset; pH 7 or pH 6.86), the left decimal point will flash as shown above. If the second pH buffer is greater than the first, the right decimal point will flash as shown below.



11. When the reading is stable (does not change by 0.01 pH in 10 seconds), the decimal point will stop flashing. Press and hold the **ENTER** key to save the first **SLOPE**. The Model 63 will flash **SAVE** on the display along with SLP to indicate that the first slope value has been saved.

12. **SLOPE** will start flashing again indicating that the slope is ready to be set using a third pH buffer.



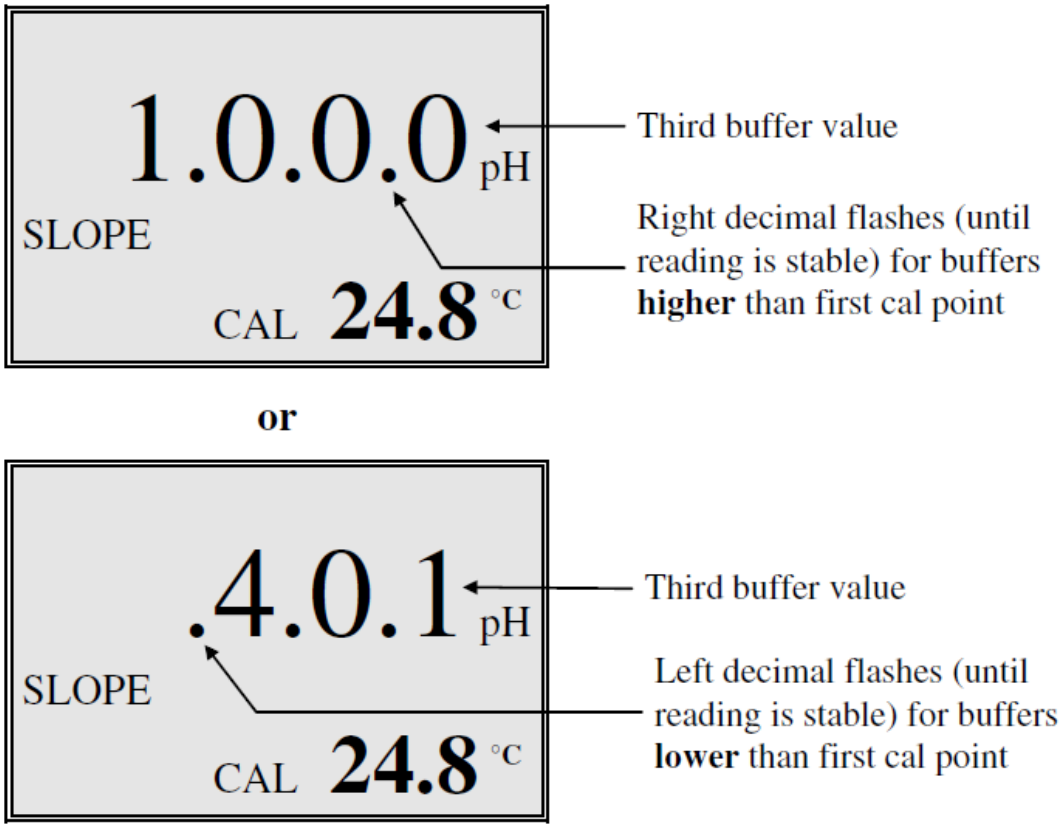
13. The system is now calibrated at two points. If you are only performing a two point calibration, press the **MODE** key to return to normal operation.
14. Rinse the probe with deionized or distilled water, then carefully dry the probe.

STOP HERE IF PERFORMING A 2-POINT CALIBRATION.

15. If you are performing a 3-point calibration, fill a clean container with the third value pH buffer (pH 4 or 10, or pH 4.01 or 9.18) and immerse the probe into the solution. Make sure that the temperature sensor is immersed.

NOTE: The third buffer must not be the same as the second buffer. For example; if the second buffer was less than pH 7, the third buffer must be greater than pH 7.

16. Press the **ENTER** key. The Model 63 display will now show **CAL** at the bottom, **SLOPE** will stop flashing and the pH calibration value (automatically sensed by the instrument) is shown with one of the decimal points flashing. If the third pH buffer is less than the first buffer (which was used to adjust the offset; usually pH 7), the left decimal point will flash. If the third pH buffer is greater than the first, the right decimal point will flash.



17. When the reading is stable (does not change by 0.01 pH in 10 seconds), the decimal point will stop flashing. Press and hold the **ENTER** key to save the second SLOPE. The Model 63 will flash **SAVE** on the display along with **SLP** to indicate that the second slope value has been saved.

The system is now calibrated at three points and will return to normal operation.

18. Rinse the probe with deionized or distilled water.

4.3 Conductivity Calibration

IMPORTANT: System calibration is rarely required because of the factory calibration of the YSI Model 63. However, from time to time it is wise to check the system calibration and make adjustments when necessary.

Prior to calibration of the YSI Model 63, it is important to remember the following:

1. Always use clean, properly stored, NIST traceable calibration solutions (see *12 Accessories and Replacement Parts*). When filling a calibration container prior to performing the calibration procedures, make certain that the level of calibrant buffers is high enough in the container to cover the entire probe. Gently agitate the probe to remove any bubbles in the conductivity cell.
2. Rinse the probe with distilled water (and wipe dry) between changes of calibration solutions.
3. During calibration, allow the probe time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration process. The readings after calibration are only as good as the calibration itself.
4. Perform conductivity calibration at a temperature as close to 25°C as possible. This will minimize any temperature compensation error.

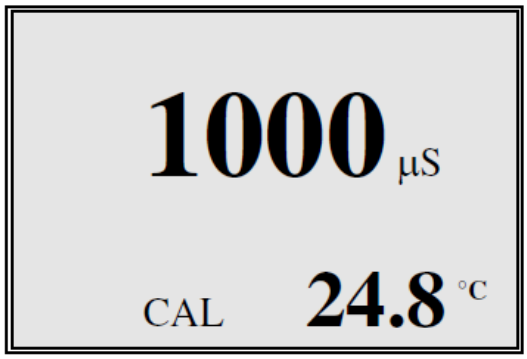
Follow these steps to perform an accurate calibration of the YSI Model 63:

1. Turn the instrument on and allow it to complete its self test procedure.
2. Select a calibration solution which is most similar to the sample you will be measuring.
    - For sea water choose a 50 mS/cm conductivity standard (YSI Catalog# 3169)
    - For fresh water choose a 1 mS/cm conductivity standard (YSI Catalog# 3167)
    - For brackish water choose a 10 mS/cm conductivity standard (YSI Catalog # 3168)
3. Place at least 7 inches of solution in the plastic container or a clean glass beaker.

NOTE: Do NOT use the 100 mL graduated cylinder. The diameter of the cylinder is too small for accurate conductivity measurements.

4. Use the **MODE** key to advance the instrument to display conductivity.
5. Insert the probe into the solution deep enough to completely cover the probe. Both conductivity ports must be submerged (see *Figure 6* on the following page).
6. Allow at least 60 seconds for the temperature reading to become stable.
7. Move the probe vigorously from side to side to dislodge any air bubbles from the electrodes.
8. Press and release the **UP ARROW** and **DOWN ARROW** keys at the same time.

The **CAL** symbol will appear at the bottom left of the display to indicate that the instrument is now in Calibration mode.



9. Use the **UP ARROW** or **DOWN ARROW** key to adjust the reading on the display until it matches the value of the calibration solution you are using.

10. Once the display reads the exact value of the calibration solution being used (the instrument will make the appropriate compensation for temperature variation from 25°C), press the **ENTER** key. The word "**SAVE"** will flash across the display for a second indicating that the calibration has been accepted.

The YSI Model 63 is designed to retain its last conductivity calibration permanently. Therefore, there is no need to calibrate the instrument after battery changes or power down.

APPENDIX IV

DESCRIPTION OF WETLAND SOIL ANALYSIS

Rational

The importance of substrate in determining the distribution of aquatic plants has been known since the early 1900s (i.e., Pearsall 1920, Misra 1938). Barko et al. (1986) list water temperature and sediment composition as 2 of the 4 most prevalent environmental factors affecting submergent vegetation communities. Soil properties that affect wetland vegetation dynamics include soil organic matter, texture, cation exchange capacity, pH, salinity, and nutrients (Sand-Jensen and Sondergaard 1979, Barko and Smart 1983, Smith and Kadlec 1983, Smith and Kadlec 1985, Barko and Smart 1986, Dunn and Scott 1987, Jackson and Charles 1988, Jackson et al. 1993, Madsen et al. 1993, Bini et al. 1999, Stolt et al. 2000). Individual and interrelated parameters of water chemistry also influence aquatic vegetation (Hutchinson 1975). Within a wetland, spatial variability in conductivity, pH, and soil parameters (pH, organic matter, CEC, and texture) may be associated with the distribution of different growth forms of aquatic vegetation (i.e., floating-leaved and submergent; Frodge et al. 1990, Reese and Moorhead 1996, Khedr and El-Demerdash 1997).

Methods and Cost

Soil core samples will be collected at a subsample of GRTS plots in each priority sample unit at participating stations. Soil samples will be placed in a Ziploc bag, labeled with the unit and plot number. When returning from the field, soil samples will be air-dried. Once dry, samples will be ground to pass through a 2 mm sieve, bagged, and sent to Utah State University Analytical Lab for analyses. Soil samples will be analyzed for the following characteristics (prices based on USU price list).

Test	Description	Price (ea)
Basic		
S6	pH, ECe (electrical conductivity, and SAR (sodium adsorption ratio)	$14.00
S14a	Carbon (organic matter) and Total N	$11.50
S23	Particle size by hydrometer	$17.00
S17b	Cation exchange capacity	$11.50
Subtotal Basic		***$ 54.00***
Nutrients		
S7c	Phosphorus (available P) and Potassium	$8.50
S8d	Ammonia N and Nitrate N	$17.00
Subtotal Nutrients		***$25.50***
Total (per sample)		**$79.50**

A minimum of 10 soil core samples per aquatic plant growth form (e.g., tall emergent, floating-leaved, submerged aquatic) within a sampling unit should be collected. If funding is available, 20 samples per aquatic growth form are desired in order to analyze abiotic variables associated with individual vegetation species in addition to growth form. Cost scenarios for a unit with two aquatic plant growth forms and three priority units sampled at each station are listed below:

#Samples SAV	#Samples Tall Emgergent	Qty	Price	Total Per Unit	#Units	Total PerStation
10	10	20	$79.50	$1,590.00	3	$4,770.00
20	20	40	$79.50	$3,180.00	3	$9,540.00

Other soil characteristics that will be measured in the field (or at the station after field collection) include: soil temperature, texture by feel, soil moisture (if sample plot has no standing water), and bulk density (see IWWWG Protocol Manual for methods).

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APPENDIX V

DOUBLE SAMPLING

We will test several different approaches to vegetation surveys in 2014 at pre-selected stations/units to help identify what will be the most effective for long-term monitoring of wetlands for our objectives across the area of interest. **Contact Jeff Warren if you are interested in assisting with one of the double-sampling efforts.** Much of the difficulty in selecting a 'best' method for quantifying wetland vegetation is associated with the question at hand – estimating species canopy cover in semi-permanently flooded wetlands in *both* emergent and submergent vegetation zones, and with clear and turbid open water states. Regardless of where we sample, or the present conditions at a site, we have to quantify the same response metric, i.e., percent canopy cover of plants.

Correlating Rake Samples to Ocular Estimates of Percent Cover—In order to use data collected via different methods, i.e., ocular estimates of SAV cover and rake estimates of SAV density, double sampling will occur at a subset of units. These units will have clear water where ocular estimates can be made; once canopy cover has been recorded at a point a rake sample will be taken. These data will then be used to examine the relationship between ocular estimates of cover and rake estimates of density, providing a way to 'correct' rake density estimates taken at turbid units.

We assume units in a turbid state will have less SAV biomass than units in a clear-water state. Therefore, double sampling to estimate the relationship between rake sample vegetation density and ocular estimates of canopy cover should occur predominantly in areas with little to middling levels of canopy cover. Select points with ≤50% canopy cover, disregarding any GRTS ordering of points.

Double-observer Sampling—The repeatability of our field methods will be assessed by estimating the amount of variation in ocular estimates among observers. We will use a double-observer approach to sample a subset of units for this purpose. The standard procedure is for one observer and one recorder when sampling wetland points. The double-observer method requires both individuals to record an estimate of canopy cover for each point. An observer's estimates must be independent from the second observer, therefore it is imperative that the observers **do not** discuss their estimates until both have recorded them. Also, observers **should not change** their estimates after discussing it with the other observer. The exception to this is for plant identification – it is allowable (recommended, in fact) for the two observers to discuss plant identification. This will eliminate variation due to detection probability and identification between observers, a source of variation we are not interested in at this time.

Stations participating in double-observer sampling **do not** need to conduct double-observer sampling on all GRTS points at their station. A general recommendation is to conduct double-observer sampling on ¼ of the GRTS points as an ordered subset. For example, if a station was going to sample a total of 40 GRTS points, they would conduct double-observer sampling on GRTS points 1–10 and do the standard survey on the remaining points. In this example, if any

points between 1–10 are dropped from the sample the double-observer subset can simply be extended using the PanelOne points.

Conducting double-observer sampling is most efficient for those stations or crews where multiple individuals will be trained in plant identification and expected to conduct vegetation surveys. For a station where a single individual will be the primary observer it is not likely worthwhile to attempt double-observer sampling.

Assessment of Quadrat Size—A second approach to vegetation surveys using a larger quadrat size will be conducted concurrently at a few locations. There are several potential benefits to larger quadrats, including better representation of community heterogeneity and increased estimation efficiency (Kenkel and Podani 1991). These surveys will consist of 3 × 2 m quadrats positioned such that the randomly generated point location demarcates the north edge of the quadrat. For surveys conducted from a boat in clear water were ocular estimates are possible (Fig. X), the quadrat is equally divided into two 3 × 1 m sub-quadrats placed lengthwise on the east and west side of the boat. If the water is too turbid to see the bottom of the quadrat (i.e., Secchi disc depth < total depth), six rake subsamples comprising 1 × 0.35 m subplots will be taken clockwise from the boat (Fig. 7; see description below) (Yin et al. 2000). If on foot, the 3 × 2 quadrat is divided in half from north to south by an imaginary line that forms a transect the observer traverses to estimate canopy cover or take rake samples.

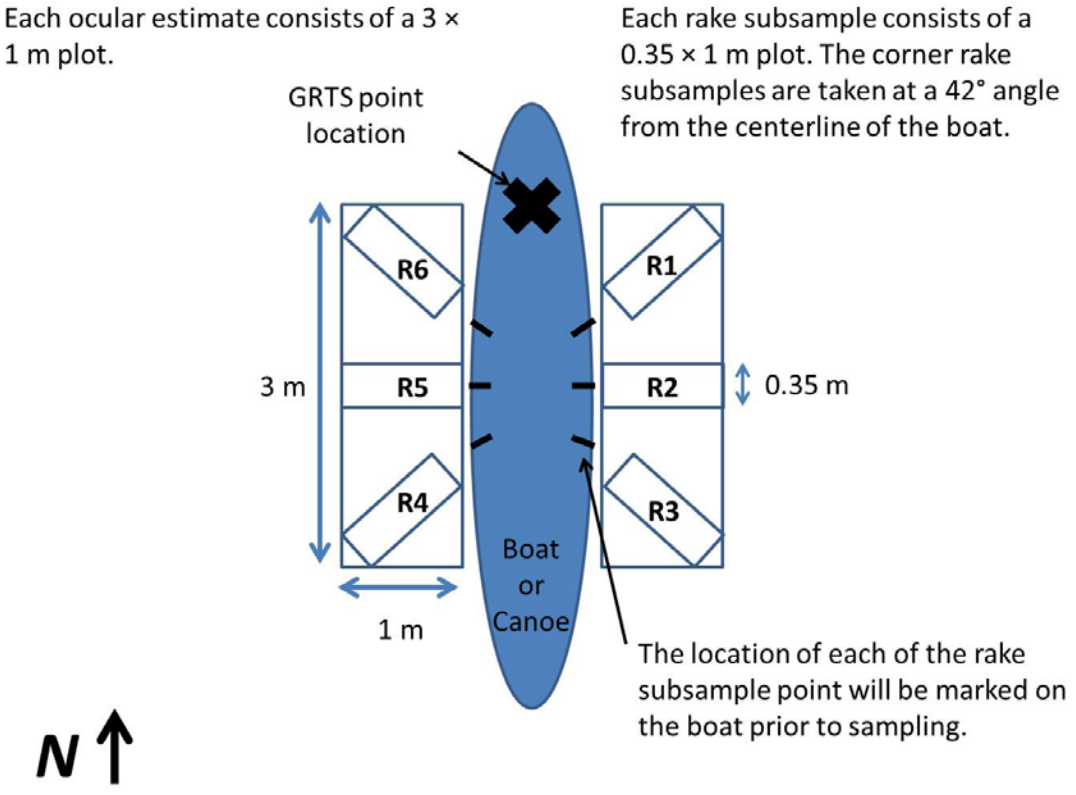

Figure 7. Placement of the three rake sub-samples in relation to the GRTS point and canoe or boat.