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QUALITY ASSURANCE PROJECT PLAN FOR THE OREGON WETLANDS STUDY

DISCLAIMER

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4.0 INTRODUCTION

Wetlands are recognized as valuable components of the landscape contributing in many ways to overall environmental quality. Comprising only about 5% of the land area in the conterminous United States (Dahl 1990), wetlands have a significant influence on the landscape because of their roles in regulating watershed hydrology and water quality. Moreover, wetlands provide habitat for a diverse flora and fauna that includes over one-third of the Nation's endangered species (U.S. Fish and Wildlife Service 1990). Wetlands encompass a wide array of habitat types (Cowardin et al. 1979) and exhibit a level of productivity second only to tropical rainforests (Tiner 1984). During the last 200 years, more than half of all wetlands in the United States have been lost due to human activities, primarily conversion for agricultural uses and urban development. Losses in some states (e.g., California, Ohio) have been on the order of 90% (Tiner 1984, Dahl 1990).

Although federal regulations such as Section 404 of the Clean Water Act and the Food Securities Act govern wetland protection, they have proven to be only partially successful. Consequently, the National Wetlands Policy Forum has recommended the adoption of a clear policy designed to achieve no overall net loss of wetlands in terms of area or function (Conservation Foundation 1988). Aiming toward fulfilling its responsibilities for wetland conservation, the U.S. Environmental Protection Agency has identified two points of national concern: 1) the need to advocate a national goal for no net loss of wetlands, and 2) the development of a risk-based approach to wetland protection and management (Leibowitz et al. 1992).

Economic pressures to develop wetlands have resulted in wetland restoration and creation projects (hereafter "projects") being constructed with increasing frequency. However, the efficacy of restoration and creation methods remains uncertain. The technology is unproven for many types of wetlands and the quality of completed projects is inconsistent. The success of projects is not well documented, because performance criteria are lacking and monitoring is insufficient (Kusler and Kentula 1991, Leibowitz et al. 1992). Where specifications for final project condition or quality exist, they are often vague and qualitative (e.g., replacement of ecological function), and thus not amenable to rigorous evaluation. Post-construction monitoring to insure that mitigation projects meet the minimum physical criteria (e.g., size, slope, or wetland type) of permit requirements is seldom conducted. When monitoring does take place, it is often noted that completed projects vary substantially from the permit specifications and design plans (Erwin 1991, Gwin and Kentula 1990, Owen 1990).

OBJECTIVES

The Oregon Wetland Study (OWS) is designed to provide technical information about natural wetlands and projects, which can be used by wetland regulators and managers to improve wetland management strategies and facilitate implementation of a policy for no net wetland loss. The OWS builds on work from the Oregon Pilot Study conducted in the metropolitan area of Portland, Oregon, in 1987. During the 1993 growing season, approximately 130 freshwater wetlands ranging from sites

1.0 SIGNATURE PAGE

Quality Assurance Project Plan

Oregon Wetlands Study

Signature Approval Page

Name: Mary Kentula Phone: (503) 754-4478
Title: Principal Investigator
EPA - ERL-C

Signature: Mary E Kentula Date: 6/4/93

Name: Mary Kentula Phone: (503) 754-4478
Title: Project Manager and Wetlands Program Leader
EPA - ERL-C

Signature: Mary E Kentula Date: 6/4/93

Name: Roger Blair Phone: (503) 754-4662
Title: Watershed Branch Chief
EPA - ERL-C

Signature: Date: 10 Jun 93

Name: Robert T. Lackey Phone: (503) 754-4601
Title: Quality Assurance Officer
EPA - ERL-C

Signature: Date: 12 June 1993

dominated by open water to those dominated by emergent vegetation will be sampled, including the sites sampled in 1987. The general approach will be to collect data that can be used to characterize and compare the structural and functional attributes of: 1) populations of natural wetlands in different land use settings, and 2) populations of natural wetlands and wetland projects. Characterizations can then be used to: 1) document direct losses of wetland area or function through conversion, 2) evaluate indirect losses of wetland function due to the impacts from surrounding land uses, and 3) evaluate the potential for restoration and replacement of lost functions. This information will aid in the development of performance criteria and design guidelines for wetland projects, and ultimately, be used to evaluate the results of management strategies and to suggest alternative approaches. Specifically, documenting the causes of direct and indirect wetland losses and developing mechanisms for preventing continued attrition are key steps in sound regulatory practices. Documentation is particularly important in rapidly developing urban areas. Direct losses arise from conversion of wetlands to other land uses such as residential or commercial construction and industrialization. Indirect losses arise primarily from two sources. Surrounding land use can cause degradation of wetland structure and function via inputs of urban run-off, influx of exotic taxa, alteration of hydrology or sedimentation rates, destruction of buffers, habitat fragmentation, and other disturbances. Inadequately designed or constructed projects contribute to indirect loss by failing to completely replace the functions of destroyed wetlands or to achieve the attainable quality possible for the associated land use setting.

Four research objectives have been identified to fill the information needs of a cohesive management and regulatory program:

Objective 1: Determine the number of freshwater wetlands that have been converted to other land types and identify causes of this direct loss.

Objective 2: Evaluate the relationship between surrounding land uses and the attainable quality of freshwater wetlands.

Objective 3: Evaluate the replacement potential of freshwater wetlands to aid in the development of performance criteria.

Objective 4: Evaluate how project design and implementation affect the replacement potential of freshwater wetlands to aid in the development of design guidelines.

PROJECT RELEVANCE TO EPA BRANCH AND PROGRAM

The OWS has been developed as a major component of the Wetland Characterization and Restoration (C&R) project within EPA's Wetlands Research Program (WRP) (Leibowitz et al. 1992). Four major tasks are intended for completion as part of the C&R five year plan:

1. Describe (characterize) wetland populations, including natural, restored, and created wetlands, to quantify wetland functions and among-wetland variability within specific geographic and land use settings.
2. Evaluate the attainable levels of wetland functions in various landscape settings and the performance of wetland restoration and creation projects.
3. Provide technical support for the development of specific performance criteria and technical design guidelines that can enhance performance and accelerate project development.
4. Develop and test an approach for prioritizing sites for wetland restoration and creation.

The Oregon Wetlands Study (OWS) addresses the first three of these tasks and contributes information necessary to address to the fourth.

PROJECT DELIVERABLES TO EPA

Deliverables will be presented in the form of reports and scientific journal papers. Anticipated titles, referenced to the Portland, Oregon Metro Region, for papers and reports include:

1. Trends in Direct Loss of Freshwater Palustrine Wetlands.
2. Compliance of Project Construction with Permit and Design Specifications.
3. Evaluation of Attainable Quality by Land Use for Freshwater Palustrine Wetlands and the Relationship of Attainable Quality to Replacement Potential for Similar Wetlands.
4. Effects of Project Design and Implementation on Replacement Potential of Freshwater Palustrine Wetlands and Recommendations for Improvements in Management Strategies.
5. Research Plan and Methods Manual for the Oregon Wetlands Study (hereafter, Research Plan). This document has cleared as an EPA external report (Magee et al. 1993) and will likely be used as an approach methods manual for other wetland studies.
6. Quality Assurance Project Plan: Oregon Wetlands Study (hereafter, QA Plan). The QA Plan will also be cleared as an external EPA document so that it may be distributed externally with the Research Plan.

All project deliverables will receive QA review as part of the ERL-C document clearance process.

5.0 PROJECT DESCRIPTION

To meet the OWS objectives, several questions and associated research approaches were developed (Table 5-1). The data obtained from the proposed research will add to basic knowledge about wetlands, and provide wetland regulators with information that can improve management strategies and facilitate implementation of a no net loss policy. The data collected during this study will be used in several ways:

1. To provide baseline characterizations of projects and natural wetlands, by describing the condition and attributes of existing wetland resources.

2. To provide assessments of attainable wetland quality in specific land use settings.

3. To aid in development of performance criteria and monitoring schedules for projects.

4. To aid in improving project design and implementation.

5. To improve decision making in permit evaluations.

6. To document trends in direct loss of wetlands.

7. To document compliance of as-built projects with permit specifications. As-built projects are projects as they actually appear on-site, which may or may not be consistent with permit specifications.

STUDY DESIGN

An overview of the study design used to meet research objectives is presented here. Sampling strategy, study area description, site selection procedures, and the variables sampled for wetland characterization are briefly discussed. For more detail see the **Research Plan and Methods Manual for the Oregon Wetlands Study** (Magee et al. 1993).

Sampling Strategy

An extensive sampling approach focusing on populations of wetlands has been adopted so that results will be regionally applicable to wetland protection and management. Populations have been chosen for study over single or paired sites, because the general representativeness of single sites often cannot be determined, and extrapolation of results from one site to other systems is, in many cases, not valid. Also, data for a single site can not provide insight into variability among wetlands of a given type or in a particular landscape setting. Extensive sampling will permit quantitative and statistical evaluation of the effects of factors such as land use or project age on wetland attributes. The OWS will also have an intensive research

component. The results of the 1987 Oregon Pilot Study suggested that hydrological modifications and increased sedimentation influence the structure and function of freshwater wetlands in the Portland metropolitan area. Hydrology and sedimentation rates in a subset of the wetlands examined in the OWS will be monitored for one year beginning in the 1993 growing season. Details of this intensive portion of the study are presented in a separate plan entitled, **"Quality Assurance Project Plan for Field Research on the Hydrology of Palustrine Wetlands in the Portland, Oregon Area"** (Shaffer, 1993).

Study Area

The study area is located in the Portland, Oregon, metropolitan region and is restricted to portions of Clackamas, Multnomah, and Washington Counties that occur within the Willamette Valley Plains subregion of the Willamette Valley ecoregion (Clarke et al. 1991). Limitation of sample sites to this subregion provides a restricted geographic and physiographic area that includes both project and natural wetlands in a variety of land use settings, allowing comparisons of wetlands while minimizing confounding influences such as lithology, soils, and climate differences (Omernik 1987). This area was chosen for study, in part, because rapid urban development has placed wetlands at high risk for modification or destruction. For example, 31% of the Section 404 permits requiring compensatory mitigation issued in Oregon from January 1977 through January 1987 involved wetlands in the Portland Metropolitan area (Kentula et al. 1992a). In addition, extensive ancillary data exist for the Portland-metro vicinity including GIS-accessible land use maps and data from intensive hydrologic monitoring. Such information will aid in research design and data interpretation. Other preliminary data for the area come from the 1987 Oregon Pilot Study which addressed similar issues and was conducted in the same location. This affords an opportunity to revisit and evaluate the continued development of previously sampled projects and the status of the previously sampled natural wetlands. Finally, the location of the study area is sufficiently close to 1) the Environmental Research Laboratory-Corvallis (ERL-C) to permit project staff at the laboratory to be integral participants in field studies, 2) a large population of teacher volunteers who will be involved in field sampling, and 3) the facilities at Portland State University that will be used for training of field crews and processing of samples.

Site Selection

Specific criteria (See Section 8, Sampling Procedures--Site Selection) were used to define populations of natural wetlands and projects in the Portland metropolitan area. The population represented a gradient from sites dominated by open water to those dominated by emergent vegetation. Most sites were $\leq$ 2 ha in area. All natural wetlands and projects in the Portland area meeting these criteria were considered for study, including 10 natural wetlands and 11 projects sampled in the 1987 Oregon Pilot Study and all mitigation projects required in Section 404 permits and/or Oregon State removal-fill permits since 1977. The most current National Wetland Inventory (NWI) maps (aerial photo dates 1981 and 1982) were used to

identify all natural wetlands of the appropriate size and type that potentially occurred in the study area. This population was then stratified by land use categories defined on METRO (Portland Metropolitan Service District) maps.

All natural wetlands and projects from the NWI maps and permit records were visited during field reconnaissance to verify that they existed, were of the appropriate size and type, and were safe to sample. This resulted in a list comprising the entire populations of both natural wetlands (111 sites) and projects (51 sites) occurring in the study area and meeting site selection criteria. The last step will be to secure access to all sites meeting the selection criteria. Because access to some wetlands may be denied, the final number of sites to be sampled may be less than the total number identified.

Wetland Characterization

Variables used to characterize wetlands sampled in the OWS were selected to provide data that describe the structural and functional features of wetlands, and that facilitate assessments of ecological condition, trends in wetland loss, and permit compliance. Wetland characterizations will be based on data describing the overall site, wetland morphology, vegetation, soils, hydrology, and land use. Table 5-2 provides a summary of the variables, the information the variables are expected to generate, and indicates the research questions addressed. Detailed rationales for selection of variables and field methodologies are presented in the Research Plan. Data will be summarized and analyzed using statistical methods to characterize and compare natural and project wetlands (Table 5-3). For a discussion of data analysis see Section 12 of this QA Plan and the Data Analysis Section of the **Research Plan and Field Manual for the Oregon Wetlands Study** (Magee et al. 1993).

PROJECT SCHEDULE

The OWS requires three kinds of activities: pre-site, on-site, and post-site. The tasks associated with each activity phase are illustrated in Table 5-4.

Initial planning, data collection and site reconnaissance for the OWS began in 1991. Site reconnaissance and selection are close to completion. Recruitment and training of field crews, field measurements, laboratory analyses, data entry, data analysis and interpretation, and reporting of results will be completed during 1993 through 1995. The schedule for completion of major components of the OWS are presented in Figure 5-1.

Table 5-1. Summary list of objectives, study questions, and research approaches for the Oregon Wetlands Study.

OBJECTIVE 1: Determine the amount and cause of direct loss of freshwater wetlands. **Question 1:** What are the short term trends in wetland loss due to conversion? **Approach:** Compare the most recent inventory based on NWI maps with current field study inventory. **Question 2:** What are the principal reasons for the wetland losses due to conversion? **Approach:** Document reasons for wetland conversion identified in the course of current inventory.
OBJECTIVE 2: Evaluate the relationship between surrounding land uses and the attainable quality of freshwater wetlands. **Question 3:** What is the relative attainable quality of wetlands in different land uses, and how are differences in quality reflected in wetland structure and function? **Approach:** Step 1 - Quantify and compare wetland structure and function by land use category. Step 2 - Rank the land uses according to the relative quality of the wetlands. Step 3 - Explore whether vegetated buffers ameliorate effects of land use.
OBJECTIVE 3: Evaluate the replacement potential of freshwater wetlands to aid in the development of performance criteria. **Question 4:** Do wetland projects replace the structure and function of similar natural wetlands, i.e., what is the replacement potential for the type of wetland? **Approach:** Step 1 - Compare structure and function in projects representing a range of ages and in similar natural wetlands as a measure of performance. Step 2 - Investigate possible differences in level of performance due to age of the project and land use setting. **Question 5:** Has replacement potential improved with time and experience? **Approach:** Compare the performance of pre-1987 projects with that of post-1987 projects at the same stage of development.

Table 5-1. cont.

OBJECTIVE 4: Evaluate how project design and implementation affect the replacement potential of freshwater wetlands to aid in the development of design guidelines.

Question 6: How can information on project design and implementation be used to improve performance?

Question 6a: How do project design and as-built conditions compare with the structural characteristics of similar natural wetlands?

Approach: Step 1 - Compare project plans, permit conditions, and as-built conditions with the structural characteristics of similar natural wetlands.

Step 2 - Investigate possible design improvements suggested by the structure of natural wetlands of the highest attainable quality.

Question 6b: How do project design specifications compare with the as-built conditions?

Approach: Compare project plans and permit conditions with the as-built conditions

Question 6c: How has project design and implementation changed with time and experience?

Approach: Compare project plans, permit conditions, and as-built conditions of pre-1987 projects with those of post-1987 projects.

Table 5-2. Variables to be studied in the Oregon Wetlands Study. Numbers in parentheses associated with variable uses refer to the study questions and research approaches summarized in Table 1-1. Primary use of variable in answering a question is indicated by bolded numbers; secondary use, by italicized numbers.

VARIABLES - ALL SITES	RATIONALE FOR INCLUSION	USES IN WETLAND CHARACTERIZATION AND COMPARISON
General		
Location	Identifies site on local map	Confirm site as part of population of interest, provide route information for sampling
Wetland Type	Documents general overall structure	Compare with project goals and NWI classification (**1, 6b**)
Structure - % bare ground - % vegetation (trees, shrubs, herbs) - % open water (unvegetated and with submerged aquatic vegetation)	Describes distribution of unvegetated land, reflects site age and condition Describes distribution of vegetation, determines wetland type Reflects hydrology, determines wetland type	Characterize site and provide general descriptive information related to temporal development, and surrounding land use. (*3, 4*, **6a, 6b**)
Surrounding Land Use	Influences inputs to wetlands (e.g., nonpoint source pollution, industrial outfalls, recreational use, source of propagules, wildlife corridors, etc.)	Relate wetland performance to surrounding land use (*2, 3*, **4, 5**)
Buffer Type/Extent	Provides a barrier to and amelioration of off-site inputs (e.g., industrial or agricultural run-off) and mediates the effects of noise, foot traffic, disturbance, etc., provides habitat pathways for animal movement	Explore the effect of vegetated buffers of different types (e.g., herbaceous, shrub, trees) and widths on ameliorating the effects of land use and in determining project success (**3**, *4, 6*)

Table 5-2. Cont.

VARIABLES - ALL SITES	RATIONALE FOR INCLUSION	USES IN WETLAND CHARACTERIZATION AND COMPARISON
Presence of Obvious Stressors or Disturbance	Documents potential causes of the erosion of wetland quality	Document presence of degraded landscape or damaging influences to aid in explaining effects of land use and in understanding outlier sites (3, 4)
Morphometry		
Area	Influences habitat value, plant community diversity, and flood storage	Compare projects to project construction specification (6)
Slope/Elevation	Influences hydrologic gradient, vegetation establishment and distribution, animal access, etc.	Determine minimum, maximum, and mean depth and slopes from topographic profiles of each site. Compare basin morphologies of project and natural wetlands (4, 5, 6)
Perimeter:Area Ratio	Influences edge effect (e.g., introductions of exotic species and extirpation of native taxa), habitat size and quality	Compare amount of edge in projects to natural wetlands, and document variation in project shape/edge over time through analysis of map data on project and natural wetland sampled in both 1987 & 1993 (4, 5, 6)

Table 5-2. Cont.

VARIABLES - ALL SITES	RATIONALE FOR INCLUSION	USES IN WETLAND CHARACTERIZATION AND COMPARISON
Vegetation		
Species Lists - Identification	Defines wetland type, habitat, and plant diversity.	Compare species composition between natural project wetlands. Compare species found on completed project with project planting or seeding lists (**4, 6**)
Species Abundance	Provides information on vegetation structure and composition via species richness, diversity, dominance, community type, ratios of native: exotic taxa, ratios of wetland:upland taxa	Describe and compare project and natural wetlands, relate vegetation to environmental or disturbance gradients, relate distribution and abundance of individual species with hydrology elevation, and soils (**3, 4, 5, 6**)
Soils		
Soil Color	Indicates hydric soil characteristics such as gleying, mottling, root oxidation channels, etc.	Used for delineating wetland boundary, tracing project development over time, identifying relationships of soil conditions to elevation and plant distribution (**3, 4, 5, 6**)
Presence of Hydrogen Sulfide	Indication of hydric soil, i.e., strongly reducing conditions	See color (**3, 4, 5, 6**)

Table 5-2. Cont.

VARIABLES - ALL SITES	RATIONALE FOR INCLUSION	USES IN WETLAND CHARACTERIZATION AND COMPARISON
Rough Description of Soil Horizons	Characterized soil profiles and development.	Characterize wetland soils in different land use settings. Evaluate differences between project and natural wetland soils (**3, 4, 5, 6**)
Soil Amendments (e.g., substrates salvaged from destroyed wetlands)	Provides baseline information about projects, influences soil development and chemistry, and vegetation establishment	Evaluate relationship of project performance and rate of development to use of amendments (***4, 5,*** **6**)
Soil Organic Matter	Indicated suitability as planted medium, conditions of soil processes and chemistry	Compare projects to natural wetlands. Document temporal change in organic matter levels (*3*, **4, 5, 6**) by comparing data from wetland samples in both 1987 & 1993
Hydrology		
Water Depth Throughout Site: - to saturated soil - of standing water during the growing season	Influences which portions of the site are wetland, vegetation patterns, wildlife and fisheries habitat	Compare project and natural wetlands. Look for relationships between water levels and plant species composition and abundance, soil conditions (*3*, **4, 5, 6**)
Flow Pattern	Influences plant establishment, plant productivity, substrate stability and chemistry	Compare flow patterns in project vs. natural wetlands (*3*, **4, 5, 6**)

Table 5-3. Statistical analyses proposed for the Oregon Wetlands Study.

Objective	Suggested Analyses
<u>Characterization</u>	Graphical Methods--to display variables and identify outliers (e.g., scatter plots, box plots, Chernoff faces, etc.) Descriptive Statistics--to summarize variables (e.g., mean, mode, range) Multivaritate Methods: Multiple regression--measure relationships between variables Correlations--measure the relationship between two variables Cluster analysis--group wetlands based on species abundance or environmental variables (e.g., CLUSB: non-hierachial, divisive; TWINSPAN: hierachial, divisive) Ordinations: Detrended correspondence analysis--summarize vegetation data and relate to environmental variables Principal components analysis--investigate which variables contribute the major sources of variability Binary logit regression/Discriminant function analysis--investigate which variables most characterize the differences between projects and natural wetlands Weighted averages--summarize vegetation data based on wetland indicator status Canonical correspondence analysis--investigate relationship between two groups of variables (e.g., vegetation and environmental variables) Shannon and Simpson's diversity and dominance measures--to summarize plant diversity and community structure.
<u>Comparison</u> A) Natural wetlands within each land use. Post-1987 projects within each land use. B) Post-1987 projects vs. natural wetlands within each land use. C) Pre-1987 projects vs. Post-1987 projects.	Univariate Methods: Graphical methods--see above T-tests/Non parametric two sample tests--compare two groups ANOVA--compare more than two groups Multivariate Methods: Hotellings T^2--compare more than one variable for two groups

Table 5-4. Project Activities Grouped by Project Phase.

Pre-Site Phase	On-Site Phase	Post-Site Phase
Site selection	Travel to site	Copy data forms and send to ERL-C
Securing permission to sample from land owners	Transect establishment	Laboratory analyses
Preparation of the Research Plan and Methods Manual for the Oregon Wetlands Study	Collection of field data	Plant specimen identification
Preparation of the Quality Assurance Plan: Oregon Wetlands Study	Collection of plant specimens and soil samples	Site map completion
Preparation of the Oregon Wetlands Intensive Study Project and QA plans	Sample and specimen storage	Data entry and verification
Development of EPA portion of teacher training program	Data sheet checks	Data analysis
Recruitment and selection of Crew Members	Site clean-up	Preliminary QA data reports
Training of crews	QA Internal Audits	Reporting of results in EPA documents and scientific papers
Site-packet and field sampling preparation	QA External Field Audits	Final QA reports

Figure 5-1. Estimated Time Frame for Major Project Activities.

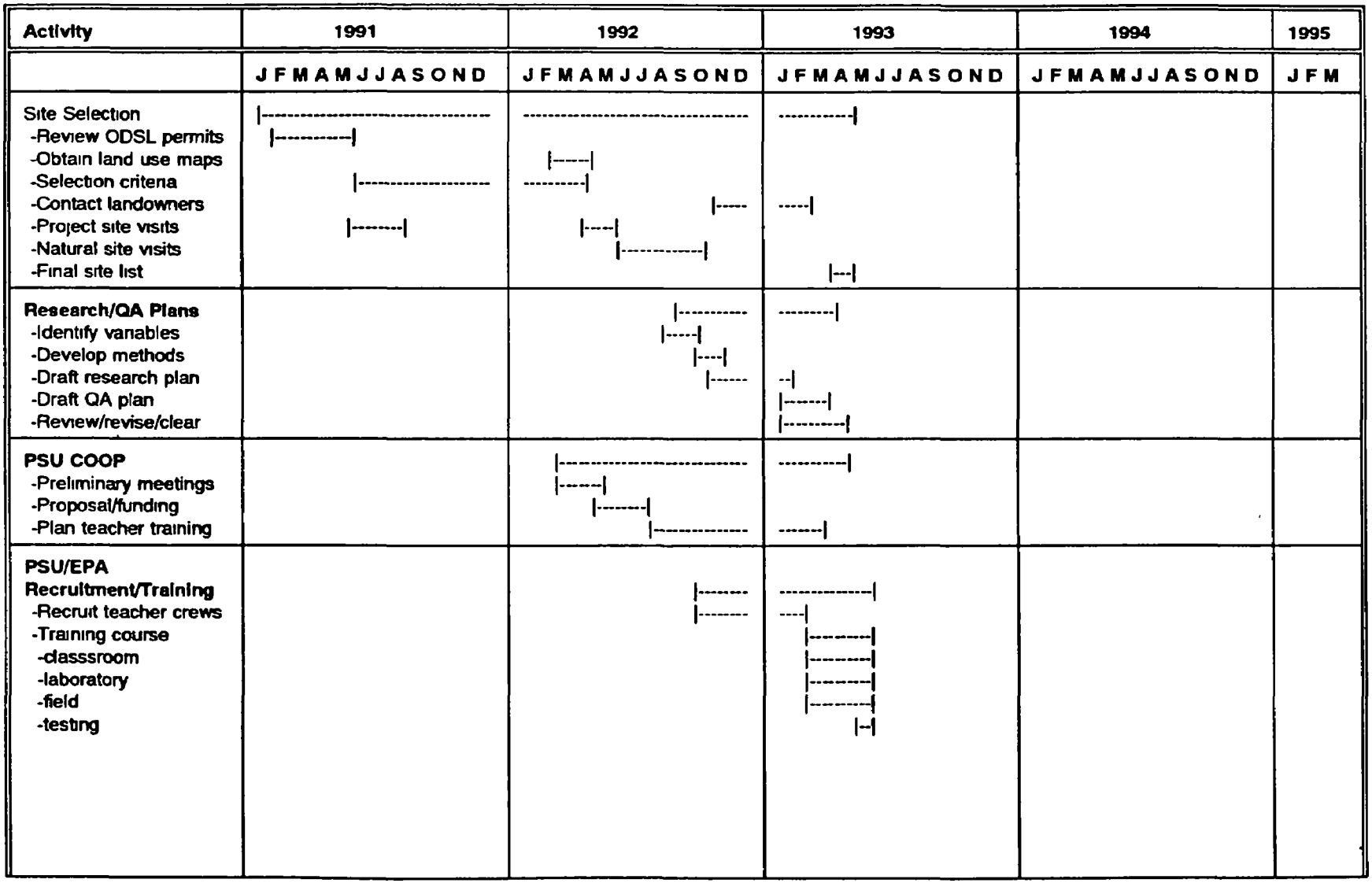
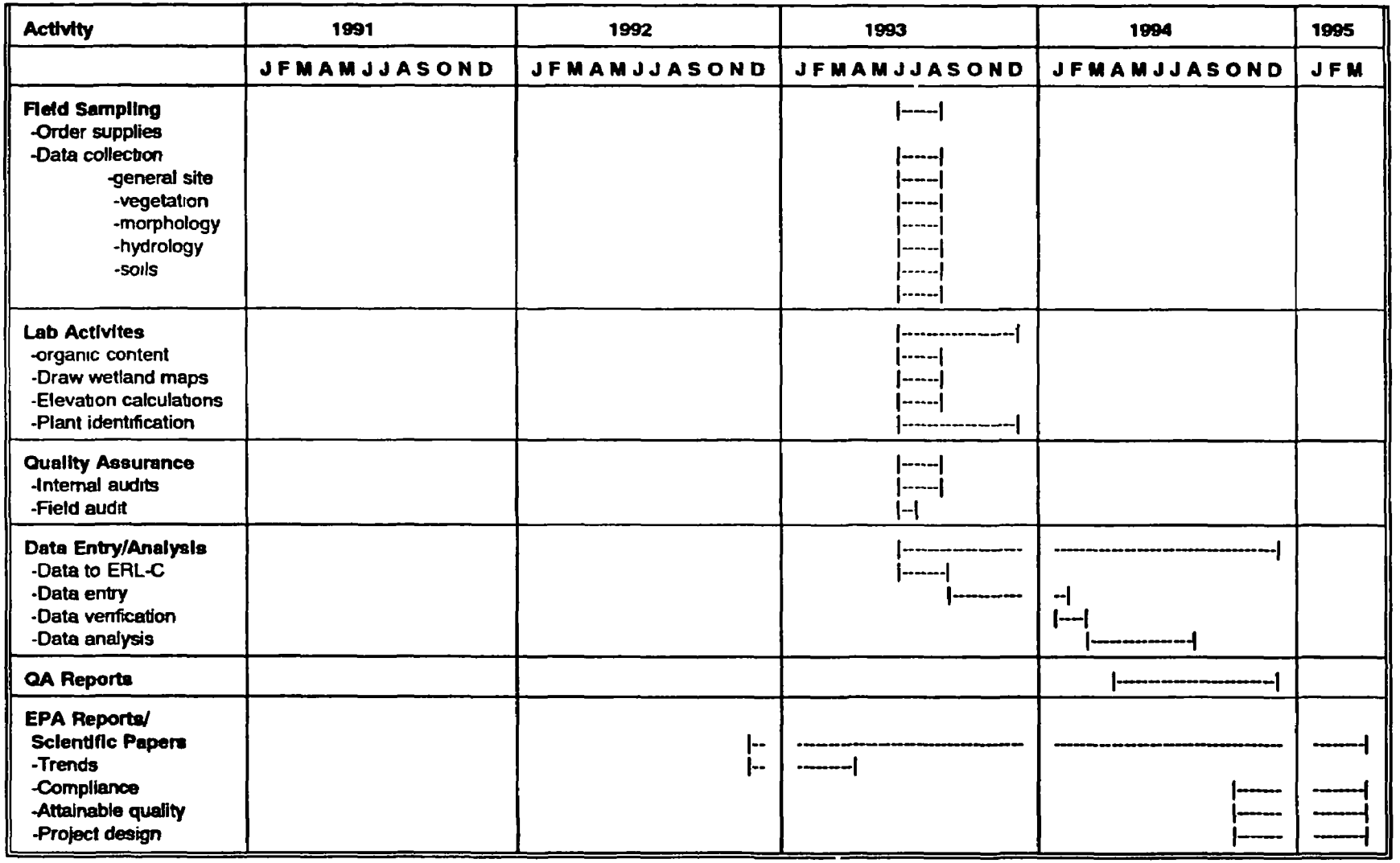


Figure 5-1 Continued.



6.0 PROJECT QA ORGANIZATION AND RESPONSIBILITY

All personnel working on the OWS, their affiliations and responsibilities, are listed in Table 6-1. Primary implementation of the study will be carried out by staff from ERL-Corvallis, in particular from the on-site contractor (currently ManTech Environmental Technology, Inc.). In addition, ERL-C has established a cooperative agreement with Portland State University (PSU) (CT-902668-01) to support 1993 field sampling activities. As part of an environmental education program for teachers, PSU staff have developed a program in which teachers will be trained in field sampling and laboratory analysis techniques. Following training, two Laboratory Technicians and three Field Crews composed of Crew Leaders from ERL-C and Teacher Volunteers will be assembled to conduct the field work. Accountability for data quality is shown in Figure 6-1. Project oversight and overall data quality is the responsibility of the Principal Investigator and Project Officer, Mary Kentula. Stephanie Gwin, Crew Supervisor, and Paul Shaffer, Soil Scientist, will have ultimate responsibility for field data quality and soils laboratory data quality, respectively. Interim field data quality maintenance rests with the Crew Leaders who will be on-site during data collection. Quality of laboratory data is the combined responsibility of Crew Leaders and the Plant Taxonomist, all of whom will make frequent visits to the laboratory at PSU. Training of crews will be conducted by WRP scientists (Kate Dwire, Stephanie Gwin, Cindy Holland, JoEllen Honea, Mary Kentula, Teresa Magee and Paul Shaffer) and PSU scientists (Bill Becker, Neal Maine, and Sherry Spencer).

CREW MEMBER RESPONSIBILITIES

Three separate field crews will work simultaneously at different field locations. Each Crew will consist of eight people: the Crew Leader, two Botanists, two Recorders, and three Surveyors. Each field crew is divided into three teams; two Vegetation Teams, each made up of one Botanist and one Recorder, and the Survey team, made up of three Surveyors.

The Crew Leader is responsible for ensuring that all aspects of the sampling and QA activities are conducted properly and completely. The Crew Leader, with input from other crew members, determines the wetland boundaries, the location and orientation of the transect baseline, and the sampling transect starting points. The Crew Leader photographs the site, ensures there is an adequate supply of the data forms and that all are filled out completely and accurately, ensures all samples are collected and stored properly, and keeps a diary of field activities. Finally, the Crew Leader is responsible for resolving questions or problems that arise in the field, filling in to assist other crew members wherever necessary, and ensuring the safety of all crew members.

The Vegetation Teams are responsible for sampling vegetation and collecting and preserving voucher specimens. The Survey Teams are responsible for mapping the site, measuring relative elevations and collecting soil samples.

Project personnel must meet minimum education and experience qualifications to perform the required tasks and make sound decisions. The positions and their requirements are:

1. **Crew Leaders:** These individuals are responsible for managing the crews in the field and for making on-site decisions regarding the execution of procedures. Therefore, the Crew Leaders must have a thorough understanding of the goals of the study, all sampling procedures, and some knowledge of plant taxonomy and experience in identification of wetland plants. In addition, the Crew Leader must possess good leadership and interpersonal skills and be able to maintain a productive, cooperative crew.

2. **Botanists:** Accurate plant species identification is of primary importance to the quality of data collected. Therefore, Botanists must, at minimum, demonstrate ability in sight recognition of common wetland taxa. Sight recognition means that the Botanist must be capable of recognizing dominant species to the level of genus and species, provided that plants are at the proper phenological stage. The individual must also be familiar with local floristic references, show proficiency in the use of diagnostic keys, and have experience with proper techniques for collection and preservation of plant specimens. A competency evaluation will be included as part of training.

3. **Recorders:** These crew members provide support for the Botanists, and when needed, for the Surveyors. Attention to detail, and a willingness to follow strict procedures and to work industriously are required. Recorders should be self-motivated and willing to "pitch-in" when needed. Some botanical expertise is desirable but training in Botanical and Survey skills will be provided. A competency evaluation will follow training.

4. **Surveyors:** Knowledge of the use of a transit and compass, and skills in elementary surveying, mapping, and soil sampling techniques are needed for these team members. Training will be provided, and a competency evaluation will be given at the end of training.

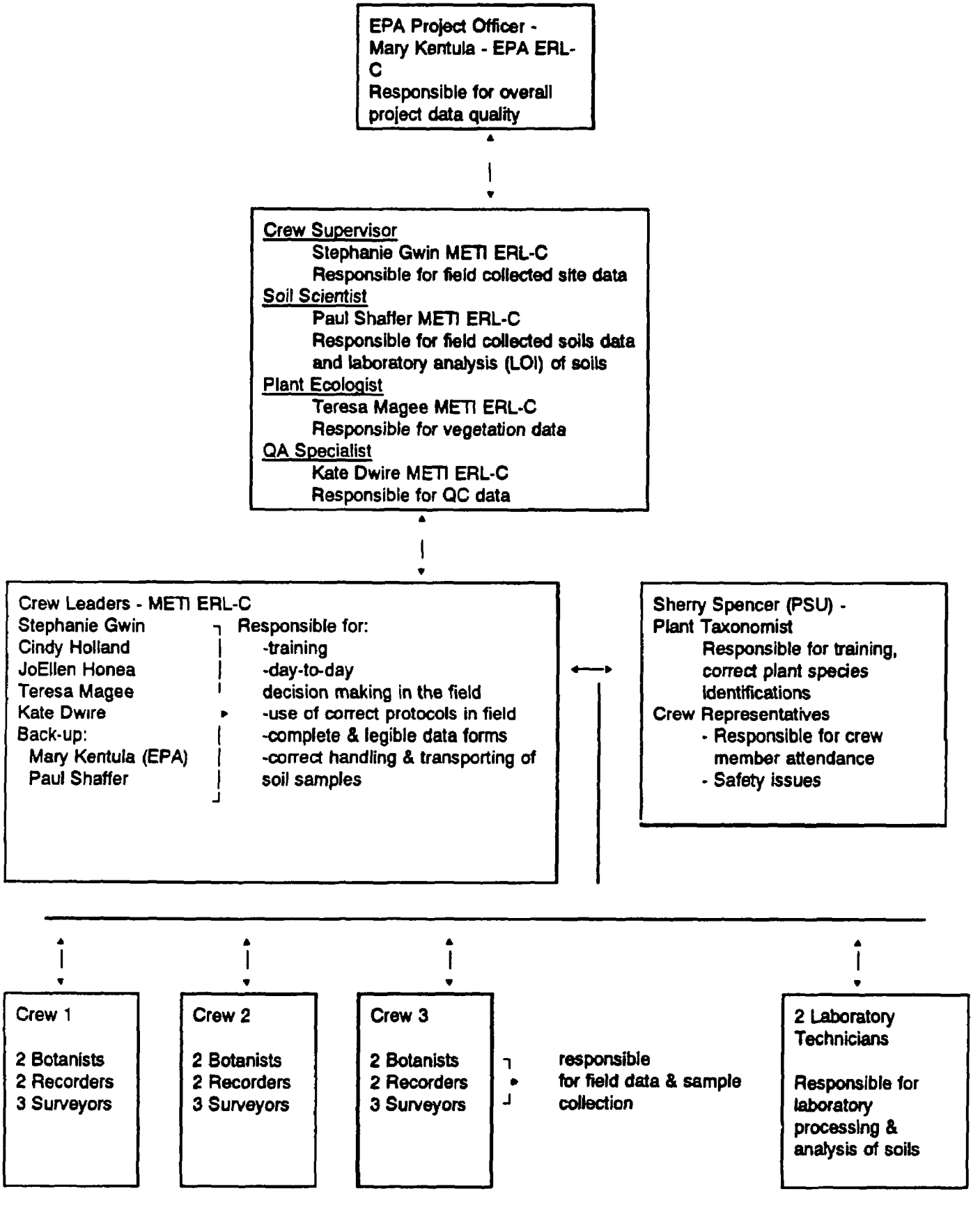
5. **Laboratory Technicians:** Knowledge and skill in processing laboratory soils to determine organic matter content via ash free dry-weights are necessary.

Table 6-1. Project QA Organization and Responsibility. 1 = EPA, 2= ManTech Environmental, 3 = PSU, 4 = Volunteer.

Title	Name	Project/QA Responsibility
Project Officer - Principal Investigator	Mary Kentula[1]	Oversight of Project, Research Plan, Training, Data Analysis and Interpretation.
QA Auditor	Deborah Coffey[2]	Review of QA and Research Plans, External Audits of Field and Lab Work.
Wetlands QA	Kate Dwire[2]	Review Research Plan, Training, QA Plan, Crew Leader, Data Analysis and Interpretation, Preparation of QA Final Report.
Plant Ecologist	Teresa Magee[2]	QA and Research Plans, Technical Guidance, Training, Crew Leader, Data Analysis and Interpretation.
Environmental Scientist	Stephanie Gwin[2]	Site Selection, QA and Research Plans, Training, Crew Leader, Data Analysis and Interpretation.
Soil Scientist	Paul Shaffer[2]	QA and Research Plans, Training, Data Analysis and Interpretation.
Environmental Scientist	Cindy Holland[2]	Site Selection, QA and Research Plans, Training, Crew Leader, Data Analysis and Interpretation.
Environmental Scientist	JoEllen Honea[2]	Site Selection, QA and Research Plans, Training, Crew Leader, Data Analysis and Interpretation.
Programmer	Robert Gibson[2]	Data Management and Verification.
Biostatistician	Jeannie Sifneos[2]	Research Plan
Statistician	Barbara Peniston[2]	Consultation and Data Analysis.

Table 6-1. Cont.

Principal Investigator - PSU Coop	Bill Becker[3]	Recruitment, Management, Training of Field Crew Members and Lab Technicians.
Principle Investigator - PSU Coop	Neil Maine[3]	Recruitment, Management, Training of Field Crew Members and Lab Technicians.
Plant Taxonomist	Sherry Spencer[3]	Plant taxonomy training of field crews, field and lab assistance in plant identification, sample custody.
6 Teacher Volunteer Botanists	Recruited[4]	Field sampling of vegetation, identification of unknown plant taxa.
6 Teacher Volunteer Recorders	Recruited[4]	Transect establishment, recording data for the Botanists, assisting the Survey team as needed.
9 Teacher Volunteer Surveyors	Recruited[4]	Site mapping, surveying wetland morphology, soil sampling and collection of water depth data.
5 Crew Leaders	Stephanie Gwin, Cindy Holland, JoEllen Honea, Kate Dwire, and Teresa Magee	Management of one Crew including oversight of field, lab, and QA activities, assisting crew members as needed, data handling and sample custody.
2 Lab Technicians	Recruited[4]	Processing laboratory soil samples to determine organic matter content via ash free dry-weights.


EPA Project Officer - Mary Kentula - EPA ERL-C
Responsible for overall project data quality
Crew Supervisor
Stephanie Gwin METI ERL-C
Responsible for field collected site data
Soil Scientist
Paul Shaffer METI ERL-C
Responsible for field collected soils data and laboratory analysis (LOI) of soils
Plant Ecologist
Teresa Magee METI ERL-C
Responsible for vegetation data
QA Specialist
Kate Dwire METI ERL-C
Responsible for QC data
Crew Leaders - METI ERL-C
Stephanie Gwin
Cindy Holland
JoEllen Honea
Teresa Magee
Kate Dwire
Back-up:
Mary Kentula (EPA)
Paul Shaffer
Responsible for:
-training
-day-to-day
decision making in the field
-use of correct protocols in field
-complete & legible data forms
-correct handling & transporting of soil samples
Sherry Spencer (PSU) - Plant Taxonomist
Responsible for training, correct plant species identifications
Crew Representatives
- Responsible for crew member attendance
- Safety issues
Crew 1
2 Botanists
2 Recorders
3 Surveyors
Crew 2
2 Botanists
2 Recorders
3 Surveyors
Crew 3
2 Botanists
2 Recorders
3 Surveyors
responsible for field data & sample collection
2 Laboratory Technicians
Responsible for laboratory processing & analysis of soils

7.0 OBJECTIVES FOR MEASUREMENT

Data quality objectives (DQOs) are statements of the level of uncertainty that is acceptable to a researcher or decision maker in results derived from environmental data. Data quality objectives for the variables being measured in the OWS are shown in Table 7.1. Procedures to be used in attaining and estimating these objectives are summarized in Table 13.1, and described in Section 13. Calculation of accuracy, precision, and completeness is described in Section 16. Achievement of data quality objectives will be discussed in the project QA report (Section 18). When possible, data quality will be expressed quantitatively for individual measurements. The estimation of five data quality attributes - accuracy, precision, comparability, completeness, and representativeness - is described below.

ACCURACY

Accuracy is the degree to which a measured value agrees with an accepted known or "true" value (Taylor 1988). Accuracy of plant species identifications will be assessed during the practical evaluation following training, and by identification checks made by a PSU Plant Taxonomist during the field season. The Plant Taxonomist will visit each crew within the first week of field activities, assist in identifying unknown plant species, and review distinctive species characteristics of difficult plants with the Vegetation Teams. The Plant Taxonomist will continue to visit each Field Crew regularly throughout the field season. Identification and subsequent verification of unknown plant species is described in Section 8. Whenever there is any doubt about the identity of a plant species, a sample will be collected for verification in the laboratory.

No "true" values exist for the subjective estimates of plant species cover, soil color, soil horizon depth, and soil mottle size and abundance; hence, "true" accuracy for these estimates cannot be determined. However, estimates obtained by the Field Crew members for these variables will be "standardized" during training. We refer to this standardization as calibration. As noted in Section 10, calibration entails comparison and correspondence of values obtained by Team Members with the "standard values" for the same estimates obtained by the Trainers. "Standard values" for plant species cover will be determined by Teresa Magee and Sherry Spencer; "standard values" for soil variables will be determined by Paul Shaffer. At the end of training and once during the field season, Botanists and Recorders will remeasure vegetation plots sampled by Teresa Magee, and Sherry Spencer. Estimates of plant cover by each Vegetation Team will be compared with the Trainers' estimates. Similarly, Soil Scientists and Surveyors will evaluate soil pedons, and their values for soil description variables will be compared with those previously recorded by Paul Shaffer. The degree of difference between the values obtained by the Team Members and the Trainers will be used to evaluate "accuracy" (Table 7-1) of the subjective estimates.

Accuracy for the analytical process of loss on ignition will be addressed by inclusion of soil audit materials in each analytical batch. The two audit soils were collected and characterized for a previous EPA research project, and are described in Appendix B. A control chart for each audit soil will be constructed using data (mean $\pm$ 2 standard deviations) resulting from analyses conducted at Oregon State University on 10 samples of each audit soil. As part of the analytical process of the research soil samples at PSU, the loss on ignition value for the audit soil sample contained in each batch will be charted following analysis. Accuracy will be evaluated by visual inspection of the control charts.

Logistical constraints (field time and money) will not allow estimation of "true values" for field measurements of basin elevation, depth of standing water, depth in the soil pit to standing water, free water surface, and saturated soil. Accuracy values in Table 7.1 for these measurements reflect the accuracy of the measurement instruments, which will be calibrated.

PRECISION

Precision is a measure of variation among repeated independent observations of the same property under controlled similar conditions (Taylor 1988). During training and the first week of data collection, Field Crew members will be "calibrated" (as described above) for data collection of vegetation and soil variables to increase within and between crew precision. During field sampling, within crew precision for plant species cover estimates will be evaluated by repeat measurements made at five plots within each wetland i.e. both Vegetation Teams on the same Field Crew will measure the same five plots. Procedures for repeat sampling are described in detail in Section B - Quality Assurance Field Procedures. The transect (SCT) for repeat measurements of vegetation plots (Vegetation QA transect) will be selected by the throw of a die; the five plots that will be sampled by both Vegetation Teams along the Vegetation QA Transect will be taken from Form 12, which contains a list of randomly generated numbers for each wetland. Within crew precision for soil profile description variables will be estimated by repeat sampling of one soil pedon per wetland, i.e. two Surveyors/Soil Scientists will independently describe the same soil pedon. The transect (SCT) containing the "QA soil plot" (Soil QA transect) will also be selected by the throw of a die (a separate throw from selection of the Vegetation QA Transect); the location of the repeat-sampled soil pedon will be taken from Form 12 (the first number on the list of random numbers corresponding to a plot number).

Between crew precision for plant cover will be estimated by independent data collection by each Vegetation Team on the same plots at 2 different times - at the end of training, and mid field season. Between crew precision for soil variables will be estimated by independent data collection by each Surveyor/Soil Scientist on the same soil pedons at the end of training. The goal of training and initial "calibration" (described above) is to train crew members so their estimates of subjective variables meet the DQOs stated in Table 7-1. The purpose of the mid-season remeasurement

is to check for an increase in within and between crew variance that may exceed the DQOs.

For determination of soil organic matter (loss on ignition), precision will be estimated by analysis of field and laboratory duplicate samples.

COMPARABILITY

Comparability is the degree of confidence with which data sets may be compared. Comparability of data collected by different Field Crews within the OWS will be increased by training, cross-comparisons and testing of Field Crews prior to field sampling, and adherence to protocols. Comparability will be assessed in terms of accuracy and precision for the subjective field variables. Comparability of the loss on ignition data will be evaluated based on analytical results of audit soils, blanks, and field and laboratory duplicate samples. There is concern that temporal variability over the course of the field season may affect data comparability, i.e. data collected at the beginning of the field season may not be comparable to data collected near the end due to changes in plant phenology and dry down of wetlands. Methods for assessing temporal variability during the sampling period are being discussed.

COMPLETENESS

Completeness is the ratio or percentage of the amount of valid data obtained compared to the planned amount (Stanley and Verner 1985, Smith et. al. 1988). Our completeness goal is to visit all wetlands selected during the site selection phase, and to collect data and samples as described in Section 8 at each wetland. Access may limit sampling of some wetlands.

Collection of data on soil attributes may be limited by occurrence of bedrock, cemented soil horizons, unconsolidated materials for which vertical soil horizons cannot by described, or impediments to digging, such as plastic liners or erosion control layers on project wetlands. Natural features (e.g. bedrock) will be described as part of the soil profile; artificial features will be noted. In an effort to maximize completeness in soil sampling, we have identified and prioritized the use of several procedures which allow sampling of soils under different environmental conditions. Procedures for numbering and tracking soil samples and plant specimens (including unknowns) will be implemented to ensure correct labeling (see Section 9).

Completeness will be assessed throughout the OWS. Before leaving each site, the Crew Leader is responsible for checking all data sheets and soil sample labels, and logging soil samples on Form G-2, the soil sample tracking form. Form G-2 will also be checked and initialed by Sherry Spencer when she picks up the soil samples from the Crew Leaders, and upon receipt of the soil samples in the laboratory at PSU. Annotation and completion of the vegetation data forms (Form 7, Form 8, and Form 9) are described in Section 11. Data forms will again be checked for completeness before copying and data entry (Section 12).

At the end of the field season, the amount of data and samples collected will be compared to the planned amount, and be presented as a percentage for soil samples and each data variable. In addition, reasons for not meeting the 100% completeness objective will be recorded. Following data entry, the amount of validated data will be compared to the amount of data collected, and be presented as a percentage for each variable. Reasons for unvalidated data will be recorded.

REPRESENTATIVENESS

Representativeness is the degree to which data truly characterize a population or environmental condition (Stanley and Verner 1985, Smith et.al 1988). Representativeness of the sample wetlands was addressed during the site selection process (see Section 5: Project Description). Representativeness of the characteristics of each site will be assessed by the field sampling design described in Section 8, Sampling Procedures.

EXISTING DATA

Several kinds of existing data (Table 7-2) were used to facilitate site selection and are intended to contribute information for evaluating trends in wetland loss and in determining the level of compliance of projects with permit specifications. National Wetlands Inventory (NWI) maps (1:24,000 scale) of the study area were acquired from the U.S. Fish and Wildlife Service in 1991. Wetland type and location data were identified from the NWI maps; thus, quality of these data is dependent on the accuracy of the maps. We were aware of several data quality problems associated with using NWI maps, which were based on aerial photographs from 1981-1982, and actions were taken to minimize effects of these problems. For example, wetland boundaries identified on NWI maps are less accurate than boundaries identified by field measurements, therefore, wetland boundaries will be obtained from field measurements taken during the OWS. Also, many small wetlands (less than 2 ha) are not identified on NWI maps, since they are often not visible on aerial photographs. Although we were aware of this limitation, the NWI inventory was the most recent wetlands inventory available for the study area, and one goal of the OWS is to compare wetland designation from the most recent wetlands inventory with the field condition encountered during site selection reconnaissance. Land use data were obtained in 1992 from METRO (Portland Metropolitan Service District), a planning agency for the Portland, Oregon metropolitan area, and are assumed to be accurate up to 1990, the year the land use information was obtained by METRO. METRO generated a map containing the NWI data on wetland location and type combined with land use data for the study area. It is recognized that land uses may have changed since 1990. Therefore, the land use data were only used to pre-stratify wetlands by land use. Land use information obtained from field observations at each wetland will be used in the analyses.

Existing permit data and construction files were acquired in 1991 by transferring information from permit files at the Oregon Division of State Lands to a permit tracking form. The information obtained accurately described the permit conditions and

requirements; however, the specifications were often vague and incomplete. Follow-up information regarding whether the wetland was actually constructed and the "as-built" specifications of the mitigation project were often lacking from the permit files.

Table 7-1. Data Quality Objectives for the Oregon Wetlands Study.

Variable	Units	Precision	Accuracy	Completeness	Comparability
SITE					
Distance	meters	±1 m	±1 m	100%	±1 m
Elevations	meters	±1 cm	±1 cm	100%	±1 cm
Buffer size	meters	not assessed	not assessed	100%	not assessed
VEGETATION					
Plant species identification	binomials (genus & species names)	95-100%	95-100%	100%	95%-100% correct identification for all botanists
Plant species abundance					
Percent canopy cover of herbaceous species	percent	5% for interval 0-25% 15% for interval 26-100%	5% for interval 0-25% 15% for interval 26-100%	100%	5% for interval 0-25% 15% for interval 26-100%
Percent relative cover of shrubs[1]	cm	±10 cm	*	100%	±10 cm
Percent relative cover of trees[2]	cm	±2 cm	*	100%	±2 cm
Percent bare ground	percent	5% for interval 0-25% 15% for interval 26-100%	5% for interval 0-25% 15% for interval 26-100%	100%	5% for interval 0-25% 15% for interval 26-100%
Percent standing water	percent				

[1] Percent relative cover for each shrub species is calculated from line-intercept distances (cm).
[2] Percent relative cover for each tree species is calculated from basal area mesaurements (cm).

Table 7-1. Cont.

Variable	Units	Precision	Accuracy	Completeness	Comparability
SOILS					
Total organic matter	% dry weight	larger of ±0.5% (absolute) or ±15% of reported value	DQO will be stated after audit soils analyzed	100%	DQO will be stated after audit soils are analyzed
Soil color	Munsell Units	±1 interval for hue, value, &/or chroma	±1 interval for hue, value, &/or chroma	100%	±1 interval for hue, value, &/or chroma
Presence of: mottles, gleying, concretions, oxidized root channels, H_2S	presence/absence	90% agreement for all repeat descriptions	90% agreement for all repeat descriptions	100%	90% agreement for all repeat descriptions
Horizon thickness	cm	±2 cm	±2 cm	100%	±5 cm
HYDROLOGY					
Depth of standing water	cm	±0.5 cm	±0.5 cm	100%	±0.5cm
Depth in soil pit to:					
standing water	cm	±1 cm	±1 cm	100%	±1.0cm
free water surface	cm	±1.0 cm	±1 cm	100%	±1.0cm
saturated soil	cm	±1.0 cm	±1 cm	100%	±1.0cm

Table 7-2. Existing data used in the Oregon Wetlands Study.

Data Type	Source of Data	Data Transfer	Use of Data
Wetland type, location	USFWS NWI[1] maps	Maps - sent through mail	Site Selection and trends study
Section 404 permit information includes: wetland type wetland size slopes location vegetation species to be planted buffer type buffer width	ODSL[2] permit files, COE[3] permit files, and construction contractors' files	Data collected at ODSL, COE and construction contractors' offices	Site Selection and compliance study
Land use	METRO[4]	Maps obtained at METRO office	Site Selection

[1]U.S. Fish and Wildlife Service, National Wetlands Inventory
[2]Oregon Division of State Lands
[3]U.S. Army Corps of Engineers
[4]Metropolitan Service District

8.0 SAMPLING PROCEDURES

The field methods and detailed procedures for executing sampling tasks are presented here. First an overview of sampling activities to be completed at each site is provided. Second, procedures for site selection and major sampling tasks are grouped under the following subheadings: Site Selection, Transect Establishment, General Site Data, Wetland Morphology, Vegetation, Soils and Hydrology. The format of each of these sections may vary slightly but each contains a detailed discussion of field methods and implementation. This includes: 1) Protocols (flowcharts) describing the order in which field activities are completed and crew member responsibilities are assigned, and 2) Step-by-step instructions for field activities. The methods used to collect data for each variable evaluated in the OWS are summarized in Table 8-1. All forms used in the OWS are contained in Appendix A.

OVERVIEW OF SAMPLING TASKS FOR EACH SITE

Each numbered paragraph, below, represents a group of tasks to be completed simultaneously. Figure 8-1 presents an overview of the sampling tasks, indicates the order in which they must be completed, and the personnel responsible for each.

1. The Crew Leader will select one wetland or two in close proximity for sampling each day. A site packet will have been prepared for each site that contains the street address (if applicable) and directions to each site, as well as identifying photographs. All crew members will congregate at a predetermined meeting point. From there, the Crew Leader will transport all crew members to the site(s).

2. Upon arriving at the study site, Recorders and Surveyors organize and distribute data forms and equipment. Use the equipment list (Form G-1) to ensure that all equipment is present. Routinely locate items in the same places within the vehicle. Keeping the equipment organized by storing and transporting items in the same locations allows items to be easily found, facilitates packing and unpacking the vehicle, minimizes mess and confusion, and helps prevent loss.

   The large number of data sheets used in this study and the nature of field work requires that data sheets be carefully organized and protected from the elements. Therefore, data sheets will be organized and stored in a portable file box. Each crew member's clipboard will be supplied with all the data sheets needed for each site. The Recorders will organize the data sheets on the clipboards while the Botanists conduct initial reconnaissance, and the Surveyors organize equipment.

   All writing on data sheets will be done in pencil or waterproof ink to prevent loss of data through water damage. Each data sheet will have a

standard heading that identifies the date, study site, personnel, and sampling activity. The heading will be completed for every data sheet used.

3. The Crew Leader and Botanists will confer to determine wetland boundaries, any predominating environmental gradients, and locate the transect baseline.

4. The Crew Leader and Recorders will lay out the transect baseline. The Crew Leader determines transect starting points along baseline and Recorders mark with stakes and appropriate flagging. Botanists conduct initial reconnaissance of wetland vegetation, and agree upon pseudonyms for unknown species. Surveyors begin mapping procedures.

5. Vegetation Teams begin the following work along the transects: plant species identification; estimation of plant species cover, bare ground and open water within 1-m^2 quadrats; line-intercept determinations and belt transect measurements. Surveyors complete mapping procedures. Crew Leader photographs the site.

6. Surveyors begin the following work along transects completed by the Vegetation Teams: measure elevations and water depths; record data on whether transects intercept vegetation, open water or bare ground; and collect soil samples. Vegetation Teams continue vegetation sampling.

7. Crew Leader and Botanists determine if additional transects are required to sufficiently characterize the vegetation. A minimum of 40 vegetation quadrats are required. If additional transects are necessary to get 40 vegetation quadrats, determine and mark locations of Vegetation Transects.

8. Vegetation Teams conduct vegetation sampling along Vegetation Transects. Surveyors follow, and measure elevations and water depths.

9. Botanists collect voucher samples, and key out and preserve plants for future identification and archiving. Recorders assist Botanists and/or Surveyors.

10. Crew Leader reviews all data forms for completeness, errors and legibility, organizes forms into the site packet, and makes entries into the field diary. Surveyors and Recorders collect and organize equipment, and replace it in the vehicle. The Recorders ensure there is an ample supply of data forms to be used at the next site. If the supply of data forms is running low, Recorders inform the Crew Leader who ensures that more are obtained.

11. Crew Leader ensures the site is left in the best possible condition and checks to ensure no equipment or samples are left behind.

Although the Crew Leader has ultimate responsibility for ensuring completeness and legibility of data sheets, each crew member should check the data sheets completed during sampling activities to be sure they are complete and legible. There should be no need for data entry personnel to interpret handwriting or numbers. All calculations and the legibility of results should be checked. The draft site map and data sheets should be checked to ensure all required information (transect locations, soil sample locations, and landmarks) are included and correct.

All sample containers should be checked for seal tightness and code accuracy and legibility. Soil pits must be filled in, and flagging, stakes, meter tapes, other supplies and equipment retrieved and replaced in the vehicle. Aside from unavoidable trampling and soil sampling disturbance, the study site should look much as it did when the crew arrived.

12. Leave the site.

SITE SELECTION

Site selection for the OWS involves a two-step process. First, the kinds of wetland projects that have been constructed in the study area were identified and the population of projects to be sampled was defined. Second, the population of natural wetlands to be sampled was defined based on correspondence with the most common wetlands types for projects. Once the populations of wetlands were identified, field reconnaissance of potential sites for sampling was conducted to ensure sites met selection criteria. Table 8-2 lists numbers of projects and natural wetlands by land use.

DEFINING THE POPULATION OF PROJECTS

Criteria for inclusion of wetland projects in the study population were: 1) location of the project in the study area (the Portland Metropolitan area within the Willamette Valley Plains subregion of the Willamette Valley ecoregion (Omernik 1987, Clarke et al. 1991); 2) wetland type (freshwater wetlands that range from sites dominated by open water to those dominated by emergent vegetation); and 3) wetland size ($\leq$ 2ha). Refer to Section 5, Project Description and to the **Research Plan and Field Manual for the Oregon Wetlands Study** (Magee et al. 1993) for details on study area selection and description. Wetland type and size criteria are discussed below. A list of Section 404 permits requiring compensatory mitigation was obtained from the Oregon Division of State Lands (ODSL), the state agency responsible for wetlands permitting, to identify potential projects for sampling. Data were compiled from permits issued between January 1987 and January 1991 by transferring the information from the files at ODSL to the Permit Tracking Form (See Appendix A). The numbers of freshwater mitigation projects identified from the permits are listed by size and type in Table 8-2. The wetland types considered are freshwater wetlands that range from sites dominated by open water to those dominated by emergent

vegetation. These types were selected because they represent the most common freshwater mitigation projects and natural wetlands found across a mosaic of land use settings in the study area. This provides an opportunity for: 1) comparing natural wetlands and wetland projects and 2) assessing land use influences on the level of wetland function.

The selection of wetland type for this study does not imply an endorsement of ponds as wetland projects. In fact, few natural ponds exist in the study area (Kentula et al. 1992b). Adoption of the wetland type criterion for study was driven by the kind of project wetland available and the best natural analogs in the study area (i.e., we designed our study to evaluate what exists). The primary considerations for making management decisions about the type of a proposed project are the relative rarity of wetland types and the need for wetland functions to be replaced. Project design and type should not be based solely on what is most convenient because of land availability or project cost (Kentula et al. 1992a). Further, the ecological ramifications of replacing impacted wetlands with wetlands of different types are unknown (Kentula et al. 1992a), so reason suggests that we exercise caution and do our best to establish types that occur naturally in the area.

All of the projects meeting the wetland type criterion were visited during Summer 1991 and Spring 1992. Access to the projects was granted by the ODSL and, as a courtesy, most of the land owners or property managers were contacted to set up a convenient time to visit the site. During each site visit, directions to the site and general site information were recorded on Form I and the site was photographed. Evaluation of reconnaissance information revealed that the most common project size was $\leq$ 2ha (approximately 5 acres). Thus, the second criterion for site selection was defined as wetlands $\leq$ 2ha in size. Projects were rejected if: 1) they were not constructed; 2) they did not meet the wetland type or size criteria; 3) conditions at the site were hazardous; or 4) project construction confounded the ability to sample the site (e.g., soils were underlain by plastic sheeting).

DEFINING AND SAMPLING THE POPULATION OF NATURAL WETLANDS

The population of natural wetlands was defined in terms of the population of project wetlands. Selection criteria for natural wetlands were: 1) freshwater palustrine wetlands that range from sites dominated by open water to those dominated by emergent vegetation; 2) size $\leq$ 2ha; and 3) location in the study area. National Wetlands Inventory (NWI) palustrine wetland types meeting the sampling criteria included aquatic bed, emergent, moss/lichen, open water, rock bottom, unconsolidated bottom, and unconsolidate shore.

Locating Natural Wetlands

Land use is a major consideration in the OWS because data from the Oregon Pilot Study suggested wetlands in different land uses within an urban setting exhibit varying levels of function. It is important to document these differences to gain information about attainable quality for wetlands within specific land uses. The pool of natural wetlands potentially meeting the selection criteria was identified using a

procedure adapted from Abbruzzese et al. (1988). A color-coded map depicting the five land use categories--undeveloped, commercial, industrial, agricultural, and residential--was created for the OWS by METRO.

The land use map was overlain with NWI digital data for wetland types and sizes appropriate to the OWS. The study area was delineated by placing overlays of the boundaries of the Willamette Valley Plains' subregion on the land use map. The 615 wetlands occurring within the study area were labeled, and surrounding land use was identified from the map and recorded. Sites with NWI special modifiers (e.g., partially drained/ditched, diked/impounded, artificial, spoil, excavated) were dropped from consideration because they were not natural wetlands. In addition, reconnaissance visits to the sites revealed the entire population of natural wetlands could be censused, because a large proportion of the sites were destroyed or altered by human activity.

Field Reconnaissance of Natural Wetlands

Preparation for field reconnaissance of natural wetlands and securing permission to sample consisted of:

1. The locations of sites identified on the land use map were transferred to an NWI composite map and a current Portland street atlas, for convenience in locating the sites.

2. A route to each site was determined and approximate geographic coordinates (latitudes and longitudes) were determined for each site. A hand-held, battery-powered navigation system (Trimble Global Positioning System [GPS], Transpak II unit) that receives data from U.S. Department of Defense satellites and calculates and displays position, velocity, time, and navigational information (Trimble Navigational Limited 1991) was used to locate each site. The geographic coordinates were entered into the unit which then displayed the distance and bearing to the site. After physically locating the site, the exact geographic position was entered into the GPS for future field reference. The GPS unit was extremely useful in site location, enabling us to find sites initially believed to be destroyed because of the difficulty in translating mapped information to exact locations on the ground.

3. We met with Portland area professionals who were able to provide information about ownership of public and private properties, and to identify individuals to contact for access and sampling permission. Permission was obtained to sample the sites located on land owned or controlled by the agencies represented by these professionals. For sites on private land, an attempt was made to determine ownership by checking information on mail boxes and real estate signs, and interviewing local residents. After ownership was determined, the owner was contacted and given a copy of a letter (Figure 8-2) explaining

the study. Using this procedure, permission to sample was secured from 40% of property owners.

Reconnaissance data were collected and site selection criteria were assessed for each wetland:

1. General site information was collected for each wetland on Form I. Observations were made at each site which were used to determine the approximate proportion of land cover types within the wetland and land uses directly surrounding the wetland. Also, a rough map of each site was sketched.

2. Each site was evaluated to see if it fit the criteria outlined for natural sites. A site was eliminated during the selection process if: 1) type or size were incorrect; 2) the wetland was destroyed; 3) conditions on or near the site would make sampling hazardous (e.g., garbage being dumped); 4) the site was altered substantially by human activities (e.g., grazing) or natural phenomena (e.g., drought); or 5) access was denied by the land owner.

TRANSECT ESTABLISHMENT

Three kinds of transects, Site Characterization, Wetland Morphology, and Vegetation Transects, are used for data collection in the OWS. Site Characterization Transects cross the wetland from edge to edge, perpendicular to a baseline (Figure 8-3). To reduce researcher bias and subjectivity as much as possible, the Site Characterization Transects will be placed systematically at evenly spaced intervals along the Baseline. The Wetland Morphology Transect is placed parallel to the Baseline and perpendicular to each Site Characterization Transect (Figure 8-3). Vegetation transects will be necessary only when fewer than 40 of the quadrats along the Site Characterization Transects contain vegetation. When used, Vegetation Transects will either be located between the Site Characterization Transects (Figure 8-4), or follow a narrow fringe of vegetation encircling a pond (Figure 8-5).

The Baseline will be oriented to permit characterization of the relationships between vegetation and environmental variables. The Baseline is placed so that it lies perpendicular to any obvious uni-directional gradient, allowing the Site Characterization Transects to span the gradient. However, if no uni-directional gradient can be identified, the Baseline is placed parallel to the longest edge of the wetland.

Sampling points will be systematically spaced along all transects based on wetland area. The sampling intervals used in this study have been adapted from Homer and Raedeke (1989) and are listed below. Additionally, the appropriate placement of the vegetation quadrat frame in relation to the transect line is (described below).

Wetland Size	Sampling Interval	Quadrat Frame Placement
< 0.1ha (0.25a)	1m	Short side parallel to transect line
≥ 0.1ha (0.25a) but < 0.3 ha (0.75a)	3m	Long side parallel to transect line
≥ 0.3ha (0.75a) but < 1.0ha (2.5a)	6m	Long side parallel to transect line
≥ 1.0ha (2.5a) but < 2.0ha (5.0a)	9m	Long side parallel to transect line

Field Methodology

The Crew Leader, Botanists, and Recorders all have roles in transect establishment. Specific responsibilities, tasks, and the order in which the tasks are completed are outlined in Figure 8-6 and discussed in greater detail in the following sections.

Site Characterization Transects

Site Characterization Transects will be used to sample several wetland variables at predetermined sampling intervals. The proportions and distribution of vegetation, open water, and bare soil will be described. Measurements of elevation will be made to determine wetland morphology. Vegetation will be characterized in terms of composition and structure. General seasonal hydrology will be assessed by obtaining values for standing water depth and depth to soil saturation. Soils will be evaluated by profile characteristics and organic matter content at a subsample of the sample points. Details of sampling procedures for each variable are described in the Supporting Data, Vegetation, and Soils and Hydrology sections.

The field procedures for placement of site characterization transects are adapted from Horner & Raedeke 1989.

1. Crew Leader and Botanists determine the approximate boundaries of the wetland to be used to guide sampling.

2. The Crew Leader selects one side of the wetland as a Baseline. The Baseline is located just upland of the wetland/upland edge, perpendicular to any topographic gradient, otherwise parallel to the long axis of the wetland. If possible, the baseline should run the entire length of the wetland. Lay out a meter tape along the baseline, and record the baseline length on Form F-1.

3. Multiply the length of the baseline, measured to the nearest 0.1m, by 0.1, 0.3, 0.5, 0.7 and 0.9 to determine the starting points of each of the Site Characterization Transects and record on Form F-1. This procedure allows each Site Characterization Transect to bisect a 20% segment of the wetland. The Site Characterization Transects (SCT) are perpendicular to the baseline and run across the wetland from the Baseline, through the near edge of the wetland, then across the wetland to the opposite wetland/upland boundary. The start and endpoints are placed one sampling interval beyond the wetland boundary.

   EXAMPLE: Using data presented in Figure 8-3.
   Baseline length: 120m
   Starting point SCT1: 120m x 0.1 = 12m
   Starting point SCT2: 120m x 0.3 = 36m
   Starting point SCT3: 120m x 0.5 = 60m
   Starting point SCT4: 120m x 0.7 = 84m
   Starting point SCT5: 120m x 0.9 = 108m

Wetland Morphology Transect

A single Wetland Morphology Transect will be placed parallel to the Baseline so that it bisects the wetland as close to the center as possible, and perpendicularly intersects the Site Characterization Transects (Figure 8-3). The start and endpoints for this transect are placed one sampling interval beyond the wetland boundary so that the ends of the transect are placed in the upland. Elevations and water depths will be measured along the Wetland Morphology Transect, and the type of land cover (vegetation, open water, bare ground) at each sampling point will be recorded. Vegetation sampling will not be conducted along this transect. Wetland Morphology Transect elevations will be used in conjunction with the elevation data collected along the Site Characterization Transects to define the cross-sectional shape (morphology) of the wetland.

Vegetation Transects

Some wetland physiognomies encountered during this study will necessitate an increase in the number of transects to adequately characterize the vegetation of a given site. This is expected to occur most frequently at sites with a narrow fringe of vegetation surrounding a large expanse of open water, a condition common in newly constructed projects. In such situations, often fewer than 40 of the quadrats placed along the Site Characterization Transects are likely to contain vegetation. Since it is our experience that a minimum of 40 quadrats per site is required to accurately represent the herbaceous vegetation on wetlands 2 ha or less in size (unpublished data from the Oregon Pilot Study, Brown 1991, Confer and Niering 1992), it will be necessary to add additional transects until a minimum of 40 vegetation quadrats are obtained. The additional transects will be referred to as Vegetation Transects to distinguish them from the Site Characterization and Wetland Morphology Transects.

Methods of data collection on the Vegetation Transects are the same as those used for the Site Characterization Transects.

Two standard procedures for Vegetation Transect placement accommodate two different, but commonly encountered, wetland scenarios and reduce the effects of observer subjectivity. These procedures address logistical problems related to the width of the vegetation band surrounding a pond.

Case 1 - If the vegetation ring is greater than two sampling intervals in width, Vegetation Transects are added until the needed number of vegetation quadrats is obtained (Figure 8-4):

1. Vegetation Transects extend across the width of the vegetation band on both sides of the open water. Non-vegetated areas are not sampled.

2. Vegetation Transects 2 through 5 run parallel to and are located at the mid-points between the Site Characterization Transects. To determine their exact positions in relation to the Baseline, multiply the length of the Baseline by 0.2, 0.4, 0.6, and 0.8 for Vegetation Transects (VT) 2, 3, 4, and 5 respectively.

   Example: Using data presented in Figure 8-4.
   Baseline length = 120m
   Starting point VT2: 120 X 0.2 = 24m
   Starting point VT3: 120 X 0.4 = 48m
   Starting point VT4: 120 X 0.6 = 72m
   Starting point VT5: 120 X 0.8 = 96m

3. Vegetation Transects 1 and 6 are placed parallel to and outside Site Characterization Transects 1 and 5 and within the wetland boundary. Their locations relative to the base-line are equidistant between the outer Site Characterization Transects (1 and 5) and the edge of the wetland. To determine their exact positions, multiply the length of the baseline by 0.05 and 0.95 for Vegetation Transects (VT) 1 and 6 respectively.

   Example: See Figure 8-4.
   Baseline length = 120m
   Starting point VT6 = 120m X 0.95 = 114m
   Starting point VT1 = 120 m X 0.05 = 6 m

4. The Vegetation Transects are not sampled in chronological order. The order is determined by randomly selecting Vegetation Transect numbers (1-6) by rolling a die. The number obtained on the first roll will be the first transect sampled, the second roll will be the second transect sampled, and so on. If the number of a transect already selected comes up on a roll of the die, disregard it and roll

again. Record the sampling order of the transects on Form F-1 and record the numbers of the transects actually sampled.

5. Establish only the number of transects required to obtain a minimum of 40 vegetation quadrats. If 40 vegetation quadrats are obtained prior to reaching the end of a transect, continue sampling until that transect is completed.

6. The first quadrat on a Vegetation Transect is placed at the first sampling interval from the transect starting point that falls within the wetland boundary (See Vegetation Section for details on identifying the first quadrat position). Sampling proceeds at the normal sampling intervals until open water is reached. The open water area(s) is skipped and sampling begins again on the other side of the water and continues to the wetland boundary (See Vegetation Section for details on identifying the last quadrat position).

Case 2 - If the vegetation band is narrower than two sampling intervals, up to six Vegetation Transects are placed so that they parallel the vegetation band (Figure 8-5). The start point for each transect is systematically determined and each transect is sampled at the standard interval for the site. Only the number of vegetation transects required to obtain 40 quadrats are randomly selected for sampling.

1. The order of placement for transects to be sampled is randomly selected by rolling a die to obtain a number from 1 to 6. These numbers correspond to pre-assigned potential start points defined as the locations where the Site Characterization Transects 2 and 4, and the Wetland Morphology Transect intersect the vegetation ring (Figure 8-5). After determining the sampling order for the six transects, list the order on Form F-1 and circle, on the diagram, the start points for each transect actually sampled.

2. To establish each transect during sampling, the meter tape is pinned at the starting point and extended left, when facing the center of the wetland, until the end of the transect is reached (e.g., the start point of the next transect) (Figure 8-5).

3. Quadrat placement differs from the normal procedure. Usually quadrats are places with their long side parallel to the transect meter tape (See Vegetation Section). Here, quadrats are placed with their short side adjacent to the meter tape. This placement allows the long dimension of the quadrat to span the maximum area possible, thus encompassing the greatest level of vegetation zonation and heterogeneity possible (Figure 8-5, inset).

General Transect Establishment Procedures

Once the locations of the transects have been determined, the process for laying out and marking all transect types is essentially the same. Wetlands are

sensitive to trampling so a sampling method that requires as few trips as possible along each transect is used, and crew members always walk on the left side (when walking from the beginning towards the end) of the transects to avoid trampling vegetation to be sampled.

1. Transect starting points are located on the transect Baseline. For wetland morphology measurements, the first sampling point along each transect will be at the Baseline/transect intersection (0m). For vegetation sampling, the first sampling point will be the first point within the wetland boundary as determined by quadrat placement according to the sampling interval for the site. The Crew Leader must clearly document how the location of each transect was determined on Form F-1 and ensure that the Recorders marking the transect starting points understand where the transects should be located.

2. The Recorders mark transect starting points with stakes and flags. The transect numbers are indicated with flags, i.e., transect one has one flag, transect two has two flags, etc. Meter tapes are firmly attached to the stakes marking the transect starting points.

3. The Recorders use a compass to determine the direction each transect should take to cross the wetland perpendicular (90°) to the transect baseline. Record the transect bearing on Form F-1.

4. The first sampling team (Botanists and Recorders along Site Characterization and Vegetation Transects, or the Surveyors along the Wetland Morphology Transect) lays out the meter tape as they proceed along a transect from its starting point, sampling the plots at the predetermined intervals. On Site Characterization and Vegetation Transects, the meter tape is left in place and sampling point locations flagged with wire pins for the second sampling team (the Surveyors). After sampling the Wetland Morphology Transect, the Surveyors remove the meter tape.

5. Sampling order along each transect is designed to minimize vegetation trampling by requiring each person to make only one pass along each transect. The Wetland Morphology Transect is traversed only by the Survey Team. As they proceed along the transect they collect land cover type, elevation and water depth measurements. Site Characterization and Vegetation Transects are traversed first by one of the Vegetation Teams and then by the Survey Team. Vegetation sampling will be conducted on two transects simultaneously by separate Vegetation Teams. A Botanist and a Recorder will sample vegetation as they proceed along a Site Characterization or a Vegetation Transect. After vegetation sampling has been completed along a given transect, the Survey Team follows and collects the appropriate data and samples. For Site Characterization Transects this includes land cover types,

elevations, water depths, soil data, and soil samples. For Vegetation Transects, only land cover type, elevation and water depth measurements are obtained.

6. After all sampling has been completed and data forms checked for completeness, the meter tapes will be removed by reeling them in from the end of each transect. The stakes and flagging are retrieved by walking around the wetland perimeter.

Transect Establishment Procedures in Atypical Situations

In cases where deep open water that cannot be crossed on foot interrupts one or more transects, special procedures are required to locate the portions of the transects lying on the far side of the wetland (Figure 8-7). This problem may affect all three types of transects.

1. Commence transect establishment and sampling using the general procedures described above. Sample the portions of all transects that can be reached on one side of the open water. Once sampling has been completed on one side of the water, walk around the perimeter of the wetland to the wetland/upland edge opposite the transect start points.

2. Standing at the opposite wetland/upland edge look directly across the water back toward the segment of a transect that has already been sampled. Establish the direction along which the unsampled portion of the transect should run by aiming a compass back toward the transect starting point stake along a bearing 180° from the bearing defining the original transect segment (Figure 8-7). Move to the left or right as needed until the correct bearing is obtained.

3. Place a stake at this point so that it is located just upland from the wetland boundary. This will be the transect endpoint. The first vegetation quadrat will be placed at the water's edge and subsequent quadrats will be placed at the appropriate sampling interval until the last sampling point within the wetland boundary is reached (Figure 8-7). The Surveyors follow the Vegetation Team. Record, on the appropriate data sheet the sampling point distances along the meter tape in chronological order beginning with zero at the water's edge and continuing with increasing numbers to the transect end-point (Figure 8-7).

4. After sampling has been completed the Survey Team uses the transit to obtain triangulation measurements (See General Site Information, Site Map Section for details) that will permit calculation of the distance from each transect's start point to its endpoint on the opposite side of the wetland.

5. All triangulation distances and calculations are recorded on a transect establishment data sheet, Form F-1, for each transect. The total length of a

given transect can then be used to convert the recorded distances for the sampling points to the actual distances of the sampling points along the transect. A completed Form F-1 is filed together with all other data forms for that transect so that data entry personnel can enter data into a computer in the correct order.

GENERAL SITE DATA

Several kinds of activities provide general background information about each site. These activities include: creating a sketch map, evaluating land use and buffers, and photographing important features of the wetland or project.

Site Mapping Methodology

The skills and methods required to make a good field map are discussed below. These skills are easy to learn and personnel can be trained quickly.

The site map will be made by determining the distance and bearing of points located along the wetland perimeter with the Surveyor's Transit (hereafter, the transit). The wetland perimeter will be identified through changes in slope and vegetation. Locations of objects, landmarks, patches of vegetation, and transect endpoints can be determined with the transit and included on the map. The distance and direction to all mapped points is recorded from a single point (the transit location) and later transferred to graph paper to make the final site map. A rough sketch map is drawn at the same time the data are collected to check the relative locations of mappable features during final map construction. Transit-stadia surveying was chosen for this study because it is sufficiently precise for reconnaissance surveys, rough surveys for the location of boundaries, and detailed surveys for maps. In addition, it is more rapid and economical than other survey methods (Davis and Kelley 1969). When calibrated with a compass, magnetic bearings can be determined with the transit to within 5 feet. The stadia hairs within the telescope of the transit allow horizontal and vertical distances to be measured accurately (Kissam 1966). Horizontal distances are accurate to +/- 1 cm and vertical distances are accurate to +/- 1 m.

Measuring distances with the transit and stadia rod is based on the principle that the intercept, or difference in reading between the two fixed stadia hairs in the telescope of the transit, is directly proportional to the distance between the target (the stadia rod) and the telescope. Stadia hairs are two supplementary horizontal cross hairs equally spaced above and below the center cross hair. The stadia hairs are fixed so that there is a constant multiplier for converting the stadia interval to distance (Figure 8-8). The multiplier is usually 100 (Buckner 1983).

Equipment

Brunton Cadet Compass
Surveyor's Transit and Tripod
Stadia Rod
Forms
Pencils

35-mm Camera
Copy of Form I from visit to the site during site selection
"Walkie Talkie" Headphones

The Brunton Cadet compass

The Brunton Cadet compass (hereafter, the compass) is used to determine direction and to measure vertical angles and percent of slopes. The principal use of the compass will be to determine direction via compass bearings and to calibrate the graduated circle of the Surveyor's Transit (discussed below) for use in mapping. The compass circle is divided into 90° quadrants or 360° counterclockwise azimuth. The azimuth or bearing is read directly off the compass circle with the compass needle as the pointer. With this method, the compass circle is numbered in reverse. Therefore, East and West are interchanged and the numbers run 0° to 360° counterclockwise. This allows the needle's north tip to point directly to the angle on the compass circle toward the line of sight (Brunton Company 1980). For mapping, the 360° azimuth is more useful than the 90° quadrants because there is less chance errors will be made in calculating directions (Lounsbury and Aldrich 1979).

The compass circle must be set for true north. The compass needle points toward magnetic north, which changes slightly with time. True north is located geographically, and maps are based on it because it does not change. The angle between magnetic north and true north is called magnetic declination. This angle is the number of degrees the compass needle bears away from true north at that locality. Declination information for every location in the United States can be obtained from U.S. Geologic Survey Maps (USGS) (Greenhood 1964). The compass circle can be adjusted for magnetic declination by manually rotating the compass dial and offsetting "N" on the compass circle by the appropriate number of degrees for the local declination. Before using the instrument, always be sure to set the circle at the declination of the locality. Declination in the Portland, Oregon, area is presently about 20 degrees E of N, so the compass dial must be rotated clockwise so that "N" reads 20° to the right (Figure 8-9).

To take a bearing, i.e., to determine the direction from one object to another, hold the compass about waist high, open the lid and slant the mirror backward at about 45°. Hold the instrument flat in the left hand with the mirror to the rear. Press the left forearm against the waist. Steady the instrument with the right hand. Any tipping of the compass will prevent the needle from swinging freely. Place your eye so that the line on the mirror (the rear sight) bisects the reflection of the front sight. Turn your whole body until the reflection of the object to be sighted is aligned with the sights (i.e., the black center sighting line of the mirror bisects both the reflected front sight and the objected sighted). The NORTH end (painted) of the needle indicates the bearing of the object sighted (Brunton Company 1980).

Setting up the transit

First, position the transit to enable the operator to see as much of the wetland's perimeter and as many sampling points as possible. Generally, a centrally located

position on a slight rise and on firm ground is best. This saves time and effort because it should allow the operator to collect all mapping and sampling information without moving the transit (a process called "turning", Wetland Morphology Section). Sink the tripod feet into the ground to stabilize the instrument, adjusting the legs to make a nominally level platform. The legs should have about a 3 1/2-foot spread. If the tripod has adjustable legs, be sure the wing nuts on the leg clamps are securely hand tightened.

Place the transit onto the platform, hand tightening the threaded stud of the tripod to the instrument base securely. While watching the level bubble on the transit, push individual tripod legs further into the ground until the bubble is somewhat centered.

Begin to level the transit using the levelling knobs; while leveling the instrument, do not touch the tripod. The three leveling screws of the transit are turned one at a time until the bubble is centered within the black indicator circle. When properly leveled, the bubble should remain in centered position during a 360° rotation of the telescope. The automatic level's pendulum compensator will maintain this level alignment even if the tripod or transit is jarred or tilted slightly.

To ensure that the transit remains level during operation, it is important to periodically check that the bubble is centered. Select a solid object (e.g., a large stone, stump, edge of a sidewalk) to use as a benchmark (the elevation control point). Sightings will be periodically made to the benchmark to ensure that the transit is level and has not shifted.

Calibrate the graduated circle of the transit with the Brunton compass. Rotate the transit's graduated circle so that 0° on the transit corresponds with 0° on the compass. (Some transits will be equipped with a compass, making this step unnecessary.)

Using the transit to map the study site

The Crew Leader will confer with the Botanists to establish the wetland perimeter based on changes in vegetation, moisture, and elevation. The Crew Leader will convey this information to the Surveyors and verbally establish the points that will be used to identify the wetland perimeter. The surveyors record the distance and direction from the transit to all "corners" on the wetland perimeter. Corners represent changes in direction in the wetland boundary. The finished map will depict the wetland as a polygon.

The distance and direction to all mapped points is recorded from a single point (the transit location) and later transferred to a map. The transit operator draws a rough sketch map on Form F-2 while in the field, to check the relative locations of mapped features during final map construction. The map should include all points recorded with the transit. Use the following procedure:

1. Assemble a clipboard, compass, transit and stadia rod, several copies of Form F-2 and map data sheets, Form F-3.

2. Set up the transit at a point where the entire wetland perimeter can be seen. If the transit must be moved during the mapping procedure, follow the procedures for "turning" (See Wetland Morphology section) and record the benchmark data on the back of Form F-3. Ensure that the transit is level and calibrated with the compass. On Form F-2 (blank sketch map) indicate approximately where the transit is located and label this point as "Transit Location 1". Draw an arrow on the map to indicate North.

3. While the Transit Operator sets up the transit, the Surveyor with the stadia rod moves along the perimeter of the wetland to the first "corner". This will be corner "A" on the sketch map. To standardize the mapping procedure, the Surveyor with the stadia rod should move clockwise around the perimeter of the wetland.

4. The stadia rod is held vertically while the transit operator uses the telescope to sight the stadia rod. The Transit Operator sketches the approximate location of the wetland "corner" on the sketch map, labels it, and then records the stadia readings (upper, middle, and lower cross-hairs) and the compass bearing for that point on Form F-3. The upper and lower stadia readings indicate the distance to the corner from the transit location, and the middle stadia reading indicates the relative elevation of that point. Stadia readings, in meters, are recorded from the meter scale on the stadia rod (Figure 8-10). The compass bearing provides the direction to that corner of the wetland from the transit location and is read directly off the compass rosette on the transit.

5. The Surveyor with the stadia rod continues moving the stadia rod from "corner" to "corner" around the perimeter of the wetland while the Transit Operator records the data and makes the rough sketch. The Transit Operator should also record any anecdotal information which might help construct the final map in the comments box on Form F-3.

6. In addition to the wetland perimeter, the Transit Operator should map the locations of all sampling transects by positioning the stadia rod to take bearings, distance and elevation readings at their beginning and end-points. It will be necessary to collect this data later during the day, i.e., after sampling transects have been placed and during collection of wetland morphology data. Record the information on Form F-3 (the map data sheet) and mark the positions of the transects on the sketch map.

7. The Transit Operator records the locations of major site features such as open water, trees, water courses, patches of monotypic vegetation, and man-made structures.

8. If a corner of the wetland perimeter cannot be reached by the Surveyor carrying the stadia rod due to deep water, unstable substrate or other obstructions, use triangulation to determine its location (Lounsbury and Aldrich 1986). First, using a meter tape, establish two points (endpoints of a baseline) which are a known distance apart (at least 30m), and record the length and the direction of the baseline on Form F-3 (Map Data Sheet). Using the transit, take compass and upper and lower stadia hair readings from both baseline endpoints to a previously measured point on the wetland perimeter (e.g., a mapped wetland "corner" or transect endpoint). These readings will be used to locate the baseline's position on the sketch map.

   Then, from both baseline endpoints, take compass readings through the transit to the corner not reached by the Surveyor and record the data on Form F-3. When constructing the final site map, the location of the corner not reached by the Surveyor will be indicated by the intersection of two rays drawn along these bearings from the baseline endpoints (illustrated in Figure 8-11).

9. After all wetland corners and site features are measured and recorded, examine the sketch map and document anything that will help complete the final map. Check that data are recorded for all wetland "corners" and that entries on the data forms are legible.

Land Use and Buffers

Buffer zones between a wetland and a developed upland area can protect the integrity of the wetland water supply, water quality, and associated wetland-dependent wildlife (Brown et. al. 1990). A buffer can act to lesson the impacts of development on adjacent wetlands (Jordan and Shisler 1988). In addition, vegetated buffers provide structural diversity and transition zones between land uses. They create visual and noise barriers, corridors and linkages to other habitats, and help ensure species diversity.

For this study, the presence of vegetated buffers will be quantitatively determined along four transects extending out from the perimeter of each wetland. After positions of the Wetland Morphology Transect and Site Characterization Transects have been determined, Survey Team members visually determine the presence or absence of vegetated buffers by viewing the area extending beyond the wetland edge from both ends of the Wetland Morphology Transect and the center Site Characterization Transect (SCT3) (Figure 8-12). If a vegetated buffer exists, the Surveyors extend a meter tape from the transect and stake and record on Form F-4, the vegetation strata present (herbs, shrubs, or trees) and the extent or distances along the meter tape which each stratum occupies. When the outside edge of the vegetated buffer is encountered, the Surveyors record the type of land use that occurs (Agricultural, Industrial, Commercial, Residential, or Transportation Corridor). If the buffer width is greater than 100m, >100m is recorded on Form F-4.

Form "I", used during site selection to collect data on surrounding land uses and determine wetland types, will be checked, and if necessary, annotated during field

sampling to determine if changes have occurred in the year since site selection, and to verify the site selection data. The Crew Leader uses a colored pencil to annotate a copy of Form I for the site by: 1) looking for evidence of changes (e.g., new construction, felled trees, new culverts); 2) estimating the portions of the surrounding area that fall into residential, commercial, industrial, agricultural, or undeveloped land use categories; and 3) comparing the estimates with those on Form I. Estimates of land use may differ with personnel collecting the data, but if wetland surroundings have not changed since site selection, completion of Form I will be adequate for the needs of this study.

Photography

A photographic record is used to visually document site characteristics. It can also be used later to verify data and provides a method for tracking changes in the wetland over time.

1. To standardize photographs, use a good quality, 35-mm camera equipped with ASA 100, 35-mm Ektachrome slide film and a 50-mm lens.

2. Label each roll of film by photographing a completed Form F-5 in the first frame. Photograph a new Form F-5 as the first photo taken with each new study site. Complete Form F-5 as follows: Using a dark magic marker, fill in the Date, Site Code, Photographer's last name and the Film Roll Code. The Film code contains two parts. The first three characters pertain to the film roll number. Rolls are numbered consecutively for each camera from the start of the field season. The fourth and fifth characters are the photographer's initials.

   For example, if Maria Melon is taking photographs on the 14th roll of film used in that camera, the code would be 014MM.

3. Document each photograph by number and topic on the photo log form (Form F-6). Make certain to record all photos taken (even accidental exposures) so that the order of the developed slides matches the order of exposures recorded in the photo log.

4. Check the camera battery frequently, carry a spare.

5. Never let the camera or film sit in the sun. Extra film should always be carried and should be stored in a sealed plastic bag in a cooler if the weather is hot.

The primary types of photographs taken at each site are general site photos, site record photos, and rare or unusual items (i.e., plants, animals, structures). Either the Crew Leader or the member of the Survey Team not handling either the transit or the stadia rod for mapping takes the general site and site record photos.

General site photos document the features of the site and the approach to sampling. Take a panoramic landscape sequence from a central location at the edge of the wetland. Photograph major wetland features such as open water areas, water channels, inlets and outlets. Be sure to photograph transect locations along the direction of the transect line. Photos of transect locations may be used to verify sampling locations, or possibly, to resample the wetlands at a later date. Interesting action photos of field crew members sampling will come in handy for future presentations discussing the research.

Site record photos provide a permanent record of the wetland from a specific vantage point. Carefully choose a vantage point to see as much of the wetland as possible. Carefully record the location on the map and on Form F-6 so that the wetland can be re-photographed from the same location in the future and changes in the wetland can be documented. Also be sure to record the compass bearings of the photos taken from the vantage point. Be sure to include likely permanent landmarks like stumps, rock outcrops, fencelines, or roadways.

VEGETATION FIELD METHODOLOGY

This section describes several aspects of the field methodology: 1) the field activities and required expertise of each crew member on the Vegetation Teams; 2) the vegetation sampling protocol outlining the order in which sampling tasks are to be completed, 3) a list of sampling equipment and supplies; and finally, 4) detailed sampling procedures for the various cover measurement techniques and other field activities. The vegetation sampling protocol (Figure 8-13) has been designed to ensure that quality data are collected and minimal trampling of the vegetation and substrate occurs. Field procedures consist of standardized methods to facilitate accuracy, precision, and comparability of the data collected. Thus, it is imperative that sampling activities be carried out in the order and manner specified.

Vegetation Team Responsibilities and Sampling Protocol

Each Vegetation Team consists of two individuals, one Botanist and one Recorder. Each field crew will have two Vegetation Teams; both work simultaneously on the same site. The Botanists must have demonstrated skill at wetland plant identification (See Section 6). The Recorders should have at least minimal botanical training, and at least one Recorder per crew should be capable of substituting for a Botanist. The sampling activities are divided into several basic task groups: equipment organization, pre-sampling reconnaissance and plant collection, vegetation sampling, data form proofing, defining transect end points, plant specimen preservation, and identification of unknowns. The order in which each task and its component parts are conducted, as well as the team member responsible for task completion is illustrated in the vegetation sampling protocol (Figure 8-13). At the site, the two Botanists will conduct a pre-sampling reconnaissance, make canopy cover estimates, gather line-intercept and belt transect data, collect plant specimens, proof vegetation data forms, and identify the transect end-points. The two Recorders are responsible for organizing data sheets, flagging and staking the transect start-points

as indicated by the Crew Leader, accurately recording cover values provided by the Botanists during cover estimation, flagging the end-points of the transect as indicated by the Botanists, and assisting the Survey Team as required.

Field Equipment and Supplies

Two 1-m^2 rectangular quadrats (0.73m x 1.40m)
Two diameter tapes (0.73m x 1.40m)
80 flagged wire pins and two carrying pouches
Vegetation data forms
Pencils or waterproof pens
Plant presses with blotters, ventilators, and cinch straps
Newsprint for plant pressing
Collection labels
Regional floras (e.g. Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, WA.)
Wetland plant species lists
Rare plant lists
Trowel for obtaining plant specimens with intact roots
Hand lenses
6-cm ruler for measuring plant parts during field keying
Gallon size zip-loc plastic bags
Large plastic bags (e.g. kitchen trash bag)
Letter-sized envelopes
Tags for marking unknowns specimens that are carried as references during sampling
Permanent marking pens
Ice chest

Pre-Sampling Activities

Prior to conducting vegetation sampling activities, the Botanists and Recorders have specific tasks related to Transect Establishment. These include:

1. Botanists confer with the Crew Leader to aid in identifying wetland boundaries, the presence and direction of any environmental gradients, and the location of the Baseline (See Transect Establishment). The Botanists then begin the pre-sampling reconnaissance.

2. Recorders organize data sheets for all crew members and then, at the instruction of the Crew Leader, flag the endpoints of the Baseline and the start points of the transects (See Transect Establishment).

Both Botanists conduct a pre-sampling reconnaissance to identify the common and dominant species and determine the general nature of the vegetation. This is accomplished by:

1. Botanists jointly conduct a floristic survey of the area to identify plant species. Care should be taken to enter and traverse the wetland as little as possible to avoid trampling damage to the site. Agreement between the Botanists regarding species names helps to ensure accurate plant identification.

2. Botanists standardize pseudonyms for plants they cannot readily identify in the field. If the genus name is known, then "sp." should be substituted for the species epithet (e.g., *Carex* sp.). If there is more than one unknown species of a genus present, then pseudonyms should include the genus name followed by numbers, letters, or an identifying characteristic (e.g., *Carex* 1, *Carex* 2, *Carex* - with 3 stigmas, or *Carex* - with bidentate perigynia and striped scale). Where neither the genus nor species names are known, the Botanists devise a pseudonym that reflects growth habit, microhabitat, or some distinctive morphological feature (e.g., bunchgrass # 1, thin-leaved aquatic herb). In cases where there are numerous unknown taxa, it may be necessary to carry tagged examples of the plants, in individual bouquets, during sampling to keep the pseudonyms straight. This is especially relevant if a single genus has several unknown representatives on the site.

3. Botanists and Recorders enter, on the Canopy Coverage Form (F-7), the names of species likely to be encountered within the sampling plots. Species names recorded during field activities are entered in the third column of the form (the first column will be used during post-field work to record the validated species name). Use the binary genus/species name if known or enter the predetermined species code discussed in item 2. If additional taxa are encountered during sampling, record their names or pseudonyms and continue data collection. Once the transects are completed, both Botanists will reconcile the names and pseudonyms of these species on their respective data forms.

4. Botanists collect voucher specimens of unknown or interesting plants. DO NOT COLLECT THREATENED OR ENDANGERED PLANT SPECIES. A list and description of rare species in the study area will be available to each crew. The Crew Leader will carefully photograph such taxa and record their precise locations in the field diary. Plant specimens are placed in plastic bags and then into an ice chest to reduce wilt prior to pressing. For especially wet specimens, the plants might be placed in a paper bag or between folds of newspaper before being deposited into a plastic bag to prevent mold development and wilting. Plastic bags should be marked, using a permanent marker, with pseudonym information, the site number, date, and the wetland area or transect number, and the plot number and plot distance from which the specimen was collected. Examples: *Carex* 1, Site 61, 7-21-93, Plot 4 (18m), or *Carex* 1, Site 61, near the north end of the Baseline east of the Wetland Morphology Transect.

5. Specimen collection continues throughout the site visit as new species are found. When a plant sample is collected place a check in the "collected" box of the appropriate vegetation data form (Forms F-7 and F-8). If a specimen is needed, but has not yet been collected, place a check in the "to be collected" box as a reminder. Collect the required specimens before leaving the site.

Vegetation Sampling

Vegetation sampling is conducted by both Vegetation Teams working simultaneously on separate transects. One Vegetation Team begins with Site Characterization Transect 1 and the other begins with Site Characterization Transect 2. The Teams continue sampling alternate transects until all the Site Characterization and Vegetation Transects have been sampled. Vegetation sampling involves several activities: 1) determination of the position of the first vegetation quadrat on each transect; 2) preparation of the data sheets; 3) placement of the meter tape along the transect line; 4) collection of line-intercept data for shrubs; 5) collection of canopy coverage estimates for herbaceous species; and 6) collection of basal area data for trees. The procedures for each sampling activity are described below, detailing the steps required to complete a single transect.

The Botanist determines the locations of the first and last vegetation quadrats on each transect and the Recorder enters the distance information on the Canopy Coverage Form F-7. The sampling interval (1, 3, 6, or 9m) selected during transect establishment is used to identify the meter tape distances, at which the quadrats or sampling points will be placed. Quadrats are placed only at these pre-defined points.

1. First quadrat location. Transects begin at the baseline at 0m. However, this position will lie in upland, and vegetation sampling is conducted only in the wetland. The position of the first quadrat on the meter tape is determined by 1) identifying the location of the wetland/upland boundary, and 2) proceeding along the meter tape from the boundary to the first sampling point inside the wetland. The first quadrat will be located at this point. For example, if a 6-m sampling interval is used for the wetland and the wetland boundary occurs at 10m from the Baseline, the nearest sampling point would be at 12m (See Figure 8-14, Site Characterization Transect 3). Thus, in this case, 12m is the location of the first quadrat on this transect. Subsequent quadrats would be placed at 6-m intervals (e.g., 18m, 24m, 30m, etc.) until the wetland boundary at the opposite end of the transect is reached. See Figure 8-14 for more examples of determining the distance from 0m to the first quadrat position. Enter the position of the first and subsequent quadrats in the section on data form F-7 marked "dist. from 0".

2. Last quadrat location. The final vegetation quadrat on a transect is placed at the last sampling point where an entire quadrat can be placed inside the far wetland boundary (i.e., the boundary across the wetland from the Baseline). The position of the last quadrat on a transect is determined during sampling.

Do not walk the length of the transect prior to sampling because this would cause unneeded trampling of the vegetation. Examples of last quadrat position determination are illustrated in Figure 8-14. On Site Characterization Transect 1 the last quadrat occurs at 48m along the meter tape even though the wetland boundary extends to approximately 60m. A quadrat placed at 54m would cross the wetland boundary and extend into upland vegetation so it would not be sampled.

Prior to beginning data collection Recorders complete the headings on all vegetation data sheets (Forms F-7 through F-9). It is important to take the time to do this before beginning to record data. Wetland width, the length of the transect that falls within the wetland boundary, should be recorded for each transect after the transect has been sampled. The start and end of the wetland boundary, i.e., the portion of the transect where vegetation is sampled, is also recorded on Forms F-7 through F-9. Vegetation sampling does not occur on the upland ends of the transects, so it is important to record the start and end of the wetland boundaries. This is particularly critical for the line-intercept and tree diameter data because wetland width is used in calculating cover percentages for trees and shrubs.

1. Canopy coverage data sheet (Form F-7). Record the distances from zero and the plot numbers for each quadrat along a transect as sampling proceeds. Use separate data sheets for each transect. If more than one data sheet is required to complete a transect, repeat the species names in the same order on each sheet. If the number of species occurring on a transect exceeds the number of spaces provided for species names, record the additional species on another data sheet. Make certain to enter the correct quadrat location (distance from zero and plot number) on the additional data sheets.

2. Line-intercept data sheet (Form F-8). List all shrub and tree species that occur on the site in the space provided. Use separate data sheets for each transect. If more than one data sheet is required to complete a transect because all the tape position/interval length spaces are filled, repeat the species names in the same order on each sheet. If more than one data sheet is required because more than five species occur on the transect, record the additional species on another data sheet. After sampling the transect be certain to record the precise wetland width in the heading of the form.

3. Diameter at Breast Height (dbh) (Form F-9). List all tree species that occur on the site in the first column of the data form.

Placing the meter tape

The Recorder pins or otherwise attaches the meter tape at the flag marking the transect beginning. The meter tape is NOT stretched the full length of transect prior to sampling; instead, during sampling, it is stretched along a compass bearing as the

Vegetation Team proceeds toward the end of the transect. The tape is left in place after the Botanist has finished cover readings so it can be used later by the Survey Team. These procedures minimize trampling of fragile wetland soils and vegetation. To avoid trampling of the vegetation that will be sampled in quadrats the Vegetation Team always travels along the transect on the left side when facing the transect from the baseline.

Sampling Order for Vegetation Data

Three kinds of data, line-intercept for shrubs, canopy coverage for herbaceous species, and basal area for trees, will be collected in a single pass along the transect. Line-intercept intervals for shrub species will be obtained along the meter tape, percentage cover values for herbaceous species will be estimated within 1-m^2 quadrats placed adjacent to the meter tape, and basal areas for tree species will be gathered in a 2-m wide belt transect centered on the meter tape (Figure 8-15). The Botanist collects all the types of vegetation data for a given segment of a transect, then proceeds to the next segment. Sampling is continued in each subsequent segment until the transect is completed. The length of a transect segment equals the sampling interval defined during transect establishment (1m, 3m, 6m, or 9m depending on wetland size). For purposes of vegetation sampling, the intervals begin at the bottom edge of the quadrat, that is the edge nearest and parallel to the baseline, and continues along the meter tape to the bottom edge of the next quadrat (Figure 8-16). Data are collected in the following order within each transect interval:

1. Line intercept data are gathered first because vegetation will be matted down due to kneeling on the transect line while reading the quadrats during estimation of canopy coverage. Kneeling on and disturbing shrubs would negatively affect the quality of the line-intercept data.

2. Canopy cover estimates are then obtained for all species occurring in the quadrat.

3. Since both the line transect and the quadrat are contained within the belt transect, basal area data is gathered last to prevent trampling of the herbaceous vegetation in the vicinity of trees prior to sampling.

Line-Intercept data collection

1. Line-intercept data are not gathered from the upland ends of the transect but only within the wetland boundaries. Shrubs and small trees are sampled along the transect length which is bounded by the outside edges of the wetland (See Figure 8-17).

2. Definition. Intercept length equals the portion of the transect, i.e., the distance along the meter tape, that a plant's foliage touches, overlies, or underlies.

3. Botanists determine the intercept length for each shrub species and each small tree (< 2m tall) by calling out the species name and the intercept length beginning and endpoints (e.g., Figure 8-17, *Salix piperi*, 3.60 to 6.10m).

4. Recorders enter data on the line-intercept data form (Form F-8) by recording beginning and ending points in the spaces provided under the correct species name. Meters are recorded as whole numbers and centimeters as decimals (e.g., continuing the previous example, in the *Salix piperi* column 3.60 to 6.10m)

5. Intercept lengths will be calculated by subtracting the beginning point from the ending point (e.g., 6.10m - 3.60m = 2.50m). Calculations will be done by computer after the data are entered.

Canopy cover estimation within quadrats

1. Sample plot placement.

   a. Sampling begins with the plot nearest the baseline on the transect that will be sampled (See procedures for the location of the first plot above). The Botanist places the 1-m^2 quadrat so that its nearest right-hand corner is adjacent to the appropriate sampling point on the meter tape and its long side is parallel to the transect (Figure 8-18).

   b. The recorder places a flagged wire pin in the nearest right-hand corner of the quadrat to mark the sampling point location for the Survey Team. The Survey Team will remove the pins as they sample the transect.

2. Definition. Plant species cover estimates are the percentage of each sampling plot that is overlain by the undisturbed canopies of each species occurring in the plot.

3. Percentages for cover estimation. Use the percentage increments defined for precision in cover estimates.

For Cover Of:	Use Increments Of:
1% to 5%	1%
>5% to 100%	5%

4. Guidelines for cover estimation (Adapted from Daubenmire 1959):

   a. Botanists make cover determinations for each species by estimating the amount of ground space in the plot overlain by the canopies of individuals or ramets of that species (See Figure 8-19). Cover determinations for microsite characteristics are made by estimating the ground space occupied by water or bare ground.

b. Do not try to subtract openings created by separated leaves in canopies of species with open habit (Figure 8-19). The space over which a plant exerts influence is approximated by the area of its undisturbed canopy even where such openings exist, since the plant's root system typically spreads at least as extensively in the horizontal direction as does the canopy.

c. The ground space is frequently covered by superimposed layers of plants due to the vertical stratification of plants within communities. Thus, the sum of all canopy-coverage estimates often substantially exceeds 100%.

5. The Recorder reports percentage cover for each of the species names or microsite characteristics on the Canopy Cover Form F-7 as they are called out by the Botanist. If a species called out by the Botanist is not already on the list, the Recorder adds it. The Recorder verbally confirms names and percent cover with the Botanist for any such information he/she has difficulty hearing or understanding.

6. Standing water. The Botanist estimates the percentage of area occupied by standing water, if any is present, within the 1-m^2 quadrat. Do not include saturated soil as standing water.

7. Bare ground. Estimate the percentage of the 1-m^2 quadrat without herbaceous vegetative cover as bare ground. Bare ground includes any area covered by water and lacking vegetation or litter. This means the bare ground and standing water could occupy the same space, thus, percentage cover for either or both variable could be recorded for the same area.

8. Plant species. Using the guidelines in item five, the Botanist estimates the cover of each plant species occurring in the sample quadrat. If a plant needs to be collected for taxonomic validation, the recorder makes a check in the "to collect box" in the second column on the Canopy Cover Form F-7. When a specimen has been collected, check the "collected box" on the form (see Collection and Preservation, later in this section).

Basal area data collection within belt-transects

1. Definition. Basal area is measured by obtaining the diameters at breast height (dbh = 1.4m) for all trees > than 2m tall and occurring within a 2-m wide belt transect that is centered on the transect line.

2. Determine the outside boundary of the belt transect by placing a meter stick on the ground perpendicular to the transect line, first on one side of the transect line, then the other (Figure 8-15). This is done whenever trees are encountered

near the transect line to determine whether or not they occur within the belt transect. Diameters for all trees occurring within the belt or with at least half of their stem routed inside the belt will be measured.

3. The Botanist measures dbh for each tree encountered, by stretching a diameter tape around the bole (trunk) of the tree at a position 1.4 m from ground level. Figure 8-20 depicts several tree stem conditions that might be encountered during sampling and illustrates correct placement of the diameter tape. Diameters are obtained for each branch and/or stem of multi-stemmed trees with a dbh $\geq$ 4.0 cm. Botanists call out the tree species name, diameter and the tree location on the transect (e.g., *Populus trichocarpa*, 37.0 cm, 16m).

4. The Recorder enters one dbh value to the nearest millimeter, and tree location to the nearest meter on the transect per box in the appropriate species row on Form F-9.

Establishing the Transect Endpoint

After the Vegetation Team has finished data collection for a transect, the transect end-point must be established so that the Survey Team will know how far to sample and so that total transect length can be determined.

1. The Botanist determines the location of the transect end-point. This is done by stretching the meter tape one complete sampling interval beyond the wetland boundary and into upland vegetation.

2. The Recorder stakes the end-point according to the Botanists instructions. The stake is marked to identify the transect by attaching pieces of flagging to correspond with the transect number, e.g., transect 3 would have 3 pieces of flagging. The Recorder notes the end of the wetland boundary.

Post-Sampling Activities

The Survey Team will need to know the number of vegetation quadrats that were sampled along the transect so they can randomly select the locations for soil sampling.

1. Following completion of a transect, the Recorder calls a Survey Team Member on a walkie-talkie and gives them the transect type and number and the number of vegetation plots sampled on the transect.

2. The Survey Team Member confirms the information by repeating the numbers to the Recorder.

After all the data have been collected for a transect, the Botanists check the data sheets for completeness and legibility. Botanists check to see whether

specimens have been obtained for all species which need to be collected and that the appropriate collection box is checked off on the data forms.

Once the vegetation sampling has been completed, the Recorders assemble and file data forms, and gather and stow all vegetation equipment. Recorders then assist the Survey Team as needed or help the Botanists with plant collection, preservation or identification.

Final Plant Collection and Plant Specimen Preservation

Botanists collect unknown plant taxa that they have not previously gathered from the site. All plant specimens are labeled and pressed for subsequent species validation. Labelling is a three step process: 1) a tie tag is attached to the plant when it is collected and labelled with pseudonym, transect, plot or other location information and the date; 2) this information is transferred to the outside of the newsprint in which the specimen is placed during pressing; and 3) a collection label is completed and included in the newsprint with the plant specimen during pressing. The label is illustrated below.

Collection Label for OWS Plant Specimens

Collector: County: Date:

Site #: Transect #: Plot #:

Species Name or Pseudonym:

Habitat (e.g. Aquatic, submerged conditions, emergent conditions, Saturated soil conditions, upland, etc.):

Plant Community/Associated Species:

Features of the plant that might fade during drying or may not be obvious from collected material (e.g. habit, rhizomatous, caespitose, flower color):

Standard procedures for plant collection and preservation are used. The steps in each procedure are briefly outlined below. More complete discussions are available in most plant taxonomy texts or laboratory manuals.

The steps in plant collection are:

1. Plants should, whenever possible, be collected when in flower and/or fruit. Mature fruit are especially important for *Carex* (sedge) species.

2. If the plant is dioecious (male plants and female plants) collect specimens from both sexes whenever possible. Wetland species likely to be dioecious are *Salix* sp. (willows) and some *Carex* sp. (sedges).

3. If the specimen is small, collect the entire plant including the roots. Collect at least enough material to fill a herbarium sheet.

4. If the specimen is large, collect some of the root, part of the stem with leaves, and part of the inflorescence (flowering stem). If the specimen is a *Carex* or a grass (Poaceae), also place a piece of the inflorescence in a small envelope to protect it from damage.

5. If the plant is woody, collect twigs with leaves and fruit.

6. Collect enough plant material to ensure adequate material for identification.

7. While in the field, temporarily store specimens in plastic bags labelled with the species name or pseudonym and the site information described in the pre-sampling reconnaissance section. If specimens are extremely wet, place them in paper bags or wrap in newspaper before storing in plastic bags.

The steps in pressing specimens are:

1. Standard 30 X 45 cm (12 X 18 inch) plant presses will be used.

2. Clean the dirt off the plants before placing them in a press.

3. Place the plants in a sheet of folded newsprint.

4. Lay the plants flat, avoid overlapping plant parts, and spread leaves, flowers, and fruits so they will be easily seen.

5. Bend long plants sharply so they fit within the frame. Do not curve or twist the stems.

6. Pad areas around thick stems with layers of newspaper so no air pockets remain.

7. Write the date, the site number, the area of the wetland or transect number, and the plot number (if applicable) from which the specimen was collected on the margin of the newsprint and attach an identifying tag with the same information to the stem of each plant.

8. Stack the plants in folded newsprint in the press by inserting the newsprint between blotters and separating the "blotter-newsprint sandwiches" with corrugated cardboard. The corrugations of the cardboard should run parallel to the shorter dimension (12 in.) for better air circulation in the press. Use two adjustable straps to firmly hold the plant press and its contents. It should not be possible to move the blotters or cardboards from the side in a properly tightened press.

Botanists and Recorders, if time permits, may wish to key non-graminoid unknowns while still in the field because it is frequently easier to key fresh specimens than dried material. Such plants should still be collected and pressed for later validation. Local floras and hand lenses should be used for field identifications.

WETLAND MORPHOLOGY FIELD METHODOLOGY

Data on wetland morphology are collected by measuring the relative elevations of points along transects to provide cross-sectional profiles of each wetland. A transit and stadia rod will be used to measure relative elevations. The transit establishes a plane over the ground at eye level, and the stadia rod measures how far the earth is below that plane. Therefore, as the stadia rod is moved downhill, the numbers read from it will increase. Because we are concerned with relative elevations, we will use the lowest reading per site (not per transect) as zero and calculate elevations relative to that point.

The Survey Team will use procedures to help assure precise data, e.g., hold a pencil on the rod to double-check a reading, and use consistent hand signals and the walkie-talkie radios to indicate if the rod is not vertical or should be moved.

Equipment

Transit & Tripod
Stadia Rod
Data Forms
Pencil
"Walkie-Talkie" Headphones
Pouch for carrying retrieved plot markers

Getting Started

1. If possible, set up the transit in a location that will allow all transects to be surveyed from one location. If the transit must be moved during surveying, carefully follow the instructions for "turning" (below).

2. Set up the tripod and mount the transit. Follow the instructions for setting up the transit in the section on General Site Data.

3. Establish a "benchmark" to use as the reference elevation. A solidly anchored natural feature, such as a stump, can be used, or one can create a reference point by driving a stake firmly into the ground. The benchmark must be visible from all transit locations. Keep this in mind if turns are required. Take a reading on the benchmark at the beginning and end of each transect, and before and after each turn. If the difference in benchmark readings at the beginning and end of a transect is greater than 0.01m (1cm), re-shoot the elevations for that transect.

4. The Surveyor with the stadia rod must hold the rod vertically, and, if the rod is extended, ensure that the extension set screw is tight and that the extension is seated properly against the stop. If the stadia rod is vertical, the telescope cross-hairs will appear exactly parallel to the stadia rod markings. Therefore, it is the Transit Operator's responsibility to indicate whether or not the stadia rod is vertical and correct the positioning through hand signals and the use of the walkie-talkies.

Collecting Wetland Morphology Data

Relative elevations, water depths, and data on bare ground, open water, or vegetation at the sampling points will be collected along all sampling transects by the Survey Team.

1. The Crew Leader, with input from the Botanists and Surveyors, establishes the transect locations and directs the Recorders in marking the transect beginning points with flagged stakes (see Transect Establishment).

2. The Surveyors carrying the stadia rod attach a meter tape to the stake that marks the starting point of the Wetland Morphology Transect and extend the meter tape as they advance the stadia rod across the wetland to sample. For the Site Characterization Transects, the Vegetation Teams will have left the meter tapes in place after they have sampled the vegetation and inserted flagged wire pins as plot markers along these transects. The Surveyors with the stadia rod advance along the meter tape in the same direction as did the Vegetation Teams along the Site Characterization Transects.

3. Record the first elevation measurement at "0m" on each transect (at the starting point). Place the stadia rod directly to the right of the meter tape at the starting point and hold it vertically until the transit operator signals that the stadia rod can be moved to the next sampling point. To reduce bias, sampling intervals along the transects will be determined systematically by the size of the wetland (see Transect Establishment). The same sampling interval will be used on all transects at a site. This interval MUST be recorded on all data sheets, and, it is IMPERATIVE that the same sampling interval be used by all teams so that data can be correlated during analysis.

4. The Transit Operator measures the elevation at each sample point by sighting the stadia rod through the transit telescope and recording the stadia reading of the center cross-hairs on Form F-10.

5. The Surveyor holding the stadia rod relays information via the "walkie-talkie" headphones to the Transit Operator. This information includes water depth measurements, the type of land cover occupying the sampling point (vegetation, barren ground, or open water), as well as general information such as where the edges of inundated areas occur, where obvious changes in vegetation composition occur, locations of landmarks, etc. This additional information is recorded by the Transit Operator in the appropriate sections of Form F-10.

6. If the stadia rod is moved out of the sight of the Transit Operator, a "turn" must be made. Before "turning", the Transit Operator must check to see that the transit is level and record the benchmark elevation. The procedure for "turning" is described in the following section. Document "turn" information on the back of Form F-10.

7. After completing all measurements along the Wetland Morphology Transect, measure elevations along the Site Characterization Transects and along the Vegetation Transects, if they are used for the site. All data gathered on the Site Characterization and Vegetation Transects MUST be made within the vegetation plots that were sampled. Therefore, it is extremely important that the meter tapes are left exactly in place, and that the stadia rod be placed within the vegetation sampling points. To facilitate this, the Recorders will have placed flagged wire pins along the transect at the lower right hand corner of each vegetation sampling plot. Place the stadia rod directly to the right of the meter tape and wire pin as you are facing toward the end of the transect, so that it touches the wire pin. After recording elevation data at each sampling point, retrieve each wire pin and carry them along the transect. You should be carrying a pouch or pack for this purpose. To avoid trampling vegetation before the Botanists have sampled, the Surveyors must follow the Vegetation Teams during sampling.

8. After all measurements have been made on each transect, take a reading of the benchmark. This reading must not differ from the first benchmark reading by more than $\pm$ 0.01m. Do this BEFORE dismantling the tripod. Show on the back of Form F-10 all benchmark readings and calculations. If the error is greater than $\pm$ 0.01m, reshoot all points measured since the last accurate benchmark check. To correct data on Form F-10, put a single line through the incorrect entry and write the correct entry above it.

9. If transects are interrupted by deep water, distance to the transect start and endpoints or the far side of the water must be determined. Therefore, upper and lower stadia readings must be made for these points and recorded on the back of Form F-10.

10. After all elevation measurements have been made for the entire site, calculate the relative elevations for all sampling points on the site -- NOT PER TRANSECT.

    a. Determine the lowest point on the site. This point corresponds to the largest stadia rod reading for the site. The stadia rod reading at this point becomes the "vertical offset" for all calculations.

    b. For each measurement, subtract the stadia rod reading from the vertical offset to determine the relative elevation for each sampling point.

    c. Leave all original stadia rod readings on Form F-10 as a data check, as well as any notes.

Turning with the Original Benchmark

If the transit operator cannot see all sampling points from the transit location, the transit must be moved. This procedure is referred to as "making a turn" or "turning".

1. BEFORE moving the tripod, take a reading of the original benchmark and record it on the back of Form F-10.

2. Determine if the original benchmark will be visible from the tripod's new position. If so, continue to use the same benchmark. If not, follow the steps in the next section for "Turning with a new Benchmark".

3. Move the tripod to its new position, set it up and level it.

4. Take a reading of the benchmark from the new position and record it on Form F-10. Then continue to measure the elevations of the sampling points.

Turning with a New Benchmark

If the original benchmark is not visible from the new tripod position, a new benchmark must be established. It is important to take and record a final reading of the first benchmark and a reading of the new benchmark BEFORE MOVING THE TRIPOD. This enables the new "eye level plane" to be correlated with the previous one, so that elevations read after the tripod is moved will correspond to those read earlier. The procedure is:

1. Record the elevation of the original benchmark.

2. Determine the new benchmark and record its elevation.

3. Move the tripod to its new position, set it up and level it.

4. Take another reading of the new benchmark and record it. This reading gives you the new eye level plane.

5. Continue to record the elevations of the remaining sampling points.

Adjusting the Eye Level Plane

If only one benchmark was required, the elevations calculated from measurements made after moving the tripod must be correlated with those measurements made before moving the tripod.

1. Determine the difference between the benchmark readings by subtracting the smaller reading from the larger. For example, the last reading of the benchmark before the tripod was moved was 5.15 m. The elevation measurement of the benchmark after the tripod was moved was 3.74m. This means the tripod was moved 1.41m downhill (5.15 - 3.74 = 1.41.). The new eye level plane is 1.41m lower than the first (Figure 8-21a).

2. Adjust the relative elevations of the sampling points measured after the tripod was moved by adding 1.41m to each.

If more than one benchmark is required, the procedure for adjusting your eye level plane is:

1. Calculate the difference between the last reading of the original benchmark and the reading of the new benchmark taken before moving the tripod. For example, the last reading of the original benchmark was 5.15m. The reading for the new benchmark is 4.04m. Therefore, the elevation of the new benchmark is 1.11m higher than the original benchmark (5.15 - 4.04 = 1.11).

2. Calculate the difference between the readings taken of the new benchmark before and after moving the tripod. For example, the reading of the second benchmark after moving the tripod is 6.32m. This means that the new eye level plane is 2.28m higher than the previous plane (6.32 - 4.04 = 2.28) (Figure 8-21b).

3. When calculating relative elevations for the site, the change in eye level plane must be considered. Using the example above, 2.28m must be subtracted from each calculated relative elevation measured after the turn.

SOILS AND HYDROLOGY FIELD METHODOLOGY

Soils will be sampled and characterized on a randomly selected set of plots in each wetland; plot selection protocols are designed to provide characterization of a representative sample of soils in each wetland. A total of 15 plots will be described and sampled in each wetland, three on each of the five Site Characterization Transects.

Figure 8-22 provides a flow chart showing the sequence of field sampling activities to be used. Based on the presence/absence of standing water and an evaluation of soil conditions, one of several alternative soil sampling procedures will be selected. Sampling at each plot will include three types of data collection:

1. Visible soil physical characteristics, such as horizon depths, color, and presence of anthropogenically-introduced materials will be described. If possible, soil pits will be excavated to a depth of 0.5m. Alternatively soils will be sampled using a core sampler, bucket auger, or by inserting a core by hand and rapping the bottom in situ.

2. Soils from two depth intervals (0-5 and 15-20cm) will be sampled and returned to the laboratory for analysis of organic matter content;

3. A limited amount of hydrologic information will be collected. At soil plots with standing water, the depth will be measured; at plots without standing water, depth to saturated soils and to the free water surface (if they occur at a depth of < 50cm) will be measured.

General Considerations in Soil Descriptions and Sampling

1. Sampling and Characterization will be conducted by the Survey Team. Teams include three members with interchangeable duties. Soil sampling and characterization will be done concurrently with measurement of basin elevations and water depths along Site Characterization Transects.

2. Soil sampling -- digging of pits, sampling of soils, and characterization -- must not be done until after the Vegetation Teams have completed all activities on a plot, to avoid trampling and other disturbance of vegetation.

3. All measurements will be reported in metric units - centimeters and meters. All depth measurements are made from the ground surface, below living vegetation or litter.

Equipment and Supplies

Field data sheets - Form F-11 (5 copies per wetland)
Soil sample bags (2 per plot, with labels)
Pencil and waterproof marking pen
Sharpshooter shovel
Bucket auger (7.5 or 10 cm diameter)
Core samplers (2.5 cm diameter)
Core sampler liners and caps
Knife, with long blade
Munsell color chart with gleyed color page
Two 0.5m rulers (or cut down meter sticks)
Ice chest with ice and rack to hold sample tubes
Squirt bottle with water for cleaning (filled with clean tap water)
Paper towels
Handi-wipes (or equivalent) for cleaning hands and equipment

Field Sampling Procedure

Soil sampling will be the final activity conducted by the Survey Teams at each sample point. Notify the Crew Leader if there are questions or problems associated with any of the soil sampling activities. Soils will be described and sampled at three locations on each of the five Site Characterization Transects.

1. At the start of each transect, determine the number of plots on the transect. The Crew Leader will identify three of the plots for soil sampling using a list of random numbers. Record the three plot numbers on Form F-11, and characterize soils and hydrology on only those plots.

2. Fill out the heading information at the top of Form F-11.

3. Upon completion of sampling by the Vegetation Team on the transect, locate plots for soil sampling during the pass along the transect to measure elevations.

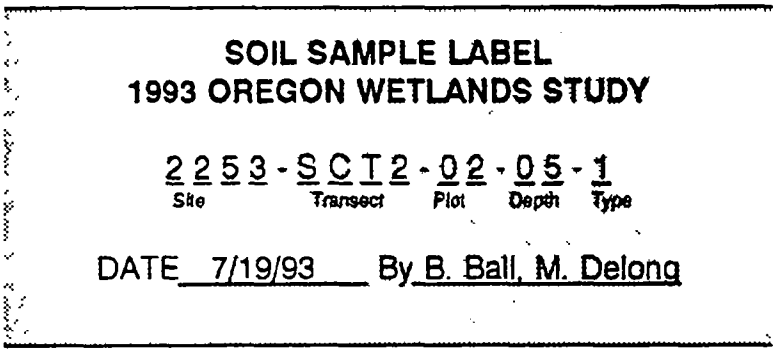
4. Depending on soil and water conditions at the plot, soils may be sampled by excavating a pit, using a bucket auger, or by using one of two types of coring devices. The choice of sampling procedures is discussed below. One of four alternate procedures will be used to sample soils on each plot. For samples

collected from a soil pit (Procedure A) or using a bucket auger (Procedure C), collect 75-100 grams of soil to insure that there is adequate material for laboratory duplicates or reanalysis (if necessary).

5. Label sample containers -- two bags for each plot if soils will be collected from a pit or using a bucket auger; a single label for core tubes. Be certain that labels are written using pencil or waterproof ink, and double check to be certain that all information on the labels is correct. Sample bags should be labelled as described below; cores labels will be the same, except that "99" should be entered on the form for sample depth, and the entire depth interval represented by the core should be recorded separately. Each sample should be labelled with the sampling date and a 13 digit code that includes:

   - characters 1-4 -- wetland number
   - characters 5-8 -- transect number
   - characters 9-10 -- plot number for each transect
   - characters 11-12 -- depth (lower limit of sampling interval, i.e., 5 or 20 cm)
   - character 13 -- sample type (1 for routine, 2 for a field duplicate (QA sample), 9 for other (note in comment field))

   As an example, 2253-SCT2-02-05-1 would be the code for a sample taken from wetland 2253, transect SCT2, plot 02, depth 0-5 cm, for a routine sample (code 1). Note that transect numbers and depth should be right justified, with a zero in any extra space.



SOIL SAMPLE LABEL
1993 OREGON WETLANDS STUDY

2253-SCT2-02-05-1
Site Transect Plot Depth Type

DATE 7/19/93 By B. Ball, M. Delong

6. After completing soil sampling on each plot, check to be certain that data forms have been completely filled out and are legible, and that samples are properly labelled (see code in step 5). Information on water depths in soil pits will only be filled in for plots where pits are dug; color and presence/absence of hydrogen sulfide will not be determined for samples collected in cores. Be sure to note deviations from routine procedures, problems with equipment or supplies, etc. Notify the Crew Leader if you have questions or if there are problems with sampling or equipment.

7. After completing soil sampling on each plot, clean all equipment to prevent contamination of soils on subsequent plots.

8. After completing each transect, replenish supplies as needed, and place samples in a cooler for return to the laboratory. Core tubes should be handled as carefully as possible to avoid mixing or other disturbance, and should be placed in a rack in the cooler. Core samples should be frozen as soon as is practical, and should remain frozen until laboratory analysis.

Upon arrival at each plot, determine whether standing water is present. If water is not present, follow the instructions for Procedure A. If standing water is present, enter "surface" in the space for depth to standing water on Form F-11, and select one of the alternate sampling procedures. For plots with standing water, there are three alternatives for soil sampling (in order of preference, corer, bucket auger, manually collected core). The choice among these ultimately is subjective, and depends on the nature of the substrate, presence and density of roots.

Evaluate soils on the site -- how dense is the material, how well consolidated, how much coarse material (stones, woody material, heavy roots or rhizomes) is present. The preferred alternative is to use the core sampler (Procedure B). In soils that are compacted, contain coarse materials (e.g., rock fragments, woody material), or are heavily ingrown with roots, it may be necessary to sample using a bucket auger (Procedure C). Finally, in wet, unconsolidated soils, it may be necessary to manually insert a core tube in the soil and cap both ends before removing it from the soil (Procedure D). Note the type of sampling device used on Form F-11. For all sampling procedures, if a rock, log or other impenetrable material, move 10-20 inches to the left along the transect and make a second attempt to collect a sample.

Procedure A. Excavation of soil pit

1. Excavate a pit approximately 25-cm wide and 50-cm deep. Using the knife, carefully clean the soil on one face of the pit to remove plant tissue, soil transferred from other depths, etc. Note that in some cases, a rock, log, a cemented horizon, or similar impenetrable material may be encountered at a depth of <50cm. In such instances, excavate the pit as deep as possible, describe and sample soils as the depth of the pit allows, and note the occurrence and depth to bedrock or the cemented horizon.

2. Using the sharpshooter shovel, excavate and remove an intact slab of soil from the clean pit face. Lay the shovel and slab carefully on a clean sheet of plastic. If the presence of water in a pit precludes sampling of a slab of soil to the 50cm depth, excavate a slab as deep as is practical; if necessary, sample subsoils using a corer or bucket auger as described in Procedures B and C.

3. If the pit contains standing water, measure the depth to the water surface; note the depth and time in the space for initial depth to standing water on Form F-11. If no standing water is present, enter "NP" (not present).

4. If soil at the margin (edge) of the pit are saturated with water, record the depth to the saturated layer. Saturation will be indicated by a sheen or glistening of the soil. At or below the depth of soil saturation, water may also be oozing from the soil into the pit. On Form F-11, record the depth to saturation and to the free water surface (where there is a visible flow of water).

5. Carefully examine soils in the pit and in the excavated slab; identify and describe pertinent features in each horizon on Form F-11, including:

   - presence of, and upper and lower depth for, each soil horizon. Horizons will be identified by changes in soil color and texture, or by changes in the presence/absence or abundance of mottles or concretions.
   - the size, nature, and abundance of stones, gravel, woody material in each horizon;
   - presence and abundance, in each horizon, of mottles, gleyed soils, iron and/or manganese concretions/stains;
   - color of the soil matrix and of mottles in each horizon (using the Munsell color chart);
   - presence and abundance of living roots and oxidized root channels;
   - presence of hydrogen sulfide. At several depths in each horizon where there is evidence of reducing conditions (e.g. gleying, mottles), remove a small piece of soil from the pit (or excavated slab); crush it between thumb and forefingers and smell it to determine whether hydrogen sulfide (rotten egg odor) is present. Note depths at which hydrogen sulfide is present;
   - presence and nature of any additional natural or anthropogenic features in any horizon (or at any discrete depth). Examples might include a buried horizon or buried organic material, presence of straw or other introduced organic material.

6. Using a clean knife, remove any foreign material (bits of vegetation) and carefully sample soils from the slab at two depths -- 0-5 and 15-20cm. Each sample should be representative of material for its respective depth interval. Place each sample in a clean, pre-labelled bag. Check labels to verify that the code for each sample is complete and correct. Wipe the knife clean between samples.

7. 30 minutes after completing sample collection and description, remeasure the depth to standing water in the pit; record the depth and time in the space for final depth/time on Form F-11.

8. Check to be certain that all information has been recorded on data forms; return the excavated slab to the pit; refill the pit and replace vegetation.

Alternate Procedure B. Core sampler

1. Detach the corer handle, and place a clean tube in the corer and reattach the handle. Fill out and verify information on a data label (i.e., the sample identification including wetland, transect, and plot numbers) prior to sample collection.

2. Remove litter and live vegetation from the soil surface (cut at ground level so vegetation will not contaminate sample soils; do not remove roots).

3. Insert the corer into soil as deeply as possible (but not more than 50 cm). Minimize disturbance to material in the core due to lifting, tipping, or twisting of the corer during sampling.

4. Withdraw the sampler, remove the handle and attach a cap on the upper end of the tube, then withdraw the core tube and carefully place an end cap on the lower end of the tube. Wipe the sides of the tube clean, and examine the tube contents. If the tube shows evidence of significant disturbance during sampling, discard the sample and repeat sample collection.

5. If the integrity of the sample in the tube is satisfactory, describe, as completely as possible, horizon depths, presence of gleying, mottles, etc. in step 5 of Procedure A. Colors determined for materials through the core tube may not be reliable, so do not spend time trying to determine color for these samples. Attach the sample label, and record the depth interval for the core on the sample label and in the space for comments on Form F-11.

Alternate Procedure C. Bucket Auger

1. Remove litter and live vegetation from the soil surface (cut at ground level so vegetation will not contaminate the sample; do not remove roots).

2. Use the auger to collect a sample from the 0-5 cm depth, and place it in a pre-labelled bag.

3. Auger a second hole to a depth of 20 cm, remove the auger and soil from the hole, and carefully extrude the soil onto a clean piece of plastic. Separate material from the 15-20 cm depth interval, and replace material from other depths in the hole. Recognize that sampling may distort the depth of the extruded material (by compaction during sampling or crumbling of material

when it is removed from the auger); if this occurs, estimate the depth as well as possible and make a note in the comment field on Form F-11.

4. Remove stones, roots and other foreign matter, then place a sample in a pre-labelled bag.

5. Using the auger, dig a third hole in the soil to a depth of $\geq$50cm; remove the soil and auger and carefully lay soil on a sheet of clean plastic. Clean the surface of the sample to remove vegetation and soil from other depths, and describe the occurrence, depth, and characteristics of soil horizons as described in step 5 under Procedure A. Replace soil in the hole after completing the description.

Alternate Procedure D Core collection by hand insertion of a core liner

1. Sample material by manually inserting a core liner into the soil to a depth of 25 cm (or as deep as possible if less than 25 cm).

2. Cap the top of the core, then reach into the soil/sediment and place a second cap on the lower end of the tube. Insertion and capping should be done in such a way as to minimize disturbance of the soil column that might cause disruption and mixing of the soil.

3. Carefully remove the core from the soil, with a minimum amount of tipping or twisting of the tube

4. Prepare a label for the core; record the depth interval for the core on the sample label and in the space for comments on Form F-11.

Table 8-1. Methods used for data collection in the Oregon Wetlands Study.

Variable	Units	Method
SITE		
Mapping	meters	Transit stadia rod--distance and bearing from transit to stadia rod placed at wetland boundary points
Elevations	cm	Transit and stadia rod--elevation markings on stadia rod indicate ground level in relation to "eye-level plane" of transit
Buffers		
presence	N/A	Visual determination of presence and type of buffer
size	meters	Width of buffer measured via transit and stadia rod or meter tape
VEGETATION		
Plant species identification	taxonomic binomials (genus & species names)	1)Identification by an experienced botanist 2)Keying plant with local floras
Plant species abundance % cover of herbaceous species	percent	Visual estimation of percent canopy cover of all herbaceous species and of shrubs and tree seedlings <2m tall within $1m^2$ quadrats
% relative cover of shrubs	percent	Line-intercept method for measuring cover of all shrubs and of trees <2m tall occurring along sampling transects

Table 8-1. Cont.

Variable	Units	Method
VEGETATION (con't)		
% relative cover of trees	percent	Basal area of all trees >2m tall encountered within 2m wide belt transects
% bare ground	percent	Visual estimation of percent
% standing water	percent	Visual estimation of percent
SOIL		
Soil organic content (loss on ignition)	percent dry weight	Dry ashing
Soil color	Munsell units	Visual matching using Munsell charts
Presence of:		
mottles	presence/absence and	Visual inspection
gleying	percent relative	"
concretions	abundance	"
oxidized root channels	"	"
H_2S	presence/absence	smell
Horizon thickness	cm	Direct measurement (ruler)
HYDROLOGY		
Depth of standing water	cm	Direct measurement (ruler)
Depth in soil pit to:		
standing water	cm	Direct measurement (ruler)
free water surface	cm	Direct measurement (ruler)
saturated soil	cm	Direct measurement (ruler)

Table 8-2. Wetlands to be sampled by the OWS, stratified by wetland origin (natural or project) and land use.

Land Use	Natural	Project
Undeveloped	58	28
Agriculture	22	5
Residential	18	11
Commercial	7	5
Industrial	8	3
Totals	111	51

Table 8-3. Numbers of the freshwater mitigation projects in Portland, Oregon, by wetland type and size required in permits issued by the U.S. Army Corps of Engineers and the Oregon Division of State Lands from January 1987 through January 1991. "?" indicates area unknown.

TYPE	SIZE (Acres)							TOTALS
	0-2	2-4	4-6	6-8	8-10	>10	?	
Marsh	9	5	0	0	0	0	2	16
Pond	24	0	1	0	1	1	12	39
Marsh and Pond	4	1	0	0	0	0	3	8
Marsh and Shrub-scrub	2	2	1	0	0	0	1	6
Marsh and Forested	0	0	0	0	0	0	1	1
Marsh, Shrub-scrub, and Forested	1	0	0	0	0	0	0	1
Marsh, Pond, Shrub-scrub, and Forested	0	1	0	0	1	1	0	3
Marsh, Pond, Aquatic Bed, and Forested	0	1	0	0	0	0	0	1
Marsh, Pond, and Flooded Grassland	0	0	1	0	0	0	0	1
Pond, and Riparian	10	0	0	0	0	0	0	10
Pond, Forested, and Stream Channel	1	0	0	0	0	0	0	1
Riverine Wetland	0	1	0	0	0	0	0	1
Stream Channel	1	0	0	0	0	0	2	3
Creek Bank	1	0	0	0	0	0	0	1
100-year Floodplain	1	0	0	0	0	0	0	1
Mud Flat	1	0	0	0	0	0	0	1
Unknown	3	0	0	0	0	0	10	13
TOTALS	58	11	3	0	2	2	31	107

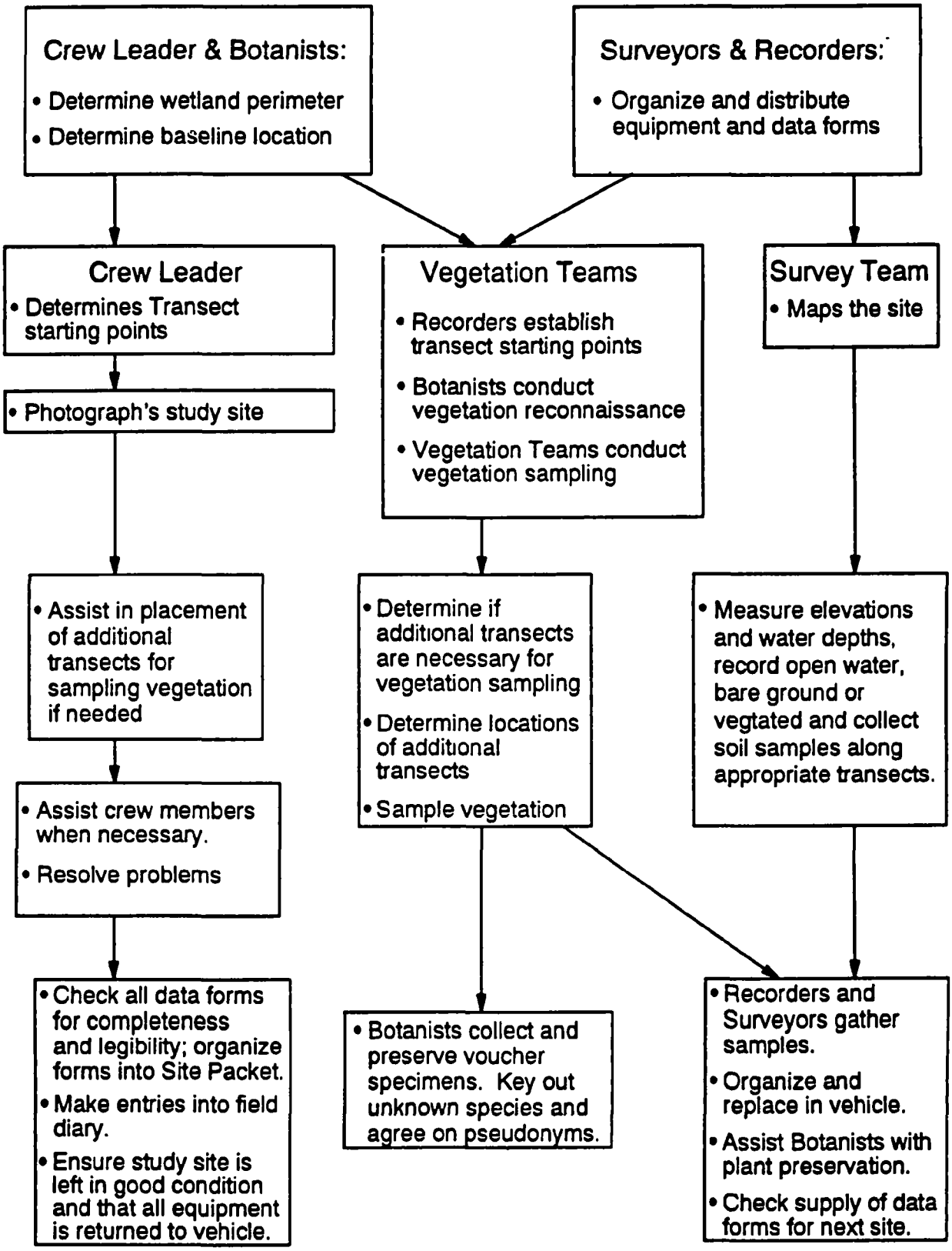


Figure 8-1. Flowchart of field crew member responsibilities and tasks. A Field Crew consists of a Crew Leader, two Vegetation Teams (each composed of a Botanist and Recorder) and one Survey Team (composed of 3 Surveyors).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL RESEARCH LABORATORY
200 S W 35TH STREET
CORVALLIS, OREGON 97333

May 27, 1992

Dear Landowner

U S Environmental Protection Agency's (EPA) Wetlands Research Program is requesting your assistance in a research project being initiated in the Portland Metropolitan Area. In recent years, humans have attempted to create wetlands to replace those destroyed in the process of development. It is still unclear how effectively these created wetlands are replacing the ecological functions of naturally-occurring wetlands. To find out how these created wetlands compare to natural sites, the EPA is looking at a number of created and naturally-occurring wetlands in the area. Your property may contain a naturally-occurring wetland that we would like to include in our study This would require allowing us on your property today to photograph and record some basic features of the wetland (e g., wetland type and size, percent open water and vegetation, and surrounding land uses)

If the wetland on your property is the type and size selected for our study, a field crew would return to the site next summer (1993) for sampling They should not be on your property for more than half a day. We will notify you of the exact day of the sampling as soon as we determine the final schedule. The field crew (consisting of 7 people) will set up temporary markers (wooden stakes), record the elevation of the site with a transit, and take notes on the vegetation. The field crew will dig no more than ten holes, no deeper than 18 inches, to take a soil sample. These samples will be scattered over the site. The field crew will remove the stakes and fill in the holes after they are finished.

It is, of course, totally up to you whether you will permit us to visit the wetland on your property. We hope you will choose to assist us in this important project. Since we are only interested in the summary statistics for the wetlands, information from your wetland will be combined with that of other similar wetlands. All wetlands will be given a code name. Your name and property will not be specifically mentioned in the published results. If you wish, we can add your name to a list of people who receive information on the Wetlands Research Program The results of the study can also be sent to you when they are available; this should be approximately two years after the sampling is complete. Simply inform the bearer of this letter, a member of the field crew, or me of your desire for this information.

Thank you in advance for your consideration and cooperation in this matter. If you have any questions or concerns, please feel free to call me at (503) 754-4478

Sincerely,

Mary E. Kentula

Mary E. Kentula, Program Leader
Wetlands Research Program

Figure 8-2. The letter given to landowners during site selection explaining the Oregon Wetlands Study.

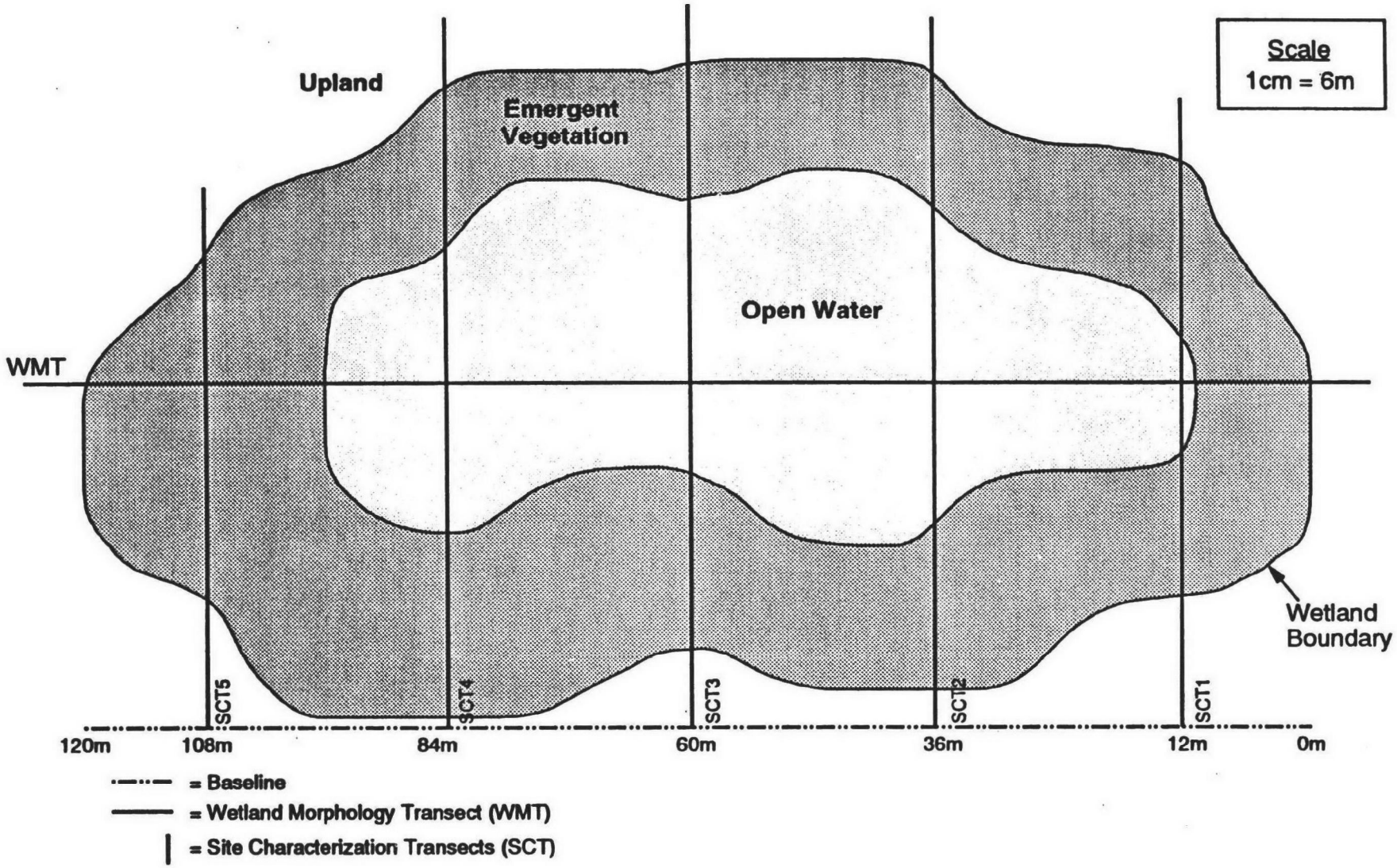


Figure 8-3. Basic transect layout used to sample sites. A Baseline is placed along one side of the wetland and is used to systematically place the Site Characterization Transects. A Wetland Morphology Transect is placed parallel to the Baseline, as near as possible to the center of the wetland. Five Site Characterization Transects originate from and are placed perpendicular to the Baseline. They span the wetland from edge-to-edge and are placed at even intervals along the Baseline. The start and endpoints of the transects are placed one sampling interval beyond the wetland boundary.

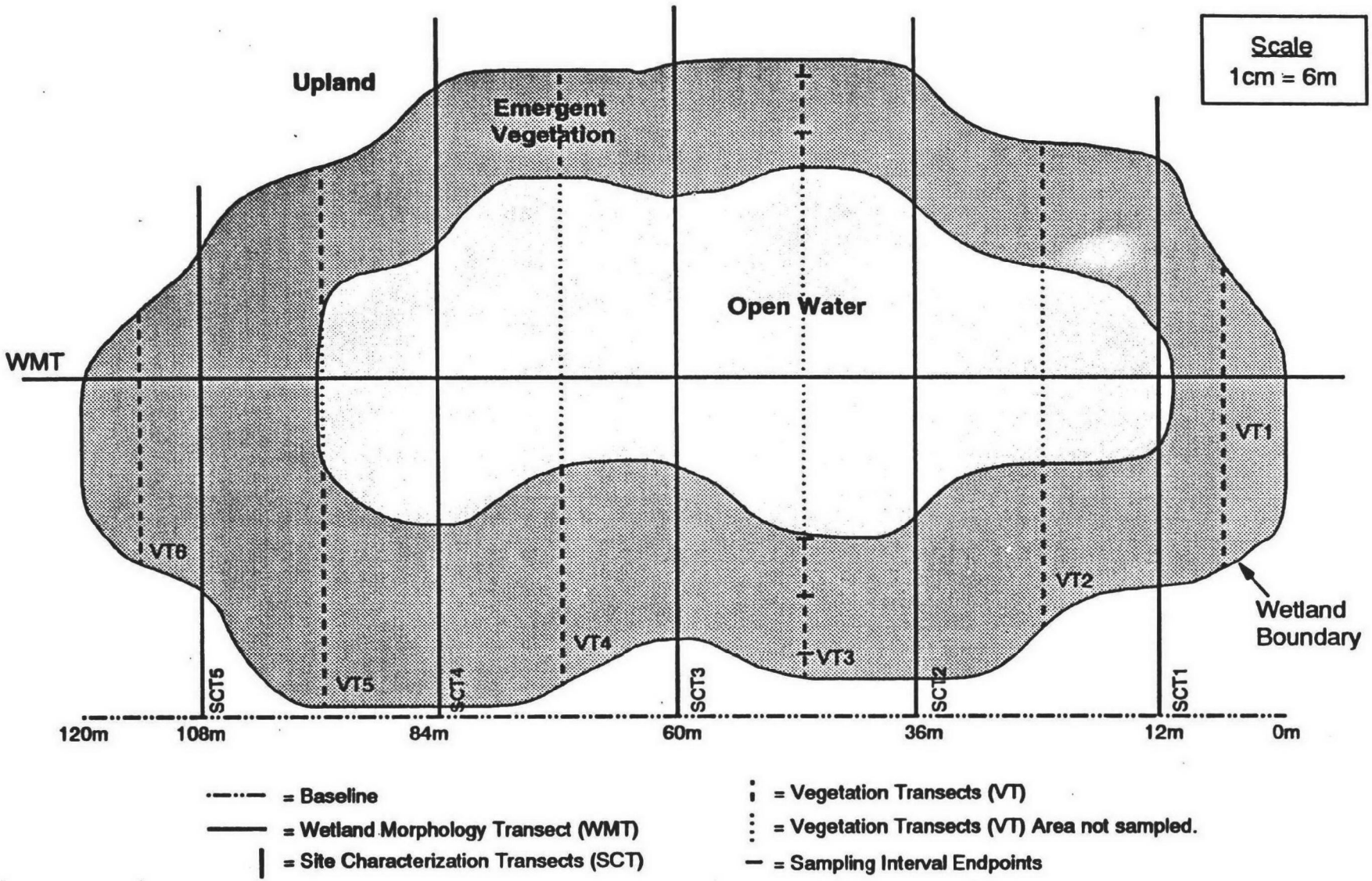


Figure 8-4. Vegetation Transect (VT) placement when the vegetation band is more than two sampling intervals wide. VTs span the wetland from edge-to-edge and are placed at even intervals along the Baseline but sampled randomly in the order determined by rolling a die until the number of transects needed to provide 40 quadrats with vegetation are sampled.

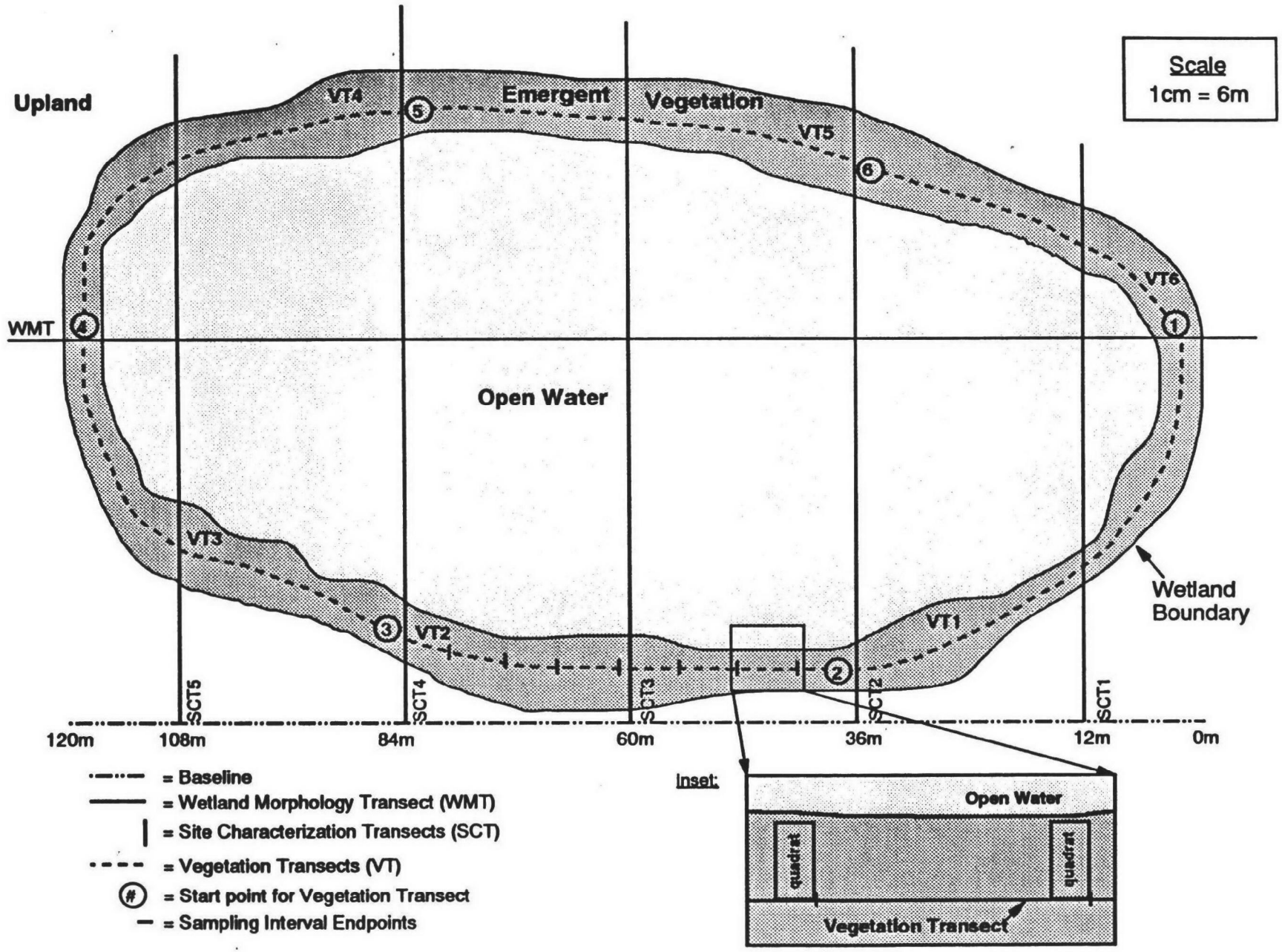


Figure 8-5. Vegetation Transect (VT) placement when the vegetation is less than two sampling intervals wide.

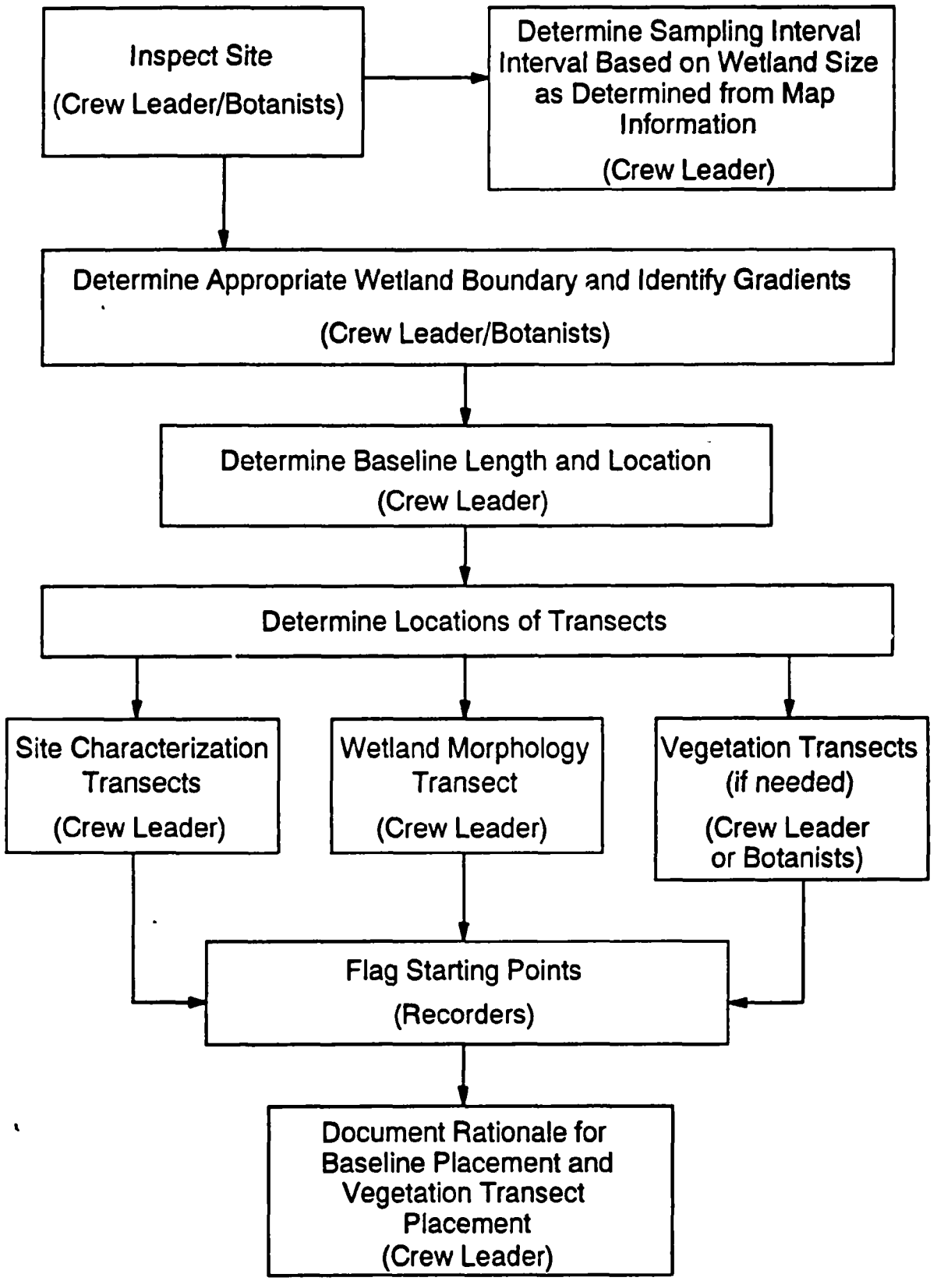


Figure 8-6. Transect Establishment Protocol Flowchart: Crew responsibilities and the order in which sampling tasks must be completed.

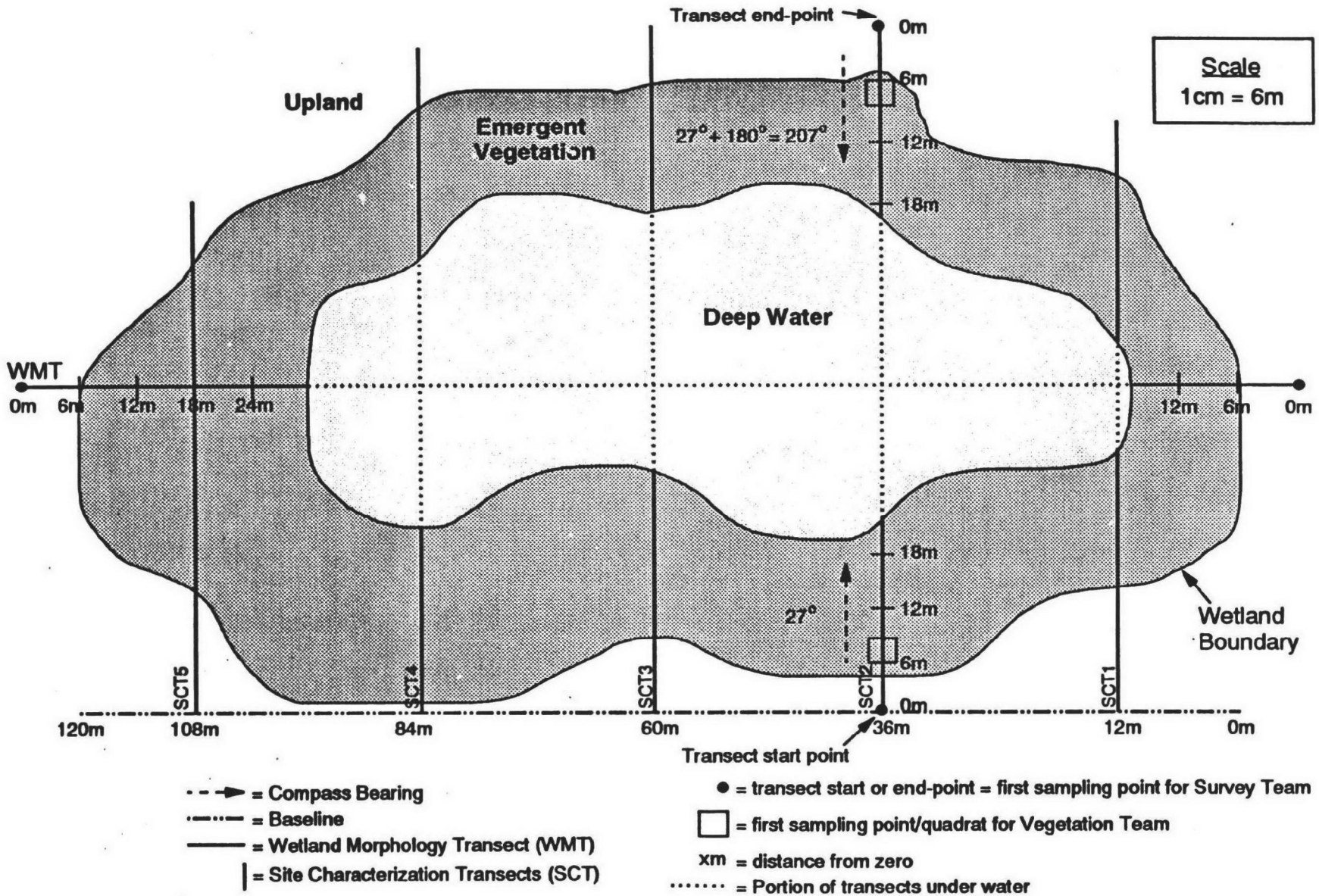


Figure 8-7. Procedure for transect establishment in cases where deep open water interrupts one or more transects.

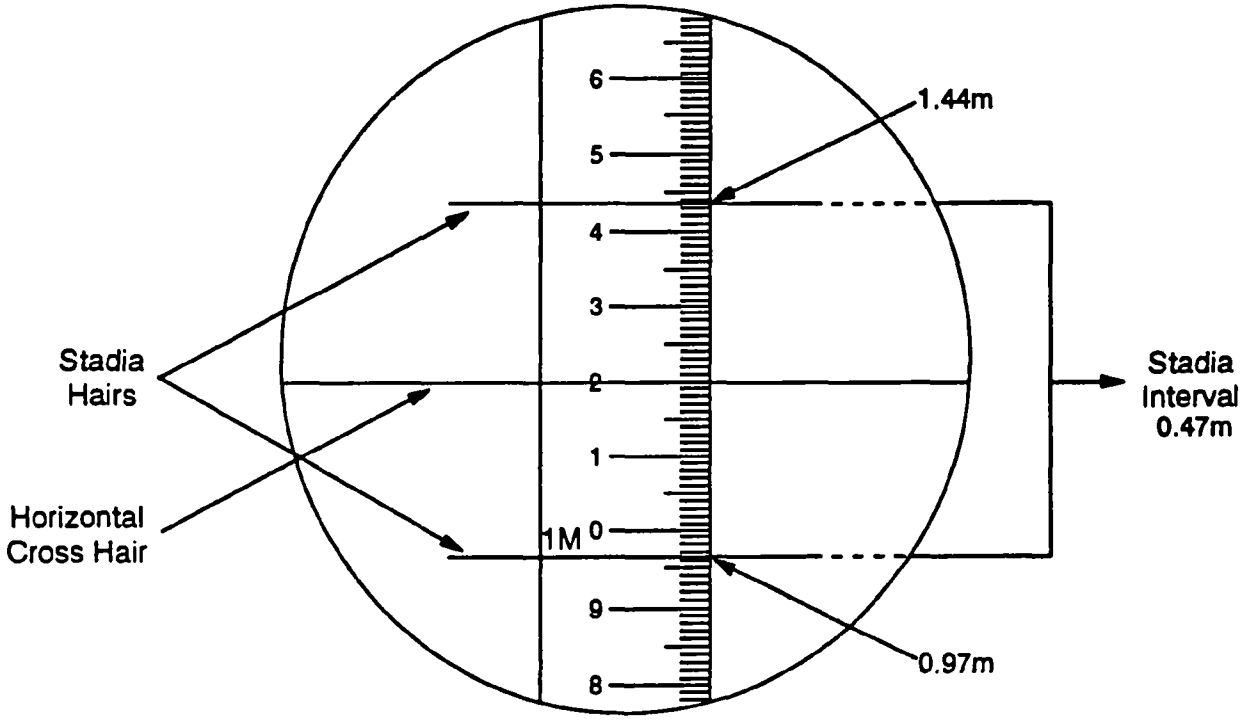


Figure 8-8. A view through the transit telescope showing the Horizontal cross-hair at 1.20m on the Stadia Rod and a Stadia Interval of 0.47m (1.44m - 0.97m = 0.47m). Distance from the transit to the Stadia Rod is 47m (0.47m x 100 = 47m).

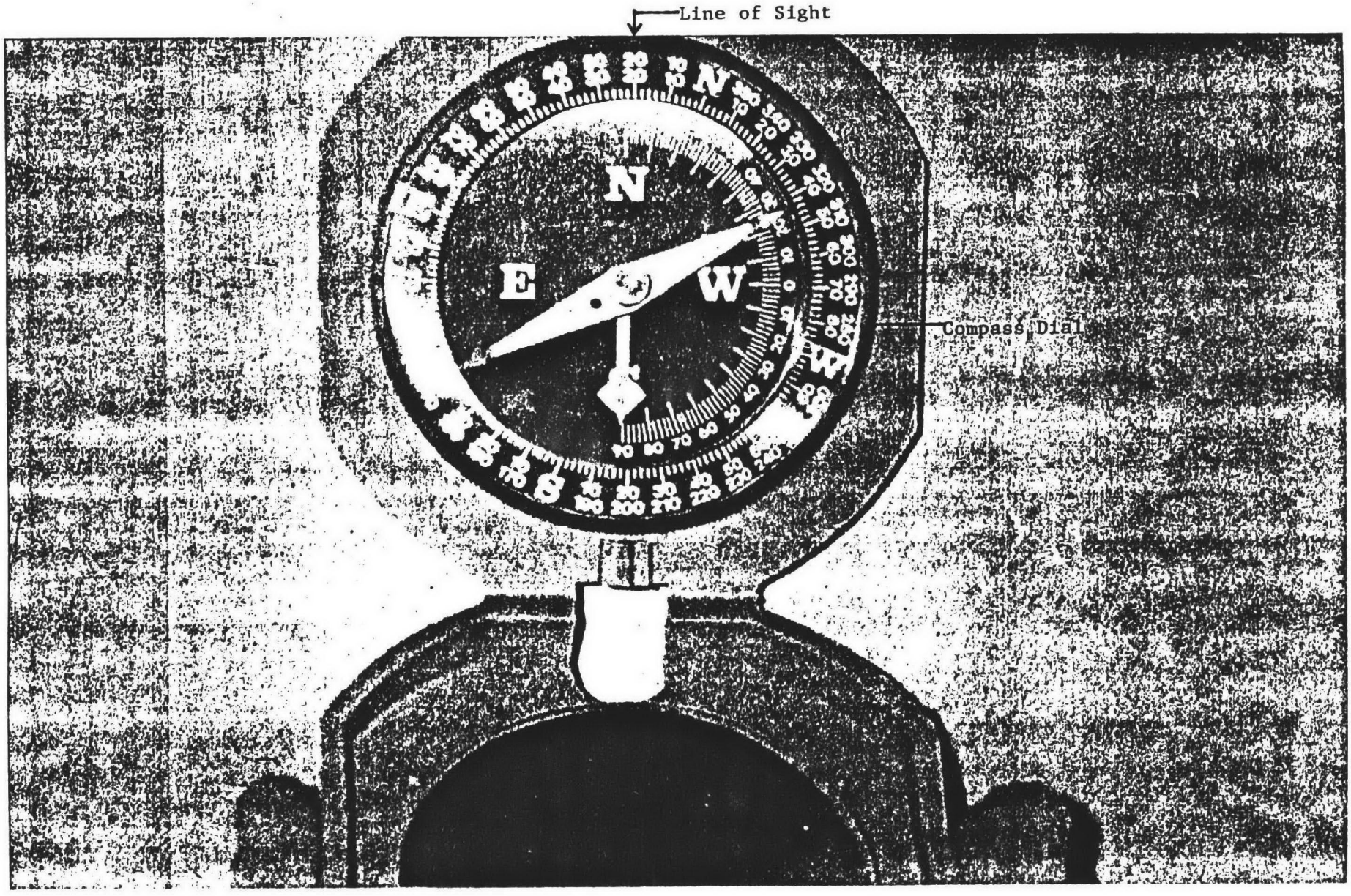


Figure 8-9. Setting the magnetic declination on a compass.

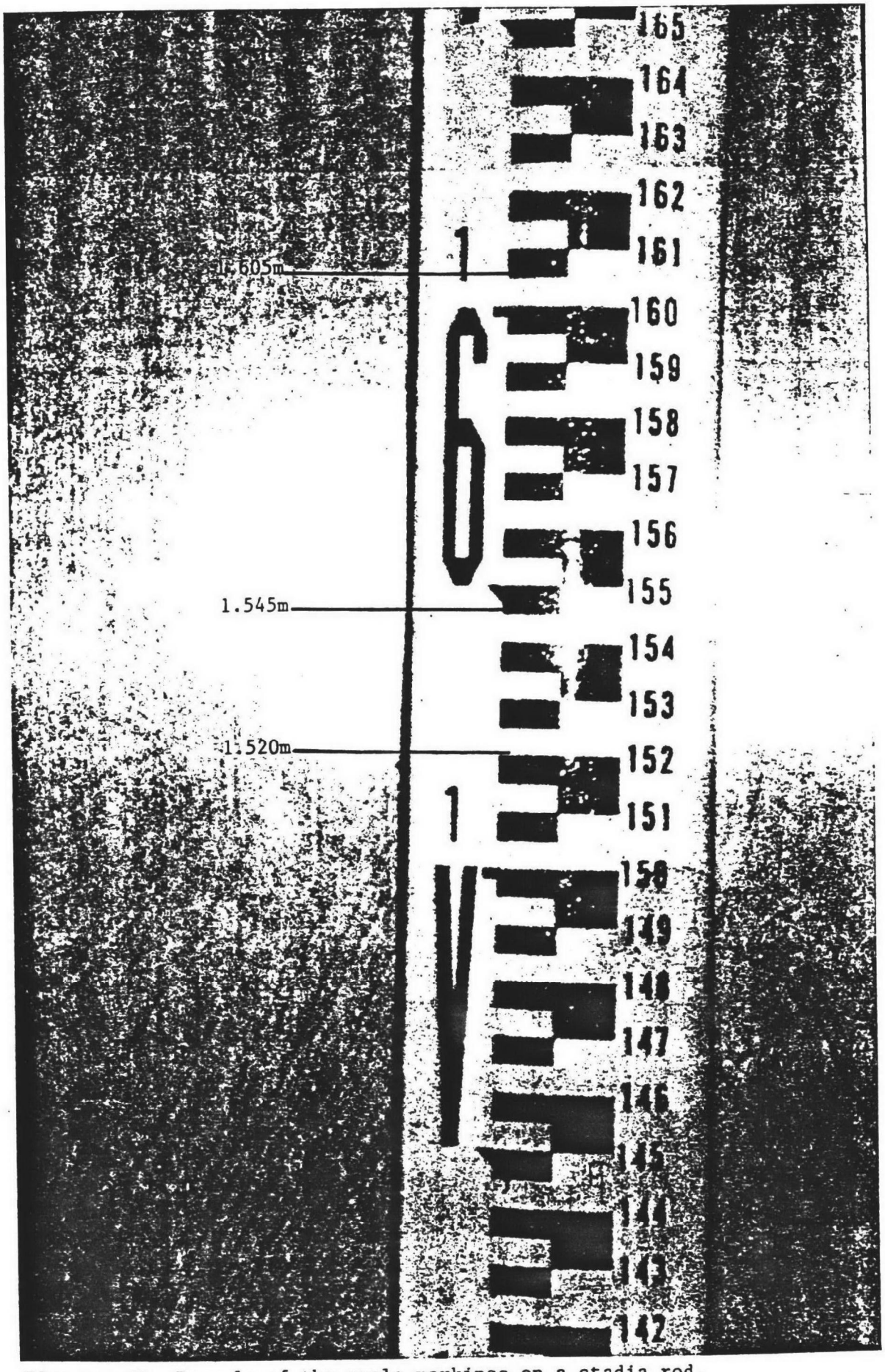


Figure 8-10. Example of the scale markings on a stadia rod.

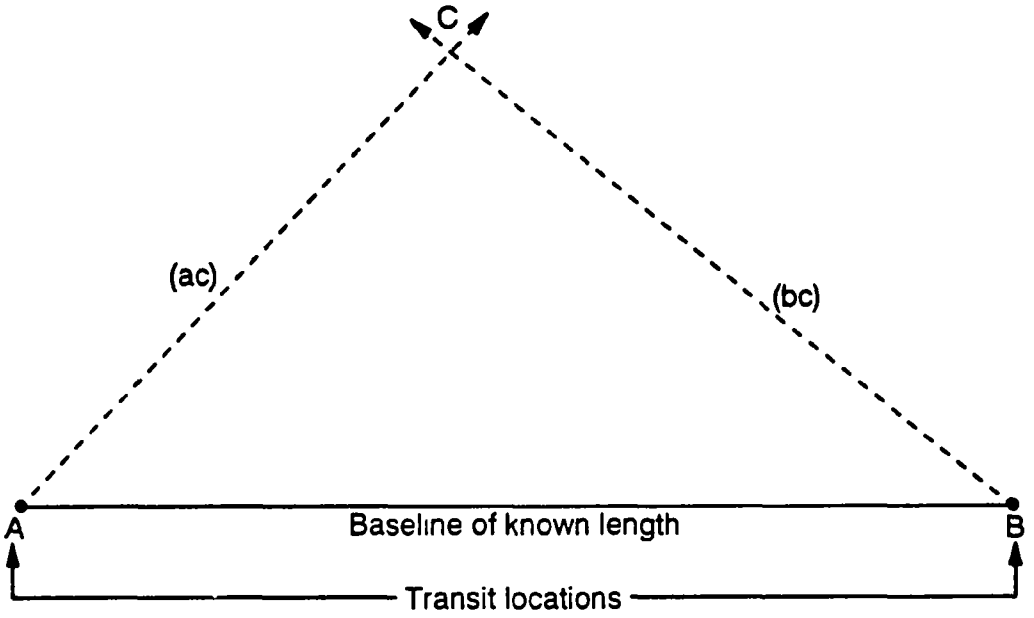


Figure 8-11. Illustration of procedure for triangulation. Triangulation is the process for determining the intersection of two rays originating from the endpoints of a baseline, and therefore, the position of the intersection in relation to the endpoints. A line of sight is made from point A to C (ray ac). A similar sighting is taken from point B to C (ray bc). The location of C is defined as the intersection of rays ac and bc (Lounsbury and Aldrich 1986).

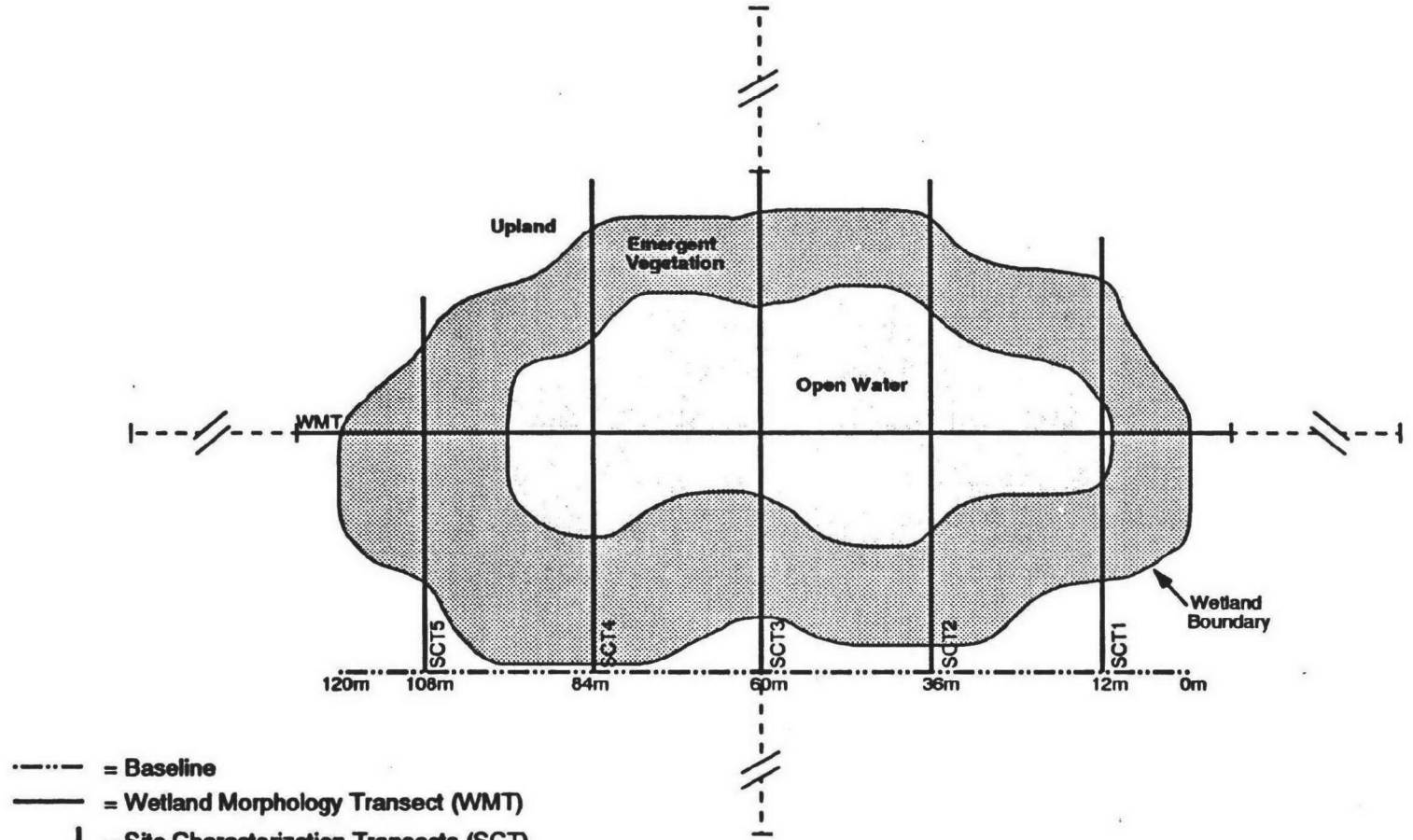


Figure 8-12. Placement of transects for determination of presence, type and width of buffers. Transects will extend 100m outward from the start and end points of the Wetland Morphology Transect (WMT) and the middle Site Characterization Transect (SCT3).

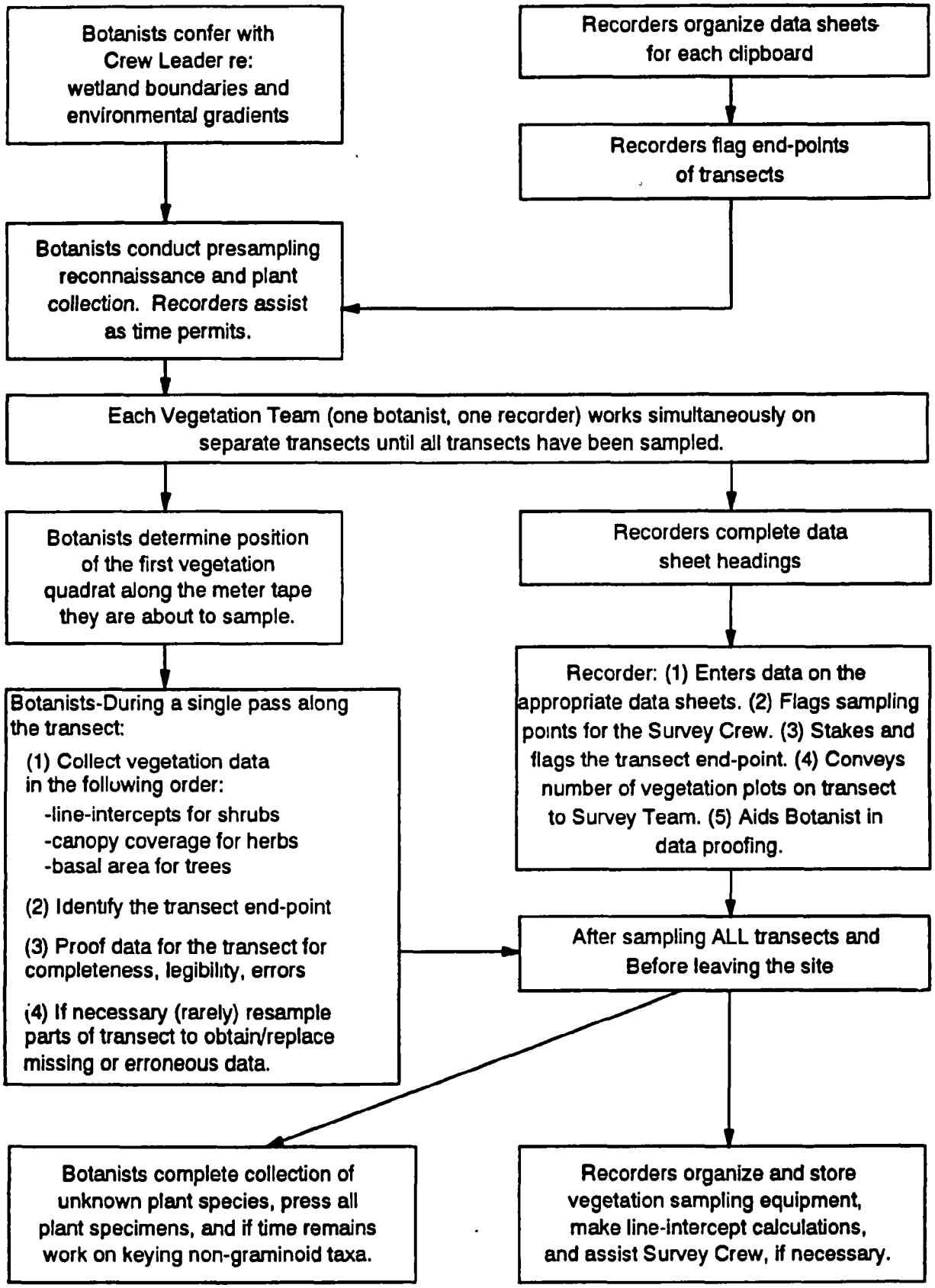


Figure 8-13. Vegetation sampling protocol illustrating order of task completion and crew responsibility.

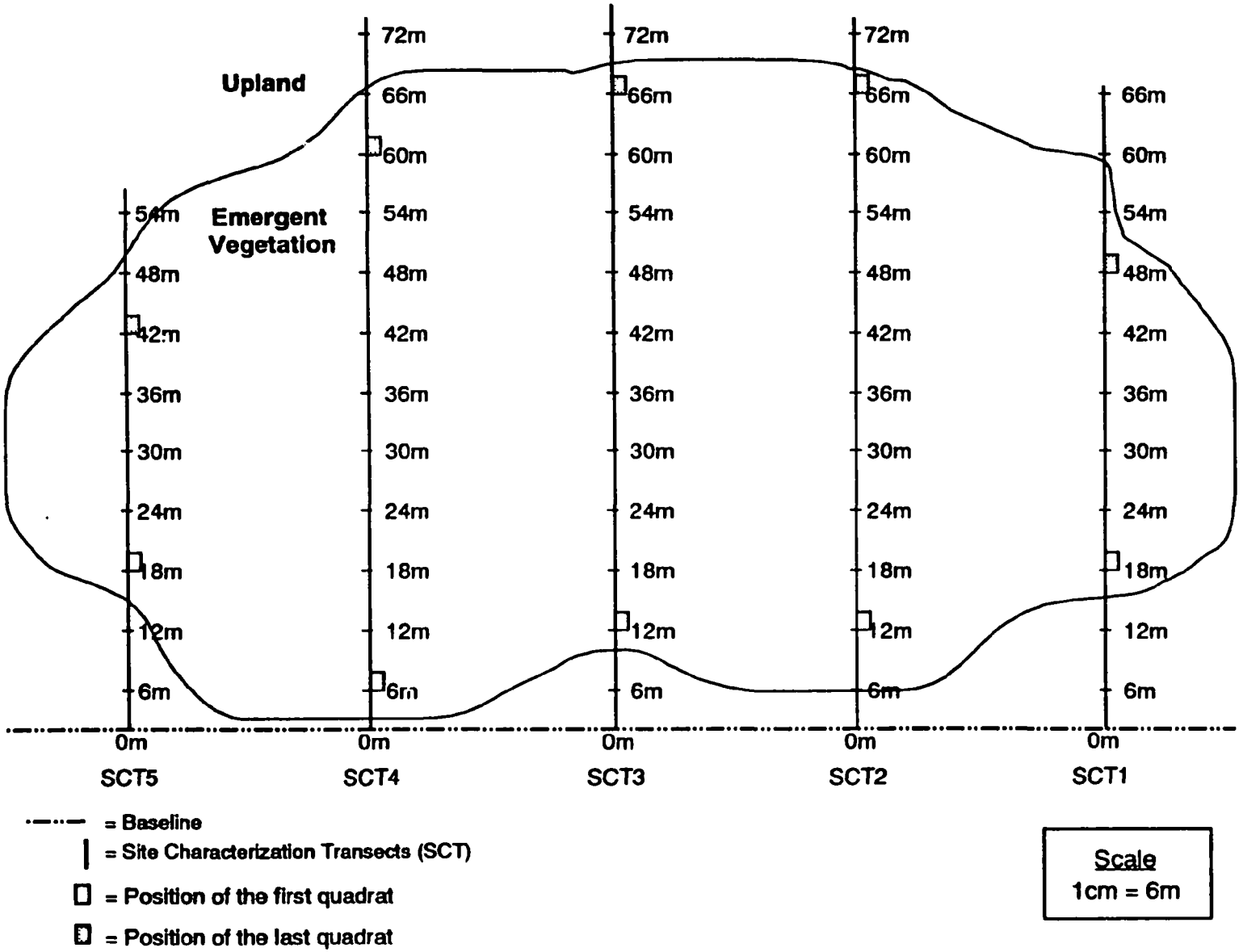


Figure 8-14. The position of the first and last quadrats on vegetation sampling transects.

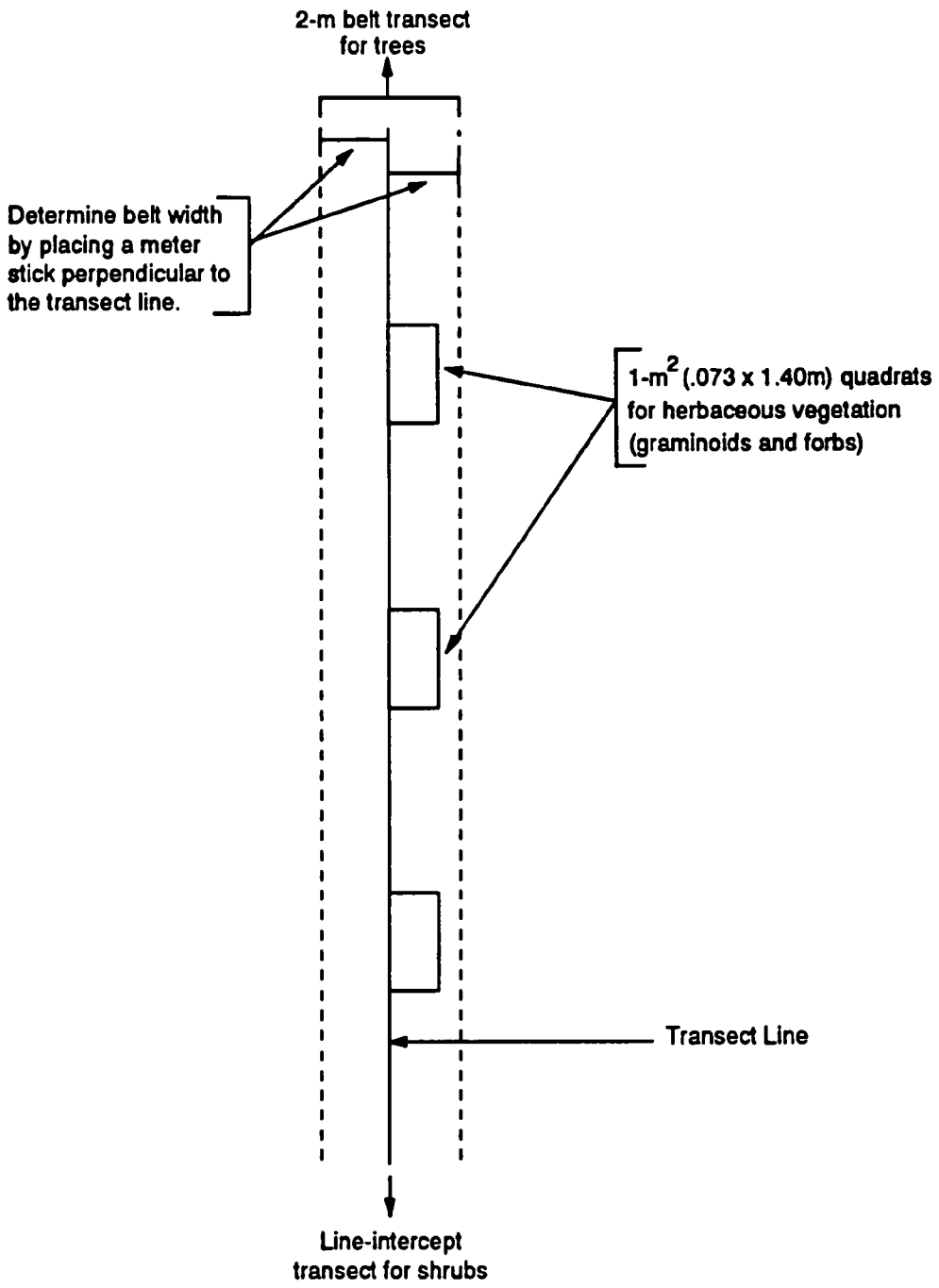


Figure 8-15. Transects used for sampling herbaceous vegetation, shrubs, and trees. (Adapted from Horner and Roedeke 1989). Scale: 1cm=1m

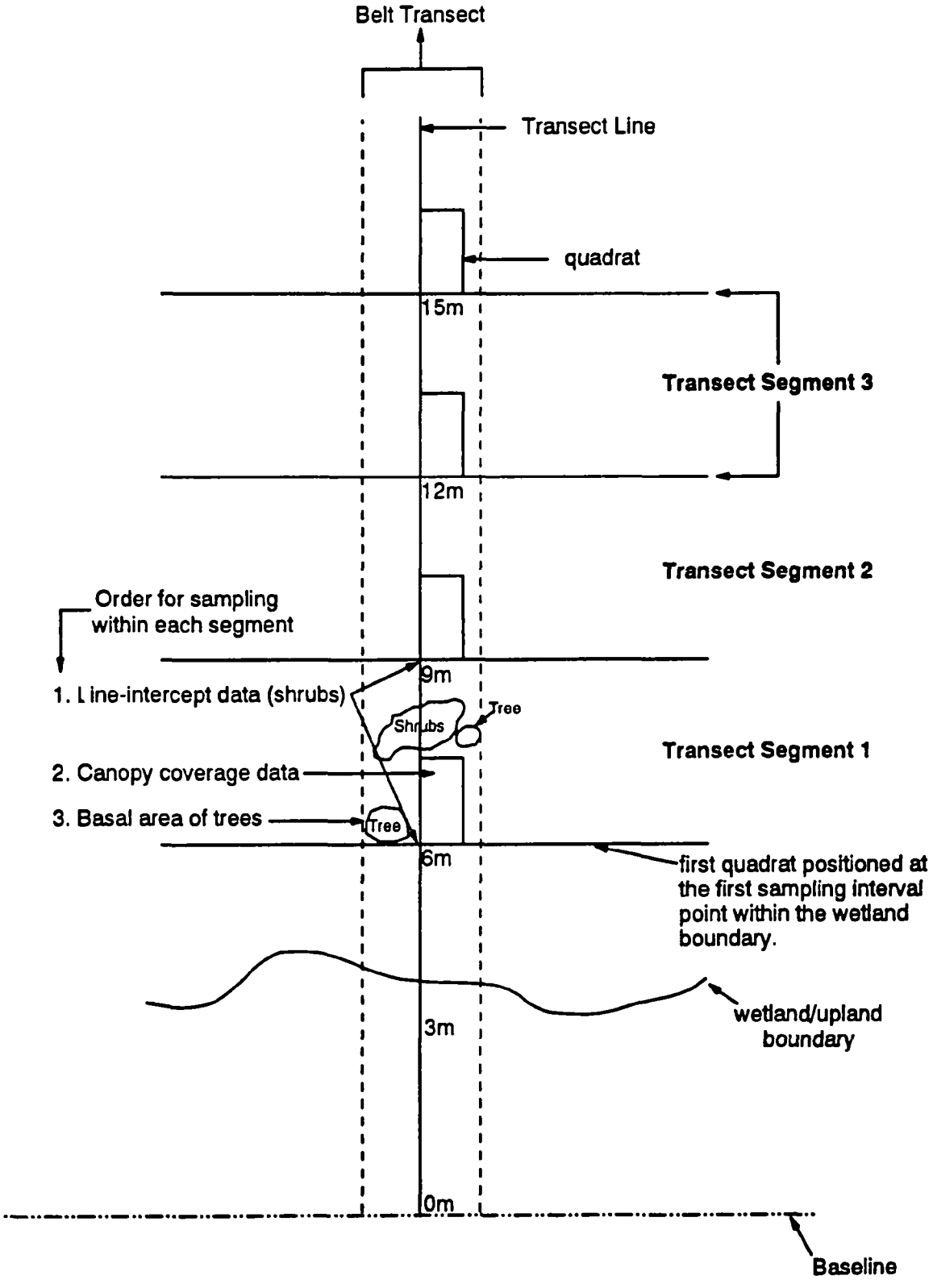
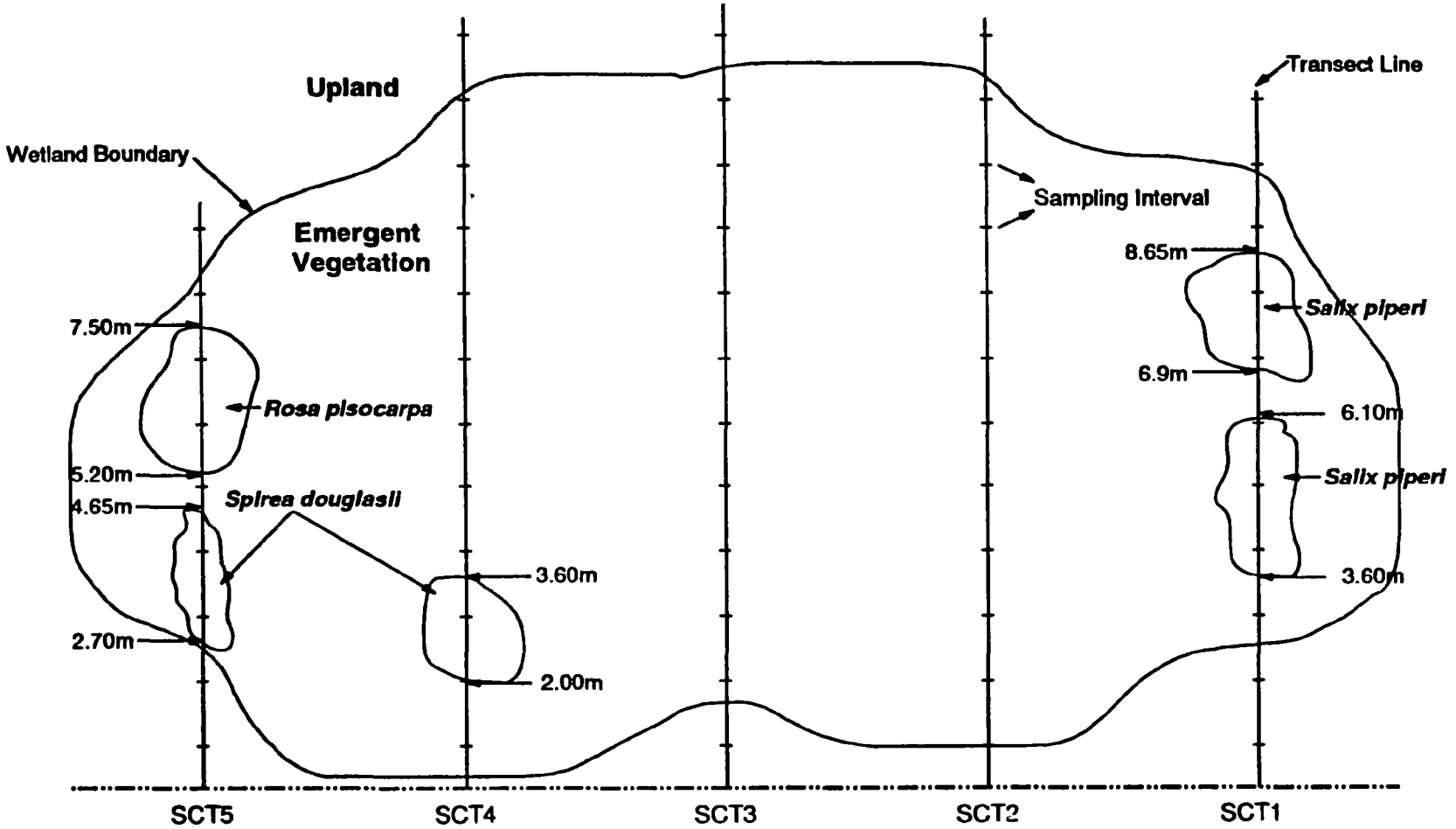


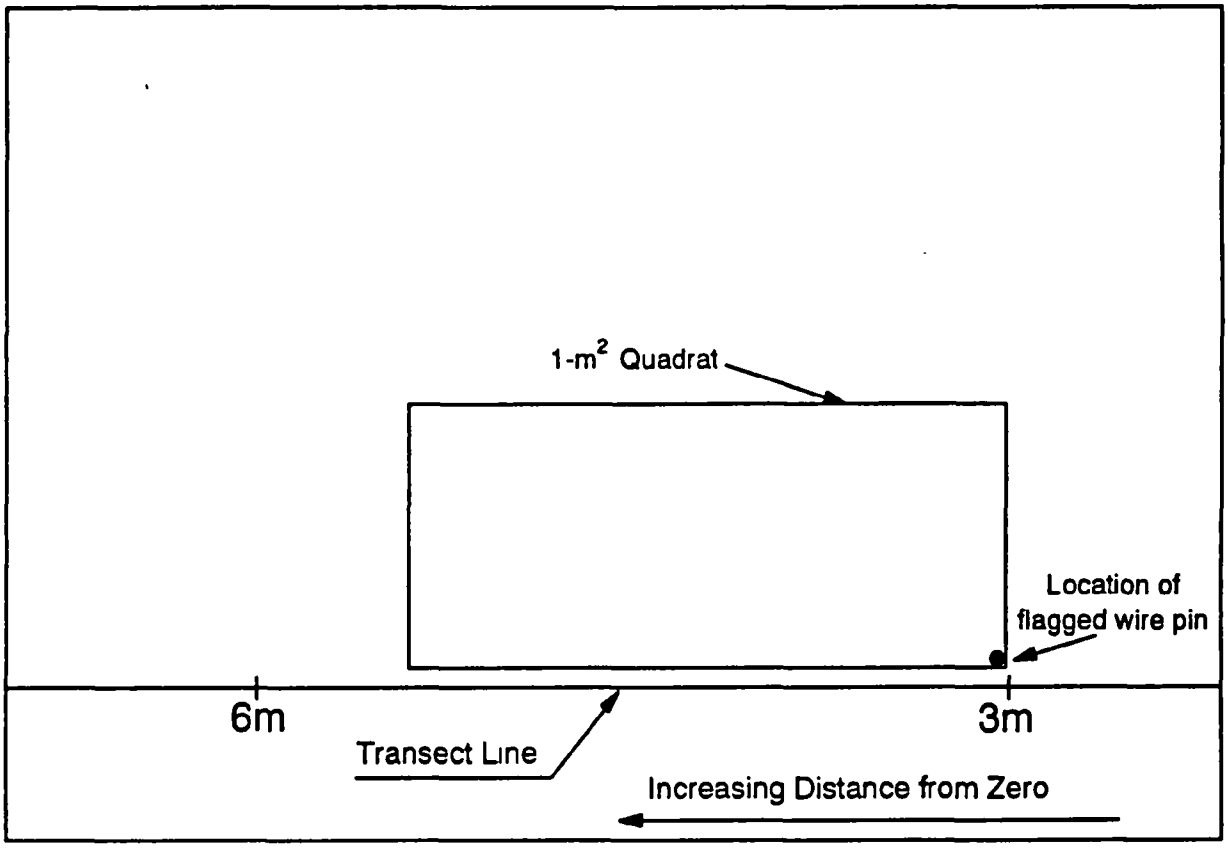
Figure 8-16. Illustration of transect segments in which vegetation data are collected and the order of data collection. All data are collected for each segment before proceeding to the next segment. Scale: 1cm=1m



Intercept Lengths:

Transect 1 - ***Salix piperi:*** 6.10m-3.60m=2.50m, 8.65m-6.90m=1.75m
Transect 4 - ***Spirea douglasii:*** 3.60m-2.00m=1.60m
Transect 5 - ***Spirea douglasii*** 4.65m-2.70m=1.95m, ***Rosa pisocarpa:*** 7.50m-5.20m=2.30m

Figure 8-17. Determining the intercept intervals for shrubs using the line-intercept method.



Enlarged to show detail. Figure is not to scale.

Figure 8-18. Placement of the 1-m² quadrat along transect line.

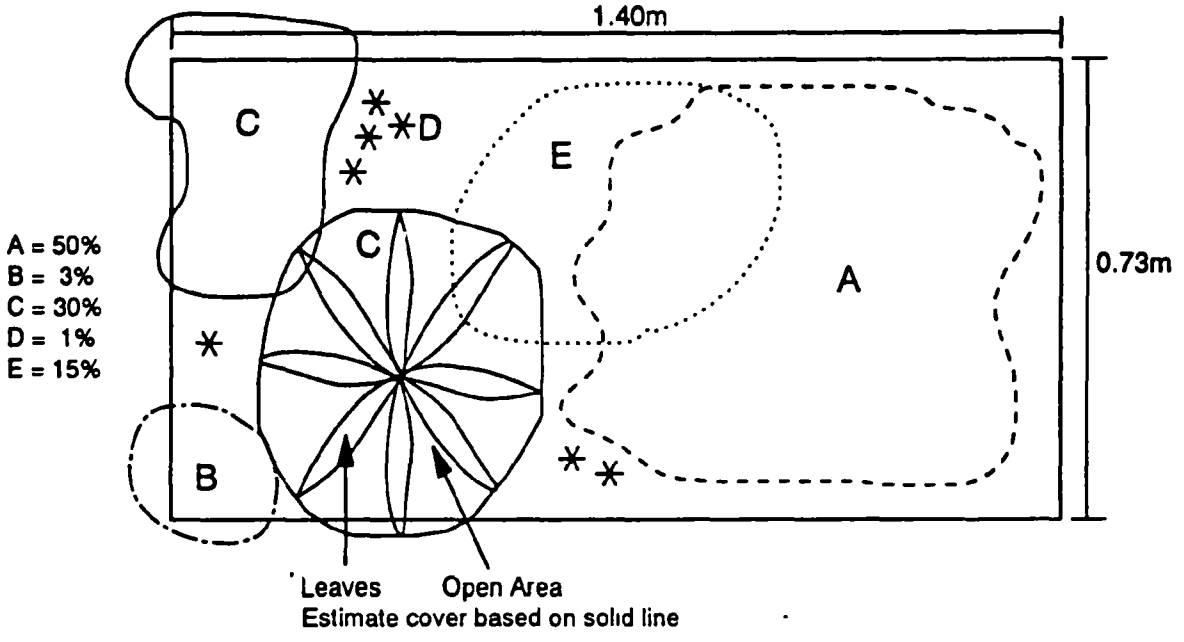
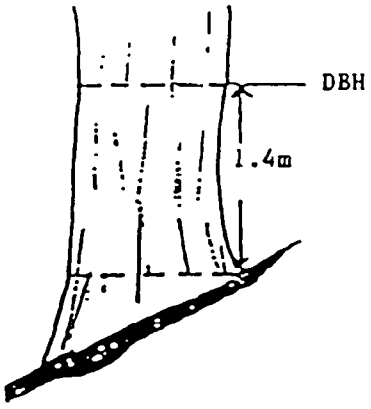
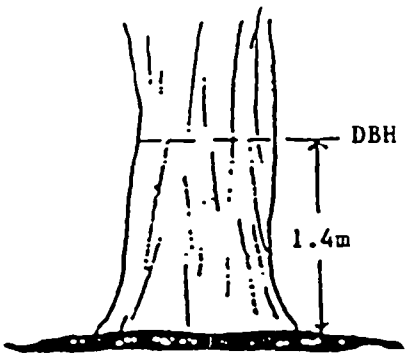


Figure 8-19. Illustration of species cover estimation within a 1-m^2 quadrat.

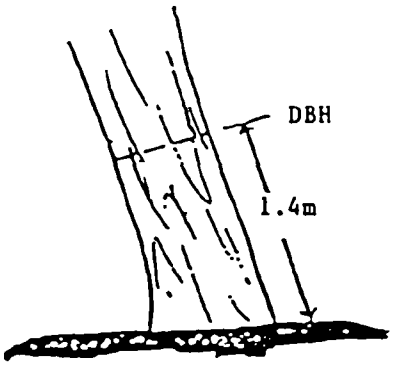
Figure 8-20. Where to measure Diameter Breast Height (DBH) in a variety of situations.



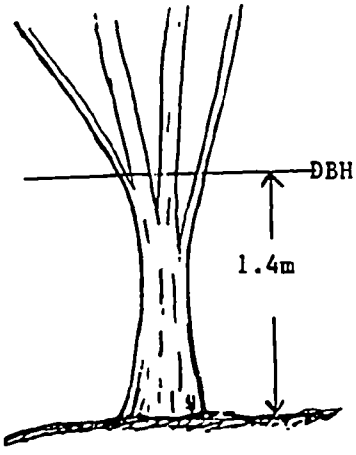
1. Tree on slope



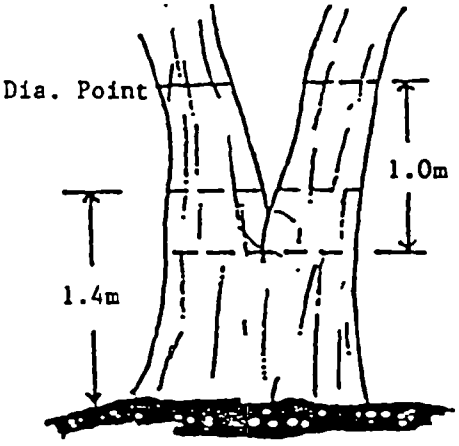
2. Tree on level ground



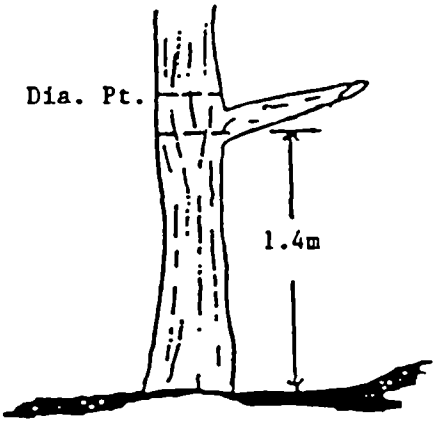
3. Leaning tree



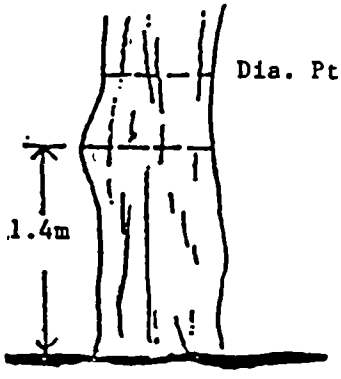
4. Tree forks above 1.4m



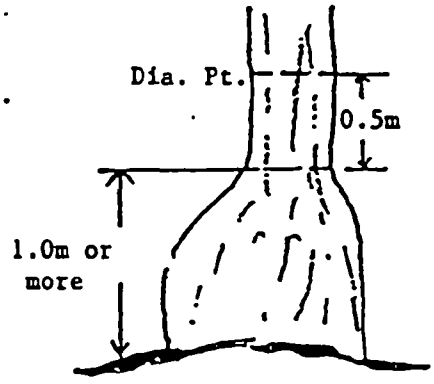
5. Tree forks below 1.4m



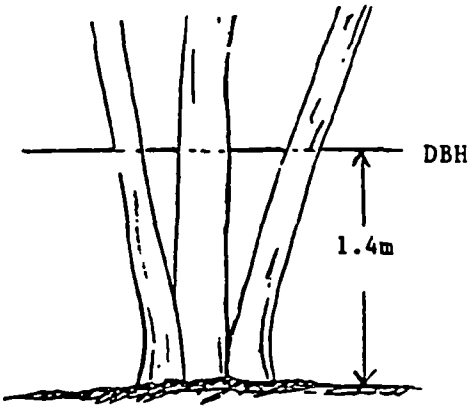
6. Tree with branch



7. Tree with swell at 1.4m



8. Bottleneck tree



9. Tree with multiple stems

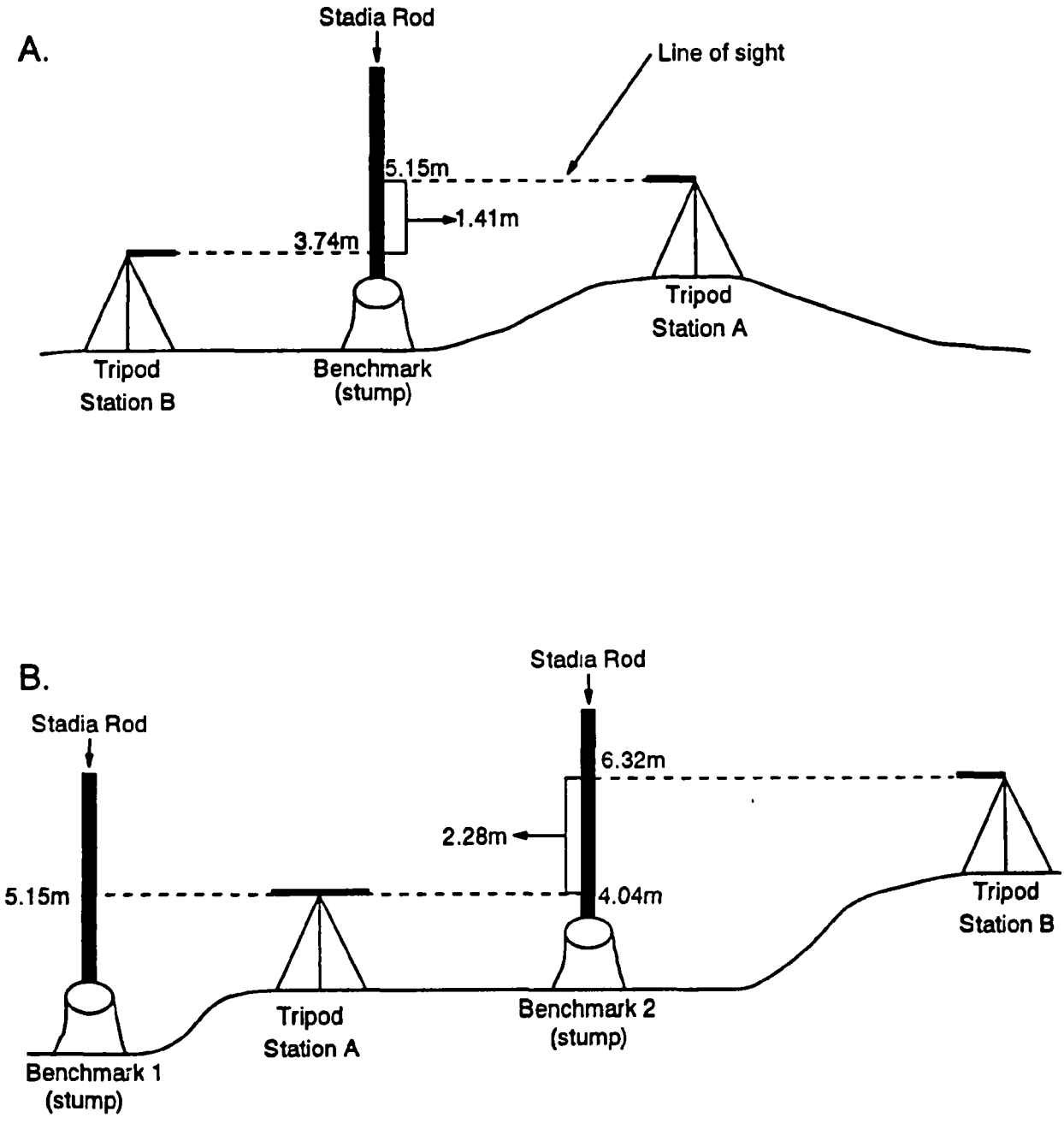


Figure 8-21. A. Adjusting the eye level plane when only one benchmark is required for making a turn. B. Adjusting the eye level plane when more than one benchmark is required to make a turn.

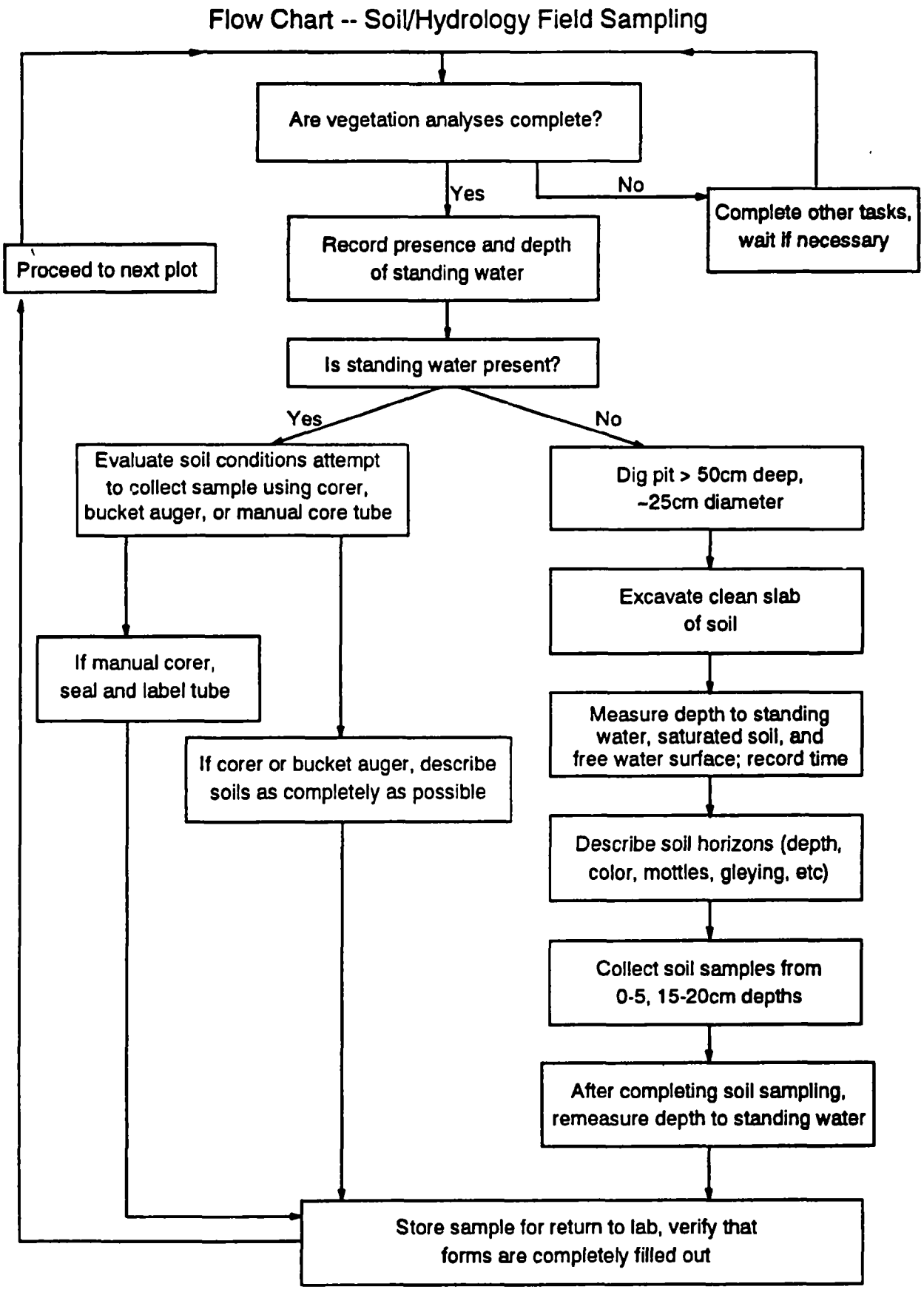


Figure 8-22. Flowchart showing sampling options and the sequence of field sampling activities for characterization of soil and hydrologic attributes.

9.0 SAMPLE CUSTODY

Soil samples will be handled and analyzed by the field teams and not shipped to multiple locations. For details of sampling handling by OWS crews see Section 8. Plant specimen handling and archiving of vouchers is described in Section 11 under Laboratory Activities for Vegetation.

10.0 CALIBRATION PROCEDURES AND FREQUENCY

EQUIPMENT

Several pieces of equipment will require calibration: the transit level, the Brunton compass, the Mettler top loading balances, drying oven, and muffle furnaces. Procedures and frequencies for calibration are listed in Table 10-1 and are conducted as part of the standard sampling or laboratory activities.

TRAINING

OWS Crew Members will be trained in field and laboratory techniques during an intensive classroom and field course, scheduled for Spring 1993 and provided by staff from ManTech, EPA, and Portland State University. Goals of the training are to develop high proficiency in conducting standardized field and laboratory activities and to achieve high levels of precision, accuracy, and comparability in data collected by different Crew Members.

An agenda defining the dates and nature of classroom activities, laboratory exercises, field training, and performance evaluation is provided below. Lectures and laboratory sessions will be held at Portland State University and field training will take place primarily at Bryant Woods in Lake Oswego, OR. Crew Members will read the Research Plan and appropriate sections of the Quality Assurance Project Plan during training.

Oregon Wetlands Study Training Agenda

Note: Crew Members need to read through "Research Plan and Methods Manual for the Oregon Wetlands Study" before the first training session

<u>General Format</u>

Reading Assignment - to be done prior to each class session

Lecture # 1
BREAK
Lecture # 2
LUNCH - Brown bag and conversation
Field Work
Laboratory Work

April 10 - Week 1

WRP staff present: Dwire, Gwin, Holland, Honea, Kentula, Magee, Shaffer

Reading assignment: Read: Chapters 1-3 in **Decision Making**
Review: Study Overview & Site Selection Sections in **Research Plan**

9:30-9:45 a.m. **Introduction:** Teacher Internships for the Oregon Wetlands Study, (Becker, Maine,)

9:45-10:30 a.m. **Overview:** Educational goals and course strategy for reaching them (Becker, Maine)

10:30-10:45 a.m. **BREAK**

10:45-11:30 a.m. **Oregon Wetlands Study:** Overview of the Science (Kentula)

Overview of wetland science, wetland regulation (EPA's interest), and its relation to the study.

Overview of Oregon Wetland Study--objectives, overall design including site selection and team organization, variables to be measured and why, and expected results.

Use of texts--how they were produced; differences in perspective presented.

What EPA can provide and what it wants from you--Provide a real life research experience; emphasis will be on getting the highest quality data. A lot of practice in the field techniques will be necessary.

11:30 a.m.-12:00 p.m. **LUNCH**

12:00-5:15 p.m. **LABORATORY OR FIELD**

Group 1. Soil/survey activities

12:00-1:00 p.m.	Overview presentations (Shaffer and Gwin) in laboratory
1:00-1:30 p.m.	Travel to Bryant Woods, split into two groups
1:30-3:00 p.m.	Group A -- mapping; Group B -- soils/hydrology
3:00-3:15 p.m.	Break
3:15-4:45 p.m.	Group A -- soils/hydrology; Group B -- mapping
4:45-5:15 p.m.	Pack up and return to laboratory

The goal for the first week is to provide an overview and hands-on introduction to field activities; what kinds of activities will be performed and why, and initial familiarization with sampling equipment. Activities will include: (1) set-up and use of transit, stadia rods, concepts of determining compass bearing, elevations and distances, etc.; (2) experience with digging and describing soils (e.g., presence of gleying and mottles color determination); and (3) introduction to project data forms.

In case of heavy rain - alternate activities will be conducted in the laboratory: look at and describe soils brought from the field, determine Munsell color, fill out forms; use compasses and transit in laboratory, start the example mapping exercise using existing data.

Group 2. Botanical activities

12:00-5:15 p.m. Laboratory session (Magee and Spencer)

- Introduction: importance of accurate plant identification, review terminology, definitions, and use of taxonomic keys (we will be using Hitchcock and Cronquist, (1973) "Flora of the Pacific Northwest")
- Practice keying a forb, grass, and sedge
- Overview of differences between major groups of wetland plants

April 24 - Week 2
WRP staff present: Dwire, Gwin, Holland, Honea, Kentula, Magee, Shaffer

Reading assignment: Review: Soils and Hydrology Section in **Research Plan**
Read: **ECOLOGY**-Chapter 2, Chapter 1, optional

9:30-10:25 a.m. **Learning What Ecologists "DO"**/Using an Ecological Framework for Study and Educational Planning (Maine)

10:25-10:40 a.m. **BREAK**

10:40 - 11:30 am **Sampling Soils/Hydrology:** Why and How (Shaffer)

11:30 a.m.-12:00 p.m. **LUNCH**

12:00-5:15 p.m. **LABORATORY OR FIELD**

Group 1. Botanical activities

Importance of accurate plant identification, terminology, use of a taxonomic key, overview of differences among major groups of wetland plants, practice identification of major plant groups

Group 2. Soil/survey activities

Soil/survey activities, using the same schedule as Group 1 from week 1

May 1 - Week 3
WRP staff present: Dwire, Gwin, Holland, Honea, Magee, Shaffer

Reading assignment: Review: Overview of Field Activities, Transect Establishment, and Vegetation in **Research Plan**
Read: **ECOLOGY**-Chapter 3-The Ecosystem

9:30-10:25 a.m. **Science as Problem-Solving**: Allowing Students to "DO" Science (Becker-Maine)

10:25-10:40 a.m. **BREAK**

10:40-11:30 a.m. **Sampling Vegetation:** Why and How (Magee)

11:30 a.m.-12:00 p.m. **LUNCH**

12:00-3:00 p.m. **FIELD**

12:00-12:30 p.m.	Travel to Bryant Woods; split to three groups
12:30-1:45 p.m.	Group A -- mapping and elevations
	Group B -- soils/hydrology, describe soils and fill out data forms
	Group C -- botany - sampling methods, cover estimates
1:45-3:00 p.m.	Rotate groups (A to soils/hydrology, etc.)
3:00-3:15 p.m.	Break
3:15-4:30 p.m.	Rotate groups
4:30-5:15 p.m.	Pack up and return to PSU

Field activities this week will include set-up and use of equipment, sampling procedures and familiarization with data forms. Mapping activities will focus on

using equipment to map a wetland perimeter and run elevation transects, and on filling out data forms. Soils/hydrology work will focus on selecting and using the proper equipment, and on examining soils and learning terminology to fill out data forms. Botanists will learn and practice field sampling procedures (plots for herbaceous vegetation, transects for shrubs and trees).

May 8 - Week 4
WRP staff present: Dwire, Gwin, Holland, Honea, Magee, Shaffer

Reading assignment:
Review: Site Selection Section in **Research Plan**
Read: **ECOLOGY**-Chapter 4, Energetics, Chapter 4 in **Decision Making, Quality Assurance** handout

9:30-10:25 a.m. **Classroom Project Selection:** Wetland Study Project-Some Options (Maine)

10:25-10:40 a.m. **BREAK**

10:40-11:30 a.m. **Sample Design and Quality Assurance:** Or How Do You Know That You Measured the Right Thing in The Right Way? (Dwire)

11:30 a.m.-12:30 p.m. **EXTENDED LUNCH** -time for chatting and questions

12:00-5:15 p.m. **Laboratory**

Soil/survey activities (in laboratory)

12:30-2:45 p.m. Mapping - process field mapping and basin morphology data; make maps and determine datum to define elevations for transects
2:45-3:00 p.m. Break
3:00-5:15 p.m. Soil analysis - laboratory preparation of soils (e.g., process cores, sieve to remove coarse material); weigh and process soils to determine loss on ignition (LOI); process data to compute LOI

Botany activities (in laboratory)

12:30-5:15 p.m. Plant identification - work on keying skills, learning family characteristics, and sight identification of dominant species

May 15 - Week 5
WRP staff present: Dwire, Gwin, Holland, Honea, Magee

Reading assignment: Review: General Site Data, Wetland Morphology, and Existing Data Sections in **Research Plan**
Read: Chapters 5 and 6 in **Decision Making**

9:30-10:25 a.m. **Working with Community Resources and Resource Specialist** (Maine-Becker)

10:25-10:40 a.m. **BREAK**

10:40-11:30 a.m. **Evaluating Wetland Project Design** (Gwin)

11:30-12:30 a.m. **LUNCH**

12:30-5:15 p.m. **FIELD**

Work as field teams for the first time; Survey Teams work on calibration of elevation measurements, Vegetation Teams work on calibration of plant species cover estimates; begin to develop cohesion in organizing at sites and setting up and implementing field activities as teams. Practice field activities appropriate individual crew members sampling responsibilities.

May 22 - Week 6
WRP staff present: Dwire, Gwin, Holland, Honea, Magee, Kentula, Shaffer

9:30-10:00 a.m. Overview of field activities, Field Crew assignments

10:00 a.m.-5:15 p.m. Survey Teams: Sampling buffers, calibration of crew members for soil descriptions
Vegetation Teams: Measuring diameter at breast height (DBH) of trees, using a compass for transect establishment, calibration of crew plant species cover estimates.

Work as 3 field crews and sample a portion of a wetland as it will be done in the study. Include end-of-sampling-day activities. Mary Kentula and ERL-C QA staff perform an informal QA review of crews and crew leaders and provide feedback.

June 5 - Week 7
WRP staff present: Dwire, Gwin, Holland, Honea, Kentula, Magee, Shaffer

Reading assignment:	Review: Overview of Field Activates in **Research Plan ECOLOGY**-Chapter 5-Materials Cycles and Physical Conditions of Existence
9:30-10:25 a.m.	**Evaluate to Determine Needs of Group** (Classroom Project Design)
10:25-10:40 am	**BREAK**
10:40 a.m.-12:00 p.m.	**FIELD -** Review of data and activities from Week 6, final practice of all field activities
12:00-12:30 p.m.	**LUNCH**
12:30-5:15 p.m.	Visit several sites to identify wetland boundaries, baseline locations, and discuss transect establishment procedures.

During Week 5 of training (May 15, 1993) the field crew members will be assigned to Survey and Vegetation Teams. Botanists and Recorder positions will be assigned within each Vegetation Team. Initial calibration of team members for measurements of elevations and for estimation of plant species cover will be conducted. Calibration entails comparison and correspondence of values obtained by Team Members with values for the same measurements or estimates obtained by the ERL-C staff who are acting as Trainers. The values determined by the Trainers are considered "standards" and Team Members are considered to be calibrated when they consistently obtain values that correspond to the standards within the ranges specified by OWS data quality objectives (see Table 7-1).

Survey Team members will be calibrated for reading the stadia rod through the transit. The Trainer (Stephanie Gwin) reads the stadia rod (upper and lower stadia hairs, and cross-hair) at each sample point. These readings serve as the "standard" against which the Surveyors readings will be evaluated. The Surveyors read the stadia rod at each sample point. Surveyors readings must be within $\pm$ 1 cm of the Trainer's readings.

Vegetation Teams will work toward consistency in making cover estimations through an initial calibration process. This procedure will consist of reviewing techniques for plant species cover estimation and making cover estimates in quadrats for which cover "standards" have been identified by the Trainers (Teresa Magee, Kate Dwire, Sherry Spencer). Cover estimates will be discussed and reconciled with the "standards."

Following calibration the individual Survey and Vegetation Teams will sample a Site Characterization Transect. Sampling a transect from start to finish will allow the Teams to begin to develop within team routines for implementing field activities.

During the sixth week of training (May 22, 1993), the field crews will work together for the first time. They will integrate all the sampling skills they have learned, and sample a wetland using standard field procedures. Also, at this time, success of the training process and the field readiness of the Crews will be evaluated to determine if the material presented by the instructors was conveyed and understood as intended. This evaluation will include calibration and field sampling activities. Basic understanding of soil description techniques, and recognition of wetland plant species and cover estimation will be assessed during calibration.

Crew Members will practice soil and vegetation sampling in order to become calibrated to "standards" for soil descriptions, plant species identification, and for cover values. Standards for these variables will be provided by consensus among the OWS scientists in the case of soils, by Teresa Magee and Sherry Spencer for plant identification and plant species cover estimates. Vegetation Teams will estimate plant species cover in a series of quadrats for which standard values have been predetermined. The goal will be to correctly identify all plant species found in a given quadrat and to obtain cover values for each species that are consistent with the standards defined for that quadrat. Soil descriptions will be made for a series of pedons by the Survey Teams. The goal will be to identify color, mottles, concretions, and oxidized root channels, and to note horizon depths, the presence of an organic layer, gleying, or hydrogen sulfide in a manner consistent with the predefined standards. This calibration process will be used to bring all Crew Members into agreement for vegetation and soil measurements, estimates, or descriptions so that DQO's for accuracy, precision, and comparability can be met. During the middle of the field season similar procedures will be used as a mid-season check on between-crew precision and to re-calibrate the Crews. The calibration process is described in detail in Section 13, Internal Quality Control Checks. Field activities will be used to evaluate the proficiency of both Crew Members and Crew Leaders in properly executing sampling procedures. Crews will sample two transects using standard procedures to collect data and fill out the appropriate data forms (See Appendix A). Mary Kentula and other ERL-C QA staff will observe the Crews, then provide feedback regarding sampling technique. Copies of the proficiency check-lists used for field evaluations are included in Appendix C. This will be the first opportunity for Crew Leaders and Crew Members to work together as Crews and to integrate all sampling techniques. Consequently, the evaluation should be viewed as an opportunity to provide constructive feedback to aid in developing routine and proficiency in sampling, not as an expectation for flawless implementation of sampling procedures.

Data collected during the Week 6 field evaluations and calibrations will be examined, in terms of the DQO's, before the final training session on June 5. Determining whether data meet the DQO's will allow 1) quantification of the effectiveness of training, 2) assessment of crew member sampling proficiency and comparability, and 3) identification of areas where improvement is needed. If data do

not meet the DQOs, an attempt will be made to determine causes of divergence related to sampling technique and appropriate procedural changes will be recommended at the final training session (June 5-Week 7) .

During Week 7 of training, the Crew Members will practice sampling techniques that need improvement and incorporate any required any changes in field procedures. Following this final practice, Crew Members will visit several sites with OWS scientists to work on uniformity between crews in identifying wetland boundaries and evaluating criteria for baseline locations. As a closure to training the Crew Members will be asked to fill out an evaluation of the training process and encouraged to discuss perceived strengths and weaknesses, and concerns or questions about the upcoming field work.

During training and subsequent evaluation of the applicability of OWS methods, it is probable that difficulties in the procedures will be recognized, and ideas for improvements will evolve. Consequently, during and following training, necessary revisions will be made to enhance the field schedule and on-site logistics, data sheet utility, and workability of field and laboratory procedures. Any changes will be communicated in detail to all Crew Members and described in the Field Operations Report (described in Section 18).

Crew Member Morale

Another facet of training that is critical to maintaining collection of high quality data and for transfer of science back to the classroom is the morale of the teacher Crew Members. The field and laboratory work will be strenuous, require long hours, at times be quite tedious, and occasionally be conducted in adverse weather conditions (e.g., heat or rain). Under such conditions, career relevance of the field work may become somewhat muddied. Also, fatigue, boredom, and feeling inadequately appreciated can decrease motivation and undermine a person's determination to consistently execute sampling and laboratory procedures. Thus, it is extremely important to acknowledge the teachers as integral and valued members of the overall project, without whom the science could not proceed.

Expressing recognition of the role of the crew members can be accomplished in several ways. During training and throughout the field season, crew members will be encouraged to participate as colleagues, to ask questions, and express concerns. Team work and cooperation should be stressed as an integral part of the training and research. Brown-bag lunches will be used to facilitate camaraderie between Crew Members and Scientists. During the field season, the Crew Leaders will concern themselves with the tenor of Crew Member attitude toward the project. Care should be taken to encourage Crew Members when the working conditions become difficult, to stress the importance of the project in terms of scientific gain and management applications, and to always maintain the connection of the research experience to anticipated educational applications. During the course of field or laboratory work, Crew Leaders will frequently solicit feedback from the Crew Members about any aspect of the work, any concerns, or positive experiences that they wish to share.

This might be done informally in passing conversations, during transportation to and from sites, during lunch periods, or in lulls during laboratory activities.

Crew Leaders will meet weekly (See Section 13, Internal Quality Control Checks) to discuss problems related to field and laboratory work or personnel considerations, and to develop solutions that may alleviate difficulties. Particular attention should be given to the overall morale of the crews and any specific personality conflicts that may develop between individual Crew Members or between a Crew Member and a Crew Leader. In the case of personality conflicts that do not appear resolvable, it may be appropriate to rotate one of the parties to another crew. This is not desirable because of QA considerations, but may be preferable to causing dissent or long-term negative feelings that could undermine data quality.

At the conclusion of the field season, there will be an informal follow-up session, lasting 4-8 hours, to permit Crew Members and ERL-C staff to discuss the success of the field season. This session will include opportunities to:

1) Acknowledge the Crew Members and to recognize their contribution to the overall project.

2) Allow the Crew Members to say good-bye to project scientists and other Crew Members.

3) Allow Crew Members time for verbal feedback to ERL-C staff about their experience.

4) Allow Crew Members to complete a written questionnaire/evaluation of the program -- identifying what they felt worked well, what did not, and how useful the research experience was in terms of personal development and its utility for education. The questionnaire will also address Crew Member evaluation of how well the training prepared them for field work and the utility of the **Research Plan and Methods Manual for the Oregon Wetlands Study** (Magee et al. 1993).

5) Describe the intended use of the data, discuss preliminary results, and indicate that the Crew Members will receive copies of final reports or journal articles.

6) Allow ERL-C to express appreciation to the Crew Members.

7) Allow time for interaction, discussion, and reminiscing among the Crew Members and OWS scientists.

Table 10-1. Calibration Procedures and Frequency for Field and Laboratory Equipment.

Equipment	Calibration Procedures	Calibration Frequency
Transit	Follow standard field procedures for set-up and leveling (See Section 8 - Sampling Procedures.	During field sampling each day.
Brunton Compass	Follow standard field procedures for adjusting declination (See Section 8 - Sampling Procedures.	Before beginning field sampling each day.
Top Loading Balance (Mettler College 300)	Zero balance according to manufacturer's instructions (see balance manual). Check calibration using standard weights.	Daily before each weighing session. The balances are calibrated annually by a manufacturer representative as part of normal maintenance.
Drying Oven Thelco Model 26 PS Scientific	Verify temperature with a thermometer placed in the center of the oven.	Prior to drying samples and monthly during sample processing
Muffle Furnace Blue M Electric Co. Model #M154-1A	Verify temperature by melting compounds with known melting point temperatures.	Prior to sample processing and monthly during sample analysis

11.0 ANALYTICAL PROCEDURES

All analytical procedures and laboratory activities for the OWS will be conducted by the Crew Members using facilities at Portland State University. Laboratory tasks include drawing final maps, drying and processing plant specimens, identifying unknown plant taxa, making elevation calculations, processing and analyzing soil samples for loss on ignition.

DRAWING THE FINAL MAP

Finished maps are drawn from the surveying data and rough sketch maps in the office or laboratory as time permits.

1. Assemble graph paper, pencils, erasers, a ruler with markings in centimeters, and a 360° protractor.

2. Examine the sketch map and map data (Forms F-2 and F-3) to estimate the appropriate scale so that the map will fit on an 8.5 x 11 inch sheet of paper. This takes some practice, if the scale is too large, the map will not fit on the paper. If too small, the map will not contain the necessary details. A wetland covering 1 to 2 ha will typically fit on an 8.5 by 11 inch sheet of paper at a scale of 1:1000 (1 m in the field equals 1 mm on the map).

3. Establish "true north" and indicate on the map with an arrow.

4. Using the sketch map as a guide, mark on the graph paper the approximate location of the transit in the wetland.

5. Calculate the distance from the transit to a map point using the data on Form F-3. To do this, subtract the lower stadia reading from the upper one and express the result in centimeters. The number of centimeters between the two stadia lines is equal to the number of meters between the transit and the mapped point.

6. Align the protractor so that the center mark is positioned on the transit location and 0° points toward north on the map sheet.

7 Using the bearing information from Form F-3, draw a light line from the transit location and through the bearing angle for the map point.

8. Using the ruler, measure the distance along the line from the transit position to the represented mapped point. This distance will depend on the map scale you have chosen. For instance, when drawing the map at a scale of 1:1000, each meter on the ground will equal 1 mm on the map. Label the point on the map.

9. Repeat this procedure for each point to be mapped. To complete the map, connect the points with a dark line representing the perimeter of the wetland.

10. Erase unwanted lines and marks, and darken the lines if necessary; to make a good copy that can be xeroxed. Draw in the site features and label the map with the site number, location, date sampled, date drawn, and the mapper's name. Also indicate the map scale, e.g., Scale: 1 cm = 8 m. See Figure 5-7 for an example of a finished map.

LABORATORY ACTIVITIES FOR VEGETATION

The principle laboratory activities related to vegetation are drying of plant specimens, identification of unknown plant taxa, checking of plant species names. Specific procedures for these tasks are outlined below.

Equipment

Dissecting microscopes
Hand lenses
Dissecting tools (e.g., single edge razor blades, forceps, dissecting needles)
Regional floras (See Table 11-1 for a list)
Plant specimens to be identified
Vegetation data sheets from sites where specimens were collected
Pens, pencils
Plant dryer

Place plant presses in a warm, dry, well-ventilated room or on a plant dryer to allow specimens to dry. Once plant specimens are dry, they should be removed from the presses and stored in labelled folders in designated herbarium cabinets at PSU. Following identification, specimens will be deposited at the PSU herbarium as vouchers, and duplicate material will be stored at ERL-C for a minimum of 5 years as a reference for future wetland studies in the vicinity.

Plant identification is critical to data quality so it is imperative that correct species names are provided. Precisely following the procedures outlined below will facilitate accurate identification and verification of species names.

1. Botanists and Recorders work together to key unknown plant species.

2. Two individuals simultaneously and independently key one unknown. After each has determined a species name, they confer to confirm that both agree on the name.

3. A Plant Taxonomist assists the Botanists and Recorders as needed and confirms their identifications. She may also wish to personally key particularly difficult species.

4. The validated species names are written on the appropriate data forms in the space provided, and on the newsprint containing the specimen. Also, a label with the correct species name and standard herbarium information is filled out and stored with the specimen inside the newsprint.

5. The specimen is filed and stored for future reference, as described above.

6. Plant specimens that cannot be identified with certainty because of missing or immature parts, difficult key characteristics, or because of poorly defined taxonomy will be sent to a wetland species expert.

To avoid confusion during data entry, it is important to check the data forms to verify that plant species names are spelled correctly and that nonexistent genus/species combinations are not listed.

1. Review the data sheets for correct spellings by comparing the names with the OWS plant species list, or with the **Flora of the Pacific Northwest** (Hitchcock and Cronquist 1973).

2. If an incorrect spelling is found, record the correct spelling in the space for validated species name on the data sheet.

3. If a genus/species combination occurs that cannot be found in the **Flora of the Pacific Northwest** (Hitchcock and Cronquist 1973) or on the Threatened and Endangered Species List in Appendix B, refer the problem to the Plant Taxonomist.

4. The Plant Taxonomist will decide how to handle the problem.

WETLAND MORPHOLOGY -- ELEVATION CALCULATIONS

Calculations of relative elevations for each wetland will generally be made in the field before leaving the sites. However, when logistics makes this difficult, calculations will be made in the laboratory by the Surveyors.

SOIL ORGANIC MATTER CONTENT -- LOSS ON IGNITION

Soil organic matter content analysis will be conducted by two Teacher Crew Members who have been selected as Laboratory Technicians. Their responsibility will be to process all soil samples collected by the field crews. The laboratory procedure used for determination of soil organic matter content is based on combustion of a soil sample in a muffle furnace at 450° C, with organic matter content determined by weight loss of the sample. The procedure is adapted from USDA (1984) and Blume et al. (1990).

Equipment and Supplies

Balance, weighing to 0.01 g
Drying oven (in operating exhaust hood)
Muffle furnace (in operating exhaust hood)
Desiccator (needed only if samples will not be weighed as soon as removed from the muffle furnace and allowed to cool to room temperature)
Sieve (U.S. Standard #10 mesh, 2.00 mm opening)
Furnace gloves
Tongs
Forceps
Disposable aluminum weigh dishes (ca 2" diameter by 0.5" high)
Data Forms L-1 and L-2, log book
Rubber gloves (disposable)
Munsell color chart with gleyed color page

General Considerations for Laboratory Analysis

1. Calibrate the balance according to routine good laboratory practices. The balance should be leveled and calibrated using standard weights at the start of analyses, weekly thereafter, and any time the balance has been moved or disturbed. Balances will be recalibrated if measured weights are not within $\pm$ 0.01g of the calibration standard. Record calibration results in the laboratory log book.

2. Place the drying oven and muffle furnace in an operating exhaust hood if possible, to insure that moisture and objectionable odors (from H_2S, organo-sulfur compounds) are not vented into the laboratory. Check temperatures for drying oven (105°C) and muffle furnace (450°C) regularly; ovens should be calibrated and temperature settings adjusted to insure that samples are dried at the proper temperature. Record information on calibration of the oven temperatures in the laboratory log book.

3. If possible, process cores and soils in an exhaust hood or other well-ventilated area tc insure that objectionable odors are not vented into the laboratory.

4. If part of a sample is spilled, or if material spills into any of the weighing dishes or crucibles, discard the sample(s), and repeat the entire procedure using a second aliquot of the sample.

Laboratory Analysis Procedure

Soil samples will be processed in the laboratory in batches; each batch will include both routine and QC samples (1 blank, 1 audit sample, and 3 field/laboratory duplicates). The number of samples in each batch will depend on the size of the muffle furnace. Number samples with the batch number, and a sample number for tracking during laboratory and data analysis. Label soil sample bags with the batch

and sample number, and record the batch, sample number, and soil identification (wetland and transect number, etc.) for each sample in the laboratory log book. Processing dates for each soil sample will also be recorded in the log book.

1. For material frozen in core tubes, thaw the outer layer of the sample (in the tube) by briefly holding the tube (with end caps still attached) under warm running water, then slide the core from the tube onto a clean sheet of plastic or a clean tray. Quickly and carefully slice the 0-5 and 15-20 cm depth segments from the core, place them in separate, sample bags labelled with the appropriate soil sample code (site #, transect #, plot #, and depth code), and allow them to thaw completely. *Discard unused portions of the core.* For samples collected using a corer, record sample identification, presence or absence of hydrogen sulfide, and color on Form L-2.

2. Carefully remove stones, twigs, live roots, invertebrates (insect larvae or snails), and obvious foreign materials (e.g., plastic or metal fragments) from each sample. Wear clear rubber gloves and use forceps to avoid contamination of the samples.

3. Sieve soil, using a 10 mesh (2.0mm) sieve, to remove rock fragments, wood chips, and other materials >2 mm in size. For wet soils, materials will probably need to be gently pushed through the sieve; this can be done using a spatula or your fingers (wear rubber gloves). Clean and dry the sieve between samples.

4. Material passing through the sieve should be mixed thoroughly to homogenize the sample, and placed in a clean, labelled plastic bag.

5. Number and pre-weigh disposable aluminum weigh boats. Numbers will be applied by pressing hard with a pencil to emboss the sample codes into the aluminum boats so that the codes will not be obliterated by heating. Record the container number and tare weight (weight of the empty container) for each container on Form L-1.

6. Fill containers approximately two-thirds full of fresh soil (10-20 g). Record the sample identification and the weight of container plus soil (FRESH_WT) on Form L-1. Excess sample material will be saved for possible reanalysis. If all of the soil for a particular sample has been used, make a note in the log book and discard the container.

7. Place containers in a drying oven and dry overnight (>12 hours) at 105°C. Cool containers to room temperature and weigh immediately upon cooling. Samples should be stored in a desiccator if they cannot be immediately weighed. Record the time samples are placed in, and removed from, the oven on Form

L-1, and record the weight of containers with dried soil under "DRY_WT" on Form L-1.

8. Carefully place containers in a muffle furnace (at <100°C). DO NOT attempt to place samples in a hot furnace; materials with high organic content are likely to ignite. Set the temperature at 450°C and turn on the oven; samples should be held at 450°C for at least 2 hours, but can be left longer (e.g., overnight) if convenient. Record the time samples are placed in the muffle furnace.

9. Turn off the furnace and remove weigh containers and remaining soil. Record the time samples are removed from the muffle furnace. Place containers in a desiccator until they have cooled to room temperature. Weigh samples immediately upon removal from the desiccator, and record weight under "ASHED_WT" on Form L-1. Allow the furnace to cool to <100°C prior to refilling with a new set of containers.

Calculations

If disposable dishes are used, blanks should be used to check weight changes in the aluminum dishes. During heating to 450°C, weights sometimes may increase by 0.01-0.02 g as a small amount of aluminum is oxidized. If such changes are observed, sample weights should be adjusted accordingly, by subtracting the average change in the weight of blanks from the "ASHED_WT" of each sample.

Moisture content is reported as a percentage of fresh sample weight; loss on ignition is reported as percentage of oven-dry (105°C) weight. Compute moisture content and loss on ignition as follows, and record on Form L-1.

Moisture content = ((FRESH_WT - DRY_WT) * 100%) / (FRESH_WT - TARE_WT)
Loss on ignition = ((DRY_WT - ASHED_WT) * 100%) / (DRY_WT - TARE_WT)

Table 11-1. List of Regional floras and references used to facilitate plant identification.

Gilkey, H.M. and L.J. Dennis. 1980. Handbook of Northwestern Plants. Oregon State University. Corvallis, OR.*

Harrington, H.D. and L.W. Durrell. 1957. How to Identify Plants. Swallow Press. Athens.

Harrington, H. D. 1977. How to Identify Grasses and Grass-like Plants. Swallow Press. Chicago.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest: An Illustrated Manual. University of Washington Press. Seattle.

Hitchcock, C.L., A. Cronquist, M. Owenbey, and J.W. Thompson. 1969. Vascular Plants of the Pacific Northwest. Part 1: Vascular Cryptograms, Gymnosperms, and Monocotyledons. University of Washington Press. Seattle.

Hitchcock, C.L., A. Cronquist, M. Owenbey, and J.W. Thompson. 1964. Vascular Plants of the Pacific Northwest. Part 2: Salicaceae to Saxifragaceae. University of Washington Press. Seattle.

Hitchcock, C.L., A. Cronquist, M. Owenbey, and J.W. Thompson. 1961. Vascular Plants of the Pacific Northwest. Part 3: Saxifragaceae to Ericaceae. University of Washington Press. Seattle.

Hitchcock, C.L., A. Cronquist, M. Owenbey, and J.W. Thompson. 1959. Vascular Plants of the Pacific Northwest. Part 4: Ericaceae through Campanulaceae. University of Washington Press. Seattle.

Hitchcock, C.L., A. Cronquist, M. Owenbey, and J.W. Thompson. 1955. Vascular Plants of the Pacific Northwest. Part 5: Compositae. University of Washington Press. Seattle.

Soil Conservation Service. Western Wetland Flora: Field Office Guide to Plant Species. SCS West National Technical Center, Portland, OR.*

Weinmann, F., M. Boule, K. Brunner, J. Malek, and V. Yoshino. 1984. Wetland Plants of the Pacific Northwest. U.S. Army Corp of Engineers, Seattle, District. *

Zika, P. (in preparation). Keys the Carex, Juncus, and Salix species occurring in the Portland Metropolitan Area.

*Starred references are incomplete for the flora of our study area, but are useful in terms of ease of use.

12.0 DATA REDUCTION, VALIDATION, AND REPORTING

Data for the OWS originates from existing sources, field sampling, and laboratory analyses. To avoid data loss, it is important to track data from their points of origin through data entry and statistical and qualitative analysis. Data custody procedures through data entry are outlined in Figure 12-1. The process of tracking and archival of field data sheets is presented below under Data Tracking and Archiving. Subsequent management of the data is described below in the Data Storage and File Back-up and under Statistical Analysis subsections.

Data entry accuracy will be safeguarded by using a computerized dual data entry system, in which two people enter, compare, and reconcile two identical data sets. Data entry errors are minimized by finding and correcting differences between the data sets. Programming for the data entry system is currently underway and a general description is provided below under Data Entry, Reconciliation, and Validation. Validation refers to several tests used to detect potential problems with the reconciled or corrected data. Formats for entering the data are discussed in the Database subsection.

Data entry and validation problems will be recorded, and a data dictionary will be maintained in a data notebook. Details are provided under Documenting Data Problems and Maintaining a Data Dictionary, in this section.

The intended uses of data are discussed briefly in the Statistical Analysis subsection. More detail is provided in the Data Analysis Section of the Research Plan. The computer system used for data entry, storage, and analysis is also described.

DATA TRACKING AND ARCHIVING

Protection of the original data forms is critical to any scientific study. The procedures adopted for the OWS described in the points listed below and in Figure 12-1.

1. At the end of each sampling day, all data collected for the study site are placed into an accordion folder called a site packet. There is a separate folder for each site.

2. At the end of each sampling week, all site packets for the week are transported back to ERL-C where they are copied.

3. Prior to copying, DATA TRACKING FORMS (Appendix A) must be filled out to indicate the level of completeness and the storage locations of original data and copies for data entry and archival. Completed data tracking forms are taped on the outside of each site packet. These forms are colored coded by the name of the crew collecting the data.

4. All data from each site packet is photocopied. It is important to copy data from only one site packet at a time, making certain to copy both sides of double-sided forms. Several copies of each data sheet are required, so to avoid confusion the copies are colored coded:

   a. Completed data forms are copied onto blue paper for archiving.

   b. Incomplete data (e.g. needs annotation of plant species names, requires completion of elevation calculations) are copied onto yellow paper for archiving. Later, after the data forms are completed they are xeroxed again onto blue paper and replaced in the archive.

   c. Completed data forms are xeroxed onto white paper for data entry.

5. Once the initial copying process is complete, the originals and copied data forms are placed into appropriate file folders and each folder is stored in a designated location (Figure 12-2). There are 6 folders for each site packet labelled as follows: General Forms, Soils Forms, Mapping and Morphology Forms, Vegetation Forms, Archive Data, and Data Entry.

   a. All COMPLETED ORIGINAL DATA FORMS are filed in their respective folders (General or Soils) in the site packets. The site packets with data tracking forms attached are filed in file cabinets at ERL-C.

   b. Incomplete ORIGINAL Vegetation Data Forms are filed in the Vegetation Form folder and placed in the project botanist's (Teresa Magee) file box. These forms can then be transported to Portland State University (PSU) for annotation by the PSU taxonomist (Sherry Spencer) and the field crews during lab days, or kept at ERL-C for the project botanist to annotate with correct plant species names.

   c. Incomplete ORIGINAL Mapping and Morphology data forms are filed in the Mapping and Morphology folder and placed in the Crew Supervisor's (Stephanie Gwin) file box. During the field season this data will be transported to PSU on lab days for field crew members to work on elevation calculations and drawing maps.

   d. A complete set of ARCHIVE DATA (both blue and yellow copies) for each site will be placed in the Archive folder and filed at an off-site location. As data forms for each site are completed, new archive copies (blue) will be made. The archive file will be routinely updated by replacing the incomplete copies (yellow) with the copies of the completed forms (blue).

e. White copies of completed data forms should be placed in the Data Entry file folders for each site and the folders should be placed in the data entry office at ERL-C on a shelf marked OWS DATA IN. Data from these folders is entered into the OWS computer database. As other forms for a given site are completed they must be copied on white for data entry. Empty Data Entry folders for these sites can be retrieved from the adjacent shelf labelled EMPTY FOLDERS. Data entry copies of completed data can be placed in the appropriate empty Data Entry folders and returned to the shelf marked DATA IN.

f. As vegetation, morphology, and mapping data forms are completed and copied, the ORIGINALS must be filed in the appropriate folder and site packet. The data tracking form must be updated to indicate the status and location of all ORIGINALS AND COPIES.

DATA ENTRY, RECONCILIATION, AND VALIDATION

Duplicate data sets will be generated by separate users and the number of initial data entry errors will be reduced by using three techniques: lookup tables, range value checking, and a duplicate key field check. Key fields are data fields used to uniquely identify each record in a database.

Lookup tables allow the user to select an item from a list. For example, the user enters the first two characters of a plant genus name to get a list of possible genus/species names. The user then selects the appropriate genus/species name from this list, eliminating the need to type in the name and code. If the user types the letters "TR", the list of genus/species names (Figure 12-3) would appear. If the user selects one of the names, the program will enter the selected name and code in the current file. If a genus/species name is not found in the master species list file, the user will be prompted to enter the species name from the form. The program will then add the name to the master species list and assign a temporary code. At the conclusion of the data entry process, the master species lists from both data sets will be copied to a floppy disk. Both lists will be reviewed, compared, and reconciled by separate individuals. After the master species list has been validated, the dual data entry program will be used to update all the vegetation files in both data sets with the correct genus/species name and code.

Range value checking is used to set acceptable limits for an entry in a field. For example, the range of acceptable values for WATER DEPTH is 0 to 6 m. If a value outside this range is entered, a warning message is displayed and the user is prompted to check the entry for a probable error in data entry and to make any needed corrections.

Another data entry problem is that of duplicate key fields. Key fields must be unique because they identify each record in a database. This error can occur by the user trying to enter the same record twice or key fields having been entered on a data form more than once. To eliminate this problem, the dual data entry program will be designed to check the key fields as they are being entered to make sure that they are

unique to the file. If the user is trying to enter an existing key field the program will display a warning message so that the cause of the problem can be identified.

Following dual data entry, the data sets are compared and corrected. Three steps are used for reconciling the two data sets (Figure 12-4): matching the filenames, comparing the key fields, and comparing the non key fields. During completion of each step, all the files in one data set are compared, record by record, with all files in the other data set. The program reports any errors found and the user corrects the problems.

Three kinds of differences can occur between data sets: non-matching filenames, invalid or missing key fields, or different field values. Non-matching filenames can be the result of a misspelled filename, entry of an inappropriate filename, or omission of a file in one of the data sets. Invalid or missing key fields are identified when the program cannot find a matching key field value in the other data set because 1) the key field was not entered, 2) the wrong key field was entered, or 3) a key field was entered that does not belong to the file. Disparate values for the same field in the two data sets can occur as a result of omission of a field value, entry of value in an incorrect field, or entry of the wrong value in a field.

When correcting differences, the program automatically highlights the proper record and field. A message describing the problem and possible causes will be displayed. To fix the problem, the user will review the appropriate data sheet and correct the error (Figure 12-5). After dealing with the problem, the user presses the appropriate key to move to the next discrepancy. After each user has reconciled their copy of the dual data set, they will trade copies via floppy disks and run a new comparison. The process is repeated until no errors can be identified and the data sets are identical.

After the data sets are reconciled, several tests are used to detect potential problems. These tests are data validation, percent completeness, relational database check, and code check.

Data validation is used to identify any unusual spellings or values. This is accomplished by producing a separate file that contains a sorted list of all unique entries for each field in a data set. If any incorrect entries (e.g. misspelled genus or species names) are found they can be changed by using the program's global search and replace option.

The completeness of the data are evaluated by calculating a percentage that describes how often a field was used to store data. This allows the analyst to consider whether or not the data quality objectives for completeness have been met and to assess the appropriateness of proceeding with analysis using the affected data.

The relational database check determines if all the records that are related by key fields in a group of files are properly aligned. If the information in such a relational database is not properly associated, then any analyses dependent upon the relationships will be erroneous or impossible to perform.

The code check identifies naming conflicts. Codes represent information in an abbreviated format. For example, in the vegetation database, codes represent the genus/species names of plants. If the same code identifies more than one

genus/species, then a naming conflict has occurred that would produce erroneous results when the data are analyzed.

DATABASE FORMATS

Database formats for entering and manipulating the OWS data must offer maximum flexibility and compatibility with the planned statistical and multivariate analyses. The format structures and the number of databases required are being finalized for the OWS. Data for like variables are grouped together by site and transect in one database composed of files for each site. For example, herbaceous plant species cover forms a data base, and hydric soil indicator data forms another. The data manager, Robert Gibson, and the project statistician, Barbara Peniston are participating in file format design.

DOCUMENTING DATA PROBLEMS AND MAINTAINING A DATA DICTIONARY

A data notebook will be maintained to track all deficiencies, manipulations, format structures, data codes, and any other data definitions used in the study. Copies will be made weekly and stored separately from the original to guard against loss or damage to this vital information. One copy will always accompany the entire data set and be available to personnel working on data management, analysis, or interpretation.

Data deficiencies identified during the data entry, reconciliation, and validation processes will be recorded into the notebook so they can be tracked and referred to during data analysis and interpretation. This section of the notebook will be organized by site and transect numbers, and used to record problems encountered during the data entry and analysis processes and to describe the solutions (Figure 12-6).

In addition, the notebook will have a dictionary that documents all file format structures, data codes, filenames, and file contents. This is intended to act as a tracking system that will indicate the condition and location of all files that are created for or during data analysis in the OWS. It is particularly important to have a copy of the raw dataset archived and to describe in detail all analysis manipulations and outputs. This record is especially important in cases of personnel changes or multiple users, and is essential to prevent misinterpretation of the results, time loss related to poor documentation of files, and inadvertently repeating work. The format for this tracking system, preferably a hierarchical method based on analysis type and the order in which the analyses are conducted, will be devised before beginning any data analysis.

DATA STORAGE AND FILE BACK-UP

Data from the field sheets will be stored on three types of computer media: hard drives, floppy disks, and magnetic tape. In addition, data from each dual entry data set will be backed up on floppy disks each time a comparison is made. Upon completion of the data entry and verification process, a final copy of each data set will be archived on two sets of floppy disks. The two sets will be stored on different colored floppy disks so that they can be easily identified. The floppy disks will be

stored in separate locations along with a copy of the notebook. If any subsequent changes are made to the data, the following steps will be followed: 1) the changes will be entered into the data notebook, 2) the data sets on the hard drives and both sets of floppy disks will be updated, and 3) the data analyst(s) will be notified.

All data sets and output files created during analysis will be named, and the appropriate content information will be recorded in the data notebook. Analysis files will be maintained on a hard drive, with two back-up copies on floppy disks. Back-up copies will be updated at the end of each day when any of the files are edited or new files are created. The two back-up sets of floppy disks will be stored in separate locations.

STATISTICAL ANALYSIS OF DATA

The data analysis section is divided into two parts. The first section lists the four study objectives and offers a brief discussion of the analyses proposed to address them. The second section describes, in more detail, the manner in which the statistical analyses will be used to facilitate characterization and comparison of the OWS wetlands.

This is an observational study, therefore, with the exception of Objective 1, causation cannot be determined. For example, the percent of organic matter in the soil could be significantly higher in the natural wetlands, however, it is not correct to say that the higher value was caused by the fact that the wetland was natural. There could be other confounding variables that are related both to the percent organic matter in the soil and to the natural status of the wetland.

Objective 1--Determine the number of freshwater wetlands that have been converted to other land types and identify causes of this direct loss.

To address this objective, the most recent wetland inventory based on NWI maps will be compared to a current inventory performed during site selection to determine the short term trends in wetland loss. Comparisons will be made between wetland types listed on NWI maps and types of existing wetlands. The wetland type most frequently destroyed and the locales where the majority of the wetland destruction has occurred will be documented and summarized. In addition, the land use in the location of the destroyed wetlands will be documented to determine the cause (if identifiable) of wetland loss. For example, if a natural wetland identified on a NWI map has been destroyed, and a shopping mall has been constructed in the location of that destroyed wetland, the cause of the wetland loss is commercial development. The information on cause of wetland loss will be summarized to detect trends.

Objective 2--Evaluate the relationship between surrounding land uses and the attainable quality of freshwater wetlands.

Comparisons will be made between wetlands in different land uses for specific variables of interest (i.e., those variables that are believed to be affected by different land uses). For example, we might expect the ratio of native to exotic plant species to be influenced by land uses with intensive human use. Summary statistics (e.g., mean, mode) will be calculated for the variables of interest, and graphical methods will be used to display the variables (e.g., box and whisker plots). Analysis of variance will be used to compare data from wetlands within the different land uses and multiple comparison tests (e.g., least significant difference) will be used to determine which group(s) of wetlands are significantly different from the others.

Another mechanism for looking at attainable quality will be to explore the structure and function of wetlands with and without vegetated buffers. Summary statistics will be calculated for variables of interest within wetlands grouped by the presence or absence of vegetated buffers. The two groups will be compared graphically and with a two sample test (e.g., Student's t test, Wilcoxon-Mann-Whitney rank-sum test).

Objective 3--Evaluate the replacement potential of freshwater wetlands to aid in the development of performance criteria.

This objective can be divided into a number of questions of interest. How does the performance of the pre-1987 projects compare with that of the post-1987 projects? How do the post-1987 projects compare with similar natural wetlands; if they are different, are there likely explanations (e.g., age of project, land use setting)?

The performance of the pre- and post-1987 projects will be investigated by comparing the two groups for certain relevant variables (e.g., the ratio of wetland to upland taxa). Data for the groups will be compared graphically and statistically. A two sample test will be used to compare the two groups for a single variable and Hotelling's T^2 for a group of related variables. In addition, multivariate analyses will be used to explore the data and determine whether there are distinct differences between pre- and post-1987 projects. Comparisons of natural wetlands and projects will be similar to those outlined for the pre- and post-1987 projects. In addition, outliers will be identified and investigated for both comparisons (i.e., comparisons of pre- and post-1987 projects and comparisons of project and natural wetlands). Cook's distance and other diagnostic tools will be used to determine if there are outliers which have influence in the statistical sense.

Objective 4--Evaluate how project design and implementation affect the replacement potential of freshwater wetlands to aid in the development of design guidelines.

Existing data compiled from Section 404 and Oregon Removal-Fill Permit files will be compared with field data to examine the compliance of projects with their permits and construction plans. In addition, both the design specifications and the as-built structural features of the projects will be compared to the structural characteristics of the natural wetlands. Differences and similarities in the structural characteristics of the two groups of wetlands will be documented and summarized to aid in the development of design guidelines for future projects.

Permit files and construction plans will be examined for information on the intended hydrologic regime of each project. Intended water levels, area to be inundated, and descriptions and locations of water sources, inlets, outlets, and control structures will be compared to as-built conditions of projects and structural conditions of natural wetlands identified from field maps and measurements of hydrologic indicators.

The intended area and shape of each project determined from blueprints and written permit conditions will be compared to as-built data for each project identified from field maps. In addition, project shapes (e.g., shoreline sinuosity), will be compared to the shapes of natural wetlands. Morphology and bank slopes intended for the projects (e.g., written bank slope specifications and contour lines on blueprints) will be compared to as-built project morphology and the structural characteristics of natural wetlands measured during field activities.

Revegetation strategies specified as conditions of permits and lists of species to be planted will be compared to the plant species identified on the projects during field sampling. The revegetation information will also be compared to the plant species identified at the natural wetlands to determine if the species listed for planting occur naturally on wetlands in the region.

Data Analysis Procedures

Checking to see that the assumptions of a statistical procedure are met is the first step in data analysis. The data used for statistical tests must fulfill various assumptions (e.g., normal distribution, independent observations, equal variances) for the use of the tests and the results to be valid. However, data can be transformed so that assumptions are met. Also, when necessary, alternative analyses including non-parametic techniques can be used.

In addition, to gain the most complete understanding of data, interim results of the analyses will be discussed with a plant community ecologist. The ecologist can provide interpretation or insight that a statistician may lack (e.g., interpretation of an axis produced by detrended correspondence analysis).

To observe trends, identify outliers, and summarize the data, descriptive statistics will be calculated (e.g., mean, mode, range) and the data will be graphically displayed. Displaying data graphically is an effective way to understand relationships

between variables. Such graphics can also be used to compare groups and develop a preliminary interpretation of results. There are many informative ways to display univariate data graphically (e.g., histograms, stem and leaf plots, and boxplots). Multivariate data can be presented as a matrix of scatter plots that is analogous to a correlation matrix.

Answering the research questions (Table 5-1) for the OWS requires two basic analysis approaches, characterization and comparison. Comparing natural wetlands to project wetlands is necessary to evaluate the degree to which projects replicate natural wetlands and to identify features that suggest improvements to project design. However, meaningful comparisons cannot be made without detailed descriptions of wetland attributes and an understanding of existing wetland resources. The first step of analysis is to characterize the wetlands by employing data that describe wetlands in terms of their vegetation, soils, hydrology, morphology, and land use (See Table 5-2 for list of variables) to identify groups of wetlands and to document the condition of wetland resources. The data analysis methods proposed for the characterization and comparison processes are outlined in Table 5-3. Both a priori groups of wetlands (e.g., those defined by land use categories, natural vs. project, pre-1987 and post-1987 projects) and groups of wetlands defined by ecological characteristics will be evaluated in data analyses.

Characterization and comparison of the wetlands

Several data analysis procedures are involved in characterizing the OWS wetlands. An example illustrating how the data and analysis approaches might be used for wetland characterization is provided in Figure 12-7. It is necessary to describe each wetland (e.g., using site averages), define groups of wetlands that can be compared (e.g., using Cluster Analysis), and identify the gradients along which the wetland groups vary or are distributed (e.g., using Ordination Analysis). The next step is to evaluate the wetlands in greater detail to 1) develop more precise understanding of wetland characteristics for comparisons, and 2) identify relationships between variables that can aid in answering some of the study questions or that suggest hypotheses to be tested in further studies. Techniques useful in this regard are Diversity Indices and Dominance Measures, Weighted Averaging Ordination, Correlations, and Multiple Regressions.

Site averages for each variable will be calculated so that each site can be described in terms of vegetation and environmental measures. The site averages will be input into several kinds of multivariate analysis programs. First, vegetation data and environmental data will both be evaluated using Classification techniques (clustering programs) to 1) describe groups of related wetlands such as projects, natural wetlands, wetlands in different land uses, and wetlands with similar plant communities or environmental attributes, and 2) identify outlier sites.

Ordinations are useful in summarizing community data, and will aid in relating community variation to environmental gradients and understanding community structure (Gauch 1982). Vegetation and environmental data will be analyzed using Ordination techniques (e.g. Detrended Correspondence Analysis) to look for

environmental gradients, such as hydrology, wetland morphology, land use, disturbance, project age, buffer presence or absence, along which the wetland groups are distributed. The position, along the Ordination axes, of the wetland groups identified during Cluster analysis will be evaluated to see if the groups are aligning along a gradient. The environmental variables will then be back correlated with the vegetation ordination axes to see if any of the variables are significantly related to the gradient(s) described by the axes. Figure 12-8 depicts a hypothetical ordination of wetland species data. Hypothetical groups resulting from clustering analysis are circled on the diagram to illustrate how wetland groups are related to the gradients represented by the ordination axes. In this case, ordination axis 1 represents a hydrologic gradient, and axis 2 represents a disturbance gradient. Along the first axis, the hypothetical wetlands do not separate according to whether they are project or natural (except that more projects are ponds), but are aligned according to inundation duration or water depth. Along the second axis, wetlands appear to be aligned based on the proportion of native to exotic species.

Several other approaches for identifying which variables are most explanatory in defining gradients are also available. Canonical Correspondence Analysis will be used to investigate the relationships between vegetation and environmental variables. Principal Components Analysis will be used to explain which variables or combinations of variables account for major sources of variation. Binary logit regression (for non-normally distributed data) or discriminant function analysis (for normally distributed data) will be used to identify the variables which best characterize differences between groups of wetlands.

More information regarding differences between individual or groups of wetlands will be obtained in several ways. Diversity and Dominance Measures will be used to summarize vegetation structure in individual wetlands and to aid in describing differences between groups of wetlands. For example, such analyses could show species diversity is greater on young projects than on natural wetlands (Figure 12-9). This might be due to the influx of weedy colonizers in early succession.

The Weighted Averages Ordination Technique will be used to rank plant species by their wetland indicator status and produce axes that distribute the wetlands along a continuum of NWI habitat categories (Wentworth et al. 1988). For example, Figure 12-10 illustrates the Weighted Averages Score for natural and project wetlands sampled in the 1987 Oregon Pilot Study. Results could illustrate differences in wetland type or "quality" that might be related to project vs. natural wetlands, land use, or presence of buffers, etc. Weighted averages may be similarly employed using hydric soil indicator and organic matter data.

Multiple regression will be used to determine the relationship between a response variable and one or more explanatory variables. For example, regression could determine if the percent of organic matter found in the soil is related to the project age and land use.

Correlations are also used to determine the degree of linear relationship between two variables. Correlation Analyses will be conducted in two ways, using either site averages or plot values for the variables. Relationships between any of the

variables sampled in the OWS (Table 5-2) can further characterize the study wetlands, and also permit inferences useful in identifying differences that relate to attainable quality or replacement potential, and suggest improvements in project design. For example, if high cover of exotic plant taxa is positively correlated to urban land use, narrow buffer width, and low soil organic matter, several ideas emerge. The condition or the attainable quality of a site that occurs in such a situation is likely to be low and influenced by these particular variables. The potential of replacing a high quality wetland would likely be low if the compensatory mitigation project was placed in an urban site that lacked buffers and had limited soil organic matter. Project design might be enhanced by relocating the project, installing buffers, or adding organic matter to the site.

Correlations involving plot values for variables could provide detailed information about relationships between plant species and environmental variables such as hydric soil indicators, soil organic matter, hydrology, and relative elevation. Such information could be used to improve project designs by providing guidelines for construction that would generate wetland morphology, hydrology, and soil conditions conducive to the establishment of desired plant species. Also, planting lists of native species that are adapted to conditions of marginally successful projects might be developed.

Following the characterization analyses, data for groups of wetlands will be statistically (e.g., T-tests, Mann-Whitney rank sum test, Hotelling's T^2, ANOVA) and graphically (e.g., histograms, boxplots, characterization and performance curves) compared to facilitate answering the research questions. For quantitative comparisons used to determine if statistical differences in wetland attributes exist between different wetland groups, the choice of statistical test will depend on the number of groups being compared and whether data are normally distributed. For comparisons of two samples, Student's T test will be used for normally distributed data, and a non-parametric test such as the Mann-Whitney rank sum test will be used for non-normally distributed data. Similarly, for comparisons of more than three groups (e.g., organic content of soils for wetlands in the five land use classes), analysis of variance or a non-parametric equivalent such as Kruskal and Wallis test will be used. Hotelling's T^2 is a multivariate extension of a t-test which could be used to summarize a group of related variables (e.g., vegetation). Graphical depiction of data in characterization or performance curves will be used to compare projects and natural wetlands, wetlands in different land use groups, and groups of wetlands defined during the characterization process. The results of these graphical comparisons will be used to aid in development of criteria for project evaluation and design (Kentula et al. 1992a). The utility of characterization and performance curves is discussed in more detail in the summary section that follows.

Summary

The OWS has been designed to collect, analyze, and report information that will contribute to sound wetland management using wetland restoration and creation. As stated in the study overview, information needs related to direct and indirect wetland

loss will be addressed by the study. The unique contribution of this study to wetland science and management is the definition of indirect losses of wetland function due to land use practices and the design and implementation of wetland projects. This contribution is best illustrated by the use of characterization curves and performance curves to represent the results of the study.

Characterization curves are frequency distribution curves in which the vertical axis represents the number of wetlands (i.e., frequency) and the horizontal axis represents some measure of function (i.e., the variable of interest). These curves will be used to summarize data and graphically compare major characteristics of the wetland groups studied. For example, Figure 12-11 illustrates the results we would anticipate for the relative function of wetlands in different land use settings based on results from the 1987 Pilot Study. The shape of the curve indicates whether the group is homogenous or heterogenous, i.e., includes sites having a similar level of the function measured (A on Figure 12-11) or includes sites with a wide range of values for the function (B on Figure 12-11). The position of the curves along the x-axis represents the relationship between the wetlands in each land use setting and level of function measured. Consequently, displaying data in characterization curves allows the presentation of a large amount of information in a way that portrays the relationship between land use and specific wetland functions.

Performance curves display the changes in a function in wetland projects over time as compared to the level of that function in similar natural wetlands. In the 1987 Pilot Study we produced the first portion of these curves for the variables measured at all wetland projects in existence at that time (Figure 12-11). One goal of the OWS is to generate the next segment of those curves to determine how pre-1987 projects have continued to develop and if they are becoming more similar to natural wetlands. Another goal is to determine if projects constructed since 1987 are developing as we would expect based on the 1987 study, or if they are developing differently due to changes in design or management. We hope that due to increased knowledge and experience in wetland restoration and creation that the newer projects are developing the functions of natural wetlands more rapidly than the projects constructed prior to 1987 (Figure 12-12). Again, the graphic display enables us to summarize and compare key information simply and rapidly.

In designing the OWS we have responded to the challenge stated in **An Approach to Improving Decision Making in Wetland Restoration and Creation** (Kentula et al. 1992a) that we continue to build the knowledge base on wetland restoration and creation through the application, testing, and evaluation of the concepts presented in **Decision Making**. The OWS employs one of those concepts by considering ecological setting in the evaluation of the function of natural wetlands and projects, and by beginning to address the relationship between land use and wetland function. It also treats existing projects as experiments in progress, making monitoring of natural wetlands and projects central to the use of restoration and creation in wetland management, and endorsing the idea that we all must

"...learn by going where we need to go..." (Roethke 1961).

COMPUTER SYSTEM DESCRIPTION

Data will be entered and analyzed on IBM compatible PC computers (AT for data entry, 386 and above for analysis). The dual entry data management system will be written using Clipper programming software which is compatible with D-Base, Paradox, and FoxPro formats.

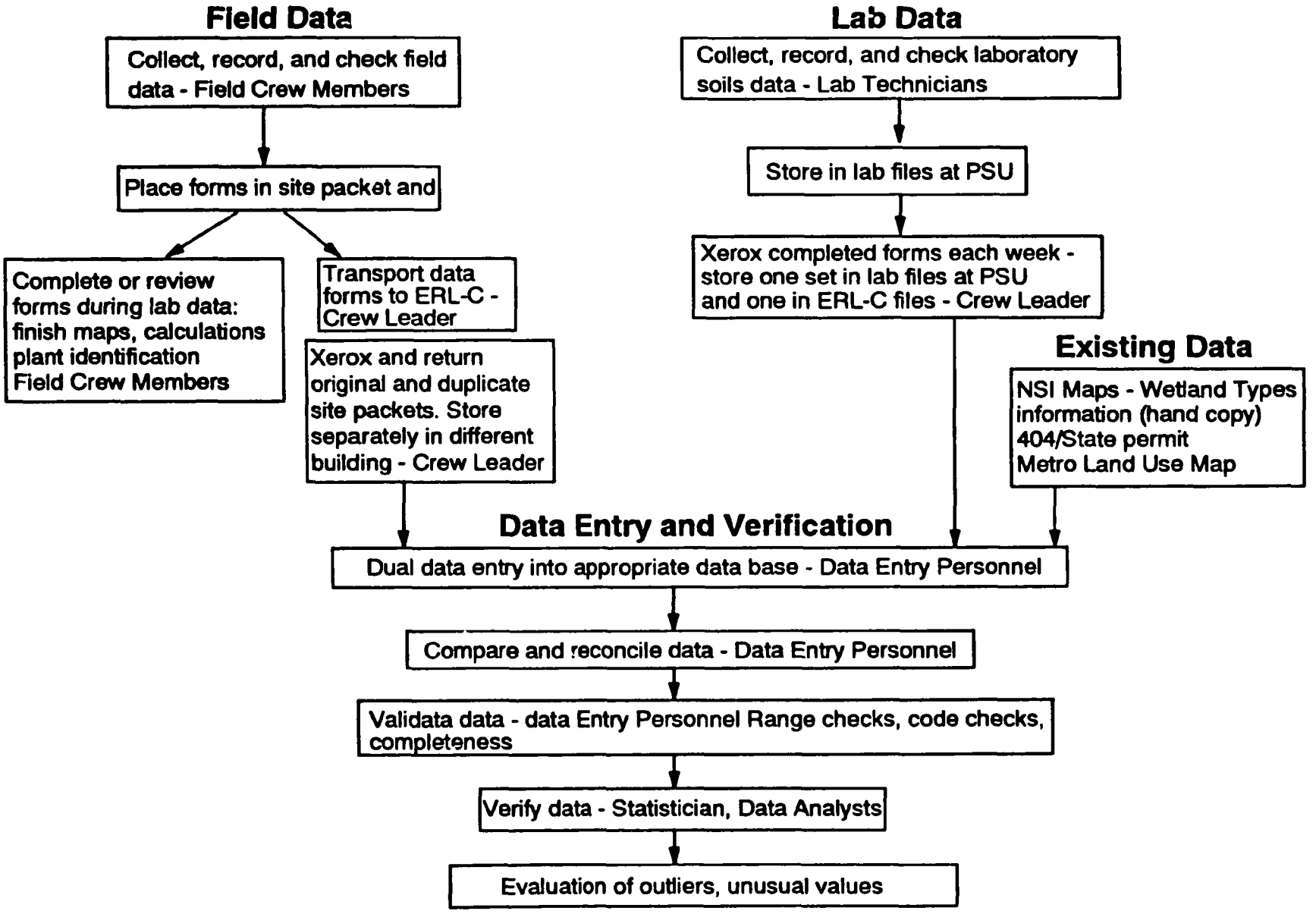


Figure 12-1. Flow chart outlining data tracking from data sources (field, laboratory existing) through data entry.

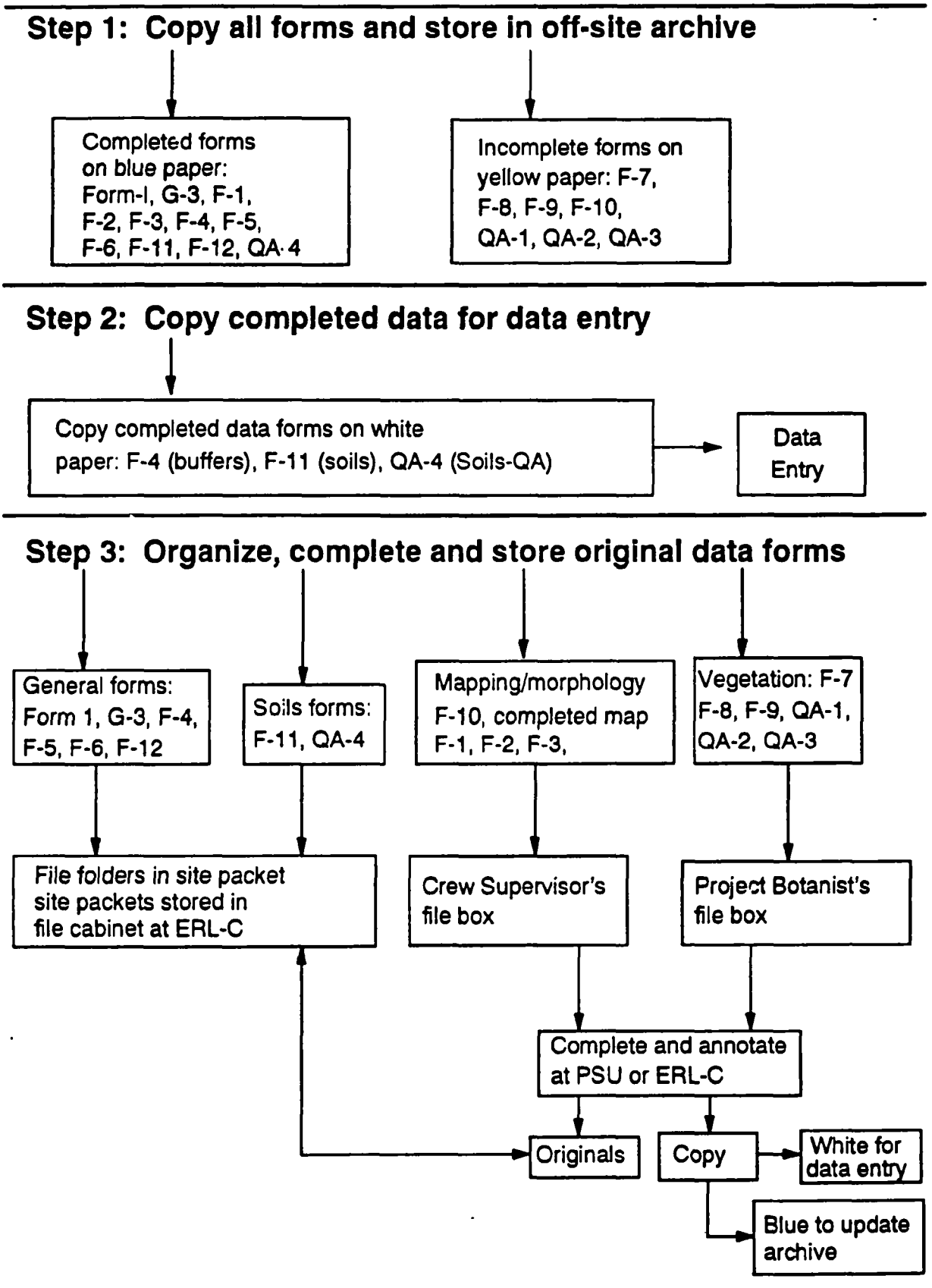


Figure 12-2. OWS data tracking, copying, and archiving procedures.

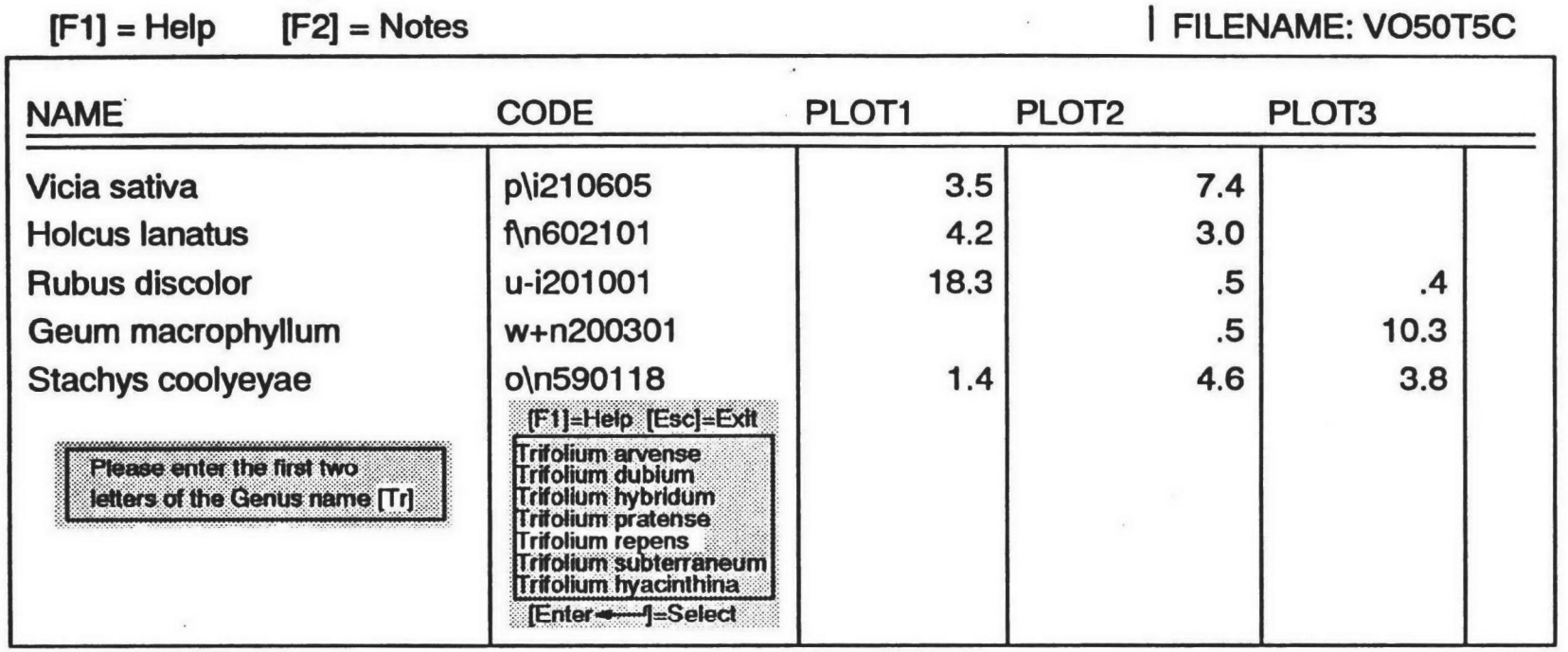


Figure 12-3. Example computer screen showing a lookup table. The user can enter the GENUS/SPECIES name by entering the first two letters of the GENUS name, then selecting the appropriate name from the lookup table.

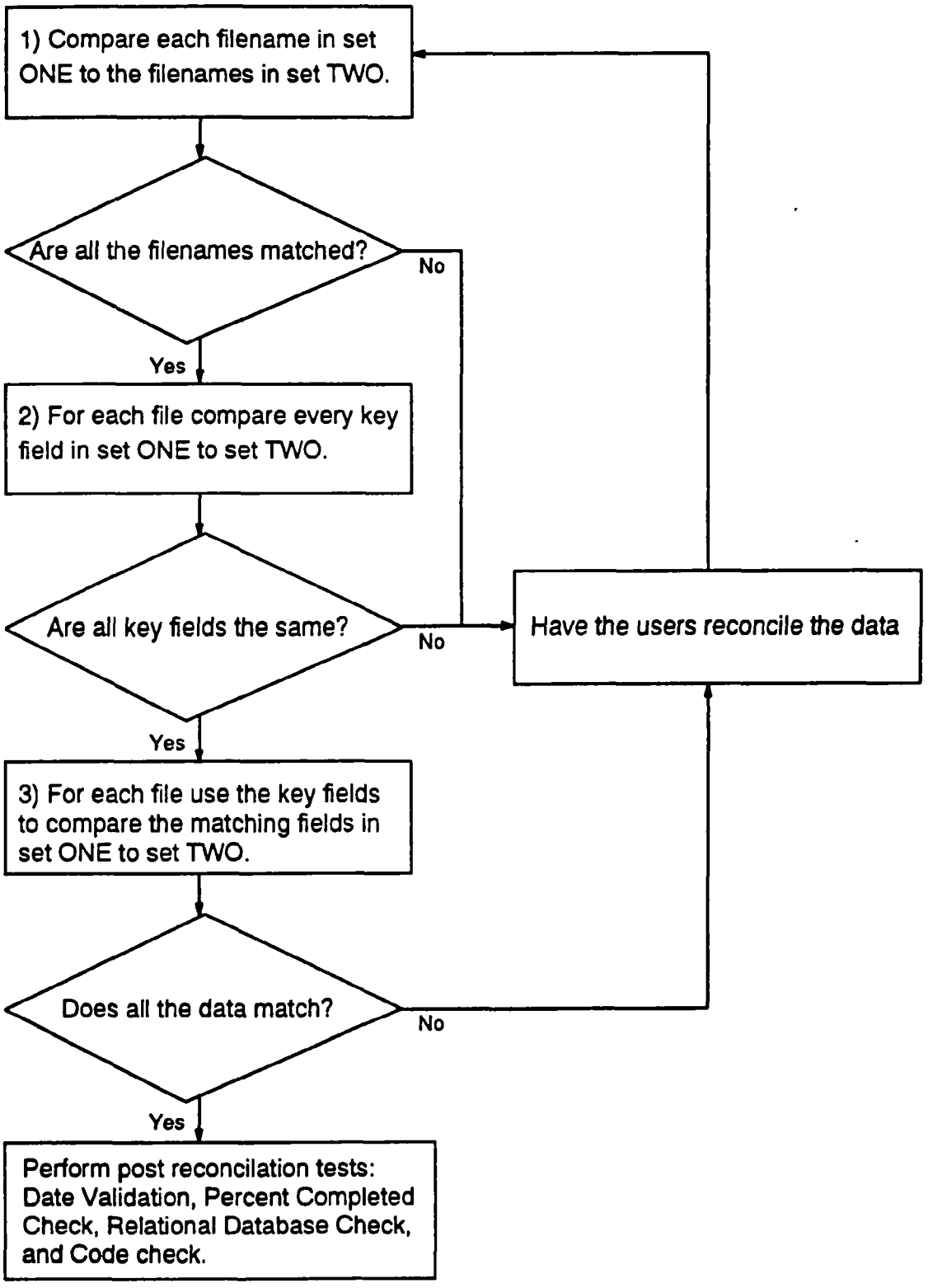


Figure 12-4. Flowchart of the three step comparison and reconciliation process.

[F1] = Help [F2] = Notes [F3] = Top/Bottom [F10] = Next | FILENAME: VO50T5C

[Their's--Record: 23]

NAME	CODE	PLOT1	PLOT2	PLOT3	
Vicia sativa	p\i210605	3.5	7.4		
Holcus lanatus	f\n602101	4.2	3.0		
Rubus discolor	u-i201001	18.3	.5	.4	
Geum macrophyllum	w+n200301		.5	10.3	
Stachys coolyeyae	o\n590118	1.4	4.6	3.8	

[Your's--Record: 23]

NAME	CODE	PLOT1	PLOT2	PLOT3	
Juncus effusus	w+n580105	40.0		.1	
Holcus lanatus	f\n602101	4.2	3.0		
Rubus discolor	u-i201001	18.3	.5	.4	
Geum macrophyllum	w+n200301		.5	10.3	
Stachys coolyeyae	o\n590118	1.4	4.6	3.8	

[PROBLEM: GENUS/SPECIES names are not the same]

POSSIBLE CAUSES: 1) You entered the wrong name. 2) They didn't enter this record. 3) You entered this record twice. 4) This record doesn't belong.

Figure 12-5. Example computer screen showing the reconciliation of a GENUS/SPECIES name in a vegetation database.

VEGETATION

SITE: 3352 TRAN: 2

FILE: V3352T1 RECORD ID: Vicia Sativa FIELD: PLOT32

PROBLEM: Could not determine the number recorded on the field sheet.

RESOLUTION: No value entered.

Figure 12-6. Example notebook entry for identifying problems encountered during the data reconciliation process and their solutions.

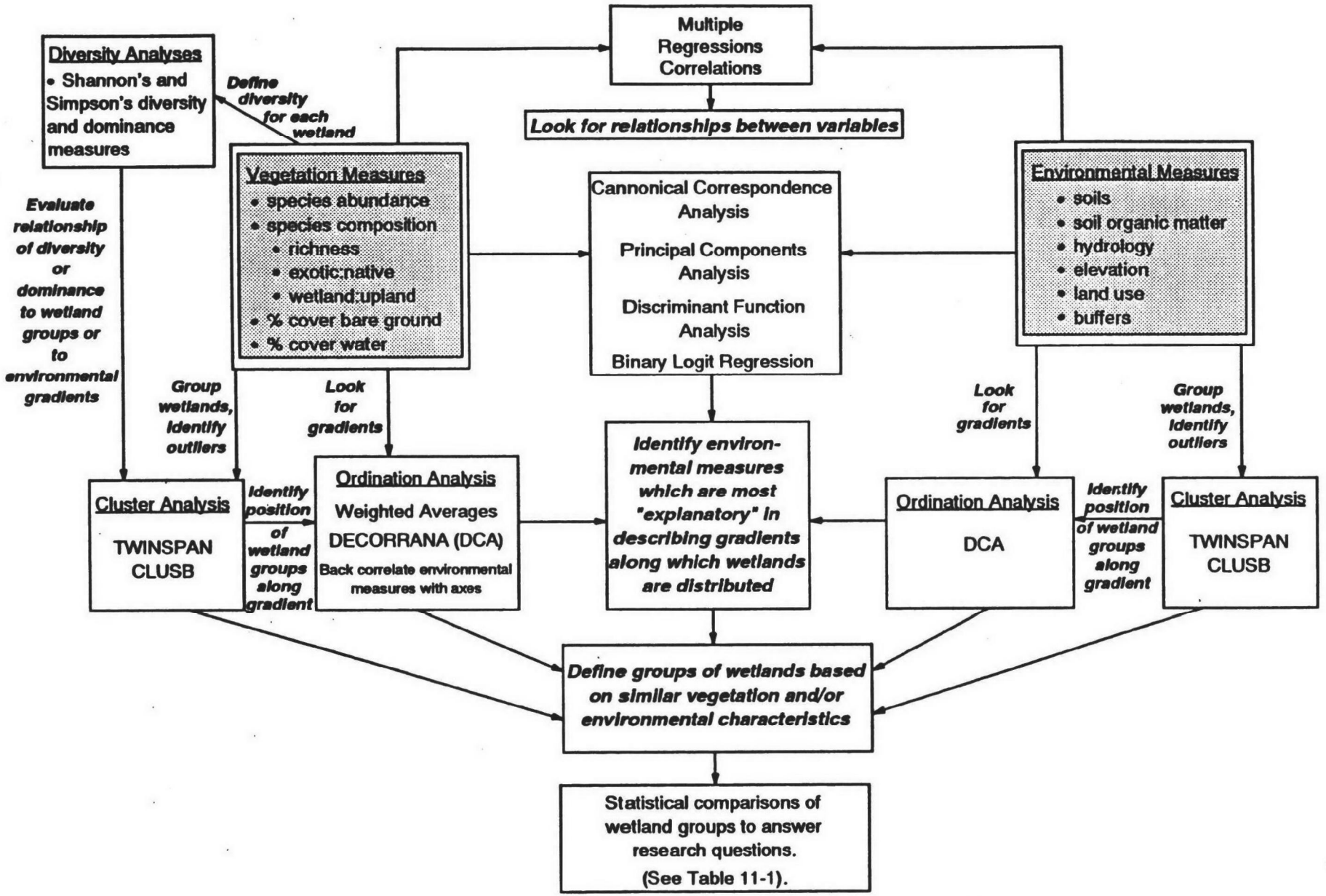


Figure 12-7. Example of approaches for characterizing and comparing wetlands. *Italics = purpose of analyses.* Shading = data sources.

HYPOTHETICAL CLASSIFICATION AND ORDINATION OF WETLAND SITES

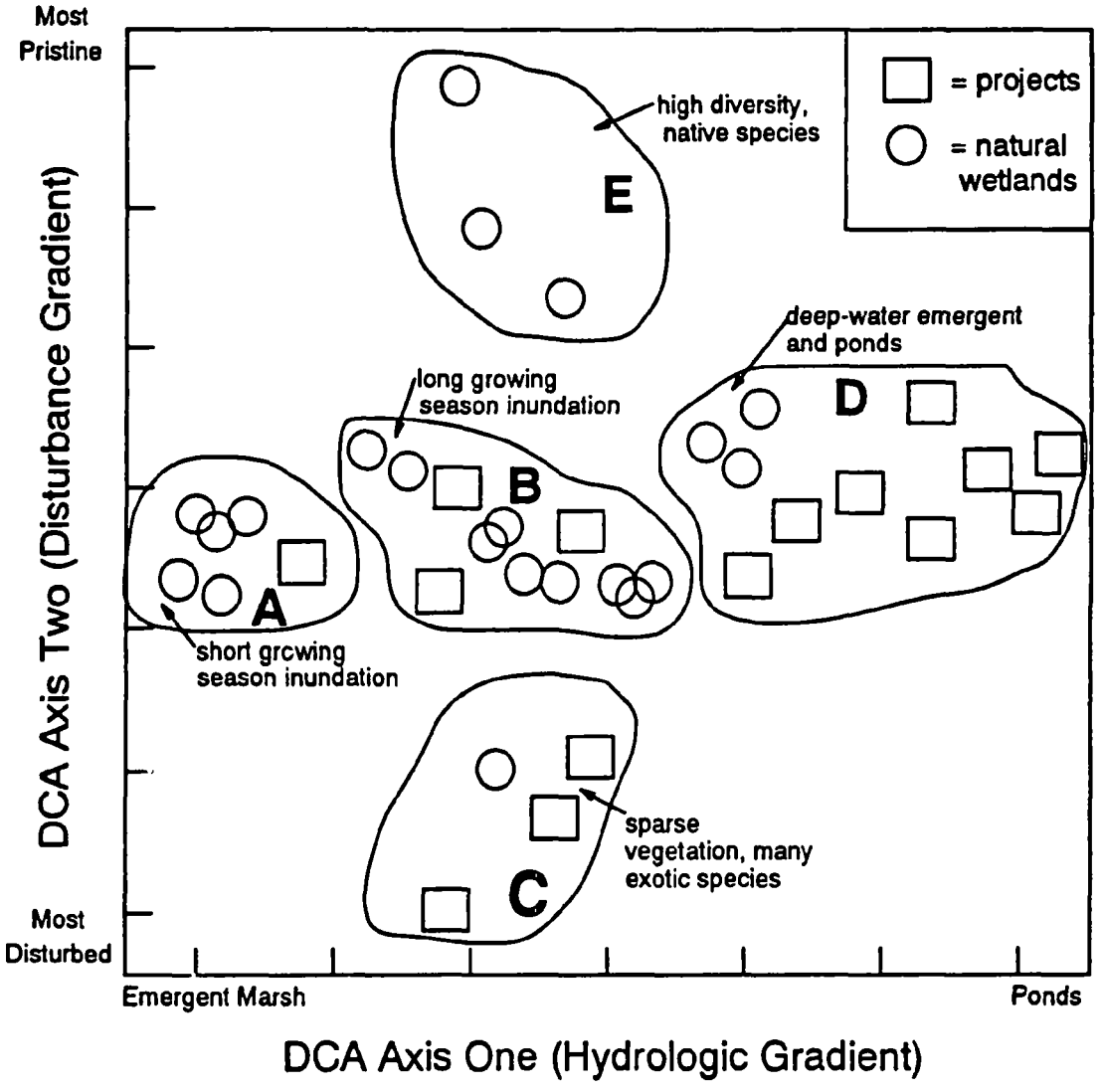


Figure 12-8. Hypothetical ordination and classification of wetland data. Natural and project wetlands are distributed along a hydrologic gradient on the first axis and along a disturbance gradient on the second axis. Circled groups of wetlands (A-E) represent hypothetical results of cluster analysis. Notes refer to characteristics of wetland groups.

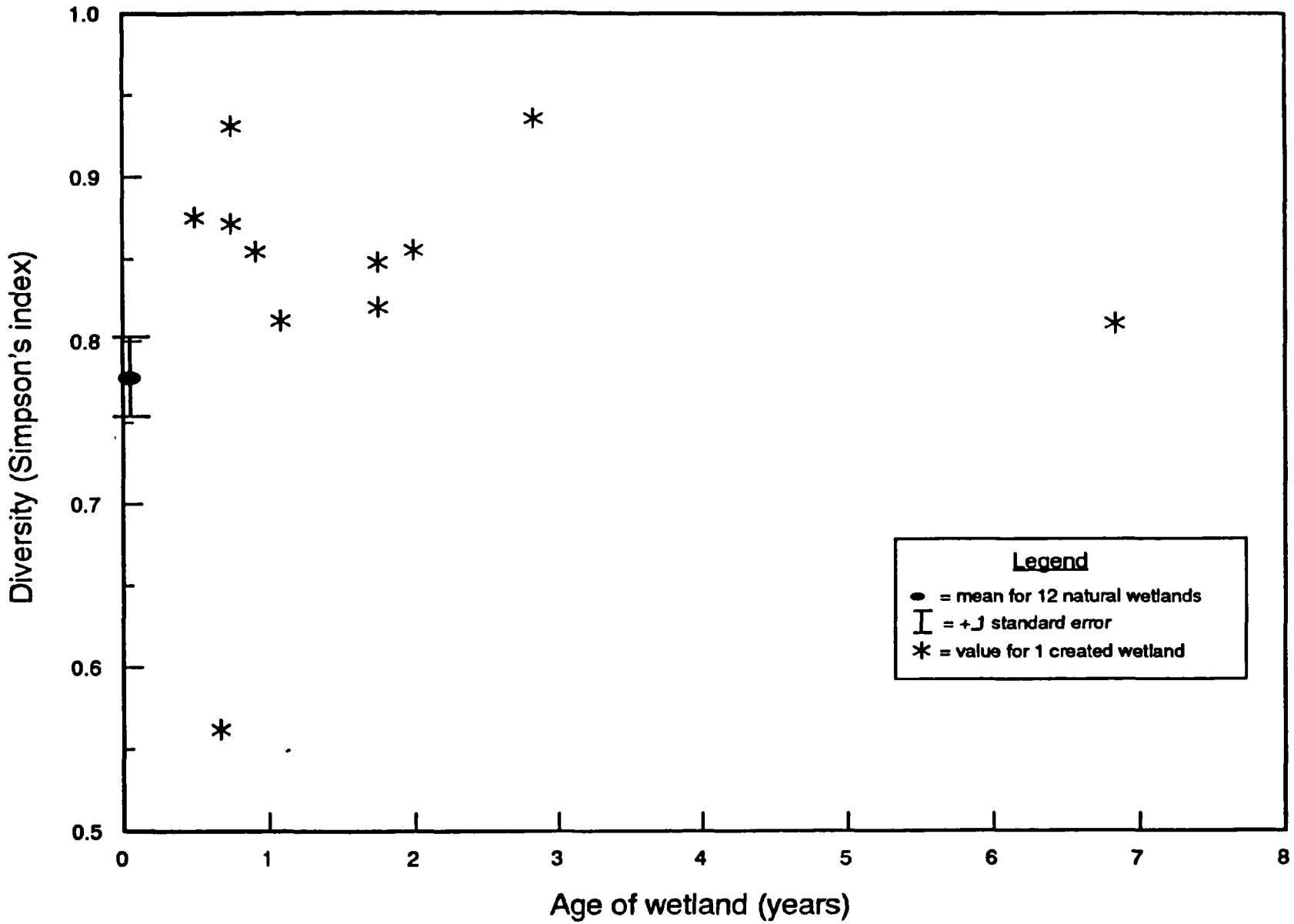


Figure 12-9. Plant diversity data from the 1987 Oregon Pilot Study (Kentula et al. 1992a).

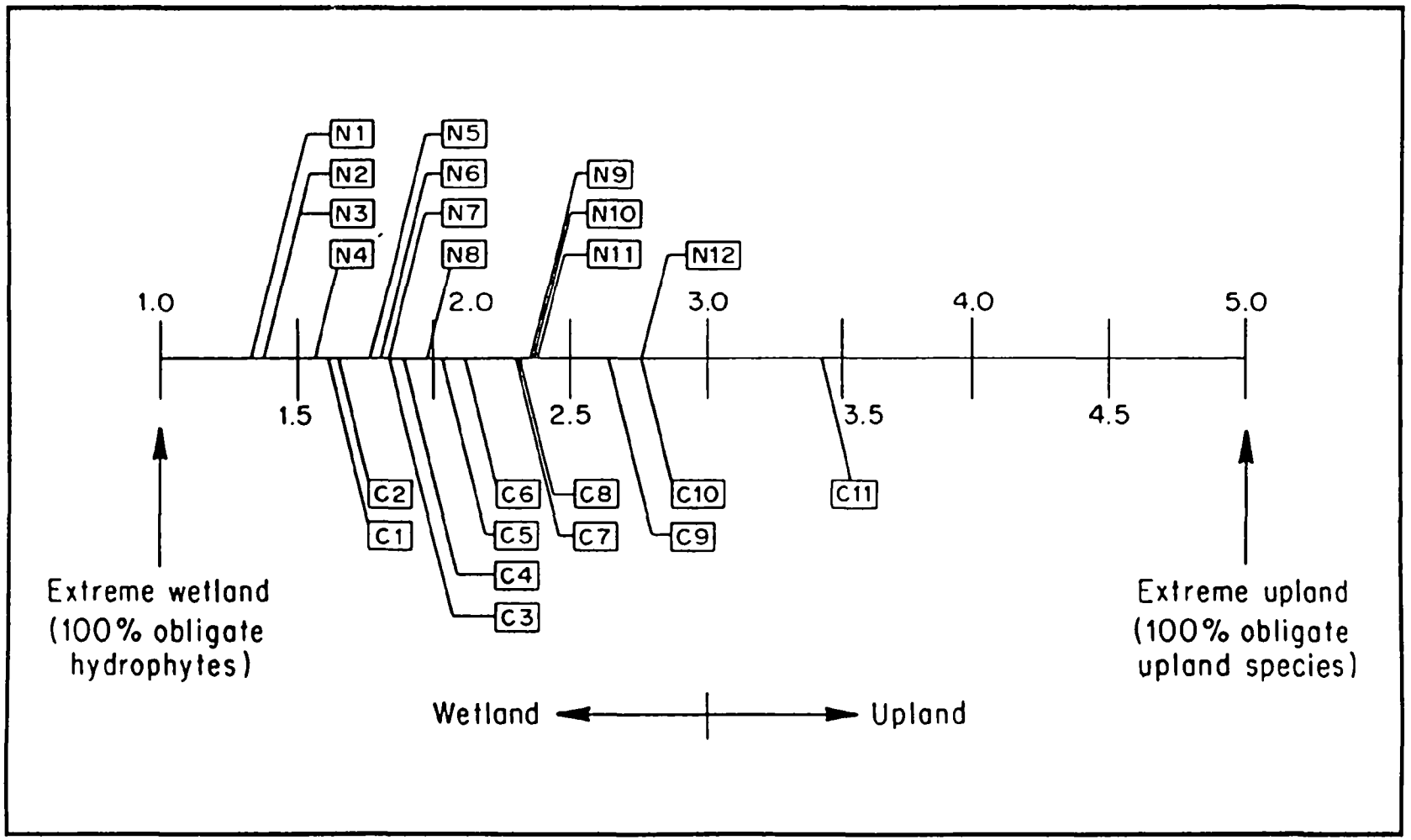


Figure 12-10. Weighted average scores for the type of vegetation found in individual project (P) and natural (N) wetlands from the 1987 Oregon Pilot Study (Kentula et al. 1992a).

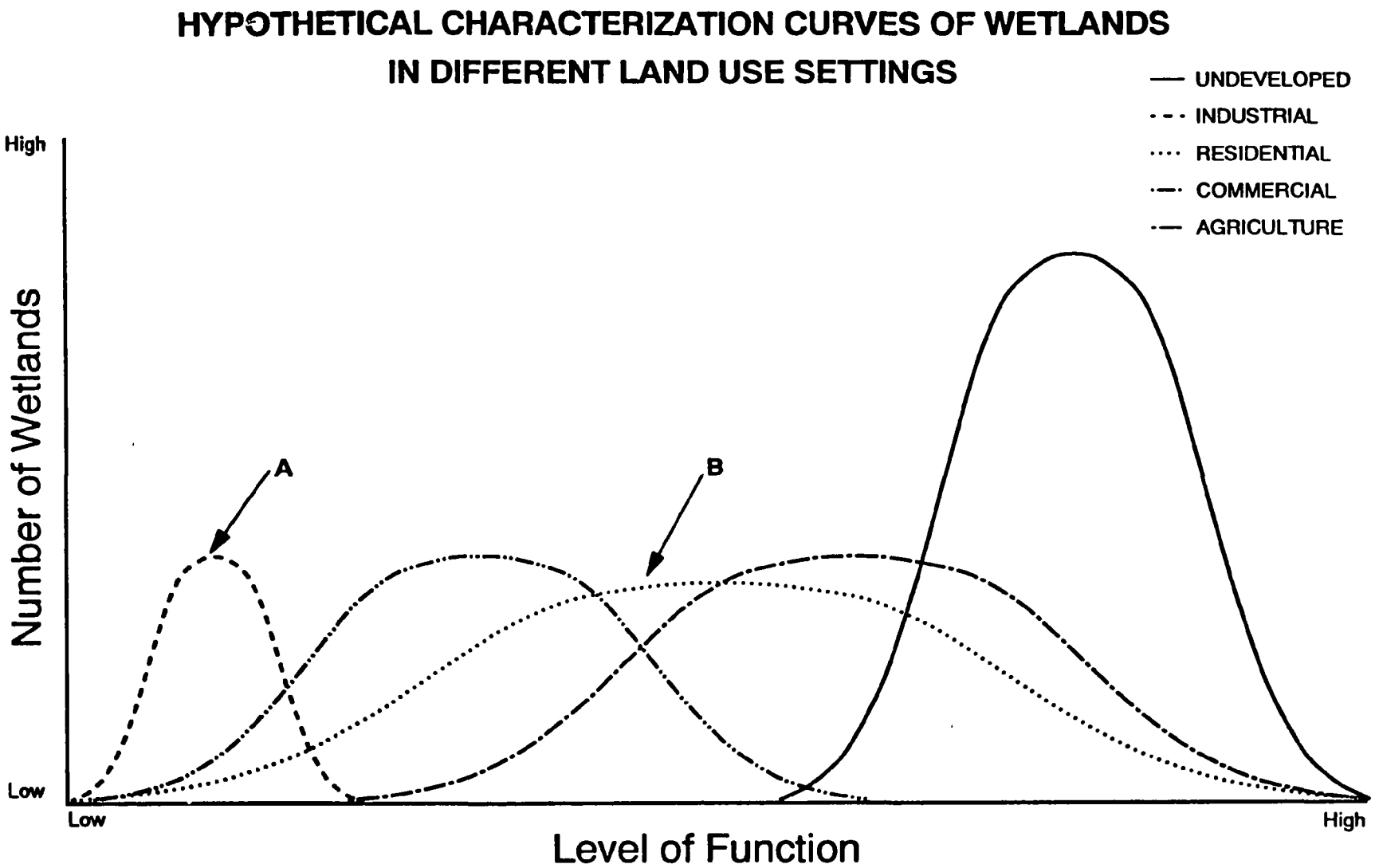


Figure 12-11. Hypothetical characterization curves comparing the level of function in groups of wetlands in different land use settings. The pattern displays the results anticipated for the OWS based on the 1987 Pilot Study. A is the characterization curve of a relatively homogeneous group of wetlands; B, of a relatively heterogeneous group of wetlands.

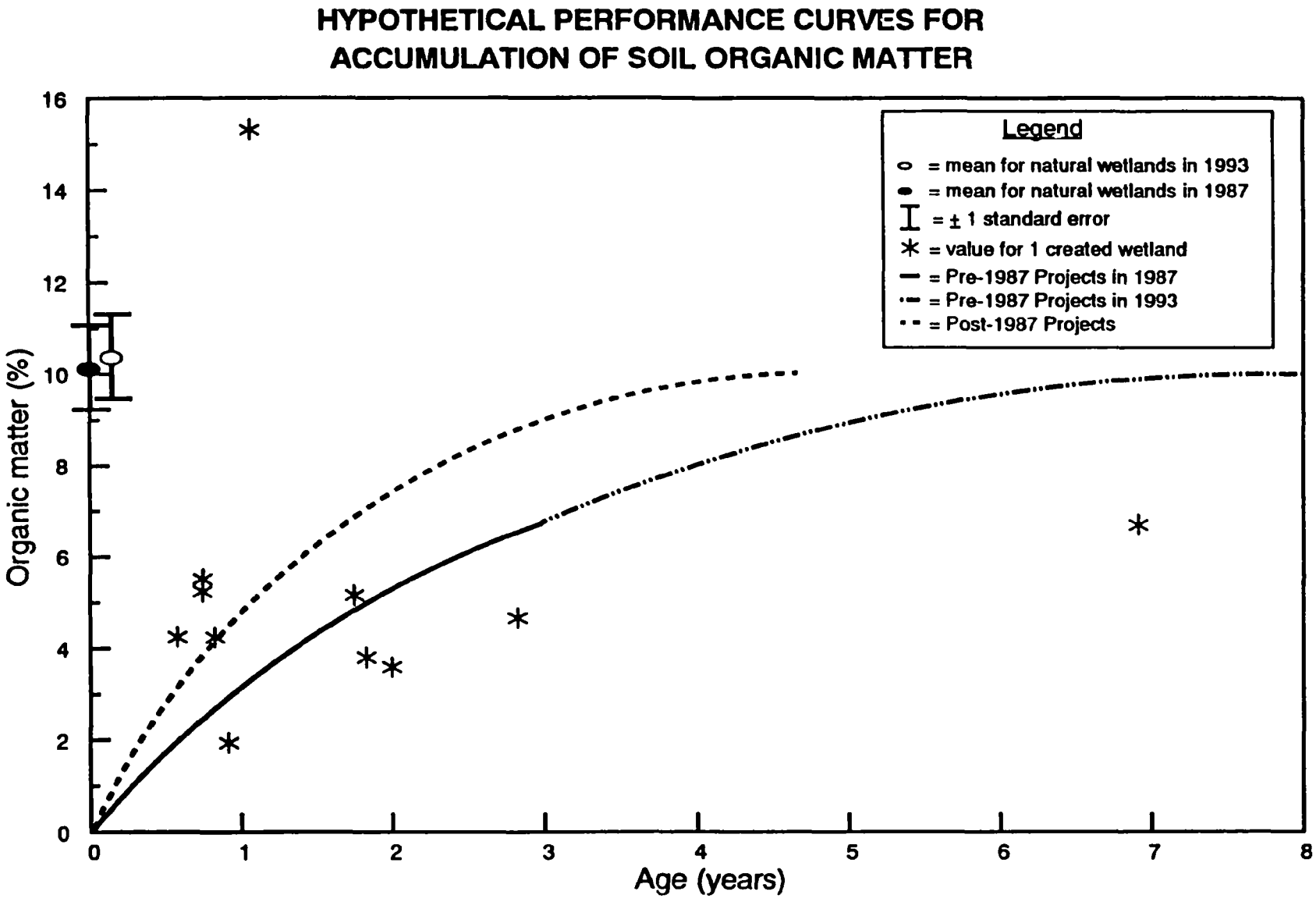


Figure 12-12. Hypothetical performance curves comparing the anticipated development of the projects contructed prior to 1987 to the development of projects constructed since 1987 and to similar natural wetlands. The curves present results of the 1987 Pilot Study and suggest the results that might be expected in the OWS.

13.0 INTERNAL QUALITY CONTROL CHECKS

Quality control (QC) checks will be conducted to ensure that field and laboratory procedures are correctly followed. QA/QC activities and frequency are summarized in Table 13-1. QC data will be gathered following standard procedures, with crew members exchanging jobs and duplicating part of the sampling and data collection. QA procedures, summarized in Tables 13-2 and 13-3, fall into three types: within-crew checks to be conducted at each site, between-crew checks to be performed twice over the field season, and Crew Leader checks. QC data will be collected for 5 vegetation quadrats, 1 transect for shrub cover and tree diameter data, and 1 soil sampling point at each wetland. Within-crew and between-crew checks will use standard procedures and involve resampling or taking replicate readings for a subset of the site, vegetation, and soil data. The within-crew checks conducted at every site are designed to ensure proper execution of standard field procedures, and assess comparability and precision between observers on the same crew. Between-crew checks are used to assess comparability between crews, to ensure that data collection procedures are executed in a consistent manner by all field crews, and to "recalibrate" the observers on different field crews against each other and an "accuracy standard". Crew Leader checks involve weekly conferences among Crew Leaders to compare problems and progress, and discuss any modifications in data collection procedures. External checks include a technical systems audit conducted by ERL-C QA staff, and visits by the EPA Program Leader.

QUALITY ASSURANCE FIELD PROCEDURES

QA/QC checks apply to data and sample collection for site, vegetation, and soil variables. Detailed QA procedures are provided for tasks in the order that they are performed in the field and are listed under the appropriate subheadings below. Refer to Section 8 in this QA plan or the **Research Plan and Field Manual for the Oregon Wetlands Study** (Magee et al. 1993) for details on standard procedures.

Vegetation – Quality Assurance Procedures

Within-crew QA procedures for vegetation sampling will be conducted by the two Botanists and two Recorders from each crew. During these procedures, one Botanist will be referred to as the "primary botanist" and the other as the "second botanist". Botanists will alternate the primary and second roles between sites, but roles must remain consistent at a site. Assuming all three vegetation strata (herbaceous, shrubs, trees) are present at a site, duplicate sampling will be done for herbaceous cover (5 quadrats on one transect), shrub line-intercept intervals (1 transect), and tree diameter measurements (1 transect). These data will allow assessment of the precision and comparability, among the two Botanists, for the line-intercept and tree diameter measurements, and cover estimation. Also, the data will provide information on the completeness and comparability with which herbaceous species are identified within the quadrats by two different Botanists.

1. The Crew Leader randomly selects the Site Characterization Transect on which to collect QC data. Roll a die to select a number from one to five to select a transect number. If a six is thrown, roll again. This is the transect used for collecting all QC data for vegetation. Shrubs and trees are resampled along the entire length of the transect. Cover of herbaceous vegetation will be re-read in five randomly selected quadrats, taken from a list of random numbers.

2. When the primary Botanist and Recorder reach the QA transect during the course of normal field activities, they sample it using standard sampling procedures to obtain shrub line-intercept data, vegetation quadrat data, and tree measurements. Data is recorded on the appropriate forms (F-7 through F-9) and the "N" for non-QA sheet is circled in the heading of each form. Once sampling is completed, they leave the tape, the flagged wire markers, and quadrat frames for QA plots in place for the second Botanist and Recorder.

3. When the second Botanist and Recorder reach the QA transect, they sample the entire transect for shrub intercept-lengths and tree diameters, and the five designated quadrats for herb cover. Data are recorded on the appropriate forms (F-7 through F-9) and the "Y" for QA sheet is circled in the heading of each form. The Recorder carefully fills out the heading for the QA data sheets so that correct transect number and plots are provided.

4. Botanists should not exchange comments on the vegetation of the re-sampled transects and plots while conducting QA sampling. When the site has been completed, the Botanists compare their results. If there appear to be discrepancies in cover estimates that exceed the DQOs, the Botanists should practice, as soon as possible, reading the same plots until they consistently obtain cover values that approach the DQOs. When QC cover data are analyzed during the field season and large differences are noted, recalibration should be conducted.

Accurate plant species identification is critical to data quality and is facilitated by training (Section 10) and the botanical expertise (Section 6) of the Botanist Crew Members, by use of standard procedures for presampling species reconnaissance, handling unknown taxa, and plant identification (Section 8 and 11), and by additional QA field checks. The QA field checks for plant species identification are as follows:

1. A Plant Taxonomist (Sherry Spencer) will visit each crew in the field at least once per week to assist Botanists with any taxonomic difficulties they may be having. She will assist with recognition of field characters that will aid in identification of difficult taxa or that separate closely related species.

2. The Taxonomist will observe the Botanists during vegetation sampling procedures and confirm or correct species determinations.

3. The Taxonomist will also retrieve any full plant presses and return them to PSU to be placed on plant driers so that specimens will dry quickly and retain their integrity for future identification.

Soils and Hydrology – Quality Assurance Procedures

1. In each wetland, the Crew Leader will randomly select one soil plot for repeat description and collection of duplicate samples.

2. If the selected plot has soil conditions that preclude description of the soil profile (e.g., unconsolidated soils or standing water), the crew leader will identify an alternate plot for description.

3. Upon arrival at the plot, the Survey Team members fill out information on the top of the QA copy of Form F-11; cross check to insure that wetland, transect, and plot numbers are the same as those on the routine copy of the data form (Form F-11).

4. The soil pit should be dug or auger samples collected as described for routine samples in Procedures A and C as in Soils and Hydrology in Section 8.

5. Each member of the Survey Team should independently fill out information describing the QA plot on both the routine and QA copies of Form F-11. Do not discuss the soil or compare information until all members of the team have finished filling out the form. When all members have completed the forms, turn them over to the Crew Leader who will check them for consistency and discuss discrepancies among Crew Members. Do not refill the pit on the QA plot after sampling; if time permits, discuss information on the data forms with the Crew Leader before refilling the pit.

6. After completing soil descriptions, Survey Team members will collect duplicate soil samples at 0-5 and at 15-20 cm depths in the pit. The intent is to collect two identical aliquots of soil, which will be analyzed to quantify uncertainty in the field. To collect the duplicate samples:
   - In lieu of the standard sample collection procedure described in step 5 of Procedure A, place soil material from the 0-5 cm depth on a clean sheet of plastic.
   - Carefully remove large roots and stones.
   - Mix the soil thoroughly, using a spatula.
   - Label Zip-loc™ plastic bag with the sample code as described in Step 5 of the field sampling procedures. Be sure to use sample type codes of "1" on one of the bags; "2" on the other (it does not matter which is which, because the containers should be filled with identical material).

- After mixing the soil, place alternate scoops of soil into the two sample bags. Place all the material in the two bags, filling the two sample containers approximately equally.
- Repeat this procedure for soil from the 15-20 cm depth interval.

7. Complete routine field sampling activities as described in Section 8.

Between-Crew Quality Assurance Procedures

Between-crew QA activities will center on maintaining high comparability in data collected by different crews. Two approaches will be used to meet this goal. First, each crew will be visited weekly by the Plant Taxonomist to determine if standard field procedures are being routinely followed. Second, twice during the field season between crew recalibration and training review will be conducted.

Standard procedure checks

1. During the course of her regular duties, a Plant Taxonomist will visit each crew at least once a week to aid with plant identification and pick up plant and soil samples. These visits will also allow her to observe any differences in the manner in which data are being collected.

2. If differences are noted, the Plant Taxonomist will document the nature of the discrepancies and report this information to the Crew Leaders.

3. At their weekly meetings (See Crew Leader checks below) the Crew Leaders will discuss any problems related to deviation from standard procedures or differences in Crew Leader style.

4. Proficiency checklists (Appendix 3), listing the sequence of sampling and data collection tasks, and notes on proper execution of methods, have been prepared for evaluating implementation of methods by individuals and teams. These checklists will be used by crew leaders during training and field data collection, by the Program Manager during field visits, and by ERL-C QA staff during training observation and the technical systems audit (see Section 14).

Calibration activities

All three crews will be assembled together twice during the field season, once at the end of training (Week 6) and once near the middle (mid-July, 5th week of sampling) for "calibration" in the collection of site, vegetation, and soil measurements. The wetlands to be used as calibration sites will not be wetlands sampled as part of the OWS. The following "calibration" activities will be performed during Week 6 of the training:

1. The morning session will address calibration of Crew Members to one another based on the "standards" determined by OWS scientists for transit use, soil descriptions, and plant species cover estimation procedures.

2. The Survey Teams will rotate through transit and soil stations, repeating procedures for transit measurements, soil sampling, and describing soils at the same sampling points.

3. The Botanist Teams will rotate through a series of quadrats making appropriate cover estimations. Results for each team will be compared to the "standard" cover values determined by the OWS Plant Ecologist and PSU Plant Taxonomist and to values estimated by the other teams. Attention will also be given to attaining uniformity and completeness in detecting all plant species in a quadrat and to accurately identifying species.

4. Throughout the course of these between-crew QC checks, the Crew Leaders and other OWS scientists will provide encouragement and show appreciation for the efforts of the Crew Members.

5. Members of the Survey Teams will describe a series of soil pedons. Results for each individual will be compared to the "standard" values determined by the OWS Soil Scientist and to the values estimated by other Survey Team members.

6. An extended break for lunch will be provided, if possible, so that Crew Members can relax, discuss experiences with their counterparts from different crews, and interact with the Crew Leaders.

7. During the lunch period, the Crew Leaders will informally assess the variation in data collected on the same transects, plots, or soil sampling points by different individuals. Any discrepancies observed will be discussed as immediate feedback to Crew Members and as part of the calibration procedures during the afternoon session.

8. In the afternoon, each crew will carry out the basic field procedures for sampling a wetland, i.e. conduct a "mock" sampling. This will be the first time that the Survey Team and Botany Teams will be working together as a Crew. The following activities will be conducted: baseline and transect establishment, complete sampling of at least one transect by each of the teams, completion of data forms.

9. Each Crew Leader, using proficiency checklists (see Appendix C), will observe and watch for deviations or discrepancies in the methods being implemented by

their crew. Immediate feedback corrections or recommendations will be given to the Crew Members.

10. Each Crew Leader will be participating in "mock" sampling, carrying out the Crew Leader activities. Consistency of Crew Leaders' implementation of methods, decision-making, and response to questions will be evaluated by the Program Manager and ERL-C QA staff, who will also be using proficiency checklists.

Similar "calibration" activities will be performed during the middle of the field data collection season (tentatively scheduled for 13 July 1993). Mid-season "calibration" will be conducted at a wetland that is not part of the study population, and will consist of the following:

1. A set of vegetation quadrats will be established and sampled by Teresa Magee, OWS Plant Ecologist and Sherry Spencer, PSU Plant Taxonomist. Their measurements will serve as "standard" values.

2. A series of soil pedons will be dug and described by Paul Shaffer, OWS Soil Scientist. His measurements will serve as "standard" values.

3. The Botanist Teams will rotate through a series of vegetation quadrats making appropriate cover estimations. Results for each team will be compared to the "standard" cover values determined by the OWS Plant Ecologist and PSU Plant Taxonomist and to values estimated by the other teams. Attention will also be given to attaining uniformity and completeness in detecting all plant species in a quadrat and to accurately identifying species.

4. Members of the Survey Teams will describe the series of soil pedons. Results for each individual will be compared to the "standard" values determined by the OWS Soil Scientist and to the values estimated by other Survey Team members.

5. Crew Leaders will informally assess the variation in the data collected on the same vegetation quadrats and soil pedons. Any discrepancies or obvious "drift" will be discussed as immediate feedback to Crew Members. If necessary, methods for estimating cover will be reviewed.

QUALITY ASSURANCE LABORATORY ANALYSIS PROCEDURES

QA laboratory procedures will be conducted by the two Laboratory Technicians who process the soils and conduct loss on ignition analyses. Each batch of soils analyzed for loss on ignition will include three types of QC samples: one audit sample (described in Appendix B), a blank (an empty weigh dish), and at least one set of duplicate samples. A set of duplicates includes four samples: the routine field sample,

a field duplicate, and laboratory splits of both the routine sample and field duplicate. More than one set of duplicates may be analyzed in a batch, but field duplicates and laboratory splits are always processed in the same batch as the associated routine sample.

1. One sample of soil audit material will be included with each batch of soils that are processed. Homogenize the audit soil sample by rolling the bottle end-over-end approximately 10 times. Label (with batch number and "AUDIT") and tare a weigh dish, and place 10-15 g of the audit material in the dish. Record the fresh weight of the sample, and process it along with other soils in the batch. Data should be recorded on Forms L-1 (standard) and L-3 (QA).

2. Label an empty weigh boat with the sample identification code, and process it along with the routine samples. Record the tare weight, dry weight, and ashed weight on Forms L-1 and L-3.

3. Identify field duplicate sample and the associated routine field sample. Following preparation of the samples as described in Steps 1-4 of the Laboratory Procedures under Soil Organic Matter Content in Section 11, set the two samples aside.

4. Label four weighing dishes with the sample identification, and sample type codes 1 through 4, and tare the containers. Aliquots of the routine sample should be put in dishes with a sample type code of "1" (the routine sample) and "3" (laboratory split of the routine sample). Similarly, aliquots of the field duplicate should be put in dishes labelled "2" (field duplicate) and "4" (laboratory split of the field duplicate). The four samples should then be processed the same as normal samples. Record data for the four samples on Forms L-2 and L-3.

QUALITY ASSURANCE CREW LEADER CHECKS

Crew Leaders will meet weekly to compare progress, to discuss and resolve problems that they may have encountered, and to address any issues brought to their attention by the external audits or internal QA checks. These meetings will be extremely important in terms of preventing data quality problems, variation in execution of sampling procedures, and tensions between noncompatible personalities among Crew Members. These meetings may take place in the evenings following field days, during return travel to Corvallis on Fridays, or at another time convenient to the Crew Leaders. Topics for discussion will include:

1. Progress in field sampling and laboratory analyses or activities. Are the crews performing the tasks at similar speeds and completing sites on schedule? If not, assess the reasons (i.e. not possible to sample more quickly, one crew is

less efficient than others, some crews are routinely receiving more difficult sites) and discuss remedies.

2. Identify problems with sampling procedures or logistics in the field. Discuss difficulties encountered in specific situations and adopt corrective actions. Discuss differences noted by the Plant Taxonomist in her weekly between crew checks and decide if they are matters of style or are important to data quality. Develop and adopt appropriate modifications for standardizing use of methods among crews.

3. Discuss personnel performance problems or personality conflicts and make recommendations for solutions (e.g. mediation between parties involved or rotation of Crew Members between crews).

4. Crew Leaders who will be working in the field on alternate weeks will need to brief their counterparts at each Crew Leader switch. These briefings may be conducted by phone on Friday evenings after returning from a week in the field or at sometime during the weekend. The returning Crew Leader should advise the Crew Leader who will go into the field on the following Monday of the status of the field work, problems encountered, or any other pertinent information.

Table 13-1. Summary of research and QA/QC activities for assuring and estimating data quality. The frequency and purpose of each activity are indicated (R=representativeness, A=accuracy, P=precision, C=comparability).

Activity	Variable	Frequency	Purpose
Field replicates (data) at each wetland	Site: · Elevation · Buffer size	· 6 transects (5 SCT and 1 WMT) through wetland	R
	Vegetation: · % cover for plant species (herbaceous, shrubs, trees) bare ground, open water	· 5 transects (SCT) through wetland; minimum of 40 vegetated plots	R
	Soils: · Soil color · Horizon thickness · Presence of mottles, gleying, concretions, oxidized root channels, H_2S	· 5 transects (SCT) through wetland (independent of vegetation transects) 2 plots per transect	R
Field replicates (samples) at each wetland	Soils: · Loss on ignition	· 5 transects per wetland; 2 plots per transect; samples collected from 0-5cm, and 15-20 cm at each plot	R
		· Duplicate soil samples from homogenized sample; 2 depths per plot; 1 plot per wetland	P Measurement process check on field sample collection
Collection of plant specimens	Plant species identification	· Unknowns at each wetland	A

Table 13-1 (con't.). Summary of research and QA/QC activities for assuring and estimating data quality. The frequency and purpose of each activity are indicated (R=representativeness, A=accuracy, P=precision, C=comparability).

Activity	Variable	Frequency	Purpose
Re-measurements	Vegetation: · % cover for plant species (herbacious, shrubs, trees) bare ground, open water	· 5 quadrats (randomly selected) within each wetland for herbaceous cover; 1 transect for shrub & tree cover	A,P (within crew) C (within crew)
		· "calibration" quadrats, 2 times during field season (training and mid-season)	A,P (between crew) C (between crew)
	Soils: · Soil color · Horizon thickness · Presence of mottles, gleying, concretions, oxidized root channels, H_2S	· at 1 quadrat (randomly selected) within each wetland	P (within crew) C (within crew)
		· "calibration" pedons, 2 times during field season (training and mid-season)	A,P (between crew) C (between crew)
Laboratory QC checks	Soils: · Loss on ignition	· Duplicate soil samples; 2 sets of duplicates per batch	Measurement process check on laboratory processing
		· Blank; 1 blank (minimum) per batch	Measurement process check on weighing
		· Audit; 1 audit sample (minimum) per batch	Measurement process check on muffle furnace performance

Table 13-1 (con't.). Summary of research and QA/QC activities for assuring and estimating data quality. The frequency and purpose of each activity are indicated (R=representativeness, A=accuracy, P=precision, C=comparability).

Activity	Variable	Frequency	Purpose
Instrument Calibration:			
Balances	Soil sample weights	Daily-before each use	A
Surveying tools	Elevation	Daily-before each use	A
Meter sticks, rulers	Depths: · standing water · in soil pit to standing water · soil horizon depths	Beginning of field season, against standard	A

Table 13-2. Internal quality control checks for assessment of individual and team proficiency in executing sampling methods.

Method	Individual Proficiency	Team Proficiency	Overall Comparability and Calibration of Individuals and Teams
Site:			
Surveying	End-of-training surveying	End-of-training practical for overall surveying methods Accuracy & precision of stadia rod reading estimated against 'standard' at end-of-training.	Individual and team proficiency checklists End-of-training and weekly crew leader discussions
Vegetation:			
Plant Species Identification	End-of-training plant identification practical	End-of-training practical for over-all vegetation sampling methods	Individual and team proficiency checklists
Plant: Species Abundance % cover of herbaceous species, shrubs, and trees; % bare ground % standing water		Accuracy of species identifications and cover measurements estimated against 'standard' at end-of-training and mid-season in 'QA quadrats' Precision of cover measurements estimated against 'standard' at end-of-training and mid-season in 'QA quadrats'	End-of-training and weekly crew leader discussions Discussions among botanists and crew leaders to 'calibrate' cover estimates. End-of-training and mid-season 'calibration' (precision and accuracy checks) in 'QA quadrats'.
Soil:			
Soil color Horizon thickness Presence of: mottles gleying concretions Oxidized root channels H_2S	End-of-training soil description practical	End-of-training practical for over-all soil data and sample collection methods Accuracy and precision of subjective measurements estimated at end-of-training and mid-season against 'standard' measures on 'QA soil plots'	Individual and team proficiency checklist End-of-training and weekly crew leader discussions Discussions among soil scientist and crew leaders 'calibrate' subjective measurements. End-of-training and mid-season 'calibration' (precision and accuracy checks)

Table 13-2. Cont.

Method	Individual Proficiency	Team Proficiency	Overall Comparability and Calibration of Individuals and Teams
Soil:			
Soil Sample Processing	Lab Technicians: End-of-training practical evaluation		
Soil Organic Matter			Audit samples, blanks, laboratory duplicates
Hydrology:			
Depth of standing water		Accuracy and precision estimated at end-of-training and mid-season against 'standard' on 'QA soil plots'	
Depth in soil pit to: standing water free water surface saturated soil			

Table 13-3. Internal quality control checks for assessment of accuracy and within and between crew precision.

Variable	Within-Crew Precision	Between-Crew Precision	Accuracy
Vegetation:			
Plant Species Identification	Remeasurement (plant species and cover) of 5 vegetation plots per wetland		Accuracy of species identifications and cover measurements estimated at end-of-training and mid-season against 'standard' in 'QA quadrats'
Plant Species Abundance % cover of herbaceous sp., shrubs and trees, % bare ground % standing H_2O	Precision of cover measurements estimated at end-of-training and mid-season in 'QA quadrats'	Precision of cover measurements estimated at end-of-training and mid-season in 'QA quadrats'	Weekly visits to each crew by Plant Taxonomist to assist in plant species identification.
Soils:			
Soil Color Horizon Thickness	Remeasurement of 1 soil plot per wetland		Accuracy estimated at end-of-training and mid-season against 'standard' measures on 'QA soil plots'
Presence of: mottles gleying concretions Oxidized root channels H_2S	Precision estimated at end-of-training and mid-season against 'standard' measures on 'QA soil plots'	Precision estimated at end-of-training and mid-season against 'standard' measures on 'QA soil plots'	
Soil Organic Matter			Accuracy estimated based on LOI results for QC audit samples
Hydrology:			
Depth of standing water			Accuracy estimated at end-of-training and mid-season against 'standard' measures on 'QA soil plots'
Depth in soil pit to: standing water free water surface saturated soil		Precision estimated at end-of-training and mid-season on 'QA soil plots'	

14.0 PERFORMANCE AND SYSTEM AUDITS

The QA coordinator of the EPA Environmental Research Laboratory-Corvallis (ERL-C) will observe field staff training on Saturday, May 22, 1993 at the Bryant Woods training site in Lake Oswego, OR. The objectives of this field visit by ERL-C QA staff are: (1) to observe implementation of field methods by the three field crews; (2) to observe OWS training methods; (3) to qualitatively assess consistency of Crew Leaders in implementation of field methods, assessment of individual and team proficiency, and answering questions. If deficiencies or problems are identified, QA staff will make recommendations to the Program Leader and crew leaders.

The ERL-C QA staff will conduct a technical systems audit of the OWS field and laboratory research and QA activities, probably during the week of 28 June, 1993, the second week of field sampling. This external evaluation will include: (1) an assessment of personnel performance, equipment, and procedures; (2) review implementation of the QA project plan; (3) determine whether DQOs are being met (review QC data collected to date); (4) assess consistency of field methods implementation by the three field crews. Any deficiencies or problems will be discussed with the Program Leader, and summarized in an audit report.

15.0 PREVENTATIVE MAINTENANCE

Maintenance information is provided in Table 10-1 in Section 10: Calibration Procedures and Frequency.

16.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA QUALITY

The following formulas will be used to calculate data quality attributes. The values obtained should be within the data quality objectives set for this study (Table 7-1).

Accuracy

As described in Section 13, accuracy will be estimated for site, vegetation, and soil measurements. Measurement values of OWS staff will serve as accuracy 'standards' (see Table 13-3) for subjective variables. Accuracy, the degree of agreement between an observed value and an accepted reference value, will be expressed as percent agreement or percent difference, and calculated by the following formulas:

$$\% \text{ agreement} = \frac{\text{\# of measurements - \# of incorrect measurements}}{\text{\# of measurements}} \times 100$$

$$\% \text{ difference} = \frac{\text{\# of measurements - \# of correct measurements}}{\text{\# of measurements}} \times 100$$

Frequency distributions of differences will be plotted (Figure 16-1) to show the range of accuracy for different crews and/or individuals.

Accuracy will not be assessed directly for organic matter content (loss on ignition) values, because the soil audit material is not being treated as a standard reference material. The loss on ignition (LOI) values for the audit material samples included in each batch will be plotted on a control chart, with warning limits of $\pm$ 2 standard deviations of the mean and control limits of $\pm$ 3 standard deviations of the mean (Appendix B).

Precision

As described in Section 13, between and within crew precision will be estimated for vegetation and soil measurements. Precision, the degree of variation among individual measurements of the same variable, will be expressed as relative percent difference, relative standard deviation, standard deviation, variance, or range. Relative percent difference will be calculated for repeat measurements as follows:

$$RPD = \frac{(C_1 - C_2) \times 100}{(C_1 + C_2)/2}$$

where: RPD = relative percent difference

C_1 = larger of the two observed values

C2 = smaller of the two observed values

For three or more repeat measures (between-crew precision), relative standard deviation will be calculated as follows:

$$RSD = (s/y) \times 100\%$$

where: RSD = relative standard deviation
s = standard deviation
y = mean of the repeat measurements

Frequency distributions of differences will be plotted (Figure 16-1) to show between crew precision. The slope and R^2 values resulting from regression analysis of repeat measurements (Figure 16-2) collected for soil and vegetation measures at each wetland for the duration of the field season will provide estimates of within-crew precision.

Comparability

Comparability, a measure of the degree to which different methods and data sets can be represented as similar, will be assessed in terms of accuracy and precision for most site, soil, vegetation, and hydrology measurements (Table 7.1). Comparability of the soil organic matter content (LOI) data will be evaluated based on results from analyses of soil audit samples and laboratory and field duplicates. Overall comparability of methods implementation and calibration of individuals and teams will be evaluated qualitatively throughout the data collection period (see Table 13-2).

Completeness

Completeness will be assessed twice during the OWS. At the end of the field season, completeness will be assessed as the amount of data (and samples) actually collected compared to the planned amount and will be calculated by the following formulas:

$$\%\ \text{completeness (data)} = \frac{\text{data collected}}{\text{planned data collected}} \times 100$$

$$\%\ \text{completeness (samples)} = \frac{\text{samples collected}}{\text{planned samples collected}} \times 100$$

Following data entry, the amount of validated data will be compared to the amount of data collected, using formulas similar to those above.

Representativeness

Representativeness of the characteristics of each site will be assessed by estimating variation (scatterplots, box plots, standard deviations, coefficients of variation) for variables collected at each site. The sample wetlands will also be sorted by wetland types, and variation within wetland type will be evaluated and compared.
Figure 16-1. Hypothetical frequency distribution of difference in percent plant cover as estimated by vegetation crews against a "standard" in "QA vegetation quadrats."

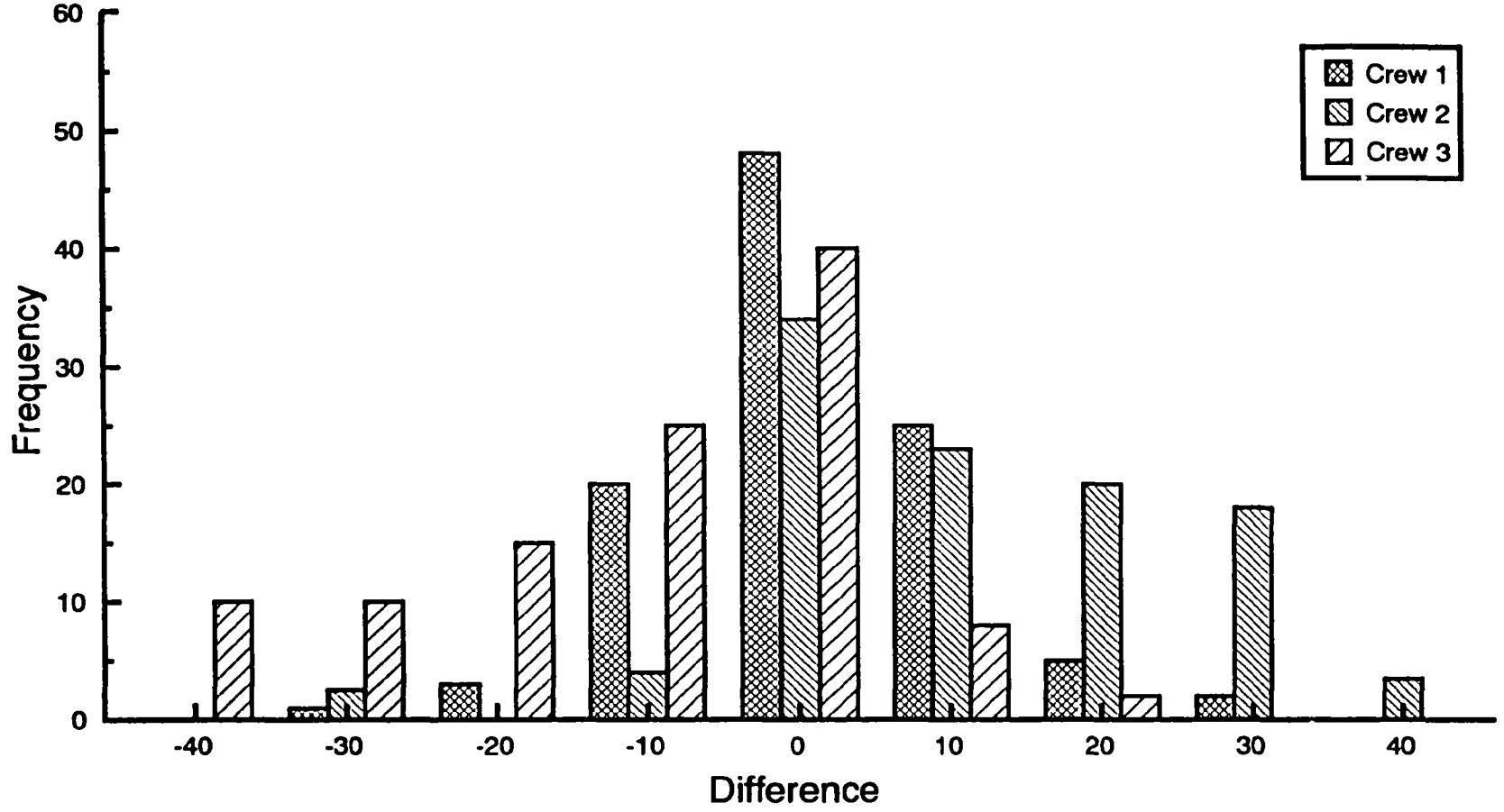


Figure 16-1. Hypothetical frequency distribution of differences in percent plant cover as estimated by vegetation crews against a "standard" in "QA vegetation quadrats." Difference from a "QA standard" provides an estimate of accuracy. Difference from other crews provides an estimate of between-crew precision.

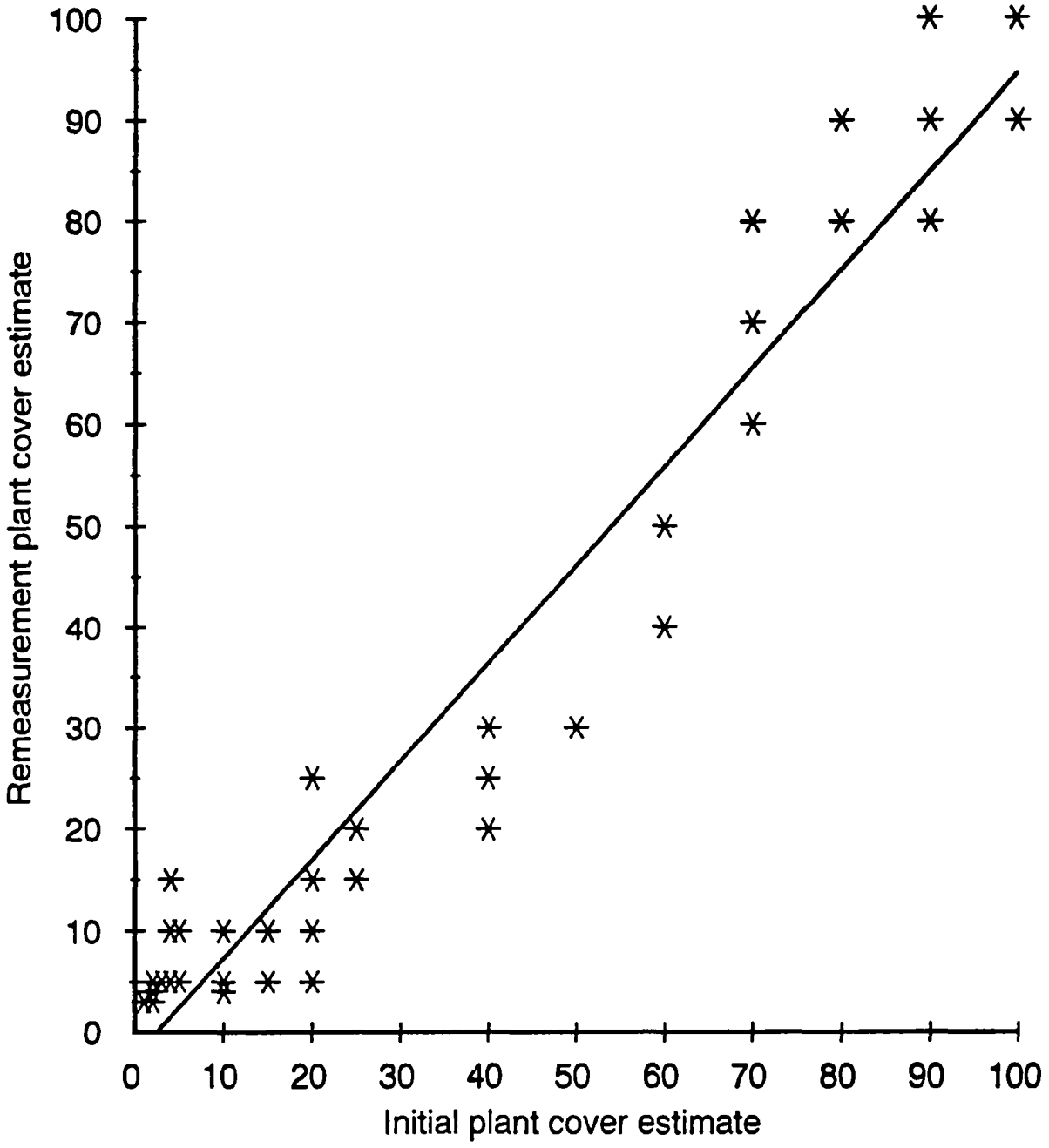


Figure 16-2. Hypothetical plot of paired (initial and remeasurement) plant cover estimates from the "QA vegetation quadrats" sampled at each wetland. The slope and and R^2 value provide an estimate of within-crew precision.

17.0 CORRECTIVE ACTIONS

We anticipate taking corrective actions when there is difficulty implementing a field or laboratory method, or when QC data reflects a violation of data quality goals. We intend to "dry run" all field methods prior to training to identify difficulties, confusing instructions or activities, and to refine sampling methods.

During training, we will note any methods that the Crew Members find confusing, and discuss modification of the method and/or the training schedule. We plan to re-evaluate all field protocols following the training. All field Crew Members will be required to pass proficiency criteria at the end of training. If crew members do not pass the proficiency criteria, they will receive additional training. Between-crew precision and accuracy for vegetation and soil measurements will be assessed at the end of training, and again in mid-season. If QC data show that crews are not sampling vegetation and soils comparably, they will receive additional training.

For laboratory analysis of soil organic matter content, methods and protocols will be evaluated during training and will be modified if required. During routine analysis, corrective actions will be taken when a need is identified based on evaluation of analytical data for blanks, audit samples, or duplicate samples. Problematic data will be promptly evaluated to determine the cause; equipment will be repaired/adjusted or methods modified as necessary, and the samples will be reanalyzed. If there is an insufficient amount of any soil(s) for reanalysis, data for affected samples will be flagged in the database and excluded from statistical analysis.

Corrective actions will be taken following any recommendations made during the field training visit and the QA audit conducted by ERL-C QA staff. Sherry Spencer, the Plant Taxonomist (PSU), will visit all field crews to check on identification of plant species. Any plant mis-identifications will be corrected, and Botanists will receive additional instruction in plant species identification.

Quality control (remeasurement) data will be collected for vegetation and soils measurements at each wetland. We plan to calculate within-crew precision at the end of each week, to assure that we are meeting our precision goals. If the goals are not being met, Crew Leaders are responsible for exploring the reasons, and recommending corrective actions to the Project Manager.

18.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Two QA reports will be prepared for the project: (1) The Field Operations Report, with a tentative deliverable data of March, 1994; (2) The Final QA Report, with a tentative deliverable date of July, 1994.

The Field Operations Report will contain the following:

1. Introduction
   a. Project Description, Objectives, Schedule
   b. Site Selection

2. Training summary
   a. Description of training, including agenda, instructors, material covered, location(s), and training materials;
   b. List of proficiency criteria for testing trainees; actions taken when trainees did not pass proficiency criteria;
   c. Summary of training results, including quantitative assessment of trainees' performance, improvements and changes made in field methods, and recommendations for future training;
   d. Description of corrective actions following field training visit by ERL-C QA staff and EPA Project Leader;
   e. Summary of results from end-of-training questionnaire.

3. Field Data Collection Activities
   a. List of sites sampled;
   b. Summary of plant specimens and soil samples collected; description of any samples lost and why; estimate of completeness for samples;
   c. Time estimates, including average number of sites sampled per day, amount of time spent at each site (sorted by wetland type), displayed as distribution (range) of time required to sample a site;
   d. Description of corrective actions following field audit by ERL-C QA staff;
   e. Summary of remeasurement data, in terms of accuracy, precision, and comparability for site, vegetation , and soil characteristics. QC data will be summarized statistically, displayed graphically, and evaluated in terms of DQO achievement.
   f. Summary of logistics and safety issues, including sampling difficult sites, access, lodging/accommodations, sampling equipment and supplies.

4. Laboratory Operations
   a. Balance calibration records;
   b. Summary of LOI QC data for blanks, duplicates, and audit samples;
   c. Control chart for muffle furnace performance;

d. Estimate of completeness - summary of samples analyzed vs. the number collected;
e. Plant identification; plant specimen collection.

5. Summary and Recommendations
   a. Summary of teachers' evaluations, exit meeting;
   b. Results (comments, reflections, criticisms) of final exit meeting (all project staff) will be summarized;
   c. Conclusion and recommendations for future studies.

The Final QA Report will contain the following:

1. Introduction
   a. Project Description, Objectives, Schedule;
   b. Site Selection.

2. Data and Information Management
   a. Summary of data entry errors, any difficulties with data;
   b. Evaluation of data entry - completeness;
   c. Documentation of project activities, including content and location of project notebooks (field, laboratory, data management), preparation of additional reports.

3. Summary of QC data

4. Discussion
   a. Summary of greatest sources of error;
   b. Summary evaluation of protocols, DQOS,and training;
   c. Use of science teachers as field assistants - how well did it work?
   d. Recommendations for future studies;
   e. How will data quality affect study results?

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APPENDIX A

FORMS USED IN THE OREGON WETLANDS STUDY

COE permit number_____

State permit number_____

Date permit issued ___/___/___

Permit Tracking System

COMPENSATORY WETLAND DATA FORM

Form designed by C C Holland and R.G. Gibson
ManTech Environmental Technology, Inc
U.S. Environmental Protection Agency,
Environmental Research Laboratory
200 SW 35th Street
Corvallis, OR 97333

Mitigation type--*Select [1]*

O Created O Enhanced O Preserved O Restored

State ____ County_____ Acres_____.__
State ____ County_____ Acres_____.__
TOTAL_____.__

Township & Range_____ Section(s)_____

Latitude/Longitude_____

USGS/NWI map name_____ Scale 1:_____

Select [1]
O Water Body
O River Body

Water/river body name _____

Specific location _____

Was the mitigation project Off-site or On-site?

Land use--*Select [1]*
O Agricultural
O Commercial
O Industrial
O Natural
O Residential

Documents available--*Select [0-4]*
O Maps
O Blueprints
O Ground photos
O Aerial photos

Date construction began ___/___/___

Date construction completed ___/___/___

Were mid-course corrections made? Yes / No
(Make notes in comments section)

COWARDIN WETLAND TYPE--*Select [1-5]*

ESTUARINE	ACRES	RIVERINE	ACRES	RIVERINE (cont)	ACRES
O subtidal aquatic bed	___.__	O tidal aquatic bed	___.__	O unknown perennial aquatic bed	___.__
O subtidal open water	___.__	O tidal beach/bar	___.__	O unknown perennial beach/bar	___.__
O subtidal reef	___.__	O tidal emergent	___.__	O unknown perennial flat	___.__
O subtidal rock bottom	___.__	O tidal flat	___.__	O unknown perennial open water	___.__
O subtidal unconsolidated bottom	___.__	O tidal open water	___.__	O unknown perennial rock bottom	___.__
O intertidal aquatic bed	___.__	O tidal rock bottom	___.__	O unknown perennial rocky shore	___.__
O intertidal beach/bar	___.__	O tidal rocky shore	___.__	O unknown perennial streambed	___.__
O intertidal emergent	___.__	O tidal streambed	___.__	O unknown perennial unconsolidated bottom	___.__
O intertidal flat	___.__	O tidal unconsolidated bottom	___.__	O unknown perennial unconsolidated shore	___.__
O intertidal forested	___.__	O tidal unconsolidated shore	___.__		
O intertidal reef	___.__	O lower perennial aquatic bed	___.__		
O intertidal rocky shore	___.__	O lower perennial beach/bar	___.__	PALUSTRINE	
O intertidal scrub/shrub	___.__	O lower perennial emergent	___.__	O aquatic bed	___.__
O intertidal streambed	___.__	O lower perennial flat	___.__	O emergent	___.__
O intertidal unconsolidated shore	___.__	O lower perennial open water	___.__	O flat	___.__
		O lower perennial rock bottom	___.__	O forested	___.__
LACUSTRINE		O lower perennial rocky shore	___.__	O moss/lichen	___.__
O limnetic aquatic bed	___.__	O lower perennial streambed	___.__	O open water	___.__
O limnetic open water	___.__	O lower perennial unconsolidated bottom	___.__	O rock bottom	___.__
O limnetic rock bottom	___.__	O lower perennial unconsolidated shore	___.__	O scrub/shrub	___.__
O limnetic unconsolidated bottom	___.__	O upper perennial aquatic bed	___.__	O unconsolidated bottom	___.__
O littoral aquatic bed	___.__	O upper perennial beach/bar	___.__	O unconsolidated shore	___.__
O littoral beach/bar	___.__	O upper perennial flat	___.__		
O littoral emergent	___.__	O upper perennial open water	___.__	MARINE	
O littoral flat	___.__	O upper perennial rock bottom	___.__	O subtidal aquatic bed	___.__
O littoral open water	___.__	O upper perennial rocky shore	___.__	O subtidal open water	___.__
O littoral rock bottom	___.__	O upper perennial streambed	___.__	O subtidal reef	___.__
O littoral rocky shore	___.__	O upper perennial unconsolidated bottom	___.__	O subtidal rock bottom	___.__
O littoral unconsolidated bottom	___.__	O upper perennial unconsolidated shore	___.__	O subtidal unconsolidated bottom	___.__
O littoral unconsolidated shore	___.__	O intermittent aquatic bed	___.__	O intertidal aquatic bed	___.__
		O intermittent beach/bar	___.__	O intertidal beach/bar	___.__
		O intermittent flat	___.__	O intertidal flat	___.__
		O intermittent open water	___.__	O intertidal reef	___.__
		O intermittent rock bottom	___.__	O intertidal rocky shore	___.__
		O intermittent rocky shore	___.__	O intertidal unconsolidated shore	___.__
		O intermittent streambed	___.__		
		O intermittent unconsolidated bottom	___.__	TOTAL AREA	___.__

REPORT INFORMATION

Title _____

Author's First Initial _____ Middle Initial _____ Last Name _____

Year _____

Content _____

CONTACT INFORMATION

First Initial _____ Middle Initial _____ Last Name _____

Organization _____

Address _____

City _____ State _____ Zip _____ Phone ( ) _____

CONTACT INFORMATION

First Initial _____ Middle Initial _____ Last Name _____

Organization _____

Address _____

City _____ State _____ Zip _____ Phone ( ) _____

CONTACT INFORMATION

First Initial _____ Middle Initial _____ Last Name _____

Organization _____

Address _____

City _____ State _____ Zip _____ Phone ( ) _____

CONTACT INFORMATION

First Initial _____ Middle Initial _____ Last Name _____

Organization _____

Address _____

City _____ State _____ Zip _____ Phone ( ) _____

COMMENTS

Objective:

Method

As-built

FORM I: GENERAL SITE INFORMATION Date 7/1/91

SITE NAME/CODE 5065 "Fosberg" STATE OR COUNTY Clackamas

WETLAND TYPE PUB PERSONNEL NAME Holland/Frostholm

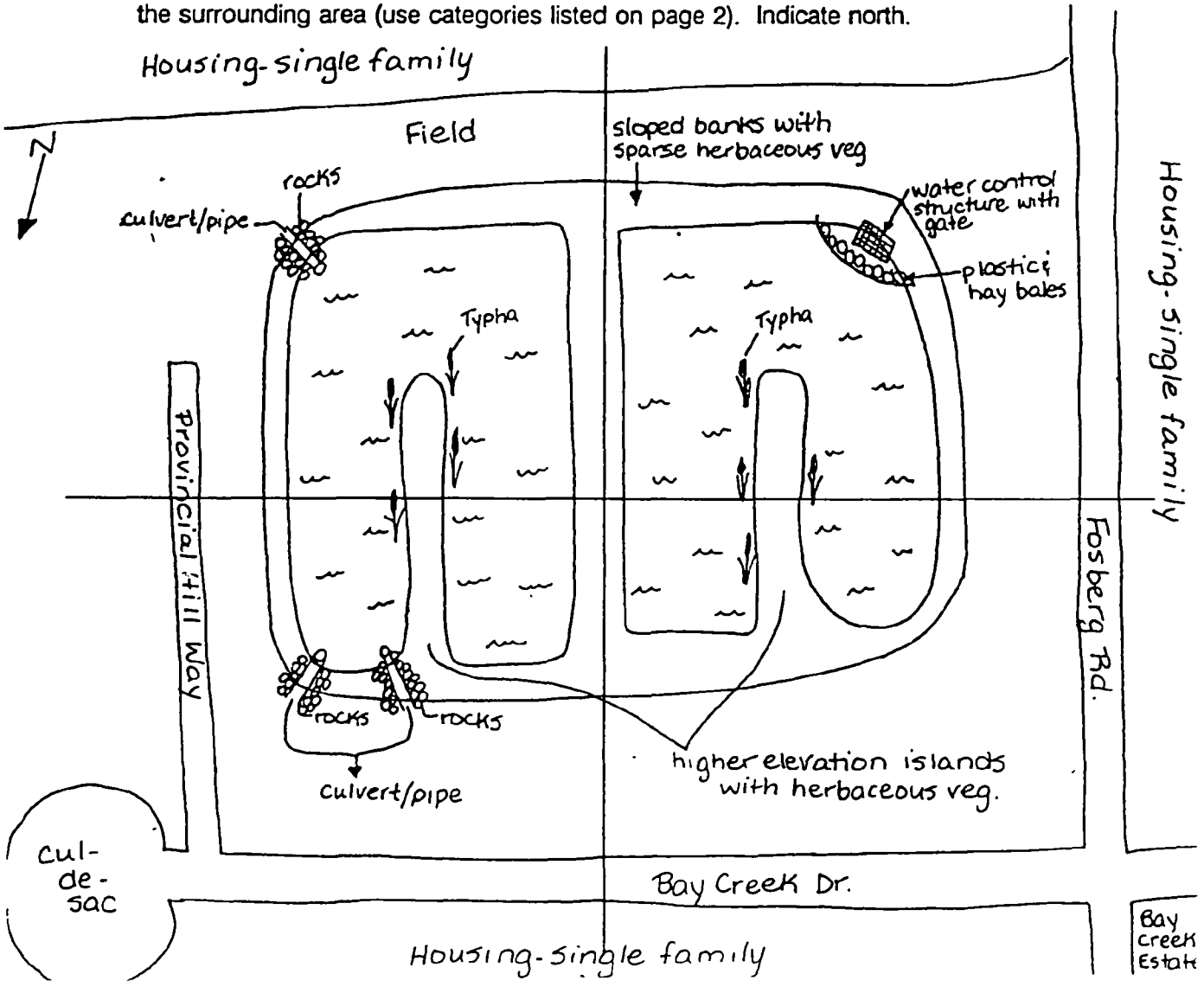
A. Describe ease of access to and within the site (roads, parking, problems due to water depth, etc.).

Easily accessible. In housing development - can park anywhere.

B. Provide directions to site. Attach a marked copy of a map if needed.
I-5 North. Take Carmen Rd exit. Turn right on Carmen Rd (go East). Turn left on SW Meadows. Turn right on Kruse Woods. Kruse Woods turns into Westlake Dr then into Fosberg Rd. Turn right on Bay Creek Dr. Wetland is on right (SE of Bay Creek/Fosberg intersection)

C. Document check of ownership of site. Was the owner contacted? (Yes)/No
Was trespass permission granted? (Yes)/No

D. Sketch the wetland below. Include information on the factors influencing hydrology (e.g., water control structures, ditching). Sketch in the landuses and natural cover on the wetland and in the surrounding area (use categories listed on page 2). Indicate north.



I. Indicate % open water, % vegetated and % non-vegetated areas within the wetland (A-C should add up to 100%)

A. 80 % open water
   1. 75 % unvegetated
   2. 5 % with submerged aquatic vegetation

B. 15 % vegetated
   1. 0 % trees
   2. 0 % shrubs (15 feet or less)
   3. 15 % herbs

C. 5 % unvegetated

TOTAL: 100%

II. Indicate % relative cover of surrounding areas within 100 meters of the wetland boundaries (A-E should add up to 100%):

A. 10 % trees
B. 2 % shrubs
C. 8 % natural herbaceous vegetation
D. 0 % water body--specify type:_____
E. 80 % human landuse
   1. 0 % crops
   2. 0 % fallow
   3. 0 % grazing
   4. 0 % industrial--specify type:_____
   5. 0 % commercial
   6. 5 % transportation corridor
   7. 75 % housing--single family dwellings
   8. 0 % housing--multiple family dwellings

TOTAL: 100% **NOTE: 1-8 should total the percentage value in E.

III. Indicate % of wetland which is disturbed and describe the disturbance (for example, ditches, water control structures, dumping, fill, and anything that might be hazardous):

5% disturbed - plastic and hay bales
3 pipes
some stakes left on site

IV. Comments:

Kingfishers using site.

OREGON WETLAND STUDY - SUMMER 1993
Form G-1 Equipment Checklist Date: _____

Site Name/Code_____ County_____

Crew_____ Personnel_____

GENERAL EQUIPMENT

____6 Clipboards
____Large rubber bands to go around clip boards
____Form Folders or File Folders
____Data Forms
____First Aid Kit including Bee/Insect bite and sting medication
____Large plastic bags
____Baskets to contain equipment & supplies
____Colored pencils
____Pencils and Waterproof Pens
____Permanent Markers
____Cups
____Cooler for lunches
____Water Jug - for drinking
____Water Jug - for washing
____Paper Towels
____Handi-wipes (or equivalent)
____Tec-nu (or equivalent) for Poison Oak

TRANSECT ESTABLISHMENT

____At least seven 100-m all weather measuring tapes (Ben Meadows #122608 or equivalent)
____Two 5-lb. Hammers
____Twelve 24"-Wooden Stakes

VEGETATION SAMPLING

____Two 1-m^2 Rectangular Quadrats (Dimensions 0.73m x 1.40m)
____Plant Presses with blotters, ventilators & cinch straps
____80 flagged wire pins
____2 Pouches or packs for wire pins (one per Recorder)
____Two diameter tapes
____Tags for marking specimens of unknown plants
____4 Meter Sticks
____Regional Flora (Hitchcock & Cronquist)
____15-cm ruler
____Trowel
____Hand Lenses
____Wetland species list
____Rare species list
____Gallon size Ziploc bags
____Ice chest w/ice
____Set of Dice

SOIL SAMPLING

____35 Soil Sample bags - prelabelled
____Bucket Auger
____Core Samplers
____Core sampler liners & caps
____Knife with long blade
____Munsell color chart with gleyed color page
____Ice chest w/ice & rack to hold sample tubes
____2 Shovels
____Squirt bottle w/clean water
____Paper towels
____Random # table

WETLAND MORPHOLOGY

____Transit & Tripod
____Stadia Rod

GENERAL SITE DATA

____Transit & Tripod
____Stadia Rod
____Florescent Flagging Tape
____100-m Measuring Tape
____Walkie Talkies
____Spare camera batteries
____35-mm Camera with 50-mm lens
____35-mm color slide film, ASA 100
____2 pouches or packs for wire pins
____360°-Azimuth Compass

OREGON WETLAND STUDY - SUMMER 1993

FORM G-2 Sample Custody Log Date: _____

Site Name/Code_____ County_____

Crew_____ Personnel_____

A copy of this form must accompany the soil samples and plant specimens to the Portland State University (PSU) lab. The originals will be included in the packets for each site. Field personnel complete items followed by (Field); lab personnel complete items followed by (Lab).

	Soil Sample #'s (Field):	
Number of Soil Samples Collected (Field): _____	_____	_____
	_____	_____
Delivered to lab personnel: (Initials of field personnel responsible)_____	_____	_____
Plant specimens received at PSU (Lab):	_____	_____
Date received:_____		
Personnel receiving:_____	_____	_____
Soil samples received at PSU (Lab):	_____	_____
Date received:_____		
Personnel receiving:_____	_____	_____
Sample condition: Good / Poor (circle one)	_____	_____
	_____	_____
Broken sample containers:_____		
_____	_____	_____
Open sample containers:_____		
_____	_____	_____
Leaking sample containers:_____		
_____	_____	_____
Other:_____		
_____	_____	_____
List damaged sample numbers:	_____	_____
_____		
_____	_____	_____

Comments:_____

_____

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FORM G-3 Field Personnel Form Date_____

Site Name & Code_____ County_____

Fill out for each site.

Crew:_____ Crew Leader:_____

Crew Members	usual/alternate
Survey:_____(Transit)	____ ____
Survey:_____(Stadia)	____ ____
Survey:_____(Soils)	____ ____
Botanist:_____(Transects _____,_____,_____)	____ ____
Botanist:_____(Transects _____,_____,_____)	____ ____
Recorder:_____(Transects _____,_____,_____)	____ ____
Recorder_____(Transects _____,_____,_____)	____ ____

Comments:

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FORM F-1 Transect Establishment

Page____of____

Date_____

Site Name & Code_____

County_____

Crew_____

Personnel_____

Baseline Length_____ Bearing_____°

Sampling Interval (Wetland Size): (Circle one)

1m (<0.1ha [0.25a])

3m (≥0.1ha [0.25a] but <0.3ha [0.75a])

6m (≥0.3ha [0.75a] but <1.0ha [2.5a])

9m (≥1.0ha [2.5a] but <2.0ha [5.0a])

Calculations of Site Characterization Transect Length:

	Baseline Length		Starting Point		Bearing
SCT1:	_____	m x 0.1=	_____	m	_____
SCT2:	_____	m x 0.3=	_____	m	_____
SCT3:	_____	m x 0.5=	_____	m	_____
SCT4:	_____	m x 0.7=	_____	m	_____
SCT5:	_____	m x 0.9=	_____	m	_____

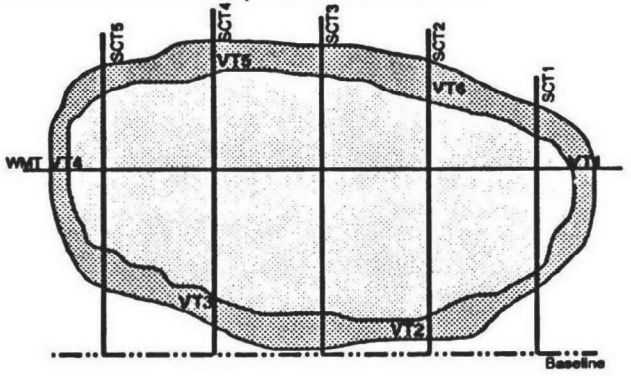
Case 1- Calculations for Vegetation Transect Starting Points:

	Baseline Length		Starting Point		Bearing
VT1:	_____	m x 0.05=	_____	m	_____
VT2:	_____	m x 0.2=	_____	m	_____
VT3:	_____	m x 0.4=	_____	m	_____
VT4:	_____	m x 0.6=	_____	m	_____
VT5:	_____	m x 0.8=	_____	m	_____
VT6:	_____	m x 0.95=	_____	m	_____

Rationale for Baseline Placement (e.g., presence/absence of uni-directional gradient) and other notes (e.g., triangulation distance calculations, compass bearing for transect segments across open water):

Case 2- List Random Sampling Order of Transects (obtained by rolling a die):_____

Circle, on the diagram below the start points of transects actually selected.



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FORM F-2 Sketch Map Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____

OREGON WETLANDS STUDY - SUMMER 1993 Page____of____

FORM F-3 Map Data Sheet Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____

QA Sheet: Y/N

Station From	Station To	Bearing	Stadia Readings	Calculated Distance	Comments
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		
			u_____ m_____ l		

Comments:

Form F-3. (cont.)

NO TURN: Benchmark (B.M.) Readings

Initial Readings u_____
m_____
l_____
Bearing_____ o

Final Readings u_____
m_____
l_____
Bearing_____ o

Error (m-m)_____

TURN: New Benchmark?
NO:

1 2nd Reading
Initial B M u_____ Station to _____
m_____
l_____
Bearing_____ o

2 Relocate Tripod

3 3rd Reading
Initial B M u_____ Station to _____
m_____
l_____
Bearing_____ o

4 Final B M
Reading u_____ Station to _____
m_____
l_____
Bearing_____ o

5 Adjustment_____
(Diff of 3 & 4m only)

TURN: New Benchmark?
YES:

1 2nd Reading
Initial B M u_____ Station to:_____
m_____
l_____
Bearing_____ o

2. Establish new Benchmark

3 1st Reading
New B M u_____ Station to._____
m_____
l_____
Bearing_____ o

4 Difference between new and initial
Benchmarks u_____
m_____
l_____

5 Relocate tripod

6. 2nd Reading
New B M u_____ Station to:_____
m_____
l_____
Bearing_____ o

7 Difference between 1st and 2nd Readings
New Benchmarks u_____
m_____
l_____

8 Adjustment_____
(Diff of 6 & 8m only)

9 Final Reading
Initial B M u_____ Station to _____
m_____
l_____
Bearing_____ o

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FORM F-4 Buffers and Surrounding Land Use Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____

Transect# (circle one) WMT_B WMT_E SCT3B SCT3E Buffer Width_____ Bearing_____

Record types of vegetation strata at changes within buffer surrounding wetland (TR=trees, SH=shrubs, HB=herbaceous). Record O.W. for Open Water and B.G. for Bare Ground. Record vegetation strata, O.W. or B.G. up to the maximum width of the buffer ≤ 100m. Record 101m if Buffer width is greater than 100m. Record Land Use outside the vegetated buffer by circling the appropriate choice.

Distance (Meters)	Buffer (TR, SH, HB, OW, BG)	Land Use outside buffer: (circle one) If Transportation Corridor, circle two.
		AG CROPS = AGC
		AG FALLOW = AGF
		AG GRAZED = AGG
		AG ORCHARD = AGO
		AG PLOWED = AGP
		INDUSTRIAL = IND
		INDUSTRY FALLOW = INF
		COMMERCIAL = COM
		COMMERCIAL FALLOW = COF
		TRANSPORTATION CORRIDOR = TRN
		RESIDENTIAL SINGLE = RSS
		RESIDENTIAL MULTI = RSM
		NATURAL = NAT

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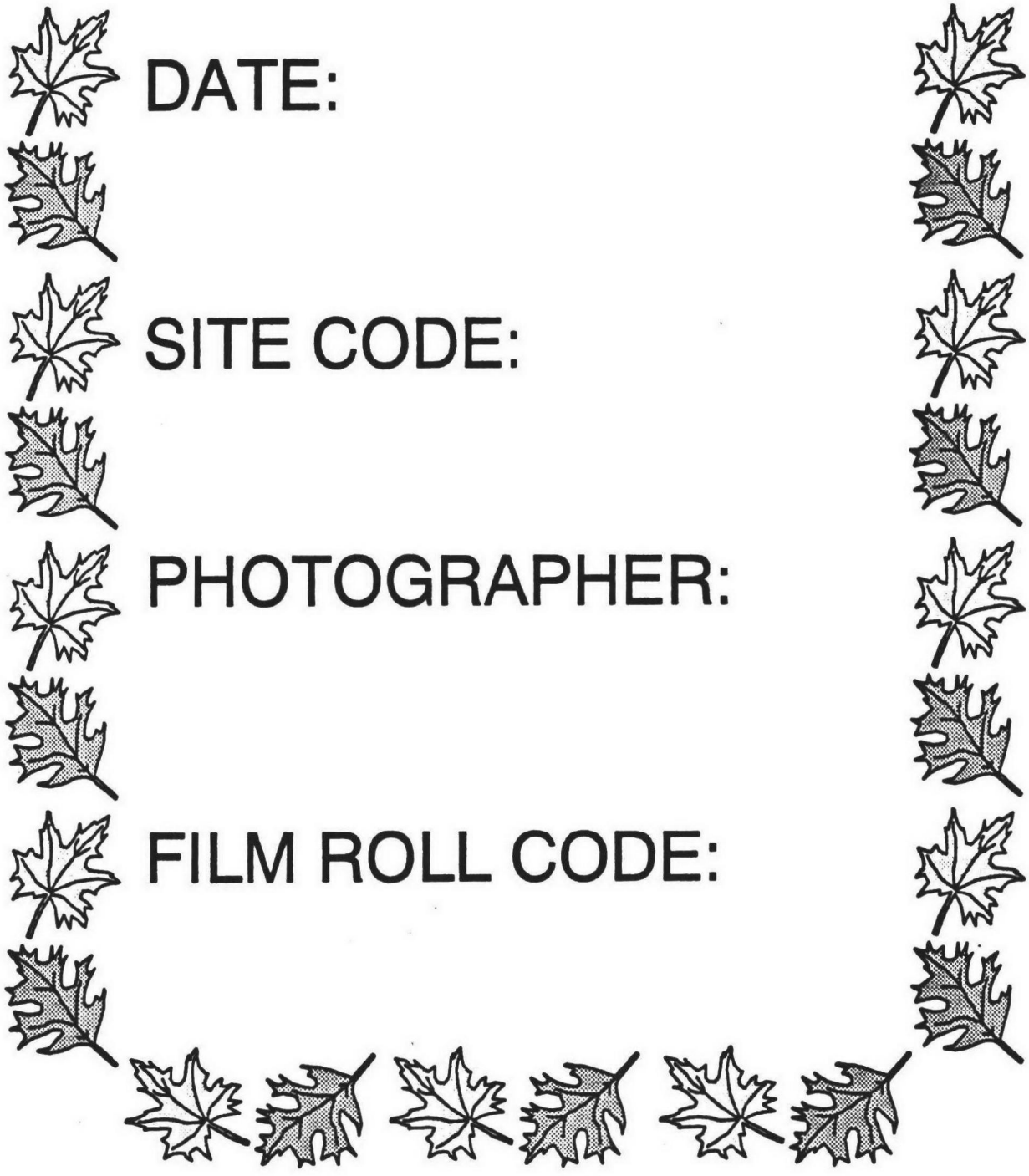
FORM F-5 Photographic Label Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____



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FORM F-6 *Photo Record* Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____

Include photographs of: surroundings, overview of wetland, representative vegetation, evidence of animal activity, disturbance or obstructions, buffers, evidence of stress, the view down the length of each transect (label by number), and other features of interest and importance. Indicate vantage point and bearing for,Site Record Photos.

Use a new record sheet for every new roll of film and every new site.

TYPE OF FILM:_____ FILM ID#_____

PHOTOGRAPH DESCRIPTION	PHOTO FRAME#	DEVELOPED SLIDE#

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FORM F-7 Herbaceous Vegetation/% Canopy Coverage Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____

Transect#_____ Wetland Width_____ Bearing_____° Sampling Interval: 1m 3m 6m 9m (circle one)

QA Sheet: Y/N

Check top box if sample needs to be collected, check bottom box when sample has been collected	Plot #																	
	Distance from 0m																	
	'Bareground																	
	Water																	
	Standing Dead and Litter																	
Species Name Corrections	Species Name																	

boundary start_____

boundary end _____ = wetland width

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FORM F-8 All Shrubs and Trees <2m Tall - Line-Intercept Data Form Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____

Transect#_____ Wetland Width_____ Bearing_____° Sampling Interval: 1m 3m 6m 9m (circle one) QA Sheet: Y/N

Check to collect
Check when collected

Record tape position as meters (whole numbers) and centimeters as decimals: e.g., 1m 14cm=1.14, 17m 7cm=17.07

Species:		Species:		Species:		Species:		Species:	
Tape Postition:		Tape Postition:		Tape Postition:		Tape Postition:		Tape Postition:	

boundary start_____

boundary end _____ = wetland width

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FORM F-9 Tree Identification and Diameter at Breast Height Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____

Transect#_____ Wetland Width_____ Bearing_____° Sampling Interval: 1m 3m 6m 9m (circle one)

QA Sheet: Y/N

Species	Diameter at Breast Height (dbh) cm/distance to nearest m						

boundary start_____

boundary end _____ = wetland width

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FORM F-10 Wetland Morphology Date_____

Site Name & Code_____ County_____

Crew_____ Personnel_____

Transect#_____ Length_____ Bearing_____° Sampling Interval: 1m 3m 6m 9m (circle one)

QA Sheet: Y/N

Sample Point	Plot #	Distance (Meters)	Stadia Reading	Vertical Offset	Relative Elevation	Water Depth	Open Water	Vegetated	Bare Ground
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

WMT Start u_____ WMT End u_____

m_____ m_____

l_____ l_____

Bearing_____° Bearing_____°

Form F-10. (cont.)

NO TURN: Benchmark (B.M.) Readings

Inital Reading_____

Final Reading_____

Error_____

Bearing_____ o

TURN: New Benchmark?

NO:

1 2nd Reading
Initial B M _____ Plot #_____
Bearing_____ o

2. Relocate Tripod

3. 3rd Reading
Initial B M _____ Plot #_____ (same as 1)
Bearing_____ o

4 Final B M
Reading _____ Plot #_____
Bearing_____ o

5 Adjustment_____
(Diff of 3 & 4)

YES:

1. 2nd Reading
Initial B M._____ Plot #_____
Bearing_____ o

2. Establish new Benchmark

3. 1st Reading
New B.M _____ Plot #_____
Bearing_____ o

4 Difference between new and initial Benchmarks_____

5. Relocate tripod

6 2nd Reading
New B M _____ Plot #_____
Bearing_____ o

7. Difference between 1st and 2nd Readings New Benchmarks_____

8 Adjustment_____
(Diff of 6 & 8)

9 Final Reading
Initial B M _____ Plot #_____
Bearing_____ o

If transects are interrupted by deep water, distance to the transect start and endpoints on the far side of the water must be determined. Therefore, record upper and lower stadia hairs for those points: Start point: u_____
l_____

End point: u_____
l_____

Comments: _____

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FORM F-11 Soil/Hydrology Characterization Date_____

Site Name & Code_____ Transect #_____ County_____

Crew_____ Personnel_____

* Samples should be labelled with an eleven digit code including wetland # (characters 1-4), Transect # (5-6), Plot # (7-8), Depth (9-10), and sample type (1 for Routine, 2 for QA Duplicate) Also include a sampling date ** FEW (<2% Surface), COMMON (2-20%), MANY (>20%)

*** FINE (<5mm diameter), MEDIUM (5-15mm); COARSE (>15mm)

	Soil Sampling Method	Sample Code # *		Hydrology				Soil Description													
		0-5 cm	15-20 cm	Depth to saturated soil (cm)	Depth to free water surface (cm)	Standing water initial depth/time (cm)	Standing water final depth/time (cm)	Horizon #	Org (O) or Mineral (M)	Horizon Depth U/L (cm)	H_2S Present (Y/N)	Gleyed Matrix (Y/N)	Matrix Color	Mottles				Fe Concretions (Y/N)	Mn Concretions (Y/N)	Oxidized root channels (Y/N)	Comments (e g., presence of rocks, woody material, buried vegetation, etc)
														Present (Y/N)	Abundance**	Size***	Color				
Plot____								1													
								2													
								3													
								4													
Plot____								1													
								2													
								3													
								4													
Plot____								1													
								2													
								3													
								4													

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Form L-2 Soil Core Characterization

Analyst Name_____ Date_____

Sample Identification				Soil Description							Comments
Wetland #	Transect #	Plot #	Depth (cm)	H_2S Present (Y/N)	Gleyed (Y/N)	Matrix Color	Mottle Color	Fe (Y/N) Concretions	Mn (Y/N) Concretions	Oxidized root channels (Y/N)	

Comments:

Form L-3 -- Determination of Soil Moisture Content and Loss on Ignition
Quality Assurance Data

Batch #	Sample [1] Code	Crucible #	TARE_WT (g)	FRESH_WT (g)	DRY_WT (g)	ASHED_WT (g)	Moisture (%)	Loss on Ignition (%)
	Blank Audit ____ ____ __ __1 ____ ____ __ __2 ____ ____ __ __3 ____ ____ __ __4							
	Blank Audit ____ ____ __ __1 ____ ____ __ __2 ____ ____ __ __3 ____ ____ __ __4							
	Blank Audit ____ ____ __ __1 ____ ____ __ __2 ____ ____ __ __3 ____ ____ __ __4							
	Blank Audit ____ ____ __ __1 ____ ____ __ __2 ____ ____ __ __3 ____ ____ __ __4							
	Blank Audit ____ ____ __ __1 ____ ____ __ __2 ____ ____ __ __3 ____ ____ __ __4							
	Blank Audit ____ ____ __ __1 ____ ____ __ __2 ____ ____ __ __3 ____ ____ __ __4							

[1] Sample type code 1 is the routine sample, 2 is the field duplicate, 3 is lab split of the routine sample, and 4 is lab split of the field duplicate

Comments.

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FORM L-1 Determination of Soil Moisture Content and Loss on Ignition Date_____

Batch #_____ Drying Oven Temperature_____ Date/time in_____ Analyst Initials_____

Date/time out_____ Analyst Initials_____

Date Weighed_____ Analyst Initials_____

Muffle Furnace Temperature_____ Date/time in_____ Analyst Initials_____

Date/time out_____ Analyst Initials_____

Date Weighed_____ Analyst Initials_____

Sample #	Sample Code	Crucible #	TARE_WT (g)	FRESH_WT (g)	DRY_WT (g)	ASHED_WT (g)	Moisture (%)	Loss on Ignition (%)

Comments:

DATA TRACKING FORM

Site#_____

FORMS	Copied On Blue (complete)	Copied On Yellow (incomplete)	Copied On White- Data Entry	Originals SG's Office/ PSU	Originals TM's Office/ PSU	Originals File Cabinet
General						
Form I						
Phone contact form						
AREM						
G-3, Personnel						
F-1, Transect Est.						
F-4, Buffers						
F-5, Photo label						
F-6, Photo record						
F-12, Random # table						
Soils						
F-11, Soils						
QA-4, Soils QA						
Vegetation						
F-7, Herbaceous						
F-8, Shrubs						
F-9, Trees						
QA-1, QA-herb						
QA-2, QA-shrubs						
QA-3, QA-trees						
Mapping/Morphology						
F-2, Sketch map						
F-3, Map data sheet						
F-10, Morphology						
Final map						

APPENDIX B

DESCRIPTION OF AUDIT SOILS USED IN THE OREGON WETLANDS STUDY

Introduction

Two soil audit materials, prepared from mineral and organic soil horizons, will be used in the Oregon Wetland Study (OWS) as checks on the analytical process for loss on ignition. The soil audit materials were prepared in 1987 for cooperators in the Forest Response Program (FRP), the forest research component of the National Acid Precipitation Assessment Program (NAPAP) that was co-funded by the US Forest Service and EPA. Although the audit materials were prepared from forest soils, they are suitable for use in the OWS because their organic matter content (LOI) is within the range expected in OWS soil samples.

Preparation of the Soil Audit Materials

The two soil audit materials were developed by Dr. Wayne Robarge and his staff at North Carolina University in spring 1987. Large volumes of soil (approximately 68 kilograms for the mineral soil material and 45 kilograms for the organic soil material) were collected from two soil horizons. The mineral soil material was prepared from soil taken from the B horizon of an exposed soil profile located on the east side of Commissary Ridge, Mount Mitchell, North Carolina (1886 m). The organic soil sample was prepared from a composite of the Oa and A horizons excavated from a pit located on Clingman's Peak, approximately 1.2 miles south of the Mt. Mitchell summit (2168 m). Forest cover type at both collection locations is spruce-fir (Dull et al., 1988). Soil was placed in large plastic bags and transported to North Carolina University. The soil was air-dried, milled in a large ball mill (30 minutes), and passed through a 2mm plastic sieve. Each soil was further homogenized using a cement mixer (15 minutes) and the method of cone and quartering (Raab et al., 1990). The homogenized soil was stored in 1 liter Nalgene™ containers.

The soil audit materials have been used by EPA QA staff to assess laboratory comparability of soil analytical data across diverse research projects (Dwire et al., in preparation) and continue to be used by researchers as internal quality control checks. The soils have been stored at room temperature since preparation, and are distributed on request.

Use of the Soil Audit Materials in the Oregon Wetland Study

Five liters of each soil audit material were requested from Dr. Robarge for use in the OWS. Two 20-30 gram samples from each liter container will be analyzed for LOI at Oregon State University, Crop and Soil Science Laboratory prior to sample collection in the OWS. A control chart (Figure A-1) will be constructed for each audit soil based on the OSU results, showing the mean soil organic matter content value, upper and lower warning limits ($\pm$ 2 standard deviations), and upper and lower control

limits (± 3 standard deviations). The LOI value for the audit sample contained in each batch will be charted. The control chart will serve as a visual check of the LOI analytical process; values near or exceeding the warning limits will alert the laboratory technicians of such problems as malfunction of the muffle furnace. In addition, LOI values from the audit materials will assist in estimating batch-to-batch variation.

Dull, C.W., J.D. Ward, H.D. Brown, G.W. Ryan, W.H. Clerke, and R.J. Uhler. 1988. Evaluation of spruce and fir in the southern Appalachian mountains. USDA Forest Service Protection Report R8-PR 13 October 1988.

Dwire, K.A., W. Burkman, R. Mickler, and D. Cassell. Comparability of analytical data in acid deposition research: results from soil, foliar, and aqueous sample exchanges in the Forest Response Program. In preparation.

Raab, G.A., M.H. Bartling, M.A. Stapanian, W.H. Cole, R.L. Tidwell, and C.A. Cappo. 1990. The homogenization if environmental soil samples in bulk. In: Hazardous Waste Measurements. M. Simmons (editor). Lewis Publishers.

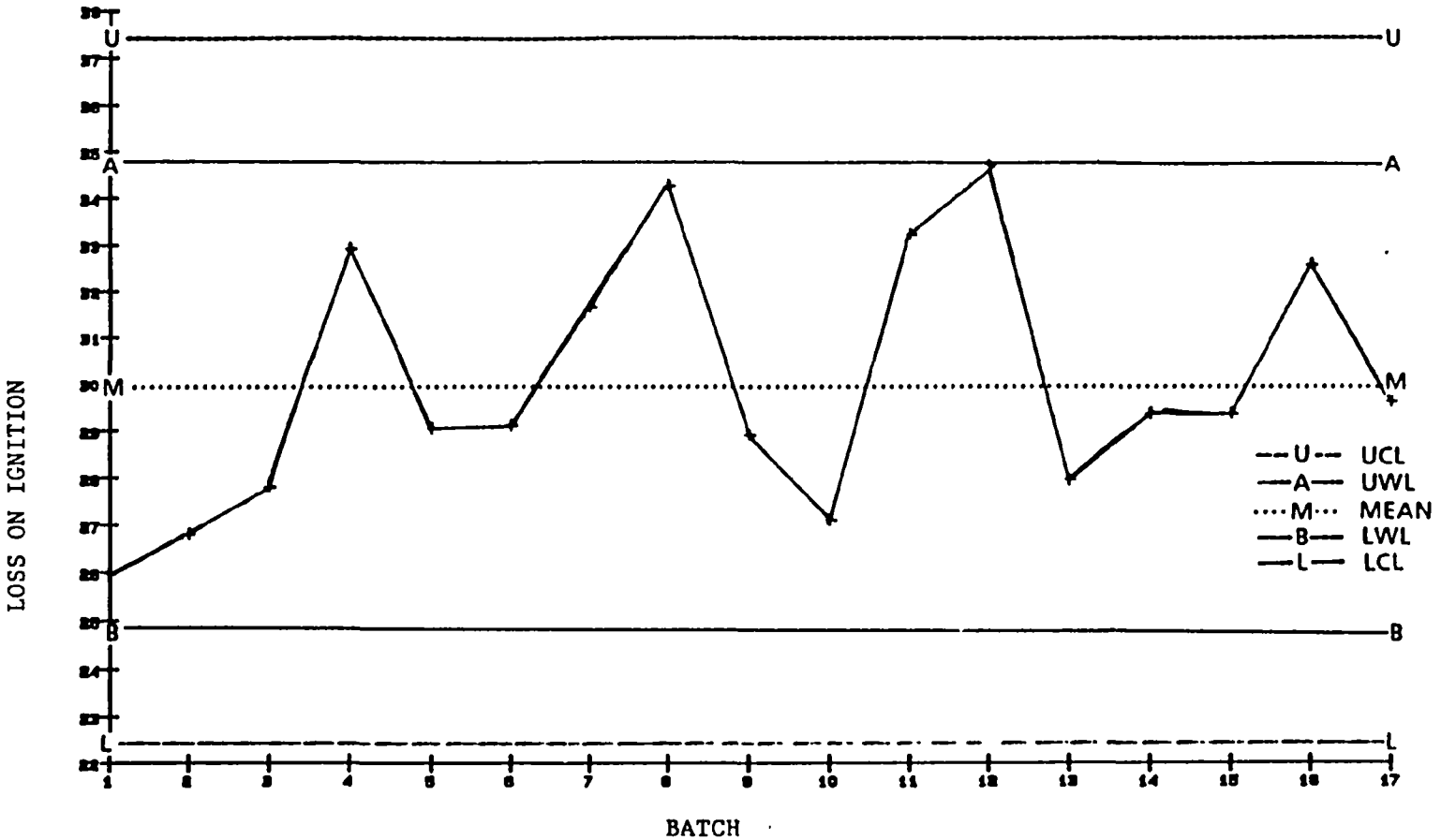

Figure B-1. Hypothetical control chart for soil audit material used in the Oregon Wetlands Study.

APPENDIX C

PROFICIENCY CHECKLISTS USED IN THE OREGON WETLANDS STUDY

Vegetation - Refer also to "Steps in Sampling Vegetation Along a Transect"

1. Recorders correctly fill out header and plot information on forms.

2. Always walking on left side of transect.

3. Tape being stretched along compass bearing.

4. Trampling minimized in each transect segment (sampling interval). Botanists and Recorders move as indicated in "Steps".

6. Transect tape is tightly stretched when line-intercept distances are obtained.

7. Botanists and Recorders avoid stepping into plot while reading cover.

8. Botanists work systematically through plot when estimating cover.

9. Botanists estimate cover to nearest 1% for cover values ranging from 1-5%, to nearest 5% for cover values ranging from 5-100%, and for values less than 1% record .1 to indicate trace amount.

10. Botanists estimate cover of all herbaceous plants, any woody plants (or portions of shrubs or trees) that occur within or overlie the plot and are less than 2m tall. Values are obtained for bareground, litter, water, and total cover of bryophytes or algae if they are present.

11. Recorders correctly record data and assist botanist as needed.

12. Botanists tag (label unknowns) for bouquets, tag and collect unknowns and place in bags as they work along the transect. Once transect is completed store the collected plants in the ice chest until they can be pressed at the end of the day.

13. Botanists uses open quadrats on plots with shrubs or trees.

14. DBH is measured properly for all trees > 4 cm diameter (dbh) -correct height; tape placed correctly around stem. (See "Steps")

15. Recorder or Botanist do not step in the quadrat in their effort to reach trees - this disturbs the area to be used by the survey team.

16. Botanists properly identify the wetland boundaries, and the positions of the first and last plot

17. Recorders remember to record boundary start and end for each transect and to calculate and record the transect length on which shrubs and trees are sampled.

Soil

1. Random number sheets correctly used to identify which soil plots will be sampled and to identify the QA plot

2. Correct equipment used for sampling dependent on soil conditions and water depth

3. Sample is collected from the correct location in the plot (near right corner, adjacent to the flag placed by botany team)

4. Soil pit/auger depth is adequate

5. Soil slab is clean and undisturbed (e.g., not contaminated with material from other depths from the side of the pit)

6. If bucket auger is used, sampling depth is adequate, and sample is removed from auger and reassembled on plastic sheet properly

7. Both surveyors participate in defining horizon boundaries, color, etc.

8. Soil horizons are properly identified, and depths are measured properly

9. Color measured properly
   - Sample is moist
   - Surveyors check and compare several possible colors before making a choice
   - Sample not held in bright sunshine while making determination
   - Sample not held next to brightly colored clothes that might alter perceived color
   - Color of matrix determined correctly, i.e., as color of matrix only, ignoring mottles, concretions, and root channels
   - Mottles and concretions correctly identified (mottles have same texture as matrix; concretions are hard)

10. Depth "0" is properly identified as the interface between litter and mineral soil

11. Samples to be used for LOI analysis are taken from proper depths, correctly labelled (team member holding stadia rod, who has relatively clean hands, should hold color charts and should label and hold sample bags)

12. Samples are stored properly, bags are sealed

13. Data forms are correctly and completely filled out

14. When sampling at a plot is completed, team members have cleaned up completely; soil is placed in the pit properly; equipment has been cleaned

15. If comments are added, they are brief, but detailed enough to be useful (e.g., include depth(s), etc.)

Survey

Person with stadia rod

GENERAL

Is a proper benchmark established--one for which a precise location can be located again that day (not permanent)?

Is stadia rod extended from bottom?

Is it extended completely so that each extension fits in notch?

Is the stadia rod extended the proper amount (not too much so that it is not vertical)?

Does person at stadia rod hold rod without blocking view of numbers?

Does person at stadia rod hold rod vertical?

MAPPING

Does person at stadia rod stop at correct locations (changes in direction) around wetland perimeter?

Does person at stadia rod correctly identify perimeter?

ELEVATIONS

Does person with stadia rod place stadia rod next to flags inside sample plots and at correct sample points as they proceed down transects?

Do surveyors take elevation readings before digging soil pits along SCTs?

Do surveyors walk on left side of transects only and avoid traversing wetland?

Are land cover (vegetation, bare ground, open water, water depth) collected at each point along SCTs and WMT and conveyed to person at transit?

Person at transit

GENERAL

Is transit set up in a location for best view of wetland?

Is transit levelled correctly?

Is transit calibrated correctly with Brunton compass?

Does person at transit give hand signals (or communicate via walkie-talkies) to insure stadia rod is vertical?

Are transit readings made correctly?

MAPPING

Are all three stadia hairs read? Is bearing read correctly?

ELEVATIONS

Is middle stadia hair being read?

Is there either a number or a slash for every data point in Water Depth column?

Person recording for transit operator

GENERAL

Is header information on forms filled out first, is header complete and accurate?

Are stadia readings and bearings recorded accurately and in correct place?

Are comments noted on back of Form F-10 (such as starting and ending points of transects and baseline, vegetation, etc)? and in comments column on Form F-3?

Is benchmark information recorded on back of Forms F-10 and F-3?

MAPPING

Is sketch map drawn with sufficient detail? labelled correctly (A-Z around perimeter)?

BUFFERS

Is buffer information collected from the start and end points of WMT and SCT3?

Is Form F-4 (buffers) filled out correctly?

If Transportation Corridor is circled, is another land use category also circled?

CREW LEADER CHECKLIST Date: _____

Site Name/Code_____County_____

Crew_____Personnel_____

1. Crew Leader, Botanists, and Surveyor using Stadia Rod determine wetland boundaries, any predominating environmental gradients, estimate approximate wetland area and locate transect baseline. _____

2. Crew Leader ensures that all data is being recorded in pencil or waterproof ink. _____

3. Recorders and remaining two Surveyors organize and distribute data forms and equipment using Form G-1 (Equipment List). _____

4. Crew Leader and Recorders lay out transect baseline. Crew leader calculates transect starting points along baseline and Recorders mark with stakes and appropriate flagging. _____

5. Crew Leader determines sampling interval from estimate of wetland area. _____

6. Botanists conduct initial reconnaissance of wetland vegetation and agree upon pseudonyms for unknown species. _____

7. Surveyors conduct mapping procedures. _____

8. Crew Leader performs QA/Proficiency Check of Transit Operator reading the Stadia Rod (± 0.5cm). Crew Leader records duplicate readings for 5 stations on Form F-4 (divide QA check points up--some close and some far from transit). _____

9. Crew Leader identifies QA transect and plots for vegetation QA activities (identification and cover estimates of herbs, line intercept for shrubs and DBH for trees). Botanists lay out entire tape and flag plots. Crew Leader places 5 sampling quadrats at the start of the QA transect for the Botanist's use. _____

10. Surveyors determine location of WMT with input from the Crew Leader. _____

11. Vegetation Teams conduct vegetation identification and estimation of cover of plant species, bare ground and open water within quadrats, make line-intercept determinations and belt transect measurements along Site Characterization Transects. _____

    A. Recorders correctly fill out header and plot information on forms, correctly record data and assist botanist as needed. _____
    B. Always walk on left side of transect and stretch tape along compass bearing. Trampling minimized in each transect segment. _____
    C. Transect tape is tightly stretched when line-intercept distances are obtained. _____

11. CONTINUED:

D. Botanists work systematically through plot when estimating cover and Botanists and Recorders avoid stepping into plot while reading cover. _____

E. Botanists estimate cover to nearest 1% for cover values ranging from 1-5%, to nearest 5% for cover values ranging from 5-100%, and for values less than 1% record .1 to indicate trace amount. _____

G. Botanists estimate cover of all herbaceous plants, any woody plants (or portions of shrubs or trees) that occur within or overlie the plot and are less than 2m tall. Values are obtained for bare ground, litter, water, and total cover of bryophytes or algae if they are present. _____

H. Botanists use take apart quadrats on plots with shrubs or trees. _____

I. Botanists tag (label unknowns) for bouquets, tag and collect unknowns and place in bags as they work along the transect. Once transect is completed store the collected plants in the ice chest until they can be pressed at the end of the day. _____

J. DBH is measured properly for all trees > 4 cm diameter (dbh) at correct height; tape placed correctly around stem. _____

K. Neither Recorder or Botanist step in the quadrat in their effort to reach trees - this disturbs the area to be used by the survey team. _____

L. Botanists properly identify the wetland boundaries, and the positions of the first and last plot. _____

N. Recorders remember to record boundary start and end for each transect and to calculate and record the transect length on which shrubs and trees are sampled. _____

12. Botanists conduct QA activities for vegetation (identification and estimation of cover of herbs, bare ground and open water by remeasuring 5 plots, and remeasuring line intercept for shrubs and DBH for trees within corresponding 5 transect intervals). _____

13. Crew Leader photographs the site. _____

14. Crew Leader annotates/updates Form I. _____

16. Surveyors measure elevations and water depths, and record land cover data at sampling points along Wetland Morphology Transect. _____

17. Crew Leader identifies QA transect for soil sampling by rolling a die, identifies routine and QA plots for soil sampling from random number table. Informs Surveyors prior to morphology and soil sampling along Site Characterization Transects. _____

18. Surveyors measure elevations and water depths, record land cover data, and collect soil samples at sampling points along Site Characterization Transects. _____

A. Stadia rod held vertically? _____
B. Stadia rod placed properly at sampling points and within plots? _____
C. Transmitting land cover data to Transit Operator? _____
D. Transmitting water depth to Transit Operator? _____
E. Water Depth MUST be a NUMBER or a SLASH in all data form spaces--NO blanks. _____
F. Transit Operator checking bubble-level? _____

19. Crew Leader performs Proficiency Check of soil sampling activities. _____

A. Sample collected from proper location at corner of plot. _____
B. Correct equipment used for soil conditions. _____
C. "Clean" soil slab extracted. _____
D. Soil horizons correctly identified. _____
E. Samples extracted from correct depths. _____
F. Munsell color chart properly used for determining color (e.g., soil is moist, charts not used in bright sunshine, charts held away from bright clothing, etc.), and colors of matrix and mottles correctly identified. _____
G. Soil samples correctly labeled and stored. _____
H. Depth 0 properly identified (interface between litter layer and top mineral layer). _____
I. Both Surveyors participating in defining horizon depths, determining color, etc. _____
J. Every box on Form filled in? _____

20. Surveyors conduct QA activities for soil sampling by recharacterizing 1 soil pit and collecting duplicate soil samples. _____

21. Botanists and Crew Leader determine if additional Vegetation Transects are necessary to obtain required number of sample plots containing vegetation. _____

22. Botanists conduct vegetation identification and estimation of cover of plant species, bare ground and open water within quadrats, make line-intercept determinations and belt transect measurements along Vegetation Transects (if necessary). _____

23. Surveyors measure elevations and water depths, and record land cover data at sampling points along Vegetation Transects (if necessary). _____

24. Botanists collect voucher samples, and key out and preserve plants for future identification and archiving. _____

25. Surveyors place soil samples in coolers for refrigeration and transport to the lab at PSU. _____

26. Crew Leader collects and reviews all data forms for completeness, errors, etc., organizes them into the site packet, and makes entries in the field diary. _____

Form G-1, Equipment Checklist (1) _____
Form G-2, Sample Custody Log (1) _____
Form G-3, Field Personnel (1) _____
Form F-1, Transect Establishment (1) _____
Form F-2, Sketch Map (1) _____
Form F-3, Map Data Sheet (# of #) per site _____
Form F-4, Buffers (# of #) per transect _____
Form F-5, Photographic Label (1) _____
Form F-6, Photo Record (# of #) per site _____
Form F-7, Herbaceous Veg (# of #) per transect _____
Form F-8, Line Intercept (# of #) per transect _____
Form F-9, Tree DBH (# of #) per transect _____
Form F-10, Morphology (# of #) per transect _____
Form F-11, Soils/Hydrology (5) 1 per SCT _____
Form L-1, LAB - none in field
Form L-2, LAB - none in field

27. Surveyors and Recorders collect and organize equipment and replace it in the vehicle. _____

28. Recorders check supply of data forms to ensure that enough copies are available for sampling the next site. Inform Crew Leader if more copies are necessary. _____

29. Crew Leader ensures site is left in the best possible condition, and checks to ensure no equipment, samples, or personnel are left behind. _____

COMMENTS: