Methods for Assessing Wetland Functions

Volume II: Depressional Wetlands in the Columbia Basin of Eastern Washington

Part 1: Assessment Methods

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The following people have also been instrumental in bringing this project to fruition. Andy McMillan has provided invaluable guidance to the authors during all aspects of the model development. Dennis Beich provided his depth of experience and knowledge to the development of the models. Tim Gates from Ecology lent us his writing skills to help produce our periodic "Updates" and provided us with formatting ideas for our documents. Mary Lynum and Sharon Aboe from Ecology, with their expert organizational and production skills, made the actual publishing of all documents a reality.

Preface

This document presents the final calibrated models that have been developed to assess the performance of wetland functions for depressional wetlands in the Columbia Basin. It is the result of almost three years of intensive fieldwork and numerous meetings that developed the models in a methodical, iterative manner.

The initial draft models were developed in 1998 by seven scientists (known collectively as the Assessment Team) based on fieldwork conducted in fall of 1997. The Assessment Team consisted primarily of individuals with expertise and local knowledge in the specific wetland functions being modeled. Seven field teams consisting of 21 resource scientists collected data from over 54 reference wetlands for the purpose of calibrating the models during the spring, summer and fall of 1999.

Additionally, the Assessment Team assessed the performance of each function at each site using their collective judgement and expertise following the process developed by the U.S. Army Corps of Engineers (the HGM approach, Smith et al. 1995). The models were then calibrated against the judgements using the collected field. The Assessment Team reviewed and revised the draft-calibrated models in January of this year. This document represents the results of this calibration and review by the Assessment Team, the Eastern Washington Technical Committee and other technical reviewers.

Overview of the Document

This document describes methods for assessing functions of depressional wetland in the Columbia Basin of Eastern Washington. This volume is divided into two parts. The first part contains background information and three methods, one each for three types of depressional wetlands occurring in the Columbia Basin. The second part contains procedures and field forms for collecting and recording the data needed to apply the methods.

Part 1

Chapter 1 — Chapter 1 is a brief description of the project, enough to provide a context for the assessment methods. It also includes a summary of the process followed, the wetland classification system used, and how reference wetlands were used in developing the methods.

Chapter 2 — Chapter 2 describes the type of methods that were developed and the technical aspects of model building, such as calibration and normalization of the equations. The chapter ends with a summary of what the numeric results of the models represent.

Chapter 3 — Chapter 3 is an introduction to applying the methods in the field using photos, maps, and field data. The issue of potentially dividing a wetland into smaller units to be assessed individually (called assessment units or AUs) is also introduced in this chapter. Detailed procedures regarding completing fieldwork at the site to be assessed are provided in Part 2.

Chapter 4 — Chapter 4 describes how to apply the results of the methods in the context of wetland management. The chapter covers some of the applications for which the results can be used, how to interpret the results, other information that should be incorporated in decision-making, and tips for the decision-maker.

Chapter 5 — The functions that are being assessed are discussed in Chapter 5. The logic behind choice of functions and generalized definitions for each function are provided. The functions specific to each subclass are described in the chapters containing the methods.

Chapters 6 through 8 — Chapters 6 through 8 contain the actual methods for depressional long-duration, depressional short-duration, and depressional alkali wetlands in the Columbia Basin of eastern Washington. Each method includes models for up to 13 individual functions. Within these chapters, each model for a function is described in its own section, and includes the following:

- Definition and description of the function
- Description of how the function is assessed for that subclass
- Summary of the model ("Model at a Glance")
- Description and scaling of variables

- Table outlining the procedure for calculating an index of performance

"Model at a Glance" displays the environmental processes or characteristics that are assessed for that function, the variables chosen to model that process, and any indicators of the variable if needed. "Model at a Glance" tables also give the equations that are used to calculate the potential of the function being performed.

The **calculations** needed to develop an index of function are presented in table format. These provide the scaling of the variables needed to compute the equations. A description of the scaling, any calculations needed to determine the scaling, and the resulting score for each variable is displayed. The field data for each variable or, where needed, the indicators used in the calculations for scaling are numbered to correspond to the field data sheets. The equation for the model is repeated here so that the scores can be inserted in the equation and the numeric index of performance or habitat suitability can be computed.

Miscellaneous — Part 1 ends with a glossary, cited references, and appendices.

Part 2

Part 2 contains the detailed procedures for collecting the data to complete the assessments. It describes how to gather information including maps and photographs, organize the field equipment needed, and preview information prior to visiting the site. Part 2 also provides guidance for determining if multiple assessment units need to be identified within a contiguous wetland boundary.

The bulk of the volume consists of the detailed procedures for collecting each datum for the assessment. Data sheets for each subclass are provided in the appendices, along with other tools.

This volume includes a diskette containing spreadsheets that provide for entry of field data and automatic calculation of the numeric results.

1. Introduction to the Project

The Washington State Wetland Function Assessment Project is a statewide partnership of government bodies and the private sector born out of the need for better information about wetlands. Managers and scientists need better technical tools to provide site-specific assessments of how well wetlands perform their functions. They also need consistency in how functions are assessed across the state. Assessment of wetland functions presently relies on a variety of approaches that are not adequately documented, tested and calibrated scientifically, or are not designed for northwest wetlands. Application of these assessment approaches has often resulted in inconsistent and inaccurate assessments, duplication of effort, and increased permitting times and costs.

1.1 The Goal and Objectives of the Project

The goal of the project is to develop relatively rapid, scientifically acceptable methods for assessing functions at individual wetlands to meet regulatory and non-regulatory needs within our existing management framework.

Use of the assessment methods is not mandated in any current regulation or policy. The methods may be endorsed by some agencies and used consistently because they provide uniform, reliable, and accurate assessments of wetland functions.

1.1.1 Potential Uses

The following are examples of potential applications of the methods:

- Assessing project impacts to wetlands
- Assessing the adequacy of compensatory mitigation proposals, the success of mitigation projects, and the success of mitigation banks
- Calculating credits and debits for mitigation banking
- Assessing restoration potential and success
- Assessing the suitability of different wetland management or conservation activities such as enhancement at wildlife preserves
- Assessing the benefits of site-specific wetland acquisition
- Assessing the relative level of performance of several or all wetlands in a watershed

1.1.2 Objectives of the Assessment Methods

The following objectives were established to help guide the development of these methods. Fulfilling all equally well was not possible, as some are mutually exclusive.

The methods are intended to do the following:

- Assess the level at which a wetland area performs a function (level of performance), not its value
- Be scientifically acceptable (based on the best available scientific information)
- Be practical, relatively rapid, and cost effective
- Be numerically based (quantitative)
- Be useful for assessing individual wetlands in making wetland management decisions
- Be sensitive to differences between regions and wetland types
- Be easy to revise in light of new knowledge
- Allow for assessments at different levels of data collection and detail
- Be "transparent" in that users can backtrack through the equations to determine how results are determined
- Be user friendly for trained people
- Generate reproducible results
- Be insensitive to small changes in input so slight variations in input will not cause significant changes in output

1.1.3 Time to Apply the Methods

The length of time needed to apply the methods will vary with size and complexity of the area being assessed; from a couple of hours for smaller wetlands to a few days for the largest and most complex sites. In most cases, "relatively" rapid and "cost effective" were intended to mean one to two days to collect data in the field and calculate the results. To obtain the best results with these methods it is recommended that the assessed wetland be visited during both the spring and fall. Though the methods will provide relatively reasonable results with one site visit, the highly variable nature of water regimes in the Columbia Basin may reduce the accuracy of some data such as the extent of inundation. **At least two site visits are recommended to collect data; one in the spring (April – June) and one again in the fall (September – October).**

1.1.4 Expertise Needed to Apply Methods

The level of expertise needed to apply the methods is similar to that needed to delineate wetlands.

The methods are designed for technical wetland experts and individuals with a strong background in wetland science. Expertise is required to make accurate and consistent observations of the variables and indicators that are included in the models. At the time of printing of these methods, Ecology is planning at least one 5-day training session for future users of the methods. Continuation of the training sessions by Ecology, or by a private training company, is dependent upon demand. **Completion of the 5-day course is strongly recommended to help ensure appropriate and accurate application of the methods.** Experience has shown that untrained users may generate index scores that vary significantly from those obtained by the assessment teams.

1.2 Who was Involved

Broad participation is one of the project's strengths. Most assessment methods reflect the biases or limitations of the authors because individuals or small groups develop them. This project protects against such biases through broad participation and review. Involvement of wetland scientists, managers, and the general public also helps ensure the methods are both scientifically acceptable and practical.

Broad participation also fosters support and acceptance of the methods, thereby increasing the likelihood that the methods will be used consistently. For Eastern Washington more than 70 individuals and organizations participated in the development, testing and review of the models. This included private citizens, environmental consultants, and representatives from local, state and federal government and academic institutions in eastern Washington.

For the statewide project, a general mailing list of over 900 individuals has been maintained. The list includes scientists, policy-makers, planners, representatives of a wide range of interest groups, and members of the general public. To help keep everyone informed about the project, periodic updates about the project are sent out to those on the general mailing list.

Broad participation has also been demonstrated by the organizations and parties that were involved with the various committees and teams consulting on the project. Members of these committees and teams are listed in Appendix 1- A. The Technical Committees were chosen for their expertise in wetland function assessment. The Assessment Teams were chosen for their expertise in specific disciplines. The committees and teams are listed below:

- Statewide Technical Committee (SWTC) - guides the technical components of the project statewide
- Eastern Washington Technical Committee - helps guide model development efforts east of the Cascade Mountains
- Implementation Committee (formerly composed of the Interagency Wetlands Review Board - IWRB) - provides guidance on the policy components of the project
- Depressional Assessment Team, Columbia Basin - an interdisciplinary team that developed the assessment methods for a portion of eastern Washington
- Depressional Field Teams - collected data at 54 reference wetlands in the Columbia Basin of eastern Washington and suggested improvements to the data collection procedure

Selected technical experts from specific disciplines reviewed the Columbia Basin models before they were calibrated. Comments were provided in writing and during a four-day technical review workshop in December of 1998. This initial review was important to ensure that the appropriate field data were collected. The workshop was followed by data collection at 54 reference wetlands and calibration of the models in 1999, and further review/revision of the calibrated models by the Assessment Team in January of 2000.

1.3 The Approach Used to Develop the Methods

The following section briefly describes the process, the wetland classification, and the technical assumptions used to develop the methods. These and other elements of the approach will be described in more detail in a separate document, along with the analysis and options that were considered for each of these topics.

The SWTC analyzed several options for adapting existing, or developing new, methods to assess functions. With concurrence from the IWRB, they determined that new methods should be developed for different wetlands and different regions of the state.

The SWTC also determined that the approach to be used in Washington should be based on the Hydrogeomorphic (HGM) Approach (Smith et. al. 1995) with modifications that include some new elements added by the committee and the Assessment Teams. In addition, the committee directed the Assessment Teams to include the useful technical components of other existing methods as a foundation on which to build the new methods. For example, many of the functions that wetlands perform, and the variables that represent performance of those functions have been defined in existing methods. These variables and the basic equations of the existing methods, as in the Wetland Evaluation Technique (WET) (Adamus et al. 1987), were used as a starting point.

The **Hydrogeomorphic Approach** is a process for developing methods that assess selected wetland functions of different wetland classes and subclasses in each region of the country. It has three major elements:

- Procedural steps used to develop the function assessment methods
- A wetland classification system based on landscape position and hydrologic characteristics
- Specific technical assumptions, including the use of reference wetlands

For a detailed description of the HGM Approach, refer to Brinson et al. (1995, 1996) and Smith et al. (1995).

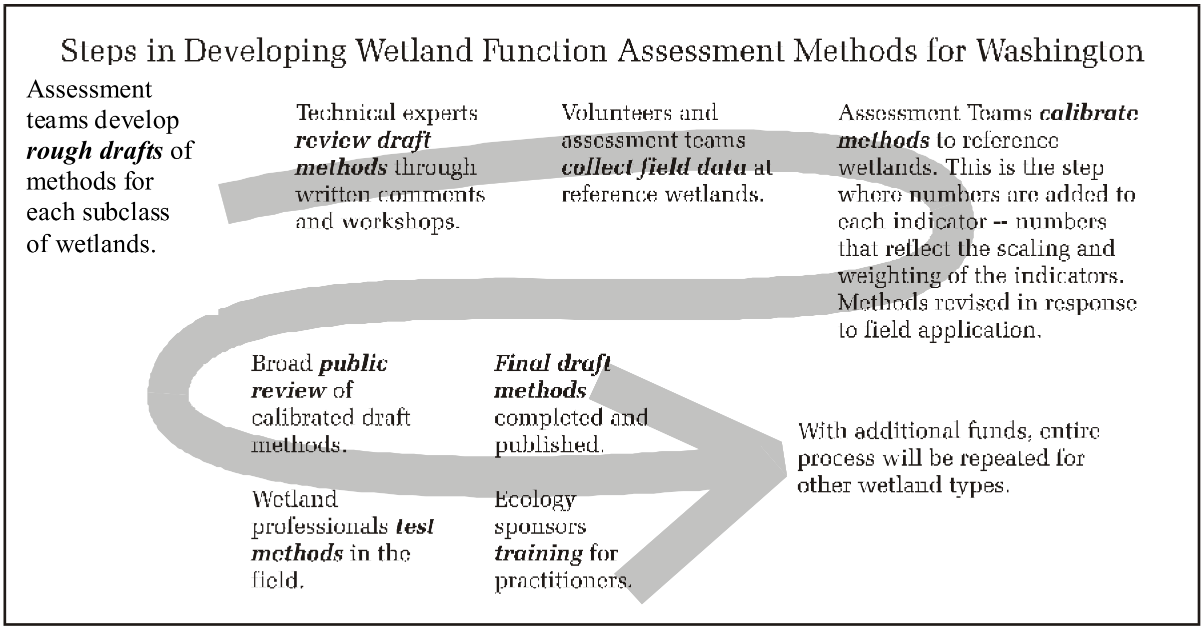

Figure 1: Steps in Developing Wetland Function Assessment Methods for Washington

1.3.1 Process Used to Develop the Methods

The process for developing methods for Washington was based on that outlined in the HGM Approach described above. Washington's approach, however, has had added oversight by technical committees and a policy board, and more extensive outside involvement, including testing of the calibrated methods before they are released (See Figure 1).

Developing and Revising the First Draft

Prior to developing the first draft of the assessment models, the Assessment Team visited selected reference wetlands in the field, refined the regional classification developed by the technical committee, identified the key criteria used to differentiate between wetland subclasses, and determined the functions that are performed by each subclass.

The team developed an initial set of models during a four-day work session and subsequent meetings. The team then worked with Ecology staff to produce a document for review that contained the initial models. The draft document was distributed to selected regional and national experts from specific disciplines for review and comment. These experts provided comments in writing or during an interactive technical workshop. The purpose of this review was to revise the models and variables as needed in order to ensure that the appropriate data were collected in the field.

Calibrating and Reviewing Draft Models

The Assessment Team revised the draft models and provided guidance to Washington State Department of Ecology (Ecology) staff for procedures to use when collecting field data. Ecology staff developed the data collection procedures and trained field teams to collect data at reference wetlands. The Assessment Teams judged the level of performance of each function for all 54 reference wetlands while the field teams were collecting data.

Using field data, the Assessment Team refined the classification, the functions assessed, and addressed any problems with variables, indicators, or procedural issues that were uncovered during the data collection and analysis process. They calibrated the models by choosing reference standards wetlands for each function, developing the numeric scaling of each variable for each function, and developing the equation used to calculate each index of performance.

Testing the Calibrated Methods

Calibrated methods were then reviewed by the general public and tested by wetland experts. The purpose of testing was to determine the efficiency, ease of understanding, reproducibility, and accuracy of the methods.

Finalizing the Methods

The Assessment Team reviewed the comments provided by reviewers and testers, as well as the results of field-testing. This information was used to make any necessary revisions, completing the methods development process. Ecology staff then prepared the final methods for publication.

Training in the Methods

At the time of this printing, Ecology is planning to conduct at least one 5-day training session for those with a strong technical background in wetlands. This is an intensive course, involving a field component, geared towards those that will be applying the methods in the field. Ecology is also planning to conduct several ½-day training sessions for wetland decision-makers; those that will be reviewing the result of assessments done with these methods. These training sessions will focus on guidance on how to understand, interpret, and use the results.

Updating the Methods

Project staff plan to periodically work with all the Assessment Teams and the SWTC to review and incorporate new research findings and address suggestions offered by users of the methods.

Pending future funding, project staff will also solicit field data collected during the routine application of the methods. These data would be used to enhance the current database for regional reference wetlands. Assessment Teams may also be reconvened to periodically review the new data to determine if the calibration of the models should be refined.

1.3.2 The HGM Classification System

The SWTC decided that the wetland classification system used in the national HGM Approach to wetland function assessment is a sound one for developing methods. This system, called the Hydrogeomorphic Classification (HGM), is hierarchical, and is designed to categorize wetlands into groups that function in similar ways (Brinson 1993, and Brinson et al. 1995).

The highest categories (i.e. classes) for wetlands in a region are defined nationally (Table 1). Subclasses for each of these classes are defined regionally by experts within that area. The wetland experts in each region can, therefore, tailor the subclasses to address differences in the performance of functions by different wetland types in their region.

In Washington, both technical committees created regions to reflect the differences in wetland functions, or differences in how functions are performed. The committees suggested that Assessment Teams revise the classification, including the draft regions, based on comments and field data collected during method development. The extent of the Columbia Basin in eastern Washington is described in Appendix 1- B.

Regions in Washington

- *Montane (statewide)*
- *Lowlands of Western Washington*
- *Columbia Basin*
- *Lowlands of Eastern Washington*

The HGM regions for eastern Washington are defined by state boundaries. However, we realize that the methods may be applicable to similar areas of north central Oregon.

The highest grouping in the classification (i.e. wetland class), as established at the national level is based on geomorphic settings (riverine, depressional, estuarine, lacustrine, flats, and slope). The second and third levels in the classification are based on hydrodynamics (the movement and duration of surface water in the wetland). The hydrologic characteristics used as criteria to separate subclasses are different for each subclass and region, and depend on characteristics specific to that subclass and region. The classification of wetlands in the Columbia Basin is given in Table 1.

Table 1: HGM Classification for Columbia Basin[1]

Class[2]	Subclass[2]	Family
Riverine	[3]	
Depressional	Freshwater	Long-duration
		Short-duration (includes vernals)
	Alkali	
Slope	[3]	
Lacustrine Fringe	[3]	

[1] Only models for depressional wetlands have been developed
[2] The classes/subclasses are described in the draft profiles included in Appendix 1- C.
[3] At present, there are no subclasses for riverine, slope, flats or lacustrine fringe. Subclasses will be added if, during future model development, differences in function are determined between wetlands within these classes.

Priorities for the First Round of Developing Methods

Methods for only a few regional subclasses can be developed during these initial years of the project due to limited time and resources. Also, most of wetlands for which function assessments are needed belong to a relatively small number of subclasses. The project, therefore, prioritized developing methods for these subclasses.

The Statewide Technical Committee and the Interagency Wetlands Review Board prioritized the lowlands of western Washington to begin the method development process. Within that region, they prioritized the riverine and depressional subclasses (excluding depressional interdunal) for which final calibrated methods have now been completed. Once the western Washington methods were nearing completion, the development of methods for eastern Washington was initiated. The eastern Washington technical committee ranked depressional wetlands of the Columbia Basin as a priority for method development.

Depressional Wetlands in the Columbia Basin

Depressional wetlands occur in topographic depressions that exhibit closed contours on three sides. Elevations within the wetland are lower than in the surrounding landscape. The shape of depressional wetlands vary, but in all cases, the movement of surface water and shallow subsurface water is toward the lowest point in the depression.

Depressional wetlands in the Columbia Basin may be isolated with no surface water inflow or outflow through defined channels, or they may have intermittent surface water flows that connects them to other surface waters or other wetlands. Outflow from depressional wetlands usually occurs early in the growing season in wetlands outside the area of the Reclamation Project. Many depressional wetlands within the Reclamation Project, however, gain surface water later in the growing season from irrigation waters, and may in some cases have occasional outflow late in the summer.

Depressional wetlands lose most of their water to evaporation, evapotranspiration, and/or movement into the ground. Surface water outflows usually represent a small part of the water lost in these wetlands. Wetlands in the Basin whose main source of water is mineral-rich groundwater can accumulate salts and become "alkali." Wetlands that are not alkali, howeverm can discharge slowly to groundwater through the underlying fractured basalt formations. This is thought to occur later in the growing season when inflow from surface water, shallow groundwater (interflow) and deeper groundwater has ceased. Wetlands situated within deeper loess or wind blown deposits may lose water in a similar manner, but the discharge to groundwater will be primarily through loess sediments and less through fractured basalts. Wetlands whose water regime is dominated by water from irrigation are also not usually alkali.

The Columbia Basin has many areas of small depressions on the surface of impermeable basalt bedrock. The soils in these depressions are shallow, or not present, and they are inundated for only brief periods during the spring that usually last less than 90 days. The water inflow of these wetlands is dependent upon precipitation, which is then rapidly lost through evaporation and evapotranspiration. These depressions are often called "vernal" pools and represent an important habitat resource in the Basin.

Some wetlands within the Reclamation Project boundaries have unusual hydrologic characteristics due to the influence of irrigation waters. Overall, limited research has been conducted in Eastern Washington to characterize and quantify the relationship between depressional wetland water regimes, groundwater and surface water dynamics.

Depressional wetlands in the Columbia Basin are located in the following geomorphic settings: 1) channel scablands created by Lake Missoula floods; 2) wind blown loess outside the area scoured by Lake Missoula floods; 3) Wind blown sand dunes within the channel scabland area; 4) glacial kettles or potholes located in Douglas County; 5) alluvial and basalt terraces, particularly along the Columbia River.

Depressional wetlands in the Basin are divided into two subclasses based on their conductivity and further subdivided by the length of time surface water is present in the wetland. These two environmental characteristics were judged to be the most important in establishing how depressional wetlands function in the Basin. Depressional long-duration wetlands have some standing or open water in them for 9 months or more during the entire year, in most years. Depressional Short-duration wetlands have standing or open water present for less than 9 months in most years. This type of wetlands also includes short-duration wetlands known as "vernals."

Alkali wetlands are not at common on the landscape as freshwater wetlands in the Columbia Basin, but they do provide some unique habitat features, not found in freshwater wetlands. The ecological processes in alkali wetlands are dominated by the high salt concentrations in the water. The most visible result of the salt is a unique set of plants that have adapted to these conditions. Only a few species have adapted to these conditions and the species richness in alkali systems is much lower than in freshwater systems. Although richness may be low, abundance can be very high for those species that have adapted (especially among some invertebrates).

1.3.3 Clarification Regarding the Wetlands Assessed

Only Vegetated Wetlands Are Classified and Assessed

It is presumed that any areas classified and assessed for performance of functions are wetlands that meet the criteria for jurisdictional wetlands (WDOE 1997). There may, however, be areas within a vegetated wetland that are not vegetated. For example, wetlands may contain areas of open water that are unvegetated. If these areas are less than 3 meters (9.9 feet) deep and less than 8 hectares (20 acres) in size (i.e. not lacustrine) they are included as part of the assessment unit. However, in cases where the area is predominantly unvegetated (there is less than 30% cover of plants), the methods should not be used. Due to brief inundation regimes, some Columbia Basin wetlands may either be unvegetated or contain non-wetland vegetation (e.g. vernal wetlands in the fall). Wetlands that are either unvegetated or contain non-wetland vegetation at the time of assessment qualify for application of these assessment methods if the wetland meets the three jurisdictional criteria during the growing season for the required length of time.

> *The methods are not designed to assess the functions of non-wetland riparian areas, unvegetated mud flats or adjacent upland areas.*

A Wetland's Current Condition Determines Classification

The current condition of the wetland is used to determine its classification, regardless of its history and type of alterations made. For example, diked wetlands that were once riverine might now be a depressional wetland (if they are flooded infrequently). A "short-duration" depressional wetland that is now flooded year-round by agricultural runoff would be classified as a "long-duration" depressional system.

Boundaries Between Subclasses

The Assessment Team developed models for wetlands that can easily be classified within a particular class and subclass. Wetlands, however, occur along a continuous gradient of geomorphic and hydrologic conditions. Some wetlands are difficult to classify, and some may contain areas that can be classified into two or more subclasses. The Field Methods (Part 2) contain more detailed guidance on determining the assessment unit boundaries adjacent to upland areas and other wetland types.

1.3.4 Using Reference Wetlands to Develop Methods

The SWTC reviewed many of the technical assumptions used in the HGM Approach and determined that many should also be used in developing Washington methods. They did not, however, adopt the HGM assumptions stating that:

- least altered wetlands would always be the reference standard wetland; and
- that the highest sustainable levels of performance for all functions is found in least altered wetlands.

Some of these assumptions, described in Chapter 2, are also common to other assessment methods.

One of the major steps in the development of these methods, not commonly used in other methods, involves using reference wetlands to calibrate the models. The Statewide technical committee agreed that reference wetlands should be used. The committee was uncertain, however, how to choose reference standard wetlands. They made their final decisions regarding which wetlands to use as reference standard sites once field data were analyzed using different assumptions for choosing the standard sites in the first set of methods developed (lowlands of western Washington).

REFERENCE DOMAIN includes all wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass.

REFERENCE WETLANDS are a group of wetlands within the reference domain that encompass the known variation of a hydrogeomorphic subclass.

REFERENCE STANDARD WETLANDS are sites within the reference data set, which establish the characteristics that must be present in a wetland for it to score the highest for a function.

Reference wetlands are a group of wetlands within the region (called reference domain in the HGM literature) that encompass the known variation of a hydrogeomorphic subclass. They are used to establish the range of performance of functioning within the subclass. Data collected at reference wetlands are needed so that the models reflect regional conditions.

Once a group of reference sites is identified and data collected, the Assessment Team determines which will serve as reference standard wetlands. Reference standard wetlands are a subset of reference wetlands that establish what characteristics must be present in a wetland for it to score the highest for a function. The characteristics of the reference standard wetlands are those against which other wetlands are compared.

HGM Assumption Not Used – Reference Wetlands are the Least Altered Wetland

The HGM Approach suggests that the major criterion for choosing reference standard sites should be their relative lack of human disturbance or alteration. These reference standard wetlands are called "least altered" wetlands. The objective is to determine the optimum levels of performance in sites that are as undisturbed as possible (Davis et al. 1995). "The approach assumes that highest, sustainable functional capacity (i.e. level of performance) is achieved in wetland ecosystems and landscapes that have not been subject to long term anthropogenic disturbance" (Smith et al. 1995 p.28). Brinson (1995) adds the concept of "self-sustaining" to reference standard sites because reference standards are to be determined from "characteristics measured in the field on wetlands that are self-sustaining..."

Another critical presumption used in the HGM Approach is that the highest sustainable levels of performance (functional capacity) for the entire suite of functions performed by wetlands in a subclass are found in the relatively undisturbed wetlands. The reference standard wetlands (those that are least altered in the least altered watersheds), by definition, have a level of performance equal to [10] for all functions (D. Smith personal communication).

With the HGM Approach, the index for "functional capacity" represents deviation from the performance of wetlands that are judged to be the least altered sites in that subclass and domain. **This basic assumption was not used in developing methods for Washington.**

Alternative Assumptions to Replace Asummptions in the HGM Approach

The Washington State Function Assessment Project uses another assumption to establish the characteristics against which other wetlands in that subclasses are compared. *The alternative assumption is that the highest level of performance for a wetland function will occur when a specific set of optimal environmental conditions are met for that function, regardless of whether or not the wetland has been subject to human disturbance*. Using this assumption, one group of wetlands may not necessarily be the reference standards for all functions.

> *Using the Washington State assumption, the index of performance represents the deviation from the highest performing sites for individual functions, regardless of level of alteration.*

Additionally, under this assumption the index for "performance of function" represents the deviation of performance from those wetlands judged to be the highest performers for each individual function in that subclass and domain. The models compare the characteristics (variables and their indicators) present in the area being assessed to those occurring in the highest performing wetlands.

For the western Washington Function Assessment Methods, the Assessment Teams identified reference wetlands that they judged to be least altered and those that they judged to be the highest performers for each function. Several draft models were then calibrated in two ways, based on each approach. The comparison showed that both least altered and more significantly altered wetlands can perform functions at low to high levels. The Assessment Teams did not consistently judge least altered wetlands as the highest performers for all functions. Based on the outcome of this analysis the eastern Washington Assessment teams did not perform the same comparison.

The Assessment Teams also found that it is difficult to predict "sustainability" in wetland functions, especially since this concept has not been defined in any documentation of the HGM Approach. Many of the watersheds in the Columbia Basin of eastern Washington, as well as the state, are experiencing ongoing disturbances and it is difficult to predict if any wetland, including those that are least altered, can sustain a particular level of performance over time.

Reference standard wetlands used to calibrate the Washington models are those reference wetlands within a subclass and domain that are judged by an Assessment Team to perform at the highest level for individual functions, regardless of level of alteration. The highest level of performance of a wetland function will occur when a specific set of environmental conditions is met.

The SWTC and western Washington Assessment Teams jointly reviewed the results of the comparison and discussed the results of both approaches in the context of wetland management. They decided that reference standard wetlands should be those reference wetlands within a subclass and domain that are judged by an Assessment Team to perform at the highest level for individual functions, regardless of the level of alteration.

2 Introduction to the Models

2.1 Understanding Wetland Analytical Methods

There is often much confusion about methods used to analyze wetlands. This confusion is, in part, the result of incorrect terms being used to describe methods. Methods for organizing our knowledge about a wetland have been referred to as classifications, categorizations, characterizations, ratings, assessments, and evaluations. Each of these terms is meant to indicate the type of information a method provides, but often methods provide information that is not consistent with their name. The methods described in this document are called assessments because they provide a numeric estimate of a relative level of performance for a function.

> *A wetland assessment method represents a group of mathematical models, one for each wetland function for a specific type of wetland. Therefore, for the Columbia Basin depressional wetlands there are three methods because there are three different types of wetlands identified: long-duration, short-duration and alkali wetlands.*

The ways in which data are analyzed within a method are called "models" or "algorithms" because most rely on equations or other mathematical rules for achieving a result. Here, the term "models" is used to represent the individual equations, and "methods" to represent a collection of models. Generally, a method has a separate model for each wetland function assessed, and there is a separate method for each wetland hydrogeomorphic subclass in a region.

> *MODEL*
> *Equation used to estimate the level of performance for a specific function of a specific wetland subclass (i.e. wetland type)*
> *AND*
> *METHOD*
> *Collection of models for a specific wetland subclass*

There are two types of computational approaches commonly used - logic and mechanistic. A model using a "logic" approach has a qualitative, verbal, description that produces a result. In a logic model, the characteristics found in a wetland (variables) are combined by "logic" statements such as "and," "or," and "if...then" to establish a characterization or rating. Logic models have also been called "rule-based" models (Starfield et al. 1989) and "descriptive" models (Terrell et al. 1982). Probably the best known method using logic models is the Wetland Evaluation Technique (Adamus et al. 1987).

Wetland methods based on a mathematical aggregation of numeric data can be called mechanistic because they follow the "mechanistic" approach to model development described by the USFWS(1981) for Habitat Evaluation Procedure (HEP) models. In mechanistic models, environmental characteristics found in a wetland are treated as variables in an equation. Different "conditions" of these variables are assigned numbers and combined mathematically to generate an index or score. Examples of wetland methods using mechanistic models are Reppert et al. (1979), the “Connecticut” method (Ammann et al. 1986), the Indicator Value Assessment (IVA) (Hruby et al. 1995), and methods developed using the HGM Approach (Brinson 1995, and Brinson et al. 1996). Almost all wetland assessment methods that generate a number use the “mechanistic” approach to model development.

2.1.1 What are Mechanistic Models?

Rapid assessment methods based on mechanistic approaches provide a clear and concise way of organizing our current, and often subjective, knowledge (based on literature and regional expertise) about wetland functions. They do not assess the rates or dynamics of ecological processes occurring in wetlands.

This is a limitation of current methods that is often misunderstood both by wetland managers and by the scientific community. The misunderstanding is fostered by the fact that many functions are defined as ecological processes that are usually expressed as rates. For example, Brinson et al. (1995) define the function “Organic Carbon Export” as “export of dissolved and particulate organic carbon from a wetland.” When an assessment method provides a number for this function it is easy to assume that this represents the “grams of carbon” exported per year, especially when the index is defined as a “level of performance” (Smith et al. 1995). For example, one may mistakenly assume that a wetland with an index of 0.5 would then be expected to export ½ of the carbon exported by a wetland with an index of 1.

This and all other rapid assessment methods are modeling a process of judgement used by experts to assess how well wetlands perform functions, or how sustainable the functions might be. They are not mathematical representations of actual environmental processes taking place.

Indices, however, are only a numeric representation of a qualitative assessment or judgement. A wetland with an index of 0.5 using a mechanistic based assessment method, means that the wetland is judged to be performing a function at a “moderate” rate relative to wetlands at the “highest or “lowest” levels.

Measuring the rates or dynamics of environmental processes requires intensive sampling because the processes are highly variable over a period of time and space within an ecosystem. Such sampling procedures, however, are not possible if the method is to be rapid. Rapid, for most wetland managers and environmental consultants, means that a result can be obtained with one site visit. The entire process of data collection and analysis, therefore, for a rapid assessment method should take no more than one day for a single site, unless the area being assessed is large and complex.

2.1.2 What Do the Results of Mechanistic Models Represent?

Mechanistic models assessing wetland functions are constructed as a set of relationships between environmental characteristics and the performance of a function. Many of the relationships are only hypothesized because specific information about the relationship may be lacking.

For example, a model for the function "Removing Sediments" might be phrased as follows: "The performance of a wetland in removing sediments from incoming surface waters is based on its ability to reduce water velocities and to filter out sediments." These environmental processes of reducing velocities and filtering sediments become variables in an equation. The equation for "Removing Sediments" would be:

Performance = reduction in water velocity + amount of filtration of sediment

It is not possible, however, to develop a rapid assessment method that measures how much a wetland reduces water velocities or filters water to estimate sediment removal. Such estimates would require measuring changes in current velocities over the entire wetland for at least one year, and measuring the relative cross section provided by vegetation. Rapid assessment methods have to rely on easily observed characteristics that are correlated with the actual environmental processes.

MECHANISTIC MODELS ARE DECISION-MAKING MODELS

It is easier to understand the information provided by logic and mechanistic models if they are treated as environmental decision-making models (also known as "multiple criteria assessment" models). Decision-making models represent "the acquisition and merging of subjective, expert knowledge. Often several persons with varying backgrounds are to be taken into the analysis, e.g., engineers, ecologists, economists, managers, and politicians" (Varis et al. 1994). Each variable in a model represents a decision criterion used to establish a level of performance, rather than an independent variable that estimates the rate of an environmental process. These decision criteria are based on the judgements and experience of the Assessment Teams and on the research that has been done to date.

2.1.3 Use of Indicators as Surrogates for Variables

When it is not feasible to use a variable, it is sometimes possible to use an indicator as a surrogate for that variable. Indicators are easily observed characteristics that are correlated with quantitative or qualitative observations of an environmental variable.

Most indicators are fixed characteristics that describe the structure of the ecosystem or its physical, chemical, and geologic properties (Brinson 1995). Such indicators are time independent (on the scale of most environmental processes), and thus cannot reflect actual rates of performance. Rather, they reflect the potential or probability that functions are performed at a certain level. Model indices based on indicators, therefore, do not reflect the levels at which a function may actually be performed. Instead, they estimate the potential or probability that a function is being performed.

The potential of a wetland to reduce water velocities might be established by using the size and shape of its outlets and the depth of water stored in the wetland as indicators. An indicator of the potential for filtration of sediment might be based on the percent cover of dense erect vegetation near the ground surface. The equation for removing sediments could then be rewritten as:

Potential performance = type of outlets + depth of water storage + %cover of different types of vegetation

In a logic model, the level of performance for the equation above would be described using conditional phrases such as "the wetland rates high for removing sediments if it has a constricted outlet and an average depth of storage that is greater than 1 meter and erect vegetation over more than 80% of its area."

With mechanistic models, the authors choose the variables and scale them based on their judgement. For example, using the equation above, they would assign a separate score to different "states" of a variable (e.g., > 80% cover of emergent vegetation might be given a score of [1]; 40 - 79% cover of emergent vegetation receives a score of [0.5], etc.). Different types of outlets, and different depths of water storage, would also be assigned scaled scores in this manner.

In developing models, the sum of the scores for the variables in an equation are adjusted (normalized), to 1, 10, or 100 for each function to generate an index for the function. Normalizing is important because each function may have a different number of variables with correspondingly different total sums. The index of each function in these methods is normalized to [10].

2.1.4 Index of Function

Application of a method results in an "index" for each wetland function. Each index is a numeric representation of the potential performance for a specific function. The index is presented as an integer between 0 and 10, with a 10 representing the highest level of performance.

Index – a numeric representation of the performance of a specific function.

Indices – The set of individual index values for all functions found calculated for the wetland being assessed.

The calculated index is independent of the wetland size. It represents an index per hectare or acre of wetland, and does not have any numeric "dimensions." For example, a small, 1-hectare wetland, and a large 100-hectare wetland may both have an index of [10] for a specific function. If the method is being used to compare levels of function in two wetlands, each index can be multiplied by the area of the wetland. For example, a 10 acre wetland with an index of 5 for the function "General Habitat Suitability" would represent 50 acre points of function. A two acre wetland with the same index would represents 10 acre-points of function. For example, this type of information can be useful in making decisions about preservation of different wetlands.

These "performance scores," in contrast to the indices, should be presented using the units of "hectare-points," or "acre-points."

2.1.5 Validation vs. Calibration

None of the wetland assessment methods developed, or being developed, to date include any significant field validation because of the cost and time involved. Validation involves doing actual direct measurements of the performance of functions and comparing this with the numeric results obtained from the decision-making model.

> *Data collected at reference sites for these methods was used for calibration, not validation of the models.*

The collection of data in the field at reference sites during model development focused on generating the numeric scaling for a variable, not on measuring the levels or rates at which wetlands perform functions. For this reason, the data collection used to scale the Washington methods is called "calibration" rather than "validation."

2.2 Understanding the Washington State Methods

The methods developed for Washington State use mechanistic models to determine performance of each function being assessed. The interdisciplinary teams developed the variables, indicators and equations, and scaled them using their judgement and data collected at reference wetlands during the calibration process.

2.2.1 Variables Used

The Assessment Teams considered many variables in developing each model. Some had to be rejected because they were not easily observed or had an indicator that could not be characterized during one site visit. Two criteria limited the choice of variables in the models: 1) the variable or its indicator had to be observable, or it could be determined, at any time the ground was not frozen or covered with snow; and 2) the variable or its indicator had to be observable during a one day site visit for most wetlands. As a result, most variables or indicators reflect chemical, or biologic characteristics of a wetland that can be observed throughout the year. Appendix 1- D (Part 1) contains a summary of each model, showing all the variables used in each one.

Most assessment methods, up to now, have been built on the premise that variables and their indicators are linked to the positive performance of a function. A wetland that has more of the appropriate variables performs a function better than one that has fewer. Variables are assigned a positive value and summed. Another option, however, is to include variables that are correlated with a reduction in the performance of a function. These would be environmental characteristics that indicate a function is not being performed as well as it could be given all the other variables present.

For some functions, these models include both types of variables. If the performance of a function was considered impaired by certain characteristics, that characteristic became a variable that was included in the model equations as a fractional multiplier. The sum for the "positive" variables is multiplied by a fraction (numbers between 0 and 1) that represents the estimated reduction in performance. These variables are called "reducers."

For example, the presence of carp in depressional long-duration wetlands is modeled as reducer for the Aquatic Invertebrate, Amphibian and Aquatic Bird functions. Because carp feed on emergent vegetation and also significantly disturb the substrate they eliminate many of the habitat niches on which invertebrate species depend. This reduces the overall species richness of invertebrates which further impacts the number of species higher in the aquatic food chain, such as amphibians and aquatic birds. Additionally, carp feed directly on tadpoles further reducing amphibian richness. The potential performance of all three of these functions is, therefore, reduced when carp are present.

2.2.2 Calibrating the Variables

The data from the reference sites used in calibrating the models are not included in this document. They are available on request on a CD-ROM in Excel spreadsheets.

To calibrate the models, the Assessment and Field Teams collected data on 50 different environmental characteristics at 54 reference sites. The data were collected in the Columbia Basin wetlands of eastern Washington during the spring, summer and fall of 1999 (24 depressional long-duration wetlands, 20 depressional short-duration wetlands and 7 depressional alkali wetlands). Field teams consisting of volunteers from local governments, consulting firms, and state and federal resource agencies collected data. Field teams were trained in the data collection methods by Ecology staff. The assessment team also visited all of the reference sites and judged the performance of functions independently of the field teams. Judgements of performance were qualitative and based on a scale of 1-7. Additionally, the A-Teams collected data on dominant plant species, invertebrate species present (this was not always possible at some of the short-duration wetlands late in the growing season), amphibian species present, conductivity, pH, dissolved oxygen and temperature.

Calibration of each function was a two step process. In the first step, all reference sites in a subclass were ranked based on their "judged" index for the function, and the data collected at the site tabulated in the order in which the wetlands were "judged." Data on each variable as it was recorded in the highest and lowest performers were tabulated and used to develop the maximum and minimum scaling for that variable. For example, the highest performers for general habitat suitability in the depressional-long-duration subclass had, on the average, 4 types of refuge present (out of 5 possible). Four or five were established as the value for V_{refuge} (denotes the variable for types of refuge) that would be scaled a [1]. The lowest performers for the function had zero types of refuge, and the bottom of the scaling for V_{refuge} was set as [0]. Values of V_{refuge} between 0 and 1 were scaled proportionally as "# of types/4."

In the second step, an index for each reference wetland was calculated using a model based on the initial scaling of the variables. For a specific function, the index from the reference wetland with the highest performance was then divided into the index for each of the remaining reference wetlands for that specific function; this process normalized all of the reference wetland scores. The "normalized" model scores for a function for all reference wetlands were then compared to the "best professional judgement" scores for those wetlands. The average deviation between the model score and "best professional judgement" score for the entire set of reference sites was used as a guide to refine both the calibration and selection of variables. The goal was to reduce the average deviation between the model scores and the "best professional judgement" scores to its lowest value, while maintaining the variables considered important by the Assessment Teams.

2.2.3 Normalizing the Indices

As outlined above, the Assessment Teams used the score from the reference site with the highest model score for that subclass to normalize to [10]. Structuring the models in this manner addresses the issue of wetlands performing high levels of functions in different ways, while still retaining the concept that certain reference sites represent the highest level of performance (Hruby, 1999). The issue of natural variability among the highest scoring sites is addressed by rounding off the indices to the nearest integer. This means that wetlands within a subclass can attain only one of 11 possible indices (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10). The Assessment Teams decided that the available data collected during the calibration phase permits this level of precision.

2.2.4 Potential and Opportunity

One of the issues inherent in developing rapid assessment methods is that the variables and indicators chosen represent structural characteristics of a wetland and its landscape. They do not measure rates or processes. We are unable, for example, to actually measure the rate of sediment removal because we will probably not be present at the time sediments are coming into the wetland. A measurement of actual sediment removal would require us to monitor the wetland during many times of the year and during several storms. This would is obviously no longer be a "rapid" method.

The assessment of function is divided into two separate models to address the inability of measuring rates, processes, and habitat usage. The first model, called Potential, uses the structural characteristics in a wetland to assess the capability of that wetland to perform a function. The question addressed is: does the wetland have the necessary structures and environmental conditions present to provide the function if it is given a chance to do so? For example, the model to assess aquatic bird habitat looks at the number of niches or special habitat features present in the wetland. It does not, however, assess whether the aquatic birds are actually using the wetland. To determine actual bird usage would require a long term monitoring program over several years. The model assessing the potential for sediment removal considers whether a wetland has all the necessary structural elements to trap sediments such as structures that reduce water velocity or that act as filters.

The second model for each function is called the "Opportunity" model. This equation assesses to what degree the wetland's position in the landscape will allow it to perform a specific function. For example, the "opportunity" models for sediment removal considers the sources of sediment in the watershed. Wetlands found in watersheds with high sediment loading (e.g. large areas of clearcuts, tilled agriculture or graded areas for new development) have a higher opportunity to perform the function than those with low sediment loading (upgradient basin is completely vegetated and undisturbed).

Opportunity models were tried for the lowlands of western Washington, but none of the data collected during the calibration could be adequately correlated with the judgements of opportunity made by the Assessment Teams. The conclusion of the western Washington Assessment Teams was that too many variables were involved in making a judgement of opportunity, and a simple model could not be developed. Instead, written guidance was developed for the user to qualitatively rate the opportunity.

In the Columbia Basin, however, it was possible to calibrate most of the "Opportunity" models developed. This was possible because the landscape of Eastern Washington is not as complex. Relatively simple models could be calibrated using data that could be collected rapidly. Users of the methods for the Columbia Basin are asked to qualitatively rate the opportunity of only a few functions that could not be calibrated.

2.2.5 "Habitat" Models Assess Suitability for Faunal Groups

The "habitat" models assess the suitability of a wetland for specific groups of organisms (e.g. aquatic birds), not for an individual species. Furthermore, the assessments neither estimate whether a species group is actually using a wetland, nor do they estimate the actual abundance or diversity of organisms in the wetland.

It is not feasible in a rapid assessment method to measure actual numbers and distributions of species. The requirement that assessment methods be "rapid" imposes limitations on the type of data that can be collected. Estimates of actual species usage would require lengthy sampling procedures geared to each species and timed to reflect their seasonal behavior patterns.

Structurally Simple Wetlands and Habitat Functions

In some cases a wetland may score low for a habitat function relative to the reference standard sites because its structural characteristics are simple. For example, a vernal wetland will score relatively low for its vertical plant structure and interspersion of different heights of vegetation and vegetation classes. Vernal pools, however, are important habitat for certain aquatic birds; they facilitate pair bonding because they provide the first open water, when other long-duration wetlands are still frozen. If you determine, during your gathering of information, that the wetland provides habitat for an important species, another method, such as HEP (USFWS 1981) is needed in order to determine the habitat suitability of that wetland.

2.3 Summary of What the Numeric Results Represent

The following is a list of points to keep in mind when interpreting the numeric indices resulting from the methods. Some points are repeated in other parts of the document and are provided here as a summary.

The mechanistic models used in wetland assessment methods model the judgement of a group of experts as to "how a wetland functions." The models are designed to approximate, to the greatest degree possible, the analytical process used by the experts to assess a wetland's functions. It is the intent of the methods to provide a process by which anyone trained in the data collection will come up with the same assessment as the best regional wetland experts.

The index of suitability for habitat functions is based on the premise that the performance of the function increases as more niches are provided (habitat heterogeneity). In the case of the models for aquatic bird habitat, a high index reflects the presence of habitat heterogeneity for a selected sub-group of birds rather than all birds. Furthermore, the models do not assess the habitat suitability for any individual species. For example, the index for wetland-associated mammals doesn't determine if the assessment unit is better habitat for beaver or muskrat. To get a species-specific assessment, another method such as HEP must be used.

The index of performance reflects level of performance "per unit area" of the wetland being assessed. Another calculation must be made to factor in the size of the assessment unit, or, in some cases, area being altered. Usually, this is done by multiplying the index for a function by the area involved. For example, if 2.5 acres (1 ha) of an assessment unit with an index of 8 for wetland-associated bird habitat were to be filled or altered the loss of bird habitat would be: 2.5 x 8 = 20 acre points. If the fill were reduced to 1 acre (0.4 ha) loss of bird habitat would be reduced by a factor of 2.5 (1 x 8 = 8 acre-points).

2.4 What Assessments of Function Don't Do

In this section, we describe what the methods don't do. Understanding the limitations of the methods is important in order to discourage misconceptions about them. Additional clarifications and cautions regarding the methods and their numeric results are provided in Chapter 4.

The methods developed under this project are improved technical tools used within the existing management and regulatory frameworks. They provide information needed to make better decisions about wetlands.

The assessment methods do not alter wetland regulations nor do they indicate to what degree different wetland types or functions should be protected. They do not change the regulations or policies that determine how wetlands are managed and are not expected to be mandatory for all permit applications. Many agencies and governments currently require an assessment of wetland functions as a part of their permitting process. Each jurisdiction will need to decide independently whether or not to formally adopt or require these methods.

The methods do not assess the economic values of wetlands or the importance of individual functions. The models only establish the levels at which wetlands perform some functions. They do not estimate monetary value; though the methods can be used to provide a numeric baseline for conducting cost/benefit analyses. They do not determine if one function is more important than another. These are "value judgements" made at the governmental, watershed, or community level. An assessment of how well wetlands perform some functions, such as reducing peak flows or removing nutrients, can be used to make value judgements about how wetlands should be managed, whether they should be filled, how much of a buffer is needed, etc.

The methods do not assess all the functions that are performed by wetlands. Not all possible functions performed by a wetland are assessed. For example, the methods don't assess the process of nutrient uptake by plants or how well the wetland breaks down and recycles organic matter (the detritus cycle). The Assessment Teams decided which functions were to be modeled using guidance from the SWTC and IWRB.

The methods do not assess cultural, recreational, educational or aesthetic functions. For example, the importance of a wetland to a local elementary school or its use by bird watchers can not be determined using these methods. The methods focus on the physical, chemical, and biological processes that occur in wetlands (i.e. the wetland ecosystem.)

The methods do not measure the rates of ecosystem processes. Rapid wetland assessment methods do not model the rates (such as amount of nutrients removed) or dynamics of ecological processes occurring in wetlands. Rather, they provide a clear and concise way of organizing our current knowledge about some wetland functions and the variables used to determine the performance of those functions. The variables are based primarily on observable physical characteristics of a wetland (i.e. % cover of plant species) that are correlated with the performance of functions.

The results do not represent an actual measurement of the performance of a function. The indices that result for each wetland function are not absolute; they are relative. They represent an assessment of performance relative to reference standard wetlands identified as having the highest level of performance possible within that wetland subclass.

The methods don't assess all wetlands, only the subclasses for which they are developed. When working with types of wetlands for which methods have not yet been developed, a user will have to apply a different assessment method. To maintain the integrity of the models, the models should <u>not</u> be modified in any way without a process involving regional Assessment Teams and public review.

The methods don't provide for direct quantitative comparison between subclasses. The level of performance is relative to wetlands in that subclass and region ONLY. An index of 8 for a function performed by depressional, freshwater, long-duration wetland is NOT comparable to an index of 8 for the same function performed by a depressional alkali wetland.

The methods don't provide a basis to compare the relative performance or habitat suitability across different functions. For example, an index of 2 for habitat suitability for amphibians is not comparable to an index of 2 for habitat suitability for invertebrates. Each model and their variables have been individually calibrated for that specific function. Also, the same variable may be used in multiple models, but is calibrated differently for each function. A large area of seasonally inundated area may result in a high performance index. for one function, whereas, the same condition would contribute to low performance index for another function.

The methods don't directly relate to protection of endangered species or cumulative effects. The methods were not designed to provide specific biological/habitat information on endangered species, or act as a substitute for an analysis of cumulative effects. Other methods or analytical tools specifically designed for addressing these issues should be used instead. For example, when a user needs to assess use of a wetland by a threatened and endangered species, it is advisable to use a method such as the Habitat Evaluation Procedure (HEP) that was developed by the US Fish and Wildlife Service (USFWS) (1981). The methods, however, may be of use for tracking impacts to specific functions, and thus may help provide additional information relating to threatened and endangered species, watershed planning, and cumulative effects.

The methods do not provide a single score or index for a wetland. Indices for functions cannot be combined to develop an overall score.

3. Applying the Methods

The following is a summary of the general guidance for applying the methods. A full description of the steps to follow when applying the methods, as well as detailed guidance on classifying and determining assessment units, are provided in Part 2 of this document. Part 2 also provides guidance for collecting background information, methods for collecting data in the field, and forms for recording data.

> ***These methods can be applied only when the ground in a wetland is not frozen or the surface is not covered with snow. Too many wetland characteristics in the Columbia Basin cannot be established during the winter.***

3.1 Steps in Applying the Methods

We recommend the following sequence be used when conducting assessments.

- Read and understand the methods, the models, and the procedures for collecting data.
- Collect information about the wetland area to be assessed, including aerial photographs and topographic maps.
- Review the information about the site and make some preliminary observations about size, shape, and wetland type.
- Visit the wetland and identify its approximate boundary.
- Determine the hydrogeomorphic type (e.g. class, subclass, family) of the potential assessment unit and develop a preliminary map of assessment units if several hydrogeomorphic types are present within one wetland.
- Determine the final assessment unit boundaries based on the hydrogeomorphic types identified above and the presence of other physical factors such as differences in water regime and physical barriers (roads, berms, dikes).
- Collect data, filling in the appropriate data sheet(s), and create maps and other graphic tools to display the location and/or extent of various characteristics.
- Calculate the indices of potential performance and habitat suitability. Use either the spreadsheets for the appropriate subclass or complete the calculations by hand using the calculation tables provided for each function in Chapters 6 through 8.
- Complete the summary sheet provided in Appendix 2 O.

- Fill out the summary form and prepare reports or other documentation as needed. Attach data forms, aerial photography, "photo" maps, sketches, and documentation of the rationale and logic for decisions made to complete the assessment

It is important to document the rationale for decisions made as a part of completing the assessment methods. This includes conclusions made regarding specific data needed to apply the methods. Decision-makers who have to interpret and apply the results must be able to understand how decisions were made about classification, assessment units, and the data.

3.2 Determining Wetland Classification

Determining the classification of the wetland being assessed is critical in choosing the appropriate method and data form to use. A preliminary determination can be made in the office using aerial photography and topographic maps; a final determination, however, must be made in the field.

Those who apply the methods must become familiar with the characteristics that distinguish the different wetland classes and subclasses. These are described in the profiles provided in Appendix 1-C (repeated in Appendix 2-E). In addition, you can use a dichotomous key of the characteristics that distinguish the wetland types. The key is included as a part of the field data forms in Part 2.

Other methods should be used to assess wetlands of hydrogeomorphic types for which Washington State methods have not yet been developed.

In some cases, due to seasonal conditions, field indicators may not provide a clear conclusion as to a wetland's classification. This may require that you use your "best professional judgement." If possible, however, we recommend that you re-visit the wetland during another season when other critical indicators might be present (e.g. aquatic bed species present, wetland drying out during the summer and fall months).

Some wetlands may encompass areas of more than one hydrogeomorphic type. In these cases, the extent of the hydrogeomorphic type should be identified and mapped, and each area assessed by collecting the appropriate data and using the appropriate method for that type.

3.3 Identifying Assessment Units

An assessment unit (AU) is the wetland area in which the level of performance of various functions is being assessed. A unit may be an entire wetland or part of a wetland. A wetland is divided into AUs if, as mentioned above, it contains different hydrogeomorphic types. For example, one continuous wetland could contain lacustrine fringe, depressional, and slope classes within its boundary. Each of the areas consisting of a distinct hydrogeomorphic type should be assessed separately.

A wetland may be broken into multiple AUs under other circumstances as well. For example, hydrologic differences such as changes in velocity of water flow within the wetland may warrant creating different AUs. Detailed guidance is provided in Part 2 and is not provided here. The following section describes situations in which a wetland should not be divided into AUs.

3.3.1 Assessment Units and Land Uses

Differences in land use within a wetland should not to be used to define AUs, unless they coincide with changes in water regime as described in Part 2. For example, if half a wetland is a scrub-shrub (e.g. willows, dogwood, quaking aspen) and emergent wetland (e.g. bulrush, burreed, cattail) and the other half is dominated by reed canary grass and pasture grasses because of grazing, the entire area functions as, and should be assessed as, one unit. For functions where the vegetation variables predominate, the performance indices will be based on a combination of conditions in the altered and unaltered portions.

3.3.2 Assessment Units and Property or Project Boundaries

Property boundaries or a project footprint should also not be used to define an AU unless they coincide with changes in water regime. For example, a project may propose to fill two acres of a 10-acre wetland. The entire 10-acre wetland should be assessed as one unit to determine the index of performance of the wetland. The index is a score per acre or hectare.

3.3.3 Assessment Units and Proposed Alterations

A wetland should not be divided into AUs by different proposed or actual alterations. For example, as long as the AU is one subclass and has no hydrologic breaks, the entire wetland is the AU even if it is proposed that one area is filled and another is ditched.

3.3.4 Dividing AUs Based on Existing Disturbance to Vegetation Communities

There may be circumstances where a wetland has no hydrologic breaks and is in one subclass, but there are areas that are dramatically different, especially in regard to disturbances in vegetation. An example is a wetland in which one part is a grazed pasture and the other is a complex mosaic of willow and aspen forest, dogwood and willow scrub shrub community and emergent community consisting of bulrush, cattails, and a variety of sedges.

A wetland should *not* be divided into sub-units for assessment based on different vegetation communities. The methods are not sensitive enough to allow a assessment of different parts of an AU based on existing disturbance to vegetation. Data collected during field-testing revealed that the methods do not produce reliable, or necessarily accurate, results when AUs are broken into sub-units.

3.3.5 Dividing AUs Based on Location of Mitigation Area

In some cases, a portion of an existing wetland may be enhanced/restored or an additional wetland area created which abuts the existing wetland. The mitigation-monitoring plan may require an assessment of wetland functions within the mitigation wetland area only in order to determine if there has been a gain in performance of wetland functions consistent with the goals and objectives set in the monitoring plan. It is not appropriate, however, to assess only the mitigation area with this method, because it is designed to assess the functions of the wetland as a whole. Any gain or decrease in the performance of function would be averaged over the entire area of the AU and not just the mitigation area.

4. *Using the Results of the Methods*

These methods will provide information about how well individual wetlands are likely to perform different functions. This information may be useful in a wide range of management applications. It is important, however, for anyone using the methods to understand what the results mean and what other information may be needed prior to making management decisions.

This section describes:

- Some ways in which the results can be used
- Other information to consider when making wetland management decisions
- A summary of what the results represent
- Tips for users

The index denotes the potential performance or habitat suitability based on the structural characteristics present in and around the AU. It does not denote the actual performance, for that requires detailed, long-term, monitoring. It is assumed that the AU will perform the function if the appropriate structural components are present, and if the opportunity is present.

4.1 Potential Uses for Regulatory or Non-regulatory Applications

The methods were developed primarily for site-specific applications. They may, however, also be used to assess a large group of wetlands for a variety of other purposes. Several of the most likely uses of the methods are described below.

Establishing baseline levels of performance. Knowing the level of performance of functions at a specific wetland is important in making management decisions about it. For example, information on the level of performance may be important when assessing the benefits of acquiring or preserving a wetland. It may also be useful to assess the current level of performance of a wetland to determine how much effort should be devoted to avoiding or minimizing impacts from a proposed project.

Comparing the same wetland at different points of time. Such comparisons will most commonly be used to evaluate a wetland before and after a proposed alteration to determine how a proposed project will change performance of functions. It may also be useful in determining the potential or actual benefits of various conservation activities such as restoration or enhancement. When evaluating the impacts of a proposed action, the user will need to first apply the methods to the existing wetland and then reapply the methods using the predicted characteristics of the wetland after the proposed action. The results of the two applications can be compared to predict the changes to each function that would result from the proposed action. However, the accuracy of the results will be only as good as one's ability to predict future conditions and provide "predictive" data for each of the questions.

Comparing different wetlands (same subclass) at the same point in time. A potential regulatory use may be to assess several wetlands in a given area to help determine where to locate a project so as to have the least impact on wetland functions. A non-regulatory application might be to assess the wetlands in a given area that are likely to provide the greatest flood control or aquatic bird habitat. This will help target the "best" wetlands for acquisition.

Establishing the adequacy or success of compensatory mitigation. The methods can be used to direct compensatory mitigation efforts by determining which functions will be affected by a proposed impact. A proposed compensation action can also be assessed to determine if it will replace the appropriate functions at an adequate level. The methods can be also used to compare alternative actions to determine which to choose. The methods can be used in conjunction with other monitoring procedures to assess the "success" of a compensatory action. Performance standards could include requirements that a certain level of performance of a function or group of functions be met. As a compensatory wetland "matures", the methods can assess increases in function over time. The latter application may be particularly useful in mitigation banking.

Using the methods for watershed-level applications. The methods were designed to assess individual wetlands, not entire watersheds, and are therefore generally too time-intensive to use for broad-scale watershed planning. They may, however, be useful if an intensive approach is warranted, particularly for small watersheds or sub-basins. In these situations, the methods can identify wetland functions that are deficient or are being lost in a watershed, develop restoration priorities, and help make decisions about where to locate future development.

Using the methods for assessing cumulative impacts. An assessment of cumulative effects to a specific wetland, as a result of internal changes in the wetland or external changes in the watershed, can best be determined if the wetland is assessed periodically over time. Predicting level of performance before and after alterations due to watershed change is dependent on the degree of accuracy of those predictions. It is difficult to predict with certainty changes to the landscape and their effects on a wetland.

Setting credits and debits for mitigation banks. . In the future, the scores generated by the assessment methods may be useful in establishing an accounting system for mitigation banks. At present, however, the lack of methods for many wetland classes prevents the use of these methods for mitigation banking.

4.2 Making Management Decisions Using the Results

Results of a function assessment will provide one important piece of information to use in managing or regulating a wetland. A decision-maker, however, will not only have to understand how to interpret the results, but also, how to incorporate other important information such as "values," to make sound wetland management decisions.

4.2.1 Interpreting the Results

The results will include two basic types of information: 1) a numerical index of the potential level of performance (water quality and quantity functions) or habitat suitability (habitat functions); and 2) a numerical index or subjective rating of the opportunity for a function to be performed.

The indices are a numerical representation of a qualitative assessment. An index score of 8 for a function does not mean that it provides "twice as much" of a function as an index score of 4 for the same function in a similar wetland. It means that a wetland that scores 8 has the potential to perform the function at a level that is almost equal to the best performing wetlands in the region. An index of 4 means it is performing at a level that is approximately halfway between the highest and the lowest performers.

In addition to understanding the potential of a wetland to perform a function, it is often important to consider the opportunity for that wetland to provide certain functions. For example, a wetland may have all the components needed to provide a high level of removal of nutrients and would therefore receive a high performance index. However, if the water moving through the wetland does not carry excessive nutrients, the wetland has no opportunity to remove them.

For these methods, an assessment of opportunity is based on simple quantitative models using variables that rely on landscape indicators. Opportunity is not modeled for the Aquatic Bird, and Reducing Downstream Erosion models because they could not be adequately calibrated. Instead, the assessment of opportunity relies on a qualitative description provided by the person using the methods. Opportunity is not assessed for the Groundwater Recharge models because opportunity is judged to be the same for all wetlands.

4.2.2 Incorporating Other Information in Making Decisions

Assessment results should **never** be used alone to make management decisions about wetlands. There are several other types of information to consider prior to making a wetland management decision. These include, but are not limited to information on:

- whether the wetland provides important "social functions" such as recreational or educational opportunities or aesthetic values;

- whether the wetland provides habitat for endangered or threatened plant or animal species;
- whether the wetland is a rare or irreplaceable type such as a sphagnum bog or mature, forested system;
- whether there is potential for adaptive management;
- whether modifications to the contributing basin will effect the water regime of the wetland (the methods do not assess this); and
- whether the wetland is located in a natural hazard area such as a floodplain or steep slope.

There are methods available that take some of these other factors into consideration, and they should be used in conjunction with these methods. The Washington State Wetland Rating System (WDOE 1993) is one method that is used in Washington to characterize some of the other aspects of wetland for management ore regulatory purposes.

4.2.3 Incorporating Values in Wetland Management Decisions

These methods do not assess the importance of any function. They simply provide information about different functions that might be "valued" by a regulatory program or the decision-maker. The "value" of a function(s) has to be established by the decision-maker using a method or process separate from these assessment methods. In most regulatory processes the applicable law or policy spells out which factors are most important in making a particular management decision. For example, the presence of an endangered species in a wetland is usually a critical piece of information that dictates a certain management decision, irrespective of other factors. Some regulatory programs place greater weight on certain functions such as flood reduction or fish habitat. Others may specify whether certain wetland types, such as sphagnum bogs, may be altered or not. Most regulatory programs have certain standards that will dictate some decisions. In many cases, however, a regulatory program will leave some decisions up to individual discretion in order to make appropriate, site-specific decisions.

It is possible to develop a specific "values overlay" based on values identified as "important" to a community or agency that can be used in conjunction with the assessment of performance. This has been done with a similar assessment method in several geographic areas of Washington, including the Mill Creek watershed in King County and the lower Snohomish River area in Everett. In these cases, a specific multiplier was developed for each function, thus allowing some functions to be valued higher than others were. Committees of different interest groups and community members developed these multipliers. These value overlays were of considerable aid to the local decision-makers in developing land use/management plans for these watersheds.

4.3 Tips for Using Results

The following are some pointers for decision-makers when reviewing results of the assessment methods.

- Make sure that any reports providing results include all of the data and documents used, including data sheets and maps. This provides an opportunity to confirm the results.

- Confirm that the appropriate method for the hydrogeomorphic type present was used. If the wrong hydrogeomorphic method is used (e.g. depressional freshwater long-duration method used on a depressional alkali wetland), the results are inaccurate.

- Be sure that all functions performed by that subclass were assessed. It is important to know the level of performance or habitat suitability for all functions to guard against management decisions that would lead unknowingly to maximizing one function at the expense of others.

- Pay close attention to the rationale for dividing a wetland based on its hydrogeomorphic type and physical breaks present. How an AU is divided can have a significant effect on assessed performance of functions. This is one place where the methods can be manipulated to produce desired results.

A comparison of performance of functions before and after alteration is only as accurate as the predictions of how the wetland characteristics will be changed by the alteration. Therefore, if the alteration involves wetland mitigation, develop relatively precise mitigation plans in order to assure reasonably accurate assessment of anticipated future performance of wetland functions at the mitigation site.

It is not possible to compare the score for a function in a wetland of one hydrogeomorphic type with the score for the same function in a wetland of a hydrogeomorphic type. An index of "7" for General Habitat Suitability in a depressional long-duration wetland is not necessarily equivalent to an index "7" for the same function in either a short-duration or alkali depressional wetland. Any comparisons made between hydrogeomorphic types and their functions must be based on a subjective judgement that includes a reasonable scientific rationale supporting such comparisons.

A "low" index (e.g. index of 1, 2, or 3) for a function does not necessarily mean the wetland is "unimportant." It may be the only wetland in the area providing that function, or the function may be critical in an area. For example, you may decide that an index of 2 for Reducing Peak Flows is "important" if you know that areas downstream of the wetland are prone to flooding. This would require application of the "value overlay" discussed above in section 4.2.3.

5. Introduction to the Functions Being Assessed

5.1 Explanation of Functions

Functions have been defined as the physical, chemical, and biological processes or attributes that contribute to the functioning of wetland ecosystems, or, in other words, they are the things that wetlands do (Smith et al. 1995). Some of these processes have an importance to society because they have an economic value, improve human safety, or have aesthetic value. For example, the storage of water in wetlands is a physical process that is important to society because it reduces the impacts of flooding further downstream.

Wetland processes, however, occur at all scales, from the microscopic (e.g. bacterial decomposition of organic matter) to continental (e.g. providing refuge and feeding for migrating waterfowl along the continental flyways). The functions defined in assessment methods usually are defined as a group of environmental processes that are related and are on a similar temporal and spatial scale.

If each environmental process were called out as a separate function, the number of functions would be almost infinite. For example, the decomposition of organic matter by bacteria is a combination of many processes; one for each individual species of bacteria found in the wetland. Each bacterial species decomposes organic matter at a different rate and under different environmental conditions, and each of these could be considered a separate wetland function.

On the other hand, the "removal of imported elements and compounds" is a function identified in the HGM Riverine Guidebook (Brinson, et al. 1995) that represents many different processes. It includes the removal of imported nutrients, contaminants, and other elements and compounds. The function, as defined, combines several hundred different environmental processes. The removal of each nutrient or compound represents a different environmental process, and there are at least a dozen nutrients and several hundred known contaminants that can be found in surface waters.

One of the initial tasks in developing methods, therefore, is to identify and group the range of environmental processes found in wetlands for which assessments will be developed into some manageable number of "functions." Draft lists of functions were developed by the Statewide and Eastern Washington Technical Committees. This list was then modified by the assessment team for the Columbia Basin and confirmed by the Eastern Washington Technical Committee.

The choice of functions was based on the following considerations:

- Functions should be easily understood by decision-makers and the public.

- Functions are closely linked to the "beneficial uses" that are regulated.

- Functions are defined as narrowly as possible.

The choice of functions is important because they apply the best current science to complex resource management needs, while demonstrating how wetland processes are beneficial to the public. For example, the functions selected in Washington are relatively narrowly defined to provide a level of specificity that is important to decision-makers. Specific information is important when making management and regulatory decisions about wetlands. Habitat functions were included for some of the main animal groups instead of a general function such as "maintaining the distribution and diversity of vertebrates," as is suggested in the HGM Riverine Guidebook (Brinson, et al, 1995). For example, the team kept waders, waterfowl, and wetland-dependent passerines in mind when identifying the appropriate variables to assess aquatic bird habitat.

This level of detail will be adequate for most general applications. Other methods, however, such as Habitat Evaluation Procedure (HEP) should be used when more detailed information is required about specific species.

The assessment team modeled each function as one or more processes that were correlated with specific wetland characteristics. The team limited model development to those characteristics that best represent the performance of the function and that could be modeled in a rapid assessment. Processes weren't modeled individually for the habitat functions. Instead, the team members identified variables that jointly assess breeding, feeding, and refuge.

5.2 List of Functions Used in the Methods

5.2.1 Summary of Functions

The functions for which assessment models were developed, and their descriptions, are provided below. Other functions that were considered and the logic behind the choices made will be presented in the approach document previously mentioned.

Functions Related to Water Quality Improvement

- Removing Sediment

- Removing Nutrients/Phosphorus

- Removing Nutrients/Nitrogen

- Removing Heavy Metals and Toxic Organics

Functions Related to Hydrology (Water Quantity)

- Decreasing Downstream Erosion and Flooding

- Recharging Groundwater

Functions Related to Habitat

- General Habitat
- Habitat for Invertebrates
- Habitat for Amphibians
- Habitat for Aquatic Birds
- Habitat for Aquatic Mammals
- Richness of Native Plants
- Supporting Local Food Webs

A function for "Fish Habitat" was not included because the Assessment Team determined that fish do not occur naturally in Columbia Basin depressional systems and are present only as an "introduced" species for recreational purposes. A separate model that deals with "values" and not performance of a habitat function in a natural system should address this type of recreational function. The presence of fish are modeled as a "reducer" for the invertebrate, amphibian and bird functions because they reduce the performance of each of these functions.

5.2.2 Descriptions of Functions

Removing Sediment is defined as the wetland processes that retain sediment within a wetland, and prevent its downstream movement.

A wetland performs this function if there is a net annual decrease of sediment load to downstream surface waters in the watershed. Settling and filtration are the major processes by which sediment is removed from surface water (either streamflow or sheetflow) in wetlands. Particles present in the water will tend to settle out when water velocity and turbulence reduced (Mitsch and Gosselink, 1993). The size of the particles that settle out is directly related to the increase in settling time achieved in the wetland. Filtration is the physical adhesion and cohesion of sediment facilitated by vegetation.

Removing Nutrients/Phosphorus is defined as the wetland processes that remove phosphorus present in surface waters, and prevent its movement into surface waters and groundwater.

A wetland performs this function if there is a net annual decrease in the amount phosphorus going to down-gradient waters (either surface or groundwater) in the watershed.   The major processes by which depressional wetlands reduce phosphorus are: 1) through the trapping of sediment on which phosphorus is adsorbed, and 2) removal of dissolved phosphorus by adsorption to soils that are high in clay content or organic matter (Mitsch and Gosselink 1993).

A model for this function was not developed for depressional alkali wetlands in the Basin because we have little knowledge of the phosphorus adsorption and solubility process at the high pH and high conductivity present in these systems.

Plant uptake of nutrients is not modeled because nutrients taken up will be released again after a plant dies. Plant uptake changes the timing of potential nutrient release from a wetland, but it does not significantly change the net balance of nutrients coming in and going out of, a wetland (Phipps and Crumpton 1994, Mitsch et al. 1995).

Removing Nutrients/Nitrogen is defined as the wetland processes that remove dissolved nitrogen present in surface waters, and prevent its movement into surface waters or groundwater.

A wetland performs this function if there is a net annual decrease in the amount of nitrogen going to down-gradient waters (either surface or groundwater) in the watershed.   The major processes by which wetlands remove nitrogen are through the nitrification and denitrification in alternating oxic and anoxic conditions (Mitsch and Gosselink 1993).

A model for this function was not developed for depressional alkali wetlands in the Basin because we have little knowledge of the denitrification/nitrification process at the high pH and high conductivity present in these systems.

Removing Metals and Toxic Organic Compounds is defined as the wetland processes that retain toxic metals and toxic organic compounds coming into the wetland, and prevent their movement into surface waters and groundwater.

A wetland performs this function if there is a net annual decrease in the amount of toxic metals and toxic organics entering down-gradient waters (either surface or groundwater) in the watershed. The major processes by which wetlands reduce the amount of toxic materials going to down-gradient waters are through sedimentation of particulate metals, adsorption, chemical precipitation, and plant uptake. Metals that tend to have a high particulate fraction, such as lead (Pb), may be removed through sedimentation. Adsorption is promoted by soils high in clay content or organic matter. Chemical precipitation is promoted by wetland areas that are inundated and remain aerobic, as well as those with pH values below 5 (Mengel and Kirkby 1982). Finally, plant uptake is maximized when there is significant wetland coverage by emergent plants (Kulzer 1990).

A model for this function was not developed for depressional alkali wetlands in the Basin because we have little knowledge of the adsorption and solubility of toxic compounds at the high pH and high conductivity present in these systems.

Reducing Downstream Erosion and Flooding is defined as the wetland attributes that attenuate high flows and their erosive capacity.

Wetlands reduce downstream erosion and flooding by storing water, thus reducing the velocity and volume of water flowing downstream. The wetland retains runoff water and reduces downstream flows during storms (water has a higher retention time in the wetland than in the stream). The amount of retention provided is dependent on the available storage and the release rate of runoff.

Overland runoff in the Columbia Basin tends to be more rapid than in western Washington because of the limited vegetative cover in many areas. Features in the landscape, such as wetlands, play an important role in detaining and slowing runoff during snowmelt.

Recharging Groundwater is defined as the wetland structures and processes that allow surface water to infiltrate into the groundwater system.

The potential for recharge in a wetland of the Columbia Basin occurs when wetlands holds back precipitation and surface flows in inundated areas. This inundated water then infiltrates into the groundwater system because of the "head" or pressure created by the depth of water on the surface. If the "hydraulic head" created by upslope groundwater is greater than the "hydraulic head" created by the ponded water, recharge will not occur. In the areas of low precipitation very little recharge will occur because surface runoff is usually too slight to create much of a "head." Thus, wetlands that have developed because of high groundwater levels from irrigation will generally not be points of recharge. Any surface water present in these wetlands does not truly represent a "head" or pressure that forces this water into the groundwater system but is instead equivalent to upgradient groundwater that discharges into a wetland. For this reason, the index of function is reduced for any wetland whose water level is controlled by an adjacent irrigation project or reservoir.

General Habitat is defined as the characteristics or processes present in a wetland that indicate a general suitability and opportunity as habitat for a broad range of species. A suitable habitat for a suite of different fauna can be provided by a broad range of structures, vegetation, and interspersion of "habitat" types within the wetland and the upland habitats contiguous to a wetland. Characteristics in a wetland can be quite different and continue to provide highly suitable conditions for a range of species.

The General Habitat function is not intended to be a duplicate assessment of the individual functions for each animal group. Rather, it focuses on capturing those elements of the overall wetland ecosystem that would provide for a wide or diverse variety of habitats. This function models the suitability and opportunity of a wetland as habitat for terrestrial bird species, non-aquatic mammals and reptiles, not as habitat for individual wetland animal groups (e.g. wetland-dependent birds, aquatic mammals, invertebrates etc.).

Habitat for Invertebrates is defined as the characteristics that help maintain a high number of invertebrate species in the wetland.

For the purposes of this model, invertebrates are narrowly defined as "macroinvertebrates" or free-living organisms readily seen with the naked eye (≥500μm) including among others, Insecta (insects), Amphipoda (scuds, sideswimmers), Eubranchiopoda (fairy, tadpole, and clam shrimps), Decapoda (crayfishes, shrimps), Gastropoda (snails, limpets), Pelecypoda (clams, mussels), Hydracarina (water mites), Arachnida (spiders), Annelida (worms and leeches), Platyhelminthes (flatworms), and Ostracoda (seed shrimp).

The intent of the assessment is to highlight those wetlands that provide a habitat for the greatest number of invertebrate species within the regional subclass. As such, almost any wetland will provide a habitat for some invertebrates. There is a distinct difference, however, between a wetland that has a high abundance of one or two species and one that has a high richness of different species. The important aspect of invertebrate populations that is being assessed with this model is species richness. Wetlands with a high richness tend to be more important in maintaining the regional biodiversity of invertebrate populations and provide a genetic source and genetic refuge that helps to maintain ecosystem integrity.

Habitat for Amphibians is defined as the wetland processes and the characteristics that contribute to the feeding, breeding, or refuge needs of amphibian species using wetlands of the regional subclass.

Amphibians are a vertebrate group that, in the Pacific Northwest, include wetland-breeding frogs (Order: Anura) and salamanders (Order: Caudata). Both their richness and abundance in wetlands indicate that they are important in wetland trophic organization. Some native species only breed for a short time in wetlands and as metamorphosed juveniles and adults live in uplands. Other species may be found in or close to wetlands throughout the year. However, the eggs and larvae of all wetland-breeding species require water for development.

The model for depressional alkali wetlands is focused on the habitat needs of the Tiger Salamander (*Abystoma tigrinum*) because it was the only amphibian found in these systems by the Assessment Team.

Habitat for Aquatic Birds is defined as the environmental characteristics in a wetland that provide suitable habitat or life resources for species of aquatic birds. Aquatic bird species are those that depend on different aspects of the aquatic ecosystem for some portion of their life needs: food, shelter, breeding, molting, or resting. The primary groups of aquatic birds considered for building the assessment model included waterfowl, shorebirds and herons.

In general, the suitability of a wetland as bird habitat increases as the number of appropriate habitat characteristics increase. It was assumed that wetlands with habitat for the greater number of aquatic-dependent bird groups are more suitable than those that have fewer. The assessment models are focused on species richness, **not** on the importance of a wetland to a specific threatened or endangered species or to a specific regionally important group of birds.

Habitat for Aquatic Mammals is defined as the capacity of the wetland to provide habitat requirements for two aquatic or semi-aquatic mammals. Habitat requirements were modeled for beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*).

The two species used in this model were selected due to their dependence on wetland habitat (Hammerson 1994), their economic importance, as well as their influence on the wetland systems (Johnston and Naiman 1987, Garbisch 1994). A model for all mammal species living in the Columbia Basin would be cumbersome and ineffective, due to the variations in habitat requirements, lack of information on many species, and the greater need to look at larger areas of the landscape. The focus of the assessment is on the wetland and associated buffer area, and in most cases does not consider surrounding landscape. This model reflects suitability in terms of species richness and assumes that wetlands providing habitat for both species have a higher level of performance of the function than those providing habitat for only one species. The model does not address species abundance.

The Richness of Native Plants is defined as the degree to which the wetland provides a habitat for many different native plant species.

Wetlands currently dominated by native plant species tend to be more capable of maintaining native plants than those wetlands dominated by non-native species. A high number of native plant species in a wetland enhances the potential for colonization to other perhaps recently disturbed wetland areas. Additionally, native plant associations more often harbor rare plant species than non-native associations.

*The assumption is valid only if the AU has **not** been recently cleared. If the AU has been recently cleared and the plants have not yet been re-established, the index from the model will not provide an accurate assessment of the function.*

Supporting Food Webs is defined as wetland processes and characteristics that support complex food webs within the wetland and surrounding ecosystems. The function combines three major ecosystem processes - primary production, secondary production, and export of production.

Wetlands are known for their high primary production, and the subsequent cycling of organic matter within the system and to adjacent ecosystems (Mitch and Gosselink, 1993). The Assessment Team has determined that Columbia Basin depressional ecosystems generally do not export their production through surface waters leaving the wetland. Much of the primary and secondary production is exported by way of mammals, birds, amphibians, reptiles, and predatory insects that feed in the wetland and then move out of it. Export also takes place when some of the aquatic insects emerge as adults and fly away from the wetland.

Wetlands in the Columbia Basin play a critical role in maintaining the structure and stability of the terrestrial animal communities around them by supporting terrestrial food webs. Their high primary productivity and the complexity of the species associations that feed on this production provide a stable food source for many terrestrial animals that would otherwise not survive in the arid environment of the Basin.

The model assesses food web support by the amount of photosynthesis that occurs in the wetland and by the richness of secondary producers. Wetlands that have high floral and faunal richness are generally more stable and able to withstand perturbations. They provide a more stable exportable resource for the surrounding ecosystems.

A model for depressional alkali wetlands was not developed for this function because all wetlands in this subclass were judged to perform this function at about the same level. The structurally simple alkali systems found at the very high range of pH and conductivity are known to be very productive. These wetlands have a relatively low species richness and simple vegetation. They do, however, have very high abundance of a few invertebrates that is supported primarily by high phytoplankton production.

6. Method for Assessing Depressional, Fresh Water, Long-duration, Wetlands

The method includes models for the following functions:

Removing Sediment

Removing Nutrients/Phosphorus

Removing Nutrients/Nitrogen

Removing Heavy Metals and Toxic Organics

Decreasing Downstream Erosion and Flooding

Recharging Groundwater

General Habitat

Habitat for Invertebrates

Habitat for Amphibians

Habitat for Aquatic Birds

Habitat for Aquatic Mammals

Richness of Native Plants

Supporting Local Food Webs

6.1 Removing Sediment— Depressional Long-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.1.1 Definition and Description of Function

Removing sediment is defined as the wetland processes that retain sediment in a wetland, and prevent its movement downstream.

A wetland performs this function if there is a net annual decrease of sediment load to downstream surface waters in the watershed. Settling and filtration are the major processes by which sediment is removed from surface water (either streamflow or sheetflow) in wetlands. Particles present in the water will tend to settle out when water velocity and turbulence reduced (Mitsch and Gosselink, 1993). The size of the particles that settle out is directly related to the increase in settling time achieved in the wetland. Filtration is the physical adhesion and cohesion of sediment facilitated by vegetation.

6.1.2 Assessing this Function for Depressional Long-duration Wetlands

The potential of depressional long-duration wetlands to remove sediment is a function of their ability to reduce water velocities and by vegetation structure near the ground surface that act as a filter (Adamus et al. 1991). Velocity reduction cannot be estimated directly in a rapid assessment method. The amount of storage (Adamus et al. 1991) is used as a variable that captures one aspect of velocity reduction – volume of water stored. The potential for filtration is modeled by amount of the AU that is covered by erect vegetation (emergent, scrub/shrub, and forest).

If, however, the AU has no outlet it has the potential to remove sediment at the highest levels. It will be scored a [10] regardless of other characteristics. All sediments coming into the AU are retained and not released to surface waters. Therefore, the AU is performing at its maximum potential.

Depressional wetlands in the Basin that have outlets, however, also remove sediments fairly effectively. The outlets found in the reference sites all have been small, narrow, and generally filled with vegetation. None of the reference AUs with an outlet were judged to remove sediments poorly. The assessment team, therefore, decided it was not appropriate to score any wetland as a zero since that might imply there is not sediment removal. All reference sites were judged to score at least a [7] out of [10]. The model is scaled so no AU will score less than a [7].

The opportunity that an AU has to remove sediment is a function of the level of disturbance in the landscape. Relatively undisturbed watersheds will carry much lower sediment loads than those that have been impacted by human activities (Hartmann et al. 1996, Reinelt and Horner 1995). The opportunity that an AU has to remove sediment, therefore, is linked to the amount of development, logging or agriculture present in the upgradient part of its contributing basin. Conditions in the buffer around an AU are also important in determining whether sediments can reach it. Buffers with intact natural vegetation will trap sediments coming from the surrounding landscape before they reach the AU. The slope of the contributing watershed also plays a role. Watersheds with steep gradients tend to have higher water velocities and more sediment transport.

6.1.3 Model at a Glance

Depressional Long-duration **Removing Sediment**

Process	Variables	Measures or Indicators
POTENTIAL		
Sediments leaving	**Vout**	Presence/absence of outlet
Velocity reduction	**Vstorage**	Elevation difference between bottom of extended inundation water level and flood marks
	Voutletw/inund	Ratio of area of outlet width to area of inundation
Filtration	**Vvegcover**	% of wetland that is vegetated
OPPORTUNITY		
Buffer interception	**Vbuffcond**	Descriptive characterization of condition of buffer
	Vbufferbypass	Presence of ditch/drain that routes surface flow around buffer
Upgradient sediment sources	**Vupsedim**	Upgradient sources of sediment within 1km
	Vslope	Degree of slope in contributing basin
Numerator for Potential If surface outlet present	Vout + Vstorage + Voutletw/inund + Vvegcover	
Numerator for Opportunity	Vbuffcond+Vbufferbypass+Vupsedim+Vslope	

6.1.4 Description and Scaling of Variables

Variables for Potential

V_{out} - Presence/absence of outlet

Rationale: All sediments coming into the wetland are retained and not released to surface waters downgradient if the AU has no outlet.

Indicators: No indicators are needed. The presence/absence of an outlet is determined in the field.

Scaling: Wetlands with no outlet have the potential to remove sediment at the highest levels and are scored a [10] for the function. AUs with an outlet are scored a [7] at a minimum, with a higher score possible based on the amount of storage and vegetation present.

$V_{storage}$ - The volume of water stored in a wetland annually. It is assessed as the average depth of annual inundation (high water level) over the AU because the variable is scaled on a per acre basis.

Rationale: Vstorage is a measure of the volume of storage available. It is related to velocity reduction because flows into the wetland will be slowed as it is filled. Wetlands that store water tend to trap more sediment than those that do not (Fennessey et al. 1994).

Indicators: The variable for storage is assessed as the difference in elevation between the surface of the extended inundation and any flood marks or water marks in the wetland or along the shore. To estimate the average depth of storage in the wetland the maximum depth of storage is corrected by a factor representing the average cross section of the inundated areas in the wetland. The calculation provides an average depth of storage across the area that is inundated every year.

Scaling: AUs with 3.5 meters or more of average seasonal storage are scored a [1]. Those with less are scaled proportionally downwards as storage (meters)/3.5.

$V_{outletw/inund}$– The ratio of the outlet width to the area of inundation.

Rationale: The ratio of the outlet width to the area of brief inundation is a predictor of the degree of downstream erosion. The lower the value of the ratio the more slowly a wetland releases water thereby reducing downstream velocities and potential for erosion.

Indicators: The width of the outlet can be directly measured. The area of brief inundation will be mapped, based on field indicators of high water marks on rocks and vegetation. This variable is treated as a dimensionless number based on areal measurements in hectares and the width measurement in meters.

Scaling: AUs with a ratio <= to 1 will score a [1] for this variable. Those with a higher ratio are scaled proportionally (1/ratio).

V$_{\mathbf{vegcover}}$ - Percent area of wetland that is covered by vegetation.

Rationale: Plants enhance sedimentation by providing a medium that acts like a filter, and causes sediment particles to drop to the wetland surface. In the Columbia Basin it is assumed that vegetation need not be erect and persistent to trap sediment. The assessment team judged that aquatic bed vegetation will trap sediments as well as erect herbaceous plants, trees, and shrubs because of the low water velocities usually associated with depressional wetlands in this region.

Indicators: No indicators are needed. The areal extent of the vegetation can be estimated directly at the wetland site.

Scaling: AUs with 100% vegetation cover score a [1] for this variable. Those with less are scored proportionally (% cover/100).

Variables for Opportunity

V$_{\mathbf{buffcond}}$ - Condition of area within 100m of the edge of the wetland, as rated by extent of undisturbed areas.

Rationale: Conditions in the buffer around a wetland are also important in determining whether sediments can reach it. Buffers with intact natural vegetation will trap sediments coming from the surrounding landscape before they reach the wetland (review in Desbonnet, et al. 1994). Undisturbed, vegetated buffers reduce the opportunity an AU has to receive sediments.

Indicators: This variable is assessed using the buffer categorization described in Part II. The categorization is sequential. An AU is categorized by the highest criterion it meets.

Scaling: AUs with a buffer category of 0 is scaled a [1]. Those with a category of 5 are scaled a [0]. Categories of 1-4 are scaled proportionally between 0.8 – 0.2.

V$_{\mathbf{bufferbypass}}$ – Ditches or drains that route surface waters around the buffer and directly into the wetland.

Rationale: Ditches or drains that route surface waters around the buffer and directly into the AU reduce the sediment trapping processes in the buffer. As a result, more sediment is delivered to the AU. This increases the opportunity that an AU has to trap sediments.

Indicators: None needed. Direct observation of ditches/drains that would capture surface runoff and route it around the buffer directly into the wetland.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there is a channel bypassing the buffer, and a [0] if there is no channel.

$V_{upsedim}$ - Conditions and land uses in the upgradient basin or watershed that add sediment to surface waters flowing into the wetland.

Rationale: Densely vegetated watersheds (e.g. undisturbed forest) stabilize soils, reduce runoff velocity, and thus export less sediment (Bormann et al. 1974, Chang et. al. 1983). In contrast, residential, urban, or agricultural, watersheds have more exposed soils and thus higher sediment loading. Wetlands with upgradient disturbances in the nearby contributing basin will have a greater opportunity to remove sediment and improve water quality than those in undisturbed watersheds.

Indicators: The indicators for upgradient sediment loading are the presence of land uses that generate sediments such as tilled fields, pasture, urban, commercial, and residential areas. Only the areas that are within 1km of the AU and within the contributing basin are considered.

Scaling: AUs with land uses that increase sediment loads within 1km of the AU are scored a [1] for this variable. AUs with no such lands uses are scored a [0].

V_{slope} - The average percent slope of the stream channels within the contributing basin of the wetland.

Rationale: Contributing basins with steeper gradients (% slope) will transport sediment more readily downslope to a wetland than contributing basins with relatively shallow gradients.

Indicators: None needed. Measured directly with clinometer or from USGS maps using contour intervals.

Scaling: AUs whose contributing basins have a slope of 5% or more are scaled a [1] for this variable. Those with a slope of 1=5% are scored a [0.5] and those with a slope of <1% are scored a [0] variable.

6.1.5 Calculation of Potential Performance

Depressional Long-duration **Removing Sediment**

Variable	Description of Scaling		Score for Variable	Results
Vout	*Highest:*	If AU has no outlet	**IF D9 = 0**	
			Enter 10 in "Final Result"	
		If AU has an outlet	Do calculations below	
Vstorage	*Highest:*	Average depth of annual storage >= 3.5m	If calculation >= 1 Enter '1'	
	Lowest:	No annual storage	If calculation=0 enter "0"	
	Calculation:	Scaling is set as average depth/3.5	Enter result of calculation if< 1	
	Calculate D9 x [(D14.1 x 0.67) + (D14.2 x 0.5) + (D14.2 x 1)] / 3.5			
Voutletw/inund	*Highest:*	Ratio <= 1.0	If calculation >=1.0 enter "1"	
	Lowest::	Ratio > 20	If calculation < 0.05 enter '0"	
	Calculation:	Scaling is set as 1/ratio if ratio>1	Enter result of calculation if < 1.0	
	Calculate 1/[D15/(D1 x D10.1 x 0.01)] IF D15 = 0 enter a [1] for result			
Vvegcover	*Highest:*	AU is100% vegetated	If calculation =1, enter "1"	
	Lowest:	AU has minimal vegetation cover	If calculation =<0.05, enter "0"	
	Calculation:	Scaling is set as % vegetated/100	Enter result of calculation if <1	
	Calculate [sum (D16.1 to D16.4)] /100 to get result			
			Total of Variable Scores:	
Index for Removing Sediment (Potential) = (7 + (Total of Variables x 0.72)) rounded to nearest 1				
			FINAL RESULT:	

6.1.6 Calculation of Opportunity

Depressional Long-duration **Removing Sediment**

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 0	If D39 = 0, enter "1"	
	High:	Buffer category of 1	If D39 = 1, enter "0.8"	
	Moderate:	Buffer category of 2	If D39 = 2, enter "0.6"	
	Medium Low:	Buffer category of 3	If D39 = 3, enter "0.4"	
	Low:	Buffer category of 4	If D39 = 4, enter "0.2"	
	Lowest:	Buffer category of 5	If D39 = 5, enter "0"	
Vbufferbypass	*Highest:*	AU has surface water bypass through buffer	If D40 = 1 Enter "1"	
	Lowest:	No surface water bypass	IF D40 = 0 Enter "0"	
Vupsedim	*Highest:*	Human land uses present within 1km	If calculation >=1enter '1'	
	Lowest:	No human land uses in basin	If calculation = 0 enter "0"	
	Calculate D7.9+D7.10+D7.11+D7.12			
Vslope	*Highest:*	Slope in contributing basin >=5%	If D2.1=2, enter "1"	
	Medium	Slope in basin <0.05%	If D2.1=1, enter "0.5"	
	Lowest:	Scaling is set as slope/5	If D2.1=2, enter "0"	
			Total of Variable Scores:	
Index for Removing Sediment (Opportunity) = Total x 2.8 rounded to nearest 1				
			FINAL RESULT:	

6.2 Removing Nutrients/Nitrogen — Depressional Long-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.2.1 Definition and Description of Function

Removing Nutrients/Nitrogen is defined as the wetland processes that remove dissolved nitrogen compounds present in surface waters or groundwater, and prevent the downgradient movement of the nutrient.

A wetland performs this function if there is a net annual decrease in the amount of nitrogen in down-gradient waters (either surface or groundwater) within the watershed. The major process by which wetlands remove nitrogen are through bacterial transformations of nitrogen (nitrification and denitrification) (Mitsch and Gosselink 1993).

In depressional wetlands of the Basin some of the nitrogen removal will also occur through the transformation of inorganic nitrogen to organic nitrogen.

6.2.2 Assessing this Function for Depressional Long-duration Wetlands

The potential of wetlands to remove nitrogen is modeled by assessing the area of the wetland that undergoes a seasonal oxic/anoxic cycling. Seasonal redox potentials that reflect this cycling, however, cannot be measured in a wetland during a rapid assessment. The indicator used is the percent of the wetland that is seasonally inundated. It is assumed that areas inundated for longer periods (extended inundation and perennial) are mostly anoxic and do not receive enough oxygen to stimulate the nitrification process significantly.

In the Columbia Basin it is often difficult to determine whether the period of inundation is long enough to cause denitrification. The area of decomposed organic matter near the surface (Vorg) in areas that are seasonally inundated is also used as a surrogate to indicate areas of the wetland that might undergo the necessary cycling of oxic and anoxic conditions. Organic soils near the surface indicate that a wetland has long periods of anoxic conditions near the surface.

The opportunity that a wetland has to remove nitrogen is a function of the level of human generated nitrogen in the contributing basin and the routing of that nutrient to the AU. Relatively undisturbed watersheds will carry much lower nitrogen loads than those that have been impacted by human activities (Hartmann et al. 1996, Reinelt and Horner 1995). The opportunity that a wetland has to remove nitrogen, therefore, is linked to the amount of agriculture and grazing present in the upgradient part of its contributing basin, and whether it is impacted by waters from the Reclamation Project.

6.2.3 Model at a Glance

Depressional Long-duration **Removing Nutrients/Nitrogen**

Process	Variables	Measures or Indicators
POTENTIAL		
Denitrification/	**Veffectarea2**	% Area of seasonal inundation
Nitrification	**Vorg**	% area of organic soils in wetland
Plant uptake	**Vpermveg**	% Area of permanent erect vegetation
OPPORTUNITY		
Upgradient nutrient sources	**Vbuffcond**	Descriptive characterization of condition of buffer
	Vproject	Wetland within the Reclamation Project Area (weighted by a factor of 2)
	Vupnut	Upgradient tilled field (irrigated agriculture), pasture or residential areas
Numerator for Potential	Veffectarea2 + Vorg + Vpermveg	
Numerator for Opportunity	Vbuffcond +2xVproject+ Vupnut	

6.2.4 Description and Scaling of Variables

Variables for Potential

V$_{effectarea2}$ - Percent of the AU that undergoes changes between oxic and anoxic conditions. It is assessed as the total area of seasonal inundation minus the area of extended inundation.

> **Rationale:** Nitrogen transformation occurs in areas of the wetland that undergo changes between oxic and anoxic regimes. The oxic regime is needed to change ammonium ions (NH_4^+) to nitrate, and the anoxic regime is needed for denitrification by bacteria (changing nitrate to nitrogen gas) (Mitsch and Gosselink 1993).
>
> **Indicators:** The indicator for the zone where oxic and anoxic regimes are present is the area that is seasonally inundated minus the area of extended inundation. The assumption for using this indicator is that areas seasonally inundated (2-9 months) are saturated for a long enough period to develop anoxic conditions and thus promote denitrification. The seasonal drying then re-introduces oxic conditions that promote nitrification.
>
> **Scaling:** AUs whose area of seasonal inundation is 85% or greater are scaled a [1] for this variable. Those with less are scaled proportionally (% area/85).

V$_{org}$ - The percent of the AU that is covered by organic soils near the surface.

Rationale: In the Columbia Basin it is often difficult to determine whether the period of inundation is long enough to cause denitrification. The area of organic matter (Vorg) is used as another surrogate to indicate areas of the wetland that might undergo the necessary cycling of oxic and anoxic conditions. Organic soils will build up only if there are long periods of anoxic conditions that reduce the rate of decomposition.

Indicators: The extent of organic soils can be determined during the site visit.

Scaling: This variable is assessed based on four five categories of areal extent (75-100%, 50 – 74%, 25 – 49%, 1 – 24%, and 0%). Scaling for this variable is [1, 0.75, 0.5, 0.25, and 0] for these categories respectively.

$\mathbf{V_{permveg}}$ - The percent of the AU with permanent, erect vegetation.

Rationale: Nitrogen removal is modeled as a function of primary productivity of the less degradable emergent and shrub vegetation because this organic nitrogen is often trapped within the system. Aquatic bed vegetation breaks down more rapidly and tends to release mor dissolved nitrogen. Generally, the organic nitrogen in emergent and shrub plants cannot be exported because the surface outlets are limited and much of the organic nitrogen will remain within the wetland. Furthermore, the transformation of inorganic to organic nitrogen removes the nutrient as a contaminant in groundwater that may be leaving the wetland. Generally, the organic nitrogen that remains in the wetland is that coming from the more refractory emergent grasses and shrubs. Aquatic bed vegetation decomposes more rapidly, releasing inorganic nitrogen, and is not included in the vegetation variable.

Indicators: None needed. The percent of the AU with permanent, erect vegetation is mapped directly.

Scaling: AUs with 100% cover of erect, permanent, vegetation are scored a [1] for this variable. Those with less are scaled proportionally (%cover / 100).

Variables for Opportunity

$\mathbf{V_{buffcond}}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: Conditions in the buffer around a wetland are also important in determining whether nitrogen can reach it. Buffers with intact natural vegetation will trap nitrogen coming from the surrounding landscape before they reach the wetland (review in Desbonnet, et al. 1994). Undisturbed, vegetated buffers reduce the opportunity an AU has to receive nitrogen.

Indicators: This variable is assessed using the buffer categorization on the data sheet.

Scaling: The scaling is proportional to the integrity of the buffer. AUs with relatively no disturbance (a buffer rating of 5) are scored a [0] and those with the least are scored a [1] (buffer rating of 0). Other AUs are scored based on the buffer rating.

$V_{project}$ - AU lies within boundaries of Reclamation Project.

Rationale: Wetlands within the boundaries of the Reclamation Project, or whose water regime is influenced by it, will most likely have high nitrogen inputs because the agriculturally influenced groundwater and surface water in this area have high nitrogen levels (Williamson et al.1998). Much of the water flows in this area are agricultural “return waters” that pick up nitrogen from fertilized fields.

Indicators: No indicators needed. Boundaries of the Reclamation Project are mapped in Part II.

Scaling: This is a “yes/no” variable. An AU scores a [1] for the variable if it is within the Reclamation Project, or influenced by an irrigation project, and a [0] if it is not. This variable was considered more important than the other two in establishing opportunity to remove nitrogen and is multiplied by a factor of 2 in the equation.

V_{upnut} - Conditions in the contributing basin that add nutrients to surface water.

Rationale: This variable characterizes those land uses or conditions in the contributing basin that usually result in high levels of nutrients being delivered to the wetland through surface waters.

Indicators: The indicator for upgradient nutrient sources is the amount of the contributing basin that is developed as tilled fields, irrigated fields, pasture, or residential areas.

Scaling: AUs whose contributing basin has more than 60% in agriculture (tilled or irrigated) or is grazed are scaled a [1] for this variable. Those with less are scaled proportionally (% agriculture or grazing / 60).

6.2.5 Calculation of Potential Performance

Depressional Long-duration Removing Nutrients/Nitrogen

Variable	Description of Scaling		Score for Variable	Result
Veffectarea2	*Highest:*	Seasonal inundation >= 85%	If calculation >=1enter '1'	
	Lowest:	0% seasonal inundation	If calculation = 0 enter "0"	
	Calculation:	Scaling = % AU inundated / 85	Enter result of calculation if <1	
	Calculate (D10.2 – D10.3)/85			
Vorg	*Highest:*	AU has >75% organic soils	If calculation =1enter '1'	
	Lowest:	AU has no organic soils	If calculation = 0 enter "0"	
	Calculation:	Scaling based on % organic soil	Enter result of calculation if <1	
	Calculate (D44.1 + D44.2)/4			
Vpermveg	*Highest:*	100% cover of erect, permanent, vegetation	If calculation >=1enter '1'	
	Lowest:	0% cover of erect, permanent, vegetation	If calculation = 0 enter "0"	
	Calculation:	Scaling based on % cover permanent vegetation/100	Enter result of calculation if <1	
	Calculate (D16.1 + D16.2 + D16.3)/100			
			Total of Variable Scores:	
Index for Removing Nitrogen (Potential) = Total x 3.33 rounded to nearest 1				
			FINAL RESULT:	

6.2.6 Calculation of Opportunity

Depressional Long-duration Removing Nutrients/Nitrogen

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 0	If D39 = 0, enter "1"	
	High:	Buffer category of 1	If D39 = 1, enter "0.8"	
	Moderate:	Buffer category of 2	If D39 = 2, enter "0.6"	
	Medium Low:	Buffer category of 3	If D39 = 3, enter "0.4"	
	Low:	Buffer category of 4	If D39 = 4, enter "0.2"	
	Lowest:	Buffer category of 5	If D39 = 5, enter "0"	
Vproject	*Highest:*	AU is in, or influenced by, project	If D3 OR D4 = 1 Enter "**2**"	
	Lowest:	AU not influenced by project	If D3 OR D4 = 01 Enter "0"	
Vupnut	*Highest:*	Nutrient sources in basin >60%	If calculation >=1enter '1'	
	Lowest:	No nutrient sources in basin	If calculation = 0 enter "0"	
	Calculation:	Scaling = nutrient sources/60	Enter result of calculation if <1	
	Calculate (D7.2 + D7.3 + D7.4 +D7.5 + D7.6) /60			
			Total of Variable Scores:	
Index for Removing Nitrogen (Opportunity) = Total x 2.6 rounded to nearest 1				
			FINAL RESULT:	

6.3 Removing Nutrients/Phosphorous — Depressional Long-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.3.1 Definition and Description of Function

Removing Nutrients/Phosphorus is defined as the wetland processes that remove dissolved or particulate phosphorus and prevent the down-gradient movement of the nutrient.

A wetland performs this function if there is a net annual decrease in the amount of phosphorus going to down-gradient waters (either surface or groundwater) in the watershed. The major processes by which depressional long-duration wetlands reduce phosphorus are: 1) through the trapping of sediment to which phosphorus is adsorbed, and 2) removal of dissolved phosphorus by adsorption to soils that are high in clay content or organic matter (Mitsch and Gosselink 1993).

Plant uptake of nutrients is not modeled because the amount of phosphorus taken up by plants is only a very small part of the phosphorus budget in a wetland. Over 80% of the incoming phosphorus is bound up with sediments as particulate phosphorus (for review see Adamus et al. 1991). The remaining 20% is dissolved, but most of this will be bound up and precipitated by inorganic processes.

6.3.2 Assessing this Function for Depressional Long-duration Wetlands

The potential that depressional long-duration wetlands have to remove phosphorus from water is modeled on their ability to trap sediments and to adsorb the compound to its surface soils. The ability to trap sediments is characterized by the index generated in the "Removing Sediments" model. The sorptive properties of the surface soils are estimated based on the organic or clay content of the soils since these are the two types of soils with the highest rates of adsorption (Mitsch and Gosselink 1993).

The opportunity that a wetland has to remove phosphorus is a function of the level of human generated phosphorus in the contributing basin and the routing of that phosphorus to the AU. Relatively undisturbed watersheds will carry much lower phosphorus loads than those that have been impacted by human activities (Hartmann et al. 1996, Reinelt and Horner 1995). The opportunity that a wetland has to remove phosphorus, therefore, is linked to the amount of agriculture and grazing present in the upgradient part of its contributing basin, and whether it is impacted by waters from the Reclamation Project. Conditions in the buffer around a wetland are also important in determining whether phosphorus can reach it. Buffers with intact natural vegetation will trap phosphorous laden sediment originating from the surrounding landscape and prevent it from reaching the adjoining wetland (review in Desbonnet et al. 1993).

6.3.3 Model at a Glance

Depressional Long-duration **Removing Nutrients/Phosphorus**

Process	Variables	Measures or Indicators
POTENTIAL		
Trapping sediment	**Ssed**	Index of potential for Removing Sediments
Adsorption	**Vsorp**	% of AU with clay soil % of AU with organic soil
OPPORTUNITY		
Conditions in buffer	**Vbufferbypass**	Presence of ditch/drain that routes surface flow around buffer
	Vbuffcond	Descriptive characterization of condition of buffer
Upgradient nutrient sources	**Vupnut**	Upgradient tilled field (irrigated agriculture), pasture or residential areas
Numerator for Potential	3xSsed + Vsorp	
Numerator for Opportunity	Vbufferbypass + Vbuffcond + Vupnut	

6.3.4 Description and Scaling of Variables

$\mathbf{S_{sed}}$ - Index of potential for Removing Sediments.

Rationale: The score is used to model the removal of phosphorus from incoming waters because much of this nutrient comes into a wetland already bound to particulate sediments (for a review see Adamus et al. 1991).

Indicators: No indicators are needed. The variable is a score from another model of a function.

Scaling: The variable is already scaled. Removal of phosphorus by sedimentation was considered to be significantly more important than removal by adsorption (for review see Adamus et al. 1991), and this variable was weighted by a factor of 3 in the equation. A factor of 3 gave the best calibration of the model to the judgements.

$\mathbf{V_{sorp}}$ - The sorptive properties of the surface soils present in an AU.

Rationale: The uptake of dissolved phosphorus through adsorption to soil particles is highest when the soils are high in clay content or organic content (Mitsch and Gosselink, 1993).

Indicators: The indicator for sorptive properties of surface soils is the extent of the AU with high content of clay or organic matter in the surface layers.

Scaling: This variable is assessed based on five categories of areal extent (75-100%, 50 – 74%, 25 – 49%, 1 – 24%, and 0%). Scaling for this variable is [1, 0.75, 0.5, 0.25, and 0] for these categories respectively. The total areas of clay soils and organic soils are added together to estimate the total area of soils with sorptive properties.

Variables for Opportunity

$V_{bufferbypass}$ – Ditches or drains that route surface waters around the buffer and directly into the AU

Rationale: Ditches or drains that route surface waters around the buffer and directly into the AU reduce the phosphorus removal processes in the buffer. As a result, more phosphorus can be delivered to the AU. This increases the opportunity that an AU has to trap nutrients coming from upgradient sources

Indicators: None needed. Ditches/drains that capture surface runoff and route it around the buffer directly into the AU can be observed during the site visit.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there is a channel bypassing the buffer, and a [0] if there is no channel.

$V_{buffcond}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: Conditions in the buffer around a wetland are also important in determining whether phosphorus can reach it. Buffers with intact natural vegetation will trap phosphorus coming from the surrounding landscape before it reach the wetland (review in Desbonnet, et al. 1994). Undisturbed, vegetated buffers reduce the opportunity an AU has to receive phosphorus.

Indicators: This variable is assessed using the buffer categorization described in Part 2 and on the data sheets.

Scaling: The scaling is proportional to the integrity of the buffer. AUs with relatively no disturbance (a buffer rating of 5) are scored a [0] and those with the least are scored a [1] (buffer rating of 0). Other AUs are scored based on the buffer rating.

V_{upnut} - Conditions in the contributing basin that add nutrients to surface water.

Rationale: This variable characterizes those land uses or conditions in the contributing basin that usually result in high levels of nutrients being delivered to the wetland through surface waters.

Indicators: The indicator for upgradient nutrient sources is the amount of the contributing basin that is developed as tilled fields, irrigated fields, pasture, or residential areas.

Scaling: AUs whose contributing basin has more than 60% in agriculture (tilled or irrigated) or is grazed are scaled a [1] for this variable. Those with less are scaled proportionally (% agriculture or grazing / 60).

6.3.5 Calculation of Potential Performance
Depressional Long-duration Removing Nutrients/Phosphorus

Variable	Description of Scaling		Score for Variable	Result
Ssed	*Score is scaled*	Index for Removing Sediment	**3 x** (Index of function)/10	
Vsorp	*Highest:*	Organic and/or clay soils 100% of AU	If D44.3 = 0 enter "1"	
	High:	Organic and/or clay soils 75% of AU	If D44.3 = 1 enter "0.75"	
	Moderate:	Organic and/or clay soils 50% of AU	If D44.3 = 2 enter "0.5"	
	Low:	Organic and/or clay soils 25% of AU	If D44.3 = 3 enter "0.25"	
	Lowest:	Organic and/or clay soils 0% of AU	If D44.3 = 4 enter "0"	
			Total of Variable Scores:	
Index for Removing Phosphorus (Potential) = Total x 2.5 rounded to nearest 1				
			FINAL RESULT:	

6.3.6 Calculation of Opportunity
Depressional Long-duration Removing Nutrients/Phosphorus

Variable	Description of Scaling		Score for Variable	Result
Vbufferbypass	*Highest:*	AU has surface water bypass through buffer	If D40 = 1 Enter "1"	
	Lowest:	No surface water bypass	IF D40 = 0 Enter "0"	
Vbuffcond	*Highest:*	Buffer category of 0	If D39 = 0, enter "1"	
	High:	Buffer category of 1	If D39 = 1, enter "0.8"	
	Moderate:	Buffer category of 2	If D39 = 2, enter "0.6"	
	Medium Low:	Buffer category of 3	If D39 = 3, enter "0.4"	
	Low:	Buffer category of 4	If D39 = 4, enter "0.2"	
	Lowest:	Buffer category of 5	If D39 = 5, enter "0"	
Vupnut	*Highest:*	Nutrient sources in basin >60%	If calculation >=1enter "1"	
	Lowest:	No nutrient sources in basin	If calculation = 0 enter "0"	
	Calculation:	Scaling = nutrient sources/60	Enter result of calculation if <1	
	Calculate (D7.2 + D7.3 + D7.4 +D7.5 + D7.6)/60			
			Total of Variable Scores:	
Index for Removing Phosphorus (Opportunity) = Total x 3.6 rounded to nearest 1				
			FINAL RESULT:	

6.4 Removing Metals and Toxic Organic Compounds — Depressional Long-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.4.1 Definition and Description of Function

Removing Metals and Toxic Organic Compounds is defined as the wetland processes that retain toxic metals and toxic organic compounds coming into the wetland and prevent the downgradient movement of these compounds.

A wetland performs this function if there is a net annual decrease in the amount of toxic metals and toxic organics flowing to down gradient waters (either surface or groundwater) in the watershed. The major processes by which wetlands reduce metals and toxic organic loading to downgradient waters are through:

- sedimentation of particulate metals,
- adsorption,
- chemical precipitation, and
- plant uptake.

Metals that tend to have a high particulate fraction, such as lead (Pb), may be removed through sedimentation. Adsorption is promoted by soils high in clay content or organic matter. Chemical precipitation is promoted by wetland areas that are inundated and remain aerobic, as well as those with pH values below 5 (Mengel and Kirkby 1982). Finally, plant uptake is maximized when there is significant cover by emergent plants (Kulzer 1990).

6.4.2 Assessing this Function for Depressional Long-duration Wetlands

The potential that wetlands in the depressional long-duration family have to remove metals and toxic organic compounds is assessed by their ability to reduce water velocities and trap sediment that might contain toxic compounds, and specific characteristics that indicate potential for adsorption, precipitation and uptake by plants. The index for sediment removal is used to simplify the model. Adsorption, precipitation and uptake by plants are each modeled by a separate variable.

The opportunity of an AU to remove metals and toxic organic compounds is modeled using the land uses of the upgradient watershed and the amount of development immediately adjacent to the AU. Those land uses or activities that contribute metals and toxic organics to surface waters include urban and residential areas and agricultural activities involving pesticide/herbicide applications. Opportunity resulting from high levels of toxic compounds in groundwater could not be modeled because the source of groundwater to a wetland cannot be determined with any level of accuracy in a rapid assessment method.

6.4.3 Model at a Glance

Depressional Long-duration **Removing Metals &Toxic Organics**

Process	Variables	Measures or Indicators
POTENTIAL		
Sedimentation	**Ssed**	Index of potential for Removing Sediments
Adsorption	**Vsorp**	% of AU with clay soil
		% of AU with organic soil
Precipitation	**Vphow**	pH of standing water
Plant uptake	**Vherbaceous**	% of AU with emergent vegetation and herbaceous understory
OPPORTUNITY		
Upgradient sources of toxic compounds	**Vdevelopment**	Presence of permanent development in buffer
	Vuptox	Agricultural and urban areas in upgradient contributing basin
Routing through buffer	**Vbufferbypass**	Presence of ditch/drain that routes surface flow around buffer
Numerator for Potential	Ssed + Vsorp + Vphow +Vherbaceous	
Numerator for Opportunity	Vdevelopment + Vuptox + Vbufferbypass	

6.4.4 Description and Scaling of Variables

$\boldsymbol{S_{sed}}$ – Index from the function "Removing Sediments."

> **Rationale:** The index is used to model the removal of toxic compounds from incoming waters because many of them are transported into an AU already bound to particulate sediments (for a review see Adamus et al. 1991).
>
> **Indicators:** No indicators are needed. The variable is a score from another model of a function..
>
> **Scaling:** The index is already scaled and this is normalized to a range of 0 - 1.

$\mathbf{V_{sorp}}$ – The sorptive properties of the surface soils present in an AU.

Rationale: Adsorption of both toxic metals and toxic organic compounds is highest when the soils have a high cation exchange capacity (Mengel and Kirkby 1982). These are the soils high in either clay or organic content.

Indicators: The indicator for sorptive properties of soils is the extent of the AU with high content of clay or organic matter.

Scaling: This variable is assessed based on five categories of areal extent (75-100%, 50 – 74%, 25 – 49%, 1 – 24%, and 0%). Scaling for this variable is [1, 0.75, 0.5, 0.25, and 0] for these categories respectively. The total areas of clay soils and organic soils are added together to estimate the total area of soils with sorptive properties.

$\mathbf{V_{phow}}$ - The pH of standing water.

Rationale: Many toxic metals are precipitated out of water when the pH is low or high. At a low pH, precipitation occurs due to the presence of sulfides and at a high pH because more hydroxyl ions are present.

Indicators: pH of surface waters can be measured directly using pH tabs or meters.

Scaling: AUs whose pH is less than, or equal to, 6, and those whose pH is greater than 8 are scored a [1] for this variable. Those with a pH between 6 and 8 are scored a [0].

$\mathbf{V_{herbaceous}}$ - The percent of the AU covered by herbaceous plants.

Rationale: Herbaceous species have, in general, been found to sequester metals and remove oils and other organics better than other plant species (Hammer, et al. 1989; Horner 1992). Wetlands dominated by herbaceous plants were judged to sequester toxic metals and remove organic compounds better than those dominated by aquatic bed, forest or scrub/shrub. Furthermore, when incoming water is exposed to the relatively large surface area of herbaceous vegetation, specialized microbes present on the vegetation surface can decompose toxicants.

Indicators: The areal extent of herbaceous vegetation is estimated in the field based on the area covered by the "emergent" vegetation class of Cowardin (1979).

Scaling: AUs with 100% coverage of emergent vegetation are scored a [1] for this variable. Those with less are scaled proportionally (% emergent / 100).

Variables for Opportunity

$\mathbf{V_{development}}$ – The presence of permanent development within the buffer such as roads and buildings

Rationale: Permanent development such as roads and buildings contribute metals and toxic organics from vehicles. This increases the potential inputs to an AU, and therefore, the opportunity for performing this function.

Indicators: None needed. Direct observation of paved roads and buildings.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there is development near the AU or roads that have a significant impact, and a [0] if there is none.

V_{uptox} - Conditions in the upgradient watershed or contributing basin that add toxic metals and toxic organic compounds to surface water.

Rationale: This variable characterizes those land uses or conditions in the contributing basin that usually result in higher levels of toxic compounds being delivered to the AU, either through surface waters or groundwater. Tilled fields and residential areas represent the addition of pesticides to the contributing basin; urban areas represent the addition of toxic metals.

Indicators: The indicator for upgradient nutrient sources is the amount of the contributing basin that is developed as tilled fields, urban, or residential.

Scaling: AUs with more than 5% urban areas in the contributing basin are scored a [1] for this variable. Those with more than 15% tilled or irrigated fields are scored a [0.5], and those with more than 1% high density residential are scored a [0.3]. All other conditions are scored a [0].

$V_{bufferbypass}$ – Ditches or drains that route surface waters around the buffer and directly into the AU.

Rationale: Ditches or drains that route surface waters around the buffer and directly into the AU reduce the ability of the buffer to trap toxic compounds before they reach the AU. As a result, more toxic compounds will be carried to the AU from surrounding sources. This increases, therefore, the opportunity for performance of the heavy metals and toxic organics removal function in the wetland.

Indicators: None needed. Direct observation of ditches/drains that would capture surface runoff and route it around the buffer directly into the wetland.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there is a channel bypassing the buffer, and a [0] if there is no channel.

6.4.5 Calculation of Potential Performance
Depressional Long-duration Removing Metals and Toxic Organics

Variable	Description of Scaling		Score for Variable	Result
Ssed	*Score is scaled*	Index for Removing Sediment	(Index of function)/10	
Vsorp	*Highest:*	Organic and/or clay soils 100% of AU	If D44.3 = 0 enter "1"	
	High:	Organic and/or clay soils 75% of AU	If D44.3 = 1 enter "0.75"	
	Moderate:	Organic and/or clay soils 50% of AU	If D44.3 = 2 enter "0.5"	
	Low:	Organic and/or clay soils 25% of AU	If D44.3 = 3 enter "0.25"	
	Lowest:	Organic and/or clay soils 0% of AU	If D44.3 = 4 enter "0"	
Vph	*Highest:*	pH <= 6 or pH >=8.0	If D25 <= 6 OR D25 >=8, enter "1"	
	Lowest::	pH between 6 and 8	If D25>6 and <8, enter "0"	
Vherbaceous	*Highest:*	100% of AU has herbaceous plants	If calculation = 1, enter "1"	
	Lowest:	AU has 0% of herbaceous plants	If calculation = 0, enter "0"	
	Calculation:	Scaling = (% of AU with emergents + understory/100)	Enter result of calculation if < 1	
	Calculate [D16.3 + (D17/100 x (D16.1+D16.2)] /100			
			Total of Variable Scores:	
	Index for Removing Toxics (Potential) = Total x 2.6 rounded to nearest 1			
			FINAL RESULT:	

6.4.6 Calculation of Opportunity
Depressional Long-duration Removing Metals and Toxic Organics

Variable	Description of Scaling		Score for Variable	Result
Vdevelopment	*Highest:*	AU has development in buffer	If D41.6+D41.7>=2 Enter "1"	
	Lowest:	No development in buffer	If D41.6+D41.7 < 2 Enter "0"	
Vuptox	*Highest:*	Urban sources in basin >5%	If D7.5 >=5 enter "1"	
	Moderately High:	Agricultural sources in basin >15%	If D7.3 + D7.4 >= 15 enter "0.5"	
	Moderately Low:	Residential sources in basin	If D7.5 >= 1 OR D7.6 >=5 enter '0.3"	
	Lowest:	No major toxic sources in basin	If none of above true enter "0"	
Vbufferbypass	*Highest:*	AU has surface water bypass through buffer	If D40 = 1 Enter "1"	
	Lowest:	No surface water bypass	IF D40 = 0 Enter "0"	
			Total of Variable Scores:	
Index for Removing Toxics (Opportunity) = Total x 3.33 rounded to nearest 1				
			FINAL RESULT:	

6.5 Reducing Downstream Erosion & Flooding — Depressional Long-duration Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

6.5.1 Definition and Description of Function

Reducing Downstream Erosion and Flooding is defined as the wetland attributes that attenuate high flows and their erosive capacity.

Wetlands reduce downstream erosion and flooding by storing water, thus reducing the velocity and volume of water flowing downstream. The wetland retains runoff water and reduces downstream flows during storms (water has a higher retention time in the wetland than in the stream). The amount of retention provided is dependent on the available storage and the outlet capacity or the release rate of runoff. Wetlands, play an important role in detaining and slowing runoff during snowmelt.

The ability to reduce erosion and flooding depends on the amount of storage in a wetland. Prior to the snowmelt and any rain-on-snow events, many of the depressional wetlands in the Columbia Basin have significant storage capacity. They tend to have poorly defined, or very constricted, outlets and slow flow through the wetland at times of high water. These wetlands to capture and hold back the rapid runoff from the snowmelt and rain-on-snow events. The stored water slowly evaporates or infiltrates into groundwater. Water levels decline in the summer and the storage is available in winter for “rain-on-snow” events.

6.5.2 Assessing This Function for Depressional Long-duration Wetlands

The potential of depressional long-duration wetlands to decrease downstream erosion and flooding is modeled as water storage and as a reduced rate of water leaving the wetland. The depth of annual inundation indicates storage capacity. The release rate is modeled by the outlet characteristics.

The opportunity for an AU to reduce peak flows will increase as upgradient watershed is developed/disturbed. Research in western Washington has shown that peak flows increase as the percentage of impermeable surface increases (Reinelt and Horner 1995). The opportunity for an AU to decrease erosion and flooding is also reduced in the Columbia Basin if it is within the boundaries of the Reclamation Project. Many wetlands within the Project have higher water levels during the summer and fall that result from irrigation-fed groundwater.

Users must make a qualitative judgement on the opportunity of the AU to actually reduce peak flows because a quantitative model could not be calibrated. None of the data collected during the calibration could be adequately correlated with the judgements of opportunity made by the Assessment Team. The conclusion of the Assessment Team was that too many variables were involved in making a judgement of opportunity, and a simple model could not be developed.

6.5.3 Model at a Glance

Depressional Long-duration Reducing Downstream Erosion and Flooding

Process	Variables	Measures or Indicators
POTENTIAL		
Storage	**Vstorage**	Elevation difference between surface of extended inundation and flood marks (this variable is weighted by a factor of 2)
Slowing release of water	**Voutletw/inund**	Ratio of outlet width to area of inundation
	Vinund/shed	Ratio of area of inundation to contributing basin
OPPORTUNITY		***Could not be calibrated, users make a qualitative judgement***
Numerator for Potential	2xVstorage + Voutletw/inund + Vinund/shed	

6.5.4 Description and Scaling of Variables

Variables for Potential

V**storage** - The amount of storage available in the AU during an inundation or flooding event.

Rationale: Vstorage is a measure of the volume of storage available during major runoff events. The assessment team assumed that wetlands having relatively more storage would decrease water velocities and peak flows more than those with less storage. This occurs because retention time is increased as volume of storage is increased for any given inflow (Fennessey et al. 1994).

Indicators: The indicator for the amount of storage in the AU is the difference in elevation between the surface of "extended inundation" and any flood marks, water marks, sediment deposits, dried algal mats or detritus on vegetation, rocks or cliffs along the shore. The depth of storage, as used in the model, is corrected by a factor reflecting the shape of the AU to estimate an average water depth over the entire portion that is inundated.

Scaling: AUs with an average depth of inundation that is greater than or equal to 1.3 meters are scored a [1] for this variable. Those with less are scored proportionally (average depth / 1.3). This variable was judged to be more important than the others and is weighted by a factor of 2 in the equation.

$V_{outletw/inund}$ – The ratio of the outlet width to the area of inundation.

Rationale: The ratio of the outlet width to the area of seasonal inundation is a predictor of the degree of downstream erosion. The lower the value of the ratio the more slowly a wetland releases water thereby reducing downstream velocities and potential for erosion.

Indicators: The width of the outlet can be directly measured. The area of annual inundation is mapped, based on field indicators of high water marks on rocks and vegetation. This variable is treated as a dimensionless number based on areal measurements in hectares and the width measurement in meters.

Scaling: AUs with a ratio <= to 1 will score a [1] for this variable. Those with a higher ratio will be scaled proportionally (1/ratio).

$V_{inund/shed}$ - The ratio of the maximum area that is inundated every year in the AU to the area of its contributing basin.

Rationale: The potential of a wetland to decrease erosion and flooding is partially a function of how much water flowing into the wetland is held back relative to the amount flowing out. This relationship determines how long the water is held in the wetland before being released (called retention time). Retention time is the relative volume coming into a unit during a storm event divided the amount of storage present.

The area of the contributing basin is used as a surrogate for the relative amount of water (volume as cubic meters/second) entering the AU, while the area of inundation is used to estimate the relative volume stored. Large contributing basins are assumed to generate larger volumes of water for any given storm event than smaller basins. The ratio of the area inundated to the area of the contributing basin was used as a surrogate for retention time. As the ratio decreases, an AU's potential to reduce hold back storm flows is also reduced because its storage capacity is quickly used up. Much of the storm flow will therefore flow directly out of the AU without being retained.

Indicators: No indicators are needed. The ratio can be estimated from map measurements.

Scaling: AUs whose ratio is >=0 1 are scored a [1] for this variable. Those whose ratio is smaller are scaled proportionally (ratio / 0.1).

6.5.5 Calculation of Potential
Depressional Long-duration Reducing Erosion and Flooding

Variable	Description of Scaling	Score for Variable	Result
Vstorage	*Highest:* Average depth storage >= 1.3 m	If calculation >=2 enter "2"	

Variable	Description of Scaling		Score for Variable	Result
	Lowest:	No storage	If calculation = 0 enter "0"	
	Calculation:	Scaling is set as average depth/1.3	Enter result of calculation if < 2	
	Calculate **2 x** [D12.1 x {(0.67 x D13.1) + (0.5 x D13.2) + (1 x D13.3)}]/1.3			
Voutletw/inund	*Highest:*	Ratio <= 1.0	If calculation >=1.0 enter "1"	
	Lowest::	Ratio > 20	If calculation < 0.05 enter '0"	
	Calculation:	Scaling is set as 1/ratio if ratio>1	Enter result of calculation if < 1.0	
	Calculate 1/[D15/(D1 x D10.1 x 0.01)] IF D15 = 0 enter a [1] for result			
Vinund/shed	*Highest:*	Ratio of area inundated to area of contributing basin is > = 0.1	If calculation >=1.0 enter "1"	
	Lowest:	0% of the AU is inundated	If calculation = 0 enter "0"	
	Calculation:	Scaling is based ratio/0.1	Enter result of calculation if < 1.0	
	Calculate [(D1 x D10.1 x 0.01)/D2]/0.1			
			Total of Variable Scores:	
Index for Reducing Flooding (Potential) = Total x 2.50 rounded to nearest 1				
			FINAL RESULT:	

6.5.6 Qualitative Rating of Opportunity

The opportunity for an AU to reduce peak flows will increase as the water regime in the contributing basin is destabilized. Research in western Washington has shown that peak flows increase as the percentage of impermeable surface increases (Reinelt and Horner 1995). The opportunity should therefore be rated by the amount of the contributing basin that is developed.

Users must make a qualitative judgement on the opportunity of the AU to actually reduce peak flows by considering the land uses in the contributing watershed. The opportunity for an AU in the depressional long-duration subclass is **"Low"** if most of its contributing watershed is forested or undisturbed, and ungrazed, grasslands or shrub-steppe. The opportunity is also **"Low"** if the AU receives most of its water from groundwater, rather than from an incoming stream, ditches, or storm drains.

The opportunity for the AU is **"High"** if the contributing watershed is mostly urban with high density residential or is heavily grazed (i.e. cattle have destroyed much of the surface vegetation), or is in tilled agriculture. The opportunity is **"Moderate"** if the development or grazing is a small part of the contributing watershed, or if these areas are relative far away from the AU. Users must use their judgement to decide whether the opportunity is low, moderate or high, and document their decision on the summary sheet (see Part 2).

6.6 Recharging Groundwater — Depressional Long-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.6.1 Definition and Description of Function

Recharging Groundwater is defined as the wetland attributes that allow infiltration of surface water into the groundwater system. Depressional wetlands in the Columbia Basin, however, are usually areas of groundwater discharge and will usually not be a major source of water to groundwater.

Generally, surface water in the Basin infiltrates through the glacio-fluvial and loess deposits or fissures of the underlying basaltic beds, eventually moving laterally along less permeable interbeds between individual basalt flows. When this groundwater intercepts the land surface, it forms a depressional or slope wetland. Other water sources to depressional wetlands include rain-on-snow events, direct snowmelt, and surface water runoff during thunderstorms.

The potential for recharge in depressional wetlands of the Columbia Basin occurs when wetlands collect precipitation and surface flows. These surface waters infiltrate underground. Wetlands that have high groundwater levels from irrigation or reservoirs will generally have limited recharge, particularly in the Potholes region around Moses Lake where the surficial geology consists of quaternary alluvial sands and gravels. Recharge is scored a maximum of 5 out of 10 in areas that are within the Reclamation Project. Recharge is not scored a [0] because some recharge may still occur during snowmelt or prolonged rainfall.

6.6.2 Assessing this Function for Depressional Long-duration Wetlands

In depressional long-duration wetlands (outside of the areas where water levels are controlled by irrigation or other artificial means) recharge when ponded waters are at their highest levels or when groundwater levels have declined significantly. During winter and early spring, rain and snowmelt will raise the water level in the wetland. The potential infiltration is modeled as this seasonal runoff and increase in water levels. The Assessment Team was unable to identify reliable indicators for assessing recharge that might occur during the late summer and fall from large storms, and this aspect of recharge was not modeled.

The Assessment Teams have judged that all AUs in the Columbia Basin of eastern Washington have a **"High"** opportunity to recharge either interflow or an unconfined aquifer if the surface soils within the AU are permeable enough. The assumption is that all AUs have some link to groundwater if they hold water for more than nine months.

6.6.3 Model at a Glance

Depressional Long-duration **Recharging Groundwater**

Process	Variables	Measures or Indicators
POTENTIAL		
Infiltration	**Vinfilt**	Rating of infiltration rate of soils
	Vannualinund	Area (as a % of AU) of inundation that dries out every year
	Vsalt	Presence of surface salts
Hydraulic head	**Vdepthannual**	Maximum depth of annual inundation
Reducers		
	Virrigation	Water levels controlled by human activities
	Vdrain	Presence of drain tiles or ditches
OPPORTUNITY		All AUs have high opportunity except those with brief periods of inundation
Numerator for Potential		(Vinfilt + Vannualinund + Vsalt + Vdepthannual) xVdrain x Virrigation

6.6.4 Description and Scaling of Variables

Variables for Potential

V_{infilt} - A rating of the infiltration capacity of the soils in the AU.

Rationale: Infiltration can occur only where the soils are permeable. Some wetlands in the Columbia Basin are formed on impermeable shallow lenses or have developed extensive peat deposits. These conditions hinder the recharge of groundwater. Recharge is an important process only if the soils have a high sand, gravel or cobble content, and a low content of clays, silts, or organic matter. The layer with the lowest infiltration in the top 60cm is used to develop the rating.

Indicators: The indicator of infiltration is the relative amount of sand, silt, gravel, clay or organic matter present in the soils. Infiltration of soils is rated down to a depth of 60 cm (2ft).

Scaling: AUs with a fast infiltration rate are scored a [1] for this variable, and those rated as "slow" are scored a [0].

$V_{annualinund}$ - Area (as a % of AU) of inundation that dries out every year. This is the area of the AU where infiltration occurs. The variable is measured as the percent of the AU that is annually inundated minus the area that has extended inundation.

Rationale: Infiltration can occur only where the surface waters provide a hydraulic head to push water into the soils. Areas of extended inundation, however, are judged by the assessment team to be at the level of groundwater during the late winter and early spring. Any water below this level does not contribute to the "head" needed to push water into the ground. The effective area where infiltration occurs, therefore, is considered only to be the area that is seasonally inundated, not inundated all the time.

Indicators: The indicator for the effective area is the total inundated area minus the area of extended inundation.

Scaling: AUs with 80% or more of their area subject to annual inundation are scored a [1] for this variable. Those with less are scored proportionally (% area/80).

V_{salt} - The presence of salt layers on the surface of AU soils.

Rationale: When standing water cannot infiltrate through wetland soils, they evaporate in place leaving salt residues. The presence of a salt precipitate on wetland soils, therefore, indicates that infiltration rate is either very slow or non-existent.

Indicators: None needed. Direct observation of salt precipitate.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there are no salt deposits, and a [0] if salt deposits are present.

$V_{depthannual}$ - The maximum depth of water (head) during annual inundation.

Rationale: Infiltration is partly a function of the depth of the water within an assessment unit. Increased water depth means that there is greater pressure to force water through soils and fractured rock formations. For non-reclamation wetlands, recharge probably occurs in late winter, early spring when the additional depth provided by surface water runoff creates a water level that is higher than the groundwater level.

Indicators: For wetlands within and outside of the Reclamation Project the indicators would be the high water mark as indicated by discoloration on rocks, trees and emergent vegetation; dried algal mats suspended on vegetation; sediment coating on rocks, trees and emergent vegetation. Measurement is made from the high water mark to the surface of the extended inundation water surface.

Scaling: AUs with an annual depth of water that is 1.5 meter or greater are scored a [1] for this variable. Those with less are scored proportionally (depth / 1.5).

Reducers

V_{drain} - Presence/absence of drain tiles or ditches.

Rationale: Drain tiles and ditches will intercept water moving down through the soil column, and reduce the amount of recharge occurring. Drains reduces the performance of the recharge function by decreasing the time water levels in a wetland are higher than groundwater levels.

Indicators: Records from the NRCS, physical evidence of tiles (outlets observed in ditches).

Scaling: AUs in which drains are present have their score for the other variables reduced by a factor of 0.8.

$V_{irrigation}$ Water levels controlled by irrigation and other human water control activities.

Rationale: wetlands that have developed because of high groundwater levels from irrigation will generally not be points of recharge. Therefore, any surface water present in these wetlands does not truly represent a "head" or pressure that forces this water into the groundwater. Under these circumstances, recharge is probably not occurring within the wetland. For this reason, the recharge is scored a maximum of 5 out of 10 in areas that are within the Reclamation Project or in other areas where water levels are controlled by irrigation or reservoirs. Recharge, however, is not scored a [0] because some recharge may still occur at very low levels during a rapid winter melt off.

Indicators: Records from the NRCS, from the Reclamation Project or evidence that the highest water levels are found in summer and early fall.

Scaling: AUs whose water levels are controlled by irrigation or human caused water level fluctuations are have their score multiplied by a factor of 0.5.

6.6.5 Calculation of Potential Performance

Depressional Long-duration Recharging Groundwater

Variable	Description of Scaling		Score for Variable	Result
Vinfilt	*Highest:*	Gravel, cobble sand >50% of soil and silt, clays, and organics <30%	If D47.1 = 1, enter "1"	
	Lowest:	Silt, clay, and organics > 30% of soil	If D47.2 = 1, enter "0"	
Vannualinund	*Highest:*	>80% of the AU, is ponded or inundated yearly and then dries	If calculation >= 1, enter "1"	
	Lowest:	0% of the AU is ponded	If calculation = 0, enter "0"	
	Calculation:	Scaling = (% of AU inundated/80)	Enter result of calculation if < 1.0	
	Calculate (D10.1 – D10.3)/80			
Vsalt	*Highest:*	No salt residues present	If D27 = 0 enter "1"	
	Lowest:	Salt residues present	If D27 = 1 enter "0"	
Vdepthannual	*Highest:*	Annual inundation >= 1.5m	If calculation >= 1.0 enter "1"	
	Lowest:	Annual inundation < 0.10m	If calculation = 0, enter "0"	
	Calculation:	Scaling = height of inundation/ 1.5	Enter result of calculation if < 1.0	
	Calculate (D12.1)/1.5			
			Total of Variable Scores:	
Reducer				
Vdrain	AU has a drain present		If D28 = 1 enter "0.8"	
	AU has no drain present		If D28 =0 enter "1"	
Virrigation	Water level in AU controlled by irrigation		If D4 = 1 enter "0.5"	
	Water level in AU is not controlled by irrigation		If D4 = 0 enter 1"	
			Score for Reducer Multiply the score of two reducers	
Index for Recharging Groundwater(Potential) = (Total of Variables)x (Reducer) x 2.5 rounded to nearest 1				
			FINAL RESULT:	

6.6.6 Qualitative Rating of Opportunity

Groundwater is an integral component of the water cycle throughout eastern Washington. The Assessment Teams have judged that all depressional, freshwater, long-duration AUs in the Columbia Basin of eastern Washington have a **"High"** opportunity to recharge either interflow or an unconfined aquifer if the surface soils within the AU are permeable enough. The assumption is that all AUs have some link to groundwater.

6.7 General Habitat — Depressional Long-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.7.1 Definition and Description of Function

General Habitat is defined as the characteristics or processes present in a wetland that indicate a general suitability as habitat for a broad range of species. The General Habitat function is not intended to be a duplicate assessment of the individual functions for each species group. Rather, it focuses on capturing those elements of the overall wetland ecosystem that provide for a wide or diverse variety of habitats used by many different animal species. It does not model the habitat for individual wetland species groups (e.g. birds, aquatic mammals, invertebrates, etc.).

> *Assessing habitat for all species (wetland and non-wetland) is particularly important in the Columbia Basin because wetlands here serve as an "oasis" within an otherwise arid and stressed environment.*

A broad range of structures, vegetation, and interspersion of "habitat" types within the wetland provide a suitable habitat for a suite of species. Characteristics in wetlands can be quite different but still provide highly suitable conditions for a range of species. The model tries to capture this diversity in structure by including many different variables even though a single wetland may never contain all of them (see discussion in Chapter 2).

Many of the variables used to assess the performance of a wetland for general habitat are also used in the assessments of habitat suitability for individual species groups. The technical committee and assessment teams, however, thought it important to assess General Habitat in broad terms as well as assessing the suitability of a wetland for groups of related species.

6.7.2 Assessing this Function for Depressional Long-duration Wetlands

A wetland in the depressional long-duration subclass provides suitable habitat for a broad range of species if it has a complex physical structure. Variables chosen to model this structure include vegetation strata, different types of interspersion, and the presence of specific characteristics such as open water and mudflats.

The model is additive so that environmental characteristics add to the General Habitat Suitability of an assessment unit. The operative assumption is that the suitability of a wetland for animal species increases as the number of appropriate characteristics in the AU increase (niches).

The opportunity is modeled based on characteristics in the landscape, such as corridors, that link the wetland to other surrounding natural areas. These characteristics are included because they play a very important role in maintaining amphibian, reptile, bird, and mammal populations throughout the region. Many species require a corridor for migration between wetlands or need a suitable upland/buffer habitat. In addition, the assessment team has determined that the presence of a mosaic of wetlands in the landscape increases the overall opportunity.

6.7.3 Model at a Glance

Depressional Long-duration **General Habitat**

Characteristics	Variables	Measures or Indicators
SUITABILITY	**Vhydrop**	Number of water regimes present
Structural	**Vprecip**	Average annual rainfall in area around AU
heterogeneity	**Vwater**	The percent of open water and aquatic bed vegetation
	Vrefuge	Presence of special habitat characteristics
	Vprichness	Number of plant species found during site visit
	Vaquatbed	Presence of aquatic bed vegetation
	Vvegclass	Number of Cowardin vegetation classes present
	Vpheight	Number of height ranges of vegetation
	Vpintersp	Rating of interspersion of vegetation height ranges
	Vedgepheight	Structural complexity of AU edge
	Vbuffcond	Descriptive characterization of condition of buffer
	Vbuffstruc	Types of physical structure present in buffer
Reducers		
	Vmilfoil	Presence of milfoil
	Vupcover	Types of land uses within 1km of AU edge
	Vgrazing	Presence of cattle in AU or its buffer
OPPORTUNITY	**Vmosaic**	Proximity to other types of wetlands
	Vcorridor	Rating of condition of corridors to other undisturbed areas
	Vhabtypes	Number of different upland habitats next to AU
Numerator for Potential:	(Vhydrop + Vprecip + Vwater + Vrefuge + Vprichness + Vaquatbed + Vvegclass +Vpheight + Vpintersp + Vedgepheight + Vbuffcond + Vbuffstruc) x (Vmilfoil x Vupcover x Vgrazing)	
Numerator for Opportunity:	Vmosaic + Vcorridor + Vhabtypes	

6.7.4 Description and Scaling of Variables

Variables for Suitability

V_{hydrop} - Number of water regimes present in AU.

Rationale: Based on field observations, the assessment team has determined that long-duration wetlands with a greater number of water regimes have the potential of supporting more faunal species. For example, many invertebrates have their life cycles keyed to different water regimes. Some invertebrate species are tolerant of wetlands with stable water levels, while others can live in pools that are strictly temporary (Wiggins et al. 1980). A greater number of invertebrate species can support a greater number of terrestrial species, including reptiles, birds and mammals.

Indicators: The variable is assessed using specific water regime classes as descriptors. These are: extended inundation, seasonal inundation, brief inundation, saturated but not inundated, perennially flowing stream, and intermittently flowing stream (see Part II for more detailed descriptions of these categories – data D11.1 – D11.6).

Scaling: AUs with four or more water regimes present are scored a [1] for this variable. Those with fewer are scored proportionally ((# of categories –1) / 3). This variable was considered more important than the others in assessing habitat suitability, and is multiplied by a factor of 2 in the equation.

V_{precip} - Average annual rainfall in area in which AU is located.

Rationale: Wetlands in low rainfall areas are an oasis for birds, amphibians and terrestrial wildlife. The assessment team has judged that the importance and suitability of a wetland within the overall ecosystem increases with a decrease in annual precipitation.

Indicator: The average rainfall will be estimated from precipitation maps or from USGS data.

Scaling: AUs in areas with 12 inches of rainfall or less are scored a [1] for this variable. Those outside this area are scored a [0].

V_{water} - % of AU that has extended-duration inundation.

Rationale: Areas of extended inundation in a wetland serves many purposes for animals. It is a valuable source of water for terrestrial wildlife. The availability of water becomes increasingly important in an arid environment, especially during the summer. Aquatic bed species will also form in shallower waters typically located between extended inundation open water and emergent species such as bulrush. Aquatic vegetation beds provides habitat for many species thus providing more food web support for terrestrial species. Open water also provides a landing place and refuge for waterfowl and an open area for feeding by insectivores such as swallows.

Indicators: The extent of extended inundation in a wetland can be easily determined during the drier summer/fall months and no indicator is needed. There is a problem, however, in establishing the size of extended inundation open water during the wet season when the wetland is flooded to its brief inundation levels. The indicators to establish the approximate extent of extended inundation are the edge of emergent vegetation or aquatic bed vegetation in the deeper portions of a wetland. Areas of aquatic bed can be directly observed during the growing season.

Scaling: AUs with 30% or more of their area in "extended inundation" are scored a [1] for this variable. Those with less are scored proportionally (% area /30).

V_{refuge} - Special habitat features that provide refuge for many different species. Several different habitat features are combined in one variable. These include: 1) rocks within the area of surface inundation, 2) large downed woody debris in the AU, 3) erect emergent vegetation within the area of extended inundation, 4) snags, and 5) undecomposed plant litter on the AU surface.

Rationale: In many instances rocks mimic the function of large woody debris typically found in western Washington, but rarely found in the Columbia Basin. Rocks provide refuge, habitat, and structure for a number of different species. Woody debris, snags, and erect vegetation, where present, provide major niches for decomposers (i.e. bacteria and fungi) and invertebrates. They also provide refuge for some amphibians and other vertebrates. Downed woody material is an important structural element of habitat for many other species. In drier areas of the wetland it provides shelter for small mammals, birds, and amphibians (Thomas 1978). The downed woody material and undecomposed plant litter are also important structural elements for invertebrate species that provide food for much of the wetland trophic web (Maser et al. 1988).

Indicators: None needed since the presence of these characteristics can be established in the field.

Scaling: AUs with 4 or 5 habitat features are scored a [1] for this variable. Those with fewer are scored proportionally (# features / 4).

$V_{prichness}$ - Number of plant species.

Rationale: The number of plant species present in a wetland reflects the potential number of niches available for invertebrates, birds, and mammals. The total number of faunal species in a wetland is expected to increase as the number of plant species increases. This variable includes both native and non-native plant species because both provide habitat for invertebrate and vertebrate species.

Indicators: The indicator of overall plant richness used is the number of plant species found during the field visit.

Scaling: AUs with 35 or more plant species are scored a [1] for this variable. Those with fewer are scored proportionally (# species / 35).

$V_{aquatbed}$ - Presence of aquatic bed vegetation.

Rationale: The increased structural complexity provided by aquatic bed is another characteristic that increases habitat niches for a number of invertebrate and vertebrate species. The A-Team observed an increase in the number of invertebrate species when aquatic bed plants were present. For example, aquatic vegetation provides nesting substrate for species that utilize floating nests (e.g. grebe species) and attracts other waterfowl species that rely on it as forage. This increased number of species in the wetland food web also supports a greater number of terrestrial species, including reptiles, birds and mammals. For example, passerine birds feed on the insects that grow in wetlands, coyotes prey on nesting aquatic birds, and reptiles forage on waterfowl eggs.

Indicators: Aquatic bed can usually observed during the site visit (e.g. floating during growing season and dried remnants during late summer and early fall). Timing may be critical because early, intense foraging by waterfowl can eliminate aquatic bed for a short period.

Scaling: This is a "yes/no" variable. AUs with aquatic bed vegetation are scored a [1] for this variable. Those with none are scored a [0].

$V_{vegclass}$ - The number of Cowardin classes of vegetation present in the AU.

Rationale: More habitat niches are provided within a wetland as the number of Cowardin vegetation classes increases. The increased structural complexity provided by different Cowardin classes optimizes potential breeding areas, escape, cover, and food production for the greatest number of species. This increased species richness in the wetland food web also supports a greater number of terrestrial species.

Indicators: None needed. The number of Cowardin Classes is determined in the field.

Scaling: AUs with 4 Cowardin vegetation classes are scored a [1] for this variable. Those with fewer are scored proportionally ((#classes-1)/3). The scaling is set up so an AU with only one class scores a [0], because any vegetated wetland has to have at least one vegetation class. This scaling allows for the variable to be scaled from 0-1 rather than 0.25-1.

$V_{pheight}$ - Number of height ranges of vegetation (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: The Assessment Team judged that different guilds of species may differentiate based primarily on "height" differences in the vegetation. This partitioning of habitat niches according to heights is similar to partitioning occurring in western Washington wetlands by groups of wetland species using different Cowardin classes (e.g. emergent, shrub-scrub, forested). Different sizes of vegetation provide different niches for organisms. The Assessment Team determined that the varying heights of emergent vegetation in the Columbia Basin played a significant role in providing structural complexity that might otherwise, in more mesic environments, be provided by scrub/shrub and forested vegetation. This increased species richness arising from the increased structural diversity also supports a greater number of terrestrial species in the overall wetland food web.

Indicators: The following strata are recorded: emergent vegetation within three height ranges (0-20cm, 30cm-1m, and >1m), and areas of aquatic bed and scrub/shrub.

Scaling: AUs with all 5 strata present are scored a [1] for this variable. Those with fewer are scored proportionally ((#strata-1)/4).

$\mathbf{V_{pintersp}}$ - Rating of degree of interspersion of vegetation of different height classes or strata.

Rationale: In general, interspersion among aquatic bed, emergent and scrub-shrub vegetation of different heights increases the suitability for some wildlife guilds. For example, a higher diversity of plant forms is likely to support a higher diversity of macro-invertebrates (Chapman 1966, Dvorak and Best 1982, Lodge 1985).

The increased structural complexity provided by interspersion optimizes potential breeding areas, escape cover, and food production for the greatest number of species. The increased number of species in the wetland food web also supports a greater number of terrestrial species, including reptiles, birds and mammals.

Indicators: The areas of vegetation of different heights (see previous variable) are rated on the amount of interspersion present based on diagrams on the field data sheets.

Scaling: AU's with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating / 3).

$\mathbf{V_{edgepheight}}$ - Structural complexity of AU edge.

Rationale: Differences in heights of vegetation structure along the edge of the AU increases the number of niches or edge habitats. Marble (1992) notes that the number of edge habitats (ecotones) increase as the structural complexity of the edge increases. The increase in the number of niches results in a greater number of terrestrial species using the edge habitat.

Indicators: The complexity of the AU edge is assessed by noting the presence or absence of a difference in vegetation heights along the AU edge.

Scaling: This is a "yes/no" variables. AUs with a difference in vegetation heights are scored a [1], and those without are scored a [0].

$\mathbf{V_{buffcond}}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The condition of the buffer affects the ability of the wetland to provide appropriate habitat for some species groups (Zeigler, 1992). Terrestrial species using the wetland are benefited by the presence of relative undisturbed upland community types immediately surrounding the wetland. Undisturbed buffers provide refuge and access to the wetland, thereby increasing the suitability of the wetland itself as habitat.

Indicators: This variable is assessed using the buffer categorization described in Part II. The categorization is sequential. A wetland is categorized by the highest criterion it meets.

Scaling: AUs rating a 5 on the buffer are scored a [1] for the variable. Those with lower ratings are scored proportionally (buffer rating / 5).

$\mathbf{V_{buffstruc}}$ - Presence of structural elements in the buffer that provide habitat. This includes forests, shrubs, rocks, talus slopes, cliffs, and downed woody debris in the buffer.

Rationale Structures in wetland buffers are important for refuge, food and habitat for wildlife. Buffers with structure are especially important in the Columbia Basin because they provide a variety of habitat niches and shading. This, in conjunction with the presence of water in an arid environment, significantly increases the use of the wetland by a wide range of aquatic and terrestrial species.

Indicator: Presence of structures in the buffer is determined on site during the field visit.

Scaling: AUs with at least four of the five structure categories present are scored a [1] for the variable. Those with fewer are scored proportionally (# categories / 4).

Reducers

$\mathbf{V_{milfoil}}$ – The presence of milfoil in extended inundation open water.

Rationale: Milfoil has a negative impact upon aquatic environments because it displaces other more useful native aquatic bed species, thereby reducing the number of habitat niches available and food available (e.g. waterfowl, fish). Milfoil does not provide a food source for native aquatic organisms as do other macrophytes such as pondweed. Because milfoil reduces the number of wetland species in the wetland food web, it also reduces the richness of terrestrial species within the same food web that directly or indirectly rely on these wetland species as a food source.

Indicator: Milfoil can be identified during the field visit.

Scaling: AUs with at least a 10% cover of Milfoil have their overall score reduced by a factor of (x 0.8).

$\mathbf{V_{upcover}}$ - The types of land uses within 1 km of the AU edge.

Rationale: Development and agriculture within a wetland's watershed indirectly affect the numbers of wetland species through impacts to the physical, chemical and biological characteristics of a wetland. The clearing of upland habitat, primarily shrub-steppe habitat, and the subsequent agricultural production increases water runoff, and transport of sediment, nutrients and harmful chemicals into the wetland. Increased sediment load, especially in agricultural areas, accelerates wetland filling, loss of diversity of water regimes, plants and other aquatic organisms. Wetland invertebrates and plants are known to decrease in richness and abundance with greater pollution loads (Schueler 1994, Ludwa 1994, Azous and Richter 1995, Hicks 1995). Cumulatively, these impacts also decrease the number of terrestrial species supported by the wetland food web.

Indicators: No indicators are needed to assess this variable. The amount and type of land uses within 1km of the AU can be directly established from aerial photographs or site visits.

Scaling: AUs where at least 10% of the surrounding landscape is tilled fields, urban or residential have their final score reduced by a factor of (x 0.9).

$\mathbf{V_{grazing}}$ - Grazing present in AU or buffer.

Rationale: Grazing in Basin wetlands has a major impact on wildlife. Cattle and sheep trample the cryptogammic crust (i.e. thereby increasing erosion and sedimentation) and rodent burrows. They reduce the diversity of grasses and herbaceous plant species through grazing and increase the eutrophication in the wetland from nutrients leached from their droppings. Furthermore, the presence of cattle disturbs birds and small mammals within the buffer and wetland area. All of these impacts act together to reduce the suitability of an AU as habitat.

Indicators: No indicators are needed to assess this variable. The presence or absence of cattle can be established during the site visit.

Scaling: AUs with evidence of cattle present have their final score reduced by a factor of (x 0.9).

Variables for Opportunity

$\mathbf{V_{mosaic}}$ - Proximity to other types of wetlands.

Rationale: The presence of adjacent wetlands increases the opportunity that the AU can provide suitable habitat for a large number of species. Reasons include: 1) a variety of upland habitat niches interspersed with different water sources results in greater habitat partitioning; and 2) more opportunities for refuge, food and migration; and 3) more opportunity for re-colonization by wildlife species in years of drought.

Indicator: The number of wetland subclasses or types within 2 km of the wetland**.**

Scaling: AUs with 2 or more different wetland types within 2 km are scored a [1] for this variable. Those with 1 type are scored a [0.5] and those with none a [0].

$\mathbf{V_{corridor}}$ - The characteristics of riparian and wegetated connections present between the AU and other nearby wetlands.

Rational: Creeks and other drainages, especially in the drier portions of the Columbia Basin, have been shown to be important migratory/dispersal and foraging areas for both terrestrial and aquatic species including amphibians, mammals, and birds. Vegetated corridors provide areas for hibernation, foraging, and migration and dispersal for some amphibians (Nussbaum and others 1983; Seaburn 1997; W. Leonard, personal observation.). The presence of natural corridors increase the opportunity that a wetland has to provide habitat because there is a larger pool of terrestrial species that can use the wetland.

Indicators: This variable is determined using a modified corridor rating system developed in the Washington State Rating System (Washington State Department of Ecology, 1993.) Corridors are rated on a scale of 0-3 for both riparian and vegetated

Scaling: AUs with a total rating for both riparian and vegetated corridors of 6 are scored a [1] for this variables. AUs with a lower sum of ratings are scored proportionally (sum or ratings/6).

$\mathbf{V_{habtypes}}$ - Presence of forest, riverine, scrub-steppe, talus and open water habitats adjacent to the AU.

Rationale: The presence of forest, riverine, scrub-steppe, talus and open water habitat adjacent to the AU provides more opportunity for terrestrial species to use the AU. Each upland habitat type has a unique distribution of fauna that can use the AU as a source of food and water. These habitats also benefit wetland organisms such as amphibians by providing, migration/dispersal, and foraging and hibernation habitat.

Indicators: No indicators are needed to assess this variable. The types of habitat adjacent to the AU will be counted.

Scaling: AUs with 3 or more habitat types adjacent to it are scored a [1]. Those with fewer are scored proportionally (# types / 3).

6.7.5 Calculation of Habitat Suitability

Depressional Long-duration **General Habitat**

Variable	Description of Scaling		Score for Variable	Result
Vhydrop	*Highest*	AU has 4 or more water regimes	If calculation >=2 enter "2"	
	Lowest	AU has only 1 water regime	If calculation = 0 enter "0"	
	Calculation	Scaled as (# regimes-1)/3	Enter result of calculation if < 2.0	
	Calculate **2 x** [(D11.1+D11.2+D11.3+D11.4+D11.5+D11.6)-1]/3			
Vprecip	*Highest*	AU has 12 inches or less of rain	If D29 <= 12 enter "1"	
	Lowest	AU has more than 12inches of rain	If D29 > 12 enter "0"	
Vwater	*Highest*	AU >=30% extended inundation	If calculation >=1 enter "1"	
	Lowest	AU < 1.5 % extended inundation	If calculation = 0 enter "0"	
	Calculation	Scaled as % extended inundation/30	Enter result of calculation if < 1.0	
	Calculate (D10.3)/30			
Vrefuge	*Highest*	AU has 4 or 5 habitat features	If calculation >=1 enter "1"	
	Lowest	AU has no habitat features	If calculation = 0 enter "0"	
	Calculation	Scaled as # features /4	Enter result of calculation if < 1.0	
	Calculate (D30.1 + D30.2 + D30.3 + D30.4 + D30.5)/4			
Vprichness	*Highest*	AU has >= 35 plant species	If calculation >=1 enter "1"	
	Lowest	AU has only 1 species present	If calculation = 0 enter "0"	
	Calculation	Scaled as # plant species/35	Enter result of calculation if < 1.0	
	Calculate (D21.1 + D21.2)/35			
Vaquatbed	*Highest*	AU has aquatic bed species	If D21.3 >= 1 enter "1"	
	Lowest	AU has no aquatic bed species	If D21.3 = 0 enter "0"	
Vvegclass	*Highest*	AU with 4 vegetation classes	If calculation >=1 enter "1"	
	Lowest	AU has only 1 vegetation class	If calculation = 0 enter "0"	
	Calculation	Scaled as (# classes –1)/3	Enter result of calculation if < 1.0	
	Calculate: Count the number of vegetation classes present in D16. Variable is scaled as : # of vegetation classes/3			
Vpheight	*Highest*	AU with 5 height ranges of veg	If calculation >=1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/4	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3 + D20.4 + D20.5)-1]/4			

Calculation of General Habitat Suitability (Cont.)

Variable	Description of Scaling	Score for Variable	Result
Vpintersp	*Highest* AU has high interspersion	If calculation =1 enter “1”	
	Lowest AU has no interspersion	If calculation = 0 enter “0”	
	Calculation Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3		
Vedgepheight	*Highest* AU has structure at edge	If D38.2 = 1 enter “1”	
	Lowest AU has no structure at edge	If D38.2 = 0 enter “0”	
Vbuffcond	*Highest:* Buffer category of 5	If D39 = 5, enter “1”	
	High: Buffer category of 4	If D39 = 4, enter “0.8”	
	Moderate: Buffer category of 3	If D39 = 3, enter “0.6”	
	Medium Low: Buffer category of 2	If D39 = 2, enter “0.4”	
	Low: Buffer category of 1	If D39 = 1, enter “0.2”	
	Lowest: Buffer category of 0	If D39 = 0, enter “0”	
Vbuffstruc	*Highest* AU has 4 or 5 structures in buffer	If calculation >=1 enter “1”	
	Lowest AU has no structures	If calculation = 0 enter “0”	
	Calculation Scaled as (# of structures)/4	Enter result of calculation if < 1.0	
	Calculate (D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/4		
		Total of Variable Scores:	
Reducers			
Vmilfoil	AU has milfoil present	If D22.1 >=2 enter “0.8”	
	AU has no milfoil present	If D22.1 <2 enter “1”	
Vupcover	AU has more than 10% major human disturbances within 1 km of AU	If (D5.3 + D5.4 + D5.7 + D5.8) >= 10 enter “0.9”	
	AU has less than 10% major disturbances	If (D5.3 + D5.4 + D5.7 + D5.8) <10 enter “1.0”	
Vgrazing	Grazing present in AU or buffer	If D32 =1 enter “0.9”	
	AU has no grazing present	If D32 =0 enter “1”	
		Score for Reducer - ***multiply scores for all three reducers***	
		Index for General Habitat (Suitability) = (Total of variables) x (score for reducers) x (0.86) rounded to the nearest 1	
		FINAL RESULT:	

6.7.6 Calculation of Opportunity

Depressional Long-duration **General Habitat**

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 2 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/2)	Enter result of calculation if < 1.0	
	Calculate	(D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/2		
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation >=1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate	(D43.1 + D43.2)/6		
Vhabtypes	*Highest*	AU has at least 3 habitat types within 1 km	If calculation >=1 enter "1"	
	Lowest	AU has no habitats within 1 km	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/3)	Enter result of calculation if < 1.0	
	Calculate	(D6.1 + D6.2 + D6.3 + D6.4 + D6.5)/3		
			Total of Variable Scores:	
			Index for General Habitat (Opportunity)= Total x 3.33 rounded to nearest 1	
			FINAL RESULT:	

6.8 Habitat for Invertebrates — Depressional Long-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.8.1 Definition and Description of Function

Habitat for Invertebrates is defined as the characteristics that help maintain a high number of invertebrate species in the wetland. For the purpose of this model, invertebrates are narrowly defined as "macroinvertebrates" or free-living organisms readily seen with the naked eye ($\geq 500\mu$m) including among others, Insecta (insects Malacostraca (scuds, sideswimmers, crayfishes, shrimps, isopods), Branchiopoda (fairy, tadpole, and clam shrimps), Maxillopoda (seed shrimps, copepods), Gastropoda (snails), Pelecypoda (clams, fingernail clams), Arachnida (spiders, mites), Annelida (worms and leeches), and Platyhelminthes (flatworms).

Invertebrates are diverse and abundant components of freshwater aquatic systems that include wetlands. As such, almost any wetland will provide a habitat for some invertebrates. There is a distinct difference, however, between a wetland that has a high abundance of one or two species and one that has a high richness of different species. The important aspect of invertebrate populations that is being assessed with this model is species richness. Wetlands with a high richness tend to be more important in maintaining the regional biodiversity of invertebrate populations and provide a genetic source and genetic refuge that helps maintain ecosystem integrity. There are, however, wetlands with low species richness that provide refuge to species unique to these systems, and may be important to that specific species. This aspect of ecosystem function is not addressed in these methods.

Invertebrates are critical as processors of organic material and in the cycling of energy and nutrients (Merritt and Cummins, 1996). Macro invertebrates, and particularly insects are especially important to many processes in wetlands and aquatic food chains. Recent focus on aquatic invertebrates in wetlands indicates the importance of macroinvertebrates in energy and nutrient transfer within aquatic ecosystems (Rosenberg and Danks, 1987). They furnish food for other invertebrates and comprise a significant part of the diets of amphibians, water birds, mammals, and fish. The trophic diversity and numerical abundance of insects (especially the Diptera) and other macro invertebrates (Annelida and Crustacea), make these organisms the most important taxa in wetland environments (Chutter, 1972; Hilsenhoff, 1988; Lang, 1970; Merritt and Cummins, 1996; Warren, 1988).

Most of the wetland invertebrate populations of the Columbia Basin exist in a stressed environment and are subject to high summer temperatures and limited rainfall. This has resulted in different invertebrate population dynamics and greater species richness than in other more temperate regions of the country. Typically, invertebrates in the Columbia basin have telescoped, or shortened life cycles, brief periods of maximum abundance, the ability to survive in stressed environments, and to emerge or go into dormancy before ponds draw down to 35 to 20% of the original surface area. This habitat partitioning appears to have resulted in the capacity for these systems to have a higher invertebrate richness than similar but more stable wetland systems in other areas (B. Lang, personal observations).

6.8.2 Assessing this Function for Depressional Long-duration Wetlands

A wetland in the depressional long-duration subclass provides the highest invertebrate species richness when it has: diverse emergent and aquatic bed plants; a varied substrate; and a fringe that is seasonally inundated (Lang, 1970, 1984, Swedberg and Lang 1983; Warren 1988, Severson-Shurtleff 1990). As a general rule, variation in water quality parameters does not significantly affect invertebrate species richness. For example, in the channeled Scablands, pH and conductance in a given pond where surface water is present most of the year vary from 7.0-10.5 and 250-850 micro-mhos during a year, respectively (Pratt, 1981; Pratt et al., 1986) without significantly affecting species richness. Generally, increased conductance is not correlated with a decrease in species richness until values of 1500-2000 umhos are reached (Lang 1973,1996). In long-duration wetlands of the Columbia Basin and the Channeled Scablands there are roughly a total of 140 species of invertebrates, with at most 52-55 species present in any individual wetland.

Preliminary data from comparisons of permanently inundated, "long-duration," wetlands and long-duration wetlands that dry out for part of the year suggests that invertebrate richness is approximately 20% higher in the former (B. Lang, unpublished data 1999). AUs with permanent surface water, therefore, have their overall score increased by a factor of 1.2 (variable, Vpermwater).

The suitability score is reduced for wetlands impacted by the presence of carp. Carp reduce the habitat structure by their feeding activity (e.g. their constant disruption of the bottom sediment prevents establishment of aquatic plants) and by fish that prey on invertebrates and reduce richness.

The opportunity that an AU has to provide habitat for invertebrates is assessed by its landscape position. AU's that are well connected to other wetlands and that lie in a mosaic of wetlands have a high opportunity to provide habitat because colonization from other locations is possible. These conditions will maintain high species richness in the AU itself.

6.8.3 Model at a Glance

Depressional Long-duration **Habitat for Invertebrates**

Characteristics	Variables	Measures or Indicators
SUITABILITY		
Structural heterogeneity	**Vannualinund**	% area of total inundation minus extended inundation
	Vdepthcat	Presence of different water depths
	Vprichness	The number of plant species found during a site visit
	Vaquabedsp	Aquatic bed plant richness (floating and submerged)
	Vrefuge	Presence/absence of rocks within the Ordinary High Water Mark (OHWM)
		Presence/absence of woody debris within OHWM
		Presence/absence of leaf litter within OHWM
	Vsubstrate	Presence of exposed sand, silt, clay, mud, rock, and organic matter
Permanent surface water	**Vpermwater**	Surface water is present throughout the year in most years
Reducers		
	Vfish	Presence of fish
	Vcarp	Presence of carp
OPPORTUNITY		
	Vcorridor	Ratings of corridors between wetlands & other habitats
	Vmosaic	Proximity of other wetlands within 2 km
Numerator for Suitability	(Vannualinund + Vdepthcat + Vprichness + Vaquabedsp + Vrefuge + Vsubstrate) x Vpermwater x (Vfish or Vcarp)	
Numerator for Opportunity	Vmosaic + Vcorridor	

6.8.4 Description and Scaling of Variables

Variables for Potential

$V_{annualinund}$ – The % area of inundation that fluctuates every year (brief and seasonal).

Rationale: AUs with areas of seasonal inundation as well as extended inundation will have a greater species richness of invertebrates because the two water regimes have different invertebrate species associated with them. Furthermore, the area that undergoes a seasonal drawdown provides a high number of niches for invertebrates that key in to different periods of inundation.

Indicators: High water lines, emergent aquatic vegetation and aerial photos (see Part 2) minus the area of extended inundation.

Scaling: AUs with 50% or more of their area subject to seasonal inundation are scored a [1] for this variable. Those with less are scored proportionally (% seasonal inundation / 50).

$V_{depthcat}$ – Presence of different categories of water depths in the long-duration or perennial parts of the AU.

Rationale: AUs with a greater variety of water depths will provide for a greater number of habitat niches and a greater species richness. Individual species of invertebrates that are associated with extended inundation can partition the habitat according to depth.

Indicators: None needed. The categories of water depths present in the AU are measured directly in the field.

Scaling: AUs with all three depth categories present (0-50cm, 51-130cm, and >130cm) are scored a [1] for this variable. Those with fewer are scored proportionally (# categories/3).

$V_{prichness}$ - The richness of plant species.

Rationale: The richness of plant species present in an AU reflects the potential number of invertebrate species in a wetland, since many invertebrates are associated with specific plant species. As the number of plant species increases the number of habitat niches for invertebrates also increases. Therefore, the species richness of plants, in the judgement of the Assessment Team, is a surrogate for habitat niches for invertebrates.

Indicators: None needed, direct field observations would determine number of plant species.

Scaling: AUs with more than 25 species of plants present at the time of the field visit are scored a [1] for this variable. AUs with less are scored proportionally (# species/25).

$\mathbf{V_{aquabedsp}}$ – The number of aquatic bed plant species present (floating and aquatic submerged).

Rationale: In the judgement of the Assessment Team, a greater number of aquatic bed species increases the number of niches present for aquatic invertebrate species and in turn has a potential to increase invertebrate richness. The aquatic bed species are "double counted" (they are included in previous variable) because this group is considered to be more important at providing niches (especially for the aquatic larvae of many invertebrates) than emergent or scrub/shrub plant species.

Indicators: Aquatic bed species can be counted in the field. Some seasonal variations may exist, however, since waterfowl grazing early in the growing season may temporarily eliminate some species of aquatic bed. In addition, aquatic bed species may not be visible during the winter.

Scaling: AUs with 6 or more species of aquatic bed present score a [1] for this variable. Those with less are scored proportionally (# species/6).

$\mathbf{V_{refuge}}$ **-** Special habitat features that provide refuge for invertebrates**.**

Rationale: Many invertebrates show marked preference for certain types of habitat structures including rocks, downed and woody debris and leaf litter (Lang, 1984; Warren, 1988). Woody debris and leaf litter, where present, are an important structural element for invertebrates, providing food, breeding, and cover habitat (Maser et al. 1988). When refuge provides "3-dimensional" structure then a more diverse invertebrate population is supported. Other important processes provided by refuge areas are egg laying, periphyton perching, and feeding by collectors /gatherers.

Indicators: None needed, direct field observation will determine the number of refuge types present.

Scaling: AUs with at least 2 of the three categories of refuge present score a [1] for this variable. Those with 1 score a [0.5] and those with none a [0].

$\mathbf{V_{substrate}}$ – Presence of different types of substrate within the AU including undecomposed "organic duff" surface, decomposed duff, fines, and coarse material**.**

Rationale: Though there is limited data on invertebrate distributions in different wetland substrates, data from rivers, stream, and lakes show that the local invertebrate species have preferences for specific substrate (Dougherty and Morgan 1991, Gorman and Karr 1978). Chironomid community composition is strongly affected by sediment characteristics (McGarrigle 1980, Minshall 1984). Unpublished research in the Columbia Basin also demonstrates that substrate type plays an important role in invertebrate diversity in wetlands (personal communication with Bruce Lang, 2/23/99). Therefore, AUs with different substates present will provide habitat for a broader group of invertebrate species then those with only one type. However, AUs with only an organic substrate layer (i.e. plant litter, decomposed organic material) will have a higher invertebrate diversity than a wetland with only a mineral substrate layer. This factor is addressed by weighting the presence of an organic substrate more in the equation.

Indicators: No indicators are required to assess this variable. The types of substrate present can be determined directly from field observation.

Scaling: The presence of an organic duff layer is weighted at twice that of a mineral surface layer or an algal mat layer. AUs with all five categories of surface layer are scored a [1] for this variable. Those with fewer are scored proportionally with organic duff layers weighted at twice that of mineral surface layer.

$\mathbf{V_{permwater}}$ **-** Surface water is present throughout the year in most years**.**

Rationale: Preliminary data from comparisons of permanently inundated, "long-duration," wetlands and those that dry out for less than 3 months suggests that invertebrate richness is approximately 20% higher in the former (B. Lang, unpublished data 1999).

Indicators: Presence of permanent water can be established by certain indicators such as the presence of fish, aerial photos taken during the driest part of the year or local knowledge. It is recommended, however, that the assessment unit be visited during October or early November to establish the presence of surface water during the driest time of the year.

Scaling: AUs with permanent surface water have their total score of variables multiplied by a factor of 1.2.

Reducers

$\mathbf{V_{carp}}$ **or** $\mathbf{V_{fish}}$ - Carp and/or fish are present in the areas that are permanently inundated.

Rationale: The assessment team determined the presence of carp, an introduced species, reduces the suitability of wetland habitats for wetland invertebrates. The carp's foraging behavior disturbs the submerged bottom to such an extent that emergent and aquatic bed vegetation is reduced which in turn limits the number of habitat niches for invertebrates. The constant disturbance also re-suspends sediment and reduces water quality. Carp may also prey on benthic invertebrates. Other species of fish also reduce invertebrate species richness by preying directly on invertebrates and amphibian eggs and larvae.

Indicators: Direct observation of carp and/or fish. Additional indicators might include observation of AUs with shallow open water areas devoid of emergent or aquatic bed vegetation, turbid water, absence of amphibians, and low diversity of invertebrate populations, evidence of dead carp and/or fish (i.e., bones, scales). Other evidence includes presence of fishing tackle and information from local residents regarding occurrence of fish in the AU.

Scaling: AUs with carp present have their overall index reduced by a factor of 0.5. Those with other fish present have their index reduced by a factor of 0.9. The presence of carp takes precedence over the presence of fish in the equation, but the two factors are not multiplied together if an AU has both fish and carp. Carp are judged to have a greater negative impact because they resuspend the bottom sediments and disturb a major habitat for invertebrates.

Variables for Opportunity

$\mathbf{V_{corridor}}$ - The characteristics of riparian or vegetated connections present between the AU and other nearby wetlands or upland habitat areas.

Rational: Creeks and other drainages have been shown to be important migratory/dispersal and foraging areas for invertebrates, amphibians, mammals, and birds. Suitable corridors, especially riparian corridors, are judged to be critical in the Columbia Basin to invertebrate colonization and dispersal.

Indicators: This variable is determined using a modified corridor rating system developed in the Washington State Rating System (Washington State Department of Ecology, 1993.) Corridors are rated on a scale of 0-3 for both riparian and vegetated corridors (see Part 2).

Scaling: AUs with a total rating for both riparian and vegetated corridors of 6 are scored a [1] for this variables. AUs with a lower sum of ratings are scored proportionally (sum or ratings/6).

$\mathbf{V_{mosaic}}$ - The AU is part of a distinct wetland/upland ecosystem encompassing different hydrogeomorphic types of wetlands.

Rationale: AUs that occur within a complex of lentic and lotic habitats may have a greater invertebrate richness than isolated wetlands. Invertebrates are transported outside of wetlands by birds, wind and through the hyporheic zone. If wetlands are isolated, then the percentage of these species reaching other wetlands is reduced. The presence of adjacent wetlands increases the opportunity for the wetland to function as suitable habitat for a large number of species. In addition, the proximity of other wetlands provides more opportunities for refuge, food and migration and successful re-colonization by invertebrates during drought years.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of wetlands in the landscape.

Scaling: AUs with 3 or more different types of wetlands present within 2 km are scored a [1] for this variable. Those with fewer types are scored proportionally (# of types/3).

6.8.5 Calculation of Habitat Suitability

Depressional Long-duration **Habitat for Invertebrates**

Variable	Description of Scaling		Score for Variable	Result
Vannualinund	*Highest:*	>50% of the AU, is annually ponded or inundated outside the area of extended inundation	If calculation >= 1, enter "1"	
	Lowest:	0% of the AU is annually ponded	If calculation = 0, enter "0"	
	Calculation:	Scaling = (% of AU inundated/50)	Enter result of calculation if < 1.0	
	Calculate (D10.1 – D10.3)/50			
Vdepthcat	*Highest:*	AU has all three depth categories present	If calculation = 1, enter "1"	
	Lowest:	AU has no depth categories present	If calculation = 0, enter "0"	
	Calculation:	Scaling = # depth categories/3	Enter result of calculation if < 1.0	
	Calculate (D14.1 + D14.2 + D14.3)/3			
Vprichness	*Highest*	AU has >= 25 plant species	If calculation >=1 enter "1"	
	Lowest	AU has only 1 species present	If calculation = 0 enter "0"	
	Calculation	Scaled as # plant species/25	Enter result of calculation if < 1.0	
	Calculate (D21.1 + D21.2)/25			
Vaquabedsp	*Highest*	AU has >= 6 aquatic bed species	If calculation >=1 enter "1"	
	Lowest	AU has no aquatic species present	If calculation = 0 enter "0"	
	Calculation	Scaled as # plant species/6	Enter result of calculation if < 1.0	
	Calculate (D21.3)/6			
Vrefuge	*Highest*	AU has >= 2 categories of refuge	If calculation >=1 enter "1"	
	Lowest	AU has no refuge present	If calculation = 0 enter "0"	
	Calculation	Scaled as # categories/2	Enter result of calculation if < 1.0	
	Calculate (D30.1 + D30.3 + D30.4)/2			
Vsubstrate	*Highest*	AU has all 5 categories of substrate	If calculation >=1 enter "1"	
	Lowest	AU has no exposed substrate	If calculation = 0 enter "0"	
	Calculation	Scaled as # substrates (organic weighted 2x)/7	Enter result of calculation if < 1.0	
	Calculate [(2xD46.1) + (2xD46.2) + D19 + D46.3 + D46.4]/7			
			Total of Variable Scores:	

Depressional Long-duration **Habitat for Invertebrates (cont.)**

Variable	Description of Scaling	Score for Variable	Result
Reducer			
Vcarp	AU has carp present	If D33 = 1 enter "0.5"	
	AU has no carp present	If D33 =0 enter "1"	
Vfish	AU has fish present	If D34 = 1 enter "0.9"	
	AU has NO fish present	If D34 =0 enter "1"	
Score for Reducer (*choose lower value*)			
Multiplier			
Vpermwater	AU has permanent surface water	If D10.6 = 1 enter "1.2"	
	AU has NO permanent surface water	If D10.6 =0 enter "1"	
Score for Mulitplier			
Index for Invertebrate Habitat (Suitability) =(Total for variables) x (score for reducer) x score for multiplier (1.48) rounded to nearest 1			
		FINAL RESULT:	

6.8.6 Calculation of Opportunity

Depressional long-duration **Habitat for Invertebrates**

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 3 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/3)	Enter result of calculation if < 1.0	
	Calculate	(D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/3		
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation >=1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate	(D43.1 + D43.2)/6		
			Total of Variable Scores:	
Index for Invertebrate Habitat (Opportunity)= Total x 5.0 rounded to nearest 1				
			FINAL RESULT:	

6.9 Habitat for Amphibians — Depressional Long-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.9.1 Definition and Description of Function

Habitat for Amphibians is defined as the wetland processes and the characteristics that contribute to the feeding, breeding, or refuge needs of native amphibian species.

Amphibians are a vertebrate group that, in the Pacific Northwest, include wetland-breeding frogs (Order: Anura) and salamanders (Order: Caudata). The richness and abundance of amphibians indicate that they are important in wetland trophic organization. Some native species only breed for a short time in wetlands and as metamorphosed juveniles and adults live in uplands. Other species may be found in or close to wetlands throughout the year. However, the eggs and larvae of all wetland-breeding species require water for development. Wetlands also play an important role in the life cycles of many amphibians by providing quiet waters and food sources needed for the early developmental stages.

The underlying principle used in this habitat model is that wetlands supporting higher species richness should score higher than those supporting less diverse amphibian assemblages. The assessment models are focused on species richness and characteristics that support many different species, not on the importance of a wetland to a specific state-federally listed Threatened or Endangered species. Other methods should be used to estimate habitat suitability for specific species (e.g., USFWS Habitat Evaluation Procedures).

6.9.2 Assessing this Function for Depressional Long-Duration Wetlands

The model for the depressional long-duration subclass is based upon the plant structure (within the wetland), the structures found within the buffer, and the connectivity to and/or proximity to other aquatic habitats. Because long-duration wetlands, by definition, have some area of standing water throughout the year, it was unnecessary to include variables dealing with the duration and timing of inundation. The assessment team concluded that the presence of introduced aquatic vertebrates (i.e. carp and bullfrogs) reduces the suitability of an assessment unit.

The opportunity that an AU has to provide habitat for amphibians is assessed by its landscape position and the presence of physical structures in the buffer that provide refuge for adults. AUs that are well connected to other wetlands and that lie in a mosaic of wetlands have a high opportunity to provide habitat because colonization from other locations is possible. This will maintain high species richness in the AU itself.

6.9.3 Model at a Glance

Depressional Long-duration **Habitat for Amphibians**

Characteristics	Variables	Measures or Indicators
SUITABILITY		
Breeding, feeding & refuge	**Vpheight**	Rating of the different height ranges of vegetation
	Vpintersp	Rating of the interspersion of plant height classes
	Vpow	Percent of AU with extended inundation, open, water
	Vwintersp1	Rating of interspersion between persistent vegetation & areas of open water of extended duration
	Vbuffstruc	Types of physical structures present in the buffer
	Vrefuge	Presence of rocks, woody debris > 10 cm , mud/silt and organic substrate and leaf litter
Reducers		
	Vfish	Presence of fish, including carp
	Vbullfrog	Presence of bullfrog
OPPORTUNITY		
Landscape position	**Vcorridor**	Rating of corridors between wetlands & other habitats
	Vmosaic	Proximity of other wetlands within 2km
Numerator for Suitability	Vpheight+Vpintersp+Vpow+Vwintersp1+Vbuffstruc+Vrefuge) x (Vfish or Vbullfrog)	
Numerator for Opportunity	Vcorridor +Vmosaic	

6.9.4 Description and Scaling of Variables

Variables for Suitability

$V_{pheight}$ – Number of height ranges of vegetation present (3 ranges for emergents, and scrub/shrub).

Rationale: Seven species of native amphibians are associated with wetlands in the Columbia Basin ecoregion (Slater 1955, 1964; Metter 1960; Stebbins 1985; Nussbaum and others 1983; Leonard and others 1993; Corkran and Thoms 1996; Dvornich and others 1997; Olson and Leonard 1997). Each of the seven species has specific structural and hydrological conditions required for achieving optimal reproduction and recruitment (Nussbaum 1983; Leonard and Darda 1995; Leonard and others 1996). The assumption is that wetland sites with a greater number of height ranges for emergent plant species optimizes the potential of providing suitable oviposition areas, larval habitat, escape cover, and food production for the greatest number of amphibian species.

Indicators: The areas of emergent vegetation within three height ranges (0-20cm, 30cm-1m, and >1m) and areas of scrub/shrub will be mapped and the number of types of vegetation recorded.

Scaling: AUs with all four-height ranges/types present score a [1] for this variable. Those with fewer are scored proportionally (# ranges /4).

$\mathbf{V_{pintersp}}$ - Rating of interspersion among the height ranges of different plants.

Rationale: Amphibian richness is increased in a mosaic of different vegetation heights. Seven species of native amphibians are associated with wetlands in the Columbia Basin ecoregion (Slater 1955, 1964; Metter 1960; Stebbins 1985; Nussbaum and others 1983; Leonard and others 1993; Corkran and Thoms 1996; Dvornich and others 1997; Olson and Leonard 1997). Each of the seven species has specific structural and hydrological conditions required for achieving optimal reproduction and recruitment (Nussbaum 1983; Leonard and Darda 1995; Leonard and others 1996). The assumption is that wetland sites with greater structural diversity (the interspersion of different heights) for emergent plant species optimizes the potential of providing suitable oviposition areas, escape cover, and food production for the greatest number of amphibian species.

Indicators: The areas of vegetation of different heights (see previous variable) are rated on the amount of interspersion present based on diagrams on the field data sheets.

Scaling: AU's with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating / 3).

$\mathbf{V_{pow}}$ – The percent area of extended inundation open water in the AU.

Rationale: The presence of areas of extended inundation open water is an indicator that the AU has water long enough to provide for the successful incubation of amphibian eggs. In addition, larger areas of open water suggest there is a greater complexity in water depths and vegetation so that a greater number of amphibian species may be supported.

Indicators: This variable can be estimated during the site visit based on the distribution of open water in the summer and fall months, or if flooded, by the extent of large emergent vegetation such as bulrush (see Part 2).

Scaling: AUs with 50% or more of their area in extended inundation open water are scored a [1] for this variable. Those with less are scored proportionally (%open water / 50).

$V_{wintersp1}$ - The amount of interspersion between areas of persistent vegetation of the AU and the areas of extended inundation that remain unvegetated.

Rationale: The area at the edge of open water and persistent vegetation provides edge habitat, protection, cover, food, and territorial boundaries. Interspersion increases the vegetation/water edge zone. These contact zones between water and vegetation also provide a point of entry for amphibians. It also increases the amount of habitat available to species requiring either vegetation or open water, which in turn increase species diversity.

Indicators: The interspersion in a wetland is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: AU's with a high or moderate interspersion (rating = 2 or 3) are scored a [1] for this variable. Those with a rating of 1 are scored a [0.5] and those with none a [0].

$V_{buffstruc}$ - The presence of rocks, talus slopes, downed woody and human placed debris in the buffer area.

Rationale: The number of structural elements in a buffer increases the number of niches for amphibians. Characteristics of wetland buffers are especially important in providing refuge for amphibians migrating to and from breeding ponds. Furthermore, the success of recently transformed juveniles is greatly enhanced by the presence of suitable cover and foraging areas adjacent to the wetland. As cover is reduced or eliminated by agricultural operations and encroaching development, amphibians are exposed to increased risks of over-heating/freezing, desiccation, and predation. Important buffer features include: downed woody debris, rocks, and mammal burrows.

Indicators: No indicators are needed. Specific structures for refuge are determined during the site visit. The structures assessed are:

- Upland trees
- Scrub-shrub or shrub-steppe
- Rock outcrops, cliffs, fractured basalts
- Talus slopes or boulder fields)
- Downed woody debris > 10 cm diameter

Scaling: AUs with 4 or more categories of structure in the buffer score a [1] for this variable. Those with fewer are scored proportionally (# of categories/4).

V_{refuge} - Special habitat features that provide refuge for amphibians**.**

Rationale: Ranids use three-dimensional structures throughout life as refuge from predators. Many amphibians show marked preference for certain types of substrate including rocks and downed and woody debris, muddy or organic substrate and leaf litter. Rocks and woody debris, where present, are important structural elements for amphibians, providing cover habitat and thermal buffering. Large woody debris also provide the first breeding sites. Muddy/silting or organic substrate and leaf litter provides escape habitat.

Indicators: None needed, structural elements that provide refuge are determined during the site visit. These include rocks and large woody debris in areas that are annually inundated, plant litter on the surface of the AU, snags, and erect emergent vegetation in the area of extended inundation.

Scaling: AUs with at least four of the five structural elements listed above are scored a [1] for the variable. AUs with less are scored proportionally (# of elements / 4).

Reducers

$\mathbf{V_{fish}}$ – Fish are present.

$\mathbf{V_{bullfrog}}$ - Bullfrogs are present.

Rationale: Bullfrogs (*Rana catesbeiana*) and fish are capable of adversely affecting amphibian populations. These impacts may be either direct (by predation), indirect (through displacement to marginal habitats), or both (Hayes and Jennings 1986, Wassersug 1997, Aker 1998, Pilliod and Peterson 1998, Leonard and others, unpublished, Conant and Collins 1998).

Indicators: Direct observation of bullfrogs or fish during site assessment. Other indicators of the presence of bullfrogs include observing their large tadpoles or hearing their distinct alarm or territorial call. Presence of fish can be determined indirectly from scales and fish bones found along the edge of open water areas. If these indicators are missing then presence of fish species will have to be determined by speaking with local fish biologists and residents.

Scaling: AUs with either fish or bullfrogs, or both, have their final score for the function reduced by multiplying by 0.9.

Variables for Opportunity

$\mathbf{V_{corridor}}$- Rating of riparian and vegetated corridor connecting AU to other wetlands.

Rationale: Creeks and other drainages have been shown to be important hibernation areas, foraging habitats, and migratory/dispersal corridors for some amphibians (Nussbaum and others 1983; Seaburn 1997; W. Leonard, pers. obs.). Because of the arid to semi-arid conditions experienced in the Columbia Basin, more aquatic amphibian species (e.g., Columbia Spotted Frog, Northern Leopard Frog [*Rana pipiens*]) are presumably unable to colonize (and are less apt to recolonize after local extinction) 'new' habitats without the presence of suitable aquatic corridors. Post-breeding amphibians often move out along drainage courses where conditions may be more favorable (W. Leonard, pers. obs.). Spadefoot toads will cross plowed fields to reach other wetlands, but some species of amphibians have need of vegetated corridors.

Indicators: This variable is determined using a modified corridor rating system developed in the Washington State Rating System (Washington State Department of Ecology, 1993.) Corridors are rated on a scale of 0-3 for both riparian and vegetated corridors (see Part 2). Riparian corridors in Eastern Washington include creeks (intermittent), drainage swales and ditches.

Scaling: AUs with a total rating for both riparian and vegetated corridors of 6 are scored a [1] for this variables. AUs with a lower sum of ratings are scored proportionally (sum or ratings/6).

V_{mosaic} - The AU is part of a distinct wetland/upland ecosystem encompassing different hydrogeomorphic types of wetlands.

Rationale: AUs that occur within a complex of lentic and lotic habitats may have a greater amphibian richness than isolated wetlands. If wetlands are isolated, then the percentage of these species reaching other wetlands is reduced. The presence of adjacent wetlands increases the opportunity for the wetland to function as suitable habitat for a larger number of species. In addition, the proximity of other wetlands provides more opportunities for refuge, food and migration and for successful re-colonization by amphibians during drought years.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of wetlands in the landscape.

Scaling: AUs with 4 or more different types of wetlands present within 2 km are scored a [1] for this variable. Those with fewer types are scored proportionally (# of types/4).

6.9.5 Calculation of Habitat Suitability

Depressional Long-duration **Habitat for Amphibians**

Variable	Description of Scaling		Score for Variable	Result
Vpheight	*Highest*	AU with 4 height ranges/types of veg	If calculation =1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/3	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3 + D20.4)-1]/3			
Vpintersp	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vpow	*Highest*	AU has >50% extended inundation open water	If calculation >=1 enter "1"	
	Lowest	AU has no open water	If calculation = 0 enter "0"	
	Calculation	Scaled as (% extended inundation open water / 50)	Enter result of calculation if < 1.0	
	Calculate D10.4/50			
Vwintersp1	*Highest*	AU has high interspersion	If calculation >=1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D36.1/2			
Vbuffstruc	*Highest*	AU has 4 or 5 structures in buffer	If calculation >=1 enter "1"	
	Lowest	AU has no structures	If calculation = 0 enter "0"	
	Calculation	Scaled as (# of structures)/4	Enter result of calculation if < 1.0	
	Calculate (D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/4			
Vrefuge	*Highest*	AU has >= 4 categories of refuge	If calculation >=1 enter "1"	
	Lowest	AU has no refuge present	If calculation = 0 enter "0"	
	Calculation	Scaled as # categories/4	Enter result of calculation if < 1.0	
	Calculate (D30.1 +D30.2 + D30.3 + D30.4 + D30.5)/4			
			Total of Variable Scores:	

Depressional long-duration **Habitat for Amphibians (cont.)**

Variable	Description of Scaling	Score for Variable	Result
Reducer			
Vbullfrog	AU has bullfrogs present	If D33 = 1 enter "0.9"	
	AU has no bullfrogs present	If D33 =0 enter "1"	
Vfish	AU has fish present	If D34 = 1 enter "0.9"	
	AU has NO fish present	If D34 =0 enter "1"	
		Score for Reducer (*Choose Lowest Value*)	
		Index for Amphibian Habitat (Suitability) = (Total for Variables) x (Score for Reducer) x(1.78) rounded to nearest 1	
		FINAL RESULT:	

6.9.6 Calculation of Opportunity

Depressional Long-duration Habitat for Amphibians

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 4 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/4)	Enter result of calculation if < 1.0	
	Calculate (D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/4			
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation >=1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate (D43.1 + D43.2)/6			
			Total of Variable Scores:	
	Index for Amphibian Habitat (Opportunity)= Total x 5.0 rounded to nearest 1			
			FINAL RESULT:	

6.10 Habitat for Aquatic Birds — Depressional Long-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.10.1 Definition and Description of Function

Habitat for Aquatic Birds is defined as the environmental characteristics in a wetland that provide suitable habitats or life resources for species of aquatic-dependent birds, and the characteristics of the surrounding landscape that indicate birds will have the opportunity to use this habitat. Aquatic bird species are those that depend on different aspects of the aquatic ecosystem for some part of their life needs: food, shelter, breeding, or resting. Wetlands also provide for specific requirements such as nesting, molting, foraging and migration. The primary groups of aquatic birds considered for building the assessment model included waterfowl, shorebirds and herons, blackbirds, rails, and marsh wrens. Other, typically terrestrial, birds, such as short-eared owls and Northern Harriers, that use these wetlands as a preferred habitat due to the "oasis effect," are modeled in the General Habitat function.

In general, the suitability of a wetland as bird habitat increases as the number of appropriate habitat characteristics increase. Wetlands can provide habitat for a large number of aquatic bird species depending on the vegetative structure, and physical characteristics of the wetland. The opportunity of a wetland to provide habitat increases in landscapes where there are numerous other wetlands or open water areas nearby.

The assessment models are focused on species richness, not on the importance of a wetland to a specific threatened or endangered species or to a specific regionally important group of birds.

If the wetland is a habitat type that appears to be critical to a specific species, another method is needed in order to better determine the habitat suitability of that wetland (e.g. USFWS Habitat Evaluation Procedures (HEP), USFWS 1981, Wakeley and O'Neil 1988).

6.10.2 Assessing this Function for Depressional Long-duration Wetlands

The suitability of depressional long-duration wetlands in the Columbia Basin for aquatic birds is modeled on structural components that have been shown, or are judged, to be important habitat features, and the condition of the buffers in the assessment unit. The model includes the index of suitability for invertebrates as an indicator of richness in types of food available to aquatic birds.

AUs that have carp populations, purple loosestrife or *Phragmites* present, or that have human disturbances in the surrounding landscape are judged to have a reduced level of performance. These conditions all reduce the suitability of an AU as habitat for birds. Purple loosestrife and *Phragmites* tend to be highly invasive and exclude other native wetland plant species, which in turn reduces habitat richness for bird species.

Size of assessment unit is not used as a variable in the equation although it is often cited as an important characteristic of wetlands that provide bird habitat (Richter and Azous, 1997). The question of size as an indicator of species richness is a difficult one. No satisfactory size thresholds have been identified in the literature that would define the importance of a small versus a large wetland as habitat specific to only wetland dependent birds. Size, however, is incorporated indirectly in the scaling of some of the other variables used. Thus, it is implicit that a wetland with a diverse structure is usually large; small wetlands usually cannot contain the same number of different structural elements as large ones.

The opportunity that an assessment unit has to provide bird habitat is a function of many landscape variables such as the presence of nearby open water, other wetlands, and proximity to the major migratory flyways. Users, however, must make a qualitative judgement on the opportunity of the AU to actually provide bird habitat because a quantitative model could not be calibrated. None of the data collected during the calibration could be adequately correlated with the judgements of opportunity made by the Assessment Team. The conclusion of the Assessment Team was that too many variables were involved in making a judgement of opportunity, and a simple model could not be developed.

6.10.3 Model at a Glance

Depressional Long-duration **Habitat for Aquatic Birds**

Characteristics	Variables	Measures or Indicators
SUITABILITY	**Vhydrop**	Number of water regimes present
Structural	**Vpow**	% area of extended inundation that is open
Heterogeneity	**Vmud/sand**	Presence/absence of mud/sand flats
	Vwintersp1	Rating of interspersion between persistent vegetation & areas of open water of extended duration
	Vpheight	Number of plant height categories present
	Vpintersp	Rating of the interspersion of plant height classes
	Vbuffcond	Descriptive table of conditions in buffer
	Vbuffstruc	Types of physical structure present in buffer
	Sinvert	Index of suitability from invertebrate model
Reducers		
	Vcarp	Presence of carp in extended inundation water
	Vinvasp	Presence of invasive plants (Loosestrife, *Phragmites*)
	Vhumandis	Presence of human activities within AU and buffer
OPPORTUNITY		***Could not be calibrated***
Numerator for Suitability	(2xVhydrop+Vpow+Vmud/sand + Vwintersp1 + Vpheight + Vpintersp + Vbuffcond + Vbuffstruc + Sinvert) x Vcarp x Vinvasive x Vhumandis	

6.10.4 Description and Scaling of Variables

Variables for suitability

V_{hydrop} - The number of different water regimes (hydroperiods) present in the AU.

Rationale: Based on field observations, the assessment team has determined that long-duration wetlands with more water regimes provide greater habitat richness for aquatic birds. AUs that have a variety of inundation regimes (varying duration, including areas of extended, seasonal and brief inundation) was found to be essential for a number of wetland bird species (Marble1992).

Indicators: The variable is assessed using specific water regime classes as descriptors. These are: extended inundation, seasonal inundation, brief inundation, saturated but not flooded, perennially flowing stream, and intermittently flowing stream (see Part 2 for more detailed descriptions of these categories – data D11.1 – D11.6).

Scaling: AUs with four or more water regimes present are scored a [1] for this variable. Those with fewer are scored proportionally ((# of categories –1) / 3). This variable was considered more important than the others in assessing habitat suitability, and is multiplied by a factor of 2 in the equation.

$\mathbf{V_{pow}}$ - The percent of the AU that is covered by open water of extended inundation.

Rationale: Open water provides an area for waterfowl access to the AU. It also is an indicator of potentially greater underwater structural heterogeneity that then supports a greater variety of invertebrate food sources for different species of waterfowl.

Indicators: The percent of open water in an AU can be easily determined during the drier summer/fall months and no indicator is needed. Additionally, areas of aquatic bed can be determined in drier summer/fall months by examining the dried vegetative cover on the mud/sandflats below the last area of emergent vegetation (i.e. typically bulrush). There is a problem, however, in establishing the size of open water that is inundated for most of the year during the wet season when the AU is flooded to its levels of brief inundation. The indicators for establishing the approximate extent of open water are the edge of emergent vegetation or aquatic bed vegetation in the deeper portions of an AU. For AUs influenced by agricultural runoff, establishing the area of "extended inundation" open water may be difficult because their level of maximum seasonal inundation occurs in late summer and fall.

Scaling: AUs with at least 20% open water of extended inundation are scored a [1] for this variable. Those with less are scored proportionally (% open water / 20).

$\mathbf{V_{mud/sandflats}}$ - presence/absence of mud or sand flats.

Rationale: Some species of shorebirds are adapted to foraging for invertebrates living in exposed mud/sand bars. Use of these mud and sandflats occurs year round. For example, they are used by migratory birds in August, and by avocets and stilts in April and May. AUs that contain exposed mud/sandflats attract shorebirds and waterfowl adapted to feeding in this habitat type most of the year. This increases the overall species richness in the AU.

Indicators: The presence of mudflats can be determined easily during the dry season. During periods of inundation, however, establishing the presence of mudflats can only be determined by interviewing local experts and residents familiar with the AU.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if has mudflats, and a [0] if it does not.

$V_{winterspl}$ - The amount of interspersion between areas of persistent vegetation of the AU and the areas of extended inundation that remain unvegetated.

Rationale: The area at the edge of open water and persistent vegetation provides edge habitat, protection, cover, food, and territorial boundaries. Interspersion increases the vegetation/water edge zone. These contact zones between water and vegetation also provide a point of entry for aquatic birds. It also increases the amount of habitat available to species requiring either vegetation or open water, which in turn increase species diversity.

Indicators: The interspersion in a wetland is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: AU's with a high interspersion (rating = 3) are scored a [1] for this variable. Those with a rating of 1 are scored proportionally (rating /3).

$V_{pheight}$ - Number of height ranges of vegetation (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: It was the judgement of the Assessment Team that the varying heights of emergent vegetation in the Columbia Basin played a significant role in providing structural complexity that might otherwise, in more mesic environments, be provided by scrub/shrub and forested vegetation.

Indicators: The presence of 5 categories of plant heights are recorded in the field (0-20cm, 30cm-1m, and >1m) for emergent species, aquatic bed and scrub/shrub.

Scaling: AUs with all five categories present are scored a [1] for this variable. Those with fewer are scored proportionally (# categories-1)/4).

$V_{pintersp}$ - Rating of interspersion among the height ranges of different plants.

Rationale: The assessment team determined that the interspersion of the different vegetation strata with each other, including height classes of emergent species, and areas of aquatic bed and scrub/shrub, increases the habitat richness of the AU for birds by providing more niches for feeding, breeding and refuge.

Indicators: The areas of vegetation of different heights (see previous variable) are rated on the amount of interspersion present based on diagrams on the field data sheets.

Scaling: AU's with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating(scale 0-3) / 3).

$V_{buffcond}$ - Condition of buffer within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The amount of disturbance in the AU buffer affects the ability of the AU to provide appropriate habitat for some guilds of birds (Zeigler, 1992). Trees and shrubs in the wetter portions of the Columbia Basin (e.g. Spokane area) provide screening for birds using the AU, as well as providing additional habitat in the buffer itself (Johnson and Jones 1977, Milligan 1985, Zeigler 1992). For the drier portions of the Columbia Basin the presence of undisturbed buffer areas at maximum widths, even though they have limited screening capabilities (e.g. shrub-steppe habitat), indicates that the habitat needs of sensitive bird species will not be disturbed by human activities (agriculture, grazing, urban uses).

Indicators: This variable is assessed using the buffer categorization described in Part 2

Scaling: AUs rating a 5 on the buffer are scored a [1] for the variable. Those with lower ratings are scored proportionally (buffer rating / 5).

$V_{buffstruc}$ - Presence of structural elements in the buffer that provide habitat for wetland dependent birds. This includes forests, shrubs, rocks, talus slopes, cliffs, and downed woody debris (includes blown in brush) in the buffer.

Rationale: Structure in wetland buffers is important for nesting habitat, cover for refuge, and food production for many species of aquatic birds. Blown in brush such as tumbleweed is commonly found at the edge of Columbia Basin wetlands and provides escape habitat for small birds. Buffers with structure are especially important in the Columbia Basin because they provide a variety of habitat niches and shading, which in conjunction with the presence of water in an arid environment significantly increases the use of the AU by a wide range of aquatic species.

Indicator: Presence of structures in the buffer is determined on site during the field visit.

Scaling: AUs with at least four of the five structure categories present are scored a [1] for the variable. Those with fewer are scored proportionally (# categories / 4). See Part 2, datum D42 for a description of the types of structure assessed.

$S_{inverts}$ - The habitat suitability index for the "invertebrate" function.

Rationale: The score is used to represent the richness of invertebrates that might be available as prey for aquatic birds. Because many aquatic birds are specifically adapted to foraging for a specific species or group of invertebrates, a "greater" invertebrate richness will mean a greater suitability for a larger number of bird species.

Indicators: No indicators are needed. The variable is a score from another function.

Scaling: The index score, which is reported on a scale of 0-10, is normalized to a scale of 0 –1.

Reducers

V_{carp} - Carp are present in the AU.

Rationale: The assessment team determined the presence of carp, an introduced species, reduces the suitability of wetland habitats for aquatic birds by the disturbance this species causes in the plant and animal communities in areas of permanent water. The carp's foraging behavior disturbs the submerged bottom to such an extent that emergent and aquatic bed vegetation is reduced. The constant disturbance also re-suspends sediment and reduces water quality in the water.

Indicators: Direct observation of carp. Additional indicators include observation of AUs with shallow open water areas devoid of emergent or aquatic bed vegetation, turbid water, and evidence of dead carp (i.e., bones, scales). Other evidence includes presence of discarded fishing tackle and information from local residents regarding occurrence of fish in the AU.

Scaling: AUs with carp have their overall index reduced by multiplying the score by a factor of 0.6.

V_{invasp} – The presence of invasive plants such as loosestrife (*Lythrum salicaria*) and phragmites (*Phragmites communis*)

Rationale: The listed invasive plants have a significant impact upon bird richness by eliminating habitat for many preferred plant species. Loosestrife and *Phragmites* can dominate the area, thereby reducing structural diversity (uniform plant height and structure) and the number of niches available for bird species. It has been observed that *Phragmites*, though limited in extent throughout the basin, colonizes within areas of loosestrife and eventually dominates.

Indicators: Direct observation of the two species of invasive plants. The presence is recorded as 1 of four categories based on percent coverage within the AU (see Part 2, datum D22).

Scaling: AUs in which either of the two species covers more than 50% of the AU have their index score reduced by a factor of 0.8.

$V_{humandis}$ – The presence of human disturbance within 100 meters of the AU edge.

Rationale: In the judgement of the Assessment Team, human disturbance is a major factor in reducing aquatic bird richness. Human presence is particularly damaging if it is regular and occurring during periods of critical life cycle needs such as breeding/nesting. Disturbance can include recreational boating, fishing, hunting, hiking and nature observation. These human activities can interfere with pair bonding, breeding/nesting , and feeding and roosting activities of aquatic birds.

Indicators: Human disturbance is rated based as high based on direct observation of activities, and by indirect evidence such as parking areas, off-road tire tracks, trash, fishing line, and foot-trails along the shoreline and through the buffer.

Scaling: If boating, fishing, hunting, grazing, roads, residences or urban areas were rated as having a high impact, the final score for an AU is reduced by a factor of 0.8.

6.10.5 Calculation of Habitat Suitability

Depressional Long-duration **Habitat for Aquatic Birds**

Variable		Description of Scaling	Score for Variable	Result
Vhydrop	*Highest*	AU has 4 or more water regimes	If calculation >=2 enter "2"	
	Lowest	AU has only 1 water regime	If calculation = 0 enter "0"	
	Calculation	Scaled as (# regimes-1)/3	Enter result of calculation if < 2.0	
	Calculate **2 x** [(D11.1+D11.2+D11.3+D11.4+D11.5+D11.6)-1]/3			
Vpow	*Highest*	AU has >=20% extended inundation with open water	If calculation >=1 enter "1"	
	Lowest	AU has no open water	If calculation = 0 enter "0"	
	Calculation	Scaled as (% extended inundation open water / 20)	Enter result of calculation if < 1.0	
	Calculate D10.4/20			
Vmud/sand	*Highest:*	AU has mud or sand flats	If D10.5 >=1 enter "1"	
	Lowest:	AU has no mud or sand flats	If D10.5 = 0 enter "0"	
Vwintersp1	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D36.1/3			
Vpheight	*Highest*	AU with 5 height ranges of veg	If calculation >=1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/4	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3 + D20.4 + D20.5)-1]/4			
Vpintersp	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vbuffcond	*Highest:*	Buffer category of 5	If D39 = 5, enter "1"	
	High:	Buffer category of 4	If D39 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D39 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D39 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D39 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D39 = 0, enter "0"	

Depressional Long-duration **Habitat for Aquatic Birds (Suitability cont.)**

Variable	Description of Scaling		Score for Variable	Result
Vbuffstruc	*Highest*	AU has 4 or 5 structures in buffer	If calculation >=1 enter "1"	
	Lowest	AU has no structures	If calculation = 0 enter "0"	
	Calculation	Scaled as (# of structures)/4	Enter result of calculation if < 1.0	
	Calculate (D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/4			
Sinverts	*Score is scaled*	Index for Habitat Suitability for Invertebrates	(Index of function)/10	
			Total of Variable Scores:	
Reducers				
Vcarp	AU has carp present		If D33 = 1 enter "0.6"	
	AU has no carp present		If D33 =0 enter "1"	
Vinvasp	AU has more than 50% loosestrife and/or Phragmites		If D22.2+D22.3 >=4 enter "0.8"	
	AU has <50% loosestrife and/or *Phragmites*		If D22.2+D22.3 <4 enter "1"	
Vhumandis	AU has high levels of human disturbance		If rating of any disturbance is high: value of 2 in any field (D41.1 to D41.8) enter "0.8"	
	AU does not have high levels of human disturbance		If ratings of disturbance are low or none (only values of "0 or 1" in data D41.1 to D41.8) enter a "1"	
			Score for Reducer - ***multiply scores for all three reducers***	
Index for Bird Habitat (Suitability) = (Total of variables) x (score for reducers) x (1.12) rounded to the nearest 1				
			FINAL RESULT:	

6.10.6 Qualitative Rating of Opportunity

The opportunity that an assessment unit has to provide bird habitat is a function of many landscape variables such as the presence of nearby open water, other wetlands, and proximity to the major migratory flyways.

Users must make a qualitative rating on the opportunity of the AU to actually provide bird habitat because a quantitative model could not be calibrated. Generally, the opportunity is **High** if the AU is located in a dense mosaic of other wetlands, lakes or riverine habitats and is on a major flyway. It should be rated as **Moderate** if it is not in a dense mosaic of other aquatic habitats, or if it is isolated but still located on a major flyway. It should be rated **Low** if the AU is isolated from other aquatic habitats by at least 10 km and is not on the usual migratory path for aquatic birds.

6.11 Habitat for Aquatic Mammals — Depressional Long Duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.11.1 Definition and Description of Function

Habitat for Aquatic Mammals is defined as the capacity of the wetland to provide suitable biophysical requirements for two aquatic mammals that use wetlands. The biological and physical requirements for beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus)* were modeled.

The two species used in this model were selected due to their dependence on wetlands (Hammerson 1994), their economic importance, as well as their influence on the wetland systems (Johnston and Naiman 1987, Garbisch 1994). A model for all mammal species of the Columbia Basin that use wetlands would be cumbersome and not rapid. There are too many variations in habitat requirements, we lack information on many species, and there is a need to assess the landscape as well as the wetland. The focus of the assessment is on wetlands and it does not try to assess the performance of the surrounding landscape. This model reflects suitability in terms of species richness and assumes that AUs providing habitat for both species have a higher level of performance of the function than those not providing such habitat. Available estimates of species abundance were not used because the model is not meant to assess that aspect of habitat.

An assessment model for suitability was developed only for the depressional freshwater long-duration and depressional alkali wetlands of the Columbia Basin because the presence of permanent surface water is a critical habitat requirement for the two species assessed. Short duration depressional wetlands (with only seasonal inundation) are assessed for opportunity. Depressional short duration wetlands may provide some habitat for these mammals if they are near a long-duration system, but they will not provide year-round habitat.

6.11.2 Assessing this Function for Depressional Long- Duration Wetlands

The presence of permanent surface water is a pre-requisite if the wetland is to provide year-round habitat for the two aquatic mammals. Permanent water is needed to provide refuge in areas where other types of refuge have been lost, and to provide access to forage, especially during the winter. Since some depressional long duration wetlands may dry out for up to 3 months the model is structured to take this into account. An index score is calculated only if the AU has permanent water. AUs that dry out in most years are scored a [0] for habitat suitability.

Habitat for Mammals – Depressional Long-duration

The model for the depressional long duration wetlands contains variables that represent structural elements in wetlands that are known or judged to provide habitat for both species of mammals. The suitability of habitat, however, is reduced if carp are present due to the impact of these fish on the wetland ecosystem. Other reducers include the presence of large, grazing livestock that impact plant communities. When indigenous plant communities are damaged by grazing invasive species often take over. The presence of cattle can also collapse burrows. The presence of certain aggressive, exotic plants is also modeled as a reducer, as is human disturbance. The latter has the potential for introducing light and noise, habitat loss, and other forms of harassment such as predation by pets.

Opportunity is modeled based on the proximity of other wetland types and on the presence of suitable natural corridors.

6.11.3 Model at a Glance

Depressional Long Duration Habitat for Aquatic Mammals

Characteristics	Variables	Measures or Indicators
SUITABILITY	**Vpermwater**	AU has areas that are permanently inundated
Structural	**Vdepthannual**	Depth of annual inundation
Heterogeneity	**Vdepthperm**	Depth >= 1.3 meters in permanent surface water
	Vpintersp	Rating interspersion of plant structures
	Vbank	Presence/absence of steep bank suitable for denning
	Vpermveg	Presence of emergent vegetation in areas of extended inundation
	Vbuffcond	Descriptive characterization of condition of buffer
	Vwintersp1	Rating interspersion between plants and open water
Reducers		
	Vgrazing	Presence of domestic livestock
	Vcarp	Presence of carp
	Vinvasp	Presence of *Lythrum* and *Phragmites spp.*
	Vhumandis	Presence of human activities within AU and buffer
OPPORTUNITY		
	Vripcorridor	Rating of riparian corridors to other wetlands
	Vvegcorridor	Rating of vegetation cover of corridors to other wetlands
	Vmosaic	Wetland hydrogeomorphic types within 1 km
Numerator for Suitability	Vdepthannual + Vdepthperm + Vpintersp+Vbank+Vpermveg+ Vbuffcond + Vwintersp1) x **Vpermwater** x (Vgrazing x Vcarp x Vinvasp x Vhumandis)	
Numerator for Opportunity	Vripcorridor + Vvegcorridor+ Vmosaic	

6.11.4 Description and Scaling of Variables

V$_{\mathbf{permwater}}$- The AU has areas that are permanently inundated.

Rationale: The presence of permanent surface water (water that last for the entire year) is critical for the long-term suitability of an AU as habitat for both muskrats and beaver. Permanent water is needed to accommodate lodges and bank dens and to allow free movement from the lodge to feeding areas.

Indicators: Presence of permanent water can be established by certain indicators such as the presence of fish, aerial photos taken during the driest part of the year or local knowledge.

Scaling: **This is a "yes/no" variable. An AU scores a [1] for the variable if has permanent water. AUs without permanent water are scored a [0], and the AU receives a [0] for the index of performance.**

Variables for Suitability

$V_{depthannual}$ - Depth of annual inundation (an indicator of water level stability).

Rationale: The indicator for water level stability is the height of the annual inundation. AUs where the annual water level fluctuations are low are considered to have a more stable water level. Beavers prefer a seasonally stable water level (Slough and Sadleir 1976). Ability to control water levels in wetlands with damable outlets increases the suitability of a wetland as habitat for beaver. Fluctuations may also affect suitability for muskrat habitat (Errington 1963). Both drought and floods disrupt living routines and security of muskrat populations. Heavy spring runoff or flash floods that raise water levels in the wetland may cause flooding of burrows and the possible flooding or evacuation of young (Errington 1963).

Indicators: Measurement is made from the high water mark to the level of extended inundation. During high water periods it may be necessary to use the vegetation to identify the approximate level of extended inundation (see Part 2).

Scaling: AUs with a depth of annual inundation less than 0.6m are scored a [1] for this variable. Those whose depths are >0.6 m but less than or equal to 0.9 m are scored a [0.8]. Those whose depths are >0.9m but less than 1.5 m are scored a [0.1], and those with depths of 1.5 m or greater are scored a [0].

$V_{depthperm}$ - Depth greater than or equal to 1.3 meters in areas of permanent inundation.

Rationale: Water depth must be sufficient to accommodate lodges and bank dens and to allow free movement from the lodge to food caches during the winter. Freezing of the food cache is a limiting factor on beaver and muskrat survival in the Columbia Basin (Tabor personal communication*)*. Freezing of a pond to the bottom can be disastrous to muskrat populations (Schmitke 1971). Deep water will also provide protection from predators (Easter-Pilcher 1977). Shallow waters can expose lodge or den entrances, leaving animals vulnerable to predators. In the Columbia Basin beaver and muskrat need at least 1.3 meters of permanent water to allow access to food caches during the winter when the surface is frozen.

Indicators: Depth can be estimated by wading or using a fishing line with a bobber.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if has depth greater than 1.3m in areas that are permanently inundated, and a [0] if it does not.

$V_{pintersp}$ - Rating of interspersion among plant species with different structures (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: Structural heterogeneity in the plant assemblages enhances the habitat for beaver and muskrat. Although beaver show distinct preferences for a small number of plant species, they are known to sample almost any woody or herbaceous species. Columbia Basin beavers have been observed grazing on forbs along the shoreline and using cattails and bulrush to build lodges and dams. Although willows are highly preferred, beaver are not as closely associated with other commonly preferred woody vegetation such as aspen or cottonwood (Tabor personal communication). This is quite likely due to the best available food sources being the most common forage. Presence of heavy growths of emergent vegetation suitable for lodge-building, notably cattails and bulrushes, commonly attract muskrats, irrespective of the nature of the shoreline (Errington 1963). It appears, therefore, that a variety of plants with different structural characteristics provide optimal conditions for these aquatic mammals.

Indicators: Emergent vegetation within different height ranges (0- 10cm, 11-20cm, 30cm-1m, and >1m), and areas of aquatic bed and scrub/shrub are mapped. The final mapped areas are compared to diagrams showing the observed general patterns of structural diversity in the Columbia Basin.

Scaling: AU's with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating(scale 0-3) / 3).

V_{bank} - The presence of slope and soil conditions that are suitable for muskrat and beaver bank burrows.

Rationale: Beaver in the Columbia Basin prefer bank dens over lodges, and a relatively steep bank (45%) with at least three feet of soil is necessary (Tabor, personal communications). While beaver are limited by steep topography in construction of channels which are used to obtain and transport food (Easter-Pilcher 1987), lack of a slope might preclude burrow construction, and increase the impacts of water fluctuations to burrows in hillsides with a lower slope. Coarse substrates have been negatively correlated with beaver presence and abundance (Slough and Sadler 1977, Rutherford 1967), whereas the distribution and status of bank-dwelling muskrats is influenced by extremes of both hardness or looseness (Errington 1963*)*.

Indicators: Presence of banks is determined at a site visit. For burrowing, a bank should be at least 45%, with at least one meter of fine soil such as sand, silt, or clay.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if it has appropriate banks, and a [0] if it does not.

$V_{permveg}$- Presence of persistent erect vegetation in area of extended inundation.

Rationale: Vegetation in areas that have extended surface inundation provides beaver and muskrat with easy, and protected access to needed food sources and material for building lodges. Access to food supplies and building materials are necessary for the establishment of beaver colony sites (Slough and Sadlier 1976).

Indicators: Direct observation of areas of extended inundation for the presence of persistent emergent vegetation. Because the level of extended inundation is typically below the rooting level of emergent vegetation in the Columbia Basin, local experts and residents would have to be consulted during the high water periods as to the level of extended inundation. During the drier summer and fall months the level of extended inundation and permanent vegetation can be observed directly.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if it has permanent vegetation in the long-duration water, and a [0] if it does not.

$\mathbf{V_{buffcond}}$ - Condition of area within 100m of the edge of the AU (the buffer), as rated by extent of undisturbed areas.

Rationale: The presence of humans and domestic animals in proximity to the wetland impacts beaver and muskrat. Undisturbed buffer of sufficient width indicates that human disturbance is at a minimum. In some areas of the Basin, upland shrubs and trees such as aspen and willows, will provide a limited source of forage and building materials for beavers and muskrat.

Indicators: This variable is assessed using the buffer categorization described in Part 2.

Scaling: AUs rating a 5 on the buffer are scored a [1] for the variable. Those with lower ratings are scored proportionally (buffer rating / 5).

$\mathbf{V_{winterspl}}$- Interspersion between areas of extended inundation and persistent vegetation.

Rationale: Wave action on larger wetlands has an effect on shore stability. A convoluted interface between open water and vegetated areas prevents the buildup of large waves or provides refuge from large waves for colony sites of beaver and muskrat. The mosaic of vegetation and open water is often made even more complex by beavers, who dig canals to create better access to riparian food reserves.

Indicators: The interspersion in a AU is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: AU's with a high interspersion (rating = 3) are scored a [1] for this variable. Those with a rating of 1 are scored proportionally (rating /3).

Reducers

$\mathbf{V_{invasp}}$ **-** Cover of *Phragmites spp. and Lythrum spp.*

Rationale: Beaver and muskrat prefer native emergent vegetation, although they will use a wide variety of plant species. During freezing weather they will dig roots of broad-leaved cattail (*Typha latifolia*) and hardstem bulrush (*Scirpus acutus*.) (Tabor 1998 Allen 1994 and Allen 1983). This emergent vegetation, however, is out-competed by introduced *Phragmites communis* and purple loosestrife (*Lythrum salicaria*), and both these introduced plant species have become a threat to beaver/muskrat habitat in the Columbia Basin by replacing the higher quality food items.

Indicator: None needed. Map area of invasive species present and calculate percent cover of total AU.

Scaling: AUs where these two invasive species are dominant, or co-dominant, over more than 50% of the AU have their final score reduced by a factor of 0.9.

$\mathbf{V_{grazing}}$ - Presence of domestic livestock.

Rationale: Grazing of livestock (e.g. cattle, horses, sheep) has detrimental effects on mammals due to decreased vegetation cover, destruction of riparian and emergent plants, changes in plant communities, and collapse of aquatic mammal burrows.

Indicators: Sign of impacts or presence of livestock at time of site visit.

Scaling: AUs where grazing is present within the AU or its buffer have their final score reduced by a factor of 0.8.

$\mathbf{V_{carp}}$ - Presence of carp.

Rationale: Carp cause major changes in the aquatic ecosystem by re-suspending bottom sediments. This impacts both aquatic macrophytes and emergent vegetation by reducing light penetration to the bottom and uprooting any young plants. As a result, AUs with carp tend to have much lower densities of emergent vegetation, to the point of elimination. Thus, carp reduce a preferred food source for beaver and muskrat in the Columbia Basin resulting in lower reproductive fitness for these aquatic mammals.

Indicator: Presence of carp is to be determined at the time of the site visit.

Scaling: AUs with carp have their final score reduced by a factor of 0.8.

$\mathbf{V_{humandis}}$ – The presence of human disturbance within 100 meters of the AU edge.

Rationale: In the judgement of the Assessment Team, human disturbance is a major factor in reducing habitat suitability for mammals. Muskrats are known to adjust to unsatisfactory conditions by shifting their centers of activity from 20 yards to many miles (Errington 1961). Major factors in reducing habitat suitability for beaver are human disturbance and associated roads and land clearing (Slough and Sadleir 1976). Commercial trapping and fishing, and recreational uses such as hunting, fishing, boating, and wildlife viewing can create unsatisfactory habitat conditions by collapsing burrows, destroying food sources, and both direct and indirect noise harassment.

Indicators: Human disturbance is rated based on direct observation of activities, and by indirect evidence such as parking areas, off-road tire tracks, trash, fishing line, foot-trails along shoreline and through buffer.

Scaling: AUs in which human activities such as boating, fishing, hunting, grazing, roads, residences or urban areas are rated as having a high impact have their final score reduced by a factor of 0.8.

Variables for Opportunity

$\mathbf{V_{ripcorridor}}$- Rating of riparian corridor connecting AU to other wetlands.

Rationale: Beavers achieve efficient habitat exploitation through extensive dispersal. Emigration of young beaver may involve movements over considerable distances, both over land and via waterways (Slough and Sadleir 1977). Corridors are important during all seasons, though they will be more important when water is present in the corridor. Riparian corridors with deeper, permanent, water are better for dispersal because they provide cover under water.

Indicators: This variable is determined using a corridor rating key described in Part 2. Riparian corridors are rated on a scale of 0-3 based on the depth and permanence of water.

Scaling: AUs with a rating of 3 for the riparian corridor are scored a [1] for this variable. AUs with a lower rating are scored proportionally (rating/3).

$\mathbf{V_{vegcorridor}}$ – Rating of vegetation cover in corridors to other wetlands.

Rationale: Vegetation in dispersal corridors provides cover during the migration from one wetland to another. AUs that are connected to other wetlands with a dense vegetation cover have a higher opportunity to provide habitat because the are more easily accessible for the mammals.

Indicators: This variable is determined using a corridor rating key described in Part 2. Vegetated corridors are rated on a scale of 0-3 based on the amount of plant cover in the corridor

Scaling: AUs with a rating of 3 for the vegetated corridor are scored a [1] for this variable. AUs with a lower rating are scored proportionally (rating/3).

$\mathbf{V_{mosaic}}$ - The AU is part of a complex of aquatic habitats encompassing several, to many, wetland and other aquatic types within a confined geographic region.

Rationale: AUs that occur as part of a complex of wetland types (e.g. long duration depressional, riverine, lacustrine) and/or perennial water bodies (rivers, streams, lakes) provide a greater opportunity for migration by aquatic mammals between wetlands. Alteration of a wetland mosaic can affect the dynamics of wetland associated organisms (Gibbs 1993). A lack of other wetlands nearby reduces the opportunity for emigration and immigration as well as reducing the options for movement when the habitat in the AU is stressed or disturbed.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of wetlands in the landscape.

Scaling: AUs with 6 or more different types of aquatic habitats present within 2 km are scored a [1] for this variable. Those with fewer types are scored proportionally (# of types/6).

6.11.5 Calculation of Habitat Suitability

Depressional Long-duration Habitat for Aquatic Mammals

Variable	Description of Scaling		Score for Variable	Result
Vpermwater	*Highest*	AU has permanent water	If D10.6 = 1 - continue"	
	Lowest	AU does not have permanent water	If D10.6 = 0 enter "0" for habitat suitability	
Vdepthannual	*Highest:*	Annual inundation < = 0.6m	If D12.1 <=0.6 enter "1"	
	Moderate:	Annual inundation 0.6 – 0.9 m	If D12.1 >0.6 and <= 0.9 enter a "0.8"	
	Low:	Annual inundation >0.9 – 1.5 m	If D12.1 >=1 and <=1.5m Enter a "0.1"	
	Lowest:	Annual inundation >1.5m	If D12.1 >1.5 enter a "0"	
Vdepthperm	*Highest:*	AU has water depths >=1.3 m in areas of extended inundation	If D14.4 = 1 enter "1"	
	Lowest:	AU water depths < 1.3 m	If D14.4 = 0 enter "0"	
Vpintersp	*Highest:*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest:	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation:	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vbank	*Highest:*	AU has banks for denning	If D31 = 1 enter "1"	
	Lowest:	AU has no banks	If D31 = 0 enter "0"	
Vpermveg	*Highest:*	AU has permanent vegetation in areas of extended inundation	If D30.5 = 1 enter "1"	
	Lowest:	AU has such vegetation	If D30.5 = 0 enter "0"	
Vbuffcond	*Highest:*	Buffer category of 5	If D39 = 5, enter "1"	
	High:	Buffer category of 4	If D39 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D39 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D39 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D39 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D39 = 0, enter "0"	
Vwintersp1	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D36.1/3			
			Total of Variable Scores:	

Depressional Long-duration **Habitat for Aquatic Mammals (Cont.)**

Variable	Description of Scaling	Score for Variable	Result
Reducers			
Vgrazing	Grazing present in AU or buffer AU has no grazing present	If D32 =1 enter "0.8" If D32 =0 enter "1"	
Vcarp	AU has carp present AU has no carp present	If D33 = 1 enter "0.8" If D33 =0 enter "1"	
Vinvasp	AU has more than 50% loosestrife and/or Phragmites AU has <50% loosestrife and/or Phragmites	If D22.2+D22.3 >=4 enter "0.9" If D22.2+D22.3 <4 enter "1"	
Vhumandis	AU has high levels of human disturbance AU does not have high levels of human disturbance	If rating of any disturbance is high: value of 2 in any field (D41.1 to D41.8) enter "0.8" If ratings of disturbance are low on none (only values of "0 or 1" in data D41.1 to D41.8) enter a "1"	
		Score for Reducer - ***multiply scores for all four reducers***	

Index for Mammal Habitat (Suitability) = (Total of variables) x (score for reducers) x (1.4)
Calculate score only if D10.6 = 1. rounded to the nearest 1

FINAL RESULT:

6.11.6 Calculation of Opportunity

Depressional Long-duration Habitat for Aquatic Mammals

Variable		Description of Scaling	Score for Variable	Result
Vmosaic	*Highest*	AU has at least 6 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/4)	Enter result of calculation if < 1.0	
	Calculate (D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/6			
Vripcorridor	*Highest*	AU has a rating of 3 for riparian corridor	If calculation =1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (corridor ratings/3)	Enter result of calculation if < 1.0	
	Calculate (D43.1) /3			
Vvegcorridor	*Highest*	AU has a rating of 3 for vegetated corridor	If calculation =1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (corridor ratings/3)	Enter result of calculation if < 1.0	
	Calculate (D43.2) /3			
			Total of Variable Scores:	
			Index for Mammal Habitat (Opportunity)= Total x 3.33 rounded to nearest 1	
			FINAL RESULT:	

6.12 Richness of Native Plants — Depressional Long-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.12.1 Definition and Description of Function

The Richness of Native Plants is defined as the degree to which a wetland provides a habitat for different native plant species.

Note: Because the presence or absence of plant species can usually be assessed during a single site visit and used as an indicator of total richness, this model represents the only direct estimate of actual performance in this function assessment method.

A wetland performs the function when the number native plant species is already high, or the number of non-native species is low. Dominance by even a few non-native species often precludes native plant species, and therefore the ability of the AU to support native plant richness at the local and regional levels. The reduction of this potential appears to be exacerbated by the presence of a few aggressive non-native plant species that colonize and dominate existing native plant associations. Thus not only is the number of non-native species important in reducing the performance of this function, the coverage of few aggressive species is perhaps more critical in determining whether native plant associations can continue to exist. Changes in vegetation composition as the result of non-native invaders have been inferred by vegetation classification through soil nutrient alteration (Parker 1974, Duebendorfer 1990, La Banca. 1993).

Wetlands currently dominated by native plant species tend to be more capable of maintaining native plants than those dominated by non-native species. A high number of native plant species in a wetland enhances the potential for colonization to other perhaps recently disturbed areas. The number and richness of native plant species increases with proximity to nearest seed source (Reinartz and Warne, 1993). Additionally, native plant associations more often harbor rare plant species than non-native associations.

The assessment teams, therefore, have judged that wetlands where one or more of the dominant species is non-native have lost some of their ability to support native plant associations. Non-native plants that become dominant tend to become mono-cultures that exclude native species. The percent of the AU dominated, or co-dominated, by non-native species is modeled as a reducer for this function.

Performance of this function is based the number of native plants present and the absence of non-native species. The model, however, is valid only if the AU has not been recently cleared or altered. If you find the assessment unit has been recently cleared or cut, the score from the model will not provide an adequate assessment of the function.

Opportunity is not modeled because it is assumed that all assessment units have the same opportunity for providing plant habitat. Seed dispersal among different AUs in the Basin is judged to be approximately the same for the level of resolution of these methods.

6.12.2 Assessing this Function for Depressional Long-duration Wetlands

The model developed for "suitability of depressional long-duration wetlands to provide native plant habitat" is based on the actual counts of native plant species made during the site visit and the proportion of native to non-native species found. The areal coverage of non-native species is used as a reducer for the level of performance of this function.

6.12.3 Model at a Glance

Depressional Long-duration **Richness of Native Plants**

Characteristics	Variables	Measures or Indicators
Richness of native plants	**V%native**	Percent of total plant species that are native
	Vnative/non	Ratio of native to non-native plant species
	Vmaxnative	Number of native plants identified during field visits
Reducers		
	Vnonnat	% cover of AU where non-natives are dominant or co-dominant
Numerator	(V%native+Vnative/non + Vmaxnative)xVnonnat	

6.12.4 Description and Scaling of Variables

Variables

$\mathbf{V_{\%native}}$ – Percent of total plant species that are native.

Rationale: The percent of total plant species that are native is one measure of how effective the AU is in providing diverse habitat for native plants and maintaining regional plant richness.

Indicators: No indicator required. Direct observation of the total number of plant species and the number of native plant species within that total.

Scaling: AUs where the native species represent more than 60% of the total are scored a [1] for this variable. Those with a smaller percentage are scored proportionally (% / 60).

$V_{native/non}$ - The ratio of native to non-native plant species.

Rationale: The ratio of native plant species to non-native present in an AU is an additional measure of how effective it is in providing diverse habitat for native plants and maintaining regional plant richness. Both the % and ratio are used as variables because this minimizes the difference that arise with collecting plant data at different times in the growing season. The actual species counts at an AU change seasonally, but the ratios remained relatively stable.

Indicators: The indicator is the number of native and non-native species observed during the site visit.

Scaling: AUs whose ratio was greater than or equal to 6 were scored a [1] for this variable. Those with a lower ratio were scored proportionally (ratio / 6).

$V_{maxnative}$ - The number of native plant species present.

Rationale: The number of native plant species present in an AU is one measure of how effective it is in providing diverse habitat for native plants and maintaining regional plant diversity. It is not possible, however, to determine the total species richness in one visit or within a few hours. Some plants are annuals and grow for only a short time, others have a very limited distribution and may occupy a small and inconspicuous patch that is easily overlooked. For this reason the count of native species determined during one site visit is only an indicator of the actual "maximum" number that could be present in an AU.

Indicators: The indicator of overall native plant richness is the number of species found during the site visit.

Scaling: AUs with 20 or more native species present are scored a [1] for this variable. Those with fewer are scored proportionally (# species / 20).

Reducers

V_{nonnat} - The percent of the AU where non-native species are dominant or co-dominant.

Rationale: AUs in which non-native plant species are dominant (>50% areal cover) or co-dominant (>20% areal cover) may hinder the ability of the AU to provide diverse habitat for native plants and maintaining regional plant diversity. Aggressive non-native species tend to outcompete native species. The estimate of areal coverage of non-native species determined during the site visit is only an indicator of the actual coverage possible.

Indicators: The areal coverage of dominant or co-dominant non-native species is estimated during the site visit.

Scaling: AUs where the non-native cover more than 75% of the area have their score reduced by a factor of (x 0.3). A 50% - 75% cover reduces the score by a factor of (x 0.5) and a cover of 25% - 49% reduces the score by a factor of (x 0.9). AUs with less than a 25% cover of non-natives do not have their score reduced.

6.12.5 Calculation of Richness

Depressional Long-duration **Native Plant Richness**

Variable	Description of Scaling		Score for Variable	Result
V%native	*Highest:*	% native plants >=60%	If calculation >=1 enter "1"	
	Lowest:	% native plants = 0%	If calculation = 0 enter "0"	
	Calculation:	Scaled as % native/60	Enter result of calculation if < 1.0	
	Calculate [D21.1/(D21.1 + D21.2)] / 0.6			
Vnative/non	*Highest:*	Ratio > = 6	If calculation >=1 enter "1"	
	Lowest:	Ratio = 0	If calculation = 0 enter "0"	
	Calculation:	Scaled as ratio/6	Enter result of calculation if < 1.0	
	Calculate (D21.1 / D21.2)/6 Note: if no non-natives are present the result of calculation is automatically > 1			
Vmaxnative	*Highest*	AU has >= 20 native species	If calculation >=1 enter "1"	
	Lowest	AU has 0 native species	If calculation = 0 enter "0"	
	Calculation	Scaled as # native plant species/20	Enter result of calculation if < 1.0	
	Calculate D21.1/20			
			Total of Variable Scores:	
Reducer				
Vnonnat	>75% cover of non-native plants		If D24.1 = 1, enter "0.3"	
	50-75% cover of non-native plants		If D24.2 = 1, enter "0.6"	
	25 - 49% cover of non-native plants		If D24.3 = 1, enter "0.9"	
	0 – 24% cover of non-native plants		If D24.4 + D24.5 = 1 enter "1"	
			Score for Reducer	
Index for Native Plant Richness = (Total for variables) x (Reducer) x (3.33) rounded to nearest 1				
			FINAL RESULT:	

6.13 Supporting Food Webs - Depressional Long-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

6.13.1 Definition and Description of Function

Supporting Food Webs is defined as wetland processes and characteristics that support complex food webs within the wetland and surrounding ecosystem(s). The function combines three major ecosystem processes - primary production, secondary production, and export of production.

AUs are known for their high primary production and the subsequent cycling of organic matter within the system and to adjacent ecosystems (Mitch and Gosselink, 1993). The assessment team has determined that Columbia Basin depressional wetlands generally do not export all, or even most, of their production through surface waters leaving the wetland. Much of the primary and secondary production is exported by way of mammals, birds, amphibians, reptiles, and predatory insects that feed in the wetland. Export also takes place when some insects emerge as adults and fly away from the wetland.

Wetlands in the Columbia Basin play a critical role in maintaining the structure and stability of the terrestrial animal communities around them. Their high primary productivity and the complexity of the species associations that feed on this production provide a stable food source for many terrestrial animals that would otherwise not survive in the semi-arid environment of the Basin.

The model assesses food web support by the amount of photosynthesis that occurs in the wetland, the potential for surface water export of production , and by the species richness of secondary producers. Wetlands with a high faunal richness provide a more stable exportable resource for the surrounding ecosystems.

6.13.2 Assessing this Function for Depressional Long-duration Wetlands

Primary production in depressional long-duration wetlands is modeled as total plant cover that provides the basic energy source (both directly and indirectly through plant debris and detritus). Secondary production and the potential complexity of the food webs in the wetland are modeled by including the scores for the invertebrate and bird models.

Opportunity for production and export was judged to be a function of the average rainfall. AUs located in drier parts of the Basin play a more important role in providing support to the terrestrial food webs. The relative regional primary production is lower in deserts, and the primary and secondary production from wetlands are, therefore, proportionally more important to the region. All wetlands in the Basin were judged, however, to have some opportunity for export of production. The assessment team decided it is not appropriate to score any wetland as a zero since that might imply there is not export. The model, therefore, was scaled for a range of function indices from 5 – 10, rather than from 0 – 10.

6.13.3 Model at a Glance

Depressional Long-duration **Supporting Food Webs**

Characteristics	Variables	Measures or Indicators
POTENTIAL		
Primary & Secondary	**Vvegcover**	% of AU that is vegetated
Production and Surface	**Vout**	AU has evidence of surface outflow
Export	**Sinverts**	Index of suitability from invertebrate model
	Sbirds	Index of suitability from bird model
OPPORTUNITY		
	Vprecip	Average annual rainfall for AU
Numerator for Potential	Vvegcover + Vout +Sinverts + Sbirds	
Numerator for Opportunity	Vprecip	

6.13.4 Description and Scaling of Variables

Variables for Potential

$\mathbf{V_{vegcover}}$ - Percent of the AU with plant cover.

Rationale: Overall, the plant cover found in the AU represents the primary photosynthetic input to the local ecosystem. Since direct photosynthesis cannot be measured, the amount of the AU actually covered by vegetation (as contrasted to open water, mud banks, rocks, etc.) is used as a surrogate.

Indicators: No indicators are needed. The percent of the AU covered by plants can be estimated directly.

Scaling: AUs completely covered by vegetation (cover 100%) are scored a [1] for this variable. Those with less are scored proportionally (%cover /100).

$\mathbf{V_{out}}$ - AU has surface water outflow at some time during the year.

Rationale: Surface outflow from an AU will carry dissolved and particulate organic matter into other aquatic and terrestrial systems. This organic matter will then be incorporated into the food web of those habitats.

Indicators: Presence of outlet and drainage features leading away from the outlet. Evidence of surface flow outside of AU including surface scour and sediment deposits.

Scaling: This is a "yes/no" variable. AUs with an outflow are scored a [1] for this variable, and those without are scored a [0].

$\mathbf{S_{inverts}}$ - The index score for the invertebrate suitability model.

Rationale: This variable acts as a surrogate for estimating export of secondary productivity and food web support for terrestrial species. After metamorphosis, wetland invertebrates typically disperse from wetlands for several miles into the surrounding upland habitat where they are preyed upon, primarily by birds. This represents secondary production that is being exported from the wetland and supporting organisms higher in the food chain that are not directly dependent on the wetland. Additionally, invertebrates that are not preyed upon will eventually die, contributing their nutrients to plant production in upland areas.

Indicators: No indicators are needed for this variable. The score from the invertebrate model is used.

Scaling: The variable is already scaled. It is normalized to 1 in the equation.

$\mathbf{S_{birds}}$ - The index score for the bird suitability model.

Rationale: Aquatic birds feed in wetlands, and excrete some of what they have consumed in adjacent terrestrial habitats since they are highly mobile. Also, the aquatic birds are preyed upon by hawks, falcons, and other predators. Both of these processes are an export of production in the AU to other ecosystems. AUs that have a high index score for aquatic bird richness have the potential to support a more complex terrestrial food web because different birds will excrete in different upland habitats and provide prey for a broader range of predators.

Indicators: No indicators are needed for this variable. The score from the bird model is used.

Scaling: The variable is already scaled. It is normalized to 1 in the equation.

Variables for Opportunity

$\mathbf{V_{precip}}$ - The average annual precipitation in the area of the AU.

Rationale: AUs located in drier parts of the Basin play a more important role in providing support to the terrestrial food webs. The relative regional primary production is lower in the deserts, and the production from wetlands are proportionally more important to the upland ecosystems.

Indicators: The average annual precipitation in the region of the AU can be determined from weather records maintained by the USGS.

Scaling: AUs in areas where the average annual precipitation is 8 inches or less are scored a 1 for this variable. Those with an average rainfall of 16 inches or less are scored a 0.5, and those with rainfalls between these two numbers are scored proportionally between 0.5 and 1.0.

6.13.5 Calculation of Potential

Depressional Long-duration Supporting Food Webs

Variable	Description of Scaling		Score for Variable	Result
Vvegcover	*Highest:*	AU is100% vegetated	If calculation =1, enter "1"	
	Lowest:	AU has minimal vegetation cover	If calculation = <0.05, enter "0"	
	Calculation:	Scaling is set as % vegetated/100	Enter result of calculation if <1	
	Calculate [sum (D16.1 to D16.4)] /100			
Vout	*Highest:*	If AU has a surface water outlet	IF D9 = 1 enter "1"	
	Lowest:	If AU has no outlet	IF D9 = 0 enter "0"	
Sinverts	*Score is scaled*	Index for Habitat Suitability for Invertebrates	(Index of function)/10	
Sbirds	*Score is scaled*	Index for Habitat Suitability for Birds	(Index of function)/10	
			Total of Variable Scores:	
		Index for Supporting Food Webs (Potential) = (Total of variables) x (2.60) rounded to the nearest 1		
			FINAL RESULT:	

6.13.6 Calculation of Opportunity

Depressional Long-duration Supporting Food Webs

Variable	Description of Scaling		Score for Variable	Result
Vprecip	*Highest:*	AU has 8 in rain/year or less	If calculation >=1, enter "1"	
	Lowest:	AU has > 16 inches rain/year	If calculation <= 0.5, enter "0.5"	
	Calculation:	Scaling is set as (8/rainfall)	Enter result of calculation if 0.5 <= calculation <1	
	Calculate 8 / D29			
			Total of Variable Scores:	
		Index for Supporting Food Webs (Opportunity) = (Total of variables) x (10) rounded to the nearest 1		
			FINAL RESULT:	

7. Method for Assessing Depressional Freshwater, Short-duration, Wetlands

The method includes models for the following functions.

Removing Sediment

Removing Nutrients/Phosphorus

Removing Nutrients/Nitrogen

Removing Heavy Metals and Toxic Organics

Decreasing Downstream Erosion and Flooding

Recharging Groundwater

General Habitat

Habitat for Invertebrates

Habitat for Amphibians

Habitat for Aquatic Birds

Habitat for Aquatic Mammals

Richness of Native Plants

Supporting Local Food Webs

7.1 Removing Sediment—Depressional short-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

7.1.1 Definition and Description of Function

Removing sediment is defined as the wetland processes that retain sediment in a wetland, and prevent its movement downstream.

A wetland performs this function if there is a net annual decrease of sediment load to downstream surface waters in the watershed. Settling and filtration are the major processes by which sediment is removed from surface water (either streamflow or sheetflow) in wetlands. Particles present in the water will tend to settle out when water velocity and turbulence reduced (Mitsch and Gosselink, 1993). The size of the particles that settle out is directly related to the increase in settling time achieved in the wetland. Filtration is the physical adhesion and cohesion of sediment facilitated by vegetation.

7.1.2 Assessing this Function for Depressional Short-duration Wetlands

The potential of depressional short-duration wetlands to remove sediment is a function of their ability to reduce water velocities and by vegetation structure near the ground surface that act as a filter (Adamus et al. 1991). Velocity reduction cannot be estimated directly in a rapid assessment method. The amount of storage (Adamus et al. 1991) is used as a variable that captures one aspect of velocity reduction – volume of water stored. The potential for filtration is modeled by amount of the AU that is covered by erect vegetation (emergent, scrub/shrub, and forest).

If, however, the AU has no outlet it has the potential to remove sediment at the highest levels. It will be scored a [10] regardless of other characteristics. All sediments coming into the AU are retained and not released to surface waters. Therefore, the AU is performing at its maximum potential.

Depressional AUs in the Basin with outlets, however, also remove sediments fairly effectively. The outlets in the reference sites all have been small, narrow, and generally filled with vegetation. None of the reference AUs with an outlet were judged to remove sediments poorly. The assessment team decided it was not appropriate to score any wetland as a zero since that might imply there is not sediment removal. All sites were judged to scored at least a [7] out of [10]. The model is scaled so no AU will score less than a [7].

The opportunity that an AU has to remove sediment is a function of the level of disturbance in the landscape. Relatively undisturbed watersheds will carry much lower sediment loads than those that have been impacted by human activities (Hartmann et al. 1996, Reinelt and Horner 1995). The opportunity that an AU has to remove sediment, therefore, is linked to the amount of development or agriculture present in the upgradient part of its contributing basin. Conditions in the buffer around an AU are also important in determining whether sediments can reach it. Buffers with intact natural vegetation will trap sediments coming from the surrounding landscape before they reach the AU. The slope of the contributing watershed also plays a role. Watersheds with steep gradients tend to have higher water velocities and more sediment transport.

7.1.3 Model at a Glance

Depressional Short-duration		**Removing Sediment**
Process	**Variables**	**Measures or Indicators**
POTENTIAL		
Velocity reduction	**Vstorage**	Elevation difference between bottom of AU and flood marks
Sediments leaving	**Vout**	Presence/absence of outlet
	Voutletw/inund	The ratio outlet width to area of inundation
Filtration	**Vvegcover**	% of AU that is vegetated
OPPORTUNITY		
Buffer interception	**Vbuffcond**	Descriptive characterization of condition of buffer
	Vbufferbypass	Presence of ditch/drain that routes surface flow around buffer
Upgradient sediment sources	**Vupsedim**	Upgradient sources of sediment within 1km
	Vslope	Degree of slope in contributing basin
Numerator for Potential	Vstorage + Vout +Voutletw/inund + Vvegcover	
Numerator for Opportunity	Vbuffcond+Vbufferbypass+Vupsedim+Vslope	

7.1.4 Description and Scaling of Variables

Variables for Potential

V_{storage} - The average volume of water stored in AU between high and low water. It is assessed as the average depth of annual inundation over the AU because the variable is scaled on a per acre basis.

Rationale: Vstorage is a measure of the volume of storage available. It is related to velocity reduction because flows into the AU will be slowed as it is filled. AUs that store water tend to trap more sediment than those that do not (Fennessey et al. 1994).

Indicators: The variable for storage is assessed as the difference in elevation between the lowest point of the AU and any flood marks or water marks in the AU or along the shore. To estimate the average depth of storage in the AU the maximum depth of storage is corrected by a factor representing the average cross section of the inundated areas in the AU. The calculation provides an average depth of storage across the area that is seasonally inundated.

Scaling: AU's with 0.5m or more of average annual storage are scored a [1]. Those with less are scaled proportionally less as storage(m)/0.5.

$\mathbf{V_{out}}$ - Presence/absence of outlet.

Rationale: All sediments coming into the AU are retained and not released to surface waters downgradient if the AU has no outlet.

Indicators: No indicators are needed. The presence/absence of an outlet is determined in the field.

Scaling: AUs with no outlet have the potential to remove sediment at the highest levels and are scored a [10] for the function. AUs with an outlet are scored a [7] at a minimum, with a higher score possible based on the amount of storage and vegetation present.

$\mathbf{V_{outletw/inund}}$– The ratio of outlet width to the area of inundation.

Rationale: The ratio of the outlet width to the area of brief inundation is a predictor of the degree of downstream erosion. The lower the value of the ratio the more slowly a wetland releases water thereby reducing downstream velocities and potential for erosion.

Indicators: The width of the outlet can be directly measured. The area of brief inundation will be mapped, based on field indicators of high water marks on rocks and vegetation. This variable is treated as a dimensionless number based on areal measurements in hectares and the width measurement in meters.

Scaling: AUs with a ratio <= to 1 will score a [1] for this variable. Those with a higher ratio are scaled proportionally (1/ratio).

$\mathbf{V_{vegcover}}$ - Percent area of AU that is covered by vegetation.

Rationale: Plants enhance sedimentation by providing a medium that acts as a filter, and causes sediment particles to drop to the AU surface. In the Columbia Basin it is assumed that vegetation need not be erect and persistent to trap sediment. The assessment team judged that aquatic bed vegetation will trap sediments as well as erect herbaceous plants, trees, and shrubs because of the low water velocities usually associated with depressional AUs in this region.

Indicators: No indicators are needed. The areal extent of the vegetation can be estimated directly at the AU site.

Scaling: AUs with 100% vegetation cover score a [1] for this variable. Those with less are scored proportionally (% cover/100).

Variables for Opportunity

$\mathbf{V_{buffcond}}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: Conditions in the buffer around an AU are also important in determining whether sediments can reach it. Buffers with intact natural vegetation will trap sediments coming from the surrounding landscape before they reach the AU (review in Desbonnet, et al. 1994). Undisturbed, vegetated buffers reduce the opportunity an AU has to receive sediments.

Indicators: This variable is assessed using the buffer categorization described in Part 2.

Scaling: AUs with a buffer category of 0 (most disturbed buffer) are scaled a [1]. Those with a category of 5 are scaled a [0]. Categories of 1-4 are scaled proportionally between 0.8 – 0.2.

$\mathbf{V_{bufferbypass}}$ **-** Ditches or drains that route surface waters around the buffer and directly into the AU.

Rationale: Ditches or drains that route surface waters around the buffer and directly into the AU reduce the sediment trapping processes in the buffer. As a result, more sediment is delivered to the AU. This increases the opportunity that an AU has to trap sediments.

Indicators: None needed. Direct observation of ditches/drains that would capture surface runoff and route it around the buffer directly into the AU.

Scaling: This is a “yes/no” variable. An AU scores a [1] for the variable if there is a channel bypassing the buffer, and a [0] if there is no channel.

$\mathbf{V_{upsedim}}$ - Conditions and land uses in the upgradient basin or watershed that add sediment to surface waters flowing into the AU.

Rationale: Densely vegetated watersheds (e.g. undisturbed forest) stabilize soils, reduce runoff velocity, and thus export less sediment (Bormann et al. 1974, Chang et. al. 1983). In contrast, residential, urban, agricultural, or logged watersheds have more exposed soils and thus higher sediment loading. AUs with upgradient disturbances to the contributing basin will have a greater opportunity to remove sediment and improve water quality than those in undisturbed watersheds.

Indicators: The indicators for upgradient sediment loading are the presence of land uses that generate sediments such as tilled fields, pasture, urban, commercial, and residential areas. Only the areas that are within 1km of the AU and within the contributing basin are considered.

Scaling: AUs with land uses that increase sediment loads within 1km of the AU are scored a [1] for this variable. AUs with no such lands uses are scored a [0].

V_{slope} - The average percent slope of the stream channels within the contributing basin of the AU.

Rationale: Contributing basins with steeper gradients (% slope) will transport sediment more readily downslope to an AU than contributing basins with relatively shallow gradients.

Indicators: None needed. Measured directly with clinometer or from USGS maps using contour intervals.

Scaling: AUs whose contributing basins have a slope of 5% or more are scaled a [1] for this variable. Those with a slope of 1=5% are scored a [0.5] and those with a slope of <1% are scored a [0] variable.

7.1.5 Calculation of Potential Performance

Depressional Short-duration Removing Sediment

Variable		Description of Scaling	Score for Variable	Results
Vout	*Highest:*	If AU has no outlet	**IF D9 = 0**	
			Enter 10 in "Final Result"	
		If AU has an outlet	Do calculations below	
Vstorage	*Highest:*	Average depth of annual storage >= 0.5m	If calculation >= 1 Enter '1'	
	Lowest:	No annual storage	If calculation=0 enter "0"	
	Calculation:	Scaling is set as average depth/0.5	Enter result of calculation if< 1	
	Calculate D9 x [(D14.1 x 0.67) + (D14.2 x 0.5) + (D14.2 x 1)] / 0.5			
Voutletw/inund	*Highest:*	Ratio <= 1.0	If calculation >=1.0 enter "1"	
	Lowest::	Ratio > 20	If calculation < 0.05 enter '0'	
	Calculation:	Scaling is set as 1/ratio if ratio>1	Enter result of calculation if < 1.0	
	Calculate 1/[D15/(D1 x D10.1 x 0.01)] IF D15 = 0 enter a [1] for result			
Vvegcover	*Highest:*	AU is100% vegetated	If calculation =1, enter "1"	
	Lowest:	AU has minimal vegetation cover	If calculation =<0.05, enter "0"	
	Calculation:	Scaling is set as % vegetated/100	Enter result of calculation if <1	
	Calculate [sum (D16.1 to D16.4)] /100 to get result			
			Total of Variable Scores:	
			Index for Removing Sediment (Potential) = (7 + (Total of Variables x 0.72)) rounded to nearest 1	
			FINAL RESULT:	

7.1.6 Calculation of Opportunity

Depressional short-duration Removing Sediment

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 0	If D39 = 0, enter "1"	
	High:	Buffer category of 1	If D39 = 1, enter "0.8"	
	Moderate:	Buffer category of 2	If D39 = 2, enter "0.6"	
	Medium Low:	Buffer category of 3	If D39 = 3, enter "0.4"	
	Low:	Buffer category of 4	If D39 = 4, enter "0.2"	
	Lowest:	Buffer category of 5	If D39 = 5, enter "0"	
Vbufferbypass	*Highest:*	AU has surface water bypass through buffer	If D40 = 1 Enter "1"	
	Lowest:	No surface water bypass	IF D40 = 0 Enter "0"	
Vupsedim	*Highest:*	Human land uses present within 1km	If calculation >=1enter '1'	
	Lowest:	No human land uses in basin	If calculation = 0 enter "0"	
	Calculate D7.9+D7.10+D7.11+D7.12			
Vslope	*Highest:*	Slope in contributing basin >=5%	If D2.1=2, enter "1"	
	Medium	Slope in basin <0.05%	If D2.1=1, enter "0.5"	
	Lowest:	Scaling is set as slope/5	If D2.1=2, enter "0"	
			Total of Variable Scores:	
Index for Removing Sediment (Opportunity) = Total x 2.8 rounded to nearest 1				
			FINAL RESULT:	

7.2 Removing Nutrients/Phosphorous — Depressional Short-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

7.2.1 Definition and Description of Function

Removing Nutrients/Phosphorus is defined as the wetland processes that remove dissolved or particulate phosphorus, and prevent the down-gradient movement of the nutrient.

A wetland performs this function if there is a net annual decrease in the amount of phosphorus going to down-gradient waters (either surface or groundwater) in the watershed. The major processes by which wetlands reduce phosphorus are: 1) through the trapping of sediment to which phosphorus is adsorbed, and 2) removal of dissolved phosphorus by adsorption to soils that are high in clay content or organic matter (Mitsch and Gosselink 1993).

Plant uptake of nutrients is not modeled because the amount of phosphorus taken up by plants is only a very small part of the phosphorus budget in an AU. Over 80% of the incoming phosphorus is bound up with sediments as particulate phosphorus (for review see Adamus et al. 1991). The remaining 20% are dissolved, but most of this will be bound up and precipitated by inorganic processes.

7.2.2 Assessing this Function for Short-duration Wetlands

The potential that depressional short-duration wetlands have to remove phosphorus from water is modeled on their ability to trap sediments and to adsorb the compound to soils within the wetland. The ability to trap sediments is characterized by the index generated in the "Removing Sediments" model. The sorptive properties of the surface soils are estimated based on the organic or clay content of the soils since these are the two types of soils with the highest rates of adsorption (Mitsch and Gosselink 1993).

The opportunity that an AU has to remove phosphorus is a function of the level of human generated phosphorus in the contributing basin and the routing on that phosphorus to the AU. Relatively undisturbed watersheds will carry much lower phosphorus loads than those that have been impacted by human activities (Hartmann et al. 1996, Reinelt and Horner 1995). The opportunity that a AU has to remove phosphorus, therefore, is linked to the amount of agriculture and grazing present in the upgradient part of its contributing basin, and whether it is impacted by waters from the Reclamation Project. Conditions in the buffer around an AU are also important in determining whether phosphorus can reach it. Buffers with intact natural vegetation will trap phosphorus-laden sediment originating form the surrounding landscape and prevent it from reaching the adjoining AU (review on Desbonnet et al. 1993).

7.2.3 Model at a Glance

Depressional Short-duration **Removing Nutrients/Phosphorus**

Process	Variables	Measures or Indicators
POTENTIAL		
Trapping sediment	**Ssed**	Index of potential for Removing Sediments
Adsorption	**Vsorp**	% of AU with clay soil % of AU with organic soil
OPPORTUNITY		
Conditions in buffer	**Vbufferbypass**	Presence of ditch/drain that routes surface flow around buffer
	Vbuffcond	Descriptive characterization of condition of buffer
Upgradient nutrient sources	**Vupnut**	Upgradient tilled field (irrigated agriculture), pasture or residential areas
Numerator for Potential	3xSsed + Vsorp	
Numerator for Opportunity	Vbufferbypass + Vbuffcond + Vupnut	

7.2.4 Description and Scaling of Variables

$\mathbf{S_{sed}}$ - Index of potential for Removing Sediments.

Rationale: The score is used to model the removal of phosphorus from incoming waters because much of this nutrient comes into a AU already bound to particulate sediments (for a review see Adamus et al. 1991).

Indicators: No indicators are needed. The variable is a score from another model of a function.

Scaling: The variable is already scaled. Removal of phosphorus by sedimentation was considered to be significantly more important than removal by adsorption (for review see Adamus et al. 1991), and this variable was weighted by a factor of 3 in the equation. A factor of 3 gave the best calibration of the model to the judgements.

$\mathbf{V_{sorp}}$ - The sorptive properties of the surface soils present in an AU.

Rationale: The uptake of dissolved phosphorus through adsorption to soil particles is highest when the soils are high in clay content or organic content (Mitsch and Gosselink, 1993).

Indicators: The indicator for sorptive properties of surface soils is the extent of the AU with high content of clay or organic matter in the surface layers.

Scaling: This variable is assessed based on five categories of areal extent (75-100%, 50 – 74%, 25 – 49%, 1 – 24%, and 0%). Scaling for this variable is [1, 0.75, 0.5, 0.25, and 0] for these categories respectively. The total areas of clay soils and organic soils are added together to estimate the total area of soils with sorptive properties.

Variables for Opportunity

$V_{bufferbypass}$ -Ditches or drains that route surface waters around the buffer and directly into the AU

Rationale: Ditches or drains that route surface waters around the buffer and directly into the AU reduce the phophorus removal processes in the buffer. As a result, more phosphorus can be delivered to the AU. This increases the opportunity that an AU has to trap nutrient coming from upgradient sources.

Indicators: None needed. Ditches/drains that capture surface runoff and route it around the buffer directly into the AU can be observed during the site visit.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there is a channel bypassing the buffer, and a [0] if there is no channel.

$V_{buffcond}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: Conditions in the buffer around an AU are also important in determining whether nitrogen can reach it. Buffers with intact natural vegetation will trap nitrogen coming from the surrounding landscape before they reach the AU (review in Desbonnet, et al. 1994). Undisturbed, vegetated buffers reduce the opportunity an AU has to receive nitrogen.

Indicators: This variable is assessed using the buffer categorization described in Part 2.

Scaling: AUs with a buffer category of 0 is scaled a [1]. Those with a category of 5 are scaled a [0]. Categories of 1-4 are scaled proportionally between 0.8 – 0.2.

V_{upnut} - Conditions in the contributing basin that add nutrients to surface water.

Rationale: This variable characterizes those land uses or conditions in the contributing basin that usually result in high levels of nutrients being delivered to the AU through surface waters.

Indicators: The indicator for upgradient nutrient sources is the amount of the contributing basin that is developed as tilled fields, irrigated fields, pasture, or residential areas.

Scaling: AUs whose contributing basin has more than 60% in agriculture (tilled or irrigated) or is grazed are scaled a [1] for this variable. Those with less are scaled proportionally (% agriculture or grazing / 60).

7.2.5 Calculation of Potential

Depressional Short-duration Removing Nutrients/Phosphorus

Variable	Description of Scaling		Score for Variable	Result
Ssed	*Score is scaled*	Index for Removing Sediment	**3 x** (Index of function)/10	
Vsorp	*Highest:*	Organic and/or clay soils 100% of AU	If D44.3 = 0 enter “1”	
	High:	Organic and/or clay soils 75% of AU	If D44.3 = 1 enter “0.75”	
	Moderate:	Organic and/or clay soils 50% of AU	If D44.3 = 2 enter “0.5”	
	Low:	Organic and/or clay soils 25% of AU	If D44.3 = 3 enter “0.25”	
	Lowest:	Organic and/or clay soils 0% of AU	If D44.3 = 4 enter “0”	
			Total of Variable Scores:	
Index for Removing Phosphorus (Potential) = Total x 2.5 rounded to nearest 1				
			FINAL RESULT:	

7.2.6 Calculation of Opportunity
Depressional Short-duration Removing Nutrients/Phosphorus

Variable	Description of Scaling		Score for Variable	Result
Vbufferbypass	*Highest:*	AU has surface water bypass through buffer	If D40 = 1 Enter "1"	
	Lowest:	No surface water bypass	IF D40 = 0 Enter "0"	
Vbuffcond	*Highest:*	Buffer category of 0	If D39 = 0, enter "1"	
	High:	Buffer category of 1	If D39 = 1, enter "0.8"	
	Moderate:	Buffer category of 2	If D39 = 2, enter "0.6"	
	Medium Low:	Buffer category of 3	If D39 = 3, enter "0.4"	
	Low:	Buffer category of 4	If D39 = 4, enter "0.2"	
	Lowest:	Buffer category of 5	If D39 = 5, enter "0"	
Vupnut	*Highest:*	Nutrient sources in basin >60%	If calculation >=1enter "1"	
	Lowest:	No nutrient sources in basin	If calculation = 0 enter "0"	
	Calculation:	Scaling = nutrient sources/60	Enter result of calculation if <1	
	Calculate (D7.2 + D7.3 + D7.4 +D7.5 + D7.6)/60			
			Total of Variable Scores:	
Index for Removing Phosphorus (Opportunity) = Total x 3.6 rounded to nearest 1				
			FINAL RESULT:	

7.3 Removing Nutrients/Nitrogen — Depressional Short-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

7.3.1 Definition and Description of Function

Removing Nutrients/Nitrogen is defined as the wetland processes that remove dissolved nitrogen compounds present in surface waters or groundwater, and prevent the downgradient movement of the nutrient.

A wetland performs this function if there is a net annual decrease in the amount of nitrogen in down-gradient waters (either surface or groundwater) within the watershed. The major processes by which wetlands remove nitrogen are through bacterial transformations of nitrogen (nitrification and denitrification) (Mitsch and Gosselink 1993).

In depressional wetlands of the Basin some of the nitrogen removal will also occur through the transformation of inorganic nitrogen to organic nitrogen.

7.3.2 Assessing this Function for Depressional Short-duration Wetlands

The potential of wetlands to remove nitrogen is modeled by assessing the area of the AU that undergoes a seasonal oxic/anoxic cycling. Seasonal redox potentials that reflect this cycling, however, cannot be measured in an AU during a rapid assessment. The indicator used is the percent of the AU that is seasonally inundated. It is assumed that areas inundated for shorter periods (brief inundation) are mostly oxic and are not anaerobic for enough time to stimulate the denitrification process.

In the Columbia Basin it is often difficult to determine whether the period of inundation is long enough to cause denitrification. The area of decomposed organic matter near the surface (Vorg) is also used as a surrogate to indicate areas of the AU that might undergo the necessary cycling of oxic and anoxic conditions. Organic soils near the surface indicate that an AU has long periods of anoxic conditions near the surface.

The opportunity that a wetland has to remove nitrogen is a function of the level of human generated nitrogen in the contributing basin and the routing of that nutrient to the AU. Relatively undisturbed watersheds will carry much lower nitrogen loads than those that have been impacted by human activities (Hartmann et al. 1996, Reinelt and Horner 1995). The opportunity that a wetland has to remove nitrogen, therefore, is linked to the amount of agriculture and grazing present in the upgradient part of its contributing basin, and whether it is impacted by waters from the Reclamation Project.

7.3.3 Model at a Glance

Depressional Short-duration **Removing Nutrients/Nitrogen**

Process	Variables	Measures or Indicators
POTENTIAL		
Denitrification/ Nitrification	**Vsow**	% Area of seasonal inundation
	Vorg	% area of organic soils in AU
OPPORTUNITY		
Upgradient nutrient sources	**Vbuffcond**	Descriptive characterization of condition of buffer
	Vproject	AU within the Reclamation Project Area (2X)
	Vupnut	Upgradient tilled field (irrigated agriculture), pasture or residential areas
Numerator for Potential	Vsow + Vorg	
Numerator for Opportunity	Vbuffcond +Vproject+ Vupnut	

7.3.4 Description and Scaling of Variables

Variables for Potential

V_{sow} - Percent of the AU with seasonal inundation (2-9 months).

Rationale: Nitrogen transformation occurs in areas of the AU that undergo changes between oxic and anoxic regimes. The oxic regime is needed to change ammonium ions (NH_4^+) to nitrate, and the anoxic regime is needed for denitrification by bacteria (changing nitrate to nitrogen gas) (Mitsch and Gosselink 1993). The indicator used is the percent of the AU that is seasonally inundated. It is assumed that areas inundated for shorter periods (brief inundation) are mostly oxic and are not anaerobic for enough time to stimulate the denitrification process.

Indicators: The indicator for the zone where oxic and anoxic regimes are present is the total area that is seasonally inundated area minus the area of brief inundation (e.g. less than 2 months of inundation). The assumption for using this indicator is that areas that have seasonal inundation (more than 2 months) are saturated for a long enough period to develop anoxic conditions and thus promote denitrification. As the short-duration area dries out later in the growing season oxic conditions are re-introduced that promote nitrification. Brief inundation (less than 2 months inundation) is not always of sufficient length to create anoxic conditions.

Scaling: AUs whose area of seasonal inundation is 50% or greater are scaled a [1] for this variable. Those with less are scaled proportionally (% area/50).

V_{org} - The percent of the AU that is covered by organic soils near the surface.

Rationale: In the Columbia Basin it is often difficult to determine whether the period of inundation is long enough to cause denitrification. The area of organic matter (Vorg) is used as another surrogate to indicate areas of the AU that might undergo the necessary cycling of oxic and anoxic conditions. Organic soils will build up only if there are long periods of anoxic conditions that reduce the rate of decomposition.

Indicators: The extent of organic soils can be determined during the site visit.

Scaling: This variable is assessed based on four five categories of areal extent (75-100%, 50 – 74%, 25 – 49%, 1 – 24%, and 0%). Scaling for this variable is [1, 0.75, 0.5, 0.25, and 0] for these categories respectively.

Variables for Opportunity

$V_{buffcond}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: Conditions in the buffer around an AU are also important in determining whether nitrogen can reach it. Buffers with intact natural vegetation will trap nitrogen coming from the surrounding landscape before they reach the AU (review in Desbonnet, et al. 1994). Undisturbed, vegetated buffers reduce the opportunity an AU has to receive nitrogen.

Indicators: This variable is assessed using the buffer categorization described in Part 2. The categorization is sequential. An AU is categorized by the highest criterion it meets.

Scaling: AUs with a buffer category of 0 is scaled a [1]. Those with a category of 5 are scaled a [0]. Categories of 1-4 are scaled proportionally between 0.8 – 0.2.

$V_{project}$ - AU lies within boundaries of Reclamation Project.

Rationale: AUs within the boundaries of the Reclamation Project, or whose water regime is influenced by it, will most likely have high nitrogen inputs because the groundwater and surface water in this area have high nitrogen levels (Williamson et al.1998). Much of the water flows in this area are agricultural "return waters" that pick up nitrogen from fertilized fields.

Indicators: No indicators needed. Boundaries of the Reclamation Project are mapped in Part 2.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if it is within the Reclamation Project, or influenced by it, and a [0] if it is not.

V_{upnut} - Conditions in the contributing basin that add nutrients to surface water.

Rationale: This variable characterizes those land uses or conditions in the contributing basin that usually result in high levels of nutrients being delivered to the AU through surface waters.

Indicators: The indicator for upgradient nutrient sources is the amount of the contributing basin that is developed as tilled fields, irrigated fields, pasture, or residential areas.

Scaling: AUs whose contributing basin has more than 80% in agriculture (tilled or irrigated) or is grazed are scaled a [1] for this variable. Those with less are scaled proportionally (% agriculture or grazing / 80).

7.3.5 Calculation of Potential Performance

Depressional Short-duration Removing Nutrients/Nitrogen

Variable	Description of Scaling		Score for Variable	Result
Vsow	*Highest:*	Seasonal inundation >= 50%	If calculation >=1enter '1'	
	Lowest:	0% seasonal inundation	If calculation = 0 enter "0"	
	Calculation:	Scaling = % AU inundated / 50	Enter result of calculation if <1	
	Calculate (D10.2)/50			
Vorg	*Highest:*	AU has >75% organic soils	If calculation =1enter '1'	
	Lowest:	AU has no organic soils	If calculation = 0 enter "0"	
	Calculation:	Scaling based on % organic soil	Enter result of calculation if <1	
	Calculate (D44.1 + D44.2)/4			
			Total of Variable Scores:	
Index for Removing Nitrogen (Potential) = Total x 5.0 rounded to nearest 1				
			FINAL RESULT:	

7.3.6 Calculation of Opportunity
Depressional Short-duration Removing Nutrients/Nitrogen

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 0	If D39 = 0, enter "1"	
	High:	Buffer category of 1	If D39 = 1, enter "0.8"	
	Moderate:	Buffer category of 2	If D39 = 2, enter "0.6"	
	Medium Low:	Buffer category of 3	If D39 = 3, enter "0.4"	
	Low:	Buffer category of 4	If D39 = 4, enter "0.2"	
	Lowest:	Buffer category of 5	If D39 = 5, enter "0"	
Vproject	*Highest:*	AU is in, or influenced by, project	If D3 OR D4 = 1 Enter "1"	
	Lowest:	AU not influenced by project	If D3 OR D4 = 0 Enter "0"	
Vupnut	*Highest:*	Nutrient sources in basin >80%	If calculation >=1enter '1'	
	Lowest:	No nutrient sources in basin	If calculation = 0 enter "0"	
	Calculation:	Scaling = nutrient sources/80	Enter result of calculation if <1	
	Calculate (D7.2 + D7.3 + D7.4 +D7.5 + D7.6)/80			
			Total of Variable Scores:	
Index for Removing Nitrogen (Opportunity) = Total x 3.33 rounded to nearest 1				
			FINAL RESULT:	

7.4 Removing Metals and Toxic Organic Compounds — Depressional Short-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

7.4.1 Definition and Description of Function

Removing Metals and Toxic Organic Compounds is defined as the wetland processes that retain toxic metals and toxic organic compounds coming into the wetland, and prevent the down gradient movement of these constituents.

A wetland performs this function if there is a net annual decrease in the amount of toxic metals and toxic organic compounds flowing to down gradient waters (either surface or groundwater) in the watershed. The major processes by which AUs reduce metals and toxic organic loading to downgradient waters are through:

- sedimentation of particulate metals,
- adsorption,
- chemical precipitation, and
- plant uptake.

Metals that tend to have a high particulate fraction, such as lead (Pb), may be removed through sedimentation. Adsorption is promoted by soils high in clay content or organic matter. Chemical precipitation is promoted by areas that are inundated and remain aerobic, as well as those with pH values below 5 (Mengel and Kirkby 1982). Finally, plant uptake of toxics is maximized when there is significant cover of emergent plants (Kulzer 1990).

7.4.2 Assessing this Function for Depressional short-duration Wetlands

The potential that AUs in the depressional short-duration subclass have to remove metals and toxic organic compounds is assessed by their ability to reduce water velocities and trap sediment that might contain toxic compounds, and specific characteristics that indicate potential for adsorption, precipitation and uptake by plants. The index for sediment removal is used to simplify the model. Adsorption, precipitation and uptake by plants are each modeled by a separate variable.

The opportunity of an AU to remove metals and toxic organic compounds is modeled using the land uses of the upgradient watershed and the amount of development immediately adjacent to the AU. Those land uses or activities that contribute metals and toxic organics to surface waters include urban and residential areas and agricultural activities involving pesticide/herbicide applications. Opportunity resulting from high levels of toxic compounds in groundwater could not be modeled because the source of groundwater to an AU cannot be determined with any level of accuracy in a rapid assessment method.

7.4.3 Model at a Glance

Depressional Short-duration **Removing Metals &Toxic Organics**

Process	Variables	Measures or Indicators
POTENTIAL		
Sedimentation	**Ssed**	Index of potential for Removing Sediments
Adsorption	**Vsorp**	% of AU with clay soil
		% of AU with organic soil
Precipitation	**Vphow**	pH of standing water
Plant uptake	**Vherbaceous**	% of AU with emergent vegetation and herbaceous understory
OPPORTUNITY		
Upgradient sources of toxic compounds	**Vdevelopment**	Presence of permanent development in buffer
	Vuptox	Agricultural and urban areas in upgradient contributing basin
Routing through buffer	**Vbufferbypass**	Presence of ditch/drain that routes surface flow around buffer
Numerator for Potential	Ssed + Vsorp + Vphow +Vherbaceous	
Numerator for Opportunity	Vdevelopment + Vuptox + Vbufferbypass	

7.4.4 Description and Scaling of Variables

S_{sed} – Index score from the function "Removing Sediments."

Rationale: The index is used to model the removal of toxic compounds from incoming waters because many of them are transported into an AU already bound to particulate sediments (for a review see Adamus et al. 1991).

Indicators: No indicators are needed. The variable is an index score for a function.

Scaling: The index is already scaled and this is normalized to a range of 0 - 1.

V_{sorp} – The sorptive properties of the surface soils present in an AU.

Rationale: Adsorption of both toxic metals and toxic organic compounds is highest when the soils have a high cation exchange capacity (Mengel and Kirkby 1982). These are the soils high in either clay or organic content.

Indicators: The indicator for sorptive properties of soils is the extent of the AU with high content of clay or organic matter.

Scaling: This variable is assessed based on five categories of areal extent (75-100%, 50 – 74%, 25 – 49%, 1 – 24%, and 0%). Scaling for this variable is [1, 0.75, 0.5, 0.25, and 0] for these categories respectively. The total areas of clay soils and organic soils are added together to estimate the total area of soils with sorptive properties.

$\mathbf{V_{phow}}$ - The pH of standing water.

Rationale: Many toxic metals are precipitated out of water when the pH is low or high. At a low pH, precipitation occurs due to the presence of sulfides and at a high pH because more hydroxyl ions are present.

Indicators: pH of surface waters can be measured directly using pH tabs or meters.

Scaling: AUs whose pH is less than, or equal to, 6, and those whose pH is greater than 8 are scored a [1] for this variable. Those with a pH between 6 and 8 are scored a [0].

$\mathbf{V_{herbaceous}}$ - The percent of the AU covered by herbaceous plants.

Rationale: Herbaceous species have, in general, been found to sequester metals and remove oils and other organics better than other plant species (Hammer, et al. 1989; Horner, 1992). AUs dominated by herbaceous plants were judged to sequester toxic metals and remove organic compounds better than those dominated by aquatic bed, forest or scrub/shrub. Furthermore, when incoming water is exposed to the relatively large surface area of herbaceous vegetation, specialized microbes present on the vegetation surface effectively decompose toxicants.

Indicators: The areal extent of herbaceous vegetation is estimated in the field based on the area covered by the "emergent" vegetation class of Cowardin (1979).

Scaling: AUs with 60% coverage, or more, of emergent vegetation are scored a [1] for this variable. Those with less are scaled proportionally (% emergent / 60).

Variables for Opportunity

$\mathbf{V_{development}}$ – The presence of permanent development within the buffer such as roads and buildings

Rationale: Permanent development such as roads and buildings contribute metals and toxic organics from vehicles. This increases the potential inputs to an AU, and therefore, the opportunity for performing this function.

Indicators: None needed. Direct observation of paved roads and buildings.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there is development near the AU or roads that have a significant impact, and a [0] if there is none.

V_{uptox} - Conditions in the upgradient watershed or contributing basin that add toxic metals and toxic organic compounds to surface water.

Rationale: This variable characterizes those land uses or conditions in the contributing basin that usually result in higher levels of toxic compounds being delivered to the AU, either through surface waters or groundwater. Tilled fields and residential areas represent the addition of pesticides to the contributing basin; urban areas the addition of toxic metals.

Indicators: The indicator for upgradient nutrient sources is the amount of the contributing basin that is developed as tilled fields, urban, or residential.

Scaling: AUs with more than 5% urban areas in the contributing basin are scored a [1] for this variable. Those with more than 15% tilled or irrigated fields are scored a [0.5], and those with more than 1% high density residential are scored a [0.3]. All other conditions are scored a [0].

$V_{bufferbypass}$ – Ditches or drains that route surface waters around the buffer and directly into the AU.

Rationale: Ditches or drains that route surface waters around the buffer and directly into the AU reduce the ability of the buffer to trap toxic compounds before they reach the AU. As a result, more toxic compounds will be carried to the AU from surrounding sources. This increases, therefore, the opportunity for performance of the heavy metals and toxic organics removal function in the AU.

Indicators: None needed. Direct observation of ditches/drains that would capture surface runoff and route it around the buffer directly into the AU.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there is a channel bypassing the buffer, and a [0] if there is no channel.

7.4.5 Calculation of Potential Performance

Depressional Short-duration Removing Metals and Toxic Organics

Variable	Description of Scaling		Score for Variable	Result
Ssed	*Score is scaled*	Index for Removing Sediment	(Index of function)/10	
Vsorp	*Highest:*	Organic and/or clay soils 100% of AU	If D44.3 = 0 enter "1"	
	High:	Organic and/or clay soils 75% of AU	If D44.3 = 1 enter "0.75"	
	Moderate:	Organic and/or clay soils 50% of AU	If D44.3 = 2 enter "0.5"	
	Low:	Organic and/or clay soils 25% of AU	If D44.3 = 3 enter "0.25"	
	Lowest:	Organic and/or clay soils 0% of AU	If D44.3 = 4 enter "0"	
Vph	*Highest:*	pH <= 6 or pH >=8.0	If D25 <= 6 OR D25 >=8, enter "1"	
	Lowest::	pH between 6 and 8	If D25>6 and <8, enter "0"	
Vherbaceous	*Highest:*	>=60% of AU has herbaceous plants	If calculation = 1, enter "1"	
	Lowest:	AU has 0% of herbaceous plants	If calculation = 0, enter "0"	
	Calculation:	Scaling = (% of AU with emergents + understory/60)	Enter result of calculation if < 1	
	Calculate [D16.3 + (D17/100 x (D16.1+D16.2)] /60			
			Total of Variable Scores:	
Index for Removing Toxics (Potential) = Total x 2.63 rounded to nearest 1				
			FINAL RESULT:	

7.4.6 Calculations of Opportunity

Depressional Short-duration Removing Metals and Toxic Organics

Variable	Description of Scaling		Score for Variable	Result
Vdevelopment	*Highest:*	AU has development in buffer	If D41.6+D41.7>=2 Enter "1"	
	Lowest:	No development in buffer	If D41.6+D41.7< 2 Enter "0"	
Vuptox	*Highest:*	Urban sources in basin >5%	If D7.5 >=5 enter "1"	
	Moderately High:	Agricultural sources in basin >15%	If D7.3 + D7.4 >= 15 enter "0.5"	
	Moderately Low:	Residential sources in basin	If D7.5 >= 1 OR D7.6 >=5 enter '0.3"	
	Lowest:	No major toxic sources in basin	If none of above true enter "0"	
Vbufferbypass	*Highest:*	AU has surface water bypass through buffer	If D40 = 1 Enter "1"	
	Lowest:	No surface water bypass	IF D40 = 0 Enter "0"	
			Total of Variable Scores:	
Index for Removing Toxics (Opportunity) = Total x 3.33 rounded to nearest 1				
			FINAL RESULT:	

7.5 Reducing Downstream Erosion & Flooding — Depressional Short-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

7.5.1 Definition and Description of Function

Reducing Downstream Erosion and Flooding is defined as the wetland attributes that attenuate high flows and their erosive capacity.

Wetlands reduce downstream erosion and flooding by storing water, thus reducing the velocity and volume of water flowing downstream. The wetland retains runoff water and reduces downstream flows during storms (water has a higher retention time in the wetland than in the stream). The amount of retention provided is dependent on the available storage and the outlet capacity or the release rate of runoff. Wetlands, play an important role in detaining and slowing runoff during snowmelt.

The ability to reduce erosion and flooding depends on the amount of storage in a wetland. Prior to the snowmelt and any rain-on-snow events, many of the depressional wetlands in the Columbia Basin have significant storage capacity. They tend to have poorly defined, or very constricted, outlets and slow flow through the wetland at times of high water. These wetlands to capture and hold back the rapid runoff from the snowmelt and rain-on-snow events. The stored water slowly evaporates or infiltrates into groundwater. Water levels decline in the summer and the storage is available in winter for "rain-on-snow" events.

7.5.2 Assessing This Function for Depressional Short-duration Wetlands

The potential of depressional short-duration AUs to decrease downstream erosion and flooding is modeled as water storage and as a reduced rate of water leaving the wetland. The depth of annual inundation indicates storage capacity. The release rate is modeled by the outlet characteristics.

The opportunity for an AU to reduce peak flows will increase as upgradient watershed is developed/disturbed. Research in western Washington has shown that peak flows increase as the percentage of impermeable surface increases (Reinelt and Horner 1995). The opportunity for an AU to decrease erosion and flooding is also reduced in the Columbia Basin if it is within the boundaries of the Reclamation Project. Many wetlands within the Project have higher water levels during the summer and fall that result from irrigation-fed groundwater.

Users must make a qualitative judgement on the opportunity of the AU to actually reduce peak flows because a quantitative model could not be calibrated. None of the data collected during the calibration could be adequately correlated with the judgements of opportunity made by the Assessment Team. The conclusion of the Assessment Team was that too many variables were involved in making a judgement of opportunity, and a simple model could not be developed.

7.5.3 Model at a Glance
Depressional Short-duration Reducing Downstream Erosion and Flooding

Process	Variables	Measures or Indicators
POTENTIAL		
Storage	**Vstorage**	Elevation difference between bottom of AU and flood marks
Slowing release of water	**Voutletw/inund**	Ratio of outlet width to area of inundation
	Vinund/shed	Ratio of area of inundation to contributing basin
OPPORTUNITY		***Could not be calibrated, users make a qualitative judgement***
Numerator for Potential	2xVstorage + Voutletw/inund + Vinund/shed	

7.5.4 Description and Scaling of Variables

Variables for Potential

***V*storage** - The amount of storage available in the AU during an inundation or flooding event.

Rationale: Vstorage is a measure of the volume of storage available during major runoff events. The assessment team assumed that AUs having relatively more storage would decrease water velocities and peak flows more than those with less storage. This occurs because retention time is increased as volume of storage is increased for any given inflow (Fennessey et al. 1994).

Indicators: The indicator for the amount of storage in the AU is the difference in elevation between the lowest point of the AU and any flood marks, water marks, sediment deposits, dried algal mats or detritus on vegetation, rocks or cliffs along the shore. The depth of storage, as used in the model, is corrected by a factor reflecting the shape of the AU to estimate an average water depth over the entire portion that is inundated.

Scaling: AUs with an average depth of annual inundation that is greater than or equal to 0.5 m are scored a [1] for this variable. Those with less are scored proportionally (average depth / 0.5). This variable was judged to be more important than the others and is weighted by a factor of 2 in the equation.

$\mathbf{V_{inunda/outletw}}$ - The ratio of the outlet width to the area of inundation.

Rationale: The ratio of the outlet width to the area of seasonal inundation is a predictor of the degree of downstream erosion. The lower the value of the ratio the more slowly an AU releases water thereby reducing downstream velocities and potential for erosion.

Indicators: The width of the outlet can be measured directly. The area of annual inundation will be mapped, based on field indicators of high water marks on rocks and vegetation. This variable is treated as a dimensionless number based on areal measurements in hectares and the width measurement in m.

Scaling: AUs with a ratio <= to 2.4 will score a [1] for this variable. Those with a higher ratio will be scaled proportionally (2.4/ratio).

$\mathbf{V_{inund/shed}}$ - The ratio of the maximum area that is inundated every year in the AU to the area of its contributing basin.

Rationale: The potential of an AU to decrease erosion and flooding is partially a function of how much water flowing into the AU is held back relative to the amount flowing out. This relationship is called retention time. Retention time is the relative volume coming into an AU during a storm event divided the amount of storage present.

The area of the contributing basin is used as a surrogate for the relative amount of water (volume as cubic meters/second) entering the AU, while the area of inundation is used to estimate the relative volume stored. Large contributing basins are assumed to generate larger volumes of water for any given storm event than smaller basins. The ratio of the area inundated to the area of the contributing basin was used as a surrogate for retention time. As the ratio decreases, an AU's potential to reduce hold back storm flows is also reduced because its storage capacity is quickly used up. Much of the storm flow will therefore flow directly out of the AU without being retained.

Indicators: No indicators are needed. The ratio can be estimated from map measurements.

Scaling: AUs whose ratio is >= 0.1 are scored a [1] for this variable. Those whose ratio is smaller are scaled proportionally (ratio / 0.1).

7.5.5 Calculation of Potential *Depressional Short-duration* Reducing Erosion and Flooding

Variable	Description of Scaling		Score for Variable	Result
Vstorage	*Highest:*	Average depth storage >= 0.5 m	If calculation >=2 enter "2"	
	Lowest:	No storage	If calculation = 0 enter "0"	
	Calculation:	Scaling is set as average depth/0.5	Enter result of calculation if < 2	
	Calculate **2 x** [D12.1 x {(0.67 x D13.1) + (0.5 x D13.2) + (1 x D13.3)}]/0.5			
Voutletw/inund	*Highest:*	Ratio <= 2.4	If calculation >=1.0 enter "1"	
	Lowest::	Ratio > 48	If calculation < 0.05 enter '0"	
	Calculation:	Scaling is set as 2.4/ratio	Enter result of calculation if < 1.0	
	Calculate 2.4/[D15/(D1 x D10.1 x 0.01)] IF D15 = 0 enter a [1] for result			
Vinund/shed	*Highest:*	Ratio of area inundated to area of contributing basin is > = 0.1	If calculation >=1.0 enter "1"	
	Lowest:	0% of the AU is inundated	If calculation = 0 enter "0"	
	Calculation:	Scaling is based ratio/0.1	Enter result of calculation if < 1.0	
	Calculate [(D1 x D10.1 x 0.01)/D2]/0.1			
			Total of Variable Scores:	
	Index for Reducing Flooding (Potential) = Total x 2.50 rounded to nearest 1			
			FINAL RESULT:	

7.5.6 Qualitative Rating of Opportunity

The opportunity for an AU to reduce peak flows will increase as the water regime in the contributing basin is destabilized. Research in western Washington has shown that peak flows increase as the percentage of impermeable surface increases (Reinelt and Horner 1995). The opportunity should therefore be rated by the amount of the contributing basin that is developed.

Users must make a qualitative judgement on the opportunity of the AU to actually reduce peak flows by considering the land uses in the contributing watershed. The opportunity for an AU in the depressional short-duration subclass is **"Low"** if most of its contributing watershed is forested or undisturbed, and ungrazed, grasslands or shrub-steppe. The opportunity is also **"Low"** if the AU receives most of its water from groundwater, rather than from an incoming stream, ditches, or storm drains.

The opportunity for the AU is **"High"** if the contributing watershed is mostly urban with high density residential or is heavily grazed (i.e. cattle have destroyed much of the surface vegetation), or is in tilled agriculture. The opportunity is **"Moderate"** if the development or grazing is a small part of the contributing watershed, or if these areas are relatively far away from the AU. Users must use their judgement to decide whether the opportunity is low, moderate, or high, and document their decision on the summary sheet (see Part 2).

7.6 Recharging Groundwater — Depressional Short-duration Wetlands

> ***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

7.6.1 Definition and Description of Function

Recharging Groundwater is defined as the wetland attributes that allow infiltration of surface water into the groundwater system. Depressional wetlands in the Columbia Basin, however, are usually areas of groundwater discharge and will usually not be a major source of water to groundwater.

Generally, surface water in the Basin infiltrates through the glacio-fluvial and loess deposits or fissures of the underlying basaltic beds, eventually moving laterally along less permeable interbeds between individual basalt flows. When this groundwater intercepts the land surface, it forms a depressional or slope wetland. Other water sources to depressional wetlands include rain-on-snow events, direct snowmelt, and surface water runoff during thunderstorms.

The potential for recharge in depressional wetlands of the Columbia Basin occurs when wetlands collect precipitation and surface flows. These surface waters infiltrate underground. Wetlands that have high groundwater levels from irrigation or reservoirs will generally have limited recharge, particularly in the Potholes region around Moses Lake where the surficial geology consists of quaternary alluvial sands and gravels. Recharge is scored a maximum of 5 out of 10 in areas that are within the Reclamation Project. Recharge is not scored a [0] because some recharge may still occur during snowmelt or prolonged rainfall.

7.6.2 Assessing this Function for Depressional Short-duration Wetlands

Depressional wetlands outside the Reclamation Project

In depressional short-duration AUs (outside of the areas where water levels are controlled by irrigation or other artificial means) recharge when ponded waters are at their highest levels or when groundwater levels have declined significantly. During winter and early spring, rain and snowmelt will raise the water level in the wetland. The potential infiltration is modeled as this seasonal runoff and increase in water levels. The Assessment Team was unable to identify reliable indicators for assessing recharge that might occur during the late summer and fall from large storms, and this aspect of recharge was not modeled.

The Assessment Teams have judged that all AUs in the Columbia Basin of eastern Washington have a **"High"** opportunity to recharge either interflow or an unconfined aquifer if the surface soils within the AU are permeable enough. The assumption is that all AUs have some link to groundwater if they hold water for more than nine months.

Washington have a **"High"** opportunity to recharge either interflow or an unconfined aquifer if the surface soils within the AU are permeable enough. The assumption is that all AUs have some link to groundwater if they hold water for more than two to three months. Vernal pools, however, with brief periods of inundation may be independent of the groundwater system and will have a **Low** opportunity to for recharge.

7.6.3 Model at a Glance

Depressional Short-duration **Recharging Groundwater**

Process	Variables	Measures or Indicators
POTENTIAL		
Infiltration	**Vinfilt**	Rating of infiltration rate of soils
	Vannualinund	Area of annual inundation (as a percent of AU)
	Vsalt	Presence of surface salt
Hydraulic head	**Vdepthannual**	Maximum depth of brief periods of inundation
Reducers		
	Virrigation	Water levels controlled by human activities
	Vdrain	Presence of drain tiles or ditches
OPPORTUNITY		All AUs have high opportunity except those with brief periods of inundation
Numerator for Potential	(Vinfilt + Vannualinund + Vsalt + Vdepthannual) x Virrigation x Vdrain	

7.6.4 Description and Scaling of Variables

Variables for Potential

$\mathbf{V_{infilt}}$ - A rating of the infiltration capacity of the soils in the AU.

> **Rationale:** Infiltration can occur only where the soils are permeable. Some AUs in the Columbia Basin are formed on impermeable shallow lenses or have developed extensive peat deposits. These conditions hinder the recharge of groundwater. Recharge is an important process only if the soils have a high sand, gravel or cobble content, and a low content of clays, silts, or organic matter. The layer with the lowest infiltration in the top 60cm will be used to develop the rating.

Indicators: The indicator of infiltration is the relative amount of sand, silt, gravel, clay or organic matter present in the soils. Infiltration of soils is rated down to a depth of 60 cm (2ft) as either fast or slow.

Scaling: AUs with a fast infiltration rate are scored a [1] for this variable, and those rated as "slow" are scored a [0].

$V_{annualinund}$ - The area of the AU where infiltration occurs. The variable is measured as the percent of the AU that is annually inundated.

Rationale: Infiltration can occur only where the surface waters provide a hydraulic head to push water into the ground. Therefore, the effective area where infiltration occurs is the area that is seasonally inundated.

Indicators: Because the extent of "brief inundation" water in an AU can be determined in the field during the early part of the growing season after the spring snow melt, no indicator is needed.

Determination of the level of brief inundation during the dry season will require use of indicators such as deposition lines, dried aquatic bed or algae species left on the substrate and/or stems of persistent AU plants, water marks and/or discoloration on rock faces or vegetation.

Scaling: AUs with 80% or more of their area subject to brief inundation are scored a [1] for this variable. Those with less are scored proportionally (% area/80).

V_{salt} - The presence of salt deposits on the surface of AU soils.

Rationale: When standing water cannot infiltrate through AU soils, it evaporates in place leaving salt residues. The presence of a salt precipitate on soils or rocks indicates that infiltration rate is either very slow or non-existent**.**

Indicators: None needed. Direct observation of salt deposits.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there are no salt deposits, and a [0] if salt deposits are present.

$V_{depthannual}$ - The maximum depth of water of surface inundation.

Rationale: Infiltration is partly a function of the depth of the water (head) within an assessment unit. Increased water depth means that there is greater pressure to force water through soils and fractured rock formations. For AUs unaffected by irrigation, recharge probably occurs in late winter and early spring when the additional depth provided by surface water runoff creates a water level that is higher than the groundwater level.

Indicators: For AUs not influenced by irrigation the indicators would be the high water mark as indicated by discoloration on rocks, trees and emergent vegetation;

dried algal mats suspended on vegetation; sediment coating on rocks, trees and emergent vegetation. Measurement is made from the high water mark to the bottom of the AU.

Scaling: AUs with an annual depth of water that is 0.2m or greater are scored a [1] for this variable. Those with less are scored proportionally (depth / 0.2).

Reducers

$\mathbf{V_{drain}}$ - Presence/absence of drain tiles or ditches.

Rationale: Drain tiles and ditches will intercept water moving down through the soil column, reducing the amount of recharge occurring. Drains reduce the performance of the recharge function by decreasing the time water levels in an AU are higher than those in the groundwater.

Indicators: Records from the NRCS, physical evidence of tiles (outlets observed in ditches).

Scaling: AUs in which drains are present have their score for the other variables reduced by a factor of 0.8.

$\mathbf{V_{irrigation}}$ - Water levels controlled by irrigation and other human water control activities.

Rationale: wetlands that have developed because of high groundwater levels from irrigation will generally not be points of recharge. Therefore, any surface water present in these wetlands does not truly represent a "head" or pressure that forces this water into the groundwater. Under these circumstances, recharge is probably not occurring within the wetland. For this reason, the recharge is scored a maximum of 5 out of 10 in areas that are within the Reclamation Project or in other areas where water levels are controlled by irrigation or reservoirs. Recharge, however, is not scored a [0] because some recharge may still occur at very low levels during a rapid winter melt off.

Indicators: Records from the NRCS, the Reclamation Project, or evidence that the highest water levels are found in summer and early fall.

Scaling: AUs whose water levels are controlled by irrigation or human caused water level fluctuations are have their score multiplied by a factor of 0.5.

7.6.5 Calculation of Potential Performance

Depressional Short-duration **Recharging Groundwater**

Variable	Description of Scaling		Score for Variable	Result
Vinfilt	*Highest:*	Gravel, cobble, sand >50% of soil and silt, clays, and organics <30%	If D47.1 = 1, enter "1"	
	Lowest:	Silt, clay, and organics > 30% of soil	If D47.2 = 1, enter "0"	
Vannualinund	*Highest:*	>80% of the AU, is annually ponded or inundated	If calculation >= 1, enter "1"	
	Lowest:	0% of the AU is annually ponded	If calculation = 0, enter "0"	
	Calculation:	Scaling = (% of AU inundated/80)	Enter result of calculation if < 1.0	
	Calculate (D10.1)/80			
Vsalt	*Highest:*	No salt residues present	If D27 = 0 enter "1"	
	Lowest:	Salt residues present	If D27 = 1 enter "0"	
Vdepthannual	*Highest:*	Annual inundation >= 0.2m	If calculation >= 1.0 enter "1"	
	Lowest:	Annual inundation = 0 m	If calculation = 0, enter "0"	
	Calculation:	Scaling = height of inundation/ 0.2	Enter result of calculation if < 1.0	
	Calculate (D12.1)/0.2			
			Total of Variable Scores:	
Reducer				
Vdrain	AU has a drain present		If D28 = 1 enter "0.8"	
	AU has no drain present		If D28 =0 enter "1"	
Virrigation	Water level in AU controlled by irrigation		If D4 = 1 enter "0.5"	
	Water level in AU is not controlled by irrigation		If D4 = 0 enter "1"	
			Score for Reducer Multiply the score of two reducers	
Index for Recharging Groundwater(Potential) = (Total of Variables)x (Reducer) x 2.5 rounded to nearest 1				
			FINAL RESULT:	

7.6.6 Qualitative Rating of Opportunity

Groundwater is an integral component of the water cycle throughout eastern Washington. The Assessment Teams have judged that most depressional, freshwater, short-duration AUs in the Columbia Basin of eastern Washington have a **"High"** opportunity to recharge either interflow or an unconfined aquifer if the surface soils within the AU are permeable enough. The assumption is that all AUs have some link to groundwater, except those with only a brief period of inundation (less than 2-3 months). These may be independent of the groundwater system. The water regime of these AUs is dependent entirely upon precipitation, which is then rapidly lost through evaporation and evapotranspiration. These short-duration AUs are often called "vernal" pools. Vernal pools will have a "**Low**" opportunity to recharge groundwater because they will most likely be independent of the groundwater systems. Users will have to use their judgement to decide if an AU with only brief inundation is, or is not, connected to the groundwater system. For example, a small, shallow (<10cm) depression that collects water in a basalt ridge will probably not be connected to groundwater. A depression with 30-50 cm of sediment may be connected even if its period of inundation is very short.

7.7 General Habitat — Depressional Short-duration Wetlands

***Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.*

7.7.1 Definition and Description of Function

General Habitat is defined as the characteristics or processes present in a wetland that indicate a general suitability and opportunity as habitat for a broad range of species. The General Habitat function is not intended to be a duplicate assessment of the individual functions for each species group. Rather, it focuses on capturing those elements of the overall wetland ecosystem that provide for a wide or diverse variety of habitats used by many different animal species. It does not model the habitat for individual wetland species groups (e.g. birds, aquatic mammals, invertebrates, etc.).

Assessing habitat for non-wetland dependent species is particularly important in the Columbia Basin because wetlands here serve as an "oasis" within an otherwise arid and stressed environment.

A broad range of structures, vegetation, and interspersion of "habitat" types within the AU provide a suitable habitat for a suite of species. Characteristics in wetlands can be quite different but still provide highly suitable conditions for a range of species. The model tries to capture this diversity in structure by including many different variables even though a single AU may never contain all of them (see discussion in Chapter 2).

Many of the variables used to assess the performance of a wetland for general habitat are also used in the assessments of habitat suitability for individual species groups. The technical committee and assessment teams, however, thought it important to assess General Habitat in broad terms as well as assess the suitability of a wetland for groups of related species.

7.7.2 Assessing this Function for Depressional Short-duration Wetlands

An AU in the depressional short-duration subclass provides suitable habitat for a broad range of species if it has a complex physical structure. Variables chosen to model this structure include vegetation strata, different types of interspersion, and the presence of specific characteristics such as open water and mudflats.

The model is additive so that environmental characteristics add to the General Habitat Suitability of an assessment unit. The operative assumption is that the suitability of an AU for all animal species increases as the number of appropriate habitat characteristics (or niches) in the AU increase.

The opportunity is modeled based on characteristics in the landscape, such as corridors, that link the AU to other surrounding natural areas. These characteristics are included because they play a very important role in maintaining amphibian, reptile, bird, and mammal populations throughout the region. Many species require a corridor for migration between AUs or need a suitable upland/buffer habitat. In addition, the assessment team determined that the presence of a mosaic of wetlands in the landscape increases the overall opportunity.

7.7.3 Model at a Glance

Depressional Short-duration **General Habitat**

Characteristics	Variables	Measures or Indicators
SUITABILITY	**Vsow**	% of AU with seasonal surface (short-duration) water
Structural	**Vprecip**	Average annual rainfall in area around AU
heterogeneity	**Vrefuge**	Presence special habitat characteristics that provide refuge
	Vprichness	Number of plant species found during site visit
	Vvegclass	Number of Cowardin vegetation classes present
	Vpheight	Number of height ranges of vegetation
	Vpintersp	Rating of interspersion of vegetation height ranges
	Vsinuosity	Rating of sinuosity of AU edge
	Vedgepheight	Structural complexity of AU edge
	Vbuffcond	Descriptive characterization of condition of buffer
	Vbuffstruc	Types of physical structure present in buffer
Reducers		
	Vgrazing	Presence of domestic livestock
	Vupcover	Types of land uses within 1km of AU edge
OPPORTUNITY	**Vmosaic**	Proximity to other types of wetlands
	Vcorridor	Rating of condition of corridors to other wetlands
	Vhabtypes	Number of different upland habitats next to AU
Numerator for Potential:	(Vsow + Vprecip + Vrefuge + Vprichness + Vvegclass +Vpheight + Vpintersp + Vsinuosity + Vedgepheight + Vbuffcond + Vbuffstruc) x (Vgrazing or Vupcover)	
Numerator for Opportunity:	Vmosaic + Vcorridor + Vhabtypes	

7.7.4 Description and Scaling of Variables

Variables for Suitability

V_{sow} - Percent of AU with seasonal (2-9 months) inundation

Rationale: The assessment team has judged that short-duration wetlands with longer periods of inundation provide better habitat because more water dependent organisms can use the AU during the year. The area of seasonal inundation (2-9 months of inundation) was chosen as an indicator of AUs with longer periods of inundation. In addition, seasonal inundation provides refuge for many species of waterfowl during the spring migration season.

Indicator: The area of seasonal inundation is estimated in the field.

Scaling: AUs with 90% or more of seasonal inundation (2-9 months) are scored a [1] for this variable. Those with less are scored proportionally (%area / 90).

V_{precip} - Average annual rainfall in area in which AU is located.

Rationale: AUs in low rainfall areas are an oasis for birds, amphibians and terrestrial wildlife. The assessment team has judged that the importance and suitability of an AU within the overall ecosystem increases with a decrease in annual precipitation.

Indicator: The average rainfall will be estimated from precipitation maps or from USGS data.

Scaling: AUs in areas with 12 inches of rainfall or less are scored a [1] for this variable. Those outside this area are scored a [0].

V_{refuge} - Special habitat features that provide refuge for different species. Several different habitat features are combined in one variable. These include: 1) rocks within the area of surface inundation, 2) large downed woody debris in the AU, 3) erect emergent vegetation within the area of surface inundation, 4) snags, and 5) undecomposed plant litter on the AU surface.

Rationale: In many instances rocks mimic the function of large woody debris typically found in western Washington, but rarely found in the Columbia Basin. Rocks provide refuge, habitat, and structure for a number of different species. Woody debris, snags, and erect vegetation, where present, provide major niches for decomposers (i.e. bacteria and fungi) and invertebrates. They also provide refuge for some amphibians and other vertebrates. Downed woody material is an important structural element of habitat for many other species. In drier areas of the wetland it provides shelter for small mammals, birds, and amphibians (Thomas 1978). The downed woody material and undecomposed plant litter are also important structural elements for invertebrate species that provide food for much of the wetland trophic web (Maser et al. 1988).

Indicators: None needed since the presence of these characteristics can be established in the field.

Scaling: AUs with 3,4 or 5 habitat features are scored a [1] for this variable. Those with fewer are scored proportionally (# features / 3).

$\mathbf{V_{prichness}}$ - Number of plant species in AU.

Rationale: The number of plant species present in an AU reflects the potential number of niches present for invertebrates, birds, and mammals. The total number of faunal species in an AU is expected to increase as the number of plant species increases. This variable includes both native and non-native plant species because both provide habitat for invertebrate and vertebrate species.

Indicators: The indicator of overall plant richness used is the number of plant species found during the field visit.

Scaling: AUs with 15 or more plant species are scored a [1] for this variable. Those with fewer are scored proportionally (# species / 15).

$\mathbf{V_{vegclass}}$ - The number of Cowardin classes of vegetation present in the AU.

Rationale: More habitat niches are provided within an AU as the number of Cowardin vegetation classes increases. The increased structural complexity provided by different Cowardin classes optimizes potential breeding areas, escape, cover, and food production for the greatest number of species. This increased species richness in the wetland food web also supports a greater number of terrestrial species.

Indicators: None needed. The number of Cowardin classes is determined in the field.

Scaling: AUs with 2 or more Cowardin vegetation classes are scored a [1] for this variable. Those with only 1 are scored a [0]. The scaling is set up so an AU with only one class scores a [0], because any vegetated AU has to have at least one vegetation class.

$\mathbf{V_{pheight}}$ - Number of height ranges of vegetation (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: The Assessment Team judged that different guilds of species may differentiate the habitat based primarily on "height" differences in the vegetation. This partitioning of habitat niches according to heights is similar to partitioning occurring in western Washington wetlands by groups of wetland species using different Cowardin classes (e.g. emergent, shrub-scrub, forested). Different sizes of vegetation provide different niches for organisms. The Assessment Team determined that the varying heights of emergent vegetation in the Columbia Basin played a significant role in providing structural complexity that might otherwise, in more mesic environments, be provided by scrub/shrub and forested vegetation. This increased species richness arising from the increased structural diversity also supports a greater number of terrestrial species in the overall wetland food web.

Indicators: The following strata are recorded: emergent vegetation within three height ranges (0-20cm, 30cm-1m, and >1m), and areas of aquatic bed and scrub/shrub.

Scaling: AUs with 4 or 5 strata present are scored a [1] for this variable. Those with fewer are scored proportionally ((#strata-1)/3).

$\mathbf{V_{pintersp}}$ - Rating of degree of interspersion of vegetation of different height classes or strata.

Rationale: In general, interspersion among aquatic bed, emergent and scrub-shrub vegetation of different heights increases the suitability for some wildlife guilds. For example, a higher diversity of plant forms is likely to support a higher diversity of macro-invertebrates (Chapman 1966, Dvorak and Best 1982, Lodge 1985).

The increased structural complexity provided by interspersion optimizes potential breeding areas, escape cover, and food production for the greatest number of species. The increased number of species in the AU food web also supports a greater number of terrestrial species, including reptiles, birds and mammals.

Indicators: The areas of vegetation of different heights (see previous variable) are rated on the amount of interspersion present based on diagrams on the field data sheets.

Scaling: AU's with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating / 3).

$\mathbf{V_{sinuosity}}$ - Measurement of the sinuosity of edge of AU.

Rationale: The sinuosity (e.g. length of edge in relation to the longest axis of an AU) is important habitat characteristics for many species. The number of edge habitat (ecotones) increase as the structural complexity of the edge increases (Marble 1992). A more irregular edge results, therefore, in a greater potential for use by different species of aquatic and terrestrial birds. Additional habitat exists within vegetated lobes and scalloped edges of AUs. Further embayments and peninsulas provide "micro-habitats" for certain species that require hiding cover, or visual isolation (USDI 1978, Verner et al. 1986, and Washington State Department of Ecology 1993).

Indicators: The sinuosity will be estimated by dividing the circumference by the straight-line length of the long axis.

Scaling: AUs with sinuosity ratio >= 2.6 are scored a [1] for this variable. Those with a lower ratio are scored a [0].

$\mathbf{V_{edgepheight}}$ - Structural complexity of AU edge.

Rationale: Differences in heights of vegetation structure along the edge of the AU increases the number of niches or edge habitats. Marble notes that the number of edge habitats (ecotones) increase as the structural complexity of the edge increases (Marble 1992). The increase in the number of niches results in a greater number of aquatic and terrestrial species using the edge habitat.

Indicators: The complexity of the AU edge is assessed by noting the presence or absence of a difference in vegetation heights along the AU edge.

Scaling: This is a "yes/no" variable. AUs with a difference in vegetation heights are scored a [1], and those without are scored a [0].

$\mathbf{V_{buffcond}}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The condition of the buffer affects the ability of the AU to provide appropriate habitat for some species groups (Zeigler, 1992). Terrestrial species using the wetland are benefited by the presence of relative undisturbed upland community types immediately surrounding the wetland. Undisturbed buffers provide refuge and access to the wetland, thereby increasing the suitability of the wetland itself as habitat.

Indicators: This variable is assessed using the buffer categorization described in Part 2. The categorization is sequential. An AU is categorized by the highest criterion it meets.

Scaling: AUs rating a 5 on the buffer are scored a [1] for the variable. Those with lower ratings are scored proportionally (buffer rating / 5).

$\mathbf{V_{buffstruc}}$ - Presence of structural elements in the buffer that provide habitat. This includes forests, shrubs, rocks, talus slopes, cliffs, and downed woody debris in the buffer.

Rationale: Structures in AU buffers are important for refuge, food, and habitat for wildlife. Buffers with structure are especially important in the Columbia Basin because they provide a variety of habitat niches and shading. This, in conjunction with the presence of water in an arid environment, significantly increases the use of the AU by a wide range of aquatic and terrestrial species.

Indicator: Presence of structures in the buffer is determined on site during the field visit. The five structures assessed are: 1) upland trees, 2) shrubs, 3) rock outcrops, cliffs, fractured basalts, 4) talus slopes and boulder fields, and 5) downed woody debris.

Scaling: AUs with all five structure categories present are scored a [1] for the variable. Those with fewer are scored proportionally (# categories / 5).

Reducers

$\mathbf{V_{grazing}}$ - Presence of domestic livestock.

Rationale: Grazing in Basin wetlands has a major impact on wildlife. Cattle and sheep trample the cryptogammic crust (i.e. thereby increasing erosion and sedimentation) and rodent burrows. They reduce the diversity of grasses and herbaceous plant species through grazing and increase the eutrophication in the wetland from nutrients leached from their droppings. Furthermore, the presence of cattle disturbs birds and small mammals within the buffer and wetland area. All of these impacts act together to reduce the suitability of an AU as habitat.

Indicators: Sign or presence of livestock at time of site visit.

Scaling: AUs where grazing is present within the AU or their buffers have their final score reduced by a factor of 0.8.

$\mathbf{V_{upcover}}$ - The types of land uses within 1 km of the AU edge.

Rationale: Development and agriculture indirectly affect the numbers of AU species by changing physical, chemical and biological characteristics of an AU. The clearing of upland habitat, primarily shrub-steppe habitat, and the subsequent agricultural production increases water runoff, and the transport of sediment, nutrients and harmful chemicals into the AU. Increased sediment load, especially in agricultural areas, accelerates wetland filling, loss of diversity of water regimes, plants and other aquatic organisms. Wetland invertebrates and plants are known to decrease in richness and abundance with greater pollution loads (Schueler 1994, Ludwa 1994, Azous and Richter 1995, Hicks 1995). Cumulatively, these impacts also decrease the number of terrestrial species supported by the wetland food web.

Indicators: No indicators are needed to assess this variable. The amount and type of land uses within 1km of the AU can be established from aerial photographs or site visits.

Scaling: AUs where at least 10% of the surrounding landscape is tilled fields, urban or residential have their final score reduced by a factor of (x 0.9).

Variables for Opportunity

$\mathbf{V_{mosaic}}$ - Proximity to other types of wetlands.

Rationale The presence of adjacent wetlands to the AU being assessed increases the opportunity that AU has to perform as a suitable habitat for a large number of species. Reasons include: 1) a variety of upland habitat niches interspersed with different water sources results in greater habitat partitioning; 2) more opportunities for refuge, food and migration; and 3) more opportunity for re-colonization by wildlife species in years of drought.

Indicator: The number of wetland subclasses or types within 2 km of the AU.

Scaling: AUs with 4 or more different wetland types within 2 km are scored a [1] for this variable. Those with fewer are scored proportionally (#types / 4).

$\mathbf{V_{corridor}}$ - The characteristics of riparian or vegetated connections present between the AU and other nearby wetlands or upland habitat areas.

Rational: Creeks and other drainages, especially in the drier portions of the Columbia Basin, have been shown to be important migratory/dispersal and foraging areas for both terrestrial and aquatic species including amphibians, mammals, and birds. Corridors provide areas for hibernation, foraging, and migration and dispersal for some amphibians (Nussbaum and others 1983; Seaburn 1997; W. Leonard, pers. obs.). The presence of natural corridors increase the opportunity that a wetland has to provide habitat because there is a larger pool of terrestrial species that can use the wetland.

Indicators: This variable is determined using a corridor rating key described in Part 2. Corridors are rated on a scale of 0-3 for both riparian and vegetated corridors (see Part 2).

Scaling: AUs with a total rating for both riparian and upland corridors of 6 are scored a [1] for this variables. AUs with a lower sum of ratings are scored proportionally (sum or ratings/6).

$\mathbf{V_{habtypes}}$ - Presence of forest, riverine, scrub-steppe, talus, and open water habitats adjacent to the AU.

Rationale: The presence of forest, riverine, scrub-steppe, talus and open water habitat adjacent to the AU provides more opportunity for terrestrial species to use the AU. Each upland habitat type has a unique distribution of fauna that can use the AU as a source of food and water. These habitats also benefit organisms such as amphibians by providing migration/dispersal, foraging, and hibernation habitat.

Indicators: No indicators are needed to assess this variable. The types of habitat adjacent to the AU will be counted.

Scaling: AUs with 4 or more habitat types adjacent to it are scored a [1]. Those with fewer are scored proportionally (# types / 4).

7.7.5 Calculation of Habitat Suitability

Depressional Short-duration **General Habitat**

Variable	Description of Scaling		Score for Variable	Result
Vsow	*Highest*	90% or more of AU is inundated	If calculation >=1 enter "1"	
	Lowest	AU has 0% seasonal inundation	If calculation = 0 enter "0"	
	Calculation	Scaled as % inundated/90	Enter result of calculation if < 1.0	
	Calculate (D10.2/90)			
Vprecip	*Highest*	AU has 12". or less of rain	If D29 <= 12 enter "1"	
	Lowest	AU has more than 12" of rain	If D29 > 12 enter "0"	
Vrefuge	*Highest*	AU has >=3 habitat features	If calculation >=1 enter "1"	
	Lowest	AU has no habitat features	If calculation = 0 enter "0"	
	Calculation	Scaled as # features /3	Enter result of calculation if < 1.0	
	Calculate (D30.1 + D30.2 + D30.3 + D30.4 + D30.5)/3			
Vprichness	*Highest*	AU has >= 15 plant species	If calculation >=1 enter "1"	
	Lowest	AU has only 1 species present	If calculation = 0 enter "0"	
	Calculation	Scaled as # plant species/15	Enter result of calculation if < 1.0	
	Calculate (D21.1 + D21.2)/15			
Vvegclass	*Highest*	AU with >=2 Cowardin vegetation classes	If calculation >=1 enter "1"	
	Lowest	AU has only 1 vegetation class	If calculation = 0 enter "0"	
	Calculation			
	Calculate [(D16.1 + D16.2 + D16.3 + D16.4)-1]/2			
Vpheight	*Highest*	AU with 4 or 5 height ranges of vegetation	If calculation >=1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/3	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3 + D20.4 + D20.5)-1]/3			
Vpintersp	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vsinuosity	*Highest*	Sinuosity >= 2.6	If D38.1 >=2.6 enter "1"	
	Lowest	Sinuosity < 2.6	If D38.1 <2.6 enter "0"	
Vedgepheight	*Highest*	AU has structure at edge	If D38.2 = 1 enter "1"	
	Lowest	AU has no structure at edge	If D38.2 = 0 enter "0"	

Depressional short-duration General Habitat (Cont.)

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 5	If D39 = 5, enter "1"	
	High:	Buffer category of 4	If D39 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D39 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D39 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D39 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D39 = 0, enter "0"	
Vbuffstruc	*Highest*	AU has or 5 structures in buffer	If calculation >=1 enter "1"	
	Lowest	AU has no structures	If calculation = 0 enter "0"	
	Calculation	Scaled as (# of structures)/5	Enter result of calculation if < 1.0	
	Calculate (D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/5			
			Total of Variable Scores:	
Reducers				
Vupcover	AU has more than 10% major human disturbances within 1 km of AU		If (D5.3 + D5.4 + D5.7 + D5.8) >= 10 enter "0.9"	
	AU has less than 10% major disturbances		If (D5.3 + D5.4 + D5.7 + D5.8) <10 enter "1"	
Vgrazing	Grazing present in AU or buffer		If D32 =1 enter "0.9"	
	AU has no grazing present		If D32 =0 enter "1"	
			Score for Reducers - *multiply scores for two reducers*	
Index for General Habitat (Suitability) = (Total of variables) x (score for reducers) x (1.06) rounded to the nearest 1				
			FINAL RESULT:	

7.7.6 Calculation of Opportunity

Depressional Short-duration **General Habitat**

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 4 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/4)	Enter result of calculation if < 1.0	
	Calculate	(D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/4		
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation =1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate	(D43.1 + D43.2)/6		
Vhabtypes	*Highest*	AU has at least 4 habitat types within 1 km	If calculation >=1 enter "1"	
	Lowest	AU has no habitats within 1 km	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/4)	Enter result of calculation if < 1.0	
	Calculate	(D6.1 + D6.2 + D6.3 + D6.4 + D6.5)/4		
			Total of Variable Scores:	
		Index for General Habitat (Opportunity)= Total x 3.33 rounded to nearest 1		
			FINAL RESULT:	

7.8 Habitat for Invertebrates — Depressional Short-duration Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.8.1 Definition and Description of Function

Habitat for Invertebrates is defined as the characteristics that help maintain a high number of invertebrate species in the wetland. For the purpose of this model, invertebrates are narrowly defined as "macroinvertebrates" or free-living organisms readily seen with the naked eye (≥500μm) including among others, Insecta (insects), Malacostraca (scuds, sideswimmers, crayfishes, shrimps, isopods), Branchiopoda (fairy, tadpole, and clam shrimps), Maxillopoda (seed shrimps, copepods), Gastropoda (snails), Pelecypoda (clams,fingernail clams), Arachnida (spiders, mites), Annelida (worms and leeches), and Platyhelminthes (flatworms).

Invertebrates are diverse and abundant components of freshwater aquatic systems that include wetlands. As such, almost any wetland will provide a habitat for some invertebrates. There is a distinct difference, however, between a wetland that has a high abundance of one or two species and one that has a high richness of different species. The important aspect of invertebrate populations that is being assessed with this model is species richness. Wetlands with a high richness tend to be more important in maintaining the regional biodiversity of invertebrate populations and provide a genetic source and genetic refuge that helps maintain ecosystem integrity. There are, however, wetlands with low species richness that provide refuge to species unique to these systems, and may be important to that specific species. This aspect of ecosystem function is not addressed in these methods.

Invertebrates are critical as processors of organic material and in the cycling of energy and nutrients (Merritt and Cummins, 1996). Macro invertebrates, and particularly insects are especially important to many processes in wetlands and aquatic food chains. Recent focus on aquatic invertebrates in wetlands indicates the importance of macroinvertebrates in energy and nutrient transfer within aquatic ecosystems (Rosenberg and Danks, 1987). They furnish food for other invertebrates and comprise significant portions of the nutritional requirements of amphibians, water birds, mammals, and fish. The trophic diversity and numerical abundance of insects (especially the Diptera) and other macro invertebrates (Annelida and Crustacea), make these organisms the most important taxa in wetland environments (Chutter, 1972; Hilsenhoff, 1988; Lang, 1970; Merritt and Cummins, 1996; Warren, 1988).

Most of the wetland invertebrate populations of the Columbia Basin exist in a stressed environment and are subject to high summer temperatures and limited rainfall. This has resulted in different invertebrate population dynamics and greater species richness than in other more temperate regions of the country. Typically, invertebrates in the Columbia basin have telescoped, or shortened life cycles, brief periods of maximum abundance, the ability to survive in stressed environments, and to emerge or go into dormancy before ponds draw down to 35 to 20% of the original surface area. This habitat partitioning appears to have resulted in the capacity for these systems to have a higher invertebrate richness than similar but more stable wetland systems in other areas.

7.8.2 Assessing this Function for Depressional Short-duration Wetlands

An AU in the depressional short-duration subclass provides the best habitat for invertebrate species richness when there is a richness of emergent plants, there is a varied substrate, and the percent of seasonal inundation is minimal (Lang, 1970, 1984, Severson-Shurtleff, 1990; Swedberg and Lang, 1983; Warren, 1988. The suitability of depressional short-duration wetlands in the Columbia Basin as invertebrate habitat is modeled on the number of native plant species present; the interspersion of wetland vegetation with open water; and physical components such as refuge provided by rocks and woody debris within the wetland. The species richness drops for AUs that have larger areas of seasonal inundation.

Based on field data collected, the Vprecip variable was found to provide the best correlation between invertebrate species richness and average annual rainfall levels; as average annual rainfall increased species richness increased.

As a general rule, variation in water quality parameters does not significantly affect invertebrate species richness. For example, in the channeled Scablands, pH and conductance in a given short-duration pond vary from 7.0-10.5 and 250-850 micromhos during a year, respectively (Pratt, 1981; Pratt et al., 1986) without significantly affecting species richness. Generally, increased conductance is not correlated with a decrease in species richness until values of 1500-2000 are reached (Lang, personal observations).

The species composition for AUs with only a brief inundation (i.e. short-duration wetlands with less than 2 months of inundation - vernal wetlands) is remarkably similar regardless of any physical differences between these vernal wetlands. This indicates that the suitability of habitat function for invertebrates is performing at the same level for all brief inundation depressional wetlands. These brief inundation wetlands, such as exposed scabrock ponds, do not have many of the characteristics of other depressional wetlands. The similarity in invertebrate species composition between these vernal "pools" and other depressional wetlands is low.

The life histories of invertebrates in these vernal wetlands are adapted to yearly sequence of wet-dry-freeze (Lang 1970-1996; Bjork 1997; Crowe et al. 1994; Pennak 1989). Dispersal takes place via wind or animals moving resistant eggs or cysts between ponds. Although the AUs with only a brief inundation may have a unique set of invertebrate species associated with them, their richness is low. Since the model assesses richness the scores for these "vernal wetlands" will usually also be low.

The opportunity that an AU has to provide habitat for invertebrates is assessed by its landscape position. AUs that are well connected to other wetlands and that lie in a mosaic of wetlands have a high opportunity to provide habitat because colonization from other locations is possible. This will maintain high species richness in the AU itself.

7.8.3 Model at a Glance

Depressional Short-duration **Habitat for Invertebrates**

Characteristics	Variables	Measures or Indicators
SUITABILITY		
Structural	**Vprichness**	The number of plant species found during a site visit
Heterogeneity	**Vsubstrate**	Presence of exposed sand, silt, clay, mud, rock, and organic matter
	Vprecip	Average annual rainfall for AU
	Vwintersp2	Rating interspersion between vegetation and seasonal open water
OPPORTUNITY		
	Vcorridor	Ratings of corridors between AUs & other habitats
	Vmosaic	Proximity of other AUs within 2 km
Numerator for Suitability	Vprichness + Vsubstrate + Vprecip + Vwintersp2	
Numerator for Opportunity	Vcorridor + Vmosaic	

7.8.4 Description and Scaling of Variables

Variables for Potential

$V_{prichness}$ - The richness of plant species.

Rationale: The richness of plant species present in an AU reflects the potential number of invertebrate species in a wetland, since many invertebrates are associated with specific plant species. As the number of plant species increases the number of habitat niches for invertebrates also increases. Therefore, the species richness of plants, in the judgement of the Assessment Team, is a surrogate for habitat niches for invertebrates.

Indicators: None needed, the number of plant species is counted in the field.

Scaling: AUs with more than 19 species of plants present at the time of the fieldwork are scored a [1] for this variable. AUs with less are scored proportionally (#species/19).

$V_{substrate}$ – Presence of different types of substrate within the AU including undecomposed "organic duff" surface, decomposed duff, fines, and coarse material**.**

Rationale: Though there is limited data on invertebrate distributions in different AU substrates, data from rivers, stream, and lakes show that the local invertebrate species have preferences for specific substrate (Dougherty and Morgan 1991, Gorman and Karr 1978). Chironomid community composition is strongly affected by sediment characteristics (McGarrigle 1980, Minshall 1984). Unpublished research in the Columbia Basin also demonstrates that substrate type plays an important role in invertebrate diversity in AUs (personal communication with Bruce Lang, 2/23/99). AUs with different substrates present will provide habitat for a broader group of invertebrate species then those with only one type. However, AUs with only an organic substrate layer (i.e. plant litter, decomposed organic material) will have a higher invertebrate diversity than an AU with only a mineral substrate layer. This factor is addressed by weighting the presence of an organic substrate more in the equation.

Indicators: No indicators are required to assess this variable. The types of substrate present can be determined directly from field observation.

Scaling: The presence of an organic duff layer is weighted at twice that of a mineral surface layer or algal mat layer. AUs with all five categories of surface layer are scored a [1] for this variable. Those with fewer are scored proportionally with organic duff layers weighted at twice that of mineral.

V_{precip} - The average annual rainfall in area around AU

Rationale: Based on field data collected, the richness of invertebrate species present in Columbia Basin AUs correlates with the average annual rainfall level. Richness increases with average rainfall.

Indicators: None needed. Rainfall levels can be taken directly from the USGS internet site. http://www.wrcc.dri.edu/summary/climsmwa.html

Scaling: AUs with 16 inches or more of rainfall a year are scored a [1] for this variable. Those with less are scored proportionally (average rainfall / 16).

$V_{wintersp2}$ – Rating of interspersion between vegetation and seasonal open water.

Rationale: AUs with a greater interspersion of vegetation with seasonal open water will provide for a greater number of habitat niches because of an increase in edges between the water and vegetation.

Indicators: None needed. The rating of the degree of interspersion of vegetation with seasonal open water will be determined in the field.

Scaling: AUs with a high interspersion (rating = 3) are scored a [1] for this variable. Those with a lower rating are scored proportionally (rating/3).

Variables for Opportunity

$V_{corridor}$ - The characteristics of riparian or vegetated connections present between the AU and other nearby wetlands.

Rational: Creeks and other drainages have been shown to be important migratory/dispersal and foraging areas for invertebrates, amphibians, mammals, and birds Suitable corridors are judged to be critical in the Columbia Basin to the colonization and dispersal of invertebrates.

Indicators: This variable is determined using a corridor rating key described in Part 2. Corridors are rated on a scale of 0-3 for both riparian and vegetated .

Scaling: AUs with a total rating for both riparian and upland corridors of 6 are scored a [1] for this variable. AUs with a lower sum of ratings are scored proportionally (sum or ratings/6).

V_{mosaic} - The AU is part of a distinct wetland/upland ecosystem encompassing different hydrogeomorphic types of AUs.

Rationale: AUs that occur within a complex of lentic and lotic habitats may have a greater invertebrate richness than isolated AUs. Invertebrates are transported outside of AUs by birds, wind and through the hyporheic zone. If AUs are isolated, then the percentage of these species reaching other wetlands is reduced. The presence of adjacent wetlands increases the opportunity for the AU to function as suitable habitat for a large number of species. In addition, the proximity of other wetlands provides more opportunities for refuge, food and migration and more opportunity for successful re-colonization by invertebrates during drought years.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of AUs in the landscape.

Scaling: AUs with 3 or more different types of wetlands present within 2 km are scored a [1] for this variable. Those with fewer types are scored proportionally (# of types/3).

7.8.5 Calculation of Habitat Suitability

Depressional Short-duration Habitat for Invertebrates

Variable	Description of Scaling		Score for Variable	Result
Vprichness	*Highest*	AU has >= 19 plant species	If calculation >=1 enter "1"	
	Lowest	AU has only 1 species present	If calculation = 0 enter "0"	
	Calculation	Scaled as # plant species/19	Enter result of calculation if < 1.0	
	Calculate	(D21.1 + D21.2)/19		
Vsubstrate	*Highest*	AU has all 5 categories of substrate	If calculation >=1 enter "1"	
	Lowest	AU has no exposed substrate	If calculation = 0 enter "0"	
	Calculation	Scaled as # substrates (organic weighted 2x)/7	Enter result of calculation if < 1.0	
	Calculate	[(2xD46.1) + (2xD46.2) + D19 + D46.3 + D46.4]/7		
Vprecip	*Highest*	AU has >= 16 in. annual precip	If calculation >=1 enter "1"	
	Lowest	AU has < 2 in precip	If calculation = 0 enter "0"	
	Calculation	Scaled as annual precip/16	Enter result of calculation if < 1.0	
	Calculate	(D29)/16		
Vwintersp2	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate	D36.2/3		
			Total of Variable Scores:	
			Index for Invertebrate Habitat (Suitability)=(Total) x (2.95) rounded to nearest 1	
			FINAL RESULT:	

7.8.6 Calculation of Opportunity

Depressional short-duration **Habitat for Invertebrates**

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 3 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/3)	Enter result of calculation if < 1.0	
	Calculate (D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/3			
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation >=1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate (D43.1 + D43.2)/6			
			Total of Variable Scores:	
Index for Invertebrate Habitat (Opportunity) = (Total) x (5.0) rounded to nearest 1				
			FINAL RESULT:	

7.9 Habitat for Amphibians — Depressional Short-duration Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.9.1 Definition and Description of Function

Habitat for Amphibians is defined as the wetland processes and the characteristics that contribute to the feeding, breeding, or refuge needs of native amphibian.

Amphibians are a vertebrate group that, in the Pacific Northwest, include wetland-breeding frogs (Order: Anura) and salamanders (Order: Caudata). The richness and abundance of amphibians indicate that they are important in wetland trophic organization. Some native species only breed for a short time in wetlands and as metamorphosed juveniles and adults live in uplands. Other species may be found in or close to wetlands throughout the year. However, the eggs and larvae of all wetland-breeding species require water for development. Wetlands also play an important role in the life cycles of many amphibians by providing quiet waters and food sources needed for the early developmental stages. The models use characteristics of wetlands that support survival of eggs, development/protection of larvae, and food for adults moving in and out of the wetland.

The underlying principle used in this habitat model is that wetlands supporting higher species richness should score higher than those supporting less diverse amphibian assemblages. The assessment models are focused on species richness and characteristics that support many different species, not on the importance of a wetland to a specific state or federally listed Threatened or Endangered species. Other methods should be used to estimate habitat suitability for specific species (e.g., USFWS Habitat Evaluation Procedures).

7.9.2 Assessing this Function for Depressional Short-duration Wetlands

The model for the depressional short-duration subclass is based upon the presence of wetland refugia (rocks, woody debris, leaf litter), interspersion of different wetland plant heights and interspersion of wetland plants with open water. Because short-duration AUs do not have standing water throughout the year, it was necessary to include variables that provided some indication of the duration and timing of inundation. The Assessment Team found that certain indicators, such as the presence of *Scirpus* spp., aquatic bed species and the area of seasonal inundation, provide a good correlation with amphibian richness.

Relatively few amphibians use depressional short-duration wetlands with only brief inundation (i.e. less than 2 months) for breeding, rearing, feeding, and/or refuge due to the timing and briefness of inundation. While some of these brief inundation wetlands (commonly known as vernal wetlands) do provide some amphibian habitat, many do not. Given the timing (i.e. December to April) and duration of surface water in these systems, it is unlikely that amphibians even attempt to breed in them. Furthermore, vernal wetlands typically lack woody debris (habitat niches and thermal/escape habitat), muddy /organic substrate and organic debris (escape cover habitat) and areas of interspersion with open water. The model scores for vernal AUs were lower than those of other short-duration AUs because much of the structure in the AU is lacking (e.g. aquatic bed and other obligate species, larger areas of seasonal inundation). This was consistent with the judgements of the Assessment Team.

The opportunity that an AU has to provide habitat for amphibians is assessed by its landscape position and the presence of physical structures in the buffer that provide refuge for adults. AUs that are well connected to other wetlands and that lie in a mosaic of wetlands have a high opportunity to provide habitat because colonization from other locations is possible. This will maintain high species richness in the AU itself.

7.9.3 Model at a Glance

Depressional Short-duration Habitat for Amphibians

Characteristics	Variables	Measures or Indicators
SUITABILITY		
Breeding, feeding & refuge	**Vout**	AU has evidence of surface outflow
	Vsow	Area of seasonal (2-9 months) inundation
	Vpheight	Number of categories of plant structures
	Vaquatbed	Presence of aquatic bed plants
	Vscirpus	Presence of *Scirpus spp.*
	Vrefuge	Presence of rocks, woody debris, mud/silt and organic substrate and leaf in AU
	Vwintersp2	Rating of interspersion between persistent vegetation & areas of open seasonal inundation
	Vbuffstruc	Types of physical structures present in buffer
OPPORTUNITY		
Landscape position	**Vcorridor**	Rating of corridors between AU and other wetlands
	Vmosaic	Proximity of other wetlands within 2km
Numerator for Suitability	Vout+Vsow+ Vpheight + Vaquatbed+ Vscirpus+ Vrefuge+ Vwintersp2+ Vbuffstruc	
Numerator for Opportunity	Vcorridor + Vmosaic	

7.9.4 Description and Scaling of Variables

Variables for Suitability

V$_{out}$ - AU has surface water outflow at some time during the year.

Rationale: Surface outflow from a short-duration wetland indicates that standing water is present within the AU. Standing water is an essential component to the habitat needs of amphibians (breeding, rearing, feeding, and refuge).

Indicators: Presence of outlet and drainage features leading away from outlet. Evidence of surface flow include surface scour and sediment deposits.

Scaling: This is a “yes/no” variable. AUs with an outflow are scored a [1] for this variable, and those without are scored a [0].

V_{sow} – Percent area of seasonal inundation (2-9 months) in AU.

Rationale: The Assessment Team found that the area of seasonal inundation (2 –9 months of inundation) acts as one surrogate for the duration of inundation. The greater the area of seasonal inundation the longer the duration. Longer duration inundation provides a greater opportunity for successful amphibian breeding and rearing. Overall, the Assessment Team found an increased species richness for short-duration AUs that had increased areas of seasonal inundation.

Indicators: The area of seasonal inundation can be estimated by indicators such as water-marks, deposition lines or other discoloration on vegetation or rocks and dried aquatic bed or algae species on substrate or on stems of vegetation.

Scaling: AUs with 80% or more of their area inundated for more than 2 months were scored a [1] for this variable. Those with less were scored proportionally (% area / 80).

$V_{pheight}$ - Number of height ranges of vegetation (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: Amphibian richness is increased in a mosaic of different vegetation heights. Seven species of native amphibians are associated with wetlands in the Columbia Basin ecoregion (Slater 1955, 1964; Metter 1960; Stebbins 1985; Nussbaum and others 1983; Leonard et al. 1993; Corkran and Thoms 1996; Dvornich et al. 1997; Olson and Leonard 1997). Each of the seven species has specific structural and hydrological conditions required for achieving optimal reproduction and recruitment (Nussbaum 1983; Leonard and Darda 1995; Leonard et al. 1996). The assumption is that sites with greater structural diversity in plant structure optimizes the potential of providing suitable oviposition areas, escape cover, and food production for the greatest number of species.

Indicators: The following strata are recorded: emergent vegetation within three height ranges (0-20cm, 30cm-1m, and >1m), and areas of aquatic bed and scrub/shrub.

Scaling: AUs with 3 or more strata present are scored a [1] for this variable. Those with fewer are scored proportionally ((#strata-1)/2).

$V_{aquatbed}$ - Presence of aquatic bed vegetation.

Rationale: The presence of aquatic bed is an indicator that the AU has surface water present for longer periods during the breeding and rearing season for amphibians. Field data collected during calibration indicate that there is increased amphibian richness in AUs with aquatic bed plants present. Additionally, the increased structural complexity provided by aquatic bed is a characteristic that increases habitat for a number of invertebrate and vertebrate species.

Indicators: Aquatic bed species can be observed directly, either during the growing season or as dried specimens when seasonal inundation is not present later in the year.

Scaling: This is a "yes/no" variable. AUs with aquatic bed vegetation are scored a [1] for this variable, and those without are scored a [0].

$V_{scirpus}$ – Presence of *Scirpus* species.

Rationale: It was the observation of the Assessment Teams that *Scirpus* species in Columbia Basin short-duration wetlands are associated with longer periods of inundation. Typically, these species are found in deeper open water relative to other obligate species (*Typha* spp.) indicating that *Scirpus* is more tolerant of longer periods of inundation. The presence of *Scirpus*, therefore, acts as another indicator of longer inundation during the growing season, which would result in more suitable habitat for amphibians.

Indicators: None needed. The presence of *Scirpus* species would be recorded during the site visit.

Scaling: This is a "yes/no" variable. AUs with *Scirpu*s sp. present are scored a [1] for this variable, and those without are scored a [0].

V_{refuge} - Special habitat features that provide refuge for amphibians.

Rationale: Many amphibians show marked preference for certain types of substrate including rocks and downed and woody debris, muddy or organic substrate and leaf litter. Rocks and woody debris, where present, are important structural elements for amphibians, providing cover habitat and thermal buffering. Large woody debris also provide the first breeding sites. Muds, silts, organic substrates and leaf litter provide escape habitat.

Indicators: None needed, structural elements that provide refuge are determined during the site visit. These include rocks and large woody debris in areas that are annually inundated, plant litter on the surface of the AU, snags, and erect emergent vegetation in the area of seasonal or extended inundation.

Scaling: AUs with at least three of the five structural elements listed above are scored a [1] for the variable. AUs with less are scored proportionally (# of elements / 3).

$V_{wintersp2}$ -Rating of interspersion between persistent emergent vegetation and the areas of "open" seasonal inundation.

Rationale: Open water and vegetation contact zones provide edge habitat, protection, cover, food, and territorial boundaries. Interspersion increases the vegetation/water edge zone. These contact zones between water and vegetation also provides a point of entry for amphibians. It also increases the amount of habitat available to species requiring either vegetation or open water, which in turn increase diversity.

Indicators: The interspersion in a AU is assessed using a series of diagrams that rate the interspersion as high, moderate, low, and none.

Scaling: AU's with a high interspersion (rating = 3) are scored a [1] for this variable. Those with a lower rating are scored proportionally (rating/3).

$V_{buffstruc}$ **-** The presence of forest, shrubs, boulder fields, rock outcrops, talus slopes, and/or downed woody debris in the buffer.

Rationale: It is assumed that amphibian richness is improved as the number of structural refuges in the buffer increase. Characteristics of wetland buffers are especially important in providing refuge for amphibians migrating to and from breeding ponds. Furthermore, the success of recently transformed juveniles is greatly enhanced by the presence of suitable cover and foraging areas adjacent to the AU. As cover is reduced or eliminated by agricultural operations and encroaching development, amphibians are exposed to increased risks of over-heating/freezing, desiccation, and predation. Important buffer features include downed woody debris and rocks.

Indicators: No indicators needed. Specific structures in the buffer are determined during site visit.

Scaling: AUs with 4 or more categories of structure in the buffer score a [1] for this variable. Those with fewer are scored proportionally (# of categories/4).

Variables for Opportunity

$V_{corridor}$- Rating of riparian and upland corridor connecting AU to other wetlands.

Rationale: Creeks and other drainages have been shown to be important hibernation areas, foraging habitats, and migratory/dispersal corridors for some amphibians (Nussbaum and others 1983; Seaburn 1997; W. Leonard, pers. obs.). Because of the arid to semi-arid conditions experienced in the Columbia Basin, more aquatic amphibian species (e.g., Columbia Spotted Frog, Northern Leopard Frog [*Rana pipiens*]) are presumably unable to colonize (and are less apt to recolonize after local extinction) "new" habitats without the presence of suitable aquatic corridors. Post-breeding amphibians often move out along drainage courses where conditions may be more favorable (W. Leonard, pers. Obs.). Spadefoot toads will cross plowed fields to reach other wetlands, but some species of amphibians need vegetated corridors.

Indicators: This variable is determined using a modified corridor rating key described in Part 2. Corridors are rated on a scale of 0-3 for both riparian and vegetated corridors. Riparian corridors in Eastern Washington include creeks (intermittent), drainage swales and ditches.

Scaling: AUs with a total rating for both riparian and vegetated corridors of 6 are scored a [1] for this variables. AUs with a lower sum of ratings are scored proportionally (sum or ratings/6).

V_{mosaic} - The AU is part of a distinct wetland/upland ecosystem encompassing different hydrogeomorphic types of wetlands.

Rationale: AUs that occur within a complex of lentic and lotic habitats may have a greater amphibian richness than isolated AUs. If wetlands are isolated, then the percentage of these species reaching other wetlands is reduced. The presence of adjacent wetlands increases the opportunity for the AU to function as suitable habitat for a large number of species. In addition, the proximity of other wetlands provides more opportunities for refuge, food and migration and more opportunity for successful re-colonization by amphibians during drought years.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of wetlands in the landscape.

Scaling: AUs with 4 or more different types of wetlands present within 2 km are scored a [1] for this variable. Those with fewer types are scored proportionally (# of types/4).

7.9.5 Calculation of Habitat Suitability

Depressional Short-duration Habitat for Amphibians

Variable	Description of Scaling		Score for Variable	Result
Vout	*Highest:*	If AU has an outlet	IF D9 = 1 enter "1"	
	Lowest	If AU has no outlet	If D9 = 0 enter "0"	
Vsow	*Highest*	AU has >=80% seasonal water	If D10.2 >=80 enter "1"	
	Lowest	AU has < 80% seasonal water	If D10.2 < 80 enter "0"	
Vpheight	*Highest*	AU with >=3 height ranges/types of vegetation	If calculation >=1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/2	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3 + D20.4)-1]/3			
Vaquatbed	*Highest:*	If AU has aquatic bed vegetation	IF D20.5 = 1 enter "1"	
	Lowest	If AU has no aquatic bed veg.	If D20.5 = 0 enter "0"	
Vscirpus	*Highest:*	If AU has Scirpus spp.	IF D23 = 1 enter "1"	
	Lowest	If AU has no Scirpus spp.	If D23 = 0 enter "0"	
Vrefuge	*Highest*	AU has >= 3 categories of refuge	If calculation >=1 enter "1"	
	Lowest	AU has no refuge present	If calculation = 0 enter "0"	
	Calculation	Scaled as # categories/3	Enter result of calculation if < 1.0	
	Calculate (D30.1 +D30.2 + D30.3 + D30.4 + D30.5)/3			
Vwintersp2	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D36.2/3			
Vbuffstruc	*Highest*	AU has 4 or 5 structures in buffer	If calculation >=1 enter "1"	
	Lowest	AU has no structures	If calculation = 0 enter "0"	
	Calculation	Scaled as (# of structures)/4	Enter result of calculation if < 1.0	
	Calculate (D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/4			
			Total of Variable Scores:	
Index for Amphibian Habitat (Suitability) = (Total for Variables) x(1.25) rounded to nearest 1				
			FINAL RESULT:	

7.9.6 Calculation of Opportunity

Depressional Short-duration **Habitat for Amphibians**

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 4 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/4)	Enter result of calculation if < 1.0	
	Calculate (D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/4			
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation >=1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate (D43.1 + D43.2)/6			
			Total of Variable Scores:	
Index for Amphibian Habitat (Opportunity)= Total x 5.0 rounded to nearest 1				
			FINAL RESULT:	

7.10 Habitat for Aquatic Birds — Depressional Short-duration Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.10.1 Definition and Description of Function

Habitat for Aquatic Birds is defined as the environmental characteristics in a wetland that provide suitable habitats or life resources for species of aquatic-dependent birds, and the characteristics of the surrounding landscape that indicate birds will have the opportunity to use this habitat. Aquatic bird species are those that depend on different aspects of the aquatic ecosystem for some part of their life needs: food, shelter, breeding, or resting. Wetlands also provide for specific requirements such as nesting, molting, foraging and migration. The primary groups of aquatic birds considered for building the assessment model included waterfowl, shorebirds and herons in addition to blackbirds, marsh wrens and rails. Other typically terrestrial birds, such as short-eared owls, Northern Harriers that use these wetlands as a preferred habitat due to the "oasis effect" are modeled in the General Habitat function.

In general, the suitability of a wetland as bird habitat increases as the number of appropriate habitat characteristics increase. Wetlands can provide habitat for a large number of bird species depending on the vegetative structure, and physical characteristics of the wetland. The opportunity of a wetland to provide habitat also increases in landscapes where there are numerous other wetlands or open water nearby.

The assessment models are focused on species richness, not on the importance of a wetland to a specific threatened or endangered species or to a specific regionally important group of birds.

If the wetland is a habitat type that appears to be critical to a specific species, another method is needed in order to better determine the habitat suitability of that wetland (e.g. USFWS Habitat Evaluation Procedures (HEP), USFWS 1981, Wakeley and O'Neil 1988).

7.10.2 Assessing this Function for Depressional Short-duration Wetlands

The suitability of depressional short-duration wetlands in the Columbia Basin for aquatic birds is modeled on structural components that have been shown, or are judged, to be important habitat features, and the condition of the buffers in the AU. The models include the indices of suitability for invertebrates as an indicator of richness in types of food available to aquatic birds.

Aquatic Bird Habitat - Short-duration Wetlands

AUs that have purple loosestrife or *Phragmites* present, or that have human disturbances in the surrounding landscape are judged to have a reduced level of performance. These conditions all reduce the suitability of the AU as habitat for birds. Purple loosestrife and *Phragmites* tend to be highly invasive and exclude other native wetland plant species, which in turn reduces habitat diversity for bird species.

Size is not used as a variable in the equation although it is often cited as an important characteristic of wetlands that provide bird habitat (Richter and Azous, 1997). The question of size as an indicator of species richness is a difficult one. No satisfactory size thresholds have been identified in the literature that would define the importance of a small versus a large wetland as habitat specific only to aquatic birds. Size, however, is incorporated indirectly in the scaling of some of the other variables used. Thus, it is implicit that a wetland with a diverse structure is usually large; small wetlands usually cannot contain the same number of different structural elements as large ones.

In general, AUs with only brief periods of inundation (e.g. less then 2 months inundation - vernal wetlands) provide limited habitat for aquatic birds in general. These vernal systems, however, are important to waterfowl early in the growing season because they often are the first areas to thaw, thereby providing area for forage and pair bonding. These vernal AUs have fewer indicators for habitat that supports a greater species richness (varying vegetation heights, interspersion of vegetation with open water, adequate areas of refuge) and therefore scored lower both in the models and in the judgement of the Assessment Team.

The opportunity that an assessment unit has to provide bird habitat is a function of many landscape variables such as the presence of nearby open water, other wetlands, and proximity to the major migratory flyways. Users, however, must make a qualitative judgement on the opportunity of the AU to actually provide bird habitat because a quantitative model could not be calibrated. None of the data collected during the calibration could be adequately correlated with the judgements of opportunity made by the Assessment Team. The conclusion of the Assessment Team was that too many variables were involved in making a judgement of opportunity, and a simple, rapid model could not be developed.

7.10.3 Model at a Glance

Depressional Short-duration Habitat for Aquatic Birds

Characteristics	Variables	Measures or Indicators
SUITABILITY		
Structural	**Vopenw**	% area of open (unvegetated) surface water
Heterogeneity	**Vmud/sand**	Presence/absence of mud/sand flats
	Vwintersp2	Rating interspersion of veg. and seasonal open water
	Vpheight	Number of plant height categories present
	Vpintersp	Rating of the interspersion of plant height classes
	Vbuffcond	Descriptive table of conditions in buffer
	Vbuffstruc	Types of physical structure present in buffer
	Sinvert	Index of suitability from invertebrate model
Reducers		
	Vinvasp	Presence of invasive plants (Loosestrife, *Phragmites*)
	Vhumandis	Presence of human activities within AU and buffer
OPPORTUNITY		***Could not be calibrated***
Numerator for Suitability	(Vopenw+Vmud/sand + Vwintersp2 + Vpheight + Vpintersp + Vbuffcond + Vbuffstruc + Sinvert) x Vinvasive x Vhumandis	

7.10.4 Description and Scaling of Variables

Variables for suitability

V_{openw} - The percent of the AU that is covered by open surface water (unvegetated) at least for part of the year.

Rationale: Open water provides refuge and a resting place for many species of waterfowl. Even AUs with only brief inundation provide important waterfowl habitat (e.g. pair bonding) early in the growing season when other AUs are still frozen over.

Indicators: The extent of seasonal open water in an AU is assessed based on the percent of sand or mudflats present. The presence of unvegetated flats within an AU indicates the area was at one time inundated and without vegetation. Trying to assess open water directly is too difficult, given the short period during which open water is actually present in short-duration wetlands.

Scaling: AUs with that are at least 50% open water at some time of the inundation cycle are scored a [1] for this variable. Those with less are scored proportionally (% open water / 50).

V$_{\mathbf{mud/sandflats}}$ - presence/absence of mud or sand flats.

Rationale: Some species of shorebirds are adapted to foraging for invertebrates living in exposed mud/sand bars. Use of these mud and sandflats occurs year round. For example, they are used by migratory birds in August, and by avocets and stilts in April and May. AUs that contain exposed mud/sandflats attract shorebirds and waterfowl adapted to feeding in this habitat type most of the year. This increases the overall species richness in the AU.

Indicators: The presence of mudflats can be determined easily during the dry season. During periods of inundation, however, establishing the presence of mudflats is more difficult. An indicator is an unvegetated area within areas of seasonal inundation.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if has mudflats, and a [0] if it does not.

V$_{\mathbf{wintersp2}}$ - The amount of interspersion between vegetated areas of the AU and the areas of short-duration open water.

Rationale: The highest number of bird species are found in AUs with a relatively even balance of open water interspersed with vegetation (Marble 1992). In general, the more complex the interspersion between plants and water the greater the number of bird species that will be supported. Open water and vegetation contact zones provide edge habitat, protection, cover, food, and territorial boundaries. Interspersion increases the vegetation/water edge zone. These contact zones between water and vegetation provides cover for breeding waterfowl. This interface also increases the amount of habitat available to species requiring either vegetation or open water, which in turn increase diversity. In addition, some species of birds are specifically adapted to this edge zone. (Note: aquatic bed vegetation is included with the open water for this variable, because, in the judgement of the Assessment Team, most bird species use this area as they would other unvegetated open water areas and the structure of the emergent vegetation provides more habitat niches for a greater number of species than aquatic bed).

Indicators: The interspersion in an AU is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: AUs with a high interspersion (rating = 3) are scored a [1] for this variable. Those with a rating of 1 are scored proportionally (rating /3).

$V_{pheight}$ - Number of height ranges of vegetation (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: Different species of vegetation provide different niches for birds. It was the judgement of the Assessment Team that the varying heights of emergent vegetation in the Columbia Basin played a significant role in providing structural complexity that might otherwise, in more mesic environments, be provided by scrub/shrub and forested vegetation.

Indicators: The presence of 5 categories of plant heights are recorded in the field (0-20cm, 30cm-1m, and >1m) for emergent species, aquatic bed and scrub/shrub.

Scaling: AUs with four or five categories present are scored a [1] for this variable. Those with fewer are scored proportionally ((# categories-1)/3).

$V_{pintersp}$ - Rating of interspersion among the height ranges of different plants.

Rationale: The assessment team determined that the interspersion of the different vegetation strata with each other, including height classes of emergent species, and areas of aquatic bed and scrub/shrub, increases the habitat richness of the AU for birds by providing more niches for feeding and refuge.

Indicators: The areas of vegetation of different heights (see previous variable) are rated on the amount of interspersion present based on diagrams on the field data sheets.

Scaling: AUs with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating(scale 0-3) / 3).

$V_{buffcond}$ - Condition of buffer within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The amount of disturbance in the AU buffer affects the ability of the AU to provide appropriate habitat for some guilds of birds (Zeigler, 1992). Trees and shrubs provide screening for birds using the AU, as well as providing additional habitat in the buffer itself (Johnson and Jones 1977, Milligan 1985, Zeigler 1992). For the drier portions of the Columbia Basin the presence of undisturbed buffer areas at maximum widths, even though they have limited screening capabilities (e.g. shrub-steppe habitat), indicates that the habitat needs of sensitive bird species will not be disturbed by human activities (agriculture, grazing, urban uses).

Indicators: This variable is assessed using the buffer categorization described in Part 2.

Scaling: AUs rating a 5 on the buffer are scored a [1] for the variable. Those with lower ratings are scored proportionally (buffer rating / 5).

$V_{buffstruc}$ - Presence of structural elements in the buffer that provide habitat for wetland dependent birds. This includes forests, shrubs, rocks, talus slopes, cliffs, and downed woody debris (includes blown in brush) in the buffer.

Rationale: Structure in AU buffers is important for nesting habitat, cover for refuge, and food production for many species of aquatic birds. Blown in brush such as tumbleweed is commonly found at the edge of Columbia Basin wetlands and provides escape habitat for small birds. Buffers with structure are especially important in the Columbia Basin because they provide a variety of habitat niches and shading, which in conjunction with the presence of water in an arid environment significantly increases the use of the AU by a wide range of aquatic species.

Indicator: Presence of structures in the buffer is determined on site during the field visit.

Scaling: AUs with at least four of the five structure categories present are scored a [1] for the variable. Those with fewer are scored proportionally (# categories / 4).

$\mathbf{S_{inverts}}$ - The habitat suitability index for the "invertebrate" function.

Rationale: The score is used to represent the richness of invertebrates that might be available as prey for many species of aquatic birds. Because many aquatic birds are specifically adapted to foraging for a specific species or group of invertebrates, a "greater" invertebrate richness will mean the AU is suitable for more bird species.

Indicators: No indicators are needed. The variable is a score from another function.

Scaling: The index score, which is reported on a scale of 0-10 is normalized to a scale of 0 –1.

Reducers

$\mathbf{V_{invasp}}$ – The presence of invasive plants such as loosestrife (*Lythrum salicaria*) and common reed (*Phragmites communis*).

Rationale: The listed invasive plants have a significant impact upon bird richness by eliminating habitat of preferred plant species. Loosestrife and the commom reed can dominate the majority of the wetland plant habitat area, thereby reducing structural diversity (uniform plant height and structure) and the number of niches available for bird species.

Indicators: Direct observation of the two species of invasive plants. The presence is recorded as one of four categories based on percent coverage within the AU (see Part 2).

Scaling: AUs in which either of the two species covers more than 50% of the AU have their index score reduced by a factor of 0.8.

$\mathbf{V_{humandis}}$ – The presence of human disturbance within 100 meters of the AU edge.

Rationale: In the judgement of the Assessment Team, human disturbance is a major factor in reducing aquatic bird richness. Human presence is particularly damaging if it is regular and occurring during periods of critical life cycle needs such as breeding/nesting. Disturbance can include recreational boating, fishing, hunting, hiking and nature observation. Depending on the time of year these human activities can interfere with pair bonding, breeding/nesting , and feeding and roosting activities of aquatic birds.

Indicators: Human disturbance is rated based as high or low based on direct observation of activities, and by indirect evidence such as parking areas, off-road tire tracks, trash, fishing line, and foot-trails along shoreline and through buffer.

Scaling: AUs in which human activities such as boating, fishing, hunting, grazing, roads, residences or urban areas are rated as having a high impact have their final score reduced by a factor of 0.8.

7.10.5 Calculation of Habitat Suitability

Depressional Short-duration Habitat for Aquatic Birds

Variable	Description of Scaling		Score for Variable	Result
Vopenw	*Highest*	AU has >=50% open water	If calculation >=1 enter "1"	
	Lowest	AU has no open water	If calculation = 0 enter "0"	
	Calculation	Scaled as (% extended inundation open water / 50)	Enter result of calculation if < 1.0	
	Calculate D10.5/50			
Vmud/sand	*Highest:*	AU has mud or sand flats	If D10.5 >=1 enter "1"	
	Lowest:	AU has no mud or sand flats	If D10.5 = 0 enter "0"	
Vwintersp2	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D36.2/3			
Vpheight	*Highest*	AU with 4 or 5 height ranges of vegetation	If calculation >=1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/4	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3 + D20.4 + D20.5)-1]/3			
Vpintersp	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vbuffcond	*Highest:*	Buffer category of 5	If D39 = 5, enter "1"	
	High:	Buffer category of 4	If D39 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D39 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D39 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D39 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D39 = 0, enter "0"	
Vbuffstruc	*Highest*	AU has 4 or 5 structures in buffer	If calculation >=1 enter "1"	
	Lowest	AU has no structures	If calculation = 0 enter "0"	
	Calculation	Scaled as (# of structures)/4	Enter result of calculation if < 1.0	
	Calculate (D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/4			
Sinverts	*Score is scaled*	Index for Habitat Suitability for Invertebrates	(Index of function)/10	
			Total of Variable Scores:	

Depressional short-duration Aquatic Bird Habitat (Suitability)(Cont.)

Variable	Description of Scaling	Score for Variable	Result
Reducers			
Vinvasp	AU has more than 50% loosestrife and/or *Phragmites*	If D22.2+D22.3 >=4 enter "0.8"	
	AU has <50% loosestrife and/or *Phragmites*	If D22.2+D22.3 <4 enter "1"	
Vhumandis	AU has high levels of human disturbance	If rating of any disturbance is high: value of 2 in any field (D41.1 to D41.8) enter "0.8"	
	AU does not have high levels of human disturbance	If ratings of disturbance are low on none (only values of "0 or 1" in data D41.1 to D41.8) enter a "1"	
		Score for Reducer - ***multiply scores for two reducers***	
		Index for Bird Habitat (Suitability) = (Total of variables) x (score for reducers) x (1.25) rounded to the nearest 1	
		FINAL RESULT:	

7.10.6 Qualitative Rating of Opportunity

The opportunity that an assessment unit has to provide bird habitat is a function of many landscape variables such as the presence of nearby open water, other wetlands, and proximity to the major migratory flyways.

Users must make a qualitative rating on the opportunity of the AU to actually provide bird habitat because a quantitative model could not be calibrated. Generally, the opportunity is **High** if the AU is located in a mosaic of other wetlands, lakes or riverine habitats and is on a major flyway. It should be rated a **Moderate** if it is not in a dense mosaic of other aquatic habitats, or if it is isolated but still located on the major flyways. It should be rated **Low** if the AU is isolated from other aquatic habitats by at least 10 km and is not on the usual migratory path for aquatic birds.

7.11 Habitat for Aquatic Mammals — Depressional Short-duration Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.11.1 Definition and Description of Function

Habitat for Aquatic Mammals is defined as the capacity of the wetland to provide habitat for two aquatic mammals. Habitat requirements were modeled for beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*).

The two species used in this model were selected due to their dependence on wetlands (Hammerson 1994), their economic importance, as well as their influence on the wetland systems (Johnston and Naiman 1987, Garbisch 1994). A model for all mammal species of the Columbia Basin that use wetlands would be cumbersome and not rapid. There are too many variations in habitat requirements, we lack information on many species, and there is a need to assess the landscape as well as the wetland. The focus of the assessment is on wetlands and it does not try to assess the performance of the surrounding landscape. This model reflects suitability in terms of species richness and assumes that AUs providing habitat for both species have a higher level of performance of the function than those not providing such habitat. Available estimates of species abundance were not used because the model is not meant to assess that aspect of habitat.

Short-duration wetlands are defined as those wetlands where surface water (inundation) is present for less than 9 months in most years. This family of wetlands also includes short-duration wetlands known as “vernals” that typically have surface water present for less than 60 days in the growing season

Depressional short-duration wetlands are modeled <u>only for opportunity</u>. Aquatic mammals may forage in short-duration wetlands if seasonal open water is present and if they are near a long-duration system. Thus, some short-duration wetlands may have an opportunity to provide some support for mammals. Short-duration wetlands, however, cannot support a permanent population either of the two species because they require the presence of permanent surface water.

.7.11.2 Assessing this Function for Depressional Short-duration Wetlands

The model for the opportunity in depressional short-duration wetlands assesses the connectivity and proximity of the AU to other habitats that are suitable for these two species of mammals.

7.11.3 Model at a Glance

Depressional Short-duration Habitat for Aquatic Mammals

Characteristics	Variables	Measures or Indicators
OPPORTUNITY		
	Vmosaicper	Aquatic habitats with permanent water within 2 km
	Vripcorridor	Rating of riparian corridors to and from AU
	Vvegcorridor	Rating of vegetated corridors to and from AU
Numerator for Opportunity	Vmosaicper + Vripcorridor + Vvegcorridor	

7.11.4 Description and Scaling of Variables

Variables for Opportunity

$\mathbf{V}_{\mathbf{mosaicper}}$ - The AU is part of a complex of aquatic habitats with permanent water within 2 km.

Rationale: The assessment team concluded that AUs that occur as part of a complex of permanent water resources (rivers, streams, lakes, permanently inundated wetlands) provide a greater opportunity for wetlands with short periods of inundation to be used by mammals. Mammals living in the permanent waters may forage in nearby seasonally inundated wetlands.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of wetlands in the landscape.

Scaling: AUs with all three types of permanent water resources (permanent long duration wetlands, perennial stream or river and lakes) within 2km are scored a[1] for the variable. Those with fewer are scored proportionally as (# types/3).

$\mathbf{V}_{\mathbf{ripcorridor}}$- Rating of riparian corridor connecting AU to other wetlands.

Rationale: Emigration of young beaver may involve movements over considerable distances, both over land and via waterways (Slough and Sadleir 1977). Corridors are important during all seasons, though they will be more important when water is present in the corridor. Riparian corridors with deeper, permanent, water are better for dispersal because they provide cover under water.

Indicators: This variable is determined using a corridor rating key described in Part 2. Riparian corridors are rated on a scale of 0-3 based on the depth and permanence of water.

Scaling: AUs with a rating of 3 for the riparian corridor are scored a [1] for this variable. AUs with a lower rating are scored proportionally (rating/3).

$V_{vegcorridor}$ – Rating of vegetation cover in corridors to other wetlands.

Rationale: Vegetation in dispersal corridors provides cover during the migration from one wetland to another. The assessment team concluded that AUs connected to other wetlands with a dense vegetation cover have a higher opportunity to provide habitat because the are more easily accessible for the mammals.

Indicators: This variable is determined using a corridor rating key described in Part 2. Vegetated corridors are rated on a scale of 0-3 based on the amount of plant cover in the corridor

Scaling: AUs with a rating of 3 for the vegetated corridor are scored a [1] for this variable. AUs with a lower rating are scored proportionally (rating/3).

7.11.5 Calculation of Habitat Suitability

Not applicable in short-duration wetlands

7.11.6 Calculation of Opportunity

Depressional Short-duration **Mammal Habitat**

Variable	Description of Scaling		Score for Variable	Result
Vmosaicper	*Highest*	AU has at least 3 permanent water resources within 2 km	If calculation =1 enter "1"	
	Lowest	AU has no perennial wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/3)	Enter result of calculation if < 1.0	
	Calculate (D8.5 + D8.7 + D8.8)/3			
Vripcorridor	*Highest*	AU has a rating of 3 for riparian corridors	If calculation =1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (corridor rating / 3)	Enter result of calculation if < 1.0	
	Calculate D43.1/3			
Vvegcorridor	*Highest*	AU has a rating of 3 for vegetated corridors	If calculation =1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (corridor rating / 3)	Enter result of calculation if < 1.0	
	Calculate D43.2/3			
			Total of Variable Scores:	
Index for Mammal Habitat (Opportunity)= Total x 3.33 rounded to nearest 1				
			FINAL RESULT:	

7.12 Richness of Native Plants — Depressional Short-duration Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.12.1 Definition and Description of Function

The Richness of Native Plants is defined as the degree to which a wetland provides a habitat for different native plant species.

Note: Because the presence or absence of plant species can usually be assessed during a single site visit and used as an indicator of total richness, this model represents the only direct estimate of actual performance in this function assessment method.

A wetland performs the function when the number native plant species is already high, or the number of non-native species is low. Dominance by even a few non-native species often precludes native plant species, and therefore the ability of the AU to support native plant richness at the local and regional levels. The reduction of this potential appears to be exacerbated by the presence of a few aggressive non-native plant species that colonize and dominate existing native plant associations. Thus not only is the number of non-native species important in reducing the performance of this function, the coverage of few aggressive species is perhaps more critical in determining whether native plant associations can continue to exist. Changes in vegetation composition as the result of non-native invaders have been inferred by vegetation classification through soil nutrient alteration (Parker 1974, Duebendorfer 1990, La Banca. 1993).

Wetlands currently dominated by native plant species tend to be more capable of maintaining native plants than those dominated by non-native species. A high number of native plant species in a wetland enhances the potential for colonization to other perhaps recently disturbed areas. The number and richness of native plant species increases with proximity to nearest seed source (Reinartz and Warne, 1993). Additionally, native plant associations more often harbor rare plant species than non-native associations.

The assessment teams, therefore, have judged that wetlands where one or more of the dominant species is non-native have lost some of their ability to support native plant associations. Non-native plants that become dominant tend to become monocultures that exclude native species. The percent of the AU dominated, or co-dominated, by non-native species is modeled as a reducer for this function.

Performance of this function is based the number of native plants present and the absence of non-native species. The model, however, is valid only if the AU has not been recently cleared or altered. If you find the assessment unit has been recently cleared or cut, the score from the model will not provide an adequate assessment of the function.

Opportunity is not modeled because it is assumed that all assessment units have the same opportunity for providing plant habitat. Seed dispersal among different AUs in the Basin is judged to be approximately the same for the level of resolution of these methods.

7.12.2 Assessing this Function for Depressional Short-duration Wetlands

The model assessing "suitability of providing native plant habitat" for depressional short-duration wetlands, is based on the actual counts of native plant species made during the site visit and the proportion of native to non-native species found. The areal coverage of non-native species is used as a reducer for the level of performance of this function.

7.12.3 Model at a Glance

Depressional Short-duration **Richness of Native Plants**

Characteristics	Variables	Measures or Indicators
Richness of native plants	**V%native**	Percent of total plant species that are native
	Vnative/non	Ratio of native to non-native plant species
	Vmaxnative	Number of native plants identified during 1 site visit
Reducers		
	Vnonnat	% cover of AU where non-natives are dominant or co-dominant
Numerator	(V%native+Vnative/non + Vmaxnative)xVnonnat	

7.12.4 Description and Scaling of Variables

Variables

$V_{\%native}$ – Percent of total plant species that are native.

> **Rationale**: The percent of total plant species that are native is one measure of how effective it is in providing diverse habitat for native plants and maintaining regional plant richness.
>
> **Indicators**: No indicator required. Direct observation of the total number of plant species and the number of native plant species within that total.

Scaling: AUs where the native species represent more than 90% of the total are scored a [1] for this variable. Those with a smaller percentage are scored proportionally (% / 90).

$\mathbf{V_{native/non}}$ - The ratio of native to non-native plant species.

Rationale: The ratio of native plant species to non-native present in an AU is an additional measure of how effective it is in providing diverse habitat for native plants and maintaining regional plant richness. Both the % and ratio are used as variables because this minimizes the difference that arise with collecting plant data at different times in the growing season. The actual species counts at an AU changed seasonally, but the ratios remained relatively stable.

Indicators: The indicator is the number of native and non-native species observed during the site visit.

Scaling: AUs whose ratio was greater than or equal to 7 were scored a [1] for this variable. Those with a lower ration were scored proportionally (ratio / 7).

$\mathbf{V_{maxnative}}$ - The number of native plant species present.

Rationale: The number of native plant species present in an AU is one measure of how effective it is in providing diverse habitat for native plants and maintaining regional plant diversity. It is not possible, however, to determine the total species richness in one visit and within a few hours. Some plants are annuals and grow for only a short time, others have a very limited distribution and may occupy a small and inconspicuous patch that is easily overlooked. For this reason the count of native species determined during the site visit is only an indicator of the actual "maximum" number that could be present in an AU.

Indicators: The indicator of overall native plant richness is the number of species found during the site visit.

Scaling: AUs with 14 or more native species present are scored a [1] for this variable. Those with fewer are scored proportionally (# species / 14).

Reducers

$\mathbf{V_{nonnat}}$ - The percent of the AU where non-native species are dominant or co-dominant.

Rationale: AUs in which non-native plant species are dominant (>50% areal cover) or co-dominant (>20% areal cover) may hinder the ability of the AU to provide diverse habitat for native plants and maintaining regional plant diversity. Aggressive non-native species tend to outcompete native species. The estimate of areal coverage of non-native species determined during the site visit is only an indicator of the actual coverage possible.

Indicators: The areal coverage of dominant or co-dominant non-native species (>20% cover within any plant association) re-estimated during the site visit.

Scaling: AUs where the non-native cover more than 75% of the area have their score reduced by a factor of (x 0.3). A 50% - 75% cover reduces the score by a factor of (x 0.5) and a cover of 25% - 49% reduces the score by a factor of (x 0.9). AUs with less than a 25% cover of non-natives do not have their score reduced.

7.12.5 Calculation of Richness

Depressional Short-duration **Native Plant Richness**

Variable	Description of Scaling		Score for Variable	Result
V%native	*Highest:*	% native plants >=90%	If calculation >=1 enter "1"	
	Lowest:	% native plants = 0%	If calculation = 0 enter "0"	
	Calculation:	Scaled as % native/90	Enter result of calculation if < 1.0	
	Calculate [D21.1/(D21.1 + D21.2)] / 0.9			
Vnative/non	*Highest:*	Ratio > = 7	If calculation >=1 enter "1"	
	Lowest:	Ratio = 0	If calculation = 0 enter "0"	
	Calculation:	Scaled as ratio/7	Enter result of calculation if < 1.0	
	Calculate (D21.1 / D21.2)/7 Note: if no non-natives present result of calculation is automatically > 1			
Vmaxnative	*Highest*	AU has >= 14 native species	If calculation >=1 enter "1"	
	Lowest	AU has 0 native species	If calculation = 0 enter "0"	
	Calculation	Scaled as # native plant species/14	Enter result of calculation if < 1.0	
	Calculate D21.1/14			
			Total of Variable Scores:	
Reducer				
Vnonnat	>75% cover of non-native plants		If D24.1 = 1, enter "0.3"	
	50-75% cover of non-native plants		If D24.2 = 1, enter "0.6"	
	25 - 49% cover of non-native plants		If D24.3 = 1, enter "0.9"	
	0 – 24% cover of non-native plants		If D24.4 + D24.5 = 1 enter "1"	
			Score for Reducer	
	Index for Native Plant Richness = (Total for variables) x (Reducer) x (3.33) rounded to nearest 1			
			FINAL RESULT:	

7.13 Supporting Food Webs – Depressional Short-duration Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.13.1 Definition and Description of Function

Supporting Food Webs is defined as wetland processes and characteristics that support complex food webs within the wetland and in the surrounding ecosystem(s). The function combines three major ecosystem processes - primary production, secondary production, and export of production.

Wetlands are known for their high primary production and the subsequent cycling of organic matter within the system and to adjacent ecosystems (Mitch and Gosselink, 1993). The assessment team has determined that Columbia Basin depressional wetlands generally do not export all, or even most, of their production through surface waters leaving the wetland because of low surface flows out of the systems. Much of the primary and secondary production is exported by way of mammals, birds, amphibians, reptiles, and predatory insects that feed in the wetland. Export also takes place when some insects emerge as adults and fly away from the wetland.

Wetlands in the Columbia Basin play a critical role in maintaining the structure and stability of the terrestrial animal communities around them. Their high primary productivity and the complexity of the species associations that feed on this production provide a stable food source for many terrestrial animals that would otherwise not survive in the semi-arid environment of the Basin. Detritivores appear to start feeding activity very early in the spring, and the algal-based food webs start in March (B. Lang, personal communications).

The model assesses food web support by the amount of photosynthesis that occurs in the wetland, the potential for surface water export of production, and by the richness of secondary producers. Wetlands with a high faunal richness provide a more stable exportable resource for the surrounding ecosystems.

7.13.2 Assessing this Function for Depressional Short-duration Wetlands

Primary production in depressional short-duration wetlands is modeled as total plant cover that provides the basic energy source (both directly and indirectly through plant debris and detritus). Secondary production and the potential complexity of the food webs in the wetland are modeled by including the score for the invertebrate and bird models.

Opportunity for production and exports was judged to be a function of the rainfall. The relative regional primary production is lower in deserts, and the primary and secondary production from wetlands are, therefore, proportionally more important to the region. All wetlands in the Basin were judged, however, to have some opportunity for export of production. The assessment team decided it is not appropriate to score any wetland as a zero since that might imply there is not export. The model, therefore, was scaled for a range of function indices from 5 – 10, rather than from 0 – 10.

7.13.3 Model at a Glance

Depressional Short-duration Supporting Food Webs

Characteristics	Variables	Measures or Indicators
POTENTIAL		
Primary & Secondary	**Vvegcover**	% of AU that is vegetated
Production and Surface	**Vout**	AU has evidence of surface outflow
Export	**Sinverts**	Index of suitability from invertebrate model
	Sbirds	Index of suitability from bird model
OPPORTUNITY		
	Vprecip	Average annual rainfall for AU
Numerator for Potential	Vvegcover + Vout +Sinverts + Sbirds	
Numerator for Opportunity	Vprecip	

7.13.4 Description and Scaling of Variables

Variables for Potential

$V_{vegcover}$ - Percent of the AU with plant cover.

Rationale: Overall, the plant cover found in the AU represents the primary photosynthetic input to the local ecosystem. Since direct photosynthesis cannot be measured, the amount of AU actually covered by vegetation (as contrasted to open water, mud banks, rocks, etc.) is used as surrogate.

Indicators: No indicators are needed. The percent of the AU covered by plants can be estimated directly.

Scaling: AUs with 99% or 100% cover of vegetation are scored a [1] for this variable. Those with less are scored proportionally (%cover /99).

$\mathbf{V_{out}}$ - AU has surface water outflow at some time during the year.

Rationale: Surface outflow from a short-duration from an AU will carry dissolved and particulate organic matter out of the AU and into other aquatic and terrestrial systems. This organic matter will then be incorporated into the food web of these habitats.

Indicators: Presence of outlet and drainage features leading away from outlet. Evidence of surface flow outside of AU including surface scour, sediment deposits.

Scaling: This is a "yes/no" variable. AUs with an outflow are scored a [1] for this variable, and those without are scored a [0].

$\mathbf{S_{inverts}}$ - The score from the "invertebrate" model.

Rationale: The invertebrate model score represents the potential of AUs to support organisms other than wetland dependent species. As such, this variable acts as a surrogate for estimating export of secondary productivity and food web support for terrestrial species. After metamorphosis, wetland invertebrates typically disperse from wetlands for several miles into the surrounding upland habitat where they are preyed upon, primarily by birds. This represents secondary production that is being exported from the AU and supports organisms higher in the food chain that are not directly dependent on the AU. Additionally, invertebrates that are not preyed upon will eventually die, contributing their nutrients to plant production in upland areas.

Indicators: No indicators are needed for this variable. The score from the invertebrate model is used.

Scaling: The variable is already scaled. It is normalized to 1 in the equation.

$\mathbf{S_{birds}}$ - The score from the "bird" model.

Rationale: Aquatic birds feed in wetlands, and excrete some of what they have consumed in adjacent terrestrial habitats since they are highly mobile. Also, the aquatic birds are preyed upon by hawks, falcons, and other predators. Both of these processes are an export of production in the AU to other ecosystems. AUs that have a high index score for aquatic bird richness have the potential to support a more complex terrestrial food web because different birds will excrete in different upland habitats and provide prey for a broader range of predators.

Indicators: No indicators are needed for this variable. The score from the bird model is used.

Scaling: the variable is already scaled. It is normalized to 1 in the equation.

Variables for Opportunity

$\mathbf{V_{precip}}$ – The average annual precipitation in the area of the AU.

Rationale: AUs located in drier parts of the Basin play a more important role in providing support to the terrestrial food webs. The relative regional primary production is lower in the deserts, and the primary and secondary production from wetlands are proportionally more important to the upland ecosystems.

Indicators: The average annual precipitation in the region of the AU can be determined from weather records maintained by the USGS.

Scaling: AUs in areas where the average annual precipitation is 8 inches or less are scored a 1 for this variable. Those with an average rainfall of 16 inches or less are scored a 0.5, and those with rainfalls between these two numbers are scored proportionally between 0.5 and 1.0.

7.13.5 Calculation of Potential
Depressional Short-duration Supporting Food

Variable	Description of Scaling		Score for Variable	Result
Vvegcover	*Highest:*	AU is 99% vegetated	If calculation >=1, enter "1"	
	Lowest:	AU has minimal vegetation cover	If calculation =<0.05, enter "0"	
	Calculation:	Scaling is set as % vegetated/99	Enter result of calculation if <1	
	Calculate [sum (D16.1 to D16.4)] /99 to get result			
Vout	*Highest:*	If AU has a surface water outlet	IF D9 = 1 enter "1"	
	Lowest:	If AU has no outlet	IF D9 = 0 enter "0"	
Sinverts	*Score is scaled*	Index for Habitat Suitability for Invertebrates	(Index of function)/10	
Sbirds	*Score is scaled*	Index for Habitat Suitability for Birds	(Index of function)/10	
			Total of Variable Scores:	
	Index for Supporting Food Webs (Potential) = (Total of variables) x (2.56) rounded to the nearest 1			
			FINAL RESULT:	

7.13.6 Calculation of Opportunity
Depressional Short-duration Supporting Food Webs

Variable	Description of Scaling		Score for Variable	Result
Vprecip	*Highest:*	AU has 8 in rain/year or less	If calculation >=1, enter "1"	
	Lowest:	AU has > 16 inches rain/year	If calculation <= 0.5, enter "0.5"	
	Calculation:	Scaling is set as (8/rainfall)	Enter result of calculation if 0.5 <= calculation <1	
	Calculate 8 / D29			
			Total of Variable Scores:	
	Index for Supporting Food Webs (Opportunity) = (Total of variables) x (10) rounded to the nearest 1			
			FINAL RESULT:	

8. Method for Assessing Depressional Alkali Wetlands

The method includes models for the following functions.

Removing Sediment

Decreasing Downstream Erosion and Flooding

General Habitat

Habitat for Invertebrates

Habitat for Amphibians

Habitat for Aquatic Birds

Habitat for Aquatic Mammals

Native Plant Richness

8.1 Removing Sediment—Depressional Alkali Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

8.1.1 Definition and Description of Function

Removing sediment is defined as the wetland processes that retain sediment in a wetland, and prevent its movement downstream.

A wetland performs this function if there is a net annual decrease of sediment load to downstream surface waters in the watershed. Settling and filtration are the major processes by which sediment is removed from surface water (either streamflow or sheetflow) in wetlands. Particles present in the water will tend to settle out when water velocity and turbulence reduced (Mitsch and Gosselink, 1993). The size of the particles that settle out is directly related to the increase in settling time achieved in the wetland. Filtration is the physical adhesion and cohesion of sediment facilitated by vegetation.

8.1.2 Assessing this Function for Depressional Alkali Wetlands

The potential of depressional alkali wetlands to remove sediment is a function of their ability to reduce water velocities and by vegetation structure near the ground surface that act as a filter (Adamus et al. 1991). Velocity reduction cannot be estimated directly in a rapid assessment method. The amount of storage (Adamus et al. 1991) is used as a variable that captures one aspect of velocity reduction – volume of water stored. The potential for filtration is modeled by amount of the AU that is covered by erect vegetation (emergent, scrub/shrub, and forest).

If, however, the AU has no outlet it has the potential to remove sediment at the highest levels. It will be scored a [10] regardless of other characteristics. All sediments coming into the AU are retained and not released to surface waters. Therefore, the AU is performing at its maximum potential. Most alkali wetlands in the Columbia Basin are closed, and, therefore, will perform at the highest levels.

Depressional wetlands in the Basin that have outlets, however, also remove sediments fairly effectively. The outlets found in the reference sites all have been small, narrow, and generally filled with vegetation. None of the reference AUs with an outlet were judged to remove sediments poorly. The assessment team, therefore, decided it was not appropriate to score any wetland as a zero since that might imply there is not sediment removal. All reference sites were judged to score at least a [7] out of [10]. The model is scaled so no AU will score less than a [7].

The opportunity that an AU has to remove sediment is a function of the level of disturbance in the landscape. Relatively undisturbed watersheds will carry much lower sediment loads than those that have been impacted by human activities (Hartmann et al. 1996, Reinelt and Horner 1995). The opportunity that an AU has to remove sediment, therefore, is linked to the amount of development, or agriculture present in the upgradient part of its contributing basin. Conditions in the buffer around an AU are also important in determining whether sediments can reach it. Buffers with intact natural vegetation will trap sediments coming from the surrounding landscape before they reach the AU. The slope of the contributing watershed also plays a role. Watersheds with steep gradients tend to have higher water velocities and more sediment transport.

8.1.3 Model at a Glance

Depressional Alkali **Removing Sediment**

Process	Variables	Measures or Indicators
POTENTIAL		
Velocity reduction	**Vstorage**	Elevation difference between bottom of extended inundation water level and flood marks
Sediments leaving	**Vout**	Presence/absence of outlet
Filtration	**Vvegcover**	% of AU that is vegetated
OPPORTUNITY		
Buffer interception	**Vbuffcond**	Descriptive characterization of condition of buffer
	Vbufferbypass	Presence of ditch/drain that routes surface flow around buffer
Upgradient sediment sources	**Vupsedim**	Upgradient sources of sediment within 1km
	Vslope	Degree of slope in contributing basin
Numerator for Potential	Vstorage + Vout + Vvegcover	
Numerator for Opportunity	Vbuffcond+Vbufferbypass+Vupsedim+Vslope	

8.1.4 Description and Scaling of Variables

Variables for Potential

$V_{storage}$ - The volume of water stored in an AU annually. It is assessed as the average depth of annual inundation (high water level) over the AU because the variable is scaled on a per acre basis.

> **Rationale:** Vstorage is a measure of the volume of storage available. It is related to velocity reduction because flows into the AU will be slowed as it is filled. AUs that store water tend to trap more sediment than those that do not (Fennessey et al. 1994).
>
> **Indicators:** The variable for storage is assessed as the difference in elevation between the surface of the areas of extended inundation and any flood marks or water marks in the AU or along its shore. In alkali wetlands the surface of the extended inundation is used as the surface from which measurements are taken unless the AU dries out completely (i.e. lowest point of AU is the point from which measurements are then taken). To estimate the average depth of storage in the AU the maximum depth of storage is corrected by a factor representing the average cross section of the inundated areas in the AU. The calculation provides an average depth of storage across the area that is inundated every year.
>
> **Scaling:** AU with 1.2 m or more of average annual storage are scored a [1]. Those with less are scaled proportionally less (storage(m)/1.2).

V_{out} - Presence/absence of an outlet in the AU.

> **Rationale:** All sediments coming into the AU are retained and not released to surface waters downgradient if the AU has no outlet.
>
> **Indicators:** No indicators are needed. The presence/absence of an outlet is determined in the field.
>
> **Scaling**: AUs with no outlet have the potential to remove sediment at the highest levels and are scored a [10] for the function. AUs with an outlet are scored a [7] at a minimum. A higher score is possible, however, for wetlands with an outlet if they have good storage and vegetation present.

$V_{vegcover}$ - Percent area of AU that is covered by vegetation.

> **Rationale:** Plants enhance sedimentation by providing a medium that acts like a filter, and causes sediment particles to drop to the AU surface. In the Columbia Basin it is assumed that vegetation need not be erect and persistent to trap sediment. The assessment team judged that aquatic bed vegetation will trap sediments as well as erect herbaceous plants, trees, and shrubs because of the low water velocities usually associated with depressional wetlands in this region.

Indicators: No indicators are needed. The areal extent of the vegetation can be estimated directly at the AU site.

Scaling: AUs with 80% vegetation cover score a [1] for this variable. Those with less are scored proportionally (% cover/80).

Variables for Opportunity

$V_{buffcond}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: Conditions in the buffer around an AU are also important in determining whether sediments can reach it. Buffers with intact natural vegetation will trap sediments coming from the surrounding landscape before they reach the wetland (review in Desbonnet, et al. 1994). Undisturbed, vegetated buffers reduce the opportunity an AU has to receive sediments.

Indicators: This variable is assessed using the buffer categorization described Part 2.

Scaling: AUs with a buffer category of 0 is scaled a [1]. Those with a category of 5 are scaled a [0]. Categories of 1-4 are scaled proportionally between 0.8 – 0.2.

$V_{bufferbypass}$ – Ditches or drains that route surface waters around the buffer and directly into the AU.

Rationale: Ditches or drains that route surface waters around the buffer and directly into the AU reduce the sediment trapping processes in the buffer. As a result, more sediment is delivered to the AU. This increases the opportunity that an AU has to trap sediments.

Indicators: None needed. Direct observation of ditches/drains that would capture surface runoff and route it around the buffer directly into the AU.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if there is a channel bypassing the buffer, and a [0] if there is no channel.

$V_{upsedim}$ - Conditions and land uses in the upgradient basin or watershed that add sediment to surface waters flowing into the AU.

Rationale: Densely vegetated watersheds (e.g. undisturbed forest) stabilize soils, reduce runoff velocity, and thus export less sediment (Bormann et al. 1974, Chang et. al. 1983). In contrast, residential, urban, agricultural, or logged watersheds have more exposed soils and thus higher sediment loading. AUs with upgradient disturbances to the contributing basin will have a greater opportunity to remove sediment and improve water quality than those in undisturbed watersheds.

Indicators: The indicators for upgradient sediment loading are the presence of land uses that generate sediments such as tilled fields, pasture, urban, commercial, and residential areas. Only the areas that are within 1 km of the AU and within the contributing basin are considered.

Scaling: AUs with land uses that increase sediment loads within 1km of the AU are scored a [1] for this variable. AUs with no such lands uses are scored a [0].

V_{slope} - The average percent slope of the stream channels within the contributing basin of the AU.

Rationale: Contributing basins with steeper gradients (% slope) will transport sediment more readily downslope to an AU than contributing basins with relatively shallow gradients.

Indicators: None needed. Measured directly with clinometer or from USGS maps using contour intervals.

Scaling: AUs whose contributing basins have a slope of 5% or more are scaled a [1] for this variable. Those with a slope of 1=5% are scored a [0.5] and those with a slope of <1% are scored a [0] variable.

8.1.5 Calculations of Potential Performance

Depressional Alkali **Removing Sediment**

Variable	Description of Scaling		Score for Variable	Results
Vout	*Highest:*	If AU has no outlet	**IF D9 = 0**	
			Enter 10 in "Final Result"	
		If AU has an outlet	Do calculations below	
Vstorage	*Highest:*	Average depth of annual storage >= 1.2m	If calculation >= 1 Enter '1'	
	Lowest:	No annual storage	If calculation=0 enter "0"	
	Calculation:	Scaling is set as average depth/1.2	Enter result of calculation if< 1	
	Calculate D9 x [(D14.1 x 0.67) + (D14.2 x 0.5) + (D14.2 x 1)] / 1.2			
Vvegcover	*Highest:*	AU is 80% vegetated	If calculation =1, enter "1"	
	Lowest:	AU has minimal vegetation cover	If calculation =<0.05, enter "0"	
	Calculation:	Scaling is set as % vegetated/80	Enter result of calculation if <1	
	Calculate (D16.1 + D16.2 + D16.3 + D16.4)] /80			
			Total of Variable Scores:	
			Index for Removing Sediment (Potential) = (7 + (Total of Variables) rounded to nearest 1	
			FINAL RESULT:	

8.1.6 Calculation of Opportunity

Depressional Alkali **Removing Sediment**

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 0	If D39 = 0, enter "1"	
	High:	Buffer category of 1	If D39 = 1, enter "0.8"	
	Moderate:	Buffer category of 2	If D39 = 2, enter "0.6"	
	Medium Low:	Buffer category of 3	If D39 = 3, enter "0.4"	
	Low:	Buffer category of 4	If D39 = 4, enter "0.2"	
	Lowest:	Buffer category of 5	If D39 = 5, enter "0"	
Vbufferbypass	*Highest:*	AU has surface water bypass through buffer	If D40 = 1 Enter "1"	
	Lowest:	No surface water bypass	IF D40 = 0 Enter "0"	
Vupsedim	*Highest:*	Human land uses present within 1km	If calculation >=1enter '1'	
	Lowest:	No human land uses in basin	If calculation = 0 enter "0"	
	Calculate D7.9+D7.10+D7.11+D7.12			
Vslope	*Highest:*	Slope in contributing basin >=5%	If calculation >=1, enter "1"	
	Lowest:	Slope in basin <0.05%	If calculation = <0.01, enter "0"	
	Calculation:	Scaling is set as slope/5	Enter result of calculation if<1	
	Calculate D2.1/5			
			Total of Variable Scores:	
Index for Removing Sediment (Opportunity) = Total x 2.8 rounded to nearest 1				
			FINAL RESULT:	

8.2 Reducing Downstream Erosion & Flooding — Depressional Alkali Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

8.2.1 Definition and Description of Function

Reducing Downstream Erosion and Flooding is defined as the wetland attributes that attenuate high flows and their erosive capacity.

Wetlands reduce downstream erosion and flooding by storing water, thus reducing the velocity and volume of water flowing downstream. The wetland retains runoff water and reduces downstream flows during storms (water has a higher retention time in the wetland than in the stream). The amount of retention provided is dependent on the available storage and the outlet capacity or the release rate of runoff. Wetlands, play an important role in detaining and slowing runoff during snowmelt.

The ability to reduce erosion and flooding depends on the amount of storage in a wetland. Prior to the snowmelt and any rain-on-snow events, many of the depressional wetlands in the Columbia Basin have significant storage capacity. They tend to have poorly defined, or very constricted, outlets and slow flow through the wetland at times of high water. These wetlands to capture and hold back the rapid runoff from the snowmelt and rain-on-snow events. The stored water slowly evaporates or infiltrates into groundwater. Water levels decline in the summer and the storage is available in winter for "rain-on-snow" events.

8.2.2 Assessing This Function for Depressional Alkali Wetlands

The potential of depressional alkali wetlands to decrease downstream erosion and flooding is modeled as water storage and as a reduced rate of water leaving the wetland. The depth of annual inundation indicates storage capacity. The release rate is modeled by the outlet characteristics.

The opportunity for an AU to reduce peak flows will increase as the water regime in the upgradient watershed is destabilized. Research in western Washington has shown that peak flows increase as the percentage of impermeable surface increase (Reinelt and Horner 1995). The opportunity for an AU to decrease erosion and flooding is also reduced in the Columbia Basin if it is within the boundaries of the Reclamation Project. Wetlands within the Project will have higher water levels during the summer and fall that result from irrigation at that time that raises groundwater. The AU, therefore, will have less opportunity to store water during the intense summer storms that may cause localized flooding.

Users must make a qualitative judgement on the opportunity of the AU to actually reduce peak flows by considering the land uses in the contributing watershed because a quantitative model could not be calibrated. None of the data collected during the calibration could be adequately correlated with the judgements of opportunity made by the Assessment Team. The conclusion of the Assessment Team was that too many variables were involved in making a judgement of opportunity, and a simple model could not be developed.

8.2.3 Model at a Glance

Depressional Alkali **Reducing Downstream Erosion & Flooding**

Process	Variables	Measures or Indicators
POTENTIAL		
Storage	**Vstorage**	Elevation difference between bottom of perennial water level and flood marks
Slowing release of water	**Voutletw/inund**	Ratio of outlet width to area of inundation
	Vinund/shed	Ratio of area of inundation to contributing basin
OPPORTUNITY		***Could not be calibrated, users make a qualitative judgement***
Numerator for Potential	2xVstorage + Voutletw/inund + Vinund/shed	

8.2.4 Description and Scaling of Variables

Variables for Potential

$V_{storage}$ - The amount of storage available in the AU during an inundation or flooding event.

Rationale: Vstorage is a measure of the volume of storage available during major runoff events. The assessment team assumed that AUs having relatively more storage would decrease water velocities and peak flows more than those with less storage. This occurs because retention time is increased as volume of storage is increased for any given inflow (Fennessey et al. 1994).

Indicators: The indicator for the amount of storage in the AU is the difference in elevation between the surface of extended inundation, or the AU bottom when dry, and any flood marks, water marks, sediment deposits, dried algal mats or detritus on vegetation, rocks or cliffs along the shore. The depth of storage, as used in the model, is corrected by a factor reflecting the shape of the AU to estimate an average water depth over the entire portion that is inundated.

Scaling: AUs with an average depth of seasonal inundation that is greater than or equal to 2 m are scored a [1] for this variable. Those with less are scored proportionally (average depth / 2). This variable was judged to be more important than the others and is weighted by a factor of 2 in the equation.

$V_{outletw/inund}$ - The ratio of outlet width to the area of inundation.

Rationale: The ratio of the outlet width to the area of seasonal inundation to the outlet width is a predictor of the degree of downstream erosion. The lower the value of the ratio the more slowly an AU releases water thereby reducing downstream velocities and potential for erosion.

Indicators: The width of the outlet can be directly measured. The area of annual inundation will be mapped, based on field indicators of high water marks on rocks and vegetation. This variable is treated as a dimensionless number based on areal measurements in hectares and the width measurement in meters.

Scaling: AUs with a ratio <= to 1 will score a [1] for this variable. Those with a higher ratio will be scaled proportionally (1/ratio). AUs without an outlet are score a [1] for this variable.

$V_{inund/shed}$ - The ratio of the maximum area that is inundated every year in the AU to the area of its contributing basin.

Rationale: The potential of a AU to decrease erosion and flooding is partially a function of how much water flowing into the AU is held back relative to the amount flowing out. This relationship determines how long is the water held in the AU before being released (called retention time). Retention time is the relative volume coming into a unit during a storm event divided the amount of storage present.

The area of the contributing basin is used as a surrogate for the relative amount of water (volume as cubic meters/second) entering the AU, while the area of inundation is used to estimate the relative volume stored. Large contributing basins are assumed to generate larger volumes of water for any given storm event than smaller basins. The ratio of the area inundated to the area of the contributing basin was used as a surrogate for retention time. As the ratio decreases, an AU's potential to reduce hold back storm flows is also reduced because its storage capacity is quickly used up. Much of the storm flow will therefore flow directly out of the AU without being retained.

Indicators: No indicators are needed. The ratio can be estimated from map measurements.

Scaling: AUs whose ratio is >= 0.1 are scored a [1] for this variable. Those whose ratio is smaller are scaled proportionally (ratio / 0.1).

8.2.5 Calculations of Potential

Depressional Alkali Reducing Erosion and Flooding

Variable	Description of Scaling		Score for Variable	Result
Vstorage	*Highest:*	Average depth storage >= 2 m	If calculation >=2 enter "2"	
	Lowest:	No storage	If calculation = 0 enter "0"	
	Calculation:	Scaling is set as average depth/1.3	Enter result of calculation if < 2	
	Calculate **2 x** [D12.1 x {(0.67 x D13.1) + (0.5 x D13.2) + (1 x D13.3)}]/2			
Voutletw/inund	*Highest:*	Ratio <= 1.0	If calculation >=1.0 enter "1"	
	Lowest::	Ratio > 20	If calculation < 0.05 enter '0"	
	Calculation:	Scaling is set as 1/ratio if ratio>1	Enter result of calculation if < 1.0	
	Calculate 1/[D15/(D1 x D10.1 x 0.01)]			
Vinund/shed	*Highest:*	Ratio of area inundated to area of contributing basin is > = 0.1	If calculation >=1.0 enter "1"	
	Lowest:	0% of the AU is inundated	If calculation = 0 enter "0"	
	Calculation:	Scaling is based ratio/0.1	Enter result of calculation if < 1.0	
	Calculate [(D1 x D10.1 x 0.01)/D2]/0.1			
			Total of Variable Scores:	
	Index for Reducing Flooding (Potential) = Total x 2.9 rounded to nearest 1			
			FINAL RESULT:	

8.2.6 Qualitative Rating of Opportunity

The opportunity for an AU to reduce peak flows will increase as the water regime in the contributing basin is destabilized. Research in western Washington has shown that peak flows increase as the percentage of impermeable surface increase (Reinelt and Horner 1995). The opportunity should therefore be rated by the amount of the contributing basin that is developed.

Users must make a qualitative judgement on the opportunity of the AU to actually reduce peak flows by considering the land uses in the contributing watershed. The opportunity for an AU in the depressional long-duration subclass is **"Low"** if most of its contributing watershed is forested or undisturbed, and ungrazed, grasslands or shrub-steppe. The opportunity is also **"Low"** if the AU receives most of its water from groundwater, rather than from an incoming stream, ditches, or storm drains.

The opportunity for the AU is **"High"** if the contributing watershed is mostly urban with high density residential or is heavily grazed (i.e. cattle have destroyed much of the surface vegetation), or is in tilled agriculture. The opportunity is **"Moderate"** if the development or grazing is a small part of the contributing watershed, or if these areas are relative far away from the AU. Users must use their judgement to decide whether the opportunity is low, moderate or high, and document their decision on the summary sheet (see Part 2).

8.3 General Habitat — Depressional Alkali Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

8.3.1 Definition and Description of Function

General Habitat is defined as the characteristics or processes present in a wetland that indicate a general suitability and opportunity as habitat for a broad range of species. The General Habitat function is not intended to be a duplicate assessment of the individual functions for each species group. Rather, it focuses on capturing those elements of the overall wetland ecosystem that provide for a wide or diverse variety of habitats used by many different animal species. It does not model the habitat for individual wetland species groups (e.g. birds, aquatic mammals, invertebrates, etc.).

Assessing habitat for non-wetland dependent species is particularly important in the Columbia Basin because wetlands serve as an "oasis" within an otherwise arid and stressed environment.

A broad range of structures, vegetation, and interspersion of "habitat" types within the wetland provide a suitable habitat for a suite of species. Characteristics in wetlands can be quite different but still provide highly suitable conditions for a range of species. The model tries to capture this diversity in structure by including many different variables even though a single wetland may never contain all of them (see discussion in Chapter 2).

Many of the variables used to assess the performance of a wetland for general habitat are also used in the assessments of habitat suitability for individual species groups. The technical committee and assessment teams, however, thought it important to assess General Habitat in broad terms as well as assess the individual species groups.

8.3.2 Assessing this Function for Depressional Alkali Wetlands

A wetland in the depressional alkali subclass provides suitable habitat for a broad range of species if it has a more complex physical structure rather than a simple one. Variables chosen to model this structure include vegetation strata, different types of interspersion, and the presence of specific characteristics such as open water and mudflats.

The model is additive so that environmental characteristics add to the General Habitat Suitability of an assessment unit. The operative assumption is that the suitability of an AU for all animal species increases as the number of appropriate characteristics in the AU increase.

The opportunity modeled is based on characteristics in the landscape, such as corridors, that link the AU to other surrounding natural areas. These characteristics are included because they play a very important role in maintaining amphibian, reptile, bird, and mammal populations throughout the region. Many species require a corridor for migration between wetlands or need a suitable upland/buffer habitat. In addition, the assessment team has determined that the presence of a mosaic of wetlands in the landscape increases the overall opportunity.

8.3.3 Model at a Glance

Depressional Alkali **General Habitat**

Characteristics	Variables	Measures or Indicators
SUITABILITY	**Vhydrop**	Number of water regimes present
	Vwater	The percent of open water and aquatic bed vegetation in AU
	Vrefuge	Presence special habitat characteristics
Structural	**Vprichness**	Number of plant species found during site visit
heterogeneity	**Vaquatbed**	Presence of aquatic bed vegetation
	Vpheight	Number of height ranges of vegetation
	Vpintersp	Rating of interspersion of vegetation height ranges
	Vbuffcond	Descriptive characterization of condition of buffer
	Vbuffstruc	Types of physical structure present in buffer
Reducers		
	Vupcover	Types of land uses within 1km of AU edge
OPPORTUNITY	**Vmosaic**	Proximity to other types of wetlands
	Vcorridor	Rating of condition of corridors to other wetlands
	Vhabtypes	Number of different upland habitats next to AU
Numerator for Potential:	(Vhydrop + Vwater + Vrefuge + Vprichness + Vaquatbed +Vpheight + Vpintersp + Vbuffcond + Vbuffstruc) x (Vupcover)	
Numerator for Opportunity:	Vmosaic + Vcorridor + Vhabtypes	

8.3.4 Description and Scaling of Variables

Variables for Suitability

V$_{\mathbf{hydrop}}$ - Number of water regimes present in AU.

Rationale: Based on field observations, the assessment team has determined that alkali AUs with a greater number of water regimes have the potential of supporting more faunal species. For example, many invertebrates have their life cycles keyed to different water regimes. Some invertebrate species are tolerant of the general condition of wetland's (pools) with fluctuating water levels, while others can live in pools that are strictly temporary (Wiggins et al. 1980). A greater number of invertebrate species in the AU food web then supports a greater number of predators, including reptiles, birds and mammals.

Indicators: The variable is assessed using specific water regime classes as descriptors. These are: extended inundation, seasonal inundation, brief inundation, and saturated but not flooded. See Part 2 for more detailed descriptions of these categories (data D11).

Scaling: AUs with two or more water regimes present are scored a [1] for this variable. Those with only one are scored a [0]. This variable was considered more important than the others in assessing habitat suitability, and is multiplied by a factor of 2 in the equation.

$\mathbf{V_{water}}$ - % of AU that has extended inundation.

Rationale: Areas of extended inundation in a wetland serves many purposes for animals. It is a valuable source of water for terrestrial wildlife. The availability of water becomes increasingly important in an arid environment, especially during the summer. Aquatic bed species may grow in some alkali systems increasing habitat complexity. Open water also provides a landing place and refuge for waterfowl and an open area for feeding by insectivores such as swallows.

Indicators: The area of extended inundation in a wetland can be easily determined during the drier summer/fall months and no indicator is needed. There is a problem, however, in establishing the area of extended inundation during the wet season when the wetland is flooded to its brief inundation levels. The indicators to establish the approximate extent of extended inundation are the edge of emergent vegetation in the deeper portions of a wetland. Areas of aquatic bed can be directly observed during the growing season.

Scaling: AUs with 20% or more of their area in open water or aquatic bed vegetation are scored a [1] for this variable. Those with less are scored proportionally (% area /20).

$\mathbf{V_{refuge}}$ - Special habitat features that provide refuge for many different species. Several different habitat features are combined in one variable. These include: 1) rocks within the area of surface inundation, 2) large downed woody debris in the AU, 3) erect emergent vegetation within the area of surface inundation, 4) snags, and 5) undecomposed plant litter on the AU surface.

Rationale: In many instances rocks mimic the function of large woody debris typically found in western Washington, but rarely found in the Columbia Basin. Rocks provide refuge, habitat, and structure for a number of different species. Woody debris, snags, and erect vegetation, where present, provide a major niches for decomposers (i.e. bacteria and fungi) and invertebrates. They also provide refuge for some amphibians and other vertebrates. Downed woody material is an important structural element of habitat for many other species. In drier areas of the wetland it provides shelter for small mammals, birds, and amphibians (Thomas 1978). The downed woody material and undecomposed plant litter are also important structural elements for invertebrate species that provide food for much of the wetland trophic web (Maser et al. 1988).

Indicators: None needed since the presence of these characteristics can be established in the field.

Scaling: AUs with 4 or 5 habitat features are scored a [1] for this variable. Those with fewer are scored proportionally (# features / 4).

$\mathbf{V_{prichness}}$ - Number of plant species.

Rationale: The number of plant species present in an AU reflects the potential number of niches present for invertebrates, birds, and mammals. The total number of faunal species in an AU is expected to increase as the number of plant species increases. This variable includes both native and non-native plant species because both provide habitat for invertebrate and vertebrate species.

Indicators: The indicator of overall plant richness used is the number of plant species found during the field visit.

Scaling: AUs with 20 or more plant species are scored a [1] for this variable. Those with fewer are scored proportionally (# species / 20).

$\mathbf{V_{aquatbed}}$ - Presence of aquatic bed vegetation.

Rationale: The increased structural complexity provided by aquatic bed is another characteristic that increases habitat for a number of invertebrate and vertebrate species. The A-Team observed an increase in the number of invertebrate species when aquatic bed was present. This increased number of species in the food web of the AU also supports a greater number of terrestrial species, including reptiles, birds and mammals.

Indicators: None typically needed since this aquatic bed can usually observed during the site visit (e.g. floating during growing season and dried remnants during late summer and early fall.

Scaling: his is a "yes/no" variable. AUs with aquatic bed vegetation are scored a [1] for this variable. Those with none are scored a [0].

$\mathbf{V_{pheight}}$ - Number of height ranges of vegetation (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: The Assessment Team judged that different guilds of species may differentiate based primarily on "height" differences in the vegetation. This partitioning of habitat niches according to heights is similar to partitioning occurring in western Washington wetlands by groups of wetland species using different Cowardin classes (e.g. emergent, shrub-scrub, forested). Different sizes of vegetation provide different niches for organisms. The Assessment Team determined that the varying heights of emergent vegetation in the Columbia Basin played a significant role in providing structural complexity that might otherwise, in more mesic environments, be provided by scrub/shrub and forested vegetation. This increased species richness arising from the increased structural diversity also supports a greater number of terrestrial species in the overall wetland food web.

Indicators: The following strata are recorded: emergent vegetation within three height ranges (0-20cm, 30cm-1m, and >1m), and areas of aquatic bed and scrub/shrub.

Scaling: AUs with at least 3 of the 5 strata present are scored a [1] for this variable. Those with fewer are scored proportionally ((#strata-1)/2).

$V_{pintersp}$ - Rating of degree of interspersion of vegetation of different height classes or strata.

Rationale: In general, interspersion among aquatic bed, emergent and scrub-shrub vegetation of different heights increases the suitability for some wildlife guilds. For example, a higher diversity of plant forms is likely to support a higher diversity of macro-invertebrates (Chapman 1966, Dvorak and Best 1982, Lodge 1985).

The increased structural complexity provided by interspersion optimizes potential breeding areas, escape cover, and food production for the greatest number of species. The increased number of species in the wetland food web also supports a greater number of terrestrial species, including reptiles, birds and mammals.

Indicators: The areas of vegetation of different heights (see previous variable) are rated on the amount of interspersion present based on diagrams on the field data sheets.

Scaling: AUs with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating / 3).

$V_{buffcond}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The condition of the buffer affects the ability of the AU to provide appropriate habitat for some species groups (Zeigler, 1992). The condition of the buffer affects the ability of the wetland to provide appropriate habitat for some species groups (Zeigler, 1992). Terrestrial species using the wetland are benefited by the presence of relative undisturbed upland community types immediately surrounding the wetland. Undisturbed buffers provide refuge and access to the wetland, thereby increasing the suitability of the wetland itself as habitat.

Indicators: This variable is assessed using the buffer categorization described in Part 2.

Scaling: AUs rating a 5 on the buffer are scored a [1] for the variable. Those with lower ratings are scored proportionally (buffer rating / 5).

V$_{buffstruc}$ - Presence of structural elements in the buffer that provide habitat. This includes forests, shrubs, rocks, talus slopes, cliffs, and downed woody debris in the buffer.

Rationale: Structures in AU buffers are important for refuge, food and habitat for wildlife. Buffers with structure are especially important in the Columbia Basin because they provide a variety of habitat niches and shading. This, in conjunction with the presence of water in an arid environment, significantly increases the use of the AU by a wide range of wetland and terrestrial species

Indicator: Presence of structures in the buffer is determined on site during the field visit.

Scaling: AUs with at least three of the five structure categories present are scored a [1] for the variable. Those with fewer are scored proportionally (# categories / 3).

Reducers

V$_{upcover}$ - The types of land uses within 1 km of the AU edge.

Rationale: Development and agriculture near an AU's indirectly affect the numbers of AU species through impacts to the physical, chemical and biological characteristics of an AU. The clearing of upland habitat, primarily shrub-steppe habitat, and the subsequent agricultural production increases water runoff, and transport of sediment, nutrients and harmful chemicals into the AU, as well as fragmenting the landscape and creating disturbance. Increased sediment load, especially in agricultural areas, accelerates AU filling, loss of diversity of water regimes, plants and other aquatic organisms. Wetland invertebrates and plants are known to decrease in richness and abundance with greater pollution loads (Schueler 1994, Ludwa 1994, Azous and Richter 1995, Hicks 1995). Cumulatively, these impacts also decrease the number of terrestrial species supported by the AU food web.

Indicators: No indicators are needed to assess this variable. The amount and type of land uses within 1km of the AU can be directly established from aerial photographs or site visits.

Scaling: AUs where at least 10% of the surrounding landscape is tilled fields, urban or residential have their final score reduced by a factor of (x 0.9).

Variables for Opportunity

V$_{mosaic}$ - Proximity to other types of wetlands.

Rationale: The presence of adjacent wetlands to the AU being assessed increases the opportunity that AU has to perform as a suitable habitat for a large number of species. Reasons include: 1) a variety of upland habitat niches interspersed with different water sources results in greater habitat partitioning; 2) more opportunities for refuge, food and migration; and 3) more opportunity for re-colonization by wildlife species in years of drought.

Indicator: The number of wetland subclasses or types within 2 km of the AU**.**

Scaling: AUs with 3 or more different wetland types within 2km are scored a [1] for this variable. Those with fewer are scored proportionally (# types/3).

$\mathbf{V_{corridor}}$ - The characteristics of riparian or vegetated connections present between the AU and other nearby wetlands.

Rational: Creeks and other drainages, especially in the drier portions of the Columbia Basin, have been shown to be important migratory/dispersal and foraging areas for both terrestrial and aquatic species including amphibians, mammals, and birds. Corridors provide areas for hibernation, foraging, and migration and dispersal for some amphibians (Nussbaum and others 1983; Seaburn 1997; W. Leonard, pers. obs.). The presence of natural corridors increase the opportunity that a wetland has to provide habitat because there is a larger pool of terrestrial species that can use the wetland.

Indicators: This variable is determined using a corridor rating key described in Part 2. Corridors are rated on a scale of 0-3 for both riparian and vegetated corridors.

Scaling: AUs with a total rating for both riparian and vegetated corridors of 6 are scored a [1] for this variables. AUs with a lower sum of ratings are scored proportionally (sum or ratings/6).

$\mathbf{V_{habtypes}}$ - Presence of forest, riverine, scrub-steppe, talus and open water habitats adjacent to the AU.

Rationale: The presence of forest, riverine, scrub-steppe, talus and open water habitat adjacent to the AU provides more opportunity for terrestrial species to use the AU. Each upland habitat type has a unique distribution of fauna that can use the AU as a source of food and water. These habitats also benefit wetland organisms such as amphibians by providing, migration/dispersal, and foraging and hibernation habitat.

Indicators: No indicators are needed to assess this variable. The types of habitat adjacent to the AU will be counted.

Scaling: AUs with 4 or more habitat types adjacent to it are scored a [1]. Those with fewer are scored proportionally (# types / 4).

8.3.5 Calculation of Habitat Suitability

Depressional Alkali **General Habitat**

Variable	Description of Scaling		Score for Variable	Result
Vhydrop	*Highest*	AU has 2 or more water regimes	If calculation >=2 enter "2"	
	Lowest	AU has only 1 water regime	If calculation = 0 enter "0"	
	Calculation			
	Calculate **2 x** [(D11.1+D11.2+D11.3+D11.4+D11.5+D11.6)-1]/2			
Vwater	*Highest*	AU >=20% extended inundation	If calculation >=1 enter "1"	
	Lowest	AU < 1.5 % extended inundation	If calculation = 0 enter "0"	
	Calculation	Scaled as % extended inundation/20	Enter result of calculation if < 1.0	
	Calculate (D10.3)/20			
Vrefuge	*Highest*	AU has 4 or 5 habitat features	If calculation >=1 enter "1"	
	Lowest	AU has no habitat features	If calculation = 0 enter "0"	
	Calculation	Scaled as # features /4	Enter result of calculation if < 1.0	
	Calculate (D30.1 + D30.2 + D30.3 + D30.4 + D30.5)/4			
Vprichness	*Highest*	AU has >= 20 plant species	If calculation >=1 enter "1"	
	Lowest	AU has only 1 species present	If calculation = 0 enter "0"	
	Calculation	Scaled as # plant species/20	Enter result of calculation if < 1.0	
	Calculate (D21.1 + D21.2)/20			
Vaquatbed	*Highest*	AU has aquatic bed species	If D21.3 >= 1 enter "1"	
	Lowest	AU has no aquatic bed species	If D21.3 = 0 enter "0"	
Vpheight	*Highest*	AU has >=3 height ranges of veg	If calculation >=1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/2	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3 + D20.4 + D20.5)-1]/2			
Vpintersp	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vbuffcond	*Highest:*	Buffer category of 5	If D39 = 5, enter "1"	
	High:	Buffer category of 4	If D39 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D39 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D39 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D39 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D39 = 0, enter "0"	

Depressional Alkali General Habitat (Cont.)

Variable	Description of Scaling		Score for Variable	Result
Vbuffstruc	*Highest*	AU has >=3 structures in buffer	If calculation >=1 enter "1"	
	Lowest	AU has no structures	If calculation = 0 enter "0"	
	Calculation	Scaled as (# of structures)/3	Enter result of calculation if < 1.0	
	Calculate (D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/3			
			Total of Variable Scores:	
Reducers				
Vupcover	AU has more than 10% major human disturbances within 1 km of AU		If (D5.3 + D5.4 + D5.7 + D5.8) >= 10 enter "0.9"	
	AU has less than 10% major disturbances		If (D5.3 + D5.4 + D5.7 + D5.8) <10 enter "1.0"	
			Score for Reducer	
Index for General Habitat (Suitability) = (Total of variables) x (score for reducer) x (1.18) rounded to the nearest 1				
			FINAL RESULT:	

8.3.6 Calculation of Opportunity

Depressional Alkali **General Habitat**

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 3 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/3)	Enter result of calculation if < 1.0	
	Calculate	(D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/3		
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation =1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate	(D43.1 + D43.2)/6		
Vhabtypes	*Highest*	AU has at least 3 habitat types within 1 km	If calculation >=1 enter "1"	
	Lowest	AU has no habitats within 1 km	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/3)	Enter result of calculation if < 1.0	
	Calculate	(D6.1 + D6.2 + D6.3 + D6.4 + D6.5)/3		
			Total of Variable Scores:	
			Index for General Habitat (Opportunity)= Total x 3.33 rounded to nearest 1	
			FINAL RESULT:	

8.4 Habitat for Invertebrates — Depressional Alkali Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

8.4.1 Definition and Description of Function

Habitat for Invertebrates is defined as the characteristics that help maintain a high number of invertebrate species in the wetland. For the purpose of this model, invertebrates are narrowly defined as "macroinvertebrates" or free-living organisms readily seen with the naked eye (≥500μm) including among others, Insecta (insects), Malacostraca (scuds, sideswimmers, crayfishes, shrimps, isopods), Branchiopoda (fairy, tadpole, and clam shrimps), Maxillopoda (seed shrimps, copepods), Gastropoda (snails), Pelecypoda (clams, fingernail clams), Arachnida (spiders, mites), Annelida (worms and leeches), and Platyhelminthes (flatworms).

Invertebrates are diverse and abundant components of freshwater aquatic systems that include wetlands. As such, almost any wetland will provide a habitat for some invertebrates. There is a distinct difference, however, between a wetland that has a high abundance of one or two species and one that has a high richness of different species. The important aspect of invertebrate populations that is being assessed with this model is species richness. Wetlands with a high richness tend to be more important in maintaining the regional biodiversity of invertebrate populations and provide a genetic source and genetic refuge that help maintain ecosystem integrity. There are, however, wetlands with low species richness that provide refuge to species unique to these systems, and may be important to that specific species. This aspect of ecosystem function is not addressed in these methods.

Invertebrates are critical as processors of organic material and in the cycling of energy and nutrients (Merritt and Cummins 1996). Recent focus on aquatic invertebrates in wetlands indicates the importance of macroinvertebrates in energy and nutrient transfer within aquatic ecosystems (Rosenberg and Danks 1987). They furnish food for other invertebrates and comprise significant component of food for amphibians, water birds, mammals, and fish. The trophic diversity and numerical abundance of insects (especially the Diptera) and other macro invertebrates (Annelida and Crustacea), make these organisms the most important taxa in wetland environments (Chutter 1972; Hilsenhoff 1988; Lang 1970; Merritt and Cummins 1996; Warren 1988).

Most of the wetland invertebrate populations of the Columbia Basin exist in a stressed environment and are subject to high summer temperatures and limited rainfall. This has resulted in different invertebrate population dynamics and greater species richness than in other more temperate regions of the country. Typically, invertebrates in the Columbia basin have telescoped, or shortened life cycles, brief periods of maximum abundance, the ability to survive in stressed environments, and to emerge or go into dormancy before ponds draw down to 35 to 20% of the original surface area. This habitat partitioning appears to have resulted in the capacity for these systems to have a higher invertebrate richness than similar but more stable wetland systems in other areas.

8.4.2 Assessing this Function for Depressional Alkali Wetlands

The suitability of depressional alkali wetlands in the Columbia Basin for invertebrate habitat is modeled on vegetation structure including aquatic bed; physical components such as refuge provided by rocks and woody debris within the AU; the area of a AU that is seasonally inundated; and whether the AU is part of a mosaic of wetlands. Generally, alkali wetlands have a lower species richness relative to the freshwater systems (Lang, 1997, 1996).

The opportunity that an AU has to provide habitat for invertebrates is assessed by its landscape position. AUs that are well connected to other wetlands and that lie in a mosaic of wetlands have a high opportunity to provide habitat because colonization from other locations is possible. These conditions will maintain high species richness in the AU itself.

8.4.3 Model at a Glance

Depressional Alkali **Habitat for Invertebrates**

Characteristics	Variables	Measures or Indicators
SUITABILITY		
Structural heterogeneity	**Vannualinund**	% area of annual inundation minus extended inundation
	Vprichness	The number of plant species found during a site visit
	Vrefuge	Presence/absence of rocks within OHWM
		Presence/absence of woody debris within OHWM
		Presence/absence of leaf litter within OHWM
	Vwintersp1	Rating interspersion between vegetation and open water
	Vhydrop	Number of water regimes present
OPPORTUNITY		
	Vcorridor	Ratings of corridors between wetlands & other habitats
	Vmosaic	Proximity of other wetlands within 2 km
Numerator for Suitability	Vannualinud + Vprichness + Vrefuge +Vwintersp1 + Vhydrop	
Numerator for Opportunity	Vcorridor + Vmosaic	

8.4.4 Description and Scaling of Variables

Variables for Potential

$\mathbf{V_{annualinund}}$ - The % area of inundation that fluctuates every year (brief and seasonal).

Rationale: AUs with areas of seasonal inundation as well as extended inundation will have a greater species richness of invertebrates because the two water regimes have different invertebrate species associated with them. Furthermore, the area that undergoes a seasonal drawdown provides a high number of niches for invertebrates that key in to different periods of inundation.

Indicators: High water lines, emergent aquatic vegetation and aerial photos (see Part 2) minus the area of extended inundation.

Scaling: AUs with 50% or more of their area subject to seasonal inundation are scored a [1] for this variable. Those with less are scored proportionally (% seasonal inundation / 50).

$\mathbf{V_{prichness}}$ - The richness of plant species.

Rationale: The richness of plant species present in an AU reflects the potential number of invertebrate species in an AU, since many invertebrates are associated with specific plant species. As the number of plant species increases the number of habitat niches for invertebrates also increases. Therefore, the species richness of plants, in the judgement of the Assessment Team, is a surrogate for habitat niches for invertebrates.

Indicators: None needed, direct field observations will determine number of plant species.

Scaling: AUs with more than 17 species of plants present at the time of the field visit are scored a [1] for this variable. AUs with less are scored proportionally (# species/17).

$\mathbf{V_{refuge}}$ - Special habitat features that provide refuge for invertebrates**.**

Rationale: Many invertebrates show marked preference for certain types of habitat structures including rocks, downed and woody debris and leaf litter (Lang, 1984; Warren, 1988). Woody debris and leaf litter, where present, are an important structural element for invertebrates, providing food, breeding, and cover habitat (Maser et al. 1988). When these structures provide "3-dimensional" structure then a more diverse invertebrate population is supported. Other important processes provided by refuge area are egg laying, periphyton perching, and feeding by collectors /gatherers.

Indicators: None needed, direct field observation will determine the number of refuge types present.

Scaling: AUs with at least 2 of the three categories of refuge present score a [1] for this variable. Those with 1 score a [0.5] and those with none a [0].

$\mathbf{V_{winterspl}}$ - The amount of interspersion between vegetated areas of the AU and the areas of extended inundation.

Rationale: Open water and vegetation contact zones provide different edge habitats and niches. Interspersion increases the vegetation/water edge zone. These contact zones between water and vegetation also provide niches for different invertebrate species and thus increases the potential species richness.

Indicators: The interspersion in a AU is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: AUs with a high or moderate interspersion (rating = 2 or 3) are scored a [1] for this variable. Those with a rating of 1 are scored a [0.5] and those with none a [0].

$\mathbf{V_{hydrop}}$ - Number of water regimes present in AU.

Rationale: The assessment team has determined that alkali AUs with a greater number of water regimes have the potential of supporting more invertebrate species. Many invertebrates have their life cycles keyed to different water regimes. Some invertebrate species are tolerant of the general condition of wetlands (pools) with fluctuating water levels, while others can live in pools that are strictly temporary (Wiggins et al. 1980).

Indicators: The variable is assessed using specific water regime classes as descriptors. These are: extended inundation, seasonal inundation, brief inundation, saturated but not inundated, perennially flowing stream, and intermittently flowing stream (see Part 2 for more detailed descriptions of these categories – data D11).

Scaling: AUs with three or more water regimes present are scored a [1] for this variable. Those with fewer are scored proportionally ((# of categories –1) / 2).

Variables for Opportunity

$\mathbf{V_{corridor}}$ - The characteristics of riparian or vegetated connections present between the AU and other nearby wetlands.

Rational: Creeks and other drainages have been shown to be important migratory/dispersal and foraging areas for invertebrates, amphibians, mammals, and birds. Suitable corridors, especially riparian corridors, are judged to be critical in the Columbia Basin to the invertebrate colonization and dispersal.

Indicators: This variable is determined using a corridor rating key described in Part 2. Corridors are rated on a scale of 0-3 for both riparian and vegetated corridors.

Scaling: AUs with a total rating for both riparian and vegetated corridors of 6 are scored a [1] for this variables. AUs with a lower sum of ratings are scored proportionally (sum of ratings/6).

V_{mosaic} - The AU is part of a distinct wetland/upland ecosystem encompassing different hydrogeomorphic types of wetlands.

Rationale: AUs that occur within a complex of lentic and lotic habitats may have a greater invertebrate diversity than isolated AUs. Invertebrates are transported outside of AUs by birds, wind and through the hyporheic zone. If AUs are isolated, then the percentage of these species reaching other wetlands is reduced. The presence of adjacent wetlands increases the opportunity for the AU to function as suitable habitat for a large number of species. In addition, the proximity of other wetlands provides more opportunities for refuge, food and migration and successful re-colonization by invertebrates during drought years.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of wetlands in the landscape.

Scaling: AUs with 3 or more different types of wetlands present within 2 km are scored a [1] for this variable. Those with fewer types are scored proportionally (# of types/3).

8.4.5 Calculation of Habitat Suitability

Depressional Alkali **Habitat for Invertebrates**

Variable	Description of Scaling		Score for Variable	Result
Vannualinund	*Highest:*	>50% of the AU, is annually ponded or inundated outside the extended inundation water	If calculation >= 1, enter "1"	
	Lowest:	0% of the AU is annually ponded	If calculation = 0, enter "0"	
	Calculation:	Scaling = (% of AU inundated/50)	Enter result of calculation if < 1.0	
	Calculate (D10.1 – D10.3)/50			
Vprichness	*Highest*	AU has >= 17 plant species	If calculation >=1 enter "1"	
	Lowest	AU has only 1 species present	If calculation = 0 enter "0"	
	Calculation	Scaled as # plant species/17	Enter result of calculation if < 1.0	
	Calculate (D21.1 + D21.2)/17			
Vrefuge	*Highest*	AU has >= 2 categories of refuge	If calculation >=1 enter "1"	
	Lowest	AU has no refuge present	If calculation = 0 enter "0"	
	Calculation	Scaled as # categories/2	Enter result of calculation if < 1.0	
	Calculate (D30.1 + D30.3 + D30.4)/2			
Vwintersp1	*Highest*	AU has high or moderate interspersion	If calculation >=1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/2	Enter result of calculation if < 1.0	
	Calculate D36.1/2			
Vhydrop	*Highest*	AU has 3 or more water regimes	If calculation >=1 enter "1"	
	Lowest	AU has only 1 water regime	If calculation = 0 enter "0"	
	Calculation	Scaled as (# regimes-1)/2	Enter result of calculation if < 2.0	
	Calculate [(D11.1+D11.2+D11.3+D11.4+D11.5+D11.6)-1]/2			
			Total of Variable Scores:	
Index for Invertebrate Habitat for (Suitability) = (Total for variables) x (2.13) rounded to nearest 1				
			FINAL RESULT:	

8.4.6 Calculation of Opportunity

Depressional Alkali Habitat for Invertebrates

Variable		Description of Scaling	Score for Variable	Result
Vmosaic	*Highest*	AU has at least 3 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/3)	Enter result of calculation if < 1.0	
	Calculate	(D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/3		
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation >=1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate	(D43.1 + D43.2)/6		
			Total of Variable Scores:	
		Index for Invertebrate Habitat (Opportunity)= Total x 5.0 rounded to nearest 1		
			FINAL RESULT:	

8.5 Habitat for Amphibians — Depressional Alkali Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

8.5.1 Definition and Description of Function

Habitat for Amphibians in alkali wetlands is defined as the wetland processes and the characteristics that contribute to the feeding, breeding, or refuge needs of tiger salamanders (*Ambystoma tigrinum*).

8.5.2 Assessing this Function for Depressional Alkali Wetlands

The suitability of alkali wetlands as amphibian habitat is assessed using characteristics of wetlands that support the life needs of tiger salamanders, including survival of eggs, development/protection of larvae, and food for adults. Tiger salamanders were the only species observed in alkali systems during the three years of fieldwork needed to complete these methods. Alkali systems may provide habitat for other species of amphibians. If they do, it was judged that the characteristics of a suitable habitat for other species would be similar to those for the tiger salamander. The Assessment Team, however, concluded that other amphibian species are probably not present in alkali systems due to the chemical characteristics (high pH and alkalinity).

The opportunity that an AU has to provide habitat for amphibians is assessed by its landscape position and the presence of physical structures in the buffer that provide refuge for adults. Wetlands that are well connected to other wetlands and that lie in a mosaic of wetlands have a high opportunity to provide habitat because colonization from other locations is possible. Refuge in the buffer is important because there will be a greater opportunity if the adults have appropriate upland habitats nearby.

8.5.3 Model at a Glance

Depressional Alkali **Habitat for Amphibians**

Characteristics	Variables	Measures or Indicators
SUITABILITY		
Breeding, feeding & refuge	**Vpheight**	Rating of the different height ranges of vegetation
	Vpintersp	Rating of the interspersion of plant height classes
	Vldstandw	% of AU with extended inundation
	Vwintersp1	Rating of interspersion between persistent vegetation and areas of open extended inundation
	Vbuffstruc	Types of physical structures present in the buffer
	Vrefuge	Presence of rocks, woody debris > 10 cm , mud/silt and /organic substrate and leaf litter
OPPORTUNITY		
Landscape position	**Vcorridor**	Rating of corridors between wetlands & other habitats
	Vmosaic	Proximity of other wetlands within 2km
Numerator for Suitability	Vpheight+Vpintersp+Vldstandw+Vwintersp1+Vbuffstruc+Vrefuge	
Numerator for Opportunity	Vcorridor +Vmosaic	

8.5.4 Description and Scaling of Variables

Variables for Suitability

$\mathbf{V_{pheight}}$ – Number of height ranges of vegetation present (3 ranges for emergents, and scrub/shrub).

Rationale: Given the large water level fluctuations found in the alkali wetlands of the Basin, the Assessment Team assumed that sites with a greater number of height ranges for emergent vegetation increase the potential of providing suitable oviposition areas, larval habitat, escape cover, and food production for tiger salamanders.

Indicators: The areas of emergent vegetation within three height ranges (0-20cm, 30cm-1m, and >1m) will be mapped and the number of ranges recorded.

Scaling: AUs with three height ranges present score a [1] for this variable. Those with fewer are scored proportionally (# ranges /3).

$\mathbf{V_{pintersp}}$ - Rating of interspersion among the height ranges of different plants.

Rationale: The assumption is that sites with greater structural diversity (the interspersion of different heights) for emergent vegetation optimizes the potential of providing suitable oviposition areas, escape cover, and food production for the tiger salamander in alkali systems.

Indicators: The areas of vegetation of different heights (see previous variable) are rated on the amount of interspersion present based on diagrams on the field data sheets.

Scaling: AUs with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating(scale 0-3) / 3).

$V_{ldstandw}$ -The percent area of extended inundation in the AU (includes vegetated and unvegetated areas).

Rationale: The presence of areas of extended inundation standing water is an indicator that the AU has inundated areas of sufficient duration to provide for the successful incubation of amphibian eggs.

Indicators: This variable can be estimated during the site visit based on the distribution of standing water, or if flooded in the spring, by the extent of emergent vegetation (see Part 2).

Scaling: AUs with 30% or more of their area in extended inundation are scored a [1] for this variable. Those with less are scored proportionally (% standing water / 30).

$V_{winterspl}$ - The amount of interspersion between areas of persistent vegetation of the AU and the areas of open, unvegetated, extended inundation.

Rationale: he area at the edge of open water and persistent vegetation provides edge habitat, protection, cover, food, and territorial boundaries. Interspersion increases the vegetation/water edge zone. These contact zones between water and vegetation also provide a point of entry for amphibians. It also increases the amount of habitat available to species requiring either vegetation or open water, which in turn increase species diversity.

Indicators: The interspersion in an AU is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: AUs with a high or moderate interspersion (rating = 2 or 3) are scored a [1] for this variable. Those with a rating of 1 are scored a [0.5] and those with none a [0].

$V_{buffstruc}$ - The presence of rocks, talus slopes, rodent burrows, downed woody in the buffer area.

Rationale: The greater the number of structural elements in a buffer the greater the potential for refuge for tiger salamanders. Characteristics of wetland buffers are especially important in providing refuge for amphibians migrating to and from breeding ponds. Furthermore, the success of recently transformed juveniles is greatly enhanced by the presence of suitable cover and foraging areas adjacent to the AU. As cover is reduced or eliminated by agricultural operations and encroaching development, amphibians are exposed to increased risks of over-heating/freezing, desiccation, and predation. Important buffer features include downed woody debris, rocks, forests, and shrubs.

Indicators: No indicators are needed. Specific structures for refuge are determined during the site visit.

Scaling: AUs with 3 or more categories of structure in the buffer score a [1] for this variable (see Part 2 for list of structures). Those with fewer are scored proportionally (# of categories/3).

$\mathbf{V_{refuge}}$ **-** Special habitat features that provide refuge for amphibians**.**

Rationale: Salamanders use three-dimensional structures throughout life as refuge from predators. They show marked preference for certain types of substrate including rocks and downed and woody debris, muddy or organic substrate and leaf litter. Rocks, and woody debris, where present, are important structural elements for amphibians, providing cover habitat and thermal buffering. Muddy, silty or organic substrate and leaf litter provides escape habitat.

Indicators: None needed, structural elements that provide refuge are determined during the site visit. These include rocks and large woody debris in areas that are annually inundated, plant litter on the surface of the AU, snags, and erect emergent vegetation in the area of extended inundation.

Scaling: AUs with at least four of the five structural elements listed above are scored a [1] for the variable. AUs with less are scored proportionally (# of elements / 4).

Variables for Opportunity

$\mathbf{V_{corridor}}$- Rating of riparian and upland corridor connecting AU to other wetlands.

Rationale: Creeks and other drainages have been shown to be important hibernation areas, foraging habitats, and migratory/dispersal corridors for some amphibians (Nussbaum and others 1983; Seaburn 1997; W. Leonard, pers. obs.). Post-breeding amphibians often move out along drainage courses and vegetated strips where conditions may be more favorable (W. Leonard, pers. obs.). AUs with corridors, therefore, have a greater opportunity to provide tiger salamander habitat.

Indicators: This variable is determined using a corridor rating key described in Part 2. Corridors are rated on a scale of 0-3 for both riparian and upland corridors.

Scaling: AUs with a total rating for both riparian and vegetated corridors of 6 are scored a [1] for this variables. AUs with a lower sum of ratings are scored proportionally (sum or ratings/6).

V_{mosaic} - The AU is part of a distinct wetland/upland ecosystem encompassing different hydrogeomorphic types of wetlands.

Rationale: AUs that occur within a complex of lentic and lotic habitats may have a greater opportunity to provide habitat for tiger salamanders than isolated AUs. The proximity of other wetlands provides more opportunities for refuge, food and migration and more opportunity for successful re-colonization by salamanders during drought years.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of wetlands in the landscape.

Scaling: AUs with 4 or more different types of wetlands present within 2 km are scored a [1] for this variable. Those with fewer types are scored proportionally (# of types/4).

8.5.5 Calculation of Habitat Suitability

Depressional Alkali **Habitat for Amphibians**

Variable	Description of Scaling		Score for Variable	Result
Vpheight	*Highest*	AU with >= 3 height ranges/types of vegetation	If calculation =1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/2	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3)-1]/2			
Vpintersp	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vldstandw	*Highest*	AU has >30% extended inund.	If calculation >=1 enter "1"	
	Lowest	AU has no extended inundation	If calculation = 0 enter "0"	
	Calculation	Scaled as (% extended inund/ 30)	Enter result of calculation if < 1.0	
	Calculate D10.3/30			
Vwintersp1	*Highest*	AU has high or moderate interspersion	If calculation >=1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/2	Enter result of calculation if < 1.0	
	Calculate D36.1/2			
Vbuffstruc	*Highest*	AU has >= 3 structures in buffer	If calculation >=1 enter "1"	
	Lowest	AU has no structures	If calculation = 0 enter "0"	
	Calculation	Scaled as (# of structures)/3	Enter result of calculation if < 1.0	
	Calculate (D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/3			
Vrefuge	*Highest*	AU has >= 4 or 5 categories of refuge	If calculation >=1 enter "1"	
	Lowest	AU has no refuge present	If calculation = 0 enter "0"	
	Calculation	Scaled as # categories/4	Enter result of calculation if < 1.0	
	Calculate (D30.1 +D30.2 + D30.3 + D30.4 + D30.5)/4			
			Total of Variable Scores:	
Index for Amphibian Habitat (Suitability) = (Total for Variables) x(1.89) rounded to nearest 1				
			FINAL RESULT:	

8.5.6 Calculation of Opportunity

Depressional Alkali **Habitat for Amphibians**

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 4 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/4)	Enter result of calculation if < 1.0	
	Calculate (D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/4			
Vcorridor	*Highest*	AU has a rating of 3 for both types of corridors	If calculation >=1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (sum of corridor ratings/6)	Enter result of calculation if < 1.0	
	Calculate (D43.1 + D43.2)/6			
			Total of Variable Scores:	
Index for Amphibian Habitat (Opportunity)= Total x 5.0 rounded to nearest 1				
			FINAL RESULT:	

8.6 Habitat for Aquatic Birds — Depressional Alkali Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

8.6.1 Definition and Description of Function

Habitat for Aquatic Birds is defined as the environmental characteristics in a wetland that provide suitable habitats or life resources for species of aquatic birds, and the characteristics of the surrounding landscape that indicate birds will have the opportunity to use this habitat. Aquatic bird species are those that depend on different aspects of the wetland ecosystem for some part of their life needs: food, shelter, breeding, or resting. Wetlands also provide for specific requirements such as nesting, molting, foraging and migration. The primary groups of aquatic birds considered for building the assessment model in alkali wetlands included waterfowl, shorebirds, rails (soras, Virginia rail, coots) and herons.

In general, the suitability of a wetland as bird habitat increases as the number of appropriate habitat characteristics increase. Wetlands can provide habitat for a large number of bird species depending on the vegetative structure, and physical characteristics of the wetland. The opportunity of a wetland to provide habitat also increases in landscapes where there are numerous other wetlands or open water nearby.

The assessment models are focused on species richness, not on the importance of a wetland to a specific threatened or endangered species or to a specific regionally important group of birds.

If the wetland is a habitat type that appears to be critical to a specific species, another method is needed in order to better determine the habitat suitability of that wetland (e.g. USFWS Habitat Evaluation Procedures (HEP), USFWS 1981, Wakeley and O'Neil 1988).

8.6.2 Assessing This Function for Depressional Alkali Wetlands

The suitability of depressional alkali wetlands in the Columbia Basin for aquatic birds is modeled on structural components that have been shown, or are judged, to be important habitat features, and the condition of the buffers in the wetland. The models include the indices of suitability for invertebrates as an indicator of richness in types of food available.

AUs that have human disturbances in the surrounding landscape are judged to have a reduced level of performance. These conditions reduce the suitability as habitat for birds.

The opportunity that an assessment unit has to provide bird habitat is a function of many landscape variables such as the presence of nearby open water, other wetlands, and proximity to the major migratory flyways. Users, however, must make a qualitative judgement on the opportunity of the AU to actually provide bird habitat because a quantitative model could not be calibrated. None of the data collected during the calibration could be adequately correlated with the judgements of opportunity made by the Assessment Team. The conclusion of the Assessment Team was that too many variables were involved in making a judgement of opportunity, and a simple model could not be developed.

Size is not used as a variable in the equation although it is often cited as an important characteristic of wetlands that provide bird habitat (Richter and Azous, 1997). The question of size as an indicator of species richness is a difficult one. No satisfactory size thresholds have been identified in the literature that would define the importance of a small versus a large wetland as habitat specific to only wetland dependent birds. Size, however, is incorporated indirectly in the scaling of some of the other variables used. Thus, it is implicit that a wetland with a diverse structure is usually large; small wetlands usually cannot contain the same number of different structural elements as large ones.

8.6.3 Model at a Glance

Depressional Alkali **Habitat for Aquatic Birds**

Characteristics	Variables	Measures or Indicators
SUITABILITY	**Vhydrop**	Number of water regimes present
Structural	**Vldstandw**	% of AU with extended inundation
Heterogeneity	**Vwintersp1**	Rating of interspersion between persistent vegetation & areas of open water of extended duration
	Vpheight	Number of plant height categories present
	Vpintersp	Rating of the interspersion of plant height classes
	Vbuffcond	Descriptive table of conditions in buffer
	Vbuffstruc	Types of physical structure present in buffer
	Sinvert	Index of suitability from invertebrate model
Reducers		
	Vhumandis	Presence of human activities within AU and buffer
OPPORTUNITY		***Could not be calibrated***
Numerator for Suitability	(2xVhydrop+Vldstandw+ Vwintersp1 + Vpheight + Vpintersp + Vbuffcond + Vbuffstruc + Sinvert) x Vhumandis	

8.6.4 Description and Scaling of Variables

Variables for suitability

V_{hydrop} - The number of different hydroperiods, or water regimes, present in the AU.

Rationale: Based on field observations, the assessment team has determined that alkali wetlands with more water regimes provide greater habitat richness for aquatic birds. AUs that have a variety of inundation regimes (varying duration, including areas of extended, seasonal and brief inundation) have been found to be essential for a number of wetland bird species (Marble 1992).

Indicators: The variable is assessed using specific water regime classes as descriptors. These are: extended inundation, seasonal inundation, brief inundation, saturated but not flooded, and intermittently flowing stream (see Part 2 for more detailed descriptions of these categories – datum D11).

Scaling: AUs with 3 or more water regimes present are scored a [1] for this variable. Those with fewer are scored proportionally ((# of categories –1) / 2). This variable was considered more important than the others in assessing habitat suitability, and is multiplied by a factor of 2 in the equation.

$V_{ldstandw}$ - The percent area of extended inundation in the AU (includes vegetated and unvegetated areas).

Rationale: Areas of extended inundation provide an area for waterfowl access to the AU.

Indicators: This variable can be estimated during the site visit based on the distribution of standing water, or if flooded in the spring, by the extent of emergent vegetation (see Part 2).

Scaling: AUs with at least 20% extended inundation standing water are scored a [1] for this variable. Those with less are scored proportionally
(% extended inudation / 20).

$V_{winterspl}$ - The amount of interspersion between areas of persistent vegetation of the AU and the areas of extended inundation without vegetation.

Rationale: The area at the edge of water and persistent vegetation provides edge habitat, protection, cover, food, and territorial boundaries. Interspersion increases the vegetation/water edge zone. These contact zones between water and vegetation also provide a point of entry for birds. It also increases the amount of habitat available to species requiring either vegetation or open water, which in turn increase species diversity.

Indicators: The interspersion in a wetland is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: AUs with a high or moderate interspersion (rating = 2, or 3) are scored a [1] for this variable. Those with a rating of 1 or 0 are scored proportionally (rating /2).

$V_{pheight}$ - Number of height ranges of vegetation (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: Different species of vegetation provide different niches for birds. It was the judgement of the Assessment Team that the varying heights of emergent vegetation in the Columbia Basin played a significant role in providing structural complexity that might otherwise, in more mesic environments, be provided by scrub/shrub and forested vegetation.

Indicators: The presence of 5 categories of plant heights are recorded in the field (0-20cm, 30cm-1m, and >1m) for emergent species, aquatic bed and scrub/shrub.

Scaling: AUs with at least 3 categories present are scored a [1] for this variable. Those with fewer are scored proportionally ((# categories-1)/2).

$V_{pintersp}$ - Rating of interspersion among the height ranges of different plants.

Rationale: The assessment team determined that the interspersion of the different vegetation strata with each other, including height classes of emergent species, and areas of aquatic bed and scrub/shrub, increases the habitat richness of the AU for birds by providing more niches for feeding and refuge.

Indicators: The areas of vegetation of different heights (see previous variable) are rated on the amount of interspersion present based on diagrams on the field data sheets.

Scaling: AUs with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating (scale 0-3) / 3).

$V_{buffcond}$ - Condition of buffer within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The amount of disturbance in the AU buffer affects the ability of the AU to provide appropriate habitat for some guilds of birds (Zeigler 1992). For the drier portions of the Columbia Basin the presence of undisturbed buffer areas at maximum widths, even though they have limited screening capabilities (e.g. shrub-steppe habitat), indicates that the habitat needs of sensitive bird species will not be disturbed by human activities (agriculture, grazing, urban uses).

Indicators: This variable is assessed using the buffer categorization described in Part 2.

Scaling: AUs rating a 5 on the buffer are scored a [1] for the variable. Those with lower ratings are scored proportionally (buffer rating / 5).

$V_{buffstruc}$ - Presence of structural elements in the buffer that provide habitat for wetland dependent birds. This includes forests, shrubs, rocks, talus slopes, cliffs, and downed woody debris (includes blown-in brush) in the buffer.

Rationale: Structure in buffers is important for nesting habitat, cover for refuge, and food production for many species of aquatic birds. Blown-in brush such as tumbleweed is commonly found at the edge of Columbia Basin wetlands and provides escape habitat for small birds. Buffers with structure are especially important in the Columbia Basin because they provide a variety of habitat niches and shading, which in conjunction with the presence of water in an arid environment significantly increases the use of the AU by a wide range of aquatic species.

Indicator: Presence of structures in the buffer is determined on site during the field visit.

Scaling: AUs with at least two of the five structure categories present are scored a [1] for the variable. Those with fewer are scored proportionally (# categories / 2).

$S_{inverts}$ - The habitat suitability index for the "invertebrate" function.

Rationale: The score is used to represent the richness of invertebrates that might be available as prey for many species of aquatic birds.

Indicators: No indicators are needed. The variable is a score from another function.

Scaling: The index score, which is reported on a scale of 0-10 is normalized to a scale of 0 –1.

Reducers

$V_{humandis}$ – The presence of human disturbance within 100 meters of the AU edge.

Rationale: In the judgement of the Assessment Team, human disturbance is a major factor in reducing aquatic bird richness. Human presence is particularly damaging if it is regular and occurring during periods of critical life cycle needs such as breeding/nesting. Disturbance can include recreational boating, fishing, hunting, hiking and nature observation. These human activities can interfere with pair bonding, breeding/nesting, feeding, and roosting activities of aquatic birds.

Indicators: Human disturbance is rated based on direct observation of activities, and by indirect evidence such as parking areas, off-road tire tracks, trash, fishing line, foot-trails along shoreline and through buffer.

Scaling: AUs in which human activities such as boating, fishing, hunting, grazing, roads, residences or urban areas are rated as having a high impact have their final score reduced by a factor of 0.8.

8.6.5 Calculation of Habitat Suitability

Depressional Alkali **Habitat for Aquatic Birds**

Variable	Description of Scaling		Score for Variable	Result
Vhydrop	*Highest*	AU has 3 or more water regimes	If calculation >=2 enter "2"	
	Lowest	AU has only 1 water regime	If calculation = 0 enter "0"	
	Calculation	Scaled as (# regimes-1)/3	Enter result of calculation if < 2.0	
	Calculate **2 x** [(D11.1+D11.2+D11.3+D11.4+D11.6)-1]/2			
Vldstandw	*Highest*	AU has >20% extended inundation	If calculation >=1 enter "1"	
	Lowest	AU has no extended inundation	If calculation = 0 enter "0"	
	Calculation	Scaled as (% extended inundation/ 20)	Enter result of calculation if < 1.0	
	Calculate D10.3/20			
Vwintersp1	*Highest*	AU has high or moderate interspersion	If calculation> =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/2	Enter result of calculation if < 1.0	
	Calculate D36.1/2			
Vpheight	*Highest*	AU with >= 3 eight ranges of veg	If calculation >=1 enter "1"	
	Lowest	AU has only 1 height range	If calculation = 0 enter "0"	
	Calculation	Scaled as (# ranges –1)/2	Enter result of calculation if < 1.0	
	Calculate [(D20.1 + D20.2 + D20.3 + D20.4 + D20.5)-1]/2			
Vpintersp	*Highest*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vbuffcond	*Highest:*	Buffer category of 5	If D39 = 5, enter "1"	
	High:	Buffer category of 4	If D39 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D39 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D39 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D39 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D39 = 0, enter "0"	

Depressional Alkali   Habitat for Aquatic Birds (Suitability cont.)

Variable	Description of Scaling		Score for Variable	Result
Vbuffstruc	*Highest*	AU has >=2 structures in buffer	If calculation >=1 enter "1"	
	Lowest	AU has no structures	If calculation = 0 enter "0"	
	Calculation	Scaled as (# of structures)/2	Enter result of calculation if < 1.0	
	Calculate	(D42.1 + D42.2 + D42.3 + D42.4 + D42.5)/2		
Sinverts	*Score is scaled*	Index for Habitat Suitability for Invertebrates	(Index of function)/10	
			Total of Variable Scores:	
Reducers				
Vhumandis	AU has high levels of human disturbance		If rating of any disturbance is high: value of 2 in any field (D41.1 to D41.8) enter "0.8"	
	AU does not have high levels of human disturbance		If ratings of disturbance are low or none (only values of "0 or 1" in data D41.1 to D41.8) enter a "1"	
			Score for Reducer	
Index for Bird Habitat (Suitability) = (Total of variables) x (score for reducer) x (1.39) rounded to the nearest 1				
			FINAL RESULT:	

8.6.6 Qualitative Rating of Opportunity

The opportunity that an assessment unit has to provide bird habitat is a function of many landscape variables such as the presence of nearby open water, other wetlands, and proximity to the major migratory flyways.

Users must make a qualitative rating on the opportunity of the AU to actually provide bird habitat because a quantitative model could not be calibrated. Generally, the opportunity is **High** if the AU is located in a dense mosaic of other wetlands, lakes or riverine habitats and is on a major flyway. It should be rated as **Moderate** if it is not in a dense mosaic of other aquatic habitats, or if it is isolated but still located on a major flyway. It should be rated **Low** if the AU is isolated from other aquatic habitats by at least 10 km and is not on the usual migratory path for aquatic birds.

8.7 Habitat for Aquatic Mammals — Depressional Alkali Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

8.7.1 Definition and Description of Function

Habitat for Aquatic Mammals is defined as the capacity of the wetland to provide suitable biophysical requirements for two aquatic mammals that use wetlands. The biological and physical requirements for beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus)* were modeled.

The two species used in this model were selected due to their dependence on wetland habitat (Hammerson 1994), their economic importance, as well as their influence on the wetland systems (Johnston and Naiman 1987, Garbisch 1994). A model for all mammal species living in the Columbia Basin would be cumbersome and ineffective due to the variations in habitat requirements, lack of information on many species, and the need to look at larger areas of the landscape. The focus of the assessment is on the wetland and it does not try to assess the performance of the surrounding landscape. This model reflects suitability in terms of species richness and assumes that AUs providing habitat for the two species have a higher level of performance of the function than those not providing such habitat. It does not address species abundance. Estimates of direct abundance were, therefore, not used.

8.7.2 Assessing this Function for Depressional Alkali Wetlands

The presence of permanent surface water is a pre-requisite if the wetland is to provide year-round habitat for the two aquatic mammals. Permanent water is needed to provide refuge in areas where other types of refuge have been lost, and to provide access to forage, especially during the winter. Since some depressional long duration wetlands may dry out for up to 3 months the model is structured to take this into account. An index score is calculated only if the AU has permanent water. AUs that dry out in most years are scored a [0] for habitat suitability.

The model for the depressional alkali wetlands contains variables that represent structural elements in the AU that are known or judged to provide habitat for both species of mammals. Reducers include the presence of large, grazing livestock that impact plant communities. When indigenous plant communities are damaged by grazing invasive species often take over. The presence of cattle can also collapse burrows. The presence of human disturbance is also modeled as a reducer. The latter has the potential for introducing light and noise, habitat loss, and other forms of harassment such as predation by pets.

Opportunity is modeled based on the proximity of other wetland types and on the presence of natural corridors with adequate vegetative cover.

8.7.3 Model at a Glance

Depressional Alkali **Habitat for Aquatic Mammals**

Characteristics	Variables	Measures or Indicators
SUITABILITY	**Vpermwater**	AU has areas that are permanently inundated
Structural	**Vdepthannual**	Depth of annual inundation
Heterogeneity	**Vdepthperm**	Depth >= 1.3 meters in permanent surface water
	Vpintersp	Rating interspersion of plant structures
	Vbank	Presence/absence of steep bank suitable for denning
	Vpermveg	Presence of emergent vegetation in areas of extended inundation
	Vbuffcond	Descriptive characterization of condition of buffer
Reducers		
	Vgrazing	Presence of domestic livestock
	Vhumandis	Presence of human activities within AU and buffer
OPPORTUNITY		
	Vripcorridor	Rating of riparian corridors to other wetlands
	Vvegcorridor	Rating of vegetation cover of corridors to other wetlands
	Vmosaic	Wetland hydrogeomorphic types within 2 km
Numerator for Suitability	Vdepthannual + Vdepthperm + Vpintersp+Vbank+Vpermveg+ Vbuffcond) x **Vpermwater** x (Vgrazing x Vhumandis)	
Numerator for Opportunity	Vripcorridor + Vvegcorridor + Vmosaic	

8.7.4 Description and Scaling of Variables

Variables for Suitability

V$_{\mathbf{permwater}}$- The AU has areas that are permanently inundated.

Rationale: The presence of permanent surface water (water that last for the entire year) is critical for the long-term suitability of an AU as habitat for both muskrats and beaver. Permanent water is needed to accommodate lodges and bank dens and to allow free movement from the lodge to feeding areas.

Indicators: Presence of permanent water can be established by certain indicators such as the presence of fish, aerial photos taken during the driest part of the year or local knowledge.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if has permanent water. AUs without permanent water are scored a [0], and the AU receives a [0] for the index of performance.

Variables for Suitability

$V_{depthannual}$ - Depth of annual inundation (an indicator of water level stability).

Rationale: The indicator for water level stability is the height of the annual inundation. AUs where the annual water level fluctuations are low are considered to have a more stable water level. Beavers prefer a seasonally stable water level (Slough and Sadleir 1976). Ability to control water levels in wetlands with damable outlets increases the suitability of a wetland as habitat for beaver. Fluctuations may also affect suitability for muskrat habitat (Errington 1963). Both drought and floods disrupt living routines and security of muskrat populations. Heavy spring runoff or flash floods that raise water levels in the wetland may cause flooding of burrows and the possible flooding or evacuation of young (Errington 1963).

Indicators: Measurement is made from the high water mark to the level of extended inundation, or surface of AU if it dries out. During high water periods it may be necessary to use the vegetation to identify the approximate level of extended inundation.

Scaling: AUs with annual inundation less than 0.6m are scored a [1] for this variable. Those whose depths are >0.6 m but less than or equal to 0.9m are scored a [0.8]. Those whose depths are >0.9m but less than 1.5 m are scored a [0.1], and those with depths of 1.5 m or greater are scored a [0].

$V_{depthperm}$ - Depth greater than or equal to 1.3 meters in areas of permanent inundation.

Rationale: Water depth must be sufficient to accommodate lodges and bank dens and to allow free movement from the lodge to food caches during the winter. Freezing of the food cache is a limiting factor on beaver and muskrat survival in the Columbia Basin (Tabor personal communication*)*. Freezing of a pond to the bottom can be disastrous to muskrat populations (Schmitke 1971). Deep water will also provide protection from predators (Easter-Pilcher 1977). Shallow waters can expose lodge or den entrances, leaving animals vulnerable to predators. In the Columbia Basin beaver and muskrat need at least 1.3 meters of permanent water to allow access to food caches during the winter when the surface is frozen.

Indicators: Depth can be estimated by wading or using a fishing line with a bobber.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if has depth greater than 1.3m in areas that are permanently inundated, and a [0] if it does not.

$V_{pintersp}$ - Rating of interspersion among plant species with different structures (i.e. emergent species of different heights, aquatic bed and scrub/shrub vegetation).

Rationale: Structural heterogeneity in the plant assemblages enhances the habitat for beaver and muskrat. Although beaver show distinct preferences for a small number of plant species, they are known to sample almost any woody or herbaceous species. Columbia Basin beavers have been observed grazing on forbs along the shoreline and using cattails and bulrush to build lodges and dams. Although willows are highly preferred, beaver are not as closely associated with other commonly preferred woody vegetation such as aspen or cottonwood (Tabor personal communication). This is quite likely due to the best available food sources being the most common forage. Presence of heavy growths of emergent vegetation suitable for lodge-building, notably cattails and bulrushes, commonly attract muskrats, irrespective of the nature of the shoreline (Errington 1963). It appears, therefore, that a variety of plants with different structural characteristics provide optimal conditions for these aquatic mammals.

Indicators: Emergent vegetation within different height ranges (0- 10cm, 11-20cm, 30cm-1m, and >1m), and areas of aquatic bed and scrub/shrub are mapped. The final mapped areas are compared to diagrams showing the observed general patterns of structural diversity in the Columbia Basin.

Scaling: AUs with a high interspersion (rating = 3) are scored a 1 for this variable. Those with a lower rating are scored proportionally (rating / 3).

V_{bank} - The presence of slope and soil conditions that are suitable for muskrat and beaver bank burrows.

Rationale: Beaver in the Columbia Basin prefer bank dens over lodges, and a relatively steep bank (45%) with at least three feet of soil is necessary (Tabor, personal communications). While beaver are limited by steep topography in construction of channels which are used to obtain and transport food (Easter-Pilcher 1987), lack of a slope might preclude burrow construction, and increase the impacts of water fluctuations to burrows in hillsides with a lower slope. Coarse substrates have been negatively correlated with beaver presence and abundance (Slough and Sadler 1977, Rutherford 1967), whereas the distribution and status of bank-dwelling muskrats is influenced by extremes of both hardness or looseness (Errington 1963).

Indicators: Presence of banks is determined at a site visit. For burrowing, a bank should be at least 45%, with at least one meter of fine soil such as sand, silt, or clay.

Scaling: This is a “yes/no” variable. An AU scores a [1] for the variable if it has appropriate banks, and a [0] if it does not.

$V_{permveg}$- Presence of persistent emergent vegetation in area of extended inundation.

Rationale: Vegetation in areas that have extended surface inundation provides beaver and muskrat with easy, and protected access to needed food sources and material for building lodges. Access to food supplies and building materials are necessary for the establishment of beaver colony sites (Slough and Sadlier 1976).

Indicators: Direct observation of areas of extended inundation for the presence of persistent emergent vegetation. Because the level of extended inundation is typically below the rooting level of emergent vegetation in the Columbia Basin, local experts and residents would have to be consulted during the high water periods as to the level of extended inundation water. During the drier summer and fall months the level of extended inundation and permanent vegetation could be observed directly.

Scaling: This is a "yes/no" variable. An AU scores a [1] for the variable if it has permanent vegetation in the long-duration water, and a [0] if it does not.

$\mathbf{V_{buffcond}}$ - Condition of area within 100m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The presence of humans and domestic animals in proximity to the wetland impacts beaver and muskrat. Undisturbed buffer of sufficient width indicates that human disturbance is at a minimum. In some areas of the Basin, upland shrubs and trees such as aspen and willows, will provide a limited source of forage and building materials for beavers and muskrat.

Indicators: This variable is assessed using the buffer categorization described in Part 2.

Scaling: AUs rating a 5 on the buffer are scored a [1] for the variable. Those with lower ratings are scored proportionally (buffer rating / 5).

Reducers

$\mathbf{V_{grazing}}$ - Presence of domestic livestock.

Rationale: Grazing of livestock (e.g. cattle, horses, sheep) has detrimental effects on mammals due to decreased vegetation cover, destruction of riparian and emergent plants, changes in plant communities, and collapse of aquatic mammal burrows.

Indicators: Sign of impacts or presence of livestock at time of site visit.

Scaling: AUs where grazing is present within the AU or its buffer have their final score reduced by a factor of 0.8.

$\mathbf{V_{humandis}}$ – The presence of human disturbance within 100 meters of the AU edge.

Rationale: In the judgement of the Assessment Team, human disturbance is a major factor in reducing habitat suitability for mammals. Muskrats are known to adjust to unsatisfactory conditions by shifting their centers of activity from 20 yards to many miles (Errington 1961). Major factors in reducing habitat suitability for beaver are human disturbance and associated roads and land clearing (Slough and Sadleir 1977).

Commercial trapping and fishing, and recreational uses such as hunting, fishing, boating, and wildlife viewing can create unsatisfactory habitat conditions by collapsing burrows, destroying food sources, and both direct and indirect noise harassment.

Indicators: Human disturbance is rated based on direct observation of activities, and by indirect evidence such as parking areas, off-road tire tracks, trash, fishing line, foot-trails along shoreline and through buffer.

Scaling: AUs in which human activities such as boating, fishing, hunting, grazing, roads, residences or urban areas are rated as having a high impact have their final score reduced by a factor of 0.8.

Variables for Opportunity

$\mathbf{V_{ripcorridor}}$- Rating of riparian corridor connecting AU to other wetlands.

Rationale: Beavers achieve efficient habitat exploitation through extensive dispersal. Emigration of young beaver may involve movements over considerable distances, both over land and via waterways (Slough and Sadleir 1977). Corridors are important during all seasons, though they will be more important when water is present in the corridor. Riparian corridors with deeper, permanent, water are better for dispersal because they provide cover under water.

Indicators: This variable is determined using a corridor rating key described in Part 2. Riparian corridors are rated on a scale of 0-3 based on the depth and permanence of water.

Scaling: AUs with a rating of 3 for the riparian corridor are scored a [1] for this variable. AUs with a lower rating are scored proportionally (rating/3).

$\mathbf{V_{vegcorridor}}$ – Rating of vegetation cover in corridors to other wetlands.

Rationale: Vegetation in dispersal corridors provides cover during the migration from one wetland to another. AUs that are connected to other wetlands with a dense vegetation cover have a higher opportunity to provide habitat because the are more easily accessible for the mammals.

Indicators: This variable is determined using a corridor rating key described in Part 2. Vegetated corridors are rated on a scale of 0-3 based on the amount of plant cover in the corridor

Scaling: AUs with a rating of 3 for the vegetated corridor are scored a [1] for this variable. AUs with a lower rating are scored proportionally (rating/3).

V_{mosaic} - The AU is part of a complex of aquatic habitats encompassing several to many wetland and other aquatic types within a confined geographic region.

Rationale: AUs that occur as part of a complex of wetland types (e.g. depressional long-duration, riverine, lacustrine) and/or perennial water bodies (rivers, streams, lakes) provide a greater opportunity for migration by aquatic mammals between wetlands. Alteration of a wetland mosaic can affect the dynamics of wetland associated organisms (Gibbs 1993). A lack of other wetlands nearby reduces the opportunity for emigration and immigration as well as reducing the options for movement when the habitat in the AU is stressed or disturbed.

Indicators: None needed, maps and aerial photos are used to determine a mosaic of wetlands in the landscape.

Scaling: AUs with 6 or more different types of wetlands present within 2 km are scored a [1] for this variable. Those with fewer types are scored proportionally (# of types/6)

8.7.5 Calculation of Habitat Suitability

Depressional Alkali Habitat for Aquatic Mammals

Variable	Description of Scaling		Score for Variable	Result
Vpermwater	*Highest*	AU has permanent water	If D10.6 = 1 - continue"	
	Lowest	AU does not have permanent water	If D10.6 = 0 enter "0" for habitat suitability	
Vdepthannual	*Highest:*	Annual inundation < = 0.6m	If D12.1 <=0.6 enter "1"	
	Moderate:	Annual inundation 0.6 – 0.9 m	If D12.1 >0.6 and <= 0.9 enter a "0.8"	
	Low:	Annual inundation >0.9 – 1.5 m	If D12.1 >0.9 and <=1.5m Enter a "0.1"	
	Lowest:	Annual inundation >1.5m	If D12.1 >1.5 enter a "0"	
Vdepthperm	*Highest:*	AU has water depths >=1.3 m in areas of extended inundation	If D14.4 = 1 enter "1"	
	Lowest:	AU water depths < 1.3 m	If D14.4 = 0 enter "0"	
Vpintersp	*Highest:*	AU has high interspersion	If calculation =1 enter "1"	
	Lowest:	AU has no interspersion	If calculation = 0 enter "0"	
	Calculation:	Scaled as (rating of interspersion)/3	Enter result of calculation if < 1.0	
	Calculate D37/3			
Vbank	*Highest:*	AU has banks for denning	If D31 = 1 enter "1"	
	Lowest:	AU has no banks	If D31 = 0 enter "0"	
Vpermveg	*Highest:*	AU has permanent vegetation in areas of extended inundation	If D30.5 = 1 enter "1"	
	Lowest:	AU has such vegetation	If D30.5 = 0 enter "0"	
Vbuffcond	*Highest:*	Buffer category of 5	If D39 = 5, enter "1"	
	High:	Buffer category of 4	If D39 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D39 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D39 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D39 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D39 = 0, enter "0"	
			Total of Variable Scores:	

Depressional Alkali Habitat for Aquatic Mammals (Cont.)

Variable	Description of Scaling	Score for Variable	Result
Reducers			
Vgrazing	Grazing present in AU or buffer	If D32 =1 enter "0.8"	
	AU has no grazing present	If D32 =0 enter "1"	
Vhumandis	AU has high levels of human disturbance	If rating of any disturbance is high: value of 2 in any field (D41.1 to D41.8) enter "0.8"	
	AU does not have high levels of human disturbance	If ratings of disturbance are low on none (only values of "0 or 1" in data D41.1 to D41.8) enter a "1"	
		Score for Reducer - ***multiply scores for two reducers***	
		Index for Mammal Habitat (Suitability) = (Total of variables) x (score for reducers) x (1.67) rounded to the nearest 1	
		FINAL RESULT:	

8.7.6 Calculation of Opportunity

Depressional Alkali **Habitat for Aquatic Mammals**

Variable	Description of Scaling		Score for Variable	Result
Vmosaic	*Highest*	AU has at least 6 other wetland types within 2 km	If calculation >=1 enter "1"	
	Lowest	AU has no wetlands nearby	If calculation = 0 enter "0"	
	Calculation	Scaled as (number of types/4)	Enter result of calculation if < 1.0	
	Calculate (D8.1 + D8.2 + D8.3 + D8.4 + D8.5 + D8.6 + D8.7)/6			
Vripcorridor	*Highest*	AU has a rating of 3 for riparian corridor	If calculation =1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (corridor ratings/3)	Enter result of calculation if < 1.0	
	Calculate (D43.1) /3			
Vvegcorridor	*Highest*	AU has a rating of 3 for vegetated corridor	If calculation =1 enter "1"	
	Lowest	AU has no corridors	If calculation = 0 enter "0"	
	Calculation	Scaled as (corridor ratings/3)	Enter result of calculation if < 1.0	
	Calculate (D43.2) /3			
			Total of Variable Scores:	
			Index for Mammal Habitat (Opportunity)= Total x 3.33 rounded to nearest 1	
			FINAL RESULT:	

8.8 Richness of Native Plants — Depressional Alkali Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

8.8.1 Definition and Description of Function

The Richness of Native Plants is defined as the degree to which a wetland provides a habitat for different native plant species.

Note: Because the presence or absence of plant species can usually be assessed during a single site visit and used as an indicator of total richness, this model represents the only direct estimate of actual performance in this function assessment method.

A wetland performs the function when the number native plant species is already high, or the number of non-native species is low. Dominance by even a few non-native species often precludes native plant species, and therefore the ability of the AU to support native plant richness at the local and regional levels. The reduction of this potential appears to be exacerbated by the presence of a few aggressive non-native plant species that colonize and dominate existing native plant associations. Thus not only is the number of non-native species important in reducing the performance of this function, the coverage of few aggressive species is perhaps more critical in determining whether native plant associations can continue to exist. Changes in vegetation composition as the result of non-native invaders have been inferred by vegetation classification through soil nutrient alteration (Parker 1974, Duebendorfer 1990, La Banca 1993).

Wetlands currently dominated by native plant species tend to be more capable of maintaining native plants than those dominated by non-native species. A high number of native plant species in a wetland enhances the potential for colonization to other perhaps recently disturbed areas. The number and richness of native plant species increases with proximity to nearest seed source (Reinartz and Warne, 1993). Additionally, native plant associations more often harbor rare plant species than non-native associations.

The assessment teams, therefore, have judged that AUs where one or more of the dominant species is non-native have lost some of their ability to support native plant associations. Non-native plants that become dominant tend to become monocultures that exclude native species. The percent of the AU dominated, or co-dominated, by non-native species is modeled as a reducer for this function.

Performance of this function is based the number of native plants present and the absence of non-native species. The model, however, is valid only if the AU has not been recently cleared or altered. If you find the assessment unit has been recently cleared or cut, the score from the model will not provide an adequate assessment of the function.

Opportunity is not modeled because it is assumed that all assessment units have the same opportunity for providing plant habitat. Seed dispersal among different AUs in the Basin is judged to be approximately the same for the level of resolution of these methods.

8.8.2 Assessing this Function for Depressional Alkali Wetlands

The model assessing native plant habitat in depressional alkali wetlands," is based on the actual counts of native plant species made during the site visit and the proportion of native to non-native species found. The areal coverage of non-native species is used as a reducer for the level of performance of this function.

8.8.3 Model at a Glance

Depressional Alkali **Richness of Native Plants**

Characteristics	Variables	Measures or Indicators
Richness of native plants	**V%native**	Percent of total plant species that are native
	Vnative/non	Ratio of native to non-native plant species
	Vmaxnative	Number of native plants identified during site visit
Reducers		
	Vnonnat	% cover of AU where non-natives are dominant or co-dominant
Numerator	(V%native+Vnative/non + Vmaxnative)xVnonnat	

8.8.4 Description and Scaling of Variables

Variables

$\mathbf{V_{\%native}}$ – Percent of total plant species that are native.

Rationale: The percent of total plant species that are native is one measure of how effective the AU is in providing diverse habitat for native plants and maintaining regional plant richness.

Indicators: Direct observation of the total number of native plant species.

Scaling: AUs where the native species represent more than 60% of the total are scored a [1] for this variable. Those with a smaller percentage are scored proportionally (% / 60).

$\mathbf{V_{native/non}}$ - The ratio of native to non-native plant species.

Rationale: The ratio of native plant species to non-native present in an AU is an additional measure of how effective it is in providing diverse habitat for native plants and maintaining regional plant richness. Both the % and ratio are used as variables because this minimizes the difference that arise with collecting plant data at different times in the growing season. The actual species counts at an AU change seasonally, but the ratios remained relatively stable.

Indicators: The indicator is the number of native and non-native species observed during the site visit.

Scaling: AUs whose ratio was greater than or equal to 5 were scored a [1] for this variable. Those with a lower ratio were scored proportionally (ratio / 5).

$\mathbf{V_{maxnative}}$ - The number of native plant species present.

Rationale: The number of native plant species present in an AU is one measure of how effective it is in providing diverse habitat for native plants and maintaining regional plant diversity. It is not possible, however, to determine the total species richness in one visit or within a few hours. Some plants are annuals and grow for only a short time, others have a very limited distribution and may occupy a small and inconspicuous patch that is easily overlooked. For this reason the count of native species determined during the site visit is only an indicator of the actual "maximum" number that could be present in an AU.

Indicators: The indicator of overall native plant richness is the number of species found during the site visit.

Scaling: AUs with 7 or more native species present are scored a [1] for this variable. Those with fewer are scored proportionally (# species / 7).

Reducers

$\mathbf{V_{nonnat}}$ - The percent of the AU where non-native species are dominant or co-dominant.

Rationale: AUs in which non-native plant species are dominant (>50% areal cover) or co-dominant (>20% areal cover) may hinder the ability of the AU to provide diverse habitat for native plants and maintaining regional plant diversity. Aggressive non-native species tend to outcompete native species. The estimate of areal coverage of non-native species determined during the site visit is only an indicator of the actual coverage possible.

Indicators: The areal coverage of dominant or co-dominant non-native species (>20% cover within any plant association) estimated during the site visit.

Scaling: AUs where the non-native cover more than 75% of the area have their score reduced by a factor of (x 0.3). A 50% - 75% cover reduces the score by a factor of (x 0.5) and a cover of 25% - 49% reduces the score by a factor of (x 0.9). AUs with less than a 25% cover of non-natives do not have their score reduced.

8.8.5 Calculation of Richness

Depressional Alkali **Native Plant Richness**

Variable	Description of Scaling		Score for Variable	Result
V%native	*Highest:*	% native plants >=60%	If calculation >=1 enter "1"	
	Lowest:	% native plants = 0%	If calculation = 0 enter "0"	
	Calculation:	Scaled as % native/60	Enter result of calculation if < 1.0	
	Calculate [D21.1/(D21.1 + D21.2)] / 0.6			
Vnative/non	*Highest:*	Ratio > = 5	If calculation >=1 enter "1"	
	Lowest:	Ratio = 0	If calculation = 0 enter "0"	
	Calculation:	Scaled as ratio/5	Enter result of calculation if < 1.0	
	Calculate (D21.1 / D21.2)/5 Note: if no non-natives present result of calculation is automatically > 1			
Vmaxnative	*Highest*	AU has >= 7 native species	If calculation >=1 enter "1"	
	Lowest	AU has 0 native species	If calculation = 0 enter "0"	
	Calculation	Scaled as # native plant species/7	Enter result of calculation if < 1.0	
	Calculate D21.1/7			
			Total of Variable Scores:	
Reducer				
Vnonnat	>75% cover of non-native plants		If D24.1 = 1, enter "0.3"	
	50-75% cover of non-native plants		If D24.2 = 1, enter "0.6"	
	25 - 49% cover of non-native plants		If D24.3 = 1, enter "0.9"	
	0 – 24% cover of non-native plants		If D24.4 + D24.5 = 1 enter "1"	
			Score for Reducer	
Index for Native Plant Richness = (Total for variables) x (Reducer) x (3.33) rounded to nearest 1				
			FINAL RESULT:	

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List of Acronyms

AU	Assessment Unit
Corps	US Army Corps of Engineers
Ecology	Washington State Department of Ecology, also "WDOE" (in publication references)
EM	Emergent
FO	Forested
GIS	Geographic Information System
HEP	Habitat Evaluation Procedure
HGM	Hydrogeomorphic
IVA	Indicator Value Assessment
IWRB	Interagency Wetland Review Board
LWD	Large woody debris
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
PHS	Priority Habitats and Species
SS	Scrub-shrub
SWTC	Statewide Technical Committee
USFWS	US Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology, also "Ecology" in text
WET	Wetland Evaluation Technique
WFAP	Wetland Function Assessment Project

Appendix 1- A: Members of the Project's Committees and Teams

Members of the Statewide Technical Committee for developing wetland assessment methods.

Name	Organization
Ken Brunner	US Army Corps of Engineers
Dr. Sarah Cooke	Cooke Scientific Services
Joel Fruedenthal	Clallam County
Robert Fuerstenberg	King County Surface Water Management
Dr. Tom Hruby	Washington State Department of Ecology
Dr. Chuck Klimas	Klimas and Associates
Ivan Lines	US Natural Resources Conservation Service (retired)
Andy McMillan	Washington State Department of Ecology
Charles Newling	Wetland Training Institute
Dr. Ken Raedeke	Raedeke Associates
Ralph Rogers	US Environmental Protection Agency
Dyanne Sheldon	Sheldon and Associates
Curtis Tanner	US Fish and Wildlife Service
Paul Wagner	Washington State Department of Transportation
Dr. Fred Weinmann (retired)	US Environmental Protection Agency
Bob Zeigler	Washington Department of Fish and Wildlife

Eastern Washington Technical Committee

Name	Organization
Dennis Beich	Water Resource Department, Okanogan County
Jeff Combs	United States Fish and Wildlife
Don Derifield	East Columbia Basin Irrigation District
Tim Dring	Natural Resources Conservation Service
Tom Duebendorfer	Wetland Consultant
Mike Folsom	Geography Department, Eastern Washington University
Glenn Grette	Pacific International Engineering
George Maddox	Consultant
Katherine March	Washington State Department of Fish and Wildlife
Andy McMillan	Washington State Department of Ecology
Chris Merker	Washington State Department of Ecology
Ron Raney	Natural Resources Conservation Service
Kevin Robinette	Washington State Department of Fish and Wildlife
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Members of the Depressional Assessment Team for the Columbia Basin of Eastern Washington

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Ron Raney	Natural Resources Conservation Service
Catherine Reed	Washington Department of Ecology
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Kim Sherwood	Washington Department of Ecology
Linda Storm	Environmental Protection Agency
Todd Thompson	Bureau of Land Management

Appendix 1- B: Description and Geographic Extent of the Columbia Basin Region

The geographic extent of the Columbia Basin region *for the purposes of these methods* is based on the Ecoregions of the Pacific Northwest as defined by Omernik (1986). The region used for these methods is the same as the "Columbia Basin Ecoregion" identified by Omernik and recently refined by the U.S. Environmental Protection Agency laboratory in Corvallis OR. Characteristics of the ecoregion as described by Omernik (1986) are summarized below.

The Columbia Basin Ecoregion is composed of irregular plains, tablelands with high relief, and low mountains. The region is characterized by deep, dry, channels cut into the underlying Columbia River Basalt formation. Depending on location and elevation the average annual precipitation ranges between 7 inches and 25 inches. Extensive loess deposits cover a large portion of the ecoregion. The region naturally supports sagebrush/wheatgrass steppe and grasslands primarily of wheatgrass with smaller amounts of bluegrass and fescue. Wetter areas support a Ponderosa pine community.

The general boundaries of the ecoregion are shown on Figure B-1. Decisions regarding areas to include, or exclude, from the region should be based on natural plant communities and ecosystems that might be found there (called ecozones). The ecozones of the Basin ecoregion include:

Wheatgrass
Bluegrass/fescue
Wheatgrass/Ponderosa Pine
Shrub steppe The shrub-steppe areas in the Columbia Basin can be roughly divided into the following five sub-zones (Taylor 1992

Standard – Dominant Species - tall sagebrush (*Artemisia tridentata*), hopsage *(Atriplex spinosa),* bitterbrush (*Purshia tridentata),* rabbit brush (*Chrysothamnus nauseosus*), various grasses such as needle and thread grass (*Stipa comata),* bluebunch wheatgrass (*Pseudoroegneria spicatum*), and steppe bluegrass (*Poa segunda*) and lupine and balsamroot species (*Lupinus* spp & *Balsamorhiza* spp.).
Lithosol – stiff sagebrush (*Artemisia rigida*), desert buckwheat (*Eriogonum* spp), and dwarf goldenweed (*Haplopappus acaulis*).
Sand dune – Rabbit brush (*Chrysothamnus nauseosus*)*,* tall sagebrush (*Artemisia tridentata*), sand dock *(Rumex venosus),* and Indian rice grass (*Oryzopsis hymenoides*),

Talus– Service berry (*Amelanchier alnifolia*), squaw currant (*Ribes cereum*), purple sage (*Salvia dorrii*), Oregon sunshine (*Eriophyllum lanatum*), and desert buckwheat *(Eriogonum* spp.)
Saline – Greasewood and saltgrass (*Sarcobatus vermiculatus, Distichlis spicata*), hopsage (*Atriplex spinosa*), and winterfat (*Eurotia lanata*).

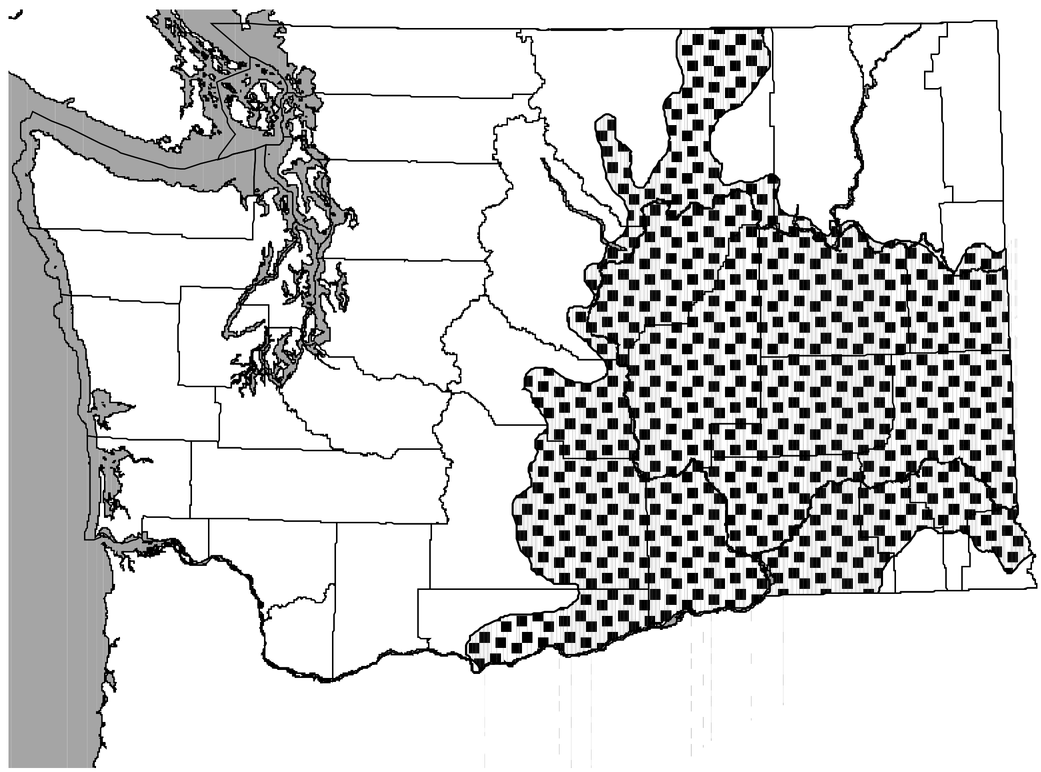

Figure B-1: Approximate outline of the "Columbia Basin" ecoregion from Omernik (1986)

Appendix 1-C - Profiles of the Depressional Wetland Class, Subclasses, and Families of the Columbia Basin

Profiles of the Depressional Wetland Class, Subclasses, and Families of the Columbia Basin

Region: Columbia Basin

Class: Depressional

Depressional wetlands occur in topographic depressions that exhibit closed contours on three sides. Elevations within the wetland are lower than in the surrounding landscape. The shape of depressional wetlands vary, but in all cases, the movement of surface water and shallow subsurface water from at least three directions in the surrounding landscape is toward the point of lowest point in the depression.

Depressional wetlands in the Columbia Basin may be isolated with no surface water inflow or outflow through defined channels, or they may have intermittent surface water flows that connects them to other surface waters or other wetlands. Outflow from depressional wetlands usually occurs early in the growing season in wetlands outside the area of the Reclamation Project. Many depressional wetlands within the Reclamation Project, however, gain surface water later in the growing season from irrigation waters, and may in some cases have occasional outflow late in the summer.

The predominant source of water for most Columbia Basin depressional wetlands outside of the Reclamation Project is from the discharge of groundwater moving laterally through the fractured interface between individual basalt flows or from surface flow during "rain-on-snow" events or summer storms.

Depressional wetlands lose most of their water evaporation, evapotranspiration, and/or infiltration into the ground. Surface water outflows usually represent a small part of the water lost in these wetlands. Wetlands in the Basin can accumulate salts and become "alkali" where mineral rich groundwaters provide the major source of water.

Wetlands that are not alkali are thought to have some regular exchange with groundwater because evaporation rates exceed rainfall throughout the region. To maintain their low alkalinity they must discharge somehow to groundwater through the underlying fractured basalt formations. This is thought to occur later in the growing season when inflow from surface water, shallow groundwater (interflow) and deeper groundwater has ceased. Wetlands situated within deeper loess or wind blown deposits may lose water in a similar manner, but the discharge to groundwater will be primarily through coarser loess sediments and less through fractured basalts. Wetlands whose water regime is dominated by water from irrigation are also not usually alkali.

The Columbia Basin has many areas of small depressions on the surface of impermeable basalt bedrock. The soils in these depressions are shallow, or not present, and they are inundated for only brief periods during the spring that usually last less than 90 days. The inflow to these wetlands is dependent upon precipitation, which is then rapidly lost through evaporation and evapotranspiration. These depressions with a brief period of inundation are often called “vernal” pools and represent an important habitat resource in the Basin.

Some wetlands within the Reclamation Project boundaries have unusual hydrologic characteristics due to the influence of irrigation waters. Overall, limited research has been conducted in Eastern Washington to characterize and quantify the relationship between depressional wetland water regimes, groundwater, and surface water dynamics.

Depressional wetlands in the Columbia Basin are located in the following geomorphic settings: 1) channeled scablands created by Lake Missoula floods, 2) wind blown loess outside the area scoured by Lake Missoula floods, 3) Wind blown sand dunes within the channeled scablands, 4) glacial kettles or potholes located in Douglas County, and 5) alluvial and basalt terraces, particularly along the Columbia River.

Depressional wetlands in the Basin are divided into two subclasses based on their conductivity and further subdivided by the length of time surface water is present in the wetland. These two environmental characteristics were judged to be the most important in establishing how depressional wetlands function in the Basin.

NOTE: The classification of wetlands into different hydrogeomorphic types can sometimes be very difficult. Classification imposes a categorization on natural systems that oversimplifies actual conditions. By categorizing natural systems into “boxes” the ecological information we are trying to assimilate is in smaller more manageable units that can be more readily understood and used by us. Natural systems, however, do not consistently conform to the boundaries of the “boxes” we have created.

The environmental conditions used to categorize wetlands occur along gradients of scale and intensity. As a result, wetland functions change gradually as the gradients change. In order to classify wetlands, however, we are forced to define sharp boundaries on these environmental gradients and assume that the functions also change significantly at these boundaries. Wetlands in which environmental conditions fluctuate around these boundaries may be difficult to classify and one will have to use his/her judgement in classifying.

For example, we have established the boundary between alkali and freshwater wetlands at a conductivity of 3000µS/cm. A wetland whose conductivity is 12,000 µS/cm during the entire year is easy to classify, but one whose conductivity fluctuates between 1700 µS/cm in the spring (during runoff) to 2400 µS/cm at the end of the summer is more difficult. Users of this method will have to use other indicators such as vegetation and their judgement to classify a wetland whose conditions lie on the boundary between wetland types.

Field Characteristics for Depressional wetlands in the Columbia Basin:

Depressional wetlands in the Columbia Basin lie in topographic depressions, and that are **not** within the active channel of a stream or river. Wetlands in an active channel or that are frequently flooded (at least once every two years) are classified as "Riverine." Depressional wetlands are also separated from lacustrine wetlands based on the area and depth of open water present. If areas of open water within the depression are less than 8 hectares (20 acres) in size and less than 3 meters in depth in more than 70% of the open water areas, the entire aquatic area is considered to be a depressional wetland. Depressional wetlands adjacent to or located within a channelized topography (e.g. Palouse) are separated from slope and riverine systems if they have a distinct restriction in their outlet and impound water in a depression behind the restriction and are usually flooded by high groundwater levels rather than by overbank flooding.

The Assessment Team has not found any depressional wetlands in the Basin whose water regime could be categorized as only "saturated." The initial classification developed prior to any field-work did include a subclass for depressional wetlands that were only saturated (i.e. without any surface water at any time of the year). In the absence of any evidence for such wetlands, however, a decision was made not include a third subclass.

Subclass – Alkali

Depressional alkali wetlands are defined as those whose conductivity is usually above 3000 µSiemens/cm. The water regime in alkali wetlands is dominated by groundwater inflow, evaporation, and evapotranspiration. Wetlands with a high conductivity are points of groundwater discharge in arid and semi-arid environments, rather than groundwater recharge (Hayashi et al. 1998).

Alkali wetlands in the Basin may lie adjacent to freshwater wetlands, though most of them are located in the drier parts of the Basin. It is difficult to predict whether a wetland will be freshwater or alkali based on its topographic position or surface geology. It is the subsurface fracturing of basalts and the flow of the local groundwater that will determine whether a wetland is freshwater or alkali. These characteristics cannot be easily determined from an examination of surface conditions.

Alkali wetlands are not as common on the landscape as freshwater wetlands in the Columbia Basin, but they do provide some unique habitat features. The ecological processes in these wetlands are dominated by the high salt concentrations in the water. The most visible result of the salt is a unique set of plants that have adapted to these conditions. Only a few species have adapted to these conditions and the species richness in alkali systems is much lower than in freshwater systems. Although richness may be low, abundance can be very high for those species that have adapted (especially among some invertebrates).

Many plants found in alkali systems are unique, or only found along the seashore. These plants tend to be sparse and relatively short (<1m). As a result, alkali systems often have extensive mudflats and meadows of short grass that attract certain species of waterfowl and shorebirds. Alkali wetlands provide critical habitat for many species of migratory birds.

Alkali wetlands were not subdivided into families based on duration of inundation because the number of alkali reference sites was too low to allow this division to be accurately made. The assessment team did not visit enough alkali wetlands where water was impounded for less than 9 months to determine if their functions were different for wetlands with a longer period of inundation.

Field indicators for the presence of alkali wetlands are as follows:

- The conductivity of the water is above 3000 µS. If it is between 1700 and 3000 you will have to use your judgement using the other field indicators listed below.
- A pH generally greater than 9. Note that some freshwater, long-duration wetlands, in the Columbia Basin may have a relatively high pH (>9) but a low conductivity (significantly less than 1.7 milliS/cm). These wetlands, however, will be dominated by freshwater plants. The few freshwater reference sites found with a high pH were all heavily used by cattle. One hypothesis for the high pH is that it is caused by the ammonia excreted by the cattle.
- Large areas of the wetland are dominated by salt tolerant vegetation such *as Distichlis spicata, Scirpus maritimus* or *Scirpus americanus*. These species may sometimes be found along the edges of freshwater systems, but they rarely become a dominant there.
- The presence of invertebrate species that are tolerant of high salt concentrations (Brine shrimp, some species of *Daphnia*).
- The presence of large numbers of shorebirds feeding in the wetland. Shorebirds prefer the short vegetation often found along the edges of open water in alkali systems. The freshwater systems tend to be dominated by high emergent species (> 1m tall) at the edge of the open water.
- The presence of tiger salamanders.
- Heavy encrustations of salt on surface of rocks within the wetland and on the surface of the wetland in areas without standing water.
- The presence of a very black and slimy hydrogen sulfide deposits at or near the surface layer of the wetland soil (this is not to be confused with an organic muck).

Subclass – Freshwater

Depressional freshwater wetlands are defined as those whose conductivity is consistently below 2000 µSiemens/cm. The water regime in non-alkali wetlands tends to be dominated by surface runoff or groundwater in areas where inflow exceeds water losses through evaporation or evapotranspiration.

Family – Long-duration

Depressional, Freshwater, Long-duration, wetlands are defined as those wetlands that have some surface water present for at least 9 contiguous months in most years. This family includes all depressional wetlands that are permanently inundated as well (the surface water is present the entire year). The surface water can be either open (unvegetated) or ponded between the stems of emergent or shrub plants. The 9 months of inundation do not have to occur within a calendar year, but rather within one dry/wet annual cycle. The driest part of the water cycle is usually from October to December for many wetlands in the Basin except for those whose water regime is modified by irrigation.

The 9 month minimum for the presence of surface water was established based on the presence of specific families and genera of invertebrates that is found in these "long-duration" wetlands. These invertebrate groups are associated with wetlands that have surface water present all, or most of, the time. Up to now, the assumption was that wetlands in which these "obligate" species were found had surface water present during the entire year. Data collected by Dr. Bruce Lang over the last few years (Lang, unpublished results), however, suggests that many invertebrate groups associated with the permanent surface water wetlands can withstand some periods of drying, but not more than 3 months. For example, two and three year old larvae of the Ditiscid beetle were found in a wetland that dried out briefly during the summer of 1999 (reference site CB04). These larvae are completely aquatic and require the presence of surface water to feed and grow. Thus, the site had enough moisture present during the last three years to support these larvae, even if the surface water may have disappeared for short periods.

Wetlands where surface water was present for less than 9 months had different families and genera of invertebrates are associated with them.

Wetlands in which surface water remains for at least 9 months, also have characteristic plants that are not found in the drier wetlands. Long-duration wetlands will have areas dominated by wetland plants such as cattails (*Typha latifolia, T. angustifolia*), bulrush (*Scirpus acutus*), white water buttercup (*Ranunculus aquatilis*), burreed (*Sparganium emersum*) or American water-plaintain (*Alisma plantago-aquatica*) often will also have areas of aquatic bed plants present such as coontail (*Ceratophyllum demersum*), pondweeds (*Potamogeton natans, Potamogeton pectinatus*), water ladysthumb (*Polygonum amphibium*), and ditchweed (*Ruppia maritima*).

The "9 month" criterion for classifying long-duration wetlands is intended only to be a guideline because the water regimes in the Basin are highly variable both in time and space. Consider the other indicators of long-duration wetlands described below when classifying your wetland.

- A ring of bulrush (*Scirpus spp.*) or cattails (*Typha* spp.) around an area of open water (or mudflats in very dry years).

- The presence of species such as white water buttercup *(Ranunculus aquatilis*), burreed (*Sparganium emersum*) or American water-plaintain *(Alisma plantago-aquatica*).

- The presence of standing or open water in September or October as shown in air photos or verified onsite.

- The presence of dried aquatic bed species (listed above) or dried obligate emergent species such as American water-plaintain (*Alisma plantago-aquatica*) late in the growing season.

- Information from local sources (farmers, fishermen, wildlife agents) who know the wetland.

Wetlands influenced by irrigation (either high groundwater or surface runoff) may have surface water present over a longer period of time relative to similar "non irrigation" influenced wetlands, but the level of standing water may fluctuate less because the wetlands are subject to two pulses of water. One inflow of water occurs during the spring that results from the natural rain and snow patterns, and one during the late summer that results from irrigation.

Family – Short-duration

Depressional Short-duration wetlands are defined as those wetlands where surface water (inundation) is present for less than 9 months in most years. This type of wetland also includes short-duration wetlands known as "vernals" that typically have surface water present for less than 90 days in the growing season.

The flora and fauna associated with the short-duration wetlands can be significantly different from those associated with long-duration wetlands. For example, the families and genera of invertebrates associated with short-duration wetlands are distinctly different from those found in long-duration wetlands. Data collected by Dr. Bruce Lang over the last 10 years (Lang, unpublished results) suggests that the groups associated with the short-duration wetlands may be found in long-duration wetlands, but the converse is not true. Taxa associated with long-duration wetlands drop out of the invertebrate population as the period of inundation falls below 9 months.

Some field indicators that indicate a wetland has only a short-duration, or seasonal, surface inundation are listed below:

- Surface inundation is mostly precipitation-driven: if groundwater is present it usually only increases the duration of surface saturation.

- Soils will almost always be mineral. Organic layers will be very shallow or non-existent because any organic debris is usually oxidized during the dry period.

- Wetlands with surface inundation between 3-9 months will usually be completely vegetated; those with surface inundation less than 3 months (vernal pools) will have extensive areas where vegetation cover is sparse or non-existent.

The assessment method for short-duration wetlands does not separate between vernal wetlands and those with slightly longer period of inundation. The assessment team was unable to define characteristics or functions that are unique to vernal systems and they are considered a subset of the short-duration family of wetlands. Vernal wetlands, however, are important in the landscape of the Columbia Basin and there is some interest in managing vernal wetlands as a separate type. Characteristics that can be used to separate vernal pools from the other short-duration wetlands for the purpose of managing them better are summarized in the following table.

Short-duration	Vernal
Water regime is precipitation driven, but groundwater may contribute to maintaining soil saturation	Water regime mostly precipitation-driven, no groundwater influences except possibly from nearby shallow subsurface flows; substrate impermeable close to the surface.
Substrate may be deep or shallow; soil texture varies. Organic soils are very infrequent.	Substrate is shallow to a hardpan or bedrock (often < 30 cm); soil texture varies. Organic soils are never present.
Average water level may be relatively deep (2m) early in the growing season; water or saturated soils may persist well into late summer/early fall	Average water level is generally very shallow early in the growing season (< 30 cm) and dries by May or June. Period of soil saturation after water levels drops is very short. Soil surface may appear cracked as it dries
Vegetation generally dominated by wetland perennials; mostly one major vegetation association per year; upland or facultative upland annual and biennial species can be found growing within the wetland boundary late in the growing season	Vegetation generally dominated by annuals appearing in two vegetation associations: obligate or facultative wetland annuals dominate early in the season; as pools dry, facultative upland to upland annual or biennial exotics invade and persist throughout fall
Rhizomatous species generally present	Rhizomatous species mostly absent except possibly in deepest portions of pool
Vegetation may be woody or emergent and is generally relatively tall	Vegetation is mostly emergent and generally less than 30 cm tall at maturity

Appendix 1- D: Summary of Assessment Models for Eastern Washington Columbia Basin Wetlands

Summary of Assessment Models for Washington's Columbia Basin Wetlands

Note: *In the model summaries below, only the numerator of the equation is shown. The denominator for each equation is the score from the highest scoring reference standard wetland during calibration. Variables shown in bold are the variables that are reducers of performance.*

Potential for Removing Sediment
Depressional Long-duration
Vout + Vstorage + Vinund/outletw + Vvegcover
Depressional Short-duration
Vstorage + Vout + Vinund/outletw + Vvegcover
Depressional Alkali
Vstorage + Vout + Vvegcover
Opportunity for Removing Sediment
Depressional Long-duration
Vbuffcond+Vbufferbypass+Vupsedim+Vslope
Depressional Short-duration
Vbuffcond+Vbufferbypass+Vupsedim+Vslope
Depressional Alkali
Vbuffcond+Vbufferbypass+Vupsedim+Vslope
Potential for Removing Nutrients/Nitrogen
Depressional Long-duration
Veffectarea2 + Vorg + Vpermveg
Depressional Short-duration
Vsow + Vorg
Depressional Alkali
Insufficient Information to Develop Model
Opportunity for Removing Nutrients/Nitrogen
Depressional Long-duration
Vbuffcond +2xVproject+ Vupnut
Depressional Short-duration
Vbuffcond +Vproject+ Vupnut
Depressional Alkali
Insufficient Information to Develop Model
Potential for Removing Nutrients/Phosphorous
Depressional Long-duration
3xSsed + Vsorp
Depressional Short-duration
3xSsed + Vsorp
Depressional Alkali
Insufficient Information to Develop Model
Opportunity for Removing Nutrients/Phosphorous
Depressional Long-duration

Vbufferbypass + Vbuffcond + Vupnut
Depressional Short-duration
Vbufferbypass + Vbuffcond + Vupnut
Depressional Alkali
Insufficient Information to Develop Model
Potential for Removing Metals and Toxic Organics
Depressional Long-duration
Ssed + Vsorp + Vphow +Vherbaceous
Depressional Short-duration
Ssed + Vsorp + Vphow +Vherbaceous
Depressional Alkali
Insufficient Information to Develop Model
Opportunity for Removing Metals and Toxic Organics
Depressional Long-duration
Vdevelopment + Vuptox + Vbufferbypass
Depressional Short-duration
Vdevelopment + Vuptox + Vbufferbypass
Depressional Alkali
Insufficient Information to Develop Model
Potential for Reducing Downstream Erosion and Flooding
Depressional Long-duration
2xVstorage + Voutletw/inund + Vinund/shed
Depressional Short-duration
2xVstorage + Voutletw/inund + Vinund/shed
Depressional Alkali
2xVstorage + Voutletw/inund + Vinund/shed
Opportunity for Reducing Downstream Erosion and Flooding
Depressional Long-duration
Could not be calibrated - uses qualitative rating
Depressional Short-duration
Could not be calibrated - uses qualitative rating
Depressional Alkali
Could not be calibrated - uses qualitative rating
Potential for Recharging Groundwater
Depressional Long-duration
(Vinfilt + Vannualinund + Vsalt + Vdepthannual) **xVdrain x Virrigation**
Depressional Short-duration
(Vinfilt + Vannualinund + Vsalt + Vdepthannual) **xVdrain x Virrigation**
Depressional Alkali
Function is not usually performed – wetlands are judged to be areas of groundwater discharge
Opportunity for Recharging Groundwater
Depressional Long-duration
All AUs have high opportunity
Depressional Short-duration
All AUs have high opportunity except those with only brief periods of inundation

Depressional Alkali
Function is not usually performed – wetlands were judged to be areas of groundwater discharge
Suitability for General Habitat
Depressional Long-duration
(Vhydrop + Vprecip + Vwater + Vrefuge + Vprichness + Vaquatbed + Vvegclass +Vpheight + Vpintersp + Vedgepheight + Vbuffcond + Vbuffstruc) x (**Vmilfoil x Vupcover x Vgrazing**)
Depressional Short-duration
(Vsow + Vprecip + Vrefuge + Vprichness + Vvegclass +Vpheight + Vpintersp + Vsinuosity + Vedgepheight + Vbuffcond + Vbuffstruc) x (**Vgrazing or Vupcover**)
Depressional Alkali
(Vhydrop + Vwater + Vrefuge + Vprichness + Vaquatbed +Vpheight + Vpintersp + Vbuffcond + Vbuffstruc) x (**Vupcover**)
Opportunity for General Habitat
Depressional Long-duration
Vmosaic + Vcorridor + Vhabtypes
Depressional Short-duration
Vmosaic + Vcorridor + Vhabtypes
Depressional Alkali
Vmosaic + Vcorridor + Vhabtypes
Habitat Suitability for Invertebrates
Depressional Long-duration
(Vannualinund + Vdepthcat + Vprichness + Vaquabedsp + Vrefuge + Vsubstrate) x Vpermwater x (**Vfish or Vcarp**)
Depressional Short-duration
Vprichness + Vsubstrate + Vprecip + Vwintersp2
Depressional Alkali
Vannualinund+ Vprichness + Vrefuge +Vwintersp1 + Vhydrop
Opportunity for Invertebrates
Depressional Long-duration
Vcorridor + Vmosaic
Depressional Short-duration
Vcorridor + Vmosaic
Depressional Alkali
Vcorridor + Vmosaic
Habitat Suitability for Amphibians
Depressional Long-duration
(Vpheight+Vpintersp+Vpow+Vwintersp1+Vbuffstruc+Vrefuge) x (**Vfish or Vbullfrog**)
Depressional Short-duration
Vout+Vsow+Vpheight+Vaquatbed+Vscirpus+Vrefuge+Vwintersp2+Vbuffstruc
Depressional Alkali
Vpheight+Vpintersp+Vldstandw+Vwintersp1+Vbuffstruc+Vrefuge
Opportunity for Amphibians
Depressional Long-duration
Vcorridor +Vmosaic
Depressional Short-duration
Vcorridor + Vmosaic

Depressional Alkali	
	Vcorridor +Vmosaic
Habitat Suitability for Aquatic Birds	
Depressional Long-duration	
	(2xVhydrop + Vpow + Vmud/sand + Vwintersp1 + Vpheight + Vpintersp + Vbuffcond + Vbuffstruc + Sinvert) x **Vcarp x Vinvasive x Vhumandis**
Depressional Short-duration	
	(Vopenw + Vmud/sand + Vwintersp2 + Vpheight + Vpintersp + Vbuffcond + Vbuffstruc + Sinvert) x **Vinvasive x Vhumandis**
Depressional Alkali	
	(2xVhydrop+Vldstandw + Vwintersp1 + Vpheight + Vpintersp + Vbuffcond + Vbuffstruc + Sinvert) **x Vhumandis**
Opportunity for Aquatic Birds	
Depressional Long-duration	
	Could not be calibrated - uses qualitative rating
Depressional Short-duration	
	Could not be calibrated - uses qualitative rating
Depressional Alkali	
	Could not be calibrated - uses qualitative rating
Habitat Suitability for Aquatic Mammals	
Depressional Long-duration	
	Vdepthannual + Vdepthperm + Vpintersp+Vbank+Vpermveg+ Vbuffcond + Vwintersp1) x **Vpermwater** x (Vgrazing x Vcarp x Vinvasp x Vhumandis)
Depressional Short-duration	
	Short-duration wetlands are not judged suitable as year-round habitat
Depressional Alkali	
	Vdepthannual + Vdepthperm + Vpintersp+Vbank+Vpermveg+ Vbuffcond) x **Vpermwater** x (Vgrazing x Vhumandis)
Opportunity for Aquatic Mammals	
Depressional Long-duration	
	Vripcorridor + Vvegcorridor+ Vmosaic
Depressional Short-duration	
	Vripcorridor + Vvegcorridor+ Vmosaicper
Depressional Alkali	
	Vripcorridor + Vvegcorridor+ Vmosaic
Richness of Native Plants	
Depressional Long-duration	
	(V%native+Vnative/non + Vmaxnative)xVnonnat
Depressional Short-duration	
	(V%native+Vnative/non + Vmaxnative)xVnonnat
Depressional Alkali	
	(V%native+Vnative/non + Vmaxnative)xVnonnat
Opportunity for Richness of Native Plants	
Depressional Long-duration	
	Not Modeled

Depressional Short-duration
Not Modeled
Depressional Alkali
Not Modeled
Potential for Supporting Food Webs
Depressional Long-duration
Vvegcover + Vout +Sinverts + Sbirds
Depressional Short-duration
Vvegcover + Vout +Sinverts + Sbirds
Depressional Alkali
No model developed – all alkali wetlands judged to perform this function at similar level
Opportunity for Supporting Food Webs
Depressional Long-duration
Vprecip
Depressional Short-duration
Vprecip
Depressional Alkali
No model developed