

# Chapter 1

## Introduction to the Document

This is the first volume of a two-volume series. This volume contains a summary and synthesis of the recent literature relevant to the science and management of wetlands in the state of Washington. Volume 1 describes what the scientific literature says directly about the topics described below. In some cases where scientific information is lacking, the authors present their own hypotheses or conclusions based on a process of deductive reasoning or their own observations. Hypotheses and conclusions based only on the authors' reasoning or observations are clearly labeled as such.

The focus of Volume 1 is freshwater wetlands in Washington. Estuarine and marine wetlands are discussed in this document only in regard to the wetland rating systems covered in the second volume.

The topics covered in Volume 1 are:

- How environmental factors control the functions of wetlands across the landscape and at individual sites, how freshwater wetlands are classified according to these controls, and what functions are performed by different classes of freshwater wetlands in the state
- How human activities and land uses affect the environmental factors that control the functions of freshwater wetlands
- How disturbances caused by human activities and land uses impact the performance of functions by freshwater wetlands
- How wetlands are protected and managed using common tools such as buffers and compensatory mitigation, including what the literature says about the relative effectiveness of these tools
- How cumulative impacts can result from current approaches to managing and regulating wetlands

Volume 2 of this series translates these scientific findings into guidance to local governments and others regarding programs they can or currently do use to protect and manage wetlands.

This work was collectively prepared by the Washington State Department of Ecology (Ecology), the Washington State Department of Fish and Wildlife (WDFW), and a private consulting firm. The U.S. Environmental Protection Agency (EPA) provided funding and assisted in its production. Representatives from these agencies, as well as staff from the private consulting firm, made up a team (the Core Team) that guided the project. See Appendix 1-A for a list of members of the Core Team.

Both volumes will be of use to all those interested in protecting and managing wetlands. The authors hope they will find these documents useful in gaining a greater understanding of the current science regarding wetlands in the state, their ecology and functions, as well as their protection and management. Examples of groups who might use these documents include federal, state, and tribal staff; planners; resource managers; wetland scientists; builders; farmers; environmentalists; and other concerned citizens.

Local governments, however, are the primary audience for this document. They are a key group involved in wetland protection in the state. Through the Growth Management Act (GMA) (Revised Code of Washington (RCW) 36.70A), every county and city in Washington must designate critical areas (including wetlands) within their boundaries and protect them. In 1995, an amendment to GMA (RCW 36.70A.172 [1]) required that all city and county governments must include best available science (BAS) when developing their critical areas policies and regulations.

This synthesis, therefore, may be of special interest to local governments that do not have the resources to complete their own review of the scientific literature. All local governments, however, should also consider locally and regionally specific information not included in this synthesis if it meets the criteria of a valid scientific process, as described below.

## **1.1 Best Available Science (BAS)**

The Washington Administrative Code (WAC 365-195-905) provides assessment criteria to assist in determining whether information constitutes the best available science, i.e., by having been developed through a valid scientific process. A valid scientific process is one that produces reliable information that is useful in understanding the consequences of regulatory decisions and in developing policies and regulations that will be effective in protecting the functions and values of wetlands and other critical areas.

Appropriate sources of scientific information as defined in WAC 365-195-905 include:

- Research
- Monitoring
- Inventory
- Survey
- Modeling
- Assessment
- Synthesis
- Expert opinion

Information derived from any one of these sources can be considered scientific information if it possesses the required characteristics in WAC 365-195-905 (see Table 1B-1 in Appendix 1-B). For example, a synthesis such as Volume 1 is considered best available science when it has undergone peer review, describes the methods used to obtain the information, presents conclusions based on reasonable assumptions that are logically derived, places the information in proper context, and is well referenced. See Appendix 1-B for a list of all the characteristics of a valid scientific process and their definitions, as well as a table displaying the characteristics needed for each of the sources listed above to be considered BAS.

### **Methods for preparing and reviewing Volume 1**

The primary steps taken to arrive at publication of this document include:

- Searching the literature
- Reviewing, sorting, and prioritizing the reference lists
- Obtaining the reference documents
- Reading and entering information from the documents in a database
- Writing and revising the text
- Obtaining peer and public review
- Responding to comments, revising the text, and completing the document

The processes used for these steps, including the scientific databases and the key words used to search them, are described in Appendix 1-C.

## **1.1.1 Volume 1 as BAS**

Volume 1 meets the definition and characteristics required for a synthesis in the WAC. Findings from scientific journal articles, government publications, technical books, and other sources that meet the definition and characteristics of BAS in WAC 365-195-905 were used and referenced in the synthesis. Conference proceedings and personal communications were occasionally used when no other information was available. In some cases, we were unable to ascertain to what level these additional sources were peer reviewed.

In a few instances, we have cited data collected during the calibration of the *Methods for Assessing Wetland Functions* (Hruby et. al. 1999, 2000) (also known as the Washington State wetland function assessment methods or WFAM) and the Washington State wetland rating systems (Hruby 2004a, b). These data have not been published in scientific journals. However, these observations reported as “unpublished data” in Volume 1, were collected in the field by interdisciplinary teams of wetland experts and used to support and calibrate the function assessment methods and the wetland rating systems. The methods and rating systems have been extensively reviewed and field tested by peer experts as well as the public. The data themselves were offered for review on request during public review and continue to be available on request.

A peer review of documents concerning wetlands, specifically the function assessment methods, wetland rating systems, and these two volumes, means that comments were solicited from a broad range of people on a mailing list of hundreds. This included experts from various disciplines, not just a select few that were in house or close associates. All comments received were addressed. For these volumes, a response to each comment, including rationales for those not used to modify the drafts, has been prepared. To read the comments on Volume 1 and the authors responses go to <http://www.ecy.wa.gov/biblio/0506007.html>.

## 1.1.2 Making Hypotheses and Assumptions

As mentioned previously, in some places in the document we offer our conclusions based on the literature when the references searched do not provide specific information on a topic important for wetland management. In such instances, the authors clearly state that a hypothesis, assumption, or conclusion is being made. For example, we use statements such as “in the absence of research to the contrary, it can be assumed....,” “it is possible to hypothesize....,” or “it can be inferred that...”

In these cases, a description of the logic being used is provided which meets the criteria in WAC 365-195-905 for expert opinion, one of the sources of valid scientific information. The criteria include logical conclusions and reasonable inferences, context, and the use of references (see Appendix 1-B for definitions of these criteria). These hypotheses can be considered expert opinion according to WAC 365-195-905 in which expert opinion is defined as a “Statement of a qualified scientific expert based on his or her best professional judgment and experience in the pertinent scientific discipline. The opinion may or may not be based on site-specific information.” To be considered best available science according to the WAC, an expert opinion must meet three of the six characteristics listed in the table in Appendix 1-B: logical conclusions and reasonable inferences, context, and references.

**Logical conclusions and reasonable inferences** are defined as “The conclusions presented are based on reasonable assumptions supported by other studies and consistent with the general theory underlying the assumptions. The conclusions are logically and reasonably derived from the assumptions and supported by the data presented. Any gaps in information and inconsistencies with other pertinent scientific information are adequately explained.”

**Context** is defined as “The information is placed in proper context. The assumptions, analytical techniques, data, and conclusions are appropriately framed with respect to the prevailing body of pertinent scientific knowledge.”

**References** are defined as “The assumptions, analytical techniques, and conclusions are well referenced with citations to relevant, credible literature and other pertinent existing information.”

The statements that are hypotheses in this document meet these criteria because they are presented with a clear and logical train of thought and the conclusions are based on reasonable assumptions supported by other credible studies that are relevant. They are placed in context and referenced.

In addition, the definition of *synthesis* in Webster's 7<sup>th</sup> Collegiate Dictionary is "deductive reasoning" and "the combining of often diverse conceptions into a coherent whole." The statements that present hypotheses and assumptions are based on deductive reasoning.

There are a few instances in the document where the authors of Volume 1 offer their observations based on their own professional experience. These are usually limited to statements relating to protection measures used to manage wetlands. Such statements are clearly labeled as those of the authors only.

## 1.2 Scope of Volume 1

The focus of this document is freshwater wetlands of Washington State. We have included information on wetlands in other regions and countries and on aquatic systems in general when more local information is lacking and the data are applicable to the wetlands in Washington. See the following section (1.3) for more discussion on this topic. Volume 1 does not address streams or riparian areas that are not wetlands. We do, however, summarize some of the literature related to buffers on streams where the information can be transferred to wetlands.

Marine and estuarine systems are discussed only in regard to wetland rating systems and wetland types for which specific management is needed. Marine and estuarine wetlands were excluded primarily to keep the scope of the project in the range of the available funding. Some recent scientific information on coastal and estuarine wetlands has been summarized by WDFW, Ecology, and other agencies through the Aquatic Habitat Guidelines Project, which is available on the internet ([www.wa.gov/wdfw/hab/ahg](http://www.wa.gov/wdfw/hab/ahg)).

There are several types of freshwater wetlands that are highlighted in the wetland rating systems (described in Volume 2) that are not specifically reviewed in this synthesis (e.g., bogs, interdunal wetlands, and vernal pools). These wetlands are subsets of wetlands in the different hydrogeomorphic (HGM) classes described in Chapter 2. At the level of detail provided in this document, general information summarized about wetlands also applies to these types of wetlands in whatever HGM class and region of the state is appropriate.

The effects of growing cranberries in wetlands are also not covered in this volume because of the time and funding constraints of the project. The limited area of the state that is affected by cranberry production was also a factor. In addition, information related to the effects of silviculture and forest practices on forested wetlands is not included because this subject is being addressed in another document currently being developed (Cooke in press).

In addition, the synthesis in Volume 1 is limited to information that has a practical application to the management and protection of wetlands. For the most part, available documents from the past ten years were used as the primary sources for this synthesis. It was assumed that this most recent literature would incorporate relevant science from the preceding years. Older documents were used in instances where they had not been superseded by more recent studies.

This volume DOES NOT contain agency recommendations or suggestions for implementation of any program to protect or manage wetlands. Any recommendations provided in Volume 1 (for instance, in the section of Chapters 5 and 6 addressing buffers and compensatory mitigation) are those that have been described in the literature. They are included here only as part of the synthesis of existing scientific information. Agency recommendations are provided in Volume 2.

### **1.3 Relevance of Scientific Information to Conditions in Washington**

One of the tasks in reviewing scientific information was to determine what is relevant to wetlands found in the state of Washington. Determining the relevance of scientific information encompasses two aspects. The first is the degree to which general conclusions and principles developed from existing information can be used to predict what will happen in new or different situations. The conclusions of a scientific study done at one time in one wetland with specific characteristics may not be directly transferable to circumstances that develop in the future or at sites that have different characteristics or situations.

The first aspect also encompasses the concept that science doesn't often provide a "bright line." In other words, science rarely supplies us with precise solutions for protecting and managing natural resources. Very few experiments demonstrate true cause-and-effect relationships. For example, in reviewing the literature for this volume, we found few studies that actually documented the effectiveness of different ways for managing the wetland resource (such as the effectiveness of buffers of a specific width at protecting a specific wetland function). Rather, most studies, for example, discuss the impacts of human activities on wetlands. As a result, guidance on protection and management based on scientific information (as presented in Volume 2) is, to a large degree, extrapolation and synthesis of all the information collected.

The second aspect is the relevance of information collected in one region to the conditions found in another region. We have relied, whenever possible, on literature that was derived in the Pacific Northwest. However, in some cases, scientific information generated in other regions of the United States, and to a lesser extent from other countries, was used. Authors of this volume judged whether each "out-of-region" reference was applicable to Washington by extrapolating, interpreting, and synthesizing the information to determine how it pertains specifically to Washington.

We understand establishing what is relevant to Washington is a subjective decision; however, two criteria were used in the decision. First, an “out-of-region” reference was incorporated in the synthesis if the basic ecological principles on which it was based are relevant to most landscapes. Second, it was incorporated if the geomorphic setting of the wetland in a scientific report was similar to those found in the Pacific Northwest and no information specific to the region (that meets the criteria of BAS) was found in our search of the literature.

One of the basic assumptions in ecological and biological research is that environmental processes operate in a similar way if the basic conditions are similar. For example, water is expected to flow downhill whether it occurs in Minnesota or in Washington. Denitrifying bacteria are assumed to transform nitrate to nitrogen gas wherever they are found as long as the soils are anaerobic. The particular wildlife species that are closely associated with wetlands may differ regionally, but frequently fill the same habitat niches in Ohio or California as they do in Washington. Thus, much of the information on functions developed outside the region is transferable to Washington. Regional differences in functions occur when the basic conditions differ, and we have tried to point this out where possible.

As mentioned previously, the definition of *synthesis* in Webster’s 7<sup>th</sup> Collegiate Dictionary is “deductive reasoning” and “the combining of often diverse conceptions into a coherent whole.” This is the goal we have set for Volume 1. Part of the role of a synthesis, thus, is to summarize many studies and scientific articles; glean the general principles that apply in most areas as well as those that relate specifically to the state of Washington; and try to determine if they will apply to future conditions based on best professional judgment of the authors and the reviewers of the document.

## 1.4 Overview of Volume 1

Volume 1 is organized into seven chapters. The chapters share a common organization, beginning with a reader’s guide that describes the topics covered in the chapter and how the chapter is organized. An introduction then provides general background information, definitions, and clarifications. Each chapter describes the sources of information used and how well the subject is documented in the literature, particularly for the Pacific Northwest. The chapters also note gaps where information on an issue could not be found. Key points are summarized at the end of major sections and conclusions provided at the end of each chapter.

A brief summary of the contents of each chapter that follows and the appendices is provided below. In this document, page numbers are assigned to each chapter individually and are not sequential. The first number represents the chapter and the second the page number in that chapter (e.g., [3-2] represents page 2 in Chapter 3).

## **Chapter 2 – Wetlands in Washington and How They Function**

Chapter 2 summarizes the information on how wetlands are categorized and how wetlands function in Washington State. It describes how functions are defined and introduces the concept that the performance of functions is controlled by a number of environmental factors within the wetland boundary (site scale) as well as in the broader landscape (landscape scale). The chapter then describes how some of the key factors that control functions are used to classify wetlands into groups that perform functions in similar ways.

The chapter goes on to describe functions of freshwater wetlands in Washington. Where applicable, the chapter discusses the differences in functions among wetland classes and in various areas of the state. The major functions described are those that were defined for the Washington State wetland function assessment methods (Hruby et al. 1999, 2000).

## **Chapter 3 – Environmental Disturbances Caused by Different Human Activities and Uses of the Land**

In Chapter 3 the discussion shifts from wetland functions and the environmental factors that control the performance of functions to the major disturbances caused by human activities that affect wetlands and their functions. In this context, a *disturbance* is an event that changes an environmental factor that controls wetland functions. Ten disturbances (listed below) are discussed.

- Changing the physical structure within a wetland (e.g., filling, removing vegetation, tilling soils, compacting soils)
- Changing the amount and velocity of water in wetlands (increasing or decreasing the amount)
- Changing the fluctuation of water levels (frequency, duration, amplitude, direction of flow)
- Changing the amount of sediment (increasing or decreasing the amount)
- Increasing the amount of nutrients
- Increasing the amount of toxic contaminants
- Changing the acidity (acidification)
- Increasing the concentration of salt (salinization)
- Fragmentation (decreasing area of habitat and its spatial configuration)
- Other disturbances (noise, etc.)

The chapter continues with separate sections for four of the major types of human land uses in Washington State (agriculture, urbanization, forest practices, and mining) and the types of disturbances they cause. For each of these four land uses, the ten types of disturbances that change the factors controlling wetland functions (listed above) are discussed where applicable.

## **Chapter 4 – Negative Impacts of Human Disturbances on the Functions of Wetlands**

Chapter 4 integrates the concepts discussed in Chapter 2 and Chapter 3. In Chapter 4, ten sections, one for each of the disturbances listed above, summarize how these disturbances ultimately leads to impacts on hydrologic functions, functions that improve water quality, and habitat functions.

## **Chapter 5 – The Effectiveness of Wetland Management Tools**

Chapter 5 presents a synthesis of what the current literature reports on four tools currently used to protect and manage wetlands and their functions: the definition of wetlands, wetland delineation methods, wetland ratings, and regulatory buffers. In the section on definitions, the issues of biological versus regulated wetlands, small wetlands, isolated wetlands, and Prior Converted Croplands that are wetlands are discussed. This chapter does not provide language or recommendations for regulations or policy—those are provided in the second, separate volume containing guidance for protecting and managing wetlands in Washington (Volume 2).

## **Chapter 6 – The Effectiveness of Wetland Mitigation**

Chapter 6 discusses another commonly used tool for managing and protecting wetlands, compensatory wetland mitigation. This topic is discussed in its own chapter because of the large volume of information available on this subject. Topics covered in this chapter include:

- Evaluation of the success of compensatory mitigation
- Compliance of mitigation projects with permit requirements
- Types of compensatory mitigation
- Replacement ratios and replacement of wetland acreage
- Functions provided by compensatory mitigation projects
- Reproducibility of particular types of wetlands (bogs, fens, vernal pools, alkali wetlands, and mature forested wetlands)
- Suggestions from the literature for improving compensatory mitigation

## **Chapter 7 - Cumulative Impacts on Wetlands**

Chapter 7 discusses different types of cumulative impacts, and the loss of wetland area as the most easily assessed indicator of cumulative impacts. It goes on to present some of the causes of cumulative impacts in Washington. These include:

- Case-by-case permitting as a cause of cumulative impacts
- Lack of consistent plans and regulations between jurisdictions as a possible cause of cumulative impacts
- Implementation of regulatory programs at the local level as a possible cause of cumulative impacts

The chapter ends with a discussion in which the types of cumulative impacts are compared to the protection measures commonly taken by local governments.

## **Glossary**

The glossary provides definitions for some of the technical terms used throughout Volume 1. Other terms are defined in the context of the sentence in which they appear and may not be included in the glossary.

## **References**

The references cited in the text are listed separately at the end of Volume 1. Some of these references represent reviews or syntheses in which a researcher describes trends observed from numerous studies conducted in previous years. In these cases, we cite only the review document and not all the citations in the review.

Citations from the review by Adamus et al. (2001), however, are an exception. Portions of Adamus et al. (2001), a review of current scientific literature on the impacts of human activities on wetlands and their functions, were adapted and included in Chapter 4 with permission from Dr. Adamus. The list of cited references at the end of the document does include the literature sources from those portions of Adamus et al. (2001) that were adapted.

## **Appendices**

The appendices of Volume 1 are as follows:

- Appendix 1-A identifies the team guiding the production of Volume 1 (the Core Team)
- Appendix 1-B describes the characteristics of a valid scientific process and types of scientific information defined by the Washington Administrative Code (WAC 365-195-905)
- Appendix 1-C details the methods used in the literature review and production of Volume 1
- Appendix 1-D lists the reviewers who commented on the draft of Volume 1
- Appendix 2-A provides information about various terms and methods that have been used to organize and group information about wetlands, such as classification, characterization, and rating
- Appendix 2-B lists the species of wildlife associated with wetlands in Washington and Oregon from Johnson and O'Neil (2001)

## **1.5 Public Involvement and Review of Volume 1**

### **1.5.1 The Process of Public Involvement**

The process for public involvement of Volume 1 included meetings of two focus groups, numerous mailings and extensive peer and public review. Ecology compiled a mailing list of scientists with wetlands expertise, local government planners, and other groups and individuals from various existing mailing lists used for other wetland-related projects.

In October 2001, Ecology sent out a focus sheet describing the project and a cover sheet that solicited the recipient's participation in the project. This sheet included a tear-off card that could be used to request that the sender be retained on the mailing list. The mailing list was then edited based on the returned cards.

Meetings of focus groups were held in January 2002 in Moses Lake and Olympia to begin the process of gathering input from the public on the project. These meetings were attended by various members of the Core Team, local planners, other staff from local government, and other interested parties. The purpose of these meetings was to help focus the project so that the synthesis would meet the needs of our primary audience, local governments. The meetings gave opportunities to the Core Team to present information on the project and to listen to questions and concerns from the attendees. Lists of keywords to use for the search of the literature were revised based on input from the focus groups.

In June 2002, Ecology sent out a mailer with an update on the project to the entire mailing list. It discussed the status of the project, timelines, and other issues.

In November 2002, Ecology staff contacted selected experts in various disciplines to solicit their review. The list of peer reviewers was not intended to be inclusive of all experts. The purpose was to make sure that each of the major topics in Volume 1 was reviewed by one or more recognized experts in that discipline. These expert reviewers were selected from academia, public agencies and private consultants.

In February 2003, Ecology sent another mailing to all those on the list to determine who wanted to comment on the draft of Volume 1. In June 2003, Ecology distributed a notice by email to update the public on revised target dates for distribution of the draft document for peer and public review.

The draft was distributed for general review in September 2003. Over 170 paper copies as well as CDs were sent to reviewers. An undetermined number of reviewers downloaded the draft from the project's web site. The experts asked to review the document were provided the draft at the same time as the general public. Instructions for providing comments and a questionnaire were also distributed with the draft document.

Several mailings were distributed since the fall of 2003 informing those listed about the status of revisions to Volume 1 as well as progress on the completion of the draft of Volume 2. The Core Team decided that a draft of Volume 2, containing guidance on

protecting and managing, should be completed before Volume 1 was completed. The draft of Volume 2 was distributed for comment in August 2004, during which time the authors began writing responses to comments and revising Volume 1. The review process for Volume 2 is described in Chapter 1 of that document.

## **1.5.2 Responding to Comments and Reviewing Suggested Literature**

Twenty-nine reviewers provided comments on the draft of Volume 1. The reviewer's comments varied from cursory to very detailed, approximately 900 comments were submitted.

Initially, the Core Team organized and reviewed the comments and developed responses to the most substantive comments as individual or synthesized comments. The responses were posted on the project's web site in the spring of 2004. In addition, Ecology posted a list of all the comments that were submitted, organized by chapter, section and page. After the draft of Volume 2 was completed, each of the original comments was addressed by the authors. Each comment and a response to it have now been posted on the project's web site at the address below. Comments are organized by chapter, except for the beginning section that contains answers to questions in a questionnaire distributed to reviewers with the draft document.

As a part of the questionnaire, the reviewers were asked to provide any additional references they felt were pertinent to the subjects discussed. In addition, those who suggested changes or additions to the text were asked to provide citations. As a result, reviewers submitted several hundred new references. The authors reviewed this list and rated each as high, medium, or low importance using the same criteria used in the original search (see Appendix 1-C). Attempts were made to obtain and review all citations rated as high or medium. The results of this process, whether the reference was or was not obtained and why, are documented in a table at the end of the document containing the responses to comments.

### **Volume 1 and the responses to comments are available online**

Ecology has developed a web site for this project on the Shorelands and Environmental Assistance Program web site. The web site includes a project description, contact information, current status of the project, and copies of the updates that were sent. The web site also includes a copy of the final version of Volume 1, as well as Volume 2, along with two documents containing the comments received and the authors' responses, one for each document. [http://www.ecy.wa.gov/programs/sea/bas\\_wetlands/index.html](http://www.ecy.wa.gov/programs/sea/bas_wetlands/index.html)

## **1.6 Conclusions**

Volume 1 provides a summary of relevant scientific information related to wetlands in the Pacific Northwest and their management. The document should be useful to all those who have an interest in the protection and management of wetlands including agency staff, consultants, interested organizations, and citizens. It should be particularly helpful to local governments that are required under the Growth Management Act, to include best available science when developing and revising regulations protecting critical areas including wetlands. Volume 1 has been reviewed by technical experts (peer reviewed) and other interested parties. The intention of the project and the review process was to produce a synthesis of the current science on wetlands in the state of Washington that is easily understood, yet thorough and scientifically rigorous.

