THE SCIENCE OF WETLAND BUFFERS AND ITS IMPLICATION FOR THE MANAGEMENT OF WETLANDS

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ABSTRACT

The Science of Wetland Buffers and Its Implication for Wetland Management

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The protection of upland buffers around wetlands is a source of controversy for wetland regulators. Despite considerable scientific evidence that buffers are necessary to maintain wetland functions, the protection of buffers is frequently challenged as being an unnecessary and overly burdensome requirement of private property owners. Most local governments in Washington require the protection of buffers around wetlands although the required widths vary greatly. In 1995, the Growth Management Act was amended to require that local governments must include the "best available science" when adopting regulations to protect wetlands and other critical areas. Guidance adopted in spring, 2000 by the state Department of Community, Trade and Economic Development defines key characteristics of good scientific information and identifies and defines sources of valid scientific information. With this information, local governments are directed to either rely upon documents provided by state agencies or conduct their own independent review of the scientific literature to determine the "best available science." Where local governments deviate from the best available science in adopting local policies and regulations, they must specify why they deviated and what the possible environmental consequences might be.

The scientific literature on wetland buffers is substantial, and unequivocal in establishing that protection of buffers is critical to maintaining a wetland's functions and values. Numerous studies conducted across the United States and elsewhere in the world document the ways that buffers protect wetlands from the adverse impacts of adjacent development. The principal buffer functions that protect wetlands are: removal of sediments, nutrients and toxic substances in surface and shallow, subsurface runoff; reduction of noise, light and human and pet intrusion into wetlands; and the provision of adjacent riparian and upland habitat critical to numerous wildlife species that utilize wetlands. The scientific literature also indicates that the buffer characteristics and widths necessary to maintain wetland functions and values are dependent on site-specific conditions. The primary factors that should dictate buffer character and width are: 1) the quality, sensitivity and functions of the wetland; 2) the nature of adjacent land uses and their potential to impact the wetland; and 3) the character of the existing buffer area, including soils, slope and vegetation. While site-specific factors should be evaluated to determine effective buffer widths, generally widths of 15 – 30 meters are the minimum necessary to protect wetland water quality and widths of 30 – 100 meters are necessary to protect wetland wildlife habitat.

According to the Washington State Growth Management Act, wetland buffer protection and management programs must incorporate the best available science.

However, local regulatory programs also need to be predictable for landowners and efficient for local staff to implement. Historically, most local buffer regulations have addressed the need for efficiency and predictability by adopting fixed buffer widths. However, given the need for site-specific consideration of the three factors outlined above, reliance on standard buffer widths may not be adequate to protect wetland functions in many cases and may require more than is necessary in other situations. By establishing standard buffer widths based on the type of wetland and the type of adjacent land use and including specific provisions for making site-specific adjustments, local governments can address the need for predictability and efficiency while incorporating the best available science.

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Introduction

Wetlands, otherwise known as marshes, bogs or swamps, are important aquatic resources that humans have only recently begun to appreciate fully. Since scientific studies in the 1960s and 1970s demonstrated the many valuable functions that wetlands provide, these areas have become the subject of increased governmental protection. In recent years, wetlands have been at the center of the debate over private property rights, as more state and local governments have begun to regulate land uses in and around wetlands.

One of the most controversial elements of wetlands regulation has been the practice of requiring narrow upland areas around wetlands to be protected as a way of buffering the wetland from the impacts of adjacent development. Despite scientific evidence documenting the value of buffers, this practice has been challenged by some as an unnecessary and overly burdensome requirement of private property owners. In this controversy, most of the attention has been focused on the width of buffer necessary to ensure that the wetland is protected.

In Washington State, the protection of buffers adjacent to wetlands and streams has been a common practice for over a decade (Castelle et al., 1992). However, the primary regulation of wetlands occurs at the local government level, and the lack of statewide minimum requirements for wetland protection has resulted in a wide range of wetland and buffer protection approaches. Recent amendments to the state Growth Management Act have added a requirement that local governments include the "best available science" in formulating their wetland policies and regulations. This change has sparked an interest in understanding exactly what constitutes "best available science" and what it has to say about wetland buffers, among other issues.

In an attempt to provide some clarity and guidance on using best available science to protect and manage wetland buffers, this paper addresses four primary issues:

1) What is best available science and what does it mean to include it in policies and regulations?

2) What does the best available science say about wetland buffers?

3) What are the primary concerns related to buffer protection and management?

4) How can best available science on buffers be incorporated into local government wetland protection policies and regulations?

Each of these issues is addressed in a separate chapter. Before turning to a discussion of these issues, this introduction briefly defines wetlands, describes their ecological and social functions, describes wetland protection approaches, and defines buffers.

Wetlands definition

Wetlands are areas in which water is at or near the surface of the land long enough to cause distinguishable changes in the soil and vegetation (Lewis, 1995; Mitsch and Gosselink, 1993). The source of water is usually one or more of the following: flooding from streams or rivers, precipitation, surface runoff from a surrounding catchment, and groundwater. Many wetlands are inundated or saturated for only a portion of the year. Wetlands can occur at the edges of lakes, streams or estuaries, on slopes where seeps or springs are found, or in depressions on the land. Many different names are used to describe different wetland types including *marshes, swamps, bogs, mires, and wet meadows.* When wet areas are inundated with standing water deeper than 2 meters for most of the year, they are called *deepwater areas.*

In Washington, the state regulatory definition of wetlands is the same as the federal definition: "*Wetlands means areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. [RCW 36.70A.030 (20)]*

This definition describes three basic elements of a wetland: 1) inundation or saturation; 2) vegetation adapted to wet conditions; and 3) saturated soils. The need to identify wetland boundaries in the field has led to the development of a field-based methodology for determining when these three factors (or parameters) are present. Currently, the principal method used in Washington to identify wetlands and delineate their boundaries is the Washington State Wetland Identification and Delineation Manual (Ecology, 1996).

Wetland functions and values

"Wetlands functions and values" is a widely used and often confusing term. Generally, *wetland functions* are considered to be the ecological processes and benefits provided by wetlands such as nutrient cycling, aquifer recharge and habitat for wildlife species. *Wetland values* are considered to be the social activities that people conduct in wetlands and the benefits that people derive from wetlands, such as recreation and aesthetic appreciation. However, many of the ecological processes of wetlands also provide social benefits such as flood damage reduction or water quality improvement. The imprecise use of these terms and other related terms such as "wetland functional values" has led to some confusion on the part of wetland scientists, managers, and the public.

Perhaps a better way of defining the many things that wetlands provide to nature and society would be to refer to the ecological processes as *ecological functions* and the social activities that people conduct in wetlands (e.g. duck hunting) as *social functions*. Then, the term *values* would refer to how much value society places on particular ecological and social functions. For example, a given wetland may store and detain floodwaters from an adjacent stream. This process of storing and detaining the flood water is an ecological function. The performance of this ecological function may result in less flood damage to human structures downstream. If so, this function may be highly "valued" by society. However, if there are no human structures downstream, then this function may not be valued highly by society.

However one defines and distinguishes the functions that wetlands perform, current federal, state and local laws, policies and regulations affirm the importance of wetlands. Over the past 30 years, wetland science has demonstrated the many ecological and social benefits that are derived from the protection of wetlands. This knowledge has led to the development of regulatory and non-regulatory efforts, at all levels of government, to protect, enhance and restore wetlands.

Wetland protection

The primary means of protecting wetlands is through regulation of land uses including activities both in and around wetlands (Kusler, 1983). Adequate protection of wetlands necessitates the regulation of direct impacts (such as filling, draining, clearing, excavating and discharge of pollutants), as well as indirect impacts (such as alterations to a wetland's water regime or microclimate, disturbances to wildlife, and non-point pollution). Numerous federal, state and local laws regulate land uses in and near wetlands. Most of these laws address broader issues such as water pollution, wildlife habitat or shoreline management; few of them provide comprehensive protection of wetlands. None of the federal laws provide comprehensive protection of wetlands and few states have a specific wetland protection statute.

In Washington State, the Shoreline Management Act, the Water Pollution Control Act and the Growth Management Act (GMA) all provide for some degree of protection for wetlands. However, none of these laws provide adequate coverage of all wetland types and all land uses (see Wetland Regulations Guidebook {Ecology, 1995} for more detail on laws covering wetlands in Washington). The Growth Management Act specifically requires local governments to designate and protect wetlands (as one of five types of "critical areas"). However, it provides no standards for how to do so other than to state that local governments must "... include the best available science in developing policies and development regulations to protect the functions and values of critical areas." The result is a wide variety of approaches and little consistency in the protection standards for wetlands across the state.

In addition to regulating land uses, several non-regulatory approaches can be effective in protecting wetlands. These include public acquisition of wetlands, public-funded restoration of wetlands, and the promotion of landowner stewardship. Stewardship activities include: education of landowners to foster voluntary protection of wetlands on their property; cash payments to landowners for the protection of wetlands and/or buffers; cost-share programs to help fund enhancement and restoration actions; and tax relief programs that reduce property taxes in exchange for protection of wetlands and/or buffers. Unfortunately, funding for non-regulatory approaches is limited and these programs are not widely utilized.

Wetland buffers

Wetland buffers are an important tool for protecting wetlands and are particularly critical for protecting wetlands from indirect impacts. A b*uffer* is broadly defined as "a barrier or treatment zone designed and maintained to protect one area from the negative impacts of an adjoining area" (Desbonet et al., 1993). They can range in size from the large buffer zones typically established around military firing ranges to minimize noise impacts on neighboring residences, to a fence or hedgerow placed between two suburban yards. A w*etland buffer is* typically defined as an upland area of natural or planted vegetation that is maintained and managed to protect a wetland from the adverse impacts of an adjacent land use.

Although the term "buffer" is commonly used to describe a protected upland fringe around an aquatic resource, other terms describe similar areas. "Vegetated Filter Strips" (VFSs) are a specific type of constructed buffer usually consisting of a narrow (5-15m) strip of planted grasses along the edge of an agricultural field. VFSs are used as a Best Management Practice (BMP) in agricultural settings and are primarily designed for sediment removal. "Riparian buffers" are widely described in the forestry literature and are typically associated with streams and rivers. While riparian buffers frequently include wetlands within them, they are usually comprised of forested upland areas along a flowing water course.

Whatever names are used to describe them, these areas are intended to help protect the character and function of aquatic resources. In many cases, establishing a buffer means simply protecting the existing vegetated area adjacent to a wetland or stream. If the upland fringe is well-vegetated with trees, shrubs, and herbaceous plants, all that may need to be done is to designate and protect a certain width of area measured horizontally from the edge of the aquatic resource. However, in many cases, the vegetation and/or the soil around the aquatic area has been significantly disturbed. In these situations, some restoration actions must be taken in order to create a properly functioning buffer.

Many factors should be considered in determining the appropriate character and width of buffer necessary to protect a wetland. Considerable debate and controversy surrounds the issue of determining appropriate buffers and most buffer regulations adopted by local governments in Washington reflect an attempt to achieve a balance between scientific understanding, administrative feasibility, and economic impacts to landowners. However, the Growth Management Act requirement to include the "best available science" in wetland protection policies and regulations, compels state and local governments to understand what best available science is, what it says about wetland buffers, and how to incorporate it into local wetland protection programs.

Chapter 1 - Best Available Science

Introduction

The Washington State Growth Management Act (GMA) requires that local governments include the best available science in developing policies and regulations for the protection of wetlands and other "critical areas" (RCW 36.70A.172). The term "best available science" is not defined in the GMA, nor does the law specify what it means to "include" it in policies and regulations. Under the GMA, local governments have adopted a wide range of approaches to protect wetlands, and some of these have been challenged as to whether they "included" the best available science. Considerable energy and attention continues to be devoted to the issue of just how best available science can and should be incorporated into local (and state) regulations.

With the recent listing of several anadromous fish species as "threatened" or "endangered" under the federal Endangered Species Act (ESA), this issue is receiving additional scrutiny. The ESA uses a term similar to best available science and requires that efforts to protect and recover species be based solely on science.

This chapter examines the available literature on best available science, and draws upon a draft rule proposed by the Washington State Department of Community, Trade and Economic Development to provide a possible definition of best available science and a framework for how to include it in policies and regulations (Draft rule, WAC 365-195, DCTED, 1999). (NOTE: Where language from WAC 365-195 appears in this chapter it is *italicized.*)

GMA Context

The Washington State Growth Management Act (GMA) was passed in 1990 in response to concerns that uncoordinated and unplanned growth posed a threat to the environment, sustainable economic development, and the quality of life in Washington. The GMA requires state and local governments to manage Washington's growth by identifying and protecting critical areas and natural resource lands, designating urban growth areas, preparing comprehensive plans, and implementing the latter through capital investments and development regulations.

Of particular concern to many citizens was the lack of protection for environmentally sensitive areas such as wetlands, streams, and habitat for fish and wildlife. To address this concern, the GMA required all cities and counties in the state to "designate and protect critical areas" (RCW 36.70A.170) "Critical areas" were defined to include wetlands, frequently flooded areas, critical aquifer recharge areas, geologically hazardous areas, and fish and wildlife conservation areas.

The GMA granted latitude to local governments in determining how best to protect critical areas. The statute provided no minimum standards and little guidance on how critical areas are to be protected. The result was a great variety of locally developed programs with a wide range of standards and methods for protecting critical areas.

In 1995, the GMA was amended to include a new requirement: "In designating and protecting critical areas under this chapter, counties and cities shall include the best available science in developing policies and development regulations to protect the functions and values of critical areas" (RCW 36.70A.172(1). However, the legislature did not define the term "best available science" nor did it clarify the meaning of the verb "include". The lack of clarity about these two terms has led to continued confusion and debate regarding the adequacy of local efforts to protect critical areas.

In an attempt to provide some clarity, the Washington State Department of Community, Trade and Economic Development (CTED), the primary state agency responsible for administering the GMA, has developed guidelines on how to include best available science in local critical area policies and regulations. These guidelines define the terms and provide direction on how to evaluate and incorporate scientific information when developing policies and regulations.

Clarity on this issue was necessary to assist local governments, state agencies, the regulated community, and the public in determining how best to protect the functions and values of critical areas through the inclusion of the best available science. This issue was particularly relevant after the listing in 1999 of several anadromous fish species as Threatened or Endangered under the federal Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) pointed out that the ESA has a similar requirement to use the "best scientific and commercial data available." Thus, clarification and guidance on how to identify and include the best available science in local land use policies and regulations may have implications beyond administration of the GMA.

Relevant Literature

The phrase "best available science" is not used in any other Washington State or federal environmental statute. The federal Endangered Species Act (ESA) contains the phrase "best scientific and commercial data available" but does not define it. Likewise, the Marine Mammal Protection Act of 1972 requires the use of "best available scientific data" but provides no definition. Federal courts have issued conflicting opinions on the ESA phrase (these opinions are reviewed below). The GMA phrase also has been the subject of several rulings of the three Growth Management Hearings Boards (Growth Boards) but has not been clearly defined in any of them. Additionally, the term "include" in this context has been the subject of Growth Board decisions.

The role of the Growth Management Hearings Boards

In 1991, the GMA was amended to create three regional Growth Management Hearings Boards to hear and determine allegations of non-compliance with the GMA and to reflect regional diversity.

- The Central Puget Sound Growth Management Hearings Board (Central Board) has jurisdiction over King, Kitsap, Pierce and Snohomish Counties and cities within them.
- The Western Washington Growth Management Hearings Board (Western Board) has jurisdiction over all cities and counties west of the crest of the Cascade Mountains that are not within the Central Board's boundaries.
- The Eastern Washington Growth Management Hearings Board (Eastern Board) has jurisdiction over all cities and counties east of the crest of the Cascade Mountains.

These boards "hear and determine" allegations that a city, county or state agency has failed to comply with the goals and requirements of the GMA. The boards are quasi-judicial panels that review local actions when a petition (appeal) is filed by a party with standing (there are several ways of obtaining "standing" under the GMA. See RCW 36.70A.280).

Actions subject to review by the boards include adoption or amendments of critical area regulations. A local government's action is presumed valid and compliant with the GMA upon adoption; therefore, a petitioner has the burden to overcome this presumption by demonstrating that the local action is *clearly erroneous* in complying with the requirements of the GMA (RCW 36.70A.320). Additionally, an appellant may request that a Growth Board invalidate the local action if it is found to substantially interfere with the goals of the GMA. Since many disputes center on conflicting views of the meaning of GMA terms or provisions, a board may need to interpret the GMA to clarify ambiguities or reconcile internal conflicts. This is particularly true in the case of appeals that claim that local critical area regulations fail to include the best available science.

GMHB decisions on best available science

The three Growth Boards have ruled on at least eleven cases related to best available science, expressing different opinions regarding the terms "best available science" and "include." The Western and Eastern Boards reached similar conclusions while the Central Board has taken a distinctly different approach. The five cases that most clearly articulate the views of the three boards are described below.

In *HEAL v. City of Seattle (1996, No. 96-3-0012)*, the Central Board deferred to local governments to determine what information constitutes best available science and concluded that the term "include" was akin to "consider" and, thus, did not require any particular substantive outcome. Rather, so long as information that the local government considered to be best available science was evaluated during the process of developing Critical Area Ordinance (CAO) regulations, the local government was free to ignore it and adopt regulations based on other factors. Further, in *Tulalip Tribes of Washington v. Snohomish County [Tulalip II] (1996, No. 96-3-0029)*, the Central Board ruled that, "As the Tribes state and the record reveals, the County had the best available science before it when it developed and adopted the CAO..... Having this information before it means that the County included it in developing its CAO." However, the *HEAL* decision was appealed to Superior Court and was remanded back to the Central Board in June, 1997 based on the Court's interpretation that the GMA term "include" requires a substantive use of the best available science. This decision has since been appealed to the State Court of Appeals.

Contrary to the Central Board, the Western Board has interpreted RCW 36.70A.172(1) to require a substantive outcome. In *Clark County Natural Resources Council v. Clark County (1996, No. 96-2-001)*, the Western Board ruled that the term "include" is different from "consider," that local governments must use a "reasoned process" to analyze scientific information, and that local governments must "include best available science in a substantive way in both the designation and protection components of critical areas." However, the Western Board deferred to local discretion to determine what constitutes best available science. They ruled that, "Local diversity has an impact in determining what is the 'best' science. The goals of the Act, the practicality of the 'science' and the fiscal impact, relating to the availability of information and to the ultimate decision, must be balanced by a local government in determining how to designate and how to protect critical areas." In other rulings on best available science, the Western Board has either explicitly or implicitly relied upon its rationale in the Clark County case.

The Eastern Board has agreed with the Western Board's conclusion that the term "include" implies a substantive outcome but has not attempted to define best available science. In two cases, *Woodmansee v. Ferry County(96, No. 95-1-0010)* and *Moore v. Whitman County (1997, No. 96-1-005)*, the Eastern Board used the term "utilize" to describe how best available science should be addressed and distinguished it from the term "consider." In another case, *Easy and Washington Environmental Council v. Spokane County (1997, No. 96-1-0016)*, the Eastern Board rejected the Central Board's reasoning in *HEAL* and echoed the Western Board's Clark County ruling in determining that the law requires a substantive inclusion of best available science.

Thus, the three Growth Boards have devoted some attention to the issue of how to include best available science but have failed to provide a clear definition of the term and have not produced a consistent approach to how best available science should be included in local policies and regulations.

The Endangered Species Act and best available science

As mentioned above, the ESA includes the requirement that implementing agencies "...shall use the best scientific and commercial data available." Neither the statute nor its implementing regulations define this phrase and the legislative history does not illuminate Congress's intentions. In a 1994 article in the Idaho Law Review, Laurence Bogert explains: "As with much of the legislative process, it can be assumed that Congress believed the language was self-explanatory.... But perhaps the omission of further illumination was purposeful." (Bogert, 1994). Another commentator claims that "Congress intended the listing process (of endangered species) to be an open door, the broadest possible net for species threatened with risk to their survival," and that the "...legislative requirement for listing remains simple and unexceptional; the decision need only be scientifically sound" (Houck 1993).

Federal courts have issued numerous rulings on the Endangered Species Act but few of them have addressed the issue of "best scientific and commercial data available." A review of those cases that have addressed this phrase fails to turn up a clear definition and shows conflicting opinions on a standard for best scientific data available (Bogert, 1994). As an illustration, in *Roosevelt Campobello International Park Commission v. EPA (1982)*, the First Circuit Court of Appeals ruled that agencies cannot rely only on scientific information that is readily available. Agencies also must do "all that is practicable" to collect relevant data or conduct additional studies. However, in *Pyramid Lake Paiute Tribe v. US Department of the Navy (1990)*, the Ninth Circuit Court ruled that even "admittedly weak" scientific information is satisfactory if no plaintiff can point to existing information that challenges the agencies' conclusions. Most court cases that have addressed this issue have clearly deferred to the federal agencies to judge the adequacy of scientific information, only requiring that they make that information available for public review and scrutiny. It is not clear whether state courts would grant this same level of deference to state agency expertise, since the state Administrative Procedures Act (APA) gives less deference to state agencies than the federal APA grants to federal agencies.

Thus, as with the GMA, the "best available science" language in the ESA is susceptible to differing interpretations. However, under the ESA, no confusion exists over how the best scientific data available should be used or "included." The ESA contains no requirements to balance science with economics or any other competing interests. The ESA requires federal agencies to base decisions regarding the listing or delisting of species <u>solely</u> on the basis of the best scientific and commercial data available [16 U.S.C. § 1533(b)(1)(A)].

Recently, the National Marine Fisheries Service has stated in public discussions of the ESA that they expect best available science to be the <u>foundation</u> for efforts to protect and recover threatened or endangered salmon species. They recognize that the best available science may provide numerous options for protection and recovery but they have stated that any efforts that ignore good science are not going to "pass muster" (Grady, 1999).

Other Federal Statutes

Several other federal laws dealing with fish and wildlife protection have included mandates for the use of best scientific information, but none have defined the terms. Additionally, unlike the ESA, none of them require sole reliance on science to make management decisions. The 1972 Marine Mammal Protection Act requires the use of "best available scientific data" as a way to counter what Congress at the time viewed as too much emotionalism in the debate and decision-making about the protection and management of marine mammals (Doremus, 1997). In the Magnuson Act (1976), Congress called for the use of the "best science available" to assist in the setting of regional fishing quotas. However, in this Act, Congress clearly intended that the scientific information include economic and sociological information (Bogert, 1994; Doremus, 1997).

Defining Best Available Science

Legislative bodies commonly use terms in statutes that are not clearly defined, but it is not always problematic. In some cases, an undefined term may have a common usage, may have been defined in other statutes, or may be a relatively unimportant term. However, in the case of best available science, none of these criteria are true. Best available science is a critical term that has no common usage; nor has it been defined in any other statute. Perhaps this "oversight" was intentional since, without a definition, each local government is able to define the term as it suits them. Or, perhaps the legislature believed best available science to be such an unambiguous term that a definition was unnecessary. More than likely, legislators were responding to two competing interests: environmental interest groups that wanted more scientific objectivity and less local politics dictating local critical area regulations, and development interest groups that feared the imposition of state-mandated standards and advocated local autonomy to develop local standards. By requiring the inclusion of best available science but not defining what it meant, the legislature gave each of the competing interest groups some of what they wanted.

At any rate, the need remains for local decision-makers to be able to identify best available science and determine how to include it in local critical area policies and regulations. The Growth Management Hearings Boards have provided little guidance on how to identify best available science and contradictory perspectives on how it should be included. Recently, the Washington Department of Community, Trade and Economic Development (CTED), the state agency responsible for administering the GMA at the state level, has stepped into this void and begun developing guidance that it is adopting into state regulations. It is a common practice for agencies responsible for the administration of a statute to adopt rules that define ambiguous legislative terms and fill in the gaps in statutes. CTED rules adopted under the GMA do not have the same legal standing as other state regulations, in that they are guidelines that local governments need only consider in developing local GMA policies and regulations. Nevertheless, in the absence of any legislative clarification of these terms, CTED guidelines likely will be considered as the state "standard."

Before describing the CTED guidelines, it may be useful to consider the meaning of each of the three words in the phrase "best available science" separately, starting with standard dictionary definitions. Additionally, while none of the statutes that require best available science define any of the words in the phrase, some judicial cases may shed light on possible meanings.

Defining "Best"

According to Webster's Encyclopedic Unabridged Dictionary of the English Language (1989), "best" means "of the highest quality, excellence or standing" or "most advantageous, suitable or desirable."

In the Clark County case, the Western Growth Management Hearings Board wrote, "'Best' means that within the evidence contained in the record, a local government must make choices based upon the scientific information presented to it. The wider the dispute of the scientific evidence, the broader the range of discretion allowed to local government." The federal judiciary has not defined "best" but have indicated that the "best" science is relative. In several cases they have upheld agency decisions based on weak or inconclusive scientific information where no conflicting evidence was presented (Bogert, 1994; Doremus, 1997).

In cases where the scientific evidence is conflicting, determining which science is the "best" is more difficult. The CTED guidelines provides a good framework for evaluating scientific information and determining which is "sound", if not which is "best." However, under the GMA, local governments are given latitude in choosing among conflicting evidence.

Defining "Available"

According to Webster's Encyclopedic Unabridged Dictionary of the English Language (1989), "available" means "suitable or ready for use," "readily attainable and accessible."

Again in the Clark County case, the Western Board wrote, "'Available' means not only that the evidence must be contained within the record, but also that the science must be practically and economically feasible." Federal court decisions have given contradictory views on how available the best scientific information must be. At times they have said that agencies are under no obligation to develop new scientific information - only that they must evaluate all information that comes to their attention (Doremus, 1997). In other cases, they have ruled that agencies must conduct additional studies, if necessary, to collect the best scientific information (Bogert, 1994).

It is possible that a Growth Board could require a local government to set up and conduct additional scientific studies where information is lacking.

However, the emphasis has been (and likely will continue to be) on the information that is provided in the public record through the lengthy process of developing and adopting local policies and regulations. This public process generally produces ample scientific information from agencies and interested public and private organizations. It is likely that any future debates over the "availability" of scientific information will center around the issue of how practical it is to apply the information and what the economic consequences of that application might be.

Defining "Science"

According to Webster's Encyclopedic Unabridged Dictionary of the English Language (1989), "science" means "systematic knowledge of the physical or material world", or "a branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws", or "knowledge gained by systematic study."

None of the Growth Management Hearings Board cases or federal court decisions have attempted to define "science," perhaps because none of the cases involved a dispute over what constituted science. Alternatively, perhaps it has been assumed that the nature of science is so obvious that no definition is needed.

However, in the context of critical areas protection, local governments frequently are in the position of needing to evaluate a wide range of information that includes scientific fact, economic data, personal opinion, and philosophical perspective. Given the mandate to "include" the best available science, local government decision-makers must be able to distinguish science from other types of information and determine which scientific information is of highest quality (best) and most accessible or practical (available).

What sets scientific information apart from other types of information is its grounding in empirical observation and its independence from individual preferences and beliefs. The scientific process is responsible for the production of these characteristics and consists of five basic steps: a) formulation of hypotheses, b) use of empirical data to test predictions of the hypotheses, c) quantification of data, if possible, d) formal peer review, and e) a willingness to reject a "proven" hypotheses in the light of new data judged to be reliable. Philosophy of science in the last forty years has added many other complexities to the debate about the nature of science and how it changes (Kuhn, 1962), but these five characteristics are generally sufficient to distinguish "scientific" information from non-scientific information.

Taken together, these five steps comprise an iterative process that produces observations and findings that are repeatable and available for critique. This tends to correct for an individual's subjective tendencies. Individually, a couple of key elements of this process make the resulting information more trustworthy than information that has not been similarly developed.

First, a scientist must describe the data collection methods used, to enable others to undertake the same experiment or observations and determine whether the resulting data are consistent. Second, a scientist presents the data and makes inferences about what the data mean, which allows others to independently examine the data and decide whether the inferences are reasonable. Third, the methods, data, and conclusions are presented for critique through established channels including journals and symposia, providing opportunity for critical peer review by others with expertise in the field of study and a mechanism for corroboration and dissent. The scientist and others interested in the subject are then able to respond to this critique by revising or developing new hypotheses, collecting additional data, and presenting new ideas and information for further review and critique.

This iterative process of the scientific method is described by Doremus (1997) as similar to building a staircase. "Data serve as the raw materials. Scientists use those materials to create a step, reinforcing it until it can bear the weight of the scientific community's skepticism. When the step is strong enough, the community climbs onto it, and begins constructing the next step. Occasionally a step collapses and must be rebuilt. Scientific knowledge thus evolves over time."

Because every individual, even a prominent scientist, is subject to bias, this process of developing scientific information serves to weed out those hypotheses or theories that cannot be supported by repeated observation and analyses of different scientists. In recent decades, the objectivity of science has been called into question and scientists have had to admit that, like all humans, they have biases. Biases may be financially or politically motivated, or the result of adherence to a certain philosophy or "school of thought." Indeed, a whole field of science may have a bias by subscribing to a certain "paradigm" about the way the natural world operates. However, the regular upheavals and subsequent "tossing-out" of once dominant paradigms demonstrates that the scientific process ultimately provides new and better knowledge, albeit sometimes rather slowly.

Thus, information produced by a rigorous scientific process is generally the most accepted type of knowledge. The more rigorous the process, the more acceptable the information is likely to be to the community of scientists.

Reliability is another aspect of scientific information that is important when dealing with biological systems. Natural systems are inherently complex and it is difficult to study nature in a controlled environment. Studies of biological systems produce results that vary widely and, thus, are more subject to different interpretations than findings in other branches of science such as physics. The wide variation in organisms, communities, climate, and other natural phenomenon produces results that are difficult to repeat and can be difficult to interpret. Reliability can be increased by conducting more expensive and time-consuming experiments or by repetition of simpler, more practical ones. Statistical tests of significance also help to establish reliability by assisting scientists in discriminating between random and meaningful variation. Generally, scientists accept that some underlying "cause" is at work, when data, which would be expected to occur by random chance less than 5% of the time, are obtained.

The acceptability and reliability of scientific information are particularly important when attempting to determine what scientific information is the "best." In general, information developed through a rigorous scientific process is "better" than information that was not. Likewise, information that is the result of multiple studies of the same or similar phenomena is "better" than information provided by a single study. For the most part, scientists regard new knowledge that has withstood the scrutiny of peers as "best".

Based on the above discussion, a reasonable definition of *best available science* is "the highest quality information developed through the scientific process that is accessible and practical to use."

However, this definition does little to help local governments identify the appropriate body of work that needs to be included in their decision-making. How does one, especially a non-scientist, identify the "highest quality" science and distinguish it from science of a lower quality? When confronted with conflicting scientific information, how does a local decision-maker evaluate which science is "better?" How accessible and practical must science be? How much effort must a local government invest in trying to locate the best available science?

A Proposed Model for Identifying Best Available Science

The CTED rule provides a good framework for answering these questions. It outlines the responsibilities of local governments to identify and evaluate scientific information and provides criteria for determining whether information is scientific and for evaluating the quality of scientific information.

Identifying Best Available Science

The CTED rule clarifies that it is the responsibility of a local government's elected decision-makers to ensure that the best available science is included in their policies and regulations. Specifically, the local government executive agencies must first identify and compile the best available science that is relevant to the critical areas they are attempting to protect. Recognizing that most local governments do not have the staff expertise or time to conduct a complete review of the available scientific literature on all critical areas, the rules recommend that local governments employ or consult with a qualified scientific expert (or team of experts) to assist them and/or consult with state natural resource agencies to provide the necessary expertise. While any local government is free to conduct its own analysis, many will choose to use the information provided by agencies with expertise, where it is available, to incorporate into their local policies and regulations.

To assist in the identification and evaluation of relevant scientific information, the CTED rule describes scientific information and provides criteria for evaluating the quality of scientific information. It lists eight sources of scientific information and specifies six different characteristics, one or more of which must be present for each of the sources to be considered scientifically objective and reliable. To determine whether information received during the public participation process is reliable scientific information, a county or city must determine whether the source of the information displays the characteristics of a valid scientific process. The characteristics generally to be expected in a valid scientific process are listed in Table 1.

Table 1 - Characteristics of a Valid Scientific Process*
1. ***Peer review.*** *The information has been critically reviewed by other persons who are experts in that scientific discipline. The criticism of the peer reviewers has been addressed by the proponents of the information. Publication in a refereed scientific journal usually indicates that the information has been appropriately peer-reviewed.*
2. ***Methods.*** *The methods that were used to obtain the information are clearly stated and able to be replicated. The methods are standardized in the pertinent scientific discipline or, if not, the methods have been appropriately peer-reviewed to assure their reliability and validity.*
3. ***Logical conclusions and reasonable inferences.*** *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.*
4. ***Quantitative analysis.*** *The data have been analyzed using appropriate statistical or quantitative methods.*
5. ***Context.*** *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.*
6. ***References.*** *The assumptions, analytical techniques, and conclusions are well-referenced with citations to relevant, credible literature and other pertinent existing information.*

* from the CTED rule.

(Note: Language from the CTED rule is in italics)

Some sources of information routinely exhibit all or some of the characteristics listed in Table 1. Information derived from one of these sources may be considered scientific information if the source possesses the characteristics necessary to ensure the information is scientifically valid and reliable. A county or city may consider information to be scientifically valid if the source possesses the characteristics listed in Table 1. Table 2 provides a general indication of the characteristics typically associated with common sources of scientific information.

Table 2 - Sources of Scientific Information (characteristics are from Table 1)	CHARACTERISTICS					
	1	*2*	*3*	*4*	*5*	*6*
A. Research. *Research data collected and analyzed as part of a controlled experiment (or other appropriate methodology) to test a specific hypothesis.*	x	x	x	x	x	x
B. Monitoring. *Monitoring data collected periodically over time to determine a resource trend or evaluate a management program.*		x	x	y	x	x
C. Inventory. *Inventory data collected from an entire population or population segment (e.g., individuals in a plant or animal species) or an entire ecosystem or ecosystem segment (e.g., the species in a particular wetland).*		x	x	y	x	x
D. Survey. *Survey data collected from a statistical sample from a population or ecosystem.*		x	x	y	x	x
E. Modeling. *Mathematical or symbolic simulation or representation of a natural system. Models generally are used to understand and explain occurrences that cannot be directly observed.*	x	x	x	x	x	x
F. Assessment. *Inspection and evaluation of site-specific information by a qualified scientific expert. An assessment may or may not involve collection of new data.*		x	x		x	x
G. Synthesis. *A comprehensive review and explanation of pertinent literature and other relevant existing knowledge by a qualified scientific expert.*	x	x	x		x	x
H. Expert Opinion.* *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.*			x		x	x
x *= characteristic must be present for information derived to be considered scientifically valid and reliable* ***y*** *= presence of characteristic strengthens scientific validity and reliability of information derived, but is not essential to ensure scientific validity and reliability*						

** Whether a person is a qualified scientific expert with expertise appropriate to the relevant critical areas is determined by the person's professional credentials and/or certification, any advanced degrees earned in the pertinent scientific discipline from a recognized university, the number of years of experience in the pertinent scientific discipline, recognized leadership in the discipline of interest, formal training in the specific area of expertise, and field and/or laboratory experience with evidence of the ability to produce peer-reviewed publications or other professional literature. No one* *factor is determinative in deciding whether a person is a qualified scientific expert.* (WAC 365-195-905).

The CTED guidance further specifies some common sources of information that local governments may receive that do not constitute science: *Common sources of nonscientific information. Many sources of information usually do not produce scientific information because they do not exhibit the necessary characteristics for scientific validity and reliability. Information from these sources may provide valuable information to supplement scientific information, but should not be used as a substitute for valid and available scientific information. Common sources of nonscientific information include the following:*

(i) Anecdotal information. One or more observations which are not part of an organized scientific effort (for example, "I saw a grizzly bear in that area while I was hiking").

(ii) Non-expert opinion. Opinion of a person who is not a qualified scientific expert in a pertinent scientific discipline (for example, "I do not believe there are grizzly bears in that area").

(iii) Hearsay. Information repeated from communication with others (for example, "At a lecture last week, Dr. Smith said their were no grizzly bears in that area (WAC 365-195-905).

The rule goes on to address the situation where valid scientific information is unavailable or incomplete. It states,

Where there is an absence of valid scientific information or incomplete scientific information relating to a county's or city's critical areas, leading to uncertainty about which development and land uses could lead to harm of critical areas or uncertainty about the risk to critical area function of permitting development, counties and cities should use one of the following approaches:

(1) A "precautionary or a no risk approach," in which development and land use activities are strictly limited until the uncertainty is sufficiently resolved; or

(2) As an interim approach, an effective adaptive management program that relies on scientific methods to evaluate how well regulatory and non-regulatory actions achieve their objectives. Management, policy, and regulatory actions are treated as experiments that are purposefully monitored and evaluated to determine whether they are effective and, if not, how they should be improved to increase their effectiveness. An adaptive management program is a formal and deliberate scientific approach to taking action and obtaining information in the face of uncertainty. To effectively implement an adaptive management program, counties and cities must be willing to (i) pay for a research program (ii) change course based on the results and interpretation of new information that resolves uncertainties, and (iii) commit to the appropriate timeframe and scale necessary to reliably evaluate regulatory and non-regulatory actions affecting critical areas protection and anadromous fisheries. (WAC 365-195-920).

The rule language outlined above provides useful guidance for identifying and evaluating scientific information. It will also provide guidance to those agencies or individuals interested in compiling scientific information for local governments to consider. However, while the identification and evaluation of scientific information is an important step, the process of "including" best available science in policies and regulations is crucial.

Including the best available science in local policies and regulations

RCW 36.70A.172 requires that local governments must "include" the best available science in critical area policies and regulations. As described above, the term is not defined in statute and has been the subject of several Growth

Management Hearings Board cases. In a law review journal article recently submitted for publication, Alan Copsey, CTEDs lead Assistant Attorney General for GMA, addresses this issue in some depth (Copsey, 1999). He analyzed the legislative record and determined that RCW 36.70A.172 was derived from a recommendation of the Governor's Task Force on Regulatory Reform which stated in its final report, "The GMA requires all local governments to provide for the protection of certain critical areas. Because of the state's interest in these areas, the Legislature must establish clear direction of the state's goals and policies for the protection of these areas. The direction should be given by requiring local governments to use the best available science when designating and protecting critical areas."(emphasis added) (Governor's Task Force on Regulatory Reform, 1994).

Further, the Final Legislative Report on this amendment also characterized the effect of the amendment as requiring counties and cities to use best available science. Copsey finds this word choice to be significant and argues that, had the Legislature not intended for local governments to substantively incorporate best available science, they would have required that local governments simply "consider" best available science, a common type of requirement in the GMA (Copsey, 1999).

In Webster's Encyclopedic Unabridged Dictionary of the English Language (1989) "include" is defined as "to contain, embrace or comprise" or "to contain as a subordinate element" or "involve as a factor." These definitions are consistent with the approach taken by the two Growth Boards, which defined "include" to require a substantive outcome, and with Copsey's analysis. Webster's definition is also consistent with the conclusion that best available science is not the sole foundation for critical area policies and regulations but must be balanced with other considerations or factors; best available science is one element or factor that must be included in the policies and regulations.

The proposed CTED rules recognize the difficulty in specifying exactly how to include best available science and the need to consider other relevant factors. Thus, they do not provide a prescriptive approach. They emphasize that local governments should explain what science was evaluated and how it was "balanced" with other factors. This approach allows others to understand and critique how best available science was "included" in local policies and regulations.

The rules state:

(1) To demonstrate that the best available science has been included in the development of critical areas policies and regulations, counties and cities should address each of the following on the record:

(a) The specific policies and development regulations adopted to protect the functions and values of the critical areas at issue.

(b) The relevant sources of best available scientific information included in the decision-making.

(c) Nonscientific information—including legal, social, cultural, economic, and political information—considered as a basis for departing from recommendations derived from the best available science. A county or city departing from science-based recommendations should: (i) identify the information in the record that supports its decision to depart from science-based recommendations; (ii) explain its rationale for departing from science-based recommendations; and (iii) identify potential risks to the functions and values of the critical area or areas at issue and any additional measures chosen to limit such risks. State Environmental Policy Act (SEPA) review often provides an opportunity to establish and publish the record of this assessment.

(2) Counties and cities must include the best available science in determining whether to grant applications for administrative variances and exceptions from generally applicable provisions in policies and development regulations adopted to protect the functions and values of critical areas. Counties and cities should adopt procedures and criteria to ensure that the best available science is included in every review of an application for an administrative variance or exception (WAC 365-195-915).

This guidance clearly leaves it to the local government to determine how to include best available science in policies and regulations but requires that the rationale be clearly articulated. This will help prevent the blatant disregard of scientific information and will expose those decisions that are based solely on politics or economics. This approach will require that local decision-makers have some understanding of what the best available science says and require them to weigh this information seriously in their deliberations. It will help ensure that scientific information is, in fact, included in local policies and regulations. Furthermore, this approach will provide more information for anyone wishing to challenge a local decision and for the Boards and courts that must evaluate such challenges. Ultimately, it will be up to the Growth Management Hearings Boards (or the courts) to provide a "bright-line" definition or standard for how best available science must be included in local policies and regulations.

Fortunately, for those needing to develop critical area policies and regulations, the science of wetland buffers is extensive and easily identifiable. Unlike other aspects of critical areas protection, the topic of buffers has been researched and documented over the past twenty years. A summary of this information is outlined in Chapter two.

Chapter 2 The science of wetland buffers: a review of the literature

The science of wetland buffers has been the subject of much study and analysis during the past twenty years. Scientific studies in the 1960s and 70s documented the important ecological functions of wetlands and led to efforts to protect them. Research and experience demonstrated that allowing development up to the edge of wetlands, streams or lakes resulted in impairment of these ecological functions and led to the practice of protecting vegetated upland zones around them.

The protection and management of vegetated areas around wetlands, streams, and lakes is now a widely used method for maintaining the various ecological and social functions performed by these aquatic resources in the face of adjacent development. While some disagreement occurs today over whether a buffer area should even be maintained around a wetland or along a stream, most debate focuses on the character and width of buffers necessary to protect aquatic system functions. Much debate also continues over what kinds of activities can be allowed within a buffer area without compromising its functions.

The determination of appropriate buffers, whether at a programmatic or site-specific scale, has usually involved a blending of science, politics, economics, and sociology. However, the Washington State Growth Management Act requires that the determination of appropriate buffers be based upon a solid scientific foundation (see Chapter 1). Fortunately, considerable scientific data currently exist from which to determine appropriate buffers for aquatic resources. What follows is a general overview of what the relevant scientific literature (i.e. "best available science") has to say about the use of buffers to protect wetland functions.

Identifying the Best Available Science on Wetland Buffers

The following scientific information on wetland buffers was derived from a variety of sources. The majority comes from studies published in refereed, peer-reviewed journals in the fields of environmental science, agriculture, forestry, and wildlife management. Considerable information comes from government publications on wetland or riparian buffers published in the past ten years. The roles and functions of wetland and riparian buffers have been widely studied and increased scientific attention has been devoted to the subject since buffers became a widely used management tool in the 1980s. There is considerable agreement among scientific researchers on the ways that buffers function to protect aquatic resources and on the buffer characteristics necessary to adequately protect them. There are, however, some gaps in our understanding of buffer functioning, with a need for additional research. A summary at the end of this chapter provides an overview of what is known and what remains to be understood.

The scientific information on buffers outlined below is divided into four sections: Buffers and Water Quantity; Buffers and Water Quality; Buffers and Wildlife Habitat; and Buffer Protection.

Buffers and Water Quantity

The role of buffers in protecting wetland hydrology

The primary hydrologic function that wetland buffers perform is "hydroperiod maintenance" i.e., moderation of water level fluctuations in the wetland. Wetland plant and animal species are adapted to the natural fluctuations in water levels within a wetland. As the land around a wetland is developed, the hydrologic regime in the wetland can change. When the impervious area within the drainage basin of a wetland increases, less water infiltrates into the ground and more water flows across the surface of the land. This means that the runoff from rainfall and snowmelt moves more quickly downgradient rather than moving slowly through the soil. Thus, the wetland's hydroperiod exhibits both higher than normal water levels during rainy periods and lower than normal levels during dry periods. This fluctuation has been shown to have an adverse effect on wetland vegetation and wildlife, particularly amphibians (Azous and Horner, 1995). Studies in King County, Washington have shown that wetland hydroperiods are adversely altered in watersheds with as little as ten to fifteen percent impervious surface (Azous and Horner, 1997). Hydroperiod alteration is particularly acute in wetlands that have significant surface water input, as opposed to groundwater input.

In addition to moderating water level fluctuations within a wetland, buffers play a role in floodwater storage and flood damage reduction. In particular, buffer areas adjacent to riverine wetlands that are subject to overbank flooding help detain flood waters. Also, since the establishment of buffers results in development being set back from the edge of wetlands, flood damage to property is less likely to occur when high water levels extend beyond the wetland boundary.

How buffers protect wetland hydrology

Wetland buffers may help moderate hydroperiod fluctuations by detaining surface runoff and slowly releasing it into the wetland. This effect is primarily a function of surface water detention and soil infiltration. In a 1982 study, Wong and McCuen determined that the most influential factors in determining the extent of buffer performance of this function were the following: vegetation cover, soil infiltration capacity, rainfall intensity and antecedent soil moisture conditions.

Buffer characteristics that affect protection of wetland hydrology

In most cases, the effect of a buffer on moderating hydroperiod fluctuations is minimal compared to the effects of large-scale watershed alteration. In wetlands with large watersheds and a high percentage of impervious surface, buffers play an insignificant role in moderating hydroperiod fluctuations.

However, in wetlands with small surface drainage areas, buffers can play an important role in maintaining natural hydroperiods. Little research has been conducted as to appropriate buffer widths to perform this function. It seems reasonable to assume that, as buffer width increases, the ability of the buffer to moderate wetland hydroperiod fluctuations also increases. However, with the exception of wetlands with small surface drainage basins, the use of buffers to protect a wetland's hydroperiod is not nearly as effective as other approaches, such as controlling the amount of impervious surface and using Best Management Practices for controlling stormwater (Herson-Jones et al., 1995).

Buffers and Water Quality

The role of buffers in protecting wetland water quality.

The most widely studied of the different buffer functions is the protection of water quality of downgradient aquatic areas. Considerable research has been devoted to a buffer's ability to remove potential pollutants from surface and ground water. Much of the attention has been devoted to how buffers protect streams and rivers, primarily from agricultural and silvicultural activities. However, buffers around wetlands perform water quality functions similarly to buffers along streams. They trap sediment, denitrify nitrates and sequester phosphorous and toxic substances. The same buffer processes remove sediment and nutrients, regardless of whether they are adjacent to a stream, a wetland or a lake. What differs is not the way in which the buffer performs its functions, but the way the aquatic resource functions and how a particular pollutant or disturbance affects those functions.

Wetlands perform many of the same water quality related functions attributed to upland buffers. However, wetlands have a limited capacity to perform these functions before they begin to suffer adverse impacts. Excessive sediment can fill in wetlands, smother vegetation and harm invertebrate habitat.

Added nutrients can spur excessive plant and algae growth. Toxic substances can accumulate to the point where they kill aquatic organisms.

Some wetlands are more susceptible to these harmful effects than others. Bogs and wetlands with open water are subject to the harmful effects of increased nutrients. However, other wetlands may not be harmed by the input of small amounts of nitrates or other pollutants. In general, however, it is wise to limit the introduction of sediment, nutrients or toxic substances into any wetland or water body in order to reduce the risk of ecological impairment within the wetland or to downgradient surface or ground water.

Our knowledge of how buffers improve water quality comes from extensive studies carried out over the past 25 years, including data collection at field sites with natural buffer conditions and controlled experiments on a variety of different buffer characteristics. The principal pollutants studied have been sediment, nitrogen (particularly nitrates) and phosphorous, and, in a few instances, bacteria and toxic substances. While most of these studies have been conducted in the Mid-Atlantic and Midwestern states and only a few in the Pacific Northwest, similar conditions exist in Washington as at the various sites that have been studied in other regions. Some generalizations can be made from the scientific literature; however, the nature and extent of pollutant removal by buffers is highly variable. The primary factors that influence pollutant removal are discussed below.

How buffers improve water quality

Buffers provide water quality benefits through a variety of mechanisms. Primarily, they improve water quality in four basic ways: 1) they remove sediment (and attached pollutants) from surface water flowing across the buffer; 2) they biologically "treat" surface and shallow groundwater through plant uptake or by biological conversion of nutrients and bacteria into less harmful forms; 3) they bind dissolved pollutants by adsorption onto clay and humus particles in the soil; and 4) they help maintain the water temperatures in the wetland through shading and wind blockage. These mechanisms are discussed in more detail below.

How buffers remove sediment

The primary mechanisms that remove sediment in a buffer are the dissipation and slowing of surface water flow and infiltration. As water flowing across a buffer is slowed, sediments drop out and are held in place by plants and organic debris. The most important factors controlling this process are sheet flow and filtration (Desbonnet et al., 1993; Castelle et al., 1992; Phillips, 1989a). If water moves across a buffer as channelized flow, most of the sediments will be carried with the water. A broad, sheet flow of water across the buffer, on the other hand, allows for more slowing and settling as well as increased water filtration by plant stems and organic debris.

The most critical buffer variables that affect sedimentation are slope and the type of vegetation (Dillaha et al., 1989; Phillips, 1989a). On steeper slopes, water is more likely to move in channels, too quickly to allow for settling. Denser vegetation and organic debris help to slow flows and to filter out sediments. The most effective types of vegetation are grassy areas, or forests with a dense understory and organic litter and woody debris (Phillips, 1989a).

In most vegetated buffers, larger sediment particles drop out readily but smaller particles may remain in suspension. If enough slowing and filtration is provided, then finer sediments are removed. This is especially important to water quality because many pollutants, such as insoluble phosphorous and certain metals, are bound to sediments, in particular the finer sediments. Deposition of fine sediments requires extensive detention time to allow for settling (Karr & Schlosser, 1977).

How buffers remove nutrients

While nutrients are essential for living organisms and are a critical component of a healthy aquatic ecosystem, excessive nutrients can have an adverse impact on aquatic systems. The primary nutrients of concern are phosphorous and nitrogen. Phosphorous is a limiting nutrient in most freshwater systems, and inputs to surface waters can cause excessive plant and algae growth. This, in turn, leads to reduced dissolved oxygen, increased suspended solids and blocking of sunlight in the water column. Nitrogen is a limiting nutrient in most estuarine (and some riverine) systems, and nitrates are a concern for human health if they get into drinking water supplies.

As much as 85% of phosphorous (P) and some forms of nitrogen (N) in surface waters are bound to sediments, and thus can be removed by the mechanisms described above (cite). However, soluble P and nitrate must be removed by other means. The principle mechanisms for removing soluble nutrients are through plant uptake and nitrification/denitrification (for nitrogen).

Plant uptake is limited to the growing season and varies widely among different plant species. Nitrification and denitrification can occur year round and are most effective in seasonally saturated areas. These processes occur in the shallow sub-surface zone of the soil (i.e. where plant roots and microbes are found) and require an extended detention time to provide much removal. While nitrates are readily removed by these processes, several studies have shown that reduction of P is very limited beyond that removed through sedimentation (Karr and Schlosser, 1977).

How buffers remove pathogens and toxic substances

Bacteria (such as fecal coliform) and toxic substances (such as pesticides and metals) are removed by buffers through mechanisms like those described above. Microbial treatment of bacteria by buffers has been demonstrated in studies of feedlot runoff (Dillaha et al., 1988; Young et al., 1980). Removal of metals occurs primarily by trapping sediments with attached metals, by plant uptake, and by adsorption of dissolved metals onto clay or humus particles in the soil. Removal of pesticides occurs primarily through biochemical processes that degrade the pesticide (Patty et al., 1997).

How buffers control erosion

Buffers are also effective at reducing erosion and scouring of lands adjacent to wetlands. The vegetation in buffers reduces the erosive effect of rainfall, dissipates surface flows and helps bind the soil, which reduces channelization and erosion of the buffer area itself (Shisler et al., 1987). Plant species with fine and very fine roots are most effective at binding the soil and preventing erosion (Kleinfelder et al., 1992). By limiting erosion, buffers reduce the deposition of sediment into wetlands.

How buffers maintain water temperature and microclimate

Buffers with forest vegetation help moderate air and water temperature through shading and blocking the wind. Adequate buffers can help reduce summer temperatures and maintain higher winter temperatures. Maintaining natural water temperatures is important for three reasons: 1) many aquatic organisms, such as fish, are adapted to a particular temperature range and cannot tolerate greater fluctuations; 2) warmer water contains less dissolved oxygen (which is necessary for aquatic life); and 3) warmer water weakens the bond between nutrients and sediment particles, thus increasing soluble nutrients in the water (Karr and Schlosser, 1977).

Buffer Characteristics that Affect Water Quality

The scientific literature on buffers makes clear that determining appropriate buffer widths and characteristics to achieve a desired water quality objective is very site-specific. How wide a buffer needs to be to improve water quality to a desired level depends on several factors, principally the loading rate of the pollutant, slope, soil type and vegetation composition and structure. A buffer with a steep slope or sparse vegetation will require greater width to achieve the same amount of sediment or nutrient removal as a buffer with a flatter slope and dense vegetation. The relative importance of each of these factors relates to the types of pollutants expected and the nature of the waterbody to be protected.

However, it is seldom possible to alter the slope or soil type present in a buffer and there is only so much one can do with vegetation. Loading rates can be reduced by pretreatment of the polluted runoff in detention basins or grassy swales. In most cases, buffer width is the easiest factor to control (Phillips, 1989a). As a general rule, the wider the buffer, the more effective it is in improving water quality (Castelle et al., 1992; Desbonnet et al., 1993). Furthermore, many studies show that the relationship of width to water quality improvement is not linear. Beyond a certain width, it takes a progressively wider buffer to achieve incremental improvements in pollutant removal (Desbonnet et al., 1993; Castelle and Johnson, in press).

Determining appropriate buffer widths for water quality protection requires a decision regarding the level of potential harm to the wetland that is acceptable, as well as an understanding of the factors that influence buffer functions. Chapter Three examines management issues in more detail but the discussion below sheds some light on what the Best Available Science says about the effectiveness of varying buffer widths in removing pollutants and protecting water quality.

Buffer effectiveness in removing sediment

The most important factors influencing how well a buffer filters out sediment from surface waters include the slope of the buffer, the roughness of the ground surface (based on vegetation and organic debris) and the way water flows across the buffer. The scientific literature on this buffer function is abundant and consistent. Studies conducted around the world have shown that if water travels as sheet flow across a well-vegetated area with little slope, then the majority of the coarse sediments will drop out within a few meters (Dillaha et al., 1989; Karr & Schlosser, 1977). Filtering of finer sediment particles requires further slowing of the water and thus usually requires additional buffer width.

In one of the earliest studies of this function, Wilson (1967) demonstrated that sand-sized sediment was deposited within 3 meters whereas silt and clay required 15 m and 122 m respectively. Numerous studies have shown that, with a slope less than 5%, a grassy buffer of 5-15 meters will effectively remove all but the fine particles from sheetflow (Desbonnet et al., 1993; Ghaffarzadeh et al., 1992). Other studies have shown sediment reduction rates of 75-92% with buffers ranging from 25-30 m (Lynch et al., 1985; Wong & McCuen, 1982; Young et al., 1980).

However, once the slope exceeds 5%, surface roughness is reduced, or flow becomes channelized, the efficiency of a buffer is significantly reduced. For example, in studies where buffer conditions were not optimal, buffer widths of 60-100 m were necessary to achieve sediment reductions of 50% (Gilliam and Skaggs, 1988; Broderson, 1973).

In a review of 19 studies, Desbonnet et al. (1993) concluded that, if properly designed, a buffer as small as 2 m wide could remove up to 60% of suspended sediment whereas a 25 m buffer could remove 80%. However, to achieve even small increases above 80%, buffer widths would have to be increased significantly. In a similar comparison, Wong & McCuen (1982) found that, under similar conditions, a 30.5 m buffer removed 90% of sediments while a 61 m buffer was needed to remove 95%.

Buffer effectiveness in removing nutrients

Numerous studies have evaluated the effectiveness of vegetated buffers at removing nitrogen and phosphorous (the primary nutrients of concern to water quality). However, the characteristics that determine buffer effectiveness at removing nitrogen are different from those that determine buffer effectiveness at removing phosphorous, as noted below.

Nitrogen removal

Since most nitrogen in surface runoff occurs in the soluble form, buffer effectiveness is dependent upon microbial action and plant uptake. These processes require significant contact time between the water and the shallow, biologically active zone in the soil. Thus, the factors that determine buffer effectiveness at removing N are slope, soil composition, and width. The desired characteristics are flat slopes, soils with high organic content, and soils that are permeable, but not too much so. Highly permeable sandy soils will allow water to infiltrate below the biologically active zone, and relatively impermeable clay soils will not allow adequate infiltration. High organic content in the soil provides the carbon necessary to fuel microbial activity.

Studies of nitrogen removal by buffers have produced variable results likely due to the wide range of conditions that were evaluated. Using the 3-zone system described below, Schultz et al. (1995) concluded that buffers 20-30 m wide would "be effective" at removing nitrogen. Other studies of varying buffer types have shown that buffers 6 to 20 m wide have resulted in N reductions of 47 to 99% (Patty et al., 1997; Daniels and Gilliam, 1996). Desbonnet et al. (1993) developed a buffer width effectiveness curve for nitrogen based on a review of 26 studies. They concluded that buffer widths as small as 9 m could reduce nitrogen as much as 60% whereas buffer widths of up to 60 m would be required to reduce nitrogen by 80%.

Phosphorous removal

Since most phosphorous in surface water runoff is bound to fine sediment particles, the effectiveness of a buffer in removing P is related to the same factors that determine effective fine sediment removal (Karr & Schlosser, 1977). These include flat slopes, sheet flow and high surface roughness. Some additional P can be removed through plant uptake but it is minimal compared to removal rates for sediment-bound P (Karr and Schlosser, 1977).

Studies have reported wide variations in P removal, ranging from reductions of 62% with a 4 m buffer (Doyle et al., 1977), and 56-93% with a 9 m buffer (Dillaha et al., 1989), to 50% with a 30 m buffer (Edwards et al., 1983). Thompson et al. (1978) obtained reductions of 44% and 70% with 12 m and 36 m buffers, respectively. Young et al. (1980) reported reductions of 67% and 88%

with buffers of 21m and 27m. Using a buffer width effectiveness curve, Desbonnet et al. (1993) plotted 27 studies of P removal and determined that, on average, a 12 m buffer would remove 60% whereas an 85 m buffer was necessary to remove 80%.

Buffer effectiveness in removing bacteria and pathogens

Effective removal of bacteria and pathogens requires the settling of suspended solids. In a study of feedlot runoff, Young et al. (1980) found that a 35 m grass buffer reduced microorganisms in surface water runoff to acceptable levels for primary contact recreational use (<1,000/100ml.). Grismer (1981) determined that a 30 m grass strip reduced fecal coliform by 60%.

Buffer effectiveness in maintaining water temperature

Studies of the temperature moderation function of buffers have examined the type and width of forested areas adjacent to open water bodies. Shade is the critical factor and is relative to the slope, aspect, and height of vegetation. Swift and Messer (1971) concluded that a 25 m width of mature forest is generally sufficient to maintain natural water temperatures. Broderson (1973) found that 15 m forested buffers were adequate for small streams (less than 5 cubic/feet/second). Lynch et al. (1985) determined that a 30 m forested buffer along a stream maintained water temperatures within 1^{o} C of background.

Summary of Buffer Effectiveness for Water Quality Improvement

Numerous studies have demonstrated the effectiveness of buffers in removing pollutants from surface and ground water. These investigations encompass 30 years of study and a wide range of conditions. While the designs of the various studies and the conditions assessed vary widely, a general consensus emerges on several points. These are as follows:

1) Vegetated buffers are effective at removing many pollutants from surface and ground water, and thus play an important role in protecting downgradient receiving waters;

2) The primary processes and mechanisms that provide water quality improvement in buffers are well understood;

3) Sheet flow and shallow ground water flow, rather than channelized flow, are necessary for effective removal of pollutants;

4) Buffer effectiveness at removing pollutants is dependent upon a few critical factors including slope, soil type, surface roughness, loading rates, vegetation type and width;

5) Precise determination of appropriate buffer widths and characteristics is dependent upon an evaluation of the above and other factors; and

6) In the absence of a site-specific evaluation of the above factors, buffer widths in the 15 -30 m range are the minimum necessary to provide an effective buffer for water quality improvement (Castelle et al., 1992; Johnson and Ryba, 1992; Desbonnet et al.,1993).

Several authors (Schultz et al., 1995; Lowrance, 1992; Welsch, 1991) advocate the use of a Riparian Buffer System that includes three distinct zones: Zone 1, a grassy strip at the outer edge of the buffer designed to maximize sheet flow; Zone 2, a managed forested area designed to provide maximal surface roughness and serve as a transition zone to the next zone; Zone 3, a natural forested area adjacent to the waterbody of concern. This 3-zone system, according to most authors, should provide adequate sediment removal as well as a wider range of buffer functions if its total width is 20 - 50 meters.

Buffers and Wildlife Habitat

The role of wetland buffers in protecting wildlife habitat

Wildlife habitat is always included in any generic list of wetland functions. This is because numerous studies have shown that wetlands are utilized by a large percentage of wildlife (Thomas, 1979; Brown, 1985; Brown et al., 1990). While some species depend on wetlands for a majority of their life requirements, other species utilize wetlands for only a portion of their life cycle or for specific needs.

All wildlife need food, water, shelter from the elements and predators, and places to breed and to rear their young. A "habitat" is defined as a place occupied or utilized by a specific population of organisms to supply one or more of these basic requirements for survival (Brown et al., 1990). Each animal species is adapted to certain habitats that meet its life needs. The health and success of any species is directly related to the quality and quantity of habitat available to it.

As humans alter the natural landscape, wildlife are crowded into smaller and increasingly isolated fragments of habitat. Roads, agricultural fields, houses, and other developments eliminate habitat available for most wildlife species and block their movement between suitable habitat areas. Furthermore, very few species (for example, most aquatic insects and fish) utilize only aquatic habitats. Most species that utilize wetlands (or other aquatic areas) require terrestrial habitats as well in order to meet their life requirements. Birds, which can fly in and out of wetland habitats, may be able to locate and utilize terrestrial habitats that are some distance from wetlands. Some birds, mammals, and amphibians need only a small area of terrestrial habitat adjacent to a wetland to meet their life needs. Other species, including mammals, reptiles, and amphibians, need larger terrestrial habitats and must travel over land to reach them, thus requiring vegetated travel corridors within which to navigate through human-altered landscapes. While the particular habitat needs of each species are unique, providing diverse, connected habitats of certain sizes can provide for the needs of many species.

Wetland buffer zones are essential to maintaining viable wildlife habitat because they can perform several essential functions: 1) they provide an ecologically rich and diverse transition zone between aquatic and terrestrial habitats; 2) they provide the necessary terrestrial habitats for many species; 3) they sometimes provide travel corridors between otherwise isolated habitat areas; and 4) they screen wetland habitat from the disturbances of adjacent human development.

How buffers protect wildlife habitat

Buffers protect wildlife habitat in two essential ways: 1) by providing habitat essential to meeting certain life requirements of many species; and 2) by ameliorating the adverse impacts of human activities adjacent to the wetland.

Providing essential habitat for wildlife

The ecological conditions of wetland and stream buffer zones are diverse, dynamic and include components of both terrestrial and aquatic habitats (Brown et al., 1990; Porter, 1981; Thomas et al., 1979). Called riparian zones, these transitional areas between terrestrial and aquatic habitats provide important habitat for a wide range of species. While these riparian zones may comprise a small portion of a larger habitat area, they receive disproportionally higher use by wildlife species (Thomas et al., 1979; Brown, 1985; Oakley et al., 1985) because they provide a diversity of habitats in a small area.

First described by Leopold (1933) as the "edge effect," this phenomenon of higher wildlife use of transition zones, particularly between aquatic and terrestrial habitats, has been demonstrated in studies of birds (Beecher, 1942; McElveen, 1977), mammals (Bider, 1968; Matthews and Strauss, 1981) and amphibians (Bury, 1988). The same pattern has been demonstrated in the Pacific Northwest in studies by Oakley et al. (1985), Knight (1988) and Cross (1988). As much as 85% of the wildlife species found in Washington State utilize wetlands and their adjacent riparian zones (Brown, 1985; Thomas, 1979).

Many wildlife that are identified as "wetland dependent" and considered by the public to be "wetland species," require adjacent upland areas for many of their critical life needs (Naiman, 1988; WDW in Castelle et al. 1992). For example, many waterfowl need access to upland areas for nesting (Duebbert and Kantrud, 1974; Foster et al., 1984; WDW in Castelle et al., 1992). Also, most species of amphibians require upland areas for a portion of their life cycle (Bury, 1988).

As described above, buffer zones provide a transition area between aquatic and terrestrial environments and provide a critical component of wildlife habitat. The specific habitat functions provided by riparian buffer areas include: 1) sites for foraging, breeding and nesting; 2) cover to escape predators or weather; and 3) corridors for dispersal and migration.

In addition, vegetated buffer zones protect habitat by maintaining the microclimate through temperature moderation and by providing a source of organic matter input to aquatic systems. This includes both large organic debris (logs, root wads, limbs), which provide habitat structure in aquatic environments, and particulate and dissolved organic matter, which provide a source of food for invertebrates and thus help form the foundation of the food chain. Consequently, buffer zones comprised of native vegetation with multi-canopy structure, snags and down logs provide habitat for the greatest range of wildlife species (Brown, 1985; Groffman et al., 91).

Ameliorating the effects of adjacent human activities

In addition to providing essential habitat for wildlife, buffer zones also "buffer" wildlife from the disturbance of adjacent human activities. The intrusion of noise, light, domestic animal predators (cats, dogs, etc.) and direct human disturbance (trampling, litter) can have a significant adverse impact on wildlife use of wetlands. Many wildlife species in wetlands are scared off by unscreened human activity within 200 feet (WDW in Castelle et al., 1992). Noise and light can disrupt feeding, breeding, and sleeping habits of wildlife. Domestic pets scare wildlife, causing them to flee and expend energy. Dogs and cats prey on some wildlife species and are particularly damaging to ground nesting species (Churcher & Lawton, 1989). Dense shrub and tree vegetation in a buffer adjacent to a wetland can limit intrusion and screen out noise, light and movement from adjacent human development (Castelle et al., 1992).

Buffer Effectiveness in Providing & Protecting Wildlife Habitat

The scientific literature on buffers makes it clear that determining appropriate buffer widths and characteristics to protect wildlife habitat requires a site-specific evaluation. While most attention in wetland buffer management is focused on width, the determination of how wide a buffer needs to be to meet the habitat requirements of wildlife depends on several factors: 1) the type of land uses adjacent to the wetland; 2) the specific type of wildlife that use the wetland and surrounding areas; 3) the vegetative character of the buffer zone; and 4) the presence of habitat features such as snags and dens. A general rule about the value of vegetated buffers to wildlife, however, is "the bigger the better and some is better than none" (Desbonnet et al., 1993).

With that noted, abundant scientific literature addresses the needs of a wide variety of wildlife species. Many of the buffer studies focus on a particular group of wildlife species such as amphibians, neotropical migratory songbirds, or waterfowl. Some studies have investigated just one species of wildlife, such as beaver or pileated woodpeckers. Additionally, a few studies have examined all of the habitat-related functions of buffers. A sample of the relevant literature, with an emphasis on Pacific Northwest sites and species, follows.

Buffers and general wildlife habitat

In addition to the numerous studies that have highlighted a particular species or group of species, several reviews of the literature have focused on buffer needs for wildlife in general and they generally agree about the appropriate width of buffers to protect wildlife.

Castelle et al. (1992) examined the literature on buffers and concluded that appropriate buffer widths for wetlands with important wildlife functions range from 60 - 90 meters (200-300 feet) in western Washington and 30 to 60 meters (100-200 feet) in eastern Washington. Desbonnet et al. (1993) reviewed twelve wildlife buffer studies and concluded that buffer widths of 15-30 meters were necessary for low intensity land uses and 30 - 100 meters for high intensity land uses. Norman (1996) analyzed numerous wildlife studies and proposed a 50 m baseline buffer to protect most wetland functions, but asserted that additional buffer area might be needed to protect certain sensitive species. Chase et al. (1995) concluded that 30 m would be adequate for certain habitat functions (invertebrates, amphibian breeding habitat, and foraging [but not nesting] for birds and some mammals) but asserted that buffers greater than 30 m would be needed to meet other wildlife habitat needs. Other studies concluded that buffers of 60 m (Howard & Allen, 1989) and 60-100 m (Groffman et al., 1991) would be sufficient to meet most wildlife needs.

Buffers and bird habitat

Numerous studies have documented avian use of wetlands and their buffers. In a study of bird use of freshwater wetlands in urban King County, Washington, Milligan (1985) determined that bird species diversity was strongly correlated with the percentage of the wetland boundary that was buffered by at least 15 m of tree and shrub vegetation. Foster et al. (1984) found that waterfowl breeding use of wetlands in the Columbia Basin of Washington was greatest in smaller (<1 acre) wetlands. They also determined that 68% of waterfowl nests were in upland areas within 30 m of the wetland edge and 95% were found within 95 m. Castelle et al. (1992) reported that wood duck nesting in wetland buffers occurred as far as 180 m from the wetland edge with an average distance of 80 m. Short & Cooper (1985) found that buffers of 50 m (for foraging) and 100 m (for nesting) were found effective at buffering great blue herons from human disturbances. Schroeder (1983) found that pileated woodpeckers nested within 50 m of water. Groffman et al. (1991) determined that most neotropical migratory species needed a 100 m buffer around wetlands to provide adequate habitat.

However, in a study of wetlands and biodiversity in Ontario, Canada, Findlay and Houlahan (1997) determined that species diversity of mammals, birds, herptiles and plants were all negatively correlated with road density within 2 km of a wetland and were positively correlated with forest cover within 2 km. They suggest that protecting buffers of less than a kilometer or two is not adequate to maintain plant and wildlife diversity in wetlands.

Buffers and amphibian habitat

While no studies have evaluated the wetland buffer requirements specifically for amphibians in the Pacific Northwest (PNW), a recent paper by Richter (1997) documented amphibian use of buffers in the PNW. Richter concurred with the conclusions from research that has been conducted elsewhere regarding appropriate buffer widths, and suggests that buffer widths equal to two to three tree heights would be optimum. Research conducted elsewhere in the country recommended buffers of 164 m in humid climates (Semlitsch, 1998) and buffers of 30 - 100 m in arid climates (Rudolph & Dickson, 1990).

Buffers and mammal habitat

Studies have shown that beaver utilize adjacent uplands within 30 m of water for most of their foraging needs in eastern Washington, while they forage as far as 100 m in western Washington (WDW in Castelle et al., 1992). Allen (1982) concluded that mink use adjacent forested areas as far as 180 m, but that most of their use is concentrated within 100 m of water.

Buffers and wildlife corridors

As described above, the maintenance of wildlife populations in wetlands often requires a suitable wildlife travel corridor between a wetland and other habitats in addition to an adequate buffer around the wetland. Amphibians and mammals both need travel corridors comprised of shrub and tree species to provide adequate cover and microclimate maintenance. Richter (1997) recommends a minimum corridor width of 150 m to ensure that soil moisture is maintained and suggests that wider corridors are required to maintain air temperature and humidity.

Buffers and human disturbance

As discussed above, wetland buffers also protect wildlife habitat by limiting intrusion by humans and pets, and by screening out the noise, light, and motion of human activities. Several studies have examined the effectiveness of buffers in limiting human disturbance.

Shisler et al. (1987) evaluated 100 sites in New Jersey and found the degree of human disturbance was correlated with the width of a buffer and the type of adjacent land use. They concluded that buffers 15 - 30m wide were needed to protect wetlands from disturbance from low intensity land uses (agriculture, recreation, and low density residential housing.) For high intensity land uses (high density residential housing and commercial/industrial development) they recommended 30-50m buffers. They also found that the most effective buffers at screening human disturbances had steep slopes with dense shrub understory vegetation.

Cooke (in Castelle et al., 1992) analyzed 21 wetland sites in western Washington and concluded that buffers < 15m were generally ineffective in screening out human disturbance. Josselyn et al. (1989) examined the effects of human recreational activity on waterbirds in the San Francisco Bay area. They concluded that unscreened human activity within 15 - 50 m was disturbing to waterbirds. Groffman et al. (1991) determined that 32 m of dense forested buffer was necessary to reduce noise from commercial areas to background levels.

Summary of Buffer Effectiveness in Providing/Protecting Wildlife Habitat

The determination of an appropriate buffer for protecting wildlife habitat must take into account a number of factors. A site-specific determination based on the species to be protected, the condition of the buffer and the type of adjacent land use will be the most effective way to select an appropriate buffer width. However, given the need for establishing general buffer widths for management considerations, the scientific evidence on buffers for wildlife could be summarized as, "An appropriate buffer to maintain wildlife habitat functions for all but the most highly degraded wetlands, would be comprised of native tree and shrub vegetation and range from 30 to 100 meters."

Buffer Protection

Buffers will only provide the necessary functions to protect wetlands for as long as the buffers themselves remain intact. Buffer areas can be altered over time in at least two primary ways: human disturbance and wind damage.

Human disturbance

Human activities are the most common mechanism for altering buffers over time. If vegetation is cut or trampled, soils are compacted, or channels are created, a buffer's ability to protect a wetland will be compromised. Cooke (in Castelle et al., 1992) analyzed 21 wetland sites in western Washington and concluded that buffers less than 15m wide were more susceptible to being reduced over time by human disturbance. Nearly all of the buffers less than 15 m in width were significantly reduced in a few years and some were eliminated by clearing of vegetation. Of the buffers wider than 15m, most were intact and showed fewer signs of human disturbance. In a study in the Monterey Bay area of California, Dyste (1995) examined 15 wetlands with buffers and determined that all of the buffers suffered from human alteration.

Wind damage

In the Pacific Northwest, long-term protection of buffers must take into account high-velocity wind storms and the potential for trees in a buffer to blow down. Maintaining a forest canopy is important to many buffer functions including shading, screening of adjacent disturbance, and wildlife habitat. In a summary of the literature on windfirmness of riparian buffers, Pollock and Kennard (1998) concluded that trees in narrow buffers less than 23 meters wide have a much higher probability of suffering significant mortality from windthrow than trees in wider buffers. They conclude that buffers in the range of 23 - 35 meters constitute the minimum width which can be expected to incur minimal windthrow losses in the long term.

Summary of what the best available science says about buffers and wetland functions

The information outlined above draws upon a significant portion of the available scientific information on wetland buffers. It represents studies spanning several countries and many years of research. It is clear that much is known about the ways buffers function to protect wetlands and other aquatic resources, and that there is considerable agreement on the buffer characteristics necessary to ensure adequate protection of these resources. Tables 3 and 4 below summarize much of this information.

However, there are some gaps in the scientific information and a few areas of dispute. Listed below are summary statements about what is certain, what is uncertain, and what is unknown but researchable.

What is certain

- Buffers are critical to maintaining wetland and aquatic resource health and functions.

- The characteristics and widths of buffers necessary to maintain aquatic resource health and functions are dependent on site-specific conditions.
- Vegetation type and density, soil type, slope, and width are the key buffer characteristics that determine the effectiveness of buffers in protecting the water quality of aquatic resources.
- Vegetation type and density, width, and connectivity to other habitat areas are the key buffer characteristics that determine the effectiveness of buffers in protecting the wildlife habitat of aquatic resources.
- Buffers have a minimal effect on protecting a wetland's hydroperiod if the wetland is in a basin with a high percentage (>15%) of impervious surface.
- Buffer effectiveness generally increases with width, though beyond a certain width (generally 30-50 m) the law of diminishing returns applies to effectiveness at removing pollutants such as coarse sediments and nutrients.
- In order to determine the appropriate width and character of buffer one must consider four factors:

  1) the quality, sensitivity and functions of the aquatic resource;
  2) the nature of adjacent land use activity and its potential for impacts on the aquatic resource;
  3) the character of the buffer area (including soils, slope, vegetation, etc.);
  4) the intended buffer functions.

<u>What is uncertain</u>

- The specific width adequate to provide a specific buffer function in all situations. Since buffer effectiveness is dependent on a variety of site-specific characteristics, it is not possible to determine a single buffer width that is adequate for all situations.
- Which studies conducted in other parts of the country and elsewhere in the world are directly applicable to Washington state.

What is unknown but researchable

- How well buffers function over time. There is concern that buffers have a finite carrying-capacity for filtering nutrients, beyond which they cease to provide this function.
- Whether maintaining a buffer without providing sufficient corridors for wildlife movement will adequately protect a wetland's wildlife species.
- Necessary buffer widths adequate to protect specific wetland dependent wildlife species in Washington.
- Necessary buffer widths adequate to maintain water quality in wetlands for different soil types and climatic conditions in different areas of Washington state.

Table 3 - Characteristics of Effective Buffers					
Buffer function	*Primary mechanisms or processes*	*Critical factors*	*Buffer characteristics*	*Range of widths*	*Selected citations*
Sediment removal	Settling of sediments via slowing surface water flows Infiltration Physical filtration	Sheetflow of surface water Residence time Surface roughness	Shallow slopes Dense vegetation Organic debris Pervious soils	5 - 100 m	Dillaha 89, Gilliam & Skaggs 88, Phillips 89, Castelle et al. 92, Ghaffarzadeh et al 92, Desbonnet et al 93,
Nitrogen removal	Nitrification & denitrification Infiltration Plant uptake	Seasonal saturation Sheetflow of surface water Residence time	Shallow slopes Dense vegetation Pervious soils Seasonal saturated areas	10-100 m	Phillips 89, Castelle et al. 92, Desbonnet et al 93, Daniels & Gilliam 96, Patty et al. 97
Phosphorous removal	Settling of sediments Plant uptake (minor)	Same as for sediment removal	Same as for sediment removal	10-200 m	Karr & Schlosser 77, Dillaha 89, Castelle et al. 92, Desbonnet et al. 93
Toxics removal - **Bacteria**	Biological breakdown by microbes	Residence time	Shallow slopes Dense vegetation Pervious soils	5 - 35 m	Young et al. 80, Grismer 81
- **Metals**	Sediment removal Plant uptake Adsorption	See above Residence time Binding soils	See above See above Clay or organic soils	unknown	Groffman et al. 91
- **Pesticides**	Biochemical degradation	Residence time	See above	18 - 35 m	Lowrance et al. 97, Patty et al. 97

Table 3 (cont.) - Characteristics of Effective Buffers					
Buffer function	*Primary mechanisms or processes*	*Critical factors*	*Buffer characteristics*	*Range of widths*	*Literature citations*
Microclimate protection	Shading Wind blockage	Vegetation height and density Aspect Slope	Dense, forested vegetation	15 - 100 m	Swift & Messer 71, Broderson 73, Lynch et al. 85, Richter 97, Pollock & Kennard 98
Wildlife habitat - Screening noise, light, intrusion, etc.	Blocking light Absorbing noise Blocking movement of humans & pets	Vegetation height & density Slope	Dense, multi-strata vegetation Steep slopes	15 - 50 m	Milligan 85, Shisler 87, Josselyn 89, Groffman et al. 91, Castelle et al. 92
Wildlife habitat **- Nesting, feeding, breeding, etc.**	Depends of species: Cover Food sources Specialized niches (snags, logs, tree canopy, etc.)	Vegetation strata Vegetation species & other food sources Presence of specialized niches	Depends on species. Generally, multi-strata vegetation with snags and down logs will provide best habitat for the greatest number of species.	15 - 200 m	Foster et al. 84, Brown 85, Bury 88, Naiman 88, Groffman et al. 91, Castelle et al. 92, Desbonnet et al. 93, Norman 96, Semlitsch 98
Wildlife habitat **- Travel corridors**	Cover Screens noise, light, etc. Maintains microclimate	Vegetation height & density	Dense, multi-strata vegetation	150+ m	Richter 97, Semlitsch 98

Table 4 - A summary of pollutant removal effectiveness & wildlife habitat value based on buffer width (Source: Desbonnet et al., 1993)		
Buffer Width (m)	**Pollutant Removal Effectiveness**	**Wildlife Habitat Value**
5	Approximately 50% or greater sediment and pollutant removal	Poor habitat value; useful for temporary activities of wildlife
10	Approximately 60% or greater sediment and pollutant removal	Minimally protects stream habitat; poor wetland habitat; useful for temporary activities of wildlife
15	Greater than 60% sediment and pollutant removal	Minimal general wildlife & avian habitat value
20	Approximately 70% or greater sediment and pollutant removal	Minimal wildlife habitat value; some value as avian habitat
30	Approximately 70% or greater sediment and pollutant removal	May have use as a wildlife travel corridor for some species as well as general avian habitat
50	Approximately 75% or greater sediment and pollutant removal	Minimal general wildlife habitat value
75	Approximately 80% or greater sediment and pollutant removal	Fair-to-good general wildlife and avian habitat value
100	Approximately 80% or greater sediment and pollutant removal	Good general wildlife habitat value; may protect significant wildlife habitat
200	Approximately 90% or greater sediment and pollutant removal	Excellent general wildlife value; likely to support a diverse community
600	Approximately 99% or greater sediment and pollutant removal	Excellent general wildlife value; supports a diverse community; protection of significant species

Chapter 3 - Wetland Buffer Protection and Management at the Local Government Level

The protection and management of wetland buffers involves a mix of science, law, sociology, politics and economics. Local governments are used to meshing many different disciplines and balancing many different viewpoints in developing local land use policies and regulations. Under the Growth Management Act (GMA), local governments are required to balance many competing interests and needs in the development of policies, programs and regulations for managing for future growth. One of these competing interests is the need to protect Critical Areas, including wetlands. As described in Chapter One, the GMA specifies that local governments must include the best available science in the development of policies and regulations aimed at protecting the functions and values of Critical Areas. Chapter Two demonstrates that the best available science is unequivocal that protection of buffer areas around wetlands is a critical component of protecting wetland functions and values. It also shows that there are many factors that need to be considered in protecting and managing buffers.

This chapter outlines the many considerations that local governments should take into account when developing policies and regulations for the protection and management of buffers. In addition to the scientific information about buffer effectiveness, there are many administrative and legal considerations that must be addressed in the regulation of buffers. Most local governments in Washington currently regulate wetlands and their buffers through local ordinances. Most of these ordinances were developed in the 1980s and early 1990s. Local governments were not required to include best available science prior to 1995 and thus, many of these ordinances were based more on political and economic expediency than on scientific information. This chapter attempts to incorporate the relevant scientific information about buffer management with the author's experience with buffer regulation and management over the past 15 years. Included in this is a discussion of the primary issues and a variety of approaches to consider when developing buffer protection and management regulations.

First, however, it is helpful to understand the legal and historical context surrounding the protection of wetlands and their buffers.

The legal context

In most cases, the protection of wetlands and their buffers is the result of government regulation and thus must be based on the government's authority to provide for the health, safety and welfare of its citizens (Platt, 1996). Protecting buffer areas around wetlands is controversial because it usually requires a landowner to forgo the use of that portion of his/her property for anything other than aesthetic enjoyment. While some landowners decide to protect wetlands and buffers because they value the ecological or aesthetic benefits provided by these areas, many choose not to do so.

The legal authority to regulate wetlands and other natural resources originates in the U.S. Constitution, which charges government to provide for "the general welfare." This provision has been interpreted by the courts over the years to include the regulation of activities that could affect the health, safety, or welfare of a community. Often referred to as "police powers," this authority allows a city or county to regulate the location of development through zoning laws and to require landowners to protect natural resources such as streams, lakes and wetlands (Platt, 1996). This power also provides the authority to restrict uses in potentially hazardous areas such as floodplains and steep slopes.

Thus, a local government's authority to protect wetlands is based upon the fact that wetlands play a role in protecting public health and safety (e.g. water quality improvement, flood reduction, groundwater recharge, and other processes) and providing for the general welfare (e.g. habitat and aesthetics). Any reasonable actions undertaken to ensure that wetlands continue to provide these functions are supportable under the government's police powers.

Establishing and implementing wetland or buffer regulations, however, must be done in a manner that does not result in the denial of reasonable use of a landowner's property. The Fifth Amendment to the Constitution states, "... nor shall private property be taken for public use without just compensation." This passage has been interpreted differently by courts over the years but is generally understood to mean that any government action that denies a landowner all "reasonable" economic use of his/her property requires compensation (Platt, 1996). If the protection of a certain width of buffer results in a property owner being unable to develop his/her property in a way otherwise allowed by law, then a government agency runs the risk of being sued for a "takings"- i.e. the taking of private property without just compensation. Most local governments avoid this dilemma through the development of "variance" procedures that allow for case-specific decisions in which buffer requirements are altered to allow reasonable use. These procedures are described in more detail below.

The historical context

The modern controversy over wetlands protection is a product of American culture's historical perspective on wetlands. While protection of lakes and streams may engender debate and conflict over the level of private property restrictions, few people argue over whether streams and lakes should be protected. People generally understand the value of streams and lakes and the need for their protection; not so with wetlands. Until very recently, wetlands have been viewed as useless wastelands that should be "reclaimed" and put to productive use. Historically, government agencies even paid landowners to clear and drain swamps and marshes (Siry, 1984).

Only during the past 30 years has the public perception of wetlands begun to change. A growing understanding that wetlands provide beneficial functions to society has led to a shift in government policy and programs. In the 1970s, after two hundred years of paying landowners to destroy wetlands, the federal government began to protect wetlands. Soon after, state and local governments began to follow suit. This relatively recent and sudden shift in attitude has contributed significantly to the considerable conflict between the government's need to protect the public interest and the desire of private property owners to use their property as they see fit.

In the eyes of many property owners, protection of wetlands on their land denies them use of acreage they believed would be developable (and that was developable in the recent past). This perspective is compounded by the fact that many people view wetlands as land that happens to be wet for part of the year, not as a water resource. In addition, wetland boundaries appear to change seasonally and are more difficult to identify than lake or stream boundaries. This leads to many disagreements over the extent of wetland area that should be protected. Furthermore, efforts to protect upland buffers around wetlands are viewed as an even greater "land grab" by the government.

Conflicts between landowners and government agencies over wetland protection increased throughout the 1980s, as more state and local governments began to restrict land uses in and near wetlands. In 1988, the National Wetlands Policy Forum, a coalition of government agencies and private interest groups, developed the concept of "No Net Loss" (Conservation Foundation, 1988). This concept holds that, since the United States already has lost as much as 60% of its original wetlands (Frayer et al., 1983), we must strive to avoid the loss of any more wetlands. Recognizing that some loss of wetlands undoubtedly will continue as a result of necessary development, the No Net Loss goal states that wetland losses should be offset by the creation and restoration of wetlands. This goal is directed at maintaining both wetland acreage and wetland functions.

Many federal, state and local government wetland protection programs have adopted No Net Loss as their primary goal. The federal government and many states (including Washington) have a further intention to achieve a net gain in wetland acreage and function, primarily through non-regulatory restoration of wetlands (Gardner, 1989).

In Washington state, the responsibility for protecting wetlands is shared by the federal , state and local levels of government. No comprehensive federal or state wetland protection laws currently exist but several laws provide some protection for wetlands (see Wetland Regulations Guidebook {Ecology, 1994}). While federal and state agencies play a significant role in protecting wetlands in Washington, local governments are the principal agencies responsible for ensuring the protection of wetlands, through local land-use regulation and provisions of the state Growth Management Act (GMA).

Efforts to protect wetlands and their buffers will continue to be rife with conflict as government agencies attempt to balance the public interest with private property rights. By basing a wetland protection program on a foundation of sound science and by providing flexibility to address site-specific situations, a government agency can achieve an appropriate balance between these two competing interests.

Buffer Management & Best Available Science

The best available science (see Chapter Two) makes clear that the protection of buffers around wetlands is necessary to protect wetland functions. The best available science also provides considerable guidance on buffer characteristics, including widths, which are necessary to protect specific wetland functions. The best available science does not provide clear direction on how to structure buffer protection and management programs. However, in addition to providing technical information on buffer effectiveness, the best available science provides information that should help guide the development of buffer protection policies and regulations. This information can be summarized as follows:

- Four primary factors should be considered in determining the appropriate width and character of buffers,:

  1) the quality, sensitivity and functions of the aquatic resource;

  2) the nature of adjacent land use activity and its potential for impacts on the aquatic resource;

  3) the character of the existing buffer area (including soils, slope, vegetation, etc.);

4) the intended buffer functions.

- Site-specific information is needed to determine effective buffer character and width;
- It is important to manage surface water discharges to wetland buffers to ensure effective treatment of pollutants.
- Generally, buffer widths "shrink" over time due to infringement from adjacent activities.

Ideally, this guidance should be incorporated into any local government buffer regulations. There are, however, many different ways to incorporate this information into a buffer protection program. The challenge for local governments in Washington is to develop buffer protection and management approaches that incorporate the best available science and which provide a reasonable and defensible means of establishing and maintaining effective wetland buffers.

Developing local buffer policies and regulations

A local government's buffer protection strategy should include both regulatory and non-regulatory components. While regulation is critical to protect adequate buffers in the face of increasing development, a non-regulatory approach can address some buffer issues that a regulatory approach cannot. In some cases, providing incentives to landowners is more effective at protecting buffers than regulation. In any case, the foundation of both regulatory and non-regulatory approaches is a sound policy framework that spells out why buffer protection is important and sets the tone and direction for how buffers are to be protected.

Buffer policy development

Buffer policy language should articulate that buffers are critical to the protection of wetlands and their functions. Typically, this policy language is contained in a local comprehensive plan and in development regulations. It should state the goals of buffer protection efforts. Stated goals could include, for example: 1) buffer protection should be based on sound science; 2) flexibility should be provided to address site-specific situations; 3) buffer standards, and criteria for varying from standards, should be predictable for landowners; 4) staff implementing the buffer programs should be well-trained; 5) non-regulatory incentives should be used to help protect buffers where regulation is impractical or onerous; and 6) buffer protection should be balanced with allowing reasonable use of private property.

Non-regulatory Incentives for Buffer Protection

Typically, buffers are formally established at the time that a new development is proposed adjacent to a wetland. However, since buffer regulation is a recent phenomenon , most existing development dating from 1985 or before likely was constructed prior to the regulation of wetlands and their buffers. In addition, agricultural activities adjacent to wetlands are largely unregulated and without buffers. Therefore, many wetlands have minimal or no buffers and will remain in this condition unless and until a new development activity is proposed adjacent to them.

In these situations, non-regulatory incentives are the primary means of providing an adequate buffer area to protect wetland functions. By providing financial incentives to landowners it is sometimes possible to restore and enhance buffer areas for wetlands that otherwise would remain unprotected. Outlined below are several programs available to local governments in Washington to provide incentives to landowners to protect wetland buffers. For more information on landowner incentive programs, see the Department of Ecology guidebook, Exploring Wetlands Stewardship (Ecology, 1996b).

Washington State's Open Space Taxation Act (RCW 84.34) is unique in the nation. It combines the strong incentive approach of "open space" property tax valuation with the fund raising opportunities of a conservation levy. Few other state's offer as strong a landowner incentive program to local governments.

Tax incentives - The Current Use Taxation Program allows counties to assess property taxes based on the "current use" of a parcel rather than on its development potential. This program establishes three categories for enrollment: Agricultural; Timber; or Open Space. Wetlands and their buffers can be enrolled under the "Open" category. Under the "Open" classification, property taxes are reduced by a percentage, based on an evaluation system (called the Public Benefit Rating System or PBRS) developed by the county. Once enrolled, the property must remain in the program for at least 10 years or be subject to early withdrawal penalties. The amount of tax reduction under the PBRS is based on the ecological value of the property and the degree of protection afforded. Each county can develop its own criteria for the type of resources that qualify for this category and the degree of tax reduction offered. All counties have programs with an Open Space category but only 14 of the 39 counties in Washington have implemented a PBRS and some of these allow tax reductions for the protection of wetland or riparian buffers.

Acquisition or Conservation Easement Programs - Another provision of RCW 84.34 is the Conservation Futures Levy. It allows counties to charge a fee of up to 6.25% per $1000.00 of assessed property value to raise funds for the purchase and management of conservation land. Once enacted by the legislative body of the county, this levy collects funds that may be used to purchase land outright, or to pay landowners to adopt conservation easements on their property. These funds can be used to pay for buffer protection and enhancement. Thus far, 11 counties in Washington have enacted this levy.

Another program available to local governments in Washington is the Real Estate Excise Tax. RCW 82.46.070 allows counties to impose a real estate excise tax on transfers of property where the proceeds are used exclusively for the acquisition of land or easements and maintenance of conservation areas. This tax can be enacted by a resolution of the county legislative body or by public petition. In either case, a majority of voters in the county must approve the tax, including a specified maximum rate. San Juan County is the only county that has adopted this program.

In addition to these local programs, there are several cost-share funding programs available from the federal government to help pay for the protection, restoration and/or enhancement of buffer areas. Most of these programs are directed at agricultural lands and are administered by the Natural Resources Conservation Service. Other states (Maryland, Virginia) have developed similar cost-share programs for assisting landowners in protecting and restoring buffers but Washington has no comparable program.

Wetland buffer regulations

Regulations for the protection of wetland buffers should address a number of issues: 1) standards for buffer character and width; 2) criteria and procedures for varying from a standard; 3) allowable uses within buffers; 4) best management practices to enhance and ensure effective buffer function; and 5) provisions for the delineation and demarcation of buffers and their maintenance over time.

In most cases, the primary concern will be "how wide does the buffer need to be?" This issue dominates any discussion of buffer regulation and generates the most conflict. However, before determining appropriate standards for buffer widths, a local government needs to decide how best to balance the need for a predictable and cost-effective approach with the desire for a flexible approach that is responsive to site-specific situations.

The options for buffer regulatory approaches range from variable-width buffers that are determined case-by-case based on multiple site-specific factors, to fixed-width buffer standards. Between these two extremes, there are many intermediate options that combine some elements of each. Each approach has its advantages and disadvantages, and deciding which is most appropriate requires careful consideration.

Variable-width Approach

The case-by-case variable-width approach is probably the most consistent with what the best available science says about buffer effectiveness. This approach usually requires the development of a detailed formula and methodology for the consideration of site-specific factors such as wetland type, adjacent land-use, vegetation, soils, and slope. By taking into consideration all relevant site-specific factors prior to determining the appropriate buffer width, this approach helps ensure that the buffer is adequate to protect wetland functions without being any larger than is necessary.

However, the above approach is time-consuming, costly to implement and provides a less predictable outcome. It requires either that the applicant hire a consultant to conduct the necessary analysis, or that the government agency staff conduct the analysis. In either event, the local government staff must have appropriate training and expertise to conduct or review the analysis. In addition, this approach requires considerable effort up-front to develop the formula and methodology for site-specific evaluation. While methods exist for evaluating site-specific buffer characteristics (Brown et al., 1990; Diamond and Nilson, 1988; Groffman et al., 1993; Roman and Good, 1985), each was developed for unique conditions that are not directly applicable to Washington. This approach also does not provide any predictability for applicants. They have no idea how large of a buffer may be required until considerable time and money are invested in the analysis.

Using a case-by-case, variable-width approach also can result in attempts to manipulate the site-specific data and frequent haggling with applicants. However, if the local jurisdiction can afford the development and implementation costs, this approach may be the most scientifically and legally defensible.

Fixed-width Approach - By contrast, a fixed-width approach provides predictability and is inexpensive to administer. The downside of this "one-size-fits-all" approach is that it results in some buffers being too small to adequately protect a wetland's functions, and some buffers being larger than necessary to protect a wetland's functions. Over time, this inequity may erode public and political support for the buffer program. Frustrated landowners can point to the "over-regulation" of those buffers that are larger than necessary and environmentally-minded citizens can point to those buffers that are smaller than needed to protect wetland functions. It also is difficult to determine an appropriate standard width, because no one size buffer can be demonstrated to protect all wetland types adequately in all situations unless that standard width is very large. Furthermore, it is difficult to argue that a fixed-width approach includes the "best available science" since the scientific literature clearly recommends different buffer widths based on a variety of different factors. While no local governments in Washington currently use a single, fixed-width approach, there are several states (California, New Hampshire, New Jersey) that do.

Combining the Fixed-width Approach with Site-specific Variables - There are, however, several ways to modify a standard, fixed-width approach to incorporate some of the factors that contribute to buffer effectiveness. Some drawbacks of the fixed-width approach can be rectified by developing a wetland rating system that divides wetlands into different categories based on specific characteristics. Then, different buffer width standards can be assigned to each category. This approach provides predictable widths, yet allows some tailoring of buffer widths to wetland functions. For example, the Washington State Wetland Rating System divides wetlands into four categories based on the following wetland characteristics: 1) rarity; 2) sensitivity to disturbance; 3) irreplaceability; and 4) habitat functions. This hierarchical rating system allows one to establish larger standard buffer widths for "more valuable" wetlands and smaller standard buffers for "less valuable" ones. Most local governments in Washington currently designate buffer widths based on the Washington State Wetland Rating System or a similar approach.

Another way to tailor a fixed-width approach to address site-specific factors is to have different standard widths based on the type of adjacent land use, thus incorporating another of the four factors that are known to affect buffer effectiveness. A buffer regulation could require a larger buffer width for high-intensity adjacent land uses and a smaller buffer width if the adjacent land use is low-intensity. This approach can be combined with a wetland rating system to provide a more scientifically valid approach.

Other critical factors, such as the character of the buffer itself and the desired buffer functions, can be addressed by establishing criteria and procedures for varying from a fixed width. This approach allows for some site-specific tailoring of the standard buffer width on a case-by-case basis without the need for developing a standard formula or methodology for determining site-specific widths. In this approach, criteria for increases or reductions from the standard buffer width are developed and the applicant or any other interested party is given the option of "making a case" as to why the standard buffer width should be increased or decreased. Agency staff then evaluate the proposal for deviation from the standard buffer width against the criteria, and decide if such a deviation is warranted.

The criteria for allowing a deviation from the standard buffer width should address the various site characteristics determined by best available science to be the most important. These include buffer characteristics such as slope, soil type and vegetative cover and/or the habitat needs of particular wildlife species. For reducing standard buffer widths, an applicant should have to demonstrate that a smaller buffer will protect the functions and values of the wetland. This will generally require hiring a qualified expert and preparing a site-specific report for the local administrator's review and approval. It is also important to have a minimum buffer width below which the buffer cannot be reduced (see chapter 4 for recommended language).

Reasonable Use Criteria

Another situation in which standard buffer widths may need to be reduced on a case-by-case basis is when protection of the buffer will result in a property owner being denied reasonable use of his/her land. For example, if a landowner has a one-acre parcel that was zoned for one single-family residence and a wetland comprises 80% of the parcel, then protection of a buffer around the wetland might mean that the parcel is undevelopable. In this case, the landowner would have a strong case that protection of the wetland and buffer would deny him/her all reasonable use of the property. However, if the buffer was reduced, it may be possible to construct a single house on the property and avoid a "takings" claim. (Another alternative would be for the government agency to purchase the lot at fair-market value; however, seldom is this economically feasible for local government agencies.) Thus, buffer regulations should include a provision allowing for buffer reduction in situations where reasonable use would be denied. Such a provision should include requirements that the applicant demonstrate that there are no feasible alternatives to reducing the buffer such as revising the development design, that critical wetland functions or public health and safety will not be impaired, and that the inability to derive reasonable economic use of the property is not the result of the applicant's own actions, such as dividing the property in a way that created an unbuildable lot (see chapter 4 for recommended language).

Buffer Averaging

Buffer averaging is a tool for balancing buffer protection with specific site development needs. It allows a buffer to vary in width around a given wetland. For example, if the standard width for a buffer around a wetland is 30 meters, buffer averaging would allow the width to vary between a minimum and a maximum width but require that the buffer area average 30 meters in width. Typically this is done to allow development to occur closer than usual to the wetland in order to fit a particular development "footprint" onto a given site.

However, it also can be used to protect a natural feature (such as a stand of trees or snags) that otherwise would fall outside of the standard buffer width. Buffer averaging can also be used to provide connectivity with adjacent habitat areas or to address those situations where pre-existing development has reduced a buffer area to a width less than the required standard. Criteria for buffer averaging typically require a minimum buffer width (either a designated width or a percentage of the standard buffer width) and documentation to ensure that the averaging of the buffer will not impair overall buffer functions (see chapter 4 for recommended language).

Uses within buffers

Another critical issue that buffer regulations need to address is the type of uses that are allowed within the buffer. Most developers will want to make some use of the buffer area to try to recoup some of their "lost" property. This usually means they will want to place stormwater treatment facilities (e.g. detention ponds and bioswales) in the buffer or construct trails or provide for some form of active or passive recreational use. In addition, over time, residents adjacent to the buffer often will want to use it for some activity. Thus, it is essential that buffer regulations address which uses are allowed in a buffer.

Generally, any use that results in the creation of impervious areas, clearing of vegetation or compaction of soils will be incompatible with buffer functions. Typically, buffers need to be densely vegetated with trees and shrubs to perform water quality and habitat related functions. In most cases, this requirement precludes any human uses of the buffer. However, it may be necessary in some situations to utilize the outer area of the buffer for initial treatment of surface water runoff, via the construction of bio-filtration swales or water spreading features to ensure sheet flow.

In other situations, it may be desirable to allow some focused use of the buffer for educational and recreational activities, and to prevent wide-spread disturbance of the buffer. If it appears inevitable that adjacent residents will use the buffer to gain access to a wetland for aesthetic or recreational enjoyment, then it may be preferable to concentrate that use in a smaller area and minimize disturbance of the soil and vegetation by constructing trails, viewing platforms, or similar facilities. Additionally, providing some educational or recreational developments in buffers may enhance the general public's understanding and appreciation of wetlands and their functions and values.

Many regulations include criteria for evaluating proposals for use of buffer areas. These criteria typically include general language about prohibited uses but allow for variances if certain conditions are met (see chapter 4 for recommended language).

Enhancement/restoration

Frequently, upland areas adjacent to wetlands have been altered by previous land use practices. In many cases, the vegetation has been cleared or significantly degraded and the soil has been disturbed. Also, it is not uncommon to find that the existing buffer area is comprised of non-native vegetation. In these situations, simply "protecting" a set width of buffer area may fail to provide the necessary characteristics to protect a wetland's functions. It is usually desirable, therefore, to restore the buffer to a more naturally vegetated condition.

In other cases, a buffer area may be in relatively good condition but still be sparsely vegetated with trees and shrubs. It may be desirable in this case to improve the screening and habitat value of the buffer by planting additional trees and shrubs.

Buffer regulations should be designed to ensure that buffer areas provide the maximum possible protection of a wetland's functions. In cases where the buffer is not well vegetated, it is helpful to have incentives for enhancement or restoration of the buffer area. Buffer regulations can encourage buffer enhancement/restoration simply by requiring a greater width to be protected if the buffer is not well-vegetated with native species. Landowners typically will prefer to invest in buffer improvements such as planting vegetation or constructing a fence, in exchange for a narrower width.

Best management practices to enhance or ensure effective buffer function

Water quality protection

It is clear from the best available science (see chapter 2) that a buffer's effectiveness at removing pollutants is largely a factor of how water carrying pollutants travels across and through the buffer. In addition, the scientific literature is full of references to pre-treatment practices that enhance a buffer's effectiveness at removing pollutants and reduce the width of buffer necessary (Dillaha et al., 1989; Lowrance et al., 1997; Welsch, 1991).

In areas with agricultural or silvicultural land uses, the primary pollutants of concern are sediments, nutrients, and pesticides. Narrow (5-10 m) grass filter strips have been shown to be effective at removing coarse sediments and attached pollutants as well as helping encourage sheetflow and infiltration of surface runoff, thus enhancing a buffer's effectiveness at removing remaining pollutants (Dillaha et al., 1989, Welsch, 1991, Wong and McCuen, 1982). Therefore, requiring or encouraging the construction of a narrow grass filter strip between agricultural or silvicultural areas and wetland buffers is strongly advised.

In urban areas, the pollutants of concern are primarily sediments and metals from roads, parking lots and construction sites. Adequate treatment of stormwater runoff is critical to remove most of the pollutants and to reduce peak flows prior to discharge to a wetland or its buffer (see below for more discussion of stormwater). To encourage sheetflow and infiltration, stormwater should be dispersed through a shallow infiltration trench at the outer edge of the buffer.

In residential areas, the pollutants of concern include sediments, metals, nutrients and pesticides (from lawns). A combination of appropriate stormwater treatment and the use of a grass filter strip or grassy swale is recommended to pretreat and disperse surface runoff prior to introduction into a buffer.

Stormwater management

In addition to the introduction of pollutants, development adjacent to or upgradient from a wetland can alter the quantity and timing of surface and/or ground water inputs to the wetland. Considerable research has been conducted by the King County Stormwater Management Project that documents the adverse impacts from alterations to a wetland's hydroperiod (see chapter 2). The best available science also shows that upland buffers around wetlands do little to ameliorate these impacts except in wetlands with small contributing basins. Thus, it is imperative that adequate stormwater management practices be applied to any project adjacent to, or upgradient from, a wetland. This includes such practices as the construction of settling/detention facilities as well as treatment with a grassy swale (Ecology, 1992). Inadequately detained and treated stormwater will overwhelm a buffer's ability to filter and treat pollutants. Direct surface discharges to buffers will usually result in channelized surface flow that significantly reduces pollutant removal and can erode buffers.

Wildlife habitat

The two primary actions that can be taken to reduce impacts to wildlife habitat are 1) to ensure that the wetland and its buffer are connected to other habitat areas, and 2) to reduce the intrusion of noise, light, people and pets.

Ensuring connectivity is usually a matter of site design. Some wetlands will already be isolated from other habitat areas and it will not be possible to provide connectivity. On sites where wetlands are currently connected to other habitat areas, it is important to maintain that connectivity through corridors. While the scientific literature indicates that wildlife travel corridors should be as wide as 150 m, it may be beneficial to provide a corridor of any size. Corridors of less than 30 m will only provide the cover for small mammals and less sensitive birds. Local wildlife experts should be consulted to determine the appropriate corridor design for a given site. Buffer averaging may be a useful tool to help ensure connectivity with adjacent habitat areas without unduly burdening the landowner.

Reducing the intrusion of noise, light, people and pets can be accomplished in many ways. As specified in chapter 2, buffers vegetated with dense trees and shrubs are effective at reducing intrusion of noise and light. Additionally, projects can be designed to reduce noise and light intrusion by locating noisy areas like parking lots, playgrounds, and loading docks away from the edge of the buffer. Lighting can be designed and located so it points away from the wetland and its buffer. Fences and/or berms can be constructed to block noise and light. Fences can also be used to limit human and pet intrusion. Dense shrubs can be planted along the edge of a development to block noise and light and limit intrusion. Shrubs with thorns are also a deterrent to human intrusion.

With forethought and careful planning, projects can be designed to reduce impacts to wildlife habitat. When combined with adequately vegetated buffers of sufficient width, these measures can help ensure that disturbance to wildlife use of a wetland is minimized.

Buffer Management Issues

Many steps need to be considered to ensure that, once established, buffers continue to provide the functions for which they were protected. These steps frequently are overlooked or given scant attention by local governments and result in the degradation of buffers over time (Cooke in Castelle et al., 1992.)

Buffer ownership

The issue of who owns the area included in a buffer is an important one. There are basically two options: the buffer area can be included in a separate tract or lot and held in common ownership by a homeowners association, agency or non-profit organization; or, it can be included into lots owned by adjacent landowners.

The second option is often pursued by a developer who wants to divide the buffer among individual lots in order to achieve a required minimum lot size. However, a study by Cooke (in Castelle et al., 1992) of buffer areas in two counties in western Washington showed that buffers that were owned by many different lot owners were more likely to be degraded over time. Even with easement language on each lot owner's deed specifying the buffer protection provisions, owners tend to clear buffer vegetation over time to expand lawns, build storage sheds or serve other uses. If the buffer area is not held in some kind of common ownership, it is much more difficult to enforce against those landowners who encroach upon its boundaries. Therefore, when feasible, wetlands and their buffer areas should be placed in a separate, non-buildable tract that is owned and maintained by an organization that is dedicated to protecting the buffer.

Buffer delineation, recording & signage

Clearly delineating and marking a buffer area helps ensure that it is not degraded over time. Following project approval, and prior to site construction, the buffer should be measured, recorded on applicable legal documents, and clearly marked on the ground. During the construction phase, constructing a temporary sediment fence or "clearing limits" fence helps to ensure that the boundary is seen by equipment operators and that the wetland and buffer are protected from erosion during construction. Following construction, a fence may still be desirable to demarcate the boundary and to limit human and pet access and reduce the intrusion of noise and light.

Placement of signs along the buffer boundary is important for two reasons: to help mark the boundary and to help educate landowners about the purpose and value of protecting buffer areas. In areas with high potential for human intrusion and degradation of the buffer, more extensive signage explaining the value of the buffer may be necessary to develop support for protecting the buffer. In addition to signs, brochures can be developed and distributed to adjacent landowners to explain the reasons why buffers and wetlands are protected and what human activities are allowed. Typically, applicants are responsible for developing and constructing fences and signs and for distributing educational materials. However, local jurisdictions can develop standards for fences, signs and educational materials to ensure consistency and effectiveness. Maintenance of fences and signs is typically the responsibility of the adjacent land owner or a homeowners association, if applicable, or lies with the local jurisdiction.

Buffer maintenance

In cases where enhancement or restoration of a buffer is required, monitoring and maintaining the buffer area is essential. A monitoring/maintenance program should include evaluation of vegetation planting success and provide for contingency measures if vegetation survival standards are not met. Responsibility for this is usually born by the developer or landowner. It is also important to monitor buffer areas when human use is allowed or expected. Adverse effects of human access such as vegetation trampling, littering and soil compaction or erosion should be evaluated periodically by a monitoring program and corrected if found. Local jurisdictions can develop and implement a buffer maintenance and monitoring program but few have done so. Alternatively, applicants can be required to monitor and maintain buffers and submit regular reports to the local jurisdiction.

Buffer enforcement

Simply designating and marking the boundaries of buffer areas is not sufficient to protect buffers in all cases. Regular monitoring of buffer areas is critical to determine whether vegetation and soils are being impacted and to ensure that adjacent development does not encroach on the buffer over time. Where illegal activities occur, enforcement actions to restore the buffer may be necessary. Local jurisdictions should establish a buffer enforcement program similar to enforcement programs for private stormwater or wastewater facilities.

This chapter has outlined the primary buffer regulation and management issues a local government should consider. Chapter 4 presents model language for three different approaches to determining appropriate buffers.

Chapter 4 - Buffer Protection Policies, Regulations and Methods Based on Best Available Science

Some local governments in Washington have staff with the expertise to evaluate scientific information on wetland buffers and to develop protection programs that include the best available science. Most local governments, however, lack staff with wetlands expertise and must rely on guidance or models developed by others. This chapter integrates the best available scientific information outlined in chapter 2 with the approaches outlined in chapter 3 to provide recommended buffer protection and management language for local policies and regulations. With minimal effort, a local government can take this language and refine it to fit within their existing critical area policies and regulations.

In addition to policy language and general standards that should be included in any buffer regulations, this chapter provides three different options for determining appropriate buffer widths to protect wetland functions and values. A local government can select the buffer width determination method that best meets its needs, taking into account the expertise of staff, the amount of time and effort they want staff to devote to site-specific evaluations, and the degree of predictability they want to provide to the regulated community.

Model Buffer Policies

Few local governments in Washington have adopted specific policies for buffer protection for wetlands or other critical areas. Buffer policies can be included in comprehensive plans and/or in development regulations. Examples of buffer policy statements include the following:

1) buffer protection should be based on sound science;
2) flexibility should be provided to address site-specific situations;

3) buffer standards, and criteria for varying from standards, should be predictable for landowners;

4) staff implementing the buffer programs should be well-trained;

5) non-regulatory incentives should be used to encourage landowners to protect buffers where regulation is impractical or onerous; and

6) buffer protection should be balanced with allowing reasonable use of private property.

Model Buffer Regulations

Wetland buffer regulations are generally located in a wetlands section of critical area regulations. Many of the standard requirements for wetland buffers will be applicable to other critical areas. Thus, much of the language in this section can be applied to any type of buffer and could be included in any section of local regulations that addresses buffers for critical areas.

Definition & Purpose Statement

Buffers are designated areas adjacent to a regulated wetland (or other critical area) that protect it from impacts of adjacent human activities. Generally, buffers are areas of native vegetation that are maintained in a natural state. Buffers protect wetlands from adjacent development by filtering surface water and shallow groundwater runoff, screening noise, light and activity, reducing human and pet intrusion, and providing upland habitat critical to the survival of wetland wildlife species.

General Buffer Standards

**Note: recommended widths in this chapter are expressed in feet rather than meters because state and local regulatory agencies and the regulated community in Washington calculate distances in English equivalents rather than metric.*

a. Buffers shall be required for all regulated wetlands, including those created or restored as compensation for approved wetland alterations.

b. Buffer width should be determined based on the method described in section _

c. Buffer width shall be measured horizontally from the wetland boundary as determined in section _.

d. A building setback zone of 15 feet is required from the outer edge of the wetland buffer. Minor structural intrusions into the building setback zone may be allowed by the (approval authority) based on a determination that such intrusion will not adversely impact the wetland or its buffer.

e. Except as otherwise specified, wetland buffer areas shall be retained in their natural condition. Where buffer disturbance has occurred, revegetation with native species may be required.

f. Buffer areas shall be protected through a permanent legal instrument such as a deed restriction or conservation easement.

g. The location of the outer edge of the buffer shall be marked in the field prior to any construction activity adjacent to the buffer, in such a way as to ensure that no unauthorized intrusion into the buffer will occur; and shall be maintained throughout the duration of any construction activities. Permanent fencing may be required on a site- specific basis.

h. A permanent physical demarcation of the outer edge of the buffer shall be erected prior to occupation of the adjacent property and maintained in perpetuity. Such demarcation may consist of fencing or signage as approved by the (approval authority). Buffer identification signs must be posted at an interval of one per lot or every 100 feet, whichever is less, and must be maintained in perpetuity. At a minimum, signs must identify the area behind the sign as a protected wetland buffer and state that disturbance of vegetation or soils is prohibited.

Permitted uses within buffers

The following activities shall be permitted within a wetland buffer to the extent they are not prohibited by any other applicable law and provided they are conducted in a manner as to minimize impacts to the buffer and adjacent wetland:

a. Conservation or restoration activities aimed at protecting the soil, water, vegetation or wildlife;
b. Passive recreation, including walkways or trails located in the outer 25% of the buffer area, wildlife viewing structures, and fishing access areas, provided these are designed and approved as part of an overall site development plan;
c. Educational and scientific research activities provided prior approval is obtained from the (approval authority);
d. Normal and routine maintenance and repair of any existing public or private facilities provided appropriate measures are undertaken to minimize impacts to the wetland and its buffer and that disturbed areas are restored immediately to a natural condition.

The following activities may be permitted within a wetland buffer for Category 3 or 4 wetlands (based on the Dept. of Ecology Wetland Rating Systems (Ecology, 1991), provided they are not prohibited by any other applicable law, they are conducted in a manner as to minimize impacts to the buffer and adjacent wetland, and written approval is obtained from the (approval authority):

a. Stormwater management facilities, limited to stormwater dispersion outfalls and bioswales, may be allowed within the outer 25% of the buffer of a Category 3 or 4 wetland, provided that a determination is made that no other location is feasible, and the location of such facilities will not have an adverse impact on the functions and values of the wetland.

Reasonable use criteria

If a property owner demonstrates that application of standard buffer regulations would deny all reasonable economic use of the property, the buffer width may be reduced by the (approval authority). The buffer width shall be reduced as needed to allow reasonable economic use, only if all of the following are demonstrated:

1) that no feasible on-site alternative design is possible that would allow for reasonable economic use of the parcel without reducing the buffer; and
2) that buffer averaging and buffer enhancement including fencing where appropriate, have been utilized to the full extent practicable to maintain the most effective buffer possible; and
3) that the buffer reduction will not adversely affect threatened or endangered plant or animal species; and
4) that the buffer reduction will not result in damage to nearby public or private property nor threaten the health or safety of people on or off the property; and
5) that the inability to derive reasonable economic use of the property is not the result of actions in segregating or dividing the property, thus creating the undevelopable condition after the effective date of these regulations.

Methods of Establishing Buffer Widths

Following are three different methods of determining buffer widths for individual wetlands. As described in chapter 3, a variety of approaches can be utilized, ranging from a single, standard buffer width for all wetlands to determining widths on a case-by-case basis. Most local jurisdictions will want to select an method that lies somewhere between these two extremes. The three methods presented below were developed to provide a range of options for local governments to consider.

Basic Buffer Method

This method is very similar to the Department of Ecology's recommended model that was developed in 1990 (Ecology, 1990). It bases standard buffer widths on intensity of land use and wetland category as determined by a four-tier wetland categorization system (see Appendix A for the criteria for each category). These standard widths can be adjusted up or down based on site-specific criteria. This method has been modified slightly from the Ecology model based on review of other local government programs and discussions with other wetland specialists. The advantages of this method are that: 1) it is relatively simple to apply; 2) it provides predictable buffer widths as well as some flexibility to address site-specific conditions; and 3) it is similar to many existing local government buffer determination methods. The disadvantages are that: 1) it does not take into account the condition of the buffer area and, thus, may prescribe a buffer width that is greater or lesser than necessary; and 2) it divides wetlands into categories based on an established rating system which was not designed specifically for buffer width decisions. The latter means that some wetlands in one category may need buffers as wide as a wetland in a higher category or as narrow as a wetland in a lower category. These disadvantages result in the need to apply variance procedures involving time consuming site-specific evaluations in order to arrive at an appropriate buffer width. Nevertheless, this type of approach is widely used in Washington, has been subjected to broad peer review, and has been accepted thus far as incorporating the best available science. The widths expressed below are generally consistent with the findings in chapter two regarding the best available science.

Standard Buffer Widths

The width of wetland buffer zones shall be determined based on wetland category and proposed land use as follows:

Category I wetland

High intensity land use	300 feet
Low intensity land use	200 feet

Category II wetland

High intensity land use	200 feet
Low intensity land use	100 feet

Category III wetland

High intensity land use	100 feet
Low intensity land use	50 feet

Category IV wetland

High intensity land use	50 feet
Low intensity land use	25 feet

Wetland categories are determined based on the Department of Ecology's Wetland Rating Systems for Eastern (Dept. of Ecology, 1991) and Western Washington (Dept. of Ecology, 1993).

High intensity land uses include those that are associated with moderate to high levels of human disturbance including, but not limited to, residential development at greater densities than 1 unit per 5 acres, including all multi-family residential development, commercial and industrial development, and active recreational development such as ball fields.

Low intensity land uses include those that are associated with low levels of human disturbance including, but not limited to, residential development at densities of 1 unit per 5 acres or less, agricultural or silvicultural activities, passive recreational development, and open space.

Increasing standard buffer widths

Standard buffer widths may be increased on a case-by-case basis when it is determined that a larger buffer is necessary to protect wetland functions and values based on site-specific characteristics. This determination shall be supported by documentation provided by the (approval authority) showing that an increased buffer is necessary based on one or more of the following criteria:
1) a larger buffer is needed to maintain existing documented use by wildlife species; or
2) the buffer or adjacent uplands are susceptible to severe erosion and standard erosion-control measures will not prevent adverse impacts to the wetland; or
3) the buffer area has minimal vegetative cover and has a slope greater than 15%.

Decreasing standard buffer widths

The (approval authority) may decrease standard buffer widths on a case-by-case basis when it is determined that a smaller area is adequate to protect wetland functions and values based on site-specific characteristics. This determination shall be supported by documentation provided by the applicant showing that a reduced buffer is adequate based on one of the following criteria:

a. an enhancement plan by a qualified wetlands specialist demonstrates that an enhanced buffer with native vegetation plantings will improve buffer functions to the point where a reduced width will provide equal or better protection of wetland functions and values than the standard width without enhancement. The city/county may require long-term monitoring of the buffer and wetland with appropriate contingency actions if adverse impacts to the wetland occur.; or

b. the existing buffer area is vegetated with greater than 90% areal cover of native species and has a slope of less than 5% and a report by a qualified wetlands specialist demonstrates that a smaller than standard buffer will provide all of the buffer functions necessary to protect all functions and values of the wetland. The city/county may require long-term monitoring of the buffer and wetland with appropriate contingency actions if adverse impacts to the wetland occur.

In no case shall the standard buffer width be reduced by more than 50%, or the buffer width be less than 25 feet.

Buffer Averaging

The (approval authority) may modify standard buffer widths on a case-by-case basis by averaging buffer widths. Averaging of buffer widths may be allowed where the applicant demonstrates through a report by a qualified wetlands specialist that either: a) averaging is necessary to avoid an extraordinary hardship to the applicant caused by circumstances peculiar to the property; or b) the wetland contains variations in sensitivity due to existing physical characteristics, and it would benefit from a wider buffer in places and would not be adversely impacted by a narrower buffer in other places; or c) the character of the buffer varies in slope, soils or vegetation and the wetland would benefit from a wider buffer in places and not be adversely impacted by a narrower buffer in other places

AND all of the following criteria are met:

i. that averaging the buffer width will not result in adverse impacts to the functions and values of the wetland; and

ii. that the total area contained within the buffer after averaging is no less than that which would be contained within the standard buffer; and

iii. in no instance shall the buffer width at any point be reduced by more than 50% of the standard width, nor less than 25 feet.

The Basic Method is a straightforward way of determining standard buffer widths and similar approaches are used widely by local governments in Washington. However, although this method requires little staff time or expertise to arrive at the standard buffer widths, local governments must be prepared for frequent requests by applicants for variances from the standard widths.

Applicants will often request reduced buffers based on site-specific buffer conditions. These requests can require considerable staff time and expertise to review and make variance decisions. The next method described can help alleviate some of this burden by incorporating buffer conditions into the initial determination of buffer widths.

Advanced Buffer Determination Method

The Advanced Buffer Determination Method provides a practical alternative to the Basic Method. It incorporates three primary factors that the scientific literature says are important in deciding on appropriate buffers to protect wetland functions: 1) wetland type; 2) type of adjacent land use; and 3) buffer characteristics. The primary advantage of this method is that it prescribes a buffer width that is more tailored to the specific characteristics of the site being evaluated without the need for a special study by a wetlands specialist.

Use of the Advanced Method will result in a more site-specific and scientifically supportable buffer width than the Basic Method, while still providing a high level of predictability for landowners. It also removes much of the subjectivity and debate that may accompany attempts to design site-specific buffers using the Basic Method.

The disadvantages of the Advanced Method are that: 1) it requires an evaluation of buffer characteristics prior to identifying an appropriate width; and 2) wetland types are divided differently than most existing wetland rating systems in use in Washington.

The Advanced Method of determining buffer widths derives from the practice of developing environmental decision-making models, also known as "multiple criteria assessment" models (Hruby, 1999). These types of models are based on the selection and scaling of key variables that are known to be related to the system or process being modeled. The variables and their scaling are founded on hypotheses about how the variables combine to determine an appropriate buffer width, since specific, quantitative data about the relationships between the variables are lacking. The variables in the Advanced Method (wetland type, land-use intensity, and buffer slope, soils and vegetation) were selected and scaled by the author following analysis of the scientific literature. The buffer widths were selected based on the literature and the author's judgment that these widths would ensure a low level of risk that a wetland's functions would be impaired. This same method could be applied using greater or lesser buffer widths if one were willing to assume a greater or lesser level of risk.

Applying the Advanced Method requires that one determine the wetland type and land use intensity adjacent to the wetland using the descriptions below, evaluate the buffer area using the buffer scoring model (Table 6), and determine the buffer width using Table 5.

Table 5 illustrates the primary factors and recommended buffer widths of this approach. The land uses, wetland types and buffer scoring method are defined below.

Table 5 - Advanced Buffer Width Determination Method

Land Use		Wetland Type A			Wetland Type B			Wetland Type C		
	Buffer Score	***3-4***	***5-7***	***8-9***	***3-4***	***5-7***	***8-9***	***3-4***	***5-7***	***8-9***
High intensity	(buffer	350	300	250	250	200	150	125	100	75
Moderate "	widths	250	200	150	200	150	100	100	75	50
Low intensity	in feet)	200	150	100	150	100	75	75	50	25

Land Use definitions

High intensity: High intensity land use includes those that are associated with moderate to high levels of human disturbance, including but not limited to residential development at greater densities than 1 unit per 5 acres, including all multi-family residential development, commercial and industrial development and active recreational development such as ball fields.

Moderate intensity: Moderate intensity land use includes those that are associated with moderate levels of human disturbance, including but not limited to residential development at densities of 1 unit per 5 acres or less, and agricultural activities.

Low intensity: Low intensity land use includes those that are associated with low levels of human disturbance, including but not limited to silvicultural activities, passive recreational development, and open space.

Wetland Types

Wetland types are divided into three categories based on three primary factors: 1) sensitivity to inputs of nutrients or toxic substances; 2) sensitivity to human disturbances (noise, light, intrusion); and 3) likely presence of wetland-dependent wildlife species needing adjacent upland habitat to meet critical life needs. The criteria for placing a wetland in one of the three categories are based on the Washington State Wetland Rating System (Ecology, 1993) and are found in Appendix A. (These three categories differ from the four categories found in the Ecology rating system because this approach is based solely on buffer needs whereas the Ecology rating system addresses buffers, mitigation ratios and impact avoidance.) For purposes of establishing buffer widths, this type of wetland categorization scheme is more consistent with the best available science than the Ecology rating systems because it groups wetlands based solely on their need for buffering from adjacent land uses.

Wetland Type A

This category contains:

1. All Category 1 wetlands
2. Category 2 wetlands with open water*
3. Category 2 estuarine wetlands

Wetland Type B

This category contains:

1. Category 2 wetlands without open water*

2. Category 3 wetlands with open water*

3. Category 3 estuarine wetlands

Wetland Type C

This category contains:

1. Category 3 wetlands without open water*

2. Category 4 wetlands

** Open water means any area of standing water present for more than one month at any time of the year without emergent, scrub-shrub or forested vegetation. [This definition is consistent with the Washington State Wetland Rating System (Ecology, 1993).]*

Buffer Score

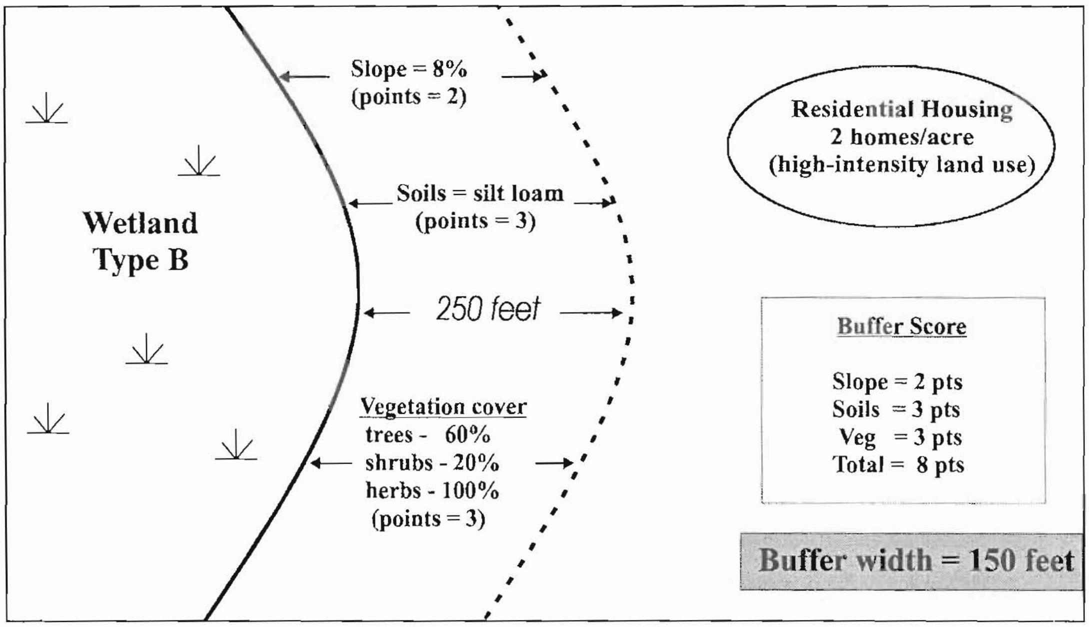
The buffer score takes into consideration three primary factors (slope, soils, and vegetation) that determine how well a buffer removes sediment, nutrients, and toxic substances, screens out adjacent human disturbances, and provides shading, microclimate protection, and general wildlife habitat. The buffer score is determined by adding scores from the three categories outlined in Table 6 below. These criteria should be applied to the existing buffer area within the maximum buffer width based on the type of wetland at issue (350 feet for Type A, 250 feet for Type B, 125 feet for Type C; Table 5). One does not need to apply these criteria to the buffer area around the entire perimeter of the wetland unless the proposed project surrounds the entire wetland. However, one must determine whether the slope, soils and plant community are uniform across the buffer. (See Appendix B for definitions of terms and guidance on how to address buffers that vary in slope, soils or plant community.)

Table 6 - Buffer Score Method						Total Score
Slope*	pts.	**Soils***	pts.	**Vegetation***	pts.	
>10% avg	= 1	Sand, loamy sand, clay or silty clay	= 1	Bare ground > 30% or Impervious surface > 20% or Herbaceous vegetation with < 30% shrub/tree cover	= 1	
5-10 % avg	= 2	Sandy clay, sandy clay loam, silty clay loam, or clay loam	= 2	Conditions other than described above or below	= 2	
<5% avg	= 3	Loam, silt loam or sandy loam	= 3	Tree cover > 50% with shrub cover > 50% or Tree cover 50% with herb cover > 80% or Shrub cover > 80%	= 3	

* See Appendix B for definitions of terms and guidance and examples of how to determine buffer scores.

Figure 1, below illustrates how the Advanced Buffer Determination Method can be applied to a hypothetical site.

Figure 1. Example of Applying the Advanced Buffer Determination Method



Application of this method will result in a buffer width that is adequate to protect a wetland's functions, based on site-specific characteristics. However, local governments that choose to use this type of method may want to include the language outlined under the Basic Method above for increasing or reducing buffer widths to address those few instances in which an even more detailed, site-specific approach is necessary. Additionally, buffer averaging and reasonable use exception language above should be included with the Advanced Method.

While the Advanced Method requires more data collection than the Basic Method to determine a buffer width, it should save local government staff time because the extra data collection costs are typically born by the applicant, and requests for variances will be less frequent, since the prescribed buffer widths are based on more site-specific information. However, occasions will arise that necessitate a more detailed, site-specific analysis and the method described below is designed for such occasions.

Making site-specific determinations of buffer widths

Most local governments likely will utilize an approach similar to one of the two options described above because these approaches provide predictability for applicants and take less staff time and expertise to implement. However, given the lack of precision involved in categorizing wetlands, land uses, and buffer characteristics, it may be appropriate to make a site-specific determination to arrive at an optimum buffer. From the landowner or project applicant standpoint, an optimum buffer generally will be the smallest that is absolutely necessary to protect the wetland's functions. From the resource protection standpoint, an optimum buffer will be the one that ensures little or no risk to the wetland and the functions it provides.

The buffer widths included in the two methods above are designed to provide a buffer that ensures a low level of risk to the wetland based on a general understanding of the wetland's functions. However, all wetlands, even those in the same category, function differently. Likewise, similar land uses can have distinctly different levels of impact on wetlands depending on site-specific practices. Additionally, local government staff frequently need to evaluate land owner requests to increase or decrease standard buffers based on site-specific information.

A site-specific approach to determining buffers allows for consideration of more detailed information. However, making a site-specific determination requires collection and evaluation of considerably more data than applying a standardized approach. The site-specific method described below provides a standard format for collecting and evaluating site-specific information to help in determining an appropriate buffer. With this format, the results can be quickly reviewed for accuracy and adequacy. This method could be used as the primary basis for determining buffers or to make decisions about increasing or decreasing a standard buffer width as determined by one of the two methods described above. However, use of this method requires that one exercise substantial judgment in evaluating the data collected and arriving at a final decision regarding buffer width.

Site Specific Buffer Determination Method

The method outlined below for making site-specific buffer determinations follows a five-step data gathering and evaluation process. Each step requires that site-specific data be collected and/or evaluated by a person or team with expertise in wetland ecology. This will most typically be conducted by a consultant hired by a project applicant. This information should be provided to the appropriate decision-maker in the form of a report and the decision-maker should ensure that someone with appropriate expertise reviews the report for accuracy and adequacy.

STEP 1: Describe the wetland's characteristics by filling out the table below.

The information in Table 7 will provide a general description of the wetland including basic physical characteristics that contribute to a wetlands functions as well as more specific information on wildlife species expected to use the wetland. This information will help in determining the wetland's needs for buffering from adjacent land uses.

Table 7 - Wetland Characteristics		
Record the following information about the wetland under consideration.		
1	Wetland area (in acres)	
2	Wetland rating (class/category) and name of rating system	
3	Hydrogeomorphic Class (riverine, depressional, slope, lacustrine fringe, estuarine fringe)	
4	Cowardin classes present (forested, scrub/shrub, emergent, open water, aquatic bed)	
5	Area of permanent open water	
6	Area of seasonal open water	
7	Area of vegetated standing water	
8	Source(es) of water input to the wetland	
9	Threatened, Endangered, Sensitive or rare plant species present	
10	Threatened/, Endangered, Sensitive or rare animal species present	
11	Known or expected bird species utilizing the wetland as habitat	
12	Known or expected mammal species utilizing the wetland as habitat	
13	Known or expected fish species utilizing the wetland as habitat	
14	Known or expected herptile species utilizing the wetland as habitat	

STEP 2: Describe the level of impact from adjacent development and measures to be taken to minimize impacts

Table 8 - Description of Potential Development Impacts		
15	Describe the type of development	
16	Describe how surface water runoff will be addressed including plans for treatment and release to wetlands or streams.	
17	Describe how surface runoff will affect the hydroperiod of the wetland and what pollutants might be introduced into the wetland.	
18	Describe the potential for noise and light to affect the wetland and steps taken to reduce noise and light impacts on the wetland.	
19	Describe the potential for human and pet intrusion into the wetland and steps taken to minimize intrusion.	

STEP 3: Describe the characteristics of the buffer

Table 9 - Buffer Characteristics			
Evaluate the area within 300 feet of the wetland edge in the vicinity of the proposed development and answer the questions below. Make a drawing to answer questions 21-22			
	SOILS		
20a	Described the mapped soil type including horizons, texture and drainage class.		Draw a typical soil horizon (0-20") for the buffer soils
20b	Do field observations confirm the mapped soil type?		
20c	If not, describe soil type observed in the field including horizons, texture and drainage class.		
	SLOPE		
21	On a drawing of the buffer area, show areas where the slope is:	<5% 5% - 10% >10%	
	VEGETATION		
22	On a drawing of the buffer area, indicate approximate percent of areal cover of each vegetative strata as well as bare areas and areas with buildings or impervious surfaces	Strata Tree Shrub Herbaceous Bare Buildings/impervious	
23	Describe measures that could be taken to improve the functioning of the buffer area.		

STEP 4: Determine the buffer functions and width needed to protect the wetland

Table 10 - Buffer Functions			
Based on the information recorded in Tables 7, 8 and 9 above, determine which buffer functions are needed to protect the wetland. For each function determined to be needed, describe the width necessary to protect the wetland and provide a rationale for the width selected. Include a description of enhancement activities proposed to improve the buffer or otherwise protect the wetland.			
Buffer Function	**Needed? Y/N**	**Needed Width & Rationale**	**Buffer or Site Enhancement**
Sediment removal			
Nutrient removal			
Toxics removal (specify type of toxic substance)			
Shading & microclimate protection			
Screening noise, light, intrusion			
General wildlife habitat			
Habitat for particular species			

STEP 5: Determine the appropriate width of buffer and enhancement actions necessary to protect the wetland.

Summary (Describe the overall width needed to protect the wetland & a summary of the enhancement actions needed)	

Currently, most site-specific buffer determinations are conducted by consultants for project applicants. The consultants provide a short narrative statement advocating a particular buffer width based on certain wetland or buffer characteristics. Rarely do these reports contain the detailed information necessary to adequately determine an appropriate buffer, and thus, it is difficult to refute or concur with the recommendation provided by the report. The five-step process outlined above provides a "transparent" method for determining site-specific buffers. This process provides all of the relevant documentation and rationale needed to make a site-specific buffer determination and displays it in a manner that is easy to review.

A local government will need to allocate considerable staff time and expertise if the Site-specific Method is used as the primary means of determining buffer widths. Even if applicants provide all of the data required for this method, local government staff will need to have the time and technical expertise to review each buffer determination and corroborate the conclusions. Thus, this method will be most helpful when used in conjunction with one of the other two methods described above. Then, it would only be applied in those few cases when the applicant or local government believes that the buffer prescribed by the Basic or Advanced Methods is wider or narrower than is scientifically justified.

Conclusion

The best available scientific information unequivocally states that buffers are necessary to protect and maintain the water quality, habitat, and hydrologic functions of wetlands. The best available science also outlines four primary factors to be considered in determining appropriate buffer widths: 1) the quality, sensitivity and functions of the aquatic resource; 2) the nature of adjacent land use activity and its potential for impacts on the aquatic resource; 3) the character of the existing buffer area (including soils, slope, vegetation, etc.); and 4) the intended buffer functions. Given the tremendous variability of wetland types, land uses and buffer conditions across the landscape, developing a single buffer width that is appropriate for all situations is not possible. Thus, methods are needed that will take into account these primary factors and prescribe appropriate buffer widths.

However, regulatory buffer methods must provide some level of predictability for land owners and must be easy to apply. The three methods of determining wetland buffers outlined above provide methods that incorporate the best available science and are practical for regulatory programs. A local government or any other entity can select the method that best fits its needs and feel confident that the method will provide a scientifically sound approach to determining wetland buffers.

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Appendix A

Summary of Rating System Criteria by Category and Data Sources

Criteria for Each Category	Data Sources
Category I Wetlands are:	
i) Those that have a documented occurrence in the wetland of a federal or state listed endangered or threatened plant, ...	DNR Natural Heritage Program
animal, or fish species; or	WA Department of Fish & Wildlife
ii) High quality native wetland communities which qualify for inclusion in the Natural Heritage Information System; or	DNR Natural Heritage Program
iii) Documented as regionally significant waterfowl or shorebird concentration areas; or	WA Department of Fish & Wildlife
iv) Wetlands with irreplaceable ecological attributes; or	Field Data Form
v) Documented wetlands of local significance.	Local Government
Category II Wetlands satisfy no Category I Criteria <u>and</u> are:	
i) Those that have a documented occurrence in the wetland of a federal or state listed sensitive plant, ...	DNR - Natural Heritage Program
animal, or fish species; or	WA Department of Fish & Wildlife
ii) Those that contain priority species or habitats recognized by state agencies; or	WA Department of Fish & Wildlife
iii) Wetlands with significant functions which may not be adequately replicated through creation or restoration; or	Field Data Form
iv) Wetlands with significant habitat value of 22 or more points; or	Field Data Form

Criteria for Each Category	Data Sources
Category III Wetlands satisfy no Category I, II, or IV criteria and are:	
i) Wetlands with significant habitat value of 21points or less; . . or	Field Data Form
ii) Documented wetlands of local significance.	Local Government
Criteria IV Wetlands satisfy no Category I, II, or III criteria, and are:	
i) Wetlands less than 1 acre and, hydrologically isolated and, comprised of one vegetated class that is dominated (> 80% areal cover) by any species from the list in Table 4 (see Rating System document).. or,	Field Data Form
ii) Wetlands less than two acres and hydrologically isolated, with one vegetated class, and > 90% of areal cover is any combination of species from the list in Table 3 (see Rating System document) ..... or,	Field Data Form
iii) Wetlands that are ponds excavated from uplands and are smaller than 1 acre without a surface water connection to streams, lakes, rivers, or other wetlands throughout the year; and that have less than 1/10 acre of vegetation.	

Source: Washington State Wetland Rating System, published by the Washington State Department of Ecology, Publication No. 93-74.

Appendix B
Guidance on Determining the Buffer Score for the Advanced Buffer Method

The following guidance is intended to help a user apply the Advanced Buffer Method for determining wetland buffers. This method requires the collection and evaluation of data on the wetland type, proposed land uses and existing or enhanced buffer conditions. The criteria and methods for determining the wetland type are found in the Washington State Wetland Rating System documents published by the Washington Department of Ecology (Ecology, 1993). The definitions of land uses are found in the body of Chapter 4. This appendix provides definitions and guidance determine the appropriate buffer score based on slope, soils and vegetation.

Buffer Score

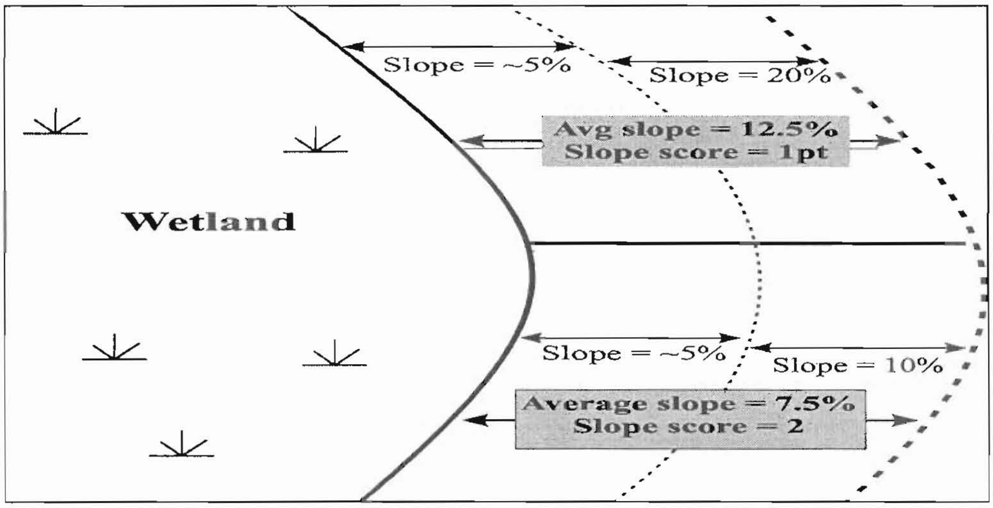
Once the wetland type and adjacent land use are determined, the buffer score can be calculated. To calculate the buffer score, evaluate the area adjacent to the wetland within the maximum width required for the wetland type and land use in Table 5. (e.g. for a Type B wetland and a high-intensity land use, the evaluation area would be 250 feet.) It will help to draw a map of the area and sketch in the vegetation, soil and slope characteristics as in the figures below.

Three characteristics of a buffer must be assessed in order to determine the buffer score. The buffer scoring method requires that one examine the buffer's slope, soils and vegetation and select the description from Table 6 that best fits the situation.

Slope - This is determined based on the percent grade of the buffer area between a flat surface (0%) and a vertical surface (100%). Many buffer areas will have a relatively uniform slope while others will vary in slope across the buffer. It is not necessary to determine the precise angle of the slope; rather, one must determine whether the average slope falls in the category of < 5%, 5-10%, or > 10%.

If the slope is not uniform perpendicular to the wetland edge, one must calculate the average slope across the buffer (see figure B-1). If the slope is not uniform parallel to the wetland edge, one should divide the buffer into segments based on the average slope perpendicular to the wetland edge and calculate a different slope score for each buffer segment (see figure B-1).

Figure B-1: Calculating buffer slope score

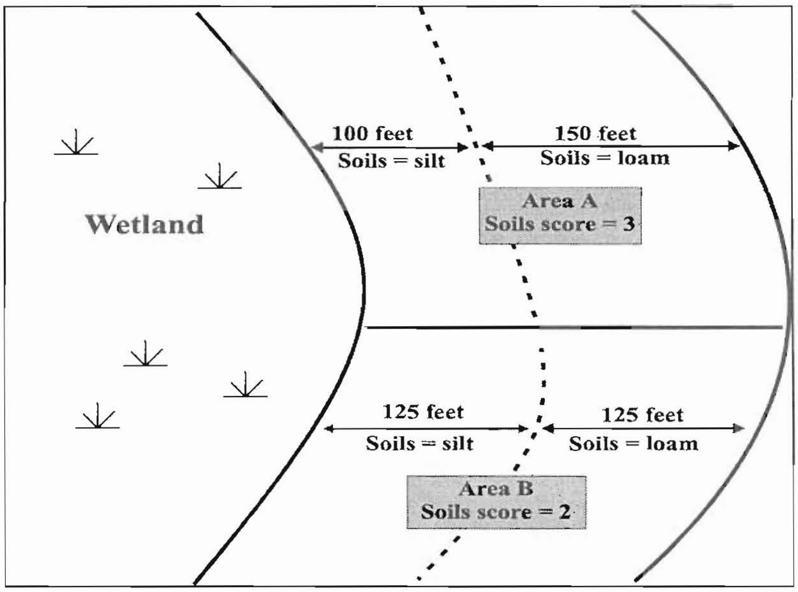


Soils - The soil score is based on the texture of the soil in the buffer area. Soils should be determined by consulting a soil survey document (such as a Soil Conservation Service survey) and making a site investigation. Since soil surveys are generally done at a very small scale, the mapped units are subject to inaccuracies. It is always important to confirm the mapped unit for a soil type by examining soils in the field to corroborate that they match the description in a soil survey. Soils should be examined to a depth of 3 feet.

Soil textures are determined based on the relative amounts of sand, silt, and clay in the soil. This is typically determined by the texture-by-feel-analysis. This involves wetting approximately 25 grams of soil and performing a serious of squeezing tests in one's hand to determine the relative texture (see Appendix C below). This test requires experience in analyzing different soil types and is best performed by a soil scientist. However, with a bit of experience and a little training from a soil scientist, anyone can learn to perform the test. Additionally, lab tests can be conducted to measure the precise percentages of sand, silt, and clay and determine the soil texture.

If soils are not uniform perpendicular to the wetland edge, one should base the buffer soil score on the soil type that constitutes the greatest percentage of the buffer area. If no soil type is dominant, use the soil type that scores lowest (see figure B-2). If soils are not uniform parallel to the wetland edge, divide the buffer into segments based on differences in the soil texture (see figure B-2).

Figure B-2: Calculating buffer soil score

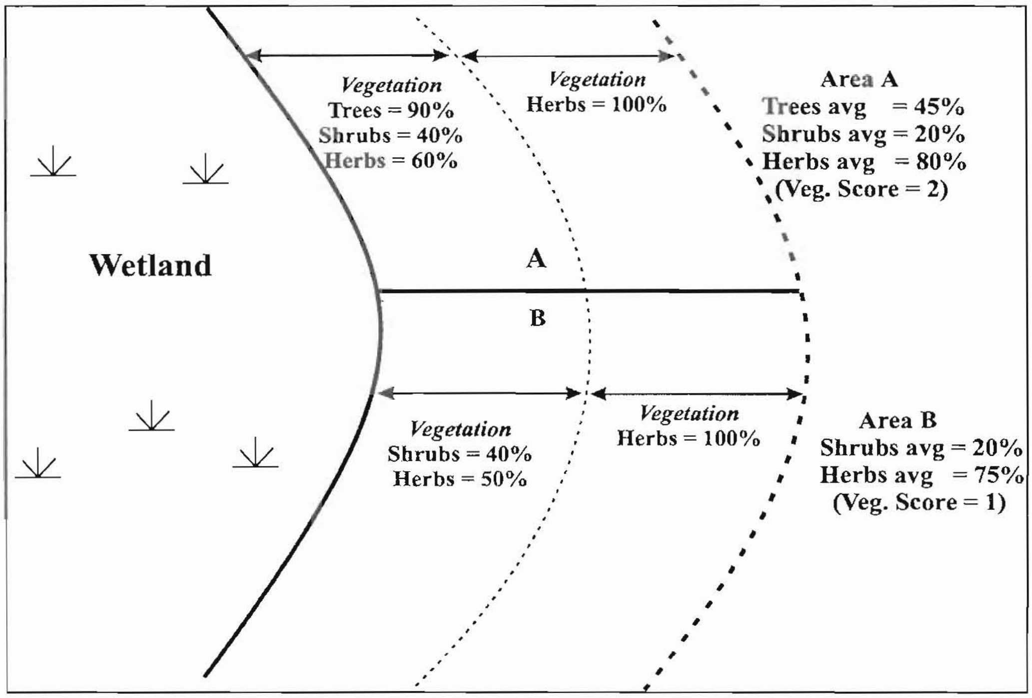


Vegetation - To determine the buffer vegetation score one must assess the entire buffer area and calculate the percent areal cover of each category of vegetation as follows:

- Impervious surface - pavement, asphalt, buildings or highly compacted bare ground.
- Bare ground - unvegetated soil or gravel
- Herbaceous strata - Non-woody vegetation such as grasses, forbs and mosses.
- Scrub-shrub strata - Woody vegetation less than 20 feet tall.
- Tree strata - Woody vegetation greater than 20 feet tall..

Once the areal cover is calculated, select the buffer vegetation description that most closely matches the area. If the vegetation is not uniform perpendicular to the wetland edge, calculate the buffer vegetation score based on an average for the entire buffer area (see figure B-3). If the vegetation is not uniform parallel to the wetland edge, divide the buffer area into segments based on differences in the vegetation. Then, calculate a buffer vegetation score for each segment (see figure B-3).

Figure B-3: Calculating buffer vegetation score



When scores have been calculated for each of the three buffer characteristics, they should be added together to produce the overall buffer score (see figure B-4). When non-uniformity of one or more of the buffer characteristics has necessitated dividing the buffer into segments, it will produce potentially different buffer scores for each segment. This may result in a buffer width that varies for each segment (see figure B-5).

Figure B-4: Calculating buffer score - general

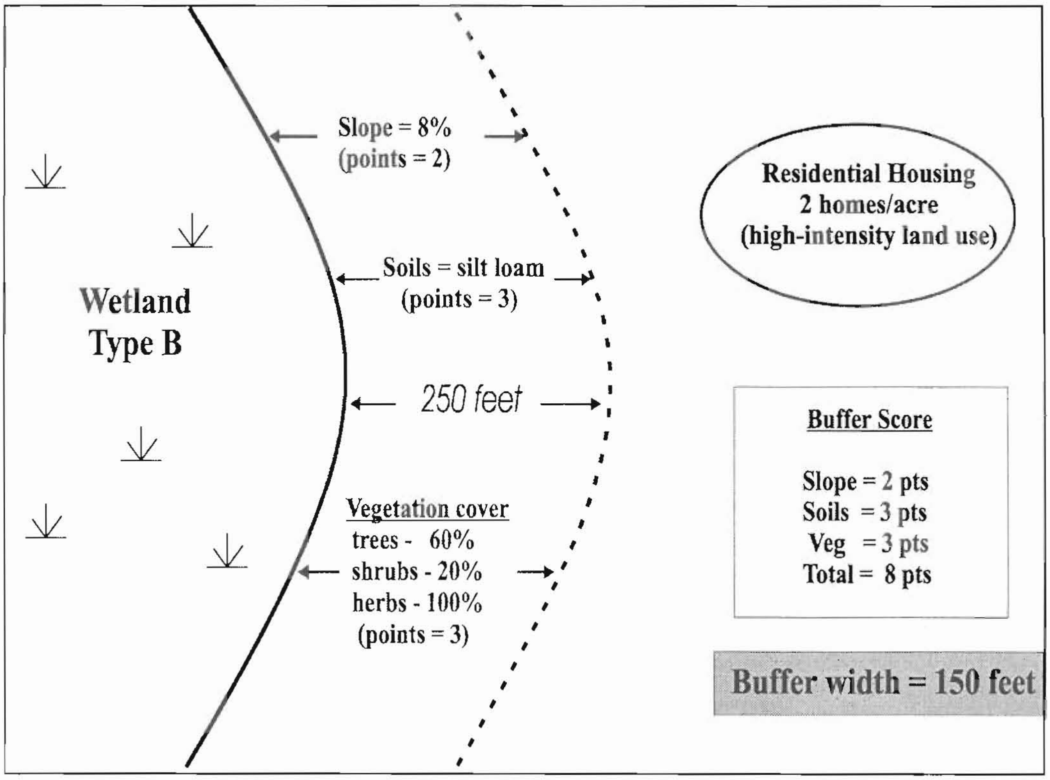
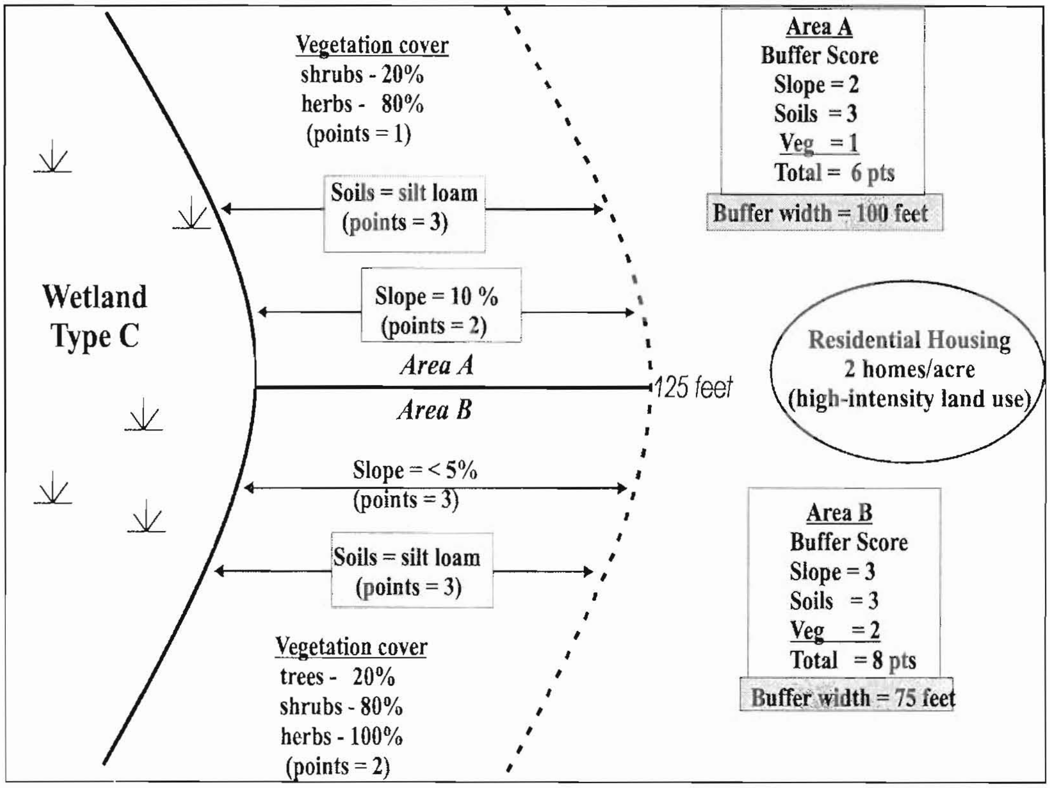


Figure B-5: Calculating buffer score - complex



Appendix C

Method for Determining Soil Texture

Texture-By-Feel Analysis