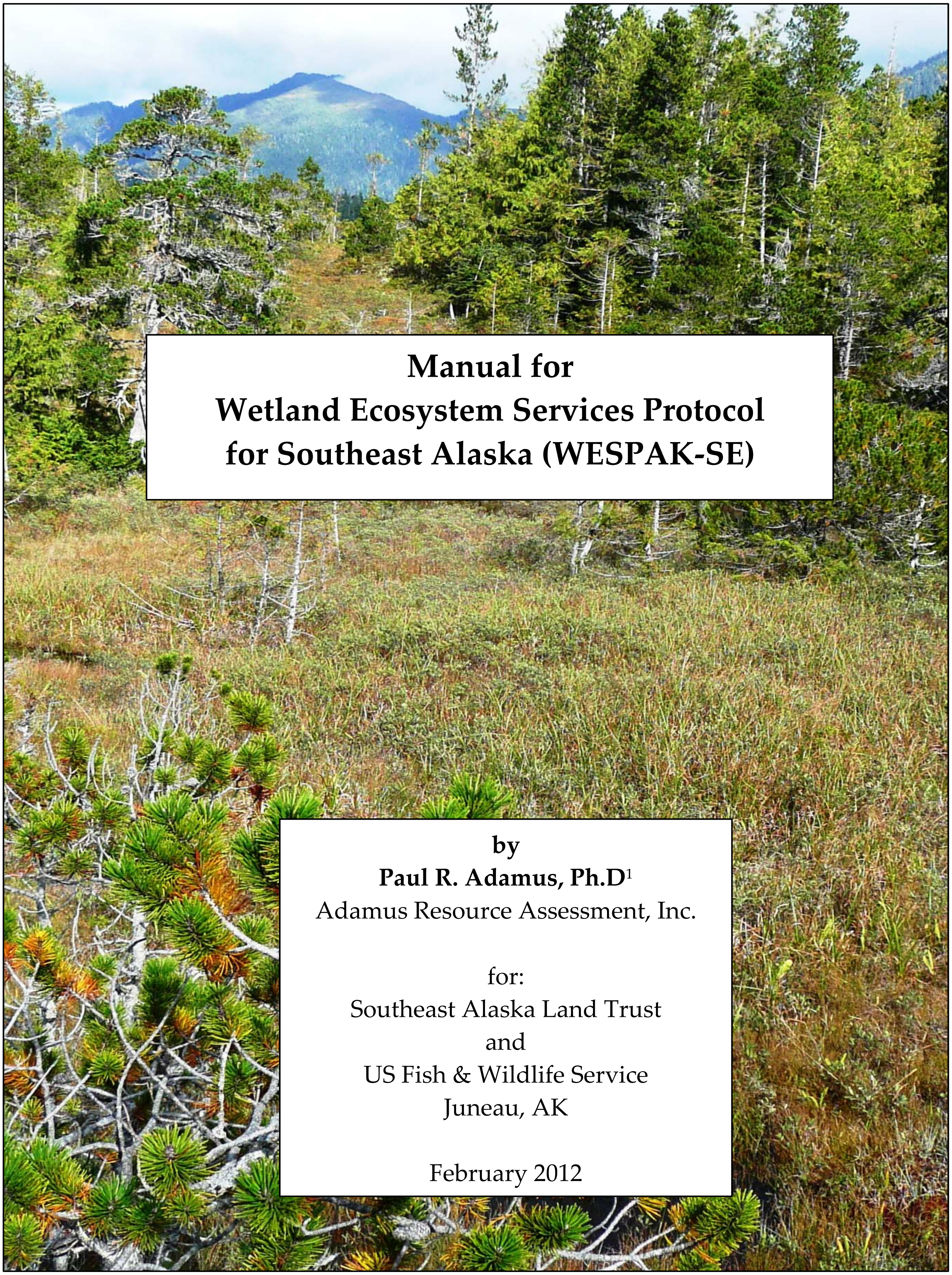

Manual for Wetland Ecosystem Services Protocol for Southeast Alaska (WESPAK-SE)

by

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for:

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Table of Contents

Appendices

1.0 Introduction

1.1 General Description

The Wetland Ecological Services Protocol for Alaska: Southeast (WESPAK-SE) is a science-based field method for rapidly assessing tidal and non-tidal wetlands of Southeast Alaska. Input data are categorical choices that are based on observations (not measurements) made during a single half-day visit to a wetland, as well as from interpretation of generally available maps and resource information. The data are entered into an Excel spreadsheet that instantly generates scores for 23 functions and values of a non-tidal wetlands, or 11 functions and values of a tidal wetland. For tidal wetlands, WESPAK-SE is applicable only to salt marshes and wooded tidal habitats, not to eelgrass, kelp, or other vegetated tidal habitats. Tidal wetlands are considered to include all wetlands inundated by tidal surface water at least once annually, e.g., during "king tides" regardless of their salinity. WESPAK-SE is applicable to wetlands at all elevations of Southeast Alaska, from Yakutat south to the Canadian border.
This Manual is not an operable version of WESPAK-SE. That is contained in accompanying Excel spreadsheets, one for non-tidal and one for tidal wetlands.

WESPAK-SE results may not always be more accurate than ratings of wetland sites made by someone who is a specialist on a particular function, particularly if they are experienced locally. However, such expertise is seldom routinely available to wetland regulators for every function of concern. Moreover, as a standardized approach, WESPAK-SE provides consistency and comparability when prioritizing wetlands or assessing the consequences of alterations on wetland ecosystem services.

WESPAK-SE uses assessments of weighted ecological characteristics (*indicators*) to generate scores for a wetland's functions and values. For non-tidal wetlands, up to 50 indicators are drawn from a pool of 125 to generate a score for 23 functions and values. For tidal wetlands, 11 functions and values are scored using up to 27 indicators from a pool of 85. Only tidal marshes and wooded tidal wetlands are included; eelgrass and kelp beds are not. The number of indicators that is applied to estimate a particular wetland function or value depends on what the function or value is. The indicators are combined using mathematical formulas (models) to generate the score for each wetland function or value. The models are logic-based rather than mechanistic. Together they provide a profile of "what a wetland does." WESPAK-SE indicators and models attempt to incorporate the best and most recent scientific knowledge available on the ecosystem services of wetlands.

Each indicator has a suite of *conditions,* e.g., different categories of percent-slope. For each wetland function or value, ranks have been pre-assigned to all conditions potentially associated with each indicator used to predict the level of that function or value. The ranks can be viewed in column E of the individual worksheets.

For most models of wetland functions, the indicators were grouped by the underlying *processes* they inform. Weights were then assigned both to individual indicators within a process, and the processes that comprise a function. Indicator and process selection was based on the author's experience and review of much of the literature he compiled initially in an indexed bibliography of science relevant to Southeast Alaskan ecosystem services (available electronically from SEAL Trust or the author).

For regulatory and management applications (e.g., wetland functional enhancement), it's often helpful to assign an indicator to one of four categories:

1. *Onsite modifiable*. These indicators are features that may be either natural or human-associated and are relatively practical to manage. Examples are water depth, flood frequency and duration, amount of large woody debris, and presence of invasive species. More important than the simple presence of these are their rates of formation and resupply, but those factors often are more difficult to control.
2. *Onsite intrinsic*. These are natural features that occur within the wetland and are not easily changed or managed. Examples are soil type and groundwater inflow rates. They are poor candidates for manipulation when the goal is to enhance a particular wetland function.
3. *Offsite modifiable.* These are human or natural features whose ability to be manipulated in order to benefit a particular wetland function depends largely on property boundaries, water rights, local regulations, and cooperation among landowners. Examples are watershed land use, stream flow in wetland tributaries, lake levels, and wetland buffer zone conditions.
4. *Offsite intrinsic*. These are natural features such as a wetland's topographic setting (contributing area size, elevation) and regional climate that in most cases cannot be manipulated. Still, they must be included in a wetland assessment method because of their sometimes-pivotal influence on wetland functions and values.

1.2 Conceptual Basis

WESPAK-SE provides models for both functions and values. It is very important to understand the conceptual difference. Functions are what a wetland potentially does, such as store water. Values attempt to answer the "So What?" question, partly by considering where a wetland is positioned relative to people or features that might benefit from its services, and whether its species or habitats have special designations. For example, when wetlands retain or remove nutrients, this can be valuable for protecting the quality of downstream waters in some settings (e.g., urban runoff impacts to estuaries) but undesirable in others (e.g., salmon rearing streams, where nutrients are needed to support algae and invertebrate components of the salmonid food chain). The Value score that WESPAK-SE computes accounts for these differences, separately from the Function score. In concept, wetland ecosystem *services* are the combination of *functions* and the *values* of those functions, judged individually. Thus, for a wetland to be considered as providing a high level of services, *both* its functions and the values (or recognized potential value) of those functions should be high.

Fundamentally, the levels and types of functions that wetlands individually and collectively provide are determined by the processes and disturbances that affect the movement and other characteristics of water, soil/sediment, plants, and animals (Zedler & Kercher 2005, Euliss et al. 2008). In particular, the frequency, duration, magnitude and timing of these processes and disturbances shapes a given wetland's functions (Smith et al. 2008). Climate, geology, topographic position, and land use strongly influence all of these. Several analyses (e.g., Hansson et al. 2005, Adamus et al. 2009) have concluded that it is unlikely to have all functions occurring in a single wetland at a high level, even in the most pristine wetlands.

1.3 Background

WESPAK-SE is a regionalized modification of ORWAP[1], the Oregon Rapid Wetland Assessment Protocol, developed by the same author from 2006 to 2009, which built on indicator-function relationships first described by the author in the early 1980s and in several agency publications and methods since then, including the 1993 Juneau Wetlands Management Plan. The State of Oregon, in collaboration with the US Army Corps of Engineers Portland District, has required ORWAP assessments since 2009 for all major wetlands permitting and mitigation. The provinces of Alberta and Nova Scotia and an international private non-profit group have also expressed a desire to

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[1] http://oregonstatelands.us/DSL/WETLAND/or_wet_prot.shtml

regionalize a generic version of the Oregon method (named WESPAK-SE)[2] for their needs. If interest is sufficient, WESPAK-SE or WESPAK-SE could be modified for use elsewhere in Alaska. In 2009, at the behest of an Interagency Review Team (IRT) and Southeast Alaska Land Trust (SEAL Trust), an independent consulting firm was contracted to review and critique 16 wetland rapid assessment methods potentially applicable to Southeast Alaska. They selected ORWAP/WESPAK-SE and recommended its adaptation and calibration in the region (CH2M Hill, 2010). The City and Borough of Juneau is considering using this WESPAK-SE method to re-prioritize its wetlands in 2012-2013, and SEAL Trust intends to use it in collaboration with the US Army Corps of Engineers for their In-Lieu Fee Mitigation program. It is anticipated that training may be available beginning in 2012.

WESPAK-SE is intended to help address a policy goal of "no net loss" of wetlands, as that goal pertains not only to wetland acreage but also to the ecosystem services (functions and values) that wetlands provide naturally. By providing these services, well-functioning wetlands can reduce the need for humans to construct alternative infrastructure necessary to provide those services, often at much higher cost (Costanza et al. 1997, Finlayson et al. 2005, Euliss et al. 2008). In addition, many laws and policies require compensation for wetland impacts, and further require that wetland functions and values be the basis for considering the adequacy of compensation. A few other methods developed for rapidly assessing wetlands in this region are briefly summarized in Appendix A.

Field-testing is an essential part of developing methods such as WESPAK-SE, both for improving the data forms and models, and for determining the range of scores that can be expected, i.e., the calibration process. Using draft versions of the data forms, the author assessed 32 wetlands throughout Southeast Alaska during September 2011 (Table 1). The wetlands were in four subregions: Juneau, Haines, Sitka, and Ketchikan. In each subregion, attempts were made to visit at least one fen, marsh, hillslope bog, hillslope forest, and riverine or tidal wetland. The assessed wetlands are not a random or systematically balanced sample of all wetlands currently mapped in Southeast Alaska. That is because access to most parts of the region is challenging and funding did not permit such a structured selection process. It is hoped that additional sites from other parts of the region – especially higher-elevation wetlands and more tidal wetlands -- can be added in the future, to provide a broader and more balanced basis for comparison of function and value scores.

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[2] http://people.oregonstate.edu/~adamusp/WESPAK-SE/

After each wetland had been assessed, data forms were edited slightly to improve clarity. In some cases new indicators that seemed useful were added, and others dropped. After all visits had been completed, final versions of the data forms were prepared, formulas were drafted for computing scores (i.e., models), and scores were computed. Model formulas were occasionally adjusted at this stage to reflect the author's perceptions of relative levels of functions at the sites. Final versions of the models were then applied to the data and the summary statistics shown in the Scores worksheet were calculated.

Table 1. Geographic coordinates for WESPAK-SE calibration sites

	Latitude	Longitude
NON-TIDAL SITES		
Haines Homestead	59.16260	-135.35930
Haines Chilkat Fen	59.28330	-135.68040
Haines Chilkat Isolated Pond	59.34498	-135.76940
Haines Riparian Restored	59.24190	-135.44560
Juneau Switzer Cr.	58.36590	-134.49610
Juneau Vanderbilt Cr.	58.35580	-134.48770
Juneau Duck Cr Nazarene	58.37600	-134.57750
Juneau NS9 Fred Meyer	58.36177	-134.56990
Juneau NS6 Montana Swamp	58.39323	-134.59387
Juneau NS2 Eaglecrest Bog	58.31400	-134.55600
Juneau NS2 FishCr WeatherStn	58.33570	-134.56400
Juneau NS3 ADOT shrub bog	58.32423	-134.50053
Juneau Eaglecrest D' Amore Bog	58.29610	-134.55030
GC bog	58.11164	-134.74887
GC fen	58.11290	-134.74570
GC forested Althea	58.11321	-134.75323
GC forestedTrib	58.11364	-134.74570
GC marsh	58.12048	-134.74703
GC shrub Bog	58.11046	-134.74329
Sitka Gavin Hill Bog	57.05749	-135.32935
Sitka Gravel Pit Forested	57.10823	-135.38595
Sitka Indian R. floodplain	57.06046	-135.30593
Sitka Indian R. shrub bog	57.06074	-135.30918
Ketchikan Gravina Bog Pond	55.32752	-131.68344
Ketchikan Gravina South Bog	55.31408	-131.65961
Ketchikan montane Shrub Bog	55.42682	-131.60895
Ketchikan Point Higgins	55.46081	-131.82872
Ketchikan Ward Lake	55.40894	-131.69873
Ketchikan Ward River	55.44297	-131.62492

	Latitude	Longitude
TIDAL SITES:		
Sitka Starrigavan	57.13190	-135.36657
Juneau Mendenhall	58.35304	-134.51614
Haines tidal forest	59.23539	-135.47631
Haines tidal flat	59.21710	-135.45110

1.4 Limitations

WESPAK-SE is not intended to answer all questions about wetlands. Users should understand the following important limitations:

1. WESPAK-SE does not change any current procedures for determining wetland jurisdictional status, delineating wetland boundaries, or requirements for monitoring wetland projects.

2. The intended users are wetland specialists for government agencies, natural resource organizations, and consulting companies, who are skilled in conducting jurisdictional delineations of wetlands. Users should be able to (a) recognize most common wetland plants, (b) determine soil texture, (c) understand wetland hydrology, (d) delineate wetland contributing area boundaries from a topographic map, (e) access and acquire information from the internet, and (f) enter data in Microsoft Excel® (1997 or later version). For field application of WESPAK-SE, a multidisciplinary team is encouraged but not required. Training in the use of WESPAK-SE also is encouraged but not required.

3. The numeric estimates WESPAK-SE provides of wetland functions, values, and other attributes are *not actual measures* of those attributes, nor are the data combined using mechanistic models of ecosystem processes. Rather, WESPAK-SE scores are estimates of those attributes arrived at by using standardized criteria (models). The models systematically combine well-accepted indicators in a logically sophisticated manner that attempts to recognize context-specific, functionally contingent relationships among indicators. As is true of all other rapid assessment methods, WESPAK-SE's scoring models have not been validated in the sense of comparing their outputs with those from long-term direct measurement of wetland processes. That is the case because the time and cost of making the measurements necessary to fully determine model accuracy would be exorbitant. Nonetheless, the lack of validation is not, by itself, sufficient reason to avoid use of any standardized rapid method, because the only practical alternative—relying entirely on non-systematic judgments (best professional judgment)—is not demonstrably better in many cases. When properly applied,

WESPAK-SE's scoring models and their indicators are believed to adequately describe the *relative* effectiveness of a wetland for performing particular functions.

4. WESPAK-SE may be used to augment the interpretations of a subject professional (e.g., a fisheries biologist, plant ecologist, ornithologist, hydrologist, biogeochemist) when such expertise is available. WESPAK-SE outputs, like those of other rapid methods, are not necessarily more accurate than judgments of a subject expert, partly because WESPAK-SE's spreadsheet models lack the intuitiveness and integrative skills of an actual person knowledgeable of a particular function. Also, a model cannot anticipate every situation that may occur in nature. WESPAK-SE outputs should always be screened by the user to see if they "make sense." Nonetheless, WESPAK-SE's scoring models provide a degree of standardization, balance, and comprehensiveness that seldom is obtainable from a single expert.

5. WESPAK-SE's logic-based process for combining indicators has attempted to reflect currently-understood paradigms of wetland hydrology, biogeochemistry, and ecology. Still, the scientific understanding of wetlands is far less than optimal to support, as confidently as some might desire, the models WESPAK-SE and other rapid methods use to score wetland attributes. To provide transparency about this uncertainty, in the Rationales column of the WESPAK-SE worksheets for individual functions, some of the more significant alternative or confounding interpretations are noted for indicators used in that function's scoring model.

6. WESPAK-SE does not assess *all* functions, values, and services that a wetland might support. In particular, WESPAK-SE does not assess the suitability of a wetland as habitat for any individual wildlife or plant *species*. The 18 functions and 21 values WESPAK-SE assesses are those most commonly ascribed to wetlands.

7. If two wetlands have similar effectiveness scores for a function and its value, the larger wetland is usually more likely to provide a greater total level of the associated ecosystem service. However, the relationship between wetland size and the total level of a service delivered is not necessarily linear. For example, if its characteristics make a particular wetland ineffective for storing or purifying water, or for supporting particular plants and animals, then simply increasing its size by adding more wetland having the same characteristics will usually not increase the total amount of water stored or purified, or plants and animals supported. The threshold below which a wetland's characteristics make it completely ineffective is unknown in many cases. Where scientific evidence has suggested that wetland size may benefit a function in a greater-than-linear manner, WESPAK-SE has included wetland size as an indicator for

that function. Those functions are Waterbird Feeding, Waterbird Nesting, Songbirds-Mammals, and Pollinators.

8. In some wetlands, the scores that WESPAK-SE's models generate may not be sufficiently sensitive to detect, in the short term, mild changes in some functions. For example, WESPAK-SE is not intended to measure small year-to-year changes in a slowly-recovering restored wetland, or minor changes in specific functions, as potentially associated with limited "enhancement" activities such as weed control. Nonetheless, in such situations, WESPAK-SE can use information about a project to predict the likely *direction* of the change for a wide array of functions. Quantifying the actual change will often require more intensive (not rapid) measurement protocols that are complementary.

9. WESPAK-SE outputs are not intended to address the important question, "Is a proposed or previous wetland creation or enhancement project in a *geomorphically appropriate* location?" That is, is the wetland in a location where key processes can be expected to adaptively sustain the wetland and the particular functions which those of its type usually support, e.g., its "site potential?" Although WESPAK-SE uses many landscape-scale indicators to estimate functions and values of a wetland, WESPAK-SE is less practical for identifying the relative influence of multiple processes that support a single wetland.

1.5 Acknowledgments

I thank Diane Mayer of SEAL Trust and Hans Ehlert of CH2M Hill for their recognition of the importance of standardized practical tools for the field-based assessment of ecosystem services of wetlands, and for their support of what became WESPAK-SE. I am also grateful to the US Fish and Wildlife Service, and particularly to Steve Brockman and Neil Stichert of the Juneau Office, for recognizing the potential of this tool for their programs and responding with financial support and scientific information. Field testing was made more productive and enjoyable with the shared knowledge and/or company of Diane Mayer, Jim Pomplun and Cheryl Fultz in Ketchikan, Marlene Campbell and Lance Henrie in Sitka, Koren Bosworth and Teri Camery in Juneau, and Jess Kayser, Ben Kirkpatrick, and Carol Tuynman in Haines. I appreciate the thoughtful and very helpful peer reviews by Richard Carstensen, Steve Paustian, Dennis Landwehr, Bob Armstrong, Terry Brock, Dave D'Amore, Chiska Derr, Lisa Hoferkamp, Andrew Piston, Deb Rudis, John Hudson, and James Ray.

2.0 Procedures for Using WESPAK-SE

You will be completing three forms: an office form (OF); and two field forms (FieldF and FieldS). In a nutshell, the procedure is as follows:

1. Read this entire section (Section 2) before proceeding to complete the forms for the first time. You may skip parts of this section if you already have a particular skill that is described, such as navigating in Google Earth.
2. Download the most recent version of the *WESPAK-SE_ Calculator* spreadsheet.
3. Also download and print (from the same sites) the PDF files of the FieldF and FieldS data forms. Do not print anything from the Excel spreadsheet at this point.
4. Complete the "office" component, which involves viewing aerial imagery and filling out the form OF worksheet in the *WESPAK-SE Calculator* file.
5. Visit the wetland and complete the "field" component by filling out data forms FieldF and FieldS and refine your answers to questions on form OF if necessary.
6. Process and interpret the results.

2.1 Office Procedures

Begin the office component of the assessment with the electronic version of form OF in the file *WESPAK-SE_Calculator.xls*. When you open that file, **you may get a message asking if you want to enable "macros." Mark yes**; the macros in this file will not harm your computer. They are necessary to automate all the calculations.

2.1.1 Obtain Aerial Images

A recent aerial image of the assessment area is needed to answer several of the questions in form OF. The **assessment area (AA)** refers to a spatial unit consisting of an entire wetland or just part of a wetland, e.g., the part in which impacts or conservation actions are anticipated. You may draw the AA to be as large or small as your needs dictate, but ideally it should encompass an entire wetland polygon. The images should be of adequate resolution, viewed at (zoomed to) and printed at a scale of 1:24,000 (1 inch = 0.5 mile) or finer, such that the entire AA nearly fills a printed page. The same aerial image should be printed again but covering the entire wetland, if the AA does not comprise all of the wetland. There are many sources of aerial imagery that can be viewed for free online. Here are just a few:

- Google Earth web site: http://earth.google.com/downloadearth.html

Easy to access and use, but image clarity is poor for some parts of Southeast Alaska.

- Alaska Mapped web site: http://www.alaskamapped.org/

2.1.2 Determine the Geographic Coordinates

To expedite finding an aerial image of your wetland online, you will need to input its geographic coordinates (latitude and longitude). Determine the latitude and longitude of the AA's center in decimal-degrees, e.g., 45.2434, -123.3425. For WESPAK-SE's purposes, the precision of the coordinates need not be any greater than about half of the width of the wetland. If the wetland's coordinates have not already been determined in the field using a GPS (NAD83 datum), determine them as follows:

a. After downloading Google Earth (if you don't already have it) from the internet, set the options display for coordinates to decimal degrees, go to the Tools dropdown menu and select options. Under Google Earth options select the 3D view tab and check **decimal degrees** in the show Lat / Long box. This defaults the display Lat / Long to be in decimal degrees.
b. If you know the Lat / Long in degrees minutes seconds you can type in that value and Google Earth will convert it to decimal degrees which will be displayed in the bottom left corner of the window.
c. Alternatively, if you enter a street address, cross streets, or other information into the "Fly To" space, the map will zoom to that approximate location. Locate your wetland and move the cursor to the center of the part you wish to assess. The correct Lat / Long is displayed in the bottom left corner of the window

2.1.3 Interpret Aerial Images

You will use aerial images at various scales to answer form OF questions D1 through D16 (non-tidal wetlands) or through D10 (tidal wetlands). Preferably, respond to these questions using the imagery before you visit the wetland. Record your responses directly in the spreadsheet (form OF worksheet tab at bottom of page), print the completed form, and take it with you during the site visit. Upon visiting the site, your estimates should be modified, if appropriate, based on your observations. If you have GIS skills, using a GIS may improve the precision of your answers but is not essential.

If you are viewing aerial images with Google Earth, you can use its *measure tool* to draw a line from the wetland outward to each of the specified distances, and visualize a circle from that. Even better, you can go to http://dev.bt23.org/keyhole/circlegen/ and input your coordinates and the circle radius you want. It will draw that circle on the Google Earth image and adjust it appropriately as you zoom in and out.

To estimate the *percentages* of a given land cover, imagine all the patches of that type that fall within the circle being "squeezed together" and determine the approximate fraction of the circle they would occupy. Note that the questions for "natural land cover" and "herbaceous open land" ask the percentage of the *land* area of the circle that is occupied by the specified land cover, whereas the questions for "ponded water" use the entire circle, including large lakes but not ocean.

In addition to assessing percentages of these land cover types, you will make two other estimates:

- Proximity (ft or mi) to the nearest land cover of the specified type and minimum size, and
- Tract size (acres) of the nearest land cover of the specified type

Some of the web sites mentioned in section 2.1.6 below provide an option for using imagery as the background on their maps, and also provide a tool for measuring distance and the area of a polygon you draw on the image. Often, the imagery available on Google Earth has better resolution but no area-measuring tool is available. The simplest manual approach to estimating area of a particular habitat patch in Google Earth is to measure a representative width and length of the patch, using the Google Earth measure tool and specifying *miles* as units, then multiply:

Width (miles) x length (miles) x 640 acres/sq. mile = acres

In most cases this estimate will be precise enough for the intended purpose. If near a category threshold, repeat the measurement a few times.

2.1.4 Obtain a Topographic Map

You will need a topographic map to draw boundaries of the *assessment area* and to estimate the boundaries of its *contributing area* (see Section 2.1.6). It will also be helpful to show the boundaries of the *watershed* within which the wetland is located (but note, this is not the same as the wetland's contributing area). To do so go to:
http://viewer.nationalmap.gov/viewer/
Then navigate to your area by using the zoom bar on the left and sliding the map by holding down the cursor button. Next, click on the Overlay tab in the upper left. In the menu that opens, check the boxes next to Scanned Topo Maps and Hydrography. The image will show topographic lines and boundaries of watersheds. Note that you can measure distances and area (as required by some questions) by selecting the Advanced tab in the upper center, then clicking on certain icons on this toolbar.

Alternatively, you can print a topo map by going to this web site:
http://www.alaskamapped.org/
navigating to your location, and selecting SDMI Topo in the SDMI menu in the upper right corner of the image.

2.1.5 Obtain Wetland Map and Draw the Assessment Area (AA) Boundaries

Obtain a map of the wetland if one exists. If not, draw approximate wetland boundaries on the aerial image and topo map by interpreting that image and, if available, consulting soils maps. Then delineate a sub-area of the wetland -- the AA -- on the aerial image and topographic map. The AA preferably will consist of the entire wetland plus, in some cases, some or all of the adjoining unvegetated water (see below). However, WESPAK-SE may be applied to an area comprising less than the entire wetland if any of three situations occur:

- The wetland extends across property lines and access permission to part of the wetland was not granted.
- The wetland is so large (e.g., >100 acres) and internally varied that an accurate assessment cannot be completed in a day.
- A project or activity will occur in only part of a wetland and the effect on functions of just that project or activity needs to be determined.

Boundaries of the AA should be based mainly on ***hydrologic connectivity****.* They normally should not be based *solely* on property lines, fence lines, mapped soil series, vegetation associations, elevation zones, land use or land use designations. The AA boundaries may need to be adjusted during the field component, but for WESPAK-SE's purposes you don't need to delineate the AA boundary with the high level of precision customary for legal delineations. Nonetheless, *where* you draw the boundaries of the AA can dramatically influence the resulting scores.

Note that a few questions ***must*** *be answered in terms of the* ***entire*** *wetland, not the more limited portion defined by just the AA. Those questions are indicated by a large* **W** *in column D of the data forms. If the AA does not occupy all of a wetland, you should report the approximate percent of the wetland it occupies. Similarly, you should estimate and note the approximate percent of the mapped AA you were able to visit (taking into account both physical restrictions and private property restrictions).*

Here are guidelines for delineating the AA in some specific situations:

a. **Dissected Wetland.** If a wetland that once was a contiguous unit is now divided or separated from its formerly contiguous part by a road or dike (Figure 1), assess the two units separately unless a functioning culvert, water control structure, or other opening connects them, and their water levels usually are simultaneously at about the same level.

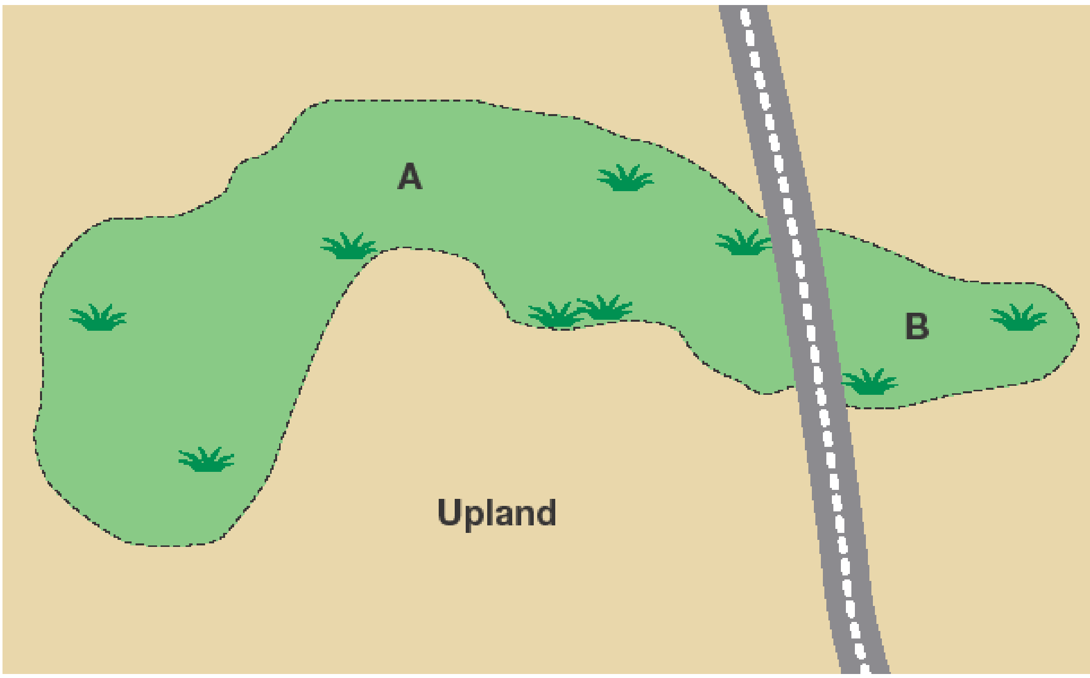


Figure 1. Dissected Wetland. A wetland is crossed by a road or filled area. Separate the wetland into two AA's and assess separately if A and B have different water levels and circulation between them is significantly impeded.

b. **Fringe Wetland**. If a wetland is a fringe wetland (that is, it borders a bay, estuary, pond, or river in which the contiguous stretch of open water is >3x wider than the wetland), the AA should include just the vegetated wetland, not the adjoining water (unless the method specifically directs you to answer a question about that). An exception is if the contiguous water body including the wetland is smaller than 20 acres, e.g., a pond. In that case, the water body itself (regardless of depth) should be included as well as the wetland (Figure 5).

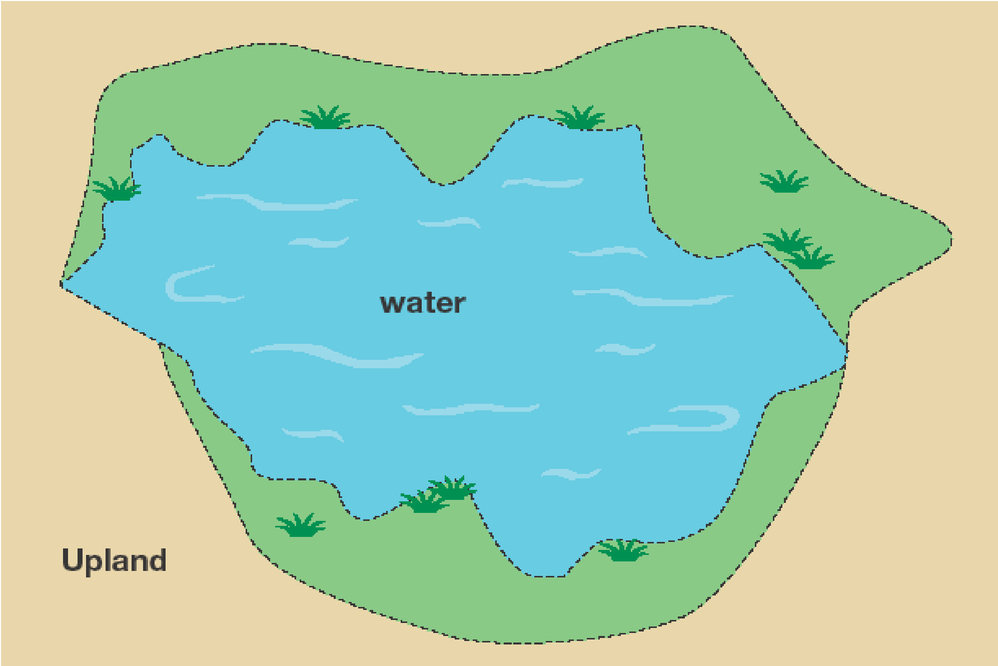


Figure 1. Fringe Wetland Type 1. The average width of the open water area is more than 3x wider than the average width of the wetland, making this a fringe wetland. If the entire polygon is smaller than 20 acres, the AA should include the open water. If larger, the AA should include only the wetland.

c. **Fringe Wetland Patches**. If patches of fringe wetlands share the same margin of a river, lake, or estuary and are separated from each other by upland over a distance of greater than 100 ft, they should be assessed as separate AA's (Figure 6) unless they appear to be the same in nearly every aspect (dominant vegetation, soil texture, hydrology, landscape position, Cowardin classification, adjoining land use, etc.) and are within 1000 ft. of each other.

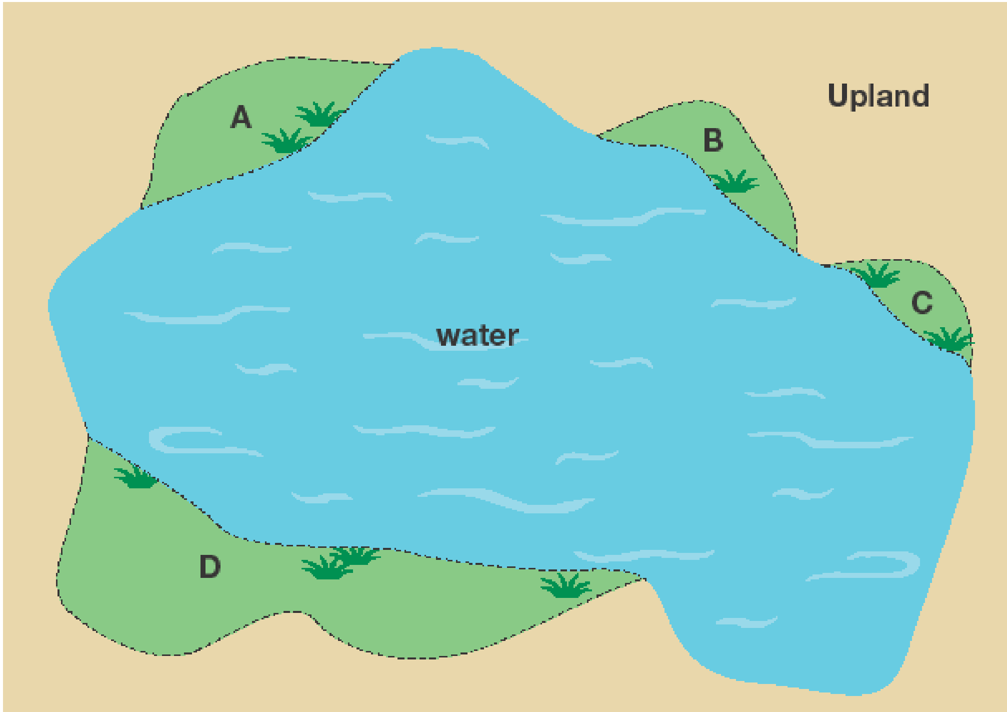


Figure 2. Fringe Wetland Type 2 (fringe wetland patches). Wetland patches B and C would be included in the same AA if separated by no more than 100 ft. by water, bare substrate, algal flats, or upland. Wetland patches A and D would be in the same AA if separated by 100 ft or less, or if they are within 1000 ft of each other and their vegetation, soil texture, water regime, and adjoining land use is the same.

d. Lacustrine Wetland With Tributary. If a lacustrine wetland is intersected by an inflowing stream, the wetland should be considered lacustrine except for the part that is more subject to seasonal overflow from the stream than from fluctuations in lake levels. That part should be assessed separately.

e. Wetland Mosaic. If the wetland is a patch in a mosaic of wetlands within uplands or other non-wetland waters (Figure 7) and none of the above rules apply, the entire mosaic should be considered and delimited as one AA if:

- Each patch of wetland is smaller than 1 acre, and
- Each patch is less than 50 ft from its nearest neighboring wetland and is not separated from them by impervious surface, and
- The areas of vegetated wetland are more than 50% of the total area. The total area is the wetlands plus other areas that are between the wetlands (such as uplands, open water, and mudflats).

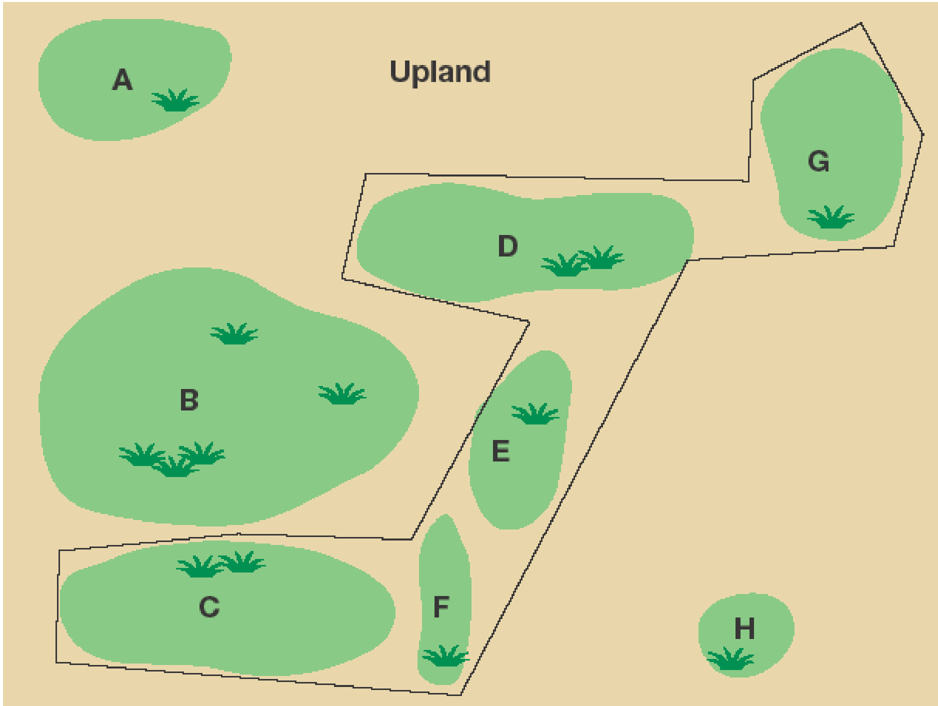


Figure 3. Wetland Mosaic Assessment Area (AA). In this diagram the dark line defines the mosaic. The circles are wetlands and the areas between them are upland. Wetlands C, D, E, F, and G comprise a mosaic because they occupy more than 50% of the total area bounded by the dark line. Wetland B is excluded because it is larger than 1 acre. Wetlands A and H are excluded because each is >100 ft from its closest neighbor.

f. Tidal/Non-Tidal Wetland. If any vegetated part of the AA is tidal (receives tide-driven surface water on any day during an average year), assess that part separately from the non-tidal part, using the WESPAK-SE data form for Tidal Wetlands.

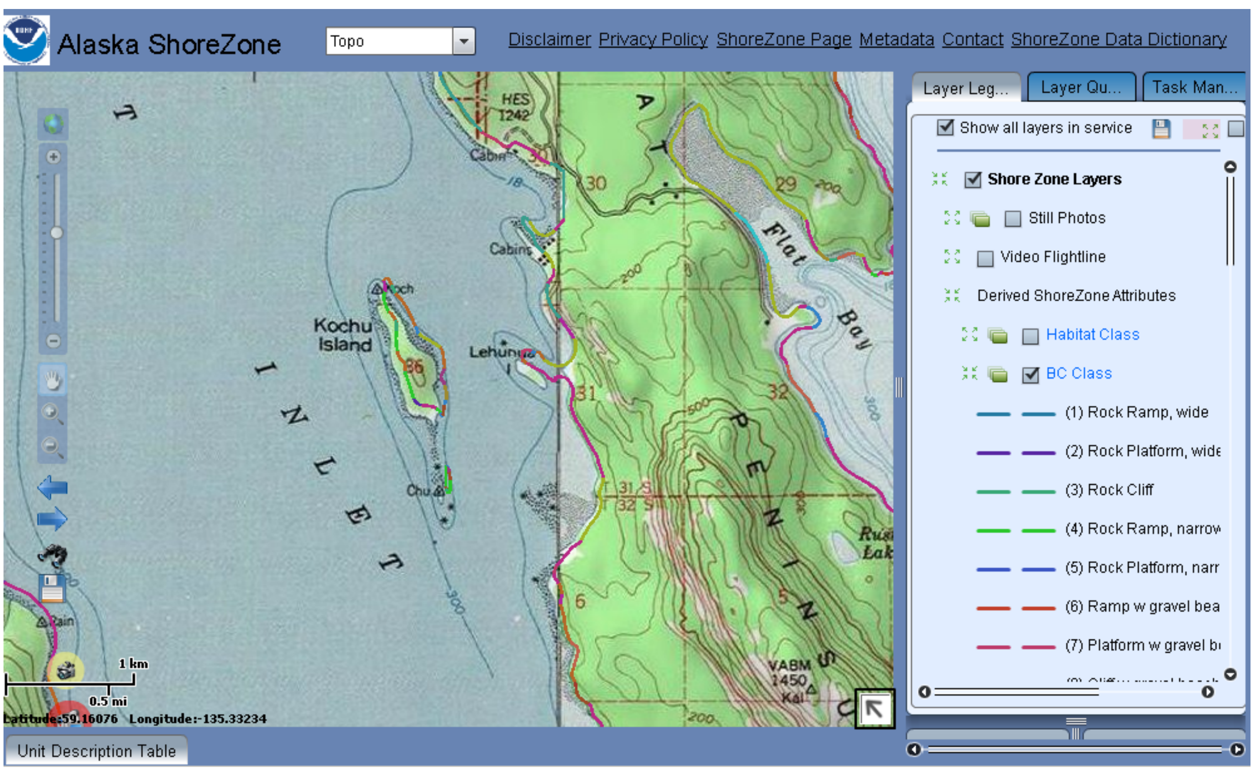
2.1.6 Obtain Required Information From Other Web Sites and Appendix

To complete the office phase of WESPAK-SE (form OF), you must obtain specific information from maps and tables in Appendices B and C, as well as from several web sites. Unfortunately, a one-stop "web portal" *that would greatly simplify this process*, as has been created in Oregon (http://oe.oregonexplorer.info/wetlands/orwap/), has not yet been established for Southeast Alaska (although some efforts are underway through the University of Alaska- Juneau). The following questions on form OF require information from these secondary sources:

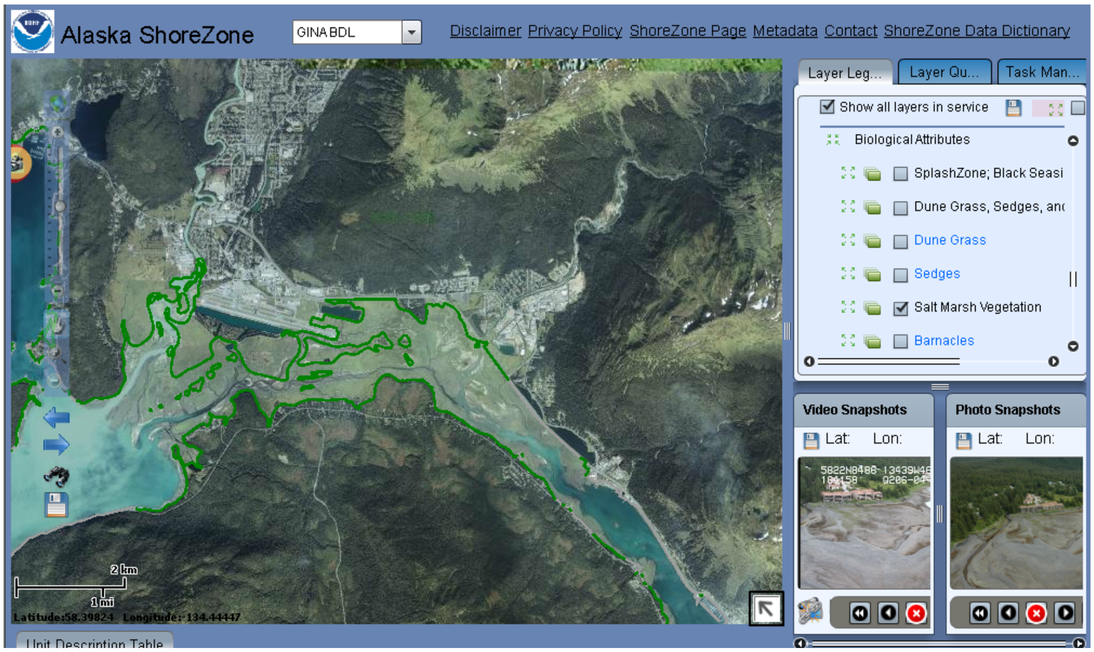
Questions D1-D16 (Non-tidal) or D1-10 (Tidal): Answer these questions about surrounding land cover by zooming to your site in Google Earth, or Alaska Mapped (http://www.alaskamapped.org/), or other imagery-viewer.

Questions D11-13, D22 (Tidal method only): The number of nearby tidal habitat types, fetch (shoreline exposure), and the distance to other tidal marshes and eelgrass/kelp can be estimated by zooming to your wetland's location at the Alaska ShoreZone web site: http://mapping.fakr.noaa.gov/szflex/ At times this web server is fairly slow as you zoom in. Try entering instead the coordinates of your site, by clicking on the binoculars icon in the lower left toolbar. Also note that just to the right of the Alaska ShoreZone heading at the top, there is a window where you can change the background image from a plain map to a topo map, aerial image, or nautical map.

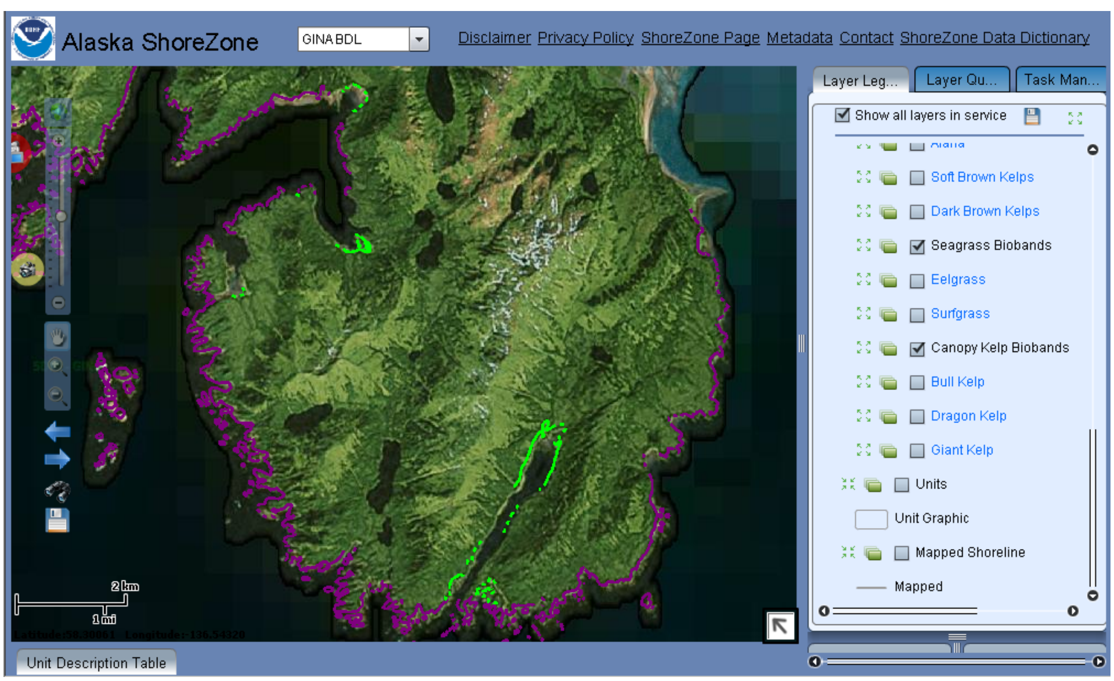
1. To estimate the number of shoreline classes (D11), go to the menu on the right, scroll down to BC Class, check the box, and press the diverging arrows icon to see the legend. Then count the number of different classes (colors) mapped within the 1-mile distance specified. Up to 35 are possible.



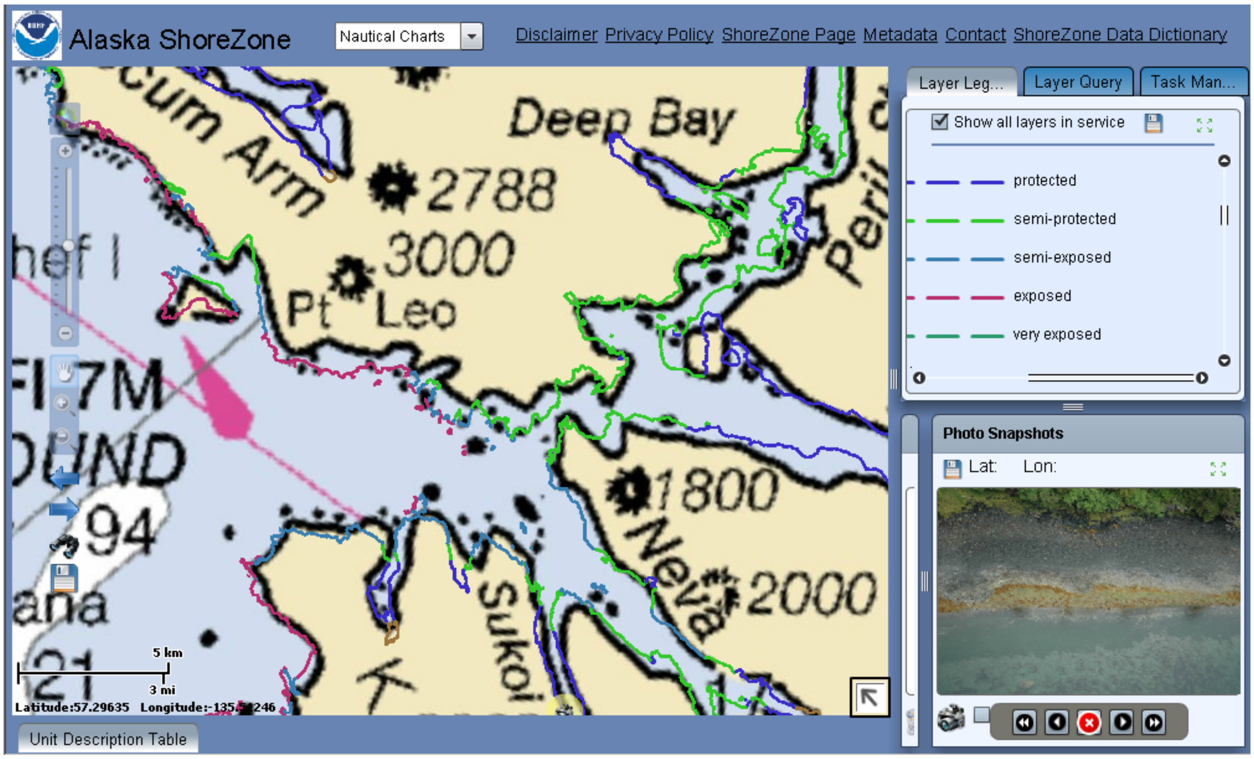
2. Clear the checkmark in the BC Class box and scroll down to Biological Attributes and check the Salt Marsh Vegetation box. Viewing the map, answer D12 (distance to nearest separate tidal marsh). Incidentally, in the image below, note that low-elevation photos and video are available for the location you pinpointed, in the boxes in the lower right.



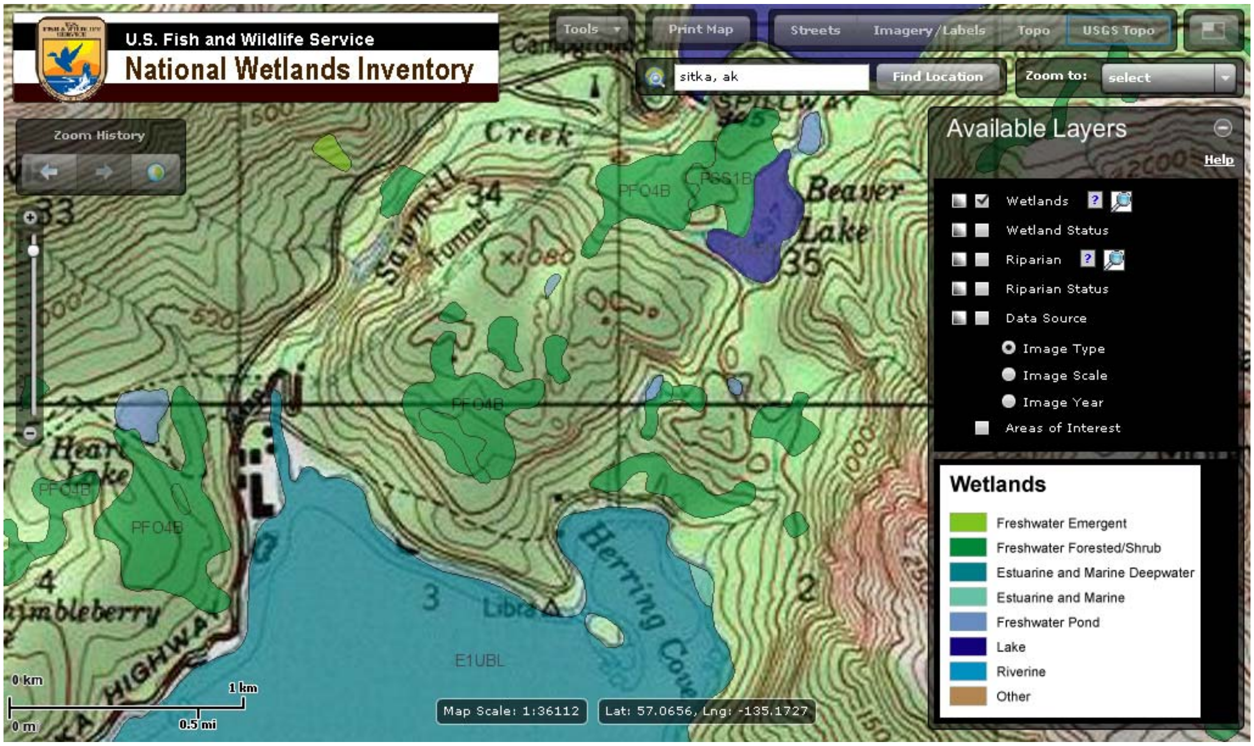
3. Clear the checkmark and scroll down to Seagrass Biobands and Canopy Kelp Biobands and check both. Viewing the map, answer question D13.



4. ShoreZone should also be consulted to select the correct Fetch category (question D22 in Tidal WESPAK-SE). Go to Biological Wave Exposure near the top of the menu on the right, open it with the diverging arrows icon, and view the fetch (habitat exposure) categories.



Questions D12-D14 (Non-tidal) or D12-13 (Tidal): Although not essential, National Wetlands Inventory maps (where available) will be also be helpful for answering these questions. Go to:
http://www.fws.gov/wetlands/Data/Mapper.html
open the window, and in the upper right where it says Zoom To Select, scroll to Alaska. Check the box that says Wetlands (uncheck Wetland Status). Then zoom to your wetland. See below for an example. For tidal wetland assessments, click on Imagery/Labels in the upper right. Then zoom in closely to see labels on the wetland polygons. Those with E_EM are tidal marshes, and those with E_AB are kelp or seagrass.
The same wetland maps can be found on the EPA web site mentioned in D39 below.



Questions D21.1-D21.3, D23.1, D24 (Non-tidal) or D31, 32, 34 (Tidal): Appendix B contains maps showing Snow Accumulation, Deer Winter Habitat, Bear Watersheds, Salmon Watersheds, Karst, and Subsistence Focal Areas. Because most of the maps show the entire region in only a 8 x 11 inch space, it will often be difficult to determine whether a particular wetland lies within a shaded area. This will hopefully be remedied in the near future if agencies support the creation and maintenance of a one-stop web portal and map viewer that contains all or most of these maps, as mentioned above. It is possible to zoom in on the PDF versions of the first four maps listed above, by going to: http://home.gci.net/~tnc/HTML/Map_gallery.html

Questions D22, D33 (Non-tidal) or D30 (Tidal): Tables listing the number of Growing Degree Days, and Estuarine Extent can be found in Appendix C.

Question D27 (Non-tidal) or D17 (Tidal): Some of the information necessary to answer the questions about Fish Access and Use can be obtained from the online Anadromous Waters Catalog of the Alaska Department of Fish and Game. If you have GoogleEarth, you can overlay maps of anadromous streams by going to:
http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=data.KMZ
You can also obtain ADFG regulatory maps in PDF format from:
http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=maps.maps

Question D28- D32 (Non-tidal) or D38-D40 (Tidal): Although not complete, records of amphibians and some species of vertebrates can be obtained by contacting the Alaska Natural Heritage Program or visiting their web site at:
http://aknhp.uaa.alaska.edu/maps/biotics/

Question D28- D32 (Non-tidal) or D38-D40 (Tidal): Although not complete, records of plant species locations can be obtained online from the Consortium of Pacific Northwest Herbaria at: http://www.pnwherbaria.org/data/search.php

Question D34 (Non-tidal): The wetland's position within its larger watershed can be determined, following the rules associated with this question, by viewing the Watershed boundary shown in the Hydrography layer at:
http://viewer.nationalmap.gov/viewer/
See also the EPA web site mentioned in D39 below.

Question D35 (Non-tidal): The proportion of the AA's contributing area (CA) that is occupied by the AA can be determined using the topographic map described in section 2.1.4, but a better option, although not available for all parts of the region, are the National Wetland Inventory (NWI) maps. Online, you can show topographic lines overlaid on approximate wetland boundaries. This is the most convenient way to draw the CA and estimate to percentage occupied by your wetland. Go to:
http://www.fws.gov/wetlands/Data/Mapper.html
open the window, and in the upper right where it says Zoom To Select, scroll to Alaska. Check the box that says Wetlands (uncheck Wetland Status). Then zoom to your wetland. Click on USGS Topo in the upper right. Click on the magnifying icon on the middle right, then on your wetland to see an estimate of its acreage (if the AA is part of a wetland mapped by NWI).

The CA is the drainage area, catchment area, or contributing upland that feeds the wetland (Figure 1). It includes all areas uphill from the AA until a ridge or topographic rise is reached, often many miles away, beyond which water would travel in a direction that would not take it to the AA. The water does not need to travel on the land surface; it may reach the AA slowly as shallow subsurface seepage[3]. The lowest point of a CA is the lowest point in the AA. The CA's highest point will be along a ridgeline or topographic mound. Although it is possible that roads, tile drains, and other diversions that run perpendicular to the slope may interfere with movement of runoff or

[3] There are often situations where subsurface flow (especially deep groundwater), that potentially feeds a wetland, ignores such topographic divides. However, due to the limitations imposed by rapid assessment, no attempt should be made to account for that process.

groundwater into a wetland (at least seasonally), it is virtually impossible to determine their relative influence without detailed maps and hydrologic modeling. Therefore, in most cases draw the CA as it would exist *without* existing infrastructure, i.e., based solely on natural topography as depicted in the topographic map. The only exception is where maps, aerial images, or field inspections show artificial ditches or drains that *obviously* intercept and divert a *substantial* part of the runoff before it reaches the wetland, or where a runoff-blocking berm, dike, or elevated road adjoins all of a wetland's uphill perimeter.

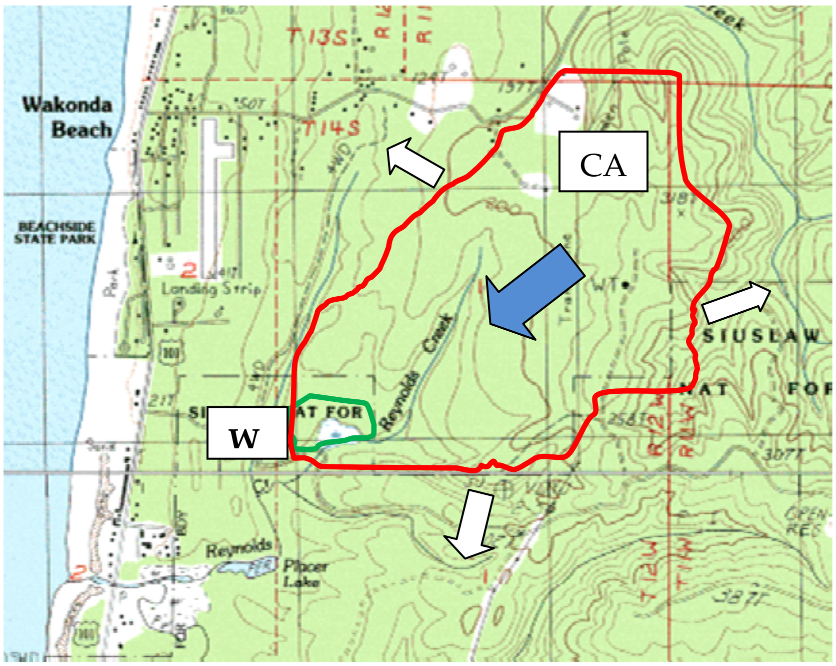
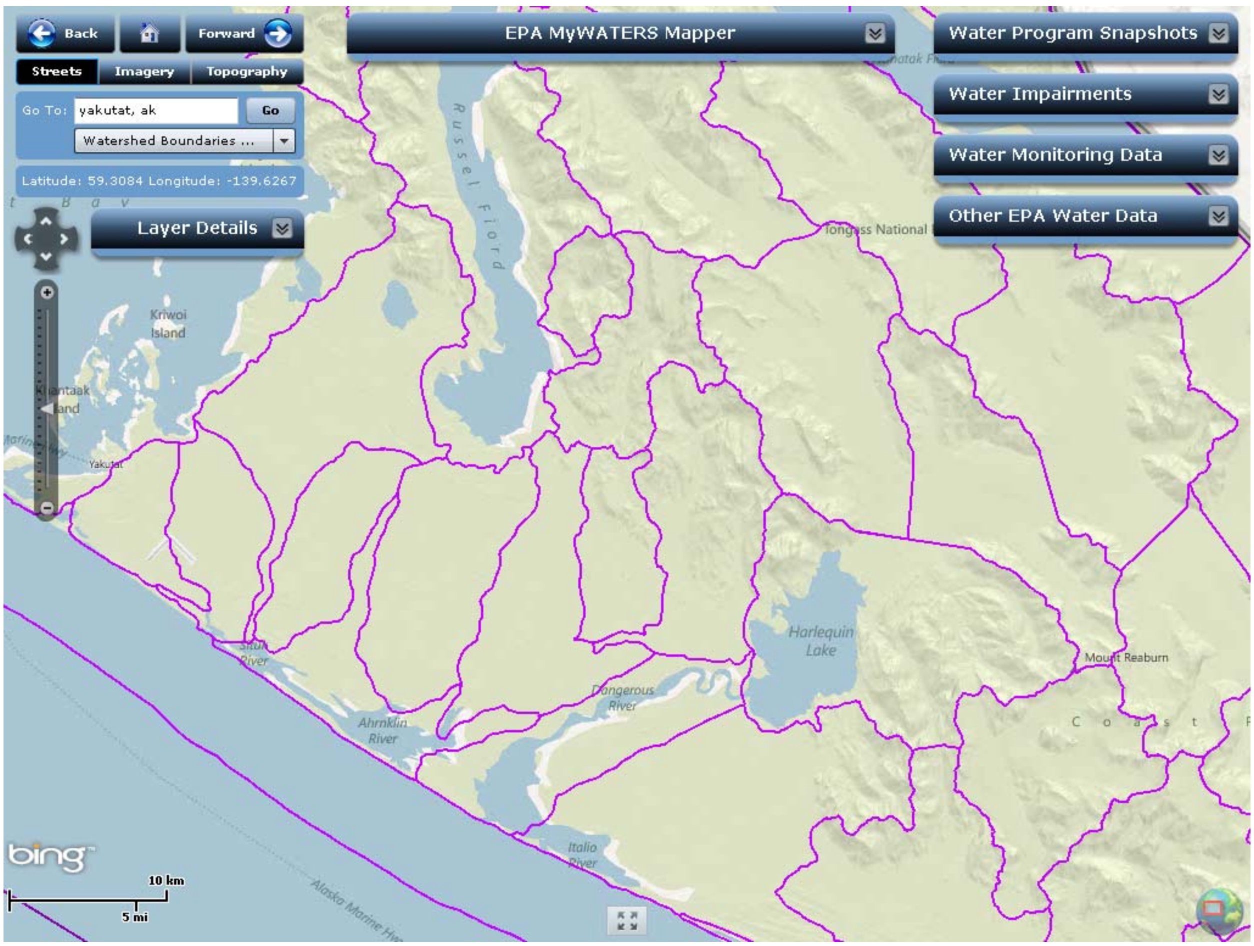


Figure 1. Delimiting a wetland's Contributing Area (CA). Wetland (to the right of the "W") is fed by its Contributing Area (CA) whose boundary is represented by the red line. The dark arrow denotes flow of water downgradient within the CA. The light arrows denote the likely path of water away from the CA and into adjoining drainages, as interpreted from the topography. Note that the CA boundary crosses a stream at only one point, that being the outlet of the wetland.

The CA may include other wetlands and ponds, even those without outlets, if they're at a higher elevation. Normally, the boundary of a CA will *cross a stream at only one point*— at the CA's and AA's outlet, if it has one. Do not include contiguous perennial deep waters at the same elevation (such as a lake, river, or bay) unless requested by the question. Especially in urban areas and areas of flat terrain, the CA boundaries can be somewhat subjective and estimation in the field may be preferable. However, for WESPAK-SE's purposes a high degree of precision is not needed.

Question D39 (Non-tidal) or D20 (Tidal): Location-specific information on water quality is available online from the EPA's STORET and USGS's NWIS systems. Some of the STORET data can be found at:
http://watersgeo.epa.gov/mwm/
In the menu on the right, click on Water Monitoring Data. Blue symbols on the map show locations of monitoring data (if any), and clicking on one will lead you to Show Monitoring Data Summary.
In the menu on the right, next check for Water Impairments.
Then in the last box, check for TMDLs. Note that you can also show wetlands, streams, and watershed boundaries on this map. (The latter is shown below).



The NWIS is at: http://waterdata.usgs.gov/nwis/news/?automated_retrieval_info
In the upper right next to Data Category, click on Water Quality, and where it says Geographic Area, click on Alaska, then hit Go and proceed from there.

Locations of contaminated sites regulated by the ADEC are mapped at:

http://www.dec.state.ak.us/EH/dw/DWP/protection_areas_map.html
Allow up to a minute for the map to show those sites.

Question D40 (Non-tidal): Drinking Water Protection Areas mapped by ADEC are also found at the DEC web address above.

2.1.8 Other Useful Information

While completing a WESPAK-SE assessment, you should ask the land owner, land manager, or neighbors about the annual extent and depth of high and low water, as well as the annual duration of surface-water connection with streams and other wetlands. Even where flood marks are pronounced, such characteristics are difficult to estimate visually during a single wetland visit. Local offices of municipal, state, tribal, and federal agencies should also be contacted for information that will improve the accuracy of your assessment. An online search of the name of a nearby feature can sometimes be productive. Also, for some areas, you can go online and easily view aerial images from other seasons and/or years. To do so, open GoogleEarth, zoom to your location, and click on the watchface icon in the toolbar in the middle top of the page. Finally, note that soils information from wider parts of the region will eventually become available online at http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm . This can be used as an aid in identifying wetlands and wetland contributing areas with high risk of landslides or soil erosion.

2.2 Instructions for Field Component

The field component involves visiting as much of the AA as possible, filling out the two field forms (FieldF and FieldS), and verifying, as needed, answers previously given on form OF. This component will generally require less than three hours (large or complex sites may take longer). If circumstances allow, visit the AA during both the wettest and driest times of year. If you cannot, you must rely more on the aerial imagery, maps, other office information, field indicators, and discussions with the landowner and other knowledgeable sources. If assessing a tidal wetland, try to be at the AA during both the low and high tide of the day.

2.2.1 Items to Take to the Field

Take the following with you into the field:

- Blank data forms FieldF and FieldS
- Completed data Form OF (to verify answers)

- Lists and explanatory illustrations from this report's appendices, if you need them
- Aerial images (to verify AA and use as a base map, if no wetland delineation map available)
- Aerial image that includes entire wetland (to answer applicable questions)
- Wetland delineation map (if any, to verify AA and use as a base map)
- Topographic map with the CA boundary you drew tentatively (to verify)
- Soil maps if available (to determine if your field determinations match)
- Shovel for soil pits
- Clip board, pencil, other items you'd normally take in the field

2.2.2 Conduct the Field Assessment

Step 1. Review the questions on the FieldF and FieldS forms to refresh your memory of what to observe during the field visit. Note that questions marked "**W**" on the FieldF form must be answered for the *entire wetland*. Also review data Form OF to see which questions you may have flagged during the office phase for checking during the field visit.

Step 2. Before answering all questions on the data forms, walk as much of the AA and wetland as possible. Plan your visit beforehand to visit each major vegetation type (these may be evident on the aerial imagery if the AA is large), each different soil map unit, each area with different topography, the wetland/upland edges and all wetland/water feature edges (e.g., ponds, lakes, streams). As you walk around, do the following:

Step 3. Create or revise a base map showing the AA boundary, location of inlets and outlets, open water, and major patches of the different vegetation forms (herbaceous, woody). If the scale and resolution are appropriate, an aerial image and/or wetland delineation map may be used as the base map. If not, use the gridded data form (the "Sketch" worksheet in the WESPAK-SE spreadsheet) to draw a map less precisely. For larger wetlands, marking of "waypoints" along wetland boundaries using a handheld GPS can expedite mapping and improve precision.

Step 4. Generally note the extent of non-native plant cover within the AA and along its upland edge, as well as any plants you don't often encounter (i.e., are marked as Rare in the PlantList worksheet), and other indicators described on the field forms.

Step 5. If you have access to the entire wetland, look for inlets and outlets, even ones that may flow only for a few days each year.

Step 6. Read the instructions at the beginning of forms FieldF and FieldS and then fill out these forms, paying attention to all the explanatory notes and definitions in the last column. As you answer the questions dealing with "percent of the area," pay particular attention to the spatial context (area) which the question is addressing. For example, in regard to a type of vegetation or land cover, be careful to note if it's asking what percentage is occupied within the:

- open water area, or
- vegetated area *of that type* (e.g., compare only with total wooded area), or
- total vegetated area, or
- upland edge, or
- assessment area (AA), or
- entire wetland, or
- contributing area (CA), or
- circle of specified radius
- circle of specified radius but excluding any water area (e.g., ocean)

Step 7. Determine the soil composition for question F41 (F15 if a tidal wetland) by first digging a soil pit 12 inches deep. The pit should be in the currently unflooded part of the AA and within the AA's predominant soil map unit. The depth of the pit should be measured from the soil surface, which is the top of the mineral soil or the top of the organic soil material that is at least slightly decomposed. "Slightly decomposed" means the organic material is decomposed enough so that the fibers can be crushed or shredded with the fingers.

Determine soil composition by using the WESPAK-SE *Soil Composition by Feel* diagnostics flow chart in Appendix D. You will be asked to categorize the pit's soil simply as *Organic, Clayey, Loamy,* or *Coarse*. If more than one composition category is encountered within the upper 12 inches, record only the upper surface composition (excluding the duff). Caution: be aware that horizons (layers) can be thin and that there is no minimum horizon (layer) thickness requirement. For WESPAK-SE's intended use, *Organic* includes organic soils (muck, mucky peat, and peat) and mucky mineral, which is a mineral soil with a high content of muck (>10% organic matter and < 17% visible fibers when rubbed). If moss or organic soils are present, determine if their depth is continuous from the surface to greater than 12 inches and greater than 16 inches.

Step 8. Look uphill of the wetland to see if any artificial feature that adjoins the wetland *unmistakably* diverts *most* of the surface runoff away from it (e.g., high berm) during normal runoff events. If such is found, redraw the CA to exclude all areas that drain to that feature and not into the wetland.

2.3 Instructions for Entering, Interpreting, and Reporting the Data

2.3.1 Data Entry

Enter data from the data forms (OF, FieldF, FieldS) into the corresponding Excel worksheets of the WESPAK-SE calculator. Check to be sure every question on all data forms was answered and entered, except where the form directed you to skip one or more questions. The scores for the functions and other attributes will compute automatically and appear in the Scores worksheet. If you wish to see which factors contributed to each function or other attribute, click on the function's worksheet and you will see both those factors and your responses. For an overview of the scores of the individual indicators, see the Matrix worksheet. In that matrix, if you have enabled macro's, the colored cells indicate which indicators are used for which functions. Cells that are colored but are blank (no numbers) indicate that indicator was not used to compute the score *in that particular wetland*, because the reported condition of another indicator rendered it irrelevant in that situation.

2.3.2 Evaluate Results

Before accepting the scores that were computed and shown in the Scores worksheet, think carefully about those results. From your knowledge of wetland functions, do they make sense for this wetland and/or AA? If not, review the worksheet for that function or other attribute, as well as Chapter 3 (Narrative Descriptions of Scoring Models), to see how the score was determined. If you disagree with some of the assumptions that led to that score, write a few sentences explaining your reasoning on the bottom portion of the CoverPg form (add additional sheets if needed). Remember, WESPAK-SE is just one tool intended to help the decision-making process, and other important tools are your common sense and professional experience with a particular function, wetland type, or species. Review again the caveats given in the Limitations section (Section 1.4).

If you believe some of the scores which WESPAK-SE generated do not match your understanding of a particular wetland function or other attribute, first examine the summary of your responses that pertain to that by clicking on the worksheet with that attribute's code (e.g., NR for Nitrate Removal). Your responses are also automatically summarized in the Matrix worksheet. If you want to reconsider one of your responses (perhaps because you weren't able to see part of the AA, or view it during a preferred time of year), change the 0 or 1 you entered on *Form OF*, *FieldF,* or *FieldS*. Then check the Scores worksheet to see what effect that had.

You may do the same (changing various 0's and 1's) if you'd like to simulate the potential effect of an enhancement or restoration measure on function scores, or the impact on those scores from some controllable or uncontrollable alteration or management activity within the AA or wetland, its contributing area, or surrounding landscape out to within 2 miles. However, understand that WESPAK-SE is not intended to predict changes to an AA – only to estimate the likely direction and relative magnitude of those changes, <u>if</u> they occur, on various functions and other attributes.

You may notice that regardless of the wetland being assessed, the scores of some functions tend to trend high, others trend low, some have a wide range (0 to 10) whereas others a narrow range (e.g., just 4 to7). That is because the author decided not to enable the spreadsheet to mathematically convert ("normalize") the raw scores from the models to a full 0-to-10 scale. There are both practical advantages and disadvantages to converting model outputs to such a scale. The "10" would ideally need to be represented by one of the highest-functioning and/or least-altered wetlands that exist for a particular function. However, too few wetlands have been subjected to the intensive multi-year studies that are essential to conclusively measure their functions, so it is unlikely that enough wetlands could be found to anchor the ends of the 0 to 10 scale. Also, in some scoring models, conditions of most of the indicators used (e.g., vegetation percent cover) are easily met in many wetlands whereas in the models for other functions, conditions of many of the indicators used tend to occur less commonly (e.g., evidence of springs). Output scores from those models would tend to trend lower, yet that does not necessarily mean that particular *function* is usually less prevalent or effective than others.

3.0 Descriptions of the WESPAK-SE Models

This chapter attempts to describe, in a narrative manner, the indicator variables (questions in data forms) that WESPAK-SE uses to assess each function and its value, and how they are combined in scoring models. The indicators mentioned in the descriptions below are shorthand versions of indicators that are defined and explained fully in the WESPAK-SE data forms: worksheets OF (office form), FF (field form), and FS (stressor form) in the WESPAK-SE Excel calculator spreadsheet.

3.1 SURFACE WATER STORAGE (WS)

Function Definition: The effectiveness of a wetland for storing water or delaying the downslope movement of surface water for long or short periods (but for longer than a tidal cycle), and in doing so to potentially influence the height, timing, duration, and frequency of inundation in downstream or downslope areas.

Scientific Support for This Function in Wetlands Generally: Moderate to High. Many non-tidal wetlands are capable of slowing the downslope movement of water, regardless of whether they have significant storage capacity, simply because they are *relatively* flat areas in the landscape. When that slowing occurs in multiple wetlands, flood peaks further downstream are muted somewhat. When wetlands are, in addition, capable of storing (not just slowing) runoff, that water is potentially available for recharging aquifers and supporting local food webs.

In Southeast Alaskan Wetlands: Many of the region's non-tidal wetlands should be capable of performing this function. Those intersected by channels and located on steep slopes are least capable. Where this function is performed to some degree, its *value* will depend partly on wetland location relative to areas potentially damaged by floods. Flood damages to infrastructure in this region have been relatively infrequent and local, and have occurred mainly as the result of ice jams or wave action associated with storms in marine waters. Also, it is likely that subsurface storage of water in many parts of this region (e.g., in deep peat, alluvium, colluvium) is more substantial than surface water storage. Unfortunately, in most cases subsurface storage cannot be estimated reliably with a rapid assessment method. Typically, it requires measurements of soil depth and texture (at greater depth than is practical to dig during a rapid assessment) and an understanding of subsurface water levels, flow direction, and exchange rate during different seasons.

The model applies only to non-tidal wetlands. No model is provided for this function for tidal wetlands because most such wetlands have little or no effect on coastal flooding.

Non-tidal Wetlands – WS Function Model

Structure: At a coarse level, three types of wetlands are recognized as pertains to this function: (1) those that never contain surface water, (2) those that lack outlets, and (3) all others. A separate model is provided for each.

- If a wetland never contains surface water, its score increases with *decreasing Gradient (flatter being better) and shorter Frozen Duration* (propensity to remain frozen for long periods). To account for the relatively limited ability of such wetlands to store water (availability of subsurface storage space being the only influence), the score is *multiplied by 0.5.*
- If a wetland contains surface water but lacks a persistently-flowing outlet, its score increases with decreasing scores of the same two factors as well as with increasing Live Storage. The score is calculated as *the average of Live Storage, Gradient, potential for Subsurface Storage, and Frozen Duration.* For all other wetland types, a Friction factor is added to the above three factors as a positive influencer of this function. *The average of Friction, Live Storage, Gradient, Subsurface Storage, and Frozen Duration is multiplied by the duration of outflow (OutDura). However, a weighting factor of 2 is first applied to Live Storage and Gradient in recognition of their presumably greater influence on this function.*
- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands can store more water. Because the model is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores for this function than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In the above calculations:

- **Frozen Duration** is assumed to decrease with decreasing Elevation (relative position in watershed), more Growing Degree Days, and less annual Snow Accumulation, as well as with increasing Tidal Proximity and south-facing Aspect. These are averaged.
- **Live Storage** is assumed to be indicated by increasing amplitude of water level fluctuation and increasing percent of the wetland's area that floods only seasonally. These are averaged.

- **Friction** is assumed to be indicated by reduced connectivity to rivers during both wet and dry conditions (IsoDry, IsoWet), by greater microtopographic variation and channel meandering within the wetland, and by presence of an artificial rather than natural outlet (the latter presumed to be less constricted). These indicators are averaged. If the wetland lacks a flow-through channel, channel meandering and outlet constriction are ignored in the calculations.
- **Subsurface Storage** potential is assumed to be indicated by deep peat soils and evidence of groundwater discharging at the surface.

<u>Potential for Future Validation</u>: The volume, duration, and frequency of water storage could be measured in a series of wetlands that encompass the scoring range, and flows could be measured at their outlets if any, and at various points downstream. Measurements should especially be made during major storm or snowmelt events. Procedures that might be used are partly described by Warne & Wakely (2000) and US Army Corps of Engineers (2005).

Non-tidal Wetlands – WS Values Model

<u>Structure</u>: If buildings or public infrastructure within 2 miles downriver from the wetland have been damaged or are in a mapped floodplain, the wetland receives the highest possible score for value. Otherwise, increasing value for the Water Storage function is influenced by the average of 3 factors, which together reflect the magnitude of potential runoff reaching a wetland and thus increasing opportunity to perform this function. One of the factors represents the extent of unvegetated upslope surfaces -- more impervious or semi-pervious proportional surface indicates more opportunity for downslope wetlands to influence flood peaks. This factor is indicated by increases in the average of CAunveg and Glacier. That is, wetlands located downstream from unvegetated contributing areas or from glaciers are assumed more likely to be exposed to high peak flows. A second factor represents increasing extent of the upslope contributing area as reflected by the average of increasing CApct (the wetland's area as a percent of its contributing area) and lower position in a regional watershed (ShedPos). The third factor, Transport, represents the potential for runoff to be transported to a wetland as related to slope and land cover of its contributing area.

3.2 STREAM FLOW SUPPORT (SFS)

Function Definition: The effectiveness of a wetland for prolonging surface water in headwater streams during seasonally dry periods.

Scientific Support for This Function in Wetlands Generally: Moderate.

In Southeast Alaskan Wetlands: Many of the region's non-tidal wetlands should be capable of performing this function. If not feeding streams directly themselves, many wetlands are at least discharge sites for groundwater which in turn feeds streams.

Non-tidal Wetlands – SFS Function Model

The model applies only to non-tidal wetlands. No model is provided for tidal wetlands because most tidal wetlands store water for (at most) a few hours and thus are unlikely to have measurable effects on the amount of marine water.

Structure: The model considers three factors: *Climate, Groundwater Input, and Connectivity.* If the wetland lacks an outlet, the score is set at 0. If an outlet is present, *Groundwater Input is given twice the weight of Climate, and the weighted average of both is multiplied by Connectivity.*

- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially deliver more water to streams if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In the above calculations:

- **Climate** (partly indicating a shorter duration of ice cover) reflects decreasing Elevation (relative position in watershed), more Growing Degree Days, and less annual Snow Accumulation, as well as increasing Water Depth, Tidal Proximity, and south-facing Aspect of a wetland's contributing area. Presence of water-holding Soils and increasing Water Depth also suggest potential for greater streamflow support and so are included. All these indicators are considered to be about equally predictive and so are averaged together.
- **Groundwater Input** is assumed to be greater with particular Wetland Types (e.g., fen) or is reflected by geomorphic characteristics (Groundw). These 2 indicators are averaged.
- **Connectivity** is considered greater in wetlands with longer-duration surface water outflows. Wetlands without outflows are scored "0" for this function.

Non-tidal Wetlands – SFS Values Model

The value of the Streamflow Support function is assumed greater in wetlands that also have high scores for supporting habitat of invertebrates, anadromous fish, and/or resident fish, as well as those not being fed by glaciers and those in headwaters of large watersheds. These indicators are considered to be about equally predictive of the value of this function and so are averaged.

3.3 STREAMWATER COOLING (WC)

Function Definition: The effectiveness of a wetland for maintaining or reducing the water temperature, primarily in headwater streams.

Scientific Support for This Function in Wetlands Generally: Moderate.

In Southeast Alaskan Wetlands: Many of the region's non-tidal wetlands should be capable of performing this function. The model applies only to non-tidal wetlands. No model is provided for this function for tidal wetlands.

Non-tidal Wetlands – WC Function Model

Structure: Higher scores for a wetland result from increased Groundwater Input and decreased Solar Heat. If a wetland never contains surface water during the summer, then only Groundwater Input is considered by the model. *In all other wetlands, the score is the average of Groundwater (with a weight of 2) and Solar Heat (unweighted).*

- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially provide a greater volume of cooled water if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In these calculations:

- **Groundwater Input** is assumed to be greater if the wetland is a fen or the topography suggests high likelihood of discharging groundwater. These two indicators are averaged.
- **Solar Heating** caused by the wetland is assumed to be less if the wetland is deep, and contains extensive shading vegetation and few isolated pools during the summer. These 3 indicators are considered to be equally predictive and so are averaged.

Non-tidal Wetlands – WC Values Model

Wetlands are assumed to be more valuable for this function if (a) accessible to anadromous fish, and/or (b) are at low elevation, surrounded by impervious surfaces, not a fringe wetland, are south-facing, and have an input tributary that is unshaded and not fed by glacier water. The conditions in (b) are all considered to be equally influential so are averaged. That average is considered to be as important as access to anadromous fish (a). The average of (a) and (b) is multiplied by the duration of the wetland's outlet flow, because longer outflows imply greater opportunity to deliver this function.

3.4 STREAMWATER WARMING (WW)

Function Definition: The effectiveness of a wetland for increasing the water temperature, primarily in headwater streams.

Scientific Support for This Function in Wetlands Generally: Moderate to High.

In Southeast Alaskan Wetlands: Many of the region's non-tidal wetlands should be capable of performing this function. The model applies only to non-tidal wetlands.

Non-tidal Wetlands – WW Function Model

Structure: The model uses the same indicators as for Water Cooling (WC), but the scoring ramps for each indicator are reversed. Also, the Groundwater and Solar Heat metrics are averaged without weighting.

Non-tidal Wetlands – WW Values Model

Structure: The capacity of a wetland to warm the water is assumed to be more valuable if the wetland also scored high for Amphibian Habitat. Alternatively, value is considered greater if the wetland is near marine waters, at low elevation, north-facing, glacially-fed, not surrounded by impervious surfaces, and/or is not a fringe wetland. These indicators are considered about equally predictive so are averaged.

3.5 SEDIMENT RETENTION AND STABILIZATION (SR)

Function Definition: The effectiveness of a wetland for intercepting and filtering suspended inorganic sediments thus allowing their deposition, as well as reduce current velocity, resist erosion, and stabilize underlying sediments or soil.

Scientific Support for This Function in Wetlands Generally: High. Being relatively flat areas located low in the landscape, many wetlands are areas of sediment deposition, a process facilitated by wetland vegetation that intercepts suspended sediments and stabilizes (with root networks) much of the sediment that is deposited.

In Southeast Alaskan Wetlands: Many of the region's wetlands should be capable of performing this function. Those intersected by channels and located on steep slopes are least capable. In this region the abundance of glaciers, clearcuts, logging roads, landslides, and wind-exposed shorelines provides many opportunities for wetlands to trap sediment and/or stabilize underlying soils and sediments. Potentially, the performance of this function has both positive and negative values. Positives include reduction in turbidity in downstream waters, provision of substrate for outward expansion of marsh vegetation into deeper water (especially important in tidal wetlands), and improved detoxification of some contaminants associated with the retained sediment. Sediment serves as a carrier for heavy metals, phosphorus, and some toxic household chemicals, which routinely bind to surfaces of suspended clay particles (Hoffman et al. 2009, Kronvang et al. 2009). Negative values potentially include progressive sedimentation of productive wetlands, slowing of natural channel migration, and increased exposure of organisms within a wetland to contaminants. The values models address only the opportunity to perform this function, not its potential positive or negative effects, which are too difficult to estimate with a rapid method.

Non-tidal Wetlands – SR Function Model

Structure:
At a coarse level, three types of non-tidal wetlands are analyzed separately as pertains to this function: (1) those that never contain surface water, (2) those that lack outlets, and (3) all others.

- If a wetland never contains surface water, its ability to stabilize underlying soil increases if it is *flatter, not frozen for long periods,* has *denser ground cover*, and more *microtopographic variation.* The average of these 4 indicators is discounted by half because it is assumed that wetlands without surface water can only stabilize soil, not trap suspended sediment.
- If a wetland lacks a surface-flow outlet, i.e., is isolated, then the highest possible score for this function (10.00) is assigned automatically.
- For all other wetland types, the score is the *average of a wetland's increased Hydrologic Entrainment capacity (weighted 2x), Storage Space (weighted 2x), Interception/Erosion Resistance (average of terrestrial and aquatic), and decreased Connectivity (weighted 2x) and Frozen Duration.*
- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially trap and store more sediment if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In the above calculations:

- **Frozen Duration** is assumed to decrease with decreasing Elevation (relative position in watershed), more Growing Degree Days, and annual Snow Accumulation, as well as with increasing Tidal Proximity and south-facing Aspect of its contributing area. These are considered equally predictive and so are averaged.
- **Interception/Erosion Resistance in the terrestrial** (dry) environment is assumed to increase with increasing ground cover, microtopographic variation, and decreasing wetland gradient. These are averaged, except that the gradient is assigned a weight equal to that of the others combined, which are all considered to be equally predictive.
- **Interception/Erosion Resistance in the aquatic** (wet) environment is assumed to increase with increasing cover of emergent plants and increased meandering of flow paths through the wetland. These are considered equally predictive and so are averaged. This factor and its indicators are ignored in the calculations if none of the vegetation is ever flooded.
- **Storage Space** is assumed to be indicated by increasing amplitude of water level fluctuation and increasing percent of the wetland's area that floods only seasonally. These are considered equally predictive and so are averaged.
- **Hydrologic Entrainment** capacity is assumed to be indicated by decreased wetland shoreline gradient and increased magnitude of water level fluctuation, extent of areas flooded only seasonally, presence of many isolated pools within the wetland during high runoff conditions, presence of waters deeper than 3 feet during most of the year. These are all considered equally predictive and so are averaged.
- A decrease in **Connectivity** (i.e., lack of a persistently-flowing outlet) also favors sediment retention, and is assumed to be indicated by decreased wetland outflow duration, presence of an artificial (presumably constricted) outlet, and increased extent of pools within the wetland during the dry season. These are all considered equally predictive and so are averaged.

Non-Tidal Wetlands – SR Values Model

The value of the Sediment Retention function is considered to be greater when more sediment is being provided to a wetland. This is inferred by lower elevation (wetland near bottom of watershed), presence of inflowing tributaries, close proximity to silt-bearing glaciers or landslides, recent erosive land use activities upslope from the wetland, greater amounts of impervious surface and less natural cover in the wetland's contributing area, steeper slopes surrounding the wetland, large water level fluctuations, younger wetland age, and water quality data that show impairment. These are all considered equally predictive of value and so are averaged.

Tidal Wetlands – SR Function Model

If the site is tidal, the sediment retention function is assigned the maximum score if condition (a) below is true. If not, then the score is based on (b).
(a) Review of historical aerial imagery indicates the *wetland is expanding outward or landward*, at least during the time period covered by the imagery or other data, *OR:*
(b) The wetland is *wide (measured perpendicular to upland runoff direction), is topographically sheltered (minimal fetch), is not shrinking (as viewed in imagery), has dense ground cover, and contains a wide adjoining mudflat.* These are all considered equally predictive of value and so are averaged.

Tidal Wetlands – SR Values Model

If the site is tidal, the sediment retention is predicted to be most *valued* where either eelgrass is present downgradient, or where opportunity for sediment inputs is greatest.

- Opportunity is assumed to be greatest where the wetland potentially receives glacier water inputs, and the immediately adjoining upland area as well as the contributing area is steep, has little natural cover, the non-natural cover is largely impervious surfaces. These are all considered equally predictive of value and so are averaged.
- Opportunity also is greatest where transport of upland sediments to the wetland is likely, as indicated by presence of an intersecting tributary or at least proximity to one, or by wetland being associated with a river rather than a bay or marine shoreline. These are considered equally predictive of value and so are averaged.
- The above two groups are assumed to be equally predictive of opportunity for sediment delivery to a tidal wetland and so are averaged.

<u>Potential for Future Validation</u>: The volume of accreted sediments could be measured in a series of wetlands that encompass the scoring range. This might be done with sediment markers, with isotopic analysis of past sedimentation rates, or with SET tables (Boumans & Day 1993). Suspended sediment could be measured at inlets and outlets if any, with simultaneous measurement of changes in water volume and flow rate (e.g., Detenbeck et al. 1995).

3.6 PHOSPHORUS RETENTION (PR)

<u>Function Definition:</u> The effectiveness for retaining phosphorus for long periods (>1 growing season) as a result of chemical adsorption and complexation, or from translocation by plants to belowground zones or decay-resistant peat such that there is

less potential for physically or chemically remobilizing phosphorus into the water column.

Scientific Support for This Function in Wetlands Generally: High. Being relatively flat areas located low in the landscape, many wetlands are areas of sediment deposition, a process facilitated by wetland vegetation that intercepts suspended sediments and stabilizes (with root networks) much of the sediment. Because phosphorus (P) is commonly adsorbed to the suspended solids, it will consequently be deposited. Also, soluble forms of P can be chemically precipitated from the water column if there are sufficient levels of certain elements (iron, aluminum, calcium), the water is aerobic, and the pH is acidic (with iron, aluminum) or basic (calcium). This chemical precipitation of P also results in retention within a wetland. Subsequently, a variable proportion of the P will re-enter the water column (i.e., be desorbed from sediments or leached from organic matter) and be exported from the wetland. This can happen when sediments or the water column become anaerobic or the pH changes. That can result from excessive loads of organic matter, rising temperature, and/or reduced aeration due to slowed water exchange rates, increased water depth, or ice that seals off diffusion of atmospheric oxygen into the water. The wetland's P balance also depends on the physical stability of deposited sediments or soil. Wind can resuspend sediments rich in P making them vulnerable to being exported downstream by currents, but can also aerate the water column, which helps retain the P in the sediments. Plant roots also can facilitate P retention by aerating the sediment and translocating aboveground P to belowground areas where P-bearing sediments are less likely to be eroded. Phosphorus can potentially accumulate in wetlands more rapidly than nitrogen, and a state can be reached (perhaps after several decades of increased P loading) where sediments become saturated and no more P is retained, at least until some is desorbed and exported (Nichols 1983, Richardson 1985).

The **values** model (as opposed to the function model) addresses only the opportunity to perform this function, not its potential positive or negative effects on ecosystems, which are too difficult to estimate with a rapid method. Phosphorus is essential for plant growth but in high concentrations can shift species composition and habitat structure in ways that sometimes are detrimental to rare plants, aquatic food chains, and valued species (Carpenter et al. 1998, Anderson et al. 2002).

Non-tidal Wetlands – PR Function Model

Structure:

At a coarse level, three types of non-tidal wetlands are analyzed separately as pertains to this function: (1) those that never contain surface water, (2) those that lack outlets, and (3) all others.

- If a wetland never contains surface water, its ability to retain phosphorus is assumed to increase with a *decrease in Gradient (flatter being better) and Frozen Duration (propensity to be frozen for shorter periods)*. These are considered equally predictive and so are averaged. *The average is then multiplied by 0.5, reflecting an assumption that such wetlands might be only about half as effective for this function as most wetlands that contain surface water.*
- If a wetland lacks a surface-flow outlet, i.e., is isolated, then the highest possible score (10.00) for this function is assigned automatically, based on an assumption that most phosphorus is associated with suspended sediment. However, some amount of phosphorus is soluble and could still escape in groundwater. That pathway cannot be estimated with a rapid assessment method.
- For all other wetland types, a high score depends on the average of a wetland's increased phosphorus *Adsorption potential (weighted 3x), its diminished Desorption potential (weighted 2x), reduced Connectivity (weighted 2x), short Frozen Duration (unweighted), and increased Interception/Erosion Resistance in the wetland's dry zone (weighted 0.5), and the same in the aquatic zone (weighted 0.5)*.
- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially retain more phosphorus if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In the above calculations:

- **Adsorption potential** is assumed to be greatest in clay and peat soils, and lowest in coarse-textured soils.
- **Desorption potential** is assumed to be least in wetlands with deep persistent water with stable water levels. These are considered about equally predictive and so are averaged. Soil respiration, carbon accumulation rate, and subsurface water table fluctuation can be important to phosphorus adsorption and desorption but cannot be assessed accurately with a rapid assessment method.
- **Connectivity** is assumed to be less in wetlands that have no outlets or that export surface water for shorter periods through an artificial (presumably constricted) outlet, have shallow gradient, and contain a large proportion of pools during the dry season. These are considered about equally predictive and so are averaged.

- **Frozen Duration** is assumed to decrease with decreasing Elevation (relative position in watershed), more Growing Degree Days, and annual Snow Accumulation, as well as with increasing Tidal Proximity. These are considered equally predictive and so are averaged.
- **Interception/Erosion Resistance in the terrestrial** (dry) environment is assumed to increase with increasing vegetated zone width, percent ground cover, and microtopographic variation. These are considered equally predictive and so are averaged.
- **Interception/Erosion Resistance in the aquatic** (wet) environment is assumed to increase with increasing cover of emergent plants and increased meandering of flow paths through the wetland. These are considered equally predictive and so are averaged. This factor and its indicators are ignored in the calculations if none of the vegetation is ever flooded.

Potential for Future Validation: Among a series of wetlands spanning the scoring range, total phosphorus could be measured simultaneously at wetland inlet and outlet, if any, and adjusted for any dilution occurring from groundwater or runoff (or concentration effect from evapotranspiration) over the intervening distance. Measurements should be made at least once monthly and more often during major runoff events (e.g., Detenbeck et al. 1995). A particular focus should be on the relative roles of soil vs. vegetation characteristics, as they affect adsorption vs. uptake processes.

Non-Tidal Wetlands – PR Values Model

This function is considered most valuable if a wetland has greater opportunity to perform it. This increases if the wetland has a small contributing area with steep erodible slopes containing human-related nutrient sources and little natural vegetation, has a glacier-fed tributary with spawning anadromous fish and a high capacity for transporting phosphorus into the wetland, is likely to have large groundwater inputs (assumed to be higher in phosphorus than most surface waters), and is low in a regional watershed.

3.7 NITRATE REMOVAL AND RETENTION (NR)

Function Definition: The effectiveness for retaining particulate nitrate and converting soluble nitrate and ammonia to nitrogen gas, primarily through the microbial process of denitrification, *while generating little or no nitrous oxide* (a potent "greenhouse gas"). Note that most published definitions of Nitrate Removal do not include the important restriction on N_2O emission.

Scientific Support for This Function in Wetlands Generally: High. The values models address only the opportunity to perform this function, not its potential positive or negative effects, which are too difficult to estimate with a rapid method. Nitrate is essential for plant growth but in chronically high concentrations, such as from urban and agricultural runoff, can be a significant "nonpoint source" that shifts species composition and habitat structure in ways that sometimes are detrimental to rare plants, aquatic food chains, and valued species (Carpenter et al. 1998, Anderson et al. 2002). High concentrations of nitrate in well water also are a human health hazard, and some levels of ammonia impair aquatic life. When excessive algal growths are triggered by abnormally high levels of nutrients in the tidal or marine water column, they block light needed by eelgrass (Williams & Ruckelshaus 1993), a submersed plant very important to fish and wildlife. Nitrate concentrations as low as 1 mg/L can change the structure of freshwater algae communities of streams (Pan et al. 2004) and contribute to blooms of toxic algae in lakes and wetlands.

Non-tidal Wetlands – NR Function Model

Structure:
At a coarse level, four types of non-tidal wetlands are analyzed separately as pertains to this function: (1) those that never contain surface water, (2) those that lack outlets, (3) all others that have organic soils, and (4) all others that do not have organic soils.

- If a wetland never contains surface water, its ability to remove N is assumed to be greater if it is a wooded riparian wetland or marsh rather than a bog, and has flatter Gradient and shorter Frozen Duration (propensity to be frozen for long periods), and has more intermixing of upland inclusions within the wetland. All these are considered equally predictive and so are averaged. The average is then multiplied by 0.8, reflecting an assumption that such wetlands might be only about 80% as effective for this function as most wetlands that contain surface water at least seasonally.
- If a wetland lacks a surface-flow outlet, i.e., is isolated, then the highest possible score (10.00) for this function is assigned automatically.
- For all other wetland types that are **peatlands**, a high score is assumed to depend on the average of a wetland's *Redox environment (weighted 3x), decreased Connectivity (weighted 2x), and increased Runoff Interception Potential and Temperature.*
- For all other wetland types that are **not peatlands**, the same model is used except *Organic Matter* is evaluated as well, with more being considered beneficial to this function.

- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially remove more nitrate if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In the above calculations:

- **Connectivity** is assumed to be less, and thus favor N retention, in wetlands that export surface water for shorter periods through an artificial (presumably constricted) outlet, have shallow gradient, and contain a large proportion of pools during the dry season. These are considered about equally predictive and so are averaged.
- **Temperature** is assumed to be greater, and thus favor N removal, in wetlands closer to marine waters, at low Elevation (relative position in watershed), more Growing Degree Days, less annual Snow Accumulation, and which are likely to have significant groundwater inputs and be fed by south-facing contributing areas. The first 5 indicators are averaged, and the last 2 are averaged separately, and then the two averages are combined because they are considered about equally predictive.
- **Interception/Erosion Resistance** is assumed to increase, and thus benefit N retention, in wetlands with increasing vegetated zone width, percent ground cover, microtopographic variation, and (if a stream is present) increased meandering of flow paths through the wetland. Also, N-interception potential is assumed to usually be greater for marshes and riparian wetlands than for bogs and fens. These indicators are considered equally predictive and so are averaged.
- The **Redox** metric reflects the interfacing of oxic and anoxic conditions in close proximity, which increases the potential for N removal. This is assumed to be greater in wetlands with many upland inclusions, large ratio of upland edge to wetland area, large interspersion of vegetation and open water, less persistent (and proportionately more seasonal) surface water, and greater water level fluctuation.
- **Organic content** of soils usually benefits N removal, so long as soils are not too acidic. It is assumed to be greater in older wetlands (ones that have not recently been uncovered by receding glaciers) and wetlands with more extensive cover of aquatic plants. Wetlands on granitic soils are assumed to be less productive and thus less likely to support the profusion of plants needed for optimal N uptake and establishment of soil organic matter. These indicators are considered equally predictive and so are averaged.

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), nitrate and ammonia could be measured simultaneously at wetland inlet and outlet, if any, and adjusted for any dilution occurring from groundwater or runoff (or concentration effects from evapotranspiration) over the intervening distance. Measurements should be made at least once monthly and more often during major runoff events (e.g., Detenbeck et al. 1995). Monitoring should also measure denitrification rates (at least potential), the nitrogen fixing rates of particular wetland plants, and nitrous oxide emissions.

Non-tidal Wetlands – NR Values Model

The value of this function is scored higher if N sources in or above the wetland are extensive, the potential for N transport into the wetland is large, and N-sensitive features are present downslope from the wetland. These three factors are assumed to influence a wetland's value about equally and so are averaged. "Sources" include spawning anadromous fish, N-fixing plants, septic systems and various other human activities, and contributing areas with limited extent of natural cover. The maximum score among these is used to represent Sources. The potential for Transport into the wetland is assumed greater if a tributary is present, the contributing area is large relative to wetland size, the wetland is not in a headwater location, and slopes nearest the wetland are steep. These are assumed to be about equally predictive and so are averaged to represent Transport. Significance of this function is considered to be higher if domestic wells are present within 1000 feet downslope from the wetland, or if the wetland is within an ADEC-designated Public Drinking Water Protection Area.

3.8 CARBON SEQUESTRATION (CS)

Function Definition: The effectiveness of a wetland both for retaining incoming particulate and dissolved carbon, and through the photosynthetic process, converting carbon dioxide gas to organic matter (particulate or dissolved). And to then retain that organic matter on a net annual basis for long periods *while emitting little or no methane* (a potent "greenhouse gas"). Note that most published definitions of Carbon Sequestration do not include the important limitation on methane emission.

Scientific Support for This Function in Wetlands Generally: Although many wetlands support exceptionally high rates of primary productivity, many other factors determine whether a wetland is a net source or sink for carbon. Artificial disturbances or extreme events, such as increased frequency of drought (e.g., from global warming, artificial drainage, glacial rebound) and perhaps flood (e.g., from glacier melt, tsunamis) can quickly reverse gains in the amount of carbon sequestered in a wetland. Moreover, some of the most productive non-tidal wetlands also tend to be among the most significant emitters of methane, a potent greenhouse gas.

In Southeast Alaskan Wetlands: Due partly to the northerly latitude (with cool temperatures and limited light), vegetation grows slowly in the region's wetlands and thus plants probably sequester carbon at a relatively slow rate. However, both cumulatively and on a per-unit-area basis, the carbon reserves (mainly in the form of peat) in these wetlands are enormous.

Non-tidal Wetlands – CS Function Model

Structure:
A wetland is scored higher if its existing carbon stores (Historical Accumulation) are assumed to be large, its current Productivity is high, it has a great ability to physically retain organic matter it produces or receives from upgradient sources (Physical Accumulation), and it lacks factors that suggest it has substantial methane emissions (Methane Limitation). In the final model, *Methane Limitation is weighted equally with the average of Productivity, Historical Accumulation, and Physical Accumulation*.

- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially sequester more carbon if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In the above calculations:

- **Historical Accumulation** (existing carbon store) is represented by the wetland type (bog> fen> marsh> wooded riparian) and organic nature of the soil. If the wetland is not a new wetland (i.e., is older than 100 years), the maximum score of these is taken and averaged with the average of percent tree cover, unlogged and undrained condition, and wetland age. If the wetland is estimated to be younger than 100 years, then the Historical Accumulation factor is represented solely by its estimated age. Ideally, peat depths exceeding 16 inches should be measured, but this is not possible within the constraint of needing an assessment method that is rapid.

- **Physical Accumulation** is assumed to increase with flatter wetland gradient, less persistent outflow, and an artificial (presumably more constricted) outlet if an outlet is present at all. These are considered equally predictive of Physical Accumulation and so are averaged.
- **Methane emissions** are considered to be least when the wetland is not a sedge fen, tree cover (if any) is coniferous, moss cover is extensive, and soils have not been recently disturbed. These are considered equally predictive of Methane Limitation and so are averaged.
- Current **Productivity** is comprised of three factors that are averaged: *Frozen Duration, Plant Cover, and Nutrient Availability*. These are described as follows:
  - *Frozen Duration* is assumed to decrease with decreasing Elevation (relative position in watershed), more Growing Degree Days, and less annual Snow Accumulation, as well as with increasing proximity to tidal waters, south-facing Aspect of its contributing area, and presence of discharging groundwater. These are considered equally predictive of Frozen Duration and so are averaged.
  - *Plant Cover* is assumed to be greater with increasing vegetated area width, as well as with increasing aquatic plant cover and decreasing bare ground extent, water depth, and glacier-water inputs. The last 4 of these are averaged, and then that average is considered equal to aquatic plant cover.
  - *Nutrient Availability* is reflected by absence of underlying granitic bedrock, decreasing cover of moss, presence of karst terrain, presence of some fluctuation in water levels, increasing cover of nitrogen fixing plants, and increasing proportion of the wetland that is inundated only seasonally. These are considered equally predictive of Nutrient Availability and so are averaged.

Tidal Wetlands – CS Function Model

<u>Structure</u>:

A tidal wetland is scored higher if its existing carbon stores *(Historical Accumulation) are assumed to be large, its current Productivity is high, and it lacks factors that suggest it has substantial methane emissions (Methane Limitation). These indicators are considered equally predictive and so are averaged.*

- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially retain more carbon if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In the above calculations:

- **Historical Accumulation** is assumed to be greater in wetlands that show a pattern of expanding, especially over long time periods. Where data on trends are lacking or no change in marsh area is apparent, then accumulation is assumed greater in tidal wetlands that are wide (at low tide), sheltered, wooded, not ditched or drained, and with organic sediments. These indicators are considered equally predictive and so are averaged.
- **Productivity** is assumed to be greater in "high" tidal wetlands that are wide (at high tide) and are closest to the ocean (less ice cover) but are sheltered, and have relatively dense ground cover and perhaps nitrogen-fixing plants along their upland edge. These indicators are considered equally predictive and so are averaged.
- **Methane emissions** are assumed to be lower in tidal wetlands that are along waters that are more saline, e.g., closer to outer coast, no river inputs.

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), particulate and dissolved organic carbon would need to be measured regularly at wetland inlet and outlet, if any, along with measurements of changes in water volume. Equally important, emissions of methane and carbon dioxide would need to be measured regularly throughout the year and throughout the day/night cycle. Plant productivity rates (especially belowground), decomposition rates, hydrology, and net carbon accumulation in sediments or soils would require measurement as well.

3.9 ORGANIC MATTER EXPORT (OE)

Function Definition: The effectiveness of a wetland for producing and subsequently exporting organic matter, either particulate (detritus) or dissolved, and including net export of nutrients (C, N, P, Si, Fe) comprising that matter. It does not include exports of carbon in gaseous form (methane and carbon dioxide).

Scientific Support for This Function in Wetlands Generally: Moderate-High. Wetlands which have outlets are potentially major exporters of organic matter to downstream or marine waters. That is partly because many wetlands support exceptionally high rates of primary productivity (i.e., carbon fixation, which provides more carbon that is available for export). Numerous studies have shown that watersheds with a larger proportion of wetlands tend to export more dissolved and/or particulate carbon, and that is important to downstream food webs. Value of the exported matter to food webs depends partly on the quality and timing of the export, but those factors cannot be estimated with a rapid assessment method.

In Southeast Alaskan Wetlands: Both cumulatively and on a per-unit-area basis, the carbon reserves (mainly in the form of peat) in Southeast Alaskan wetlands are enormous, and due to large annual precipitation much of this carbon is exported to streams, rivers, lakes, and marine waters. Once there, much of it supports food chains important to fish, wildlife, and people.

Non-tidal Wetlands – OE Function Model

Structure: If no surface flow ever exits a wetland, its OE function is automatically scored 0. For all other wetlands, the score increases with increasing *Export Potential, Historical Accumulation, and current Productivity. Export Potential is assumed to be twice as predictive as either of the other two factors.*

- **Important Note**: The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially produce and export more carbon if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

In the above calculations:

- **Export Potential** is assumed to be greater if wetland vegetated width and the proportion of pools within a wetland is less, a natural (presumably unconstricted) outlet is present, a melting glacier is present upslope, and the wetland is located relatively low in a watershed. These indicators are considered equally predictive and so are averaged. Considered as equally predictive as that average are steeper wetland gradient, more persistent outflow, and carbon export rating shown on an existing map for the wetland's entire watershed.
- **Historical Accumulation** (existing carbon store) is represented by the wetland type (bog> fen> marsh> wooded riparian), and increasing wetland age and assumed organic content of soil.
- Current **Productivity** is comprised of three factors that are averaged: *Frozen Duration*, *Nutrient Availability*, and *Plant Cover*. These are described as follows:

- *Frozen Duration* is assumed to decrease with decreasing Elevation (relative position in watershed) and more Growing Degree Days, as well as with increasing proximity to tidal waters and discharging groundwater. These are considered equally predictive of Frozen Duration and so are averaged.
- *Plant Cover* is assumed to be greater with decreasing extent of persistent water and increasing vegetated area width, as well as with increasing aquatic plant cover and decreasing bare ground extent, water depth, and glacier-water inputs. The last 4 of these are averaged, and then that average is weighted the same as the first 2 indicators individually.
- *Nutrient Availability* is reflected by absence of underlying granitic bedrock; presence of karst terrain, fluctuating water levels, connections to other water bodies, and spawning salmon; and increasing cover of nitrogen fixing plants and proportion of the wetland that is inundated only seasonally. These are considered equally predictive of Nutrient Availability and so are averaged.

Tidal Wetlands – OE Function Model

Structure: The score takes into account a tidal wetland's existing carbon stores *(Historical Accumulation), its current Productivity, and the Exporting Opportunity of the landscape in which it exists. The scores for the first two factors are averaged, and then that is considered to be as important as the Exporting Opportunity, so is averaged with that.*

In the above calculations:

- **Historical Accumulation** is assumed to be greater in tidal wetlands that show a pattern of expanding, especially over long time periods. Where data on trends are lacking or no change in marsh area is apparent, then accumulation is assumed greater in tidal wetlands that are wide (at low tide), sheltered, wooded, not ditched or drained, and with organic sediments. These indicators are considered equally predictive and so are averaged.
- **Productivity** is assumed to be greater in "high" tidal wetlands that are wide (at high tide) and are geographically closer to the ocean (less ice cover) but are sheltered, and have relatively dense ground cover and perhaps nitrogen-fixing plants along their upland edge. These indicators are considered equally predictive and so are averaged.

- **Exporting Opportunity** is assumed to be greater in "low" tidal wetlands that are narrow, unsheltered, close to the ocean (less ice cover) or along rivers (currents facilitate export), with freshwater tributaries, unconfined outlets, complex internal channel networks, and steep adjoining upland slopes and tributary channels. These indicators are considered equally predictive and so are averaged.

VALUES MODEL: No model is provided for either tidal or non-tidal wetlands because this function's values are diffused throughout all receiving water bodies.

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), particulate and dissolved organic carbon would need to be measured regularly at wetland inlet and outlet, if any, along with measurements of changes in water volume and flow rate.

3.10 AQUATIC INVERTEBRATE HABITAT (INV)

Function Definition: The capacity to support an abundance and diversity of invertebrate animals which spend all or part of their life cycle underwater, on the water surface, or in moist soil. Includes dragonflies, aquatic flies, clams, snails, crustaceans, aquatic beetles, aquatic worms, aquatic bugs, and others, including semi-aquatic species. The model described below will not predict habitat suitability accurately for every species, nor the importance of any species or functional group in the diet of important fish or birds. No model is provided for tidal wetlands because of lack of information on which variables contribute to differences in invertebrate abundance and diversity among tidal wetlands in Southeast Alaska.

Scientific Support for This Function in Wetlands Generally: High. All wetlands support invertebrates, and many wetlands support aquatic invertebrate species not typically found in streams or lakes, thus diversifying the local fauna. Densities of aquatic invertebrates can be exceptionally high in some wetlands, partly due to high primary productivity and warmer water temperatures, and partly because submerged, floating, and emergent vegetation provide additional structure (vertical habitat space).

Non-tidal Wetlands – INV Function Model

Structure: In all types of non-tidal wetlands, the score is the unweighted average of four factors, and the score increases as each of these increase: *Productivity (Food), Habitat Structure, and the average of four similarly-predictive factors: wetland hydroperiod,* *connectivity, naturalness of the surrounding land cover (Landscape), and absence of human-related stressors.* Thus, *Productivity* and *Structure* account for more than the other factors. In these calculations:

- **Productivity** is assumed to be greater where the wetland contains or is adjoined by hardwood cover (especially alder), has plentiful amounts of downed wood, is situated in karst terrain, contains mostly shallow water, and is not glacier-fed. These indicators are considered equally predictive and so are averaged. Of equal weight as that average is the score based on wetland type productivity, as follows: Riparian Shrub/Forest> Marsh> Sedge Fen> Peatland Slope> Peatland Bog.
- **Structure** is assumed to increase with increased ground cover, microtopographic variation, downed wood, and large woody debris. These indicators are considered equally predictive and so are averaged. That average is then weighted equally with cover of aquatic plants – perhaps the most important indicator of Structure.
- **Landscape** condition is assumed better for invertebrates when land cover in the contributing area is mostly natural, as represented by the average of 3 indicators which reflect that.
- **Hydroperiod** is assumed most favorable when water levels fluctuate moderately and seasonally, the wetland experiences occasional complete drawdown of water levels, and there is evidence of groundwater discharging to the wetland. These indicators of hydroperiod effects on invertebrates are considered equally predictive and so are averaged. That average is then weighted equally with proportional extent of persistent water – perhaps the most important indicator of hydroperiod influence on aquatic invertebrates.
- **Connectivity** is reflected by increased proportion of the wetland that is connected with other water bodies, greater interspersion of patches of vegetation and open water, and more sinuous internal channels that intersect woody vegetation. These indicators are considered equally predictive and so are averaged.
- **Stressors** are represented by increased soil disturbance, sediment inputs, and fish access. These are considered equally predictive and so are averaged.

<u>Potential for Future Validation</u>: The aquatic invertebrate richness, density, and (ideally) productivity would need to be measured regularly throughout the year among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity).

Non-tidal Wetlands – INV Values Model

<u>Structure</u>: A wetland with the potential to support invertebrates is assumed to be more valuable if it has a high habitat score for the average of several other functions:

Amphibians, Anadromous Fish, Resident Fish, Feeding Waterbirds, Nesting Waterbirds, and Songbirds & Mammals.

3.11 ANADROMOUS FISH HABITAT (FA)

Function Definition: The capacity to support an abundance of native anadromous fish (chiefly salmonids) for functions other than spawning. See worksheet *WetVerts* for list of the species. The model described below will not predict habitat suitability accurately for every species, nor is it intended to assess the potential to restore fish access to a currently inaccessible wetland.

Scientific Support for This Function in Wetlands Generally: Moderate-high, depending mainly on accessibility of a wetland to anadromous fish. Many accessible wetlands provide rich feeding opportunities, shelter from predators, and a beneficial thermal environment.

Non-tidal Wetlands – FA Function Model

Structure: Wetlands are scored 0 if not accessible to anadromous fish or if no surface water is ever present. In all other wetlands, the score increases with increasing fish *access to the wetland and persistence of the wetland's outflow. These two factors are averaged and then multiplied by the average of increased wetland Productivity, Structure, Hydrologic Regime, Landscape condition, and a lack of human-related Stressors. This assumes these last 3 factors are much less important if Access and Outflow Persistence are impaired.* In these calculations:

- **Productivity** is assumed to be greater where the wetland contains or is adjoined by alder, is situated in karst terrain, not on granitic bedrock, is at low elevation, near marine waters, and there is evidence of significant groundwater input. These indicators are considered equally predictive and so are averaged.
- **Structure** beneficial to anadromous fish is assumed to increase with increased shade and cover of aquatic plants, boulders, and large woody debris.
- **Hydrologic Regime** is assumed most favorable for rearing anadromous fish when surface water is present persistently or seasonally and there is increased proportion of the wetland that is connected with other water bodies both during wet and dry seasons, greater interspersion of patches of vegetation and open water, more complex internal channel networks that intersect woody vegetation, lake environment, and moderate water depths. These indicators are considered equally predictive and so are averaged.

- **Landscape** condition is assumed to be better when land cover in the contributing area and area closest to the wetland is mostly natural.
- **Stressors** are represented by the average of: known toxicity of contaminants and increased altered flows, soil disturbance, sediment inputs, and glacier-water inputs. These are considered equally predictive.

Non-tidal Wetlands – FA Values Model

A wetland with the potential to support anadromous fish is assumed to be more valuable if it in a conservation priority watershed for anadromous fish, or has a high habitat score for Feeding Waterbirds or Songbirds & Mammals, or if near a known focal area for fisheries Subsistence and there is observed evidence of fishing.

Tidal Wetlands – FA Function Model

Structure: The model first addresses a tidal wetland's Accessibility to anadromous fish. *If there is even minimal fish Access to the wetland, the model then considers the likely extent and duration of access, potentially predictive Landscape-scale factors, and secondarily the wetland's potential Productivity and general Habitat Structure. The latter two together are given the same weight as each of the former.*

In the above calculations:

- **Access** is assumed to be greater in wetlands having extensive areas that fish can reach even at monthly low tide, and those with extensive internal channel networks and natural outlets. These indicators are considered equally predictive and so are averaged.
- **Productivity** is assumed to be greater in tidal wetlands that don't receive glacier-water inputs, as well as those with wide vegetation zones, groundwater seeps, large adjoining trees (especially deciduous), having or being near tributaries, and with no existing data that indicate presence of toxic pollution levels in or near the wetland. These indicators are considered equally predictive and so are averaged.
- **Structure** is assumed to be greater in tidal wetlands that have a variety of marine shoreline types within 1 mile, and either are wooded or have much large woody debris or other fish cover. These indicators are considered equally predictive and so are averaged.
- **Landscape** factors that favor anadromous fish include whether the wetland is located in a priority watershed for anadromous fish within its biogeographic province (subregion) in Southeast Alaska (from Schoen & Dovichin 2007). Considered equally influential is the average of 5 indicators: geographic position

(outer coast, inner coast, mainland), location along a major river or in a bay/lagoon, proximity to eelgrass, the average of the distance to the nearest other tidal wetland and extent of tidal wetlands generally in the associated watershed, and the average of the proximity to connected freshwater ponds/wetlands (positive), aquaculture facilities (negative), and percent of the upland buffer that is natural land cover (positive).

Tidal Wetlands – FA Values Model

Structure: This function is presumably valued to a greater degree if the wetland (1) is in a watershed with many salmon species, and/or is in a watershed with good bear habitat (the average of those 3), or (3) is fished and/or is known to be in or near a focal area for subsistence.

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), the number of anadromous fish and their duration of use would need to be measured regularly throughout the times when usually expected to be present, and weight gain during the period of wetland habitation should be measured.

3.12 RESIDENT FISH HABITAT (FR)

Function Definition: The capacity to support an abundance and diversity of *native* non-anadromous fish. See worksheet *WetVerts* in the *WESPAK_SE_SuppInfo* file for list of the species. The model described below will not predict habitat suitability accurately for every species, nor is it intended to assess the ability to restore fish access to a currently inaccessible wetland. No model is provided for tidal wetlands because of lack of information on which variables contribute to differences in non-anadromous fish abundance and diversity among tidal wetlands in Southeast Alaska.

Scientific Support for This Function in Wetlands Generally: High. Many accessible wetlands provide rich feeding opportunities, shelter from predators, and thermal refuge (especially if groundwater is a significant water source).

Non-tidal Wetlands – FR Function Model

Structure: A wetland automatically scores a 0 if there is no fish access and it is not known to contain resident fish, or if it never contains surface water. For all other wetlands, the score increases with increased wetland *Productivity, Hydrologic Regime, and* *habitat Structure, and decreased Stressors and risk of winterkill from Anoxia. These 5 factors are considered equally predictive of resident fish habitat suitability and so are averaged.*

In the above calculations:

- **Productivity** is assumed to be greater where the wetland contains both an inlet and outlet, is adjoined by alder, is situated in karst terrain, has evidence of significant groundwater input, is not on granitic bedrock, has not been recently deglaciated, and (in order of decreasing productivity) is a Riparian Shrub/Forested wetland > Marsh > Sedge Fen > Slope Peatland > Flat Peatland. These indicators are considered equally predictive and so are averaged.
- **Structure** beneficial to resident fish is assumed to increase with increased cover of aquatic plants, boulders, and large woody debris, and the known or potential presence of beaver.
- **Hydrologic Regime** is assumed most favorable for resident fish when surface water is present persistently and there is increased proportion of the wetland that is connected with other water bodies both during the dry season, greater interspersion of patches of vegetation and open water, more complex internal channel networks that intersect woody vegetation, and a variety of water depths in fairly equal proportions. These indicators are considered equally predictive and so are averaged.
- **Stressors** are represented by the average of: known toxicity of contaminants and increased alteration of flow timing, sediment inputs, and glacier-water inputs. These are considered equally predictive.
- **Anoxia Risk** is assumed to increase with two factors that are averaged. The first is represented by the average of increasing water depth and outflow persistence. The second is the average of decreasing Elevation (relative position in watershed), more Growing Degree Days, and less annual Snow Accumulation, as well as increasing Tidal Proximity and wetland fringing on a lake. These are considered equally predictive of resident fish winterkill and so are averaged.

<u>Potential for Future Validation</u>: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), the number of native non-anadromous fish and their onsite productivity and diversity would need to be measured regularly. For transient species, the duration of use and weight gain throughout the times when usually expected to be present should be determined.

Non-tidal Wetlands – FR Values Model

Structure: This function is presumably valued to a greater degree if there is evidence of fishing at the site, if its feeding waterbird score is high, and/or if it is in a region ranked high for Subsistence. These 3 indicators are considered equally important so are averaged.

3.13 AMPHIBIAN HABITAT (AM)

Function Definition: The capacity of a wetland to support an abundance and diversity of native amphibians (frogs, toads, salamanders). See worksheet *WetVerts* in the *WESPAK_SE_SuppInfo* file for list of the species. The model described below will not predict habitat suitability accurately for **every** species. No model is provided for tidal wetlands because of absence of amphibians from most such wetlands, and lack of information on which variables contribute to differences in amphibian use among the high-marsh tidal wetlands in Southeast Alaska that are sometimes used.

Scientific Support for This Function in Wetlands Generally: High. Many amphibian species occur almost exclusively in wetlands. Densities of amphibians can be noticeably higher in some wetlands, partly due to high productivity of algae and invertebrates, and partly because submerged vegetation provides shelter and sites for egg-laying and larval rearing.

Non-tidal Wetlands – AM Function Model

Structure: Any non-tidal wetland where amphibian presence has been documented is automatically assigned the maximum score (10). For other wetlands, the score increases with increasingly favorable conditions of Climate, Hydrologic Regime, Aquatic Structure, Terrestrial Structure, wetland Productivity, "Waterscape", Landscape, and minimal impacts from human Stressors. These 8 factors are considered equally predictive and so are averaged.

In the above calculations:

- **Climate** is considered more suitable for amphibians in wetlands at lower elevations, with shorter duration of ice cover, closer to marine waters, more Growing Degree Days, and less snow cover. These indicators are considered equally predictive and so are averaged.
- **Hydrologic Regime** is assumed more suitable in wetlands with more persistent surface water, including some depths greater than 3 feet, with groundwater inputs, only minor water level fluctuations, and a larger proportion of their surface water in

pools than in areas that connect to other surface waters during dry and/or wet seasons. These indicators are considered equally predictive and so are averaged.

- **Aquatic Structure** that is more suitable for amphibians is represented by a wide zone of aquatic plants, large woody debris, and high interspersion of vegetation and open water. These indicators are considered equally predictive and so are averaged.
- **Terrestrial Structure** is considered best in wetlands with moderate ground cover and cover of shrubs, extensive microtopographic variation, and much downed wood.
- **Productivity** is assumed to be highest in flat-gradient wetlands with gentle shore slopes, larger-diameter trees, south-facing contributing areas, that are not in recently deglaciated areas or on granitic bedrock. Also, wetland types are ranked for amphibian suitability as follows: Marsh > Sedge Fen > Riverine Shrub/Forest > Peatland Flat > Peatland Slope. All these indicators of productivity are considered equally predictive so are averaged together.
- **Waterscape** is represented by increasing number and proportion of ponded areas within 2 miles of a wetland, and increasing proximity to the nearest other ponded wetland. These are all averaged.
- **Landscape** conditions are considered better for amphibians when natural cover comprises a large and proximate part of the upland cover. Several indicators of this are averaged.
- **Stressors** of potential detriment to amphibians are considered to include increasing proximity to nearest road, blockage of movements by the road configuration around a wetland, documented toxicity from contaminants, glacially-fed tributaries (high turbidity), and ready access to a wetland by fish. These indicators are considered equally predictive and so are averaged.

<u>Potential for Future Validation</u>: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), amphibian density and (ideally) productivity and survival would need to be measured during multiple years and seasons by comprehensively surveying (as applicable) the eggs, tadpoles, and adults.

Non-tidal Wetlands – AM Values Model

<u>Structure:</u> The value of this function is represented by the average of the scores for Feeding Waterbird Habitat, Songbird-Mammal habitat, and whether the wetland contains the only patch of a particular vegetation form within 0.5 mile.

3.14 WATERBIRD FEEDING HABITAT (WBF)

Function Definition: The capacity to support an abundance and diversity of feeding waterbirds, primarily outside of the usual nesting season. See worksheet *WetVerts* for list of the species. The model described below will not predict habitat suitability accurately for every species in this group.

Scientific Support for This Function in Wetlands Generally: High. Dozens of waterbird species occur almost exclusively in wetlands during migration and winter. Densities can be exceptionally high in some wetlands, partly due to high productivity of vegetation and invertebrates, and partly because wetland vegetation provides shelter in close proximity to preferred foods.

Non-tidal Wetlands – WBF Function Model

Structure: Wetlands are scored 0 if they are a peatland slope wetland or if no water is ever present. In all other wetlands, the score increases with more favorable Climate and Structure, increased wetland Productivity, optimal Hydrologic Regime, good Landscape condition, and less impact from human-associated Stressors. These 6 factors are considered about equally predictive of wetland suitability for feeding (principally migratory) waterbirds, so are averaged.

In the above calculations:

- **Climate** is considered more suitable for amphibians in wetlands at lower elevations, with shorter duration of ice cover, closer to marine waters, more Growing Degree Days, and less snow cover. These indicators are considered equally predictive of a climate favorable for feeding waterbirds and so are averaged.
- Habitat **Structure** is assumed to be better for feeding waterbirds in wetlands that have extensive cover of aquatic vegetation and mudflats, relatively little woody cover, and open water areas well-interspersed with vegetation. If channels are present in the wetland they are complex and winding. These indicators are considered equally predictive of good habitat structure and so are averaged.
- Wetlands with higher **Productivity** are assumed to include those with flatter gradients, fish access, a recent history of temporarily drying out, and wetland types

in this order of decreasing assumed aquatic productivity: Marsh > Sedge Fen & Riverine Shrub/Forested > Peatland Flat > Peatland Slope. These indicators are considered equally predictive of aquatic productivity and so are averaged.

- **Hydrologic Regime** is assumed to be more suitable in wetlands with large patches of herbaceous (non-moss) vegetation, at least 0.5 acre of moderately deep and persistent surface water, a large proportion of vegetation that is inundated only seasonally, a variety of depth classes in relatively equal proportions, including some depths greater than 3 feet, and with a larger proportion of their surface water in pools rather than in areas that connect to other surface waters. These indicators are considered equally predictive and so are averaged.
- **Landscape** context which is considered most important to predicting the abundance and diversity feeding waterbirds in Southeast Alaska is proximity to major mainland rivers (Stikine, Taku, etc.) and the proximity to lakes. These comprise nearly half the Landscape score. The rest is influenced equally by proximity to nearest pond, proportion of landscape comprised of ponded areas, nearest openland area (e.g., marsh, field, treeless bog), proportion of landscape comprised of openland, and the actual or potential presence of beaver.
- **Stressors** of significant concern to feeding waterbirds are documented toxicity from contaminants, and visitation of nearly the entire wetland by people on foot.

<u>Potential for Future Validation</u>: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), feeding waterbird species richness and density would need to be determined monthly and more often during migration (see USEPA 2001 for methods). Ideally, daily duration of use and seasonal weight gain should be measured.

Non-tidal Wetlands – WBF Values Model

This function is assumed to be more valuable where a wetland has been officially designated an IBA (Important Bird Area), or is known to host a rare migratory waterbird species, or as reflected by the average of 4 indicators: greater local scarcity of herbaceous vegetation (if it is an herbaceous wetland), documented use by hunters, near a population center, and most of wetland is visible. The last 3 of these suggest potential for more frequent enjoyment by recreationists.

Tidal Wetlands – WBF Function Model

<u>Structure</u>: The suitability of tidal wetlands for migratory and wintering waterbirds is assumed to be greater with increased aquatic Productivity, Structure, Landscape

condition, and availability of Refugia. The model assigns half the score to the Landscape metric and half to the remaining three metrics, which are averaged. These are determined as follows:

- **Landscape-**scale indicators of waterbird feeding in tidal wetlands are assumed to include proximity to major mainland rivers (Stikine, Skagway, etc.), proximity to other tidal marshes, and proportion of the wetland's watershed occupied by tidal wetlands.
- **Productivity** is assumed to be greater in tidal wetlands that have a large vegetated width; are a freshwater tidal wetland or are intersected by a stream; are known to not be contaminated by toxic substances; and are on a shoreline having many distinct tidal habitats including eelgrass.
- **Structure** desired by the most feeding waterbirds in tidal wetlands is assumed to include a general lack of woody vegetation, substantial portions of the wetland still covered with water at low tide, a complex internal channel network, and extensive adjoining mudflats.
- **Refugia** are comprised of areas where feeding waterfowl can find shelter from coastal storms or temporary escape from recreationists. This factor is assumed to be reflected by small open-water distance (fetch), estuarine position (sheltered embayments and river deltas preferred), proximity to a lake, and to a lesser extent: limited wetland visitation by people on foot, proximity to a pond, and a large proportion of the surrounding landscape occupied by openlands and ponds. The first three indicators together are given 75% of the weight for Refugia.

Tidal Wetlands – WBF Values Model

This function is assumed to be more valuable where a tidal wetland (a) has been officially designated an IBA (Important Bird Area), or (b) is known to host a rare migratory waterbird species, or (c) is in a general area considered generally important for Subsistence, or (d) is in a watershed having few other tidal wetlands, or (e) the average of: near a population center, visible from roads, visited by waterfowl hunters. The value score is the maximum of (a-e).

3.15 WATERBIRD HABITAT - BREEDING (WBN)

<u>Function Definition:</u> The capacity to support an abundance and diversity of nesting waterbirds. See worksheet *WetVerts* in the *WESPAK_SE_SuppInfo* file for list of the species. The model described below will not predict habitat suitability accurately for every species in this group. No model is provided for tidal wetlands because it appears that few waterbirds place their nests within tidal wetlands.

Non-tidal Wetlands – WBN Function Model

<u>Structure:</u> The model first eliminates (assigns a score of 0) any wetlands on slopes of greater than 10 percent. Although a few waterbird species do nest along steep-sloped streams (e.g., harlequin duck, American dipper), they nest more often in the drier upland areas near those streams than in floodplains or wetlands. The model then eliminates wetlands that have less than 0.5 acre of surface water during the breeding season, are not near a lake, and are not a fringe wetland. Then it computes the average of 5 indicators: aquatic plant cover, wetland size (unless emergent vegetation occupies <5% of the wetland), wetland type (it assumes suitability is Marsh> Sedge Fen> Riparian Shrub/Forested> Peatland Flat> Peatland Slope), the Waterscape metric, and the average of these 4 metrics: Stressors, Productivity, Structure, and HydroRegime. These are determined as follows:

- **Waterscape** is represented by increasing proximity to lakes and ponds, proportion of ponded areas within 2 miles, and actual or potential presence of beaver. These are assumed to be equally predictive so are averaged.
- **Stressors** are represented by decreased proportion and amount of natural cover around the wetland, closer proximity to roads, increased proportion of the wetland visited often by people on foot, and evidence of toxic contaminants. These are averaged and subtracted from 1 to represent the *absence* of these stressors.
- **Productivity** is assumed to be greater in non-acidic wetlands with flat gradients at lower elevations, that have undergone occasional drawdowns, and are a more productive wetland type (in descending order, this is assumed to be: Marsh> Sedge Fen> Riparian Shrub/Forest> Peatland Flat> Peatland Slope. These indicators are assumed to be equally predictive so are averaged.
- **Structure** most suitable for breeding waterfowl habitat includes a large cover of aquatic plants and of herbaceous plants generally, diversity of wetland cover heights, wider vegetated zone, snags, large channel complexity (if channels are present), and good interspersion of aquatic plants and open water. These indicators are assumed to be equally predictive so are averaged.
- **HydroRegime** is assumed to be more suitable in herbaceous wetlands that are large, have intermediate depth, with a large proportion of their surface water in pools rather than in areas that connect to other surface waters, or are fringe wetlands

along a river or (especially) a lake, and contain large areas that are either persistently or seasonally inundated. These 8 indicators are considered equally predictive and so are averaged.

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), nesting waterbird species richness and density would need to be determined during the usual breeding period -- approximately April through July (see USEPA 2001 for methods). Ideally, nest success and juvenile survival rates should be measured.

Non-tidal Wetlands – WBN Values Model

This function is assumed to be more valuable where a wetland has been officially designated an IBA (Important Bird Area), or is known to host a rare breeding waterbird species, or has the largest local patch of herbaceous vegetation.

3.16 SONGBIRD, RAPTOR, AND MAMMAL HABITAT (SBM)

Function Definition: The capacity to support, at multiple spatial scales, an abundance and diversity of songbirds, raptors, and mammals, especially species that are most dependent on wetlands or water. See worksheet *WetVerts* for list of the species. The model described below will not predict habitat suitability accurately for every species in this group.

Scientific Support for This Function in Wetlands Generally: High. Several large mammals, such as moose and bear, as well as several species of songbirds and raptors, depend on Southeast Alaska's wetlands. Densities can be exceptionally high in some wetlands, due partly to high productivity of vegetation and invertebrates, and partly because wetland vegetation provides nest sites in close proximity to preferred foods.

Non-tidal Wetlands – SBM Function Model

Structure: If the entire wetland is always water-covered, the model assigns the lowest score (0). For all other wetland types, half of the score is based on geography (i.e., wetlands located in major mainland watersheds are scored higher) and the other half on the average of 6 metrics: Productivity, StructureA, StructureB, Landscape, Waterscape, and Stressors. It is assumed that geography plays a very large role in predicting the species composition, diversity, and abundance of mammals and songbirds in Southeast Alaska. The other metrics are described as follows:

- **Productivity** is assumed to be greatest in wetlands with more hardwood cover, nitrogen-fixing plants, at low elevation, near marine waters, with high edge-to-area ratio and numerous upland inclusions. These are all considered to be equally predictive of SBM habitat, and their average is multiplied by the average of the scores for the wetland's size and vegetated width.
- **StructureA** is a group of indicators that together represent some beneficial components of SBM habitat. This includes cliffs, snags, downed wood, increased ground cover, diverse heights within the herbaceous stratum, and varied microtopography. These indicators are assumed to be equally predictive so are averaged.
- **StructureB** is another group of indicators that together reflect beneficial components of SBM habitat. This includes increased amounts of multi-layered tree and shrub cover in and around the wetland, more mature trees, some small forest gaps, and a diversity of shrub species and height classes. These indicators are assumed to be equally predictive so are averaged.
- **Landscape** condition is assumed better for SBM where there is a large proportion of natural vegetation in the wetland's contributing area and areas within 2 miles, as represented by 6 indicators which are assumed to be equally predictive so are averaged.
- **Waterscape** condition is assumed better for SBM where a large proportion of the surrounding area is ponded areas, the wetland itself is near a pond or is a fringe wetland, has vegetation that is well-interspersed with patches of open water, and is actually or potentially used by beaver. These indicators are assumed to be equally predictive so are averaged.
- **Stressors** which could affect SBM use of a wetland include frequent human visitation, proximity to population centers, proximity to a road, and road blockage of access to the wetland. These indicators are assumed to be equally predictive so are averaged.

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), species richness and density of songbirds, raptors, and mammals would need to be determined monthly and more often during migration or seasonal movements (see USEPA 2001 for methods). Ideally, daily duration of use and seasonal weight gain of key species should be measured.

Non-tidal Wetlands – SBM Values Model

This function is assumed to be more valuable where a wetland has been officially designated an IBA (Important Bird Area), or is known to host a rare breeding waterbird species, or has the largest local patch of a major vegetation form. Wetlands on small islands are also considered more valuable, as they may be the only source of fresh surface water available to many individual animals.

Tidal Wetlands – SBM Function Model

Structure: If the tidal wetland has no "high marsh" (i.e., no part is ever free of surface water), then the score is automatically 0. For all other tidal wetlands, the score is the average of 3 metrics: Productivity, Structure, and Landscape. These are calculated as follows:

- **Productivity** of the tidal wetland is assumed to be greater with increased freshwater inputs from tributaries, adjoined by a non-tidal wetland, sheltered location, and located in a priority habitat area for bear as indicated in the Southeast Alaska Conservation Assessment (Schoen & Dovichin 2007). These indicators are assumed to be equally predictive so are averaged.
- **Structure** beneficial to SBM is represented by increased proportion of the wetland which is high marsh; greater vegetated width of the high marsh; increased size and diversity of trees in or adjoining the tidal wetland; presence of a convoluted wetland edge with uplands; a mature (not recently deglaciated or uplifted) successional condition, and the greater of: woody cover, driftwood extent, or other large woody debris extent. These 6 indicators are assumed to be equally predictive of SBM so are averaged.
- **Landscape** score is comprised one-third by location (tidal wetlands along the Stikine or in other mainland rivers are scored the highest), one-third by wetland size, and one-third by the average of several indicators, which include some stressors: proximity to a cliff, proportion of landscape comprised of natural land cover at two scales, isolation from population centers, and absence of barriers that could hinder mammal movements.

Tidal Wetlands – SBM Values Model

For tidal wetlands, this function is assumed to be more valuable where a wetland has been officially designated an IBA (Important Bird Area), or is known to host a rare feeding waterbird species. If neither, the wetland is nonetheless assigned some value (1.0).

3.17 NATIVE PLANT HABITAT (PH)

Function Definition: The capacity to support, at multiple spatial scales, a diversity of native vascular and non-vascular (e.g., bryophytes, lichens) species and functional groups, especially those that are most dependent on wetlands or water. See worksheet *WIS-plants* for list of the wetland vascular plant species in Southeast Alaska.

Scientific Support for This Function in Wetlands Generally: High. Many plant species grow only in wetlands, and thus diversify the local flora, with consequent benefits to food webs and energy flow. Plant communities of tidal marshes are relatively simple, with high redundancy among tidal wetlands (e.g., Phillips 1977, Burg et al. 1980).

Non-tidal Wetlands – PH Function Model

Structure: *The model is the average of 7 weighted metrics: Species-Area (weighted 4x), Aquatic Fertility (weighted 2x), Terrestrial Fertility (weighted 2x), Climate (weighted 2x), Landscape, Competition, and Stressors*. These are calculated as follows:

- **Species-Area** score increases with increased wetland size and vegetated width, the scores of which are averaged.
- **Aquatic Fertility** is assumed to increase with increased proportion of the wetland that floods only seasonally, likelihood of groundwater input, lower elevation, presence of a tributary, not recently deglaciated, mild water level fluctuation, and recent occurrence of a complete but temporary drawdown of surface water. These indicators are assumed to be equally predictive so are averaged.
- **Terrestrial Fertility** is assumed to increase (up to 75% cover) with increased cover of hardwoods (particularly nitrogen-fixers), karst bedrock, presence of finer-textured

and moderately organic soils, limited cover of moss, lack of granitic bedrock, and wetland type in this order of descending assumed fertility: Riparian Shrub/Forest > Marsh > Sedge Fen > Peatland Slope > Peatland Flat. These indicators are all assumed to be equally predictive so are averaged.

- **Climate** includes increased Growing Degree Days and proximity to marine waters, decreased elevation and snow cover, and south-facing aspect of the wetland's contributing area. These indicators are assumed to be equally predictive so are averaged.
- **Landscape** condition is assumed better for native plants where the proximate upland land cover is mostly natural, ponded areas are numerous and nearby, a landslide has occurred in or near the wetland, actual or potential use by beaver has been noted, and the wetland is not located on a small island distant from others and the mainland. These indicators are assumed to be equally predictive and so are averaged.
- **Competition** encompasses several indicators. The conditions assumed to be most beneficial for plant diversity are an absence of invasive plant species (both in the wetland and adjoining uplands), a diverse shrub community, varied microtopography, more herbaceous than woody cover, a diversity of herbaceous plant heights, and no strong dominance by any single herb species. The same weight is given to the first of these indicators (invasive species) as is given to the average of all the rest.
- **Stressors** are represented by increased wetland visitation by humans; proximity to roads and population centers; presence of deer; mowing; logging; or other removal of vegetation; more-altered timing of runoff reaching the wetland; and increased soil disturbance. These indicators are assumed to be equally predictive and so are averaged.

<u>Potential for Future Validation</u>: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), all plant species would be surveyed and percent-cover determined at their appropriate flowering times during the growing season.

Non-tidal Wetlands – PH Values Model

To represent the value of native plant habitat, the model takes the maximum of: (a) rare plant species is present in or near the wetland, or (b) average of vegetation form uniqueness (i.e., some form of vegetation in the wetland represents the only such form within 0.5 mile), wetland score for Songbird & Mammal Habitat, Pollinator Habitat, and Subsistence.

Tidal Wetlands – PH Function Model

Structure: For tidal wetland plant habitat, the model is the average of 5 weighted metrics: *Salinity (weighted 2x), Substrate (weighted 2x), Structure, Invasive Potential, and Landscape*. These are calculated as follows:
Salinity decrease, which enhances tidal plant diversity, is assumed to occur where a tidal wetland is located along a major mainland river (especially if nearer the head of tide) or there is high likelihood of groundwater discharge.
Substrate conditions beneficial to tidal plant diversity are assumed to be finer-textured soils, large proportion of high marsh, and large marsh width.
Structure that is assumed to be predictive includes mature marsh age (not recently uplifted), relatively even proportions of graminoids and forbs, moderate ground cover, and little or no woody canopy.
Invasive Potential by non-native plants is assumed to be greatest among small wetlands in which a large proportion is physically accessible to people, located near population centers, with only limited natural cover in their contributing area and upland buffer.
Landscape conditions beneficial to tidal plant diversity are assumed to include proximity to natural land cover and located in a watershed considered to be a priority habitat area for bear as indicated in the Southeast Alaska Conservation Assessment.

Tidal Wetlands – PH Values Model

Tidal wetlands with high plant diversity are assumed to be valuable if they are in a watershed with few other tidal wetlands, or contain a rare plant species. If neither, the wetland is nonetheless assigned some value (1.0).

3.18 POLLINATOR HABITAT (POL)

Function Definition: The capacity to support pollinating insects, such as bees, wasps, butterflies, moths, flies, and beetles, and also pollinating birds (hummingbirds and perhaps others). No model is provided here for tidal wetlands due to their presumed limited capacity to support pollinating insects and birds, and due to lack of knowledge of features that would be predictive.

Scientific Support for This Function in Wetlands Generally: High. Many plant species grow only in wetlands, and thus diversify the local flora, with consequent benefits to food webs and energy flow.

In Southeast Alaskan Wetlands: Very little is known about the habitat requirements of pollinators in this region, and there have been no studies specifically of wetlands.

Non-tidal Wetlands – POL Function Model

Structure: The model is *comprised of 3 metrics: Pollen Onsite, Pollen Offsite, and Nest Sites*. These indicators are assumed to be equally predictive so are averaged. They are calculated as follows:

- **Pollen Onsite** is assumed to be predicted by decreased coverage by persistent surface water, invasive plants, graminoid cover, and woody canopy cover; and increased herbaceous plant height diversity, more snags, larger trees (especially deciduous, which depend more on pollinators than do evergreens).
- **Pollen Offsite** is assumed to increase with increased amount of open lands (which are assumed to contain a greater abundance of forbs important to pollinators).
- **Nest Sites** available for pollinating insects are assumed to increase with increased snags, large-diameter trees, downed wood, microtopographic variation, and cliffs, as well as with less soil disturbance. Loose rock associated with cliffs or talus slopes provides nest areas for some pollinating insects.

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity).

Non-tidal Wetlands – POL Values Model

Pollination is presumably valued to a greater degree if a wetland contains a rare plant (although not all plants are insect-pollinated) or contains the only patch type of a particular vegetation form within 0.5 mile.

3.19 PUBLIC USE & RECOGNITION (PU)

Definition: The potential and actual capacity of a wetland to sustain low-intensity human uses such as hiking, nature photography, education, and research.

Non-tidal Wetlands

Structure: The score for Public Use value of a wetland is assumed to increase with an increase in scores for 4 metrics. Convenience, Investment, and Recreation Potential are considered equally predictive so are averaged, then are averaged with Ownership which thus is considered far more important. These are comprised of the following indicators:

- **Ownership**: score is greater if wetland is on public lands and where public access is unrestricted. Scores for these indicators are averaged.
- **Convenience**: score is greater where most of wetland is visible from roads, much of wetland is physically accessible, low elevation, near a population center and marine waters. Scores for these are averaged.
- **Investment**: This is intended to reflect positively any past expenditure of public funds for the wetland's conservation, as well as designation as a mitigation site or regular use for scientific research or non-regulatory monitoring. The metric's score is based on the maximum of these indicator scores.
- **Recreation Potential**: score is greater if wetland has trails, visitor center, and similar educational or recreational enhancements. Scores for these are averaged.

Tidal Wetlands

The model is similar to that for non-tidal wetlands, except that the final average includes consideration of the rarity of tidal wetlands in the watershed (if rare, the Public Use value is considered to be greater).

3.20 SUBSISTENCE & PROVISIONING SERVICES (Subsist)

Definition: The passive and sustainable providing of tangible natural items of potential commercial or subsistence value.

Non-tidal Wetlands

Wetlands considered more valuable are those in which humans harvest natural products sustainably and with minimal impact. If a wetland is located in a designated Non-Subsistence Use area, its assigned score is 0. For all other non-tidal wetlands, the score is based on whichever score is higher: (a) a score based on ADFW Subsistence Area maps, or (b) the average of these indicators: lower elevation, increased proximity to a population center, tidal waters, or (c) average of these indicators: location in a priority habitat area for deer, location in a priority habitat area for salmon (according to the Southeast Alaska Conservation Assessment), intersected by stream accessible to anadromous fish, direct evidence of wild game or fish harvest.

Tidal Wetlands

The score is based on whichever score is higher: (a) a score based on ADFW Subsistence Area maps, or (b) the average of these indicators: lower elevation, increased proximity to a population center, tidal waters, or (c) average of these indicators: location in a priority habitat area for salmon (according to the Southeast Alaska Conservation Assessment), located in a watershed with few other tidal wetlands, intersected by stream accessible to anadromous fish, direct evidence of wild game or fish harvest, proximity to a population center.

3.21 WETLAND SENSITIVITY (SENS)

Definition: the lack of intrinsic resistance and resilience of the wetland to human and natural stressors (Niemi et al. 1990), including but not limited to changes in water chemistry, shade, frequency and duration of inundation or soil saturation, water depth, biological invasion, habitat fragmentation, and others as described in the USEPA report by Adamus et al. (2001).

Non-tidal Wetlands

Structure: The model assumes that wetland sensitivity, especially to human activities, can be represented by the *unweighted average of the following 6 metrics*, all considered equally predictive:

- **Abiotic Resistance** is assumed to be less (i.e., wetland more sensitive) in shallow wetlands at higher elevations, with relatively small contributing areas, steep surrounding slopes, long duration freezing, constricted outlets, and seasonal-only inundation with water mainly confined to isolated pools.
- **Biotic Resistance** is assumed to be less (i.e., wetland more sensitive) in wetlands that are small; have a narrow vegetated width; are already dominated by native plant species; also support rare amphibians, waterbirds, songbirds, mammals, or plants; and (less predictably) limited ground cover, convoluted upland edge, few shrub species. Indicators in this last group are averaged, and their average is then combined with the average of the preceding more-predictive indicators.
- **Site Fertility** is assumed to speed recovery time from disturbance, which is a component of Wetland Sensitivity. It is predicted to be greater in wetlands that have

not been deglaciated recently, have more cover of nitrogen-fixing plants, and are a type of wetland that typically has greater nutrient availability, in this order: Riparian Shrub/Forest > Marsh > Sedge Fen > Peatland Slope > Peatland Flat.

- **Climate** also influences recovery rate. The most sensitive wetlands are assumed to be those in regions with heavy snow cover, few Growing Degree Days, distant from tidal waters, and in headwater locations.
- **Availability of Colonizers** also affects the recovery rate. Recovery times in wetlands might be greater if surrounding lands are dominated by natural land cover, including a high proportion and proximity of ponded wetlands and lakes, and the wetland has a diversity of shrub heights (implying a variety of shrub species), and with no herbaceous species being strongly dominant.
- **Growth Rates** of wetland vegetation, and thus the time to full recovery, also depend on the plant species. Trees grow the slowest and live the longest, so if a wetland contains much tree cover, especially of large-diameter trees, and that is removed, full recovery takes longer. Thus, such wetlands could be considered less resilient and more sensitive.

Tidal Wetlands

The most sensitive tidal wetlands are assumed to be those that are narrow, mostly unsheltered from waves, have shrunk in size in recent years, lack nitrogen-fixing vegetation, are distant from other tidal marshes, are in watersheds that have little tidal wetland area, are adjoined by steep slopes with limited natural cover, and support a waterbird or other wildlife or plant species of conservation concern. These indicators are assumed to be equally predictive so are averaged.

3.22 WETLAND ECOLOGICAL CONDITION (CQ)

Definition: The integrity or health of the wetland as defined primarily by its vegetation composition (because that is the only meaningful indicator that can be estimated rapidly). More broadly, the structure, composition, and functions of a wetland as compared to reference wetlands of the same type, operating within the bounds of natural or historic disturbance regimes. However, in the case of WESPAK-SE, the model outputs were not scaled to reference wetlands. A model is hypothesized only for non-tidal wetlands, as too few **rapid** indicators relevant to tidal wetlands could be identified.

Non-tidal wetlands in excellent ecological condition often have varied microtopography, multiple height classes of shrubs, little bare ground, no strongly dominant herbaceous or shrub species, beaver, and at least one species of conservation concern. However, many wetlands perceived to be in excellent condition – like most of those in Southeast Alaska – do not have any of these characteristics.

3.23 WETLAND STRESS (STR)

Definition: The degree to which the wetland is or has recently been altered by, or exposed to risk from, human-related factors that degrade its ecological condition and/or reduce its capacity to perform one or more of the functions listed in this document.

Non-tidal Wetlands

If toxic levels of contaminants have been measured at the site, a stressor score of 10 is assigned automatically. Otherwise, half of the stressor score is the maximum of the scores of the 9 stressor categories used in Form FS:

Wetter Water Regime - Internal Causes
Wetter Water Regime - External Causes
Drier Water Regime - Internal Causes
Drier Water Regime - External Causes
Altered Timing of Water Inputs
Accelerated Inputs of Nutrients, Contaminants, and/or Salts
Excessive Sediment Loading from Contributing Area
Soil or Sediment Alteration Within the Assessment Area
Vegetated Cover Removal Within the Assessment Area

The other half is an average of the following, indicating increased stress:

- greater cover of invasive plants along a wetland's upland edge
- greater proportion of a wetland is accessible to humans on foot
- closer proximity to a population center
- closer proximity to a road
- greater portion of wetland is visible from a road
- wildlife access to and from a wetland is limited by roads or other barriers
- contributing area has a large extent of impervious surface
- contributing area has a limited extent of natural vegetation
- not public lands

Tidal Wetlands

If toxic levels of contaminants have been measured at the site, a stressor score of 10 is assigned automatically. Otherwise, the stressor score is the average of the following groups:

Group A: This is the average of the 9 stressor categories listed above.

Group B: The average of: proximity to a road, large portion of wetland visible from roads, close to a population center, barriers to animal movements.

Group C: The average of: distance to natural vegetation, size of that patch, extent of impervious surface near the wetland.

Group D: Just one indicator (available data indicate toxic levels of contaminants but not necessarily onsite).

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Appendix A. Examples of Other Methods for Rapid Assessment of Wetlands in Southeast Alaska

1. **Juneau Wetlands Management Plan** (and subsequent modified criteria)

This includes the following documents:

- Adamus Resource Assessment, Inc. (ARA). 1987. Juneau Wetlands: Functions and Values. Community Development Department, City and Borough of Juneau, AK.
- Community Development Department (CDD), City and Borough of Juneau. 1997. Revised City and Borough of Juneau Wetlands Management Plan. CDD, Juneau, AK.
- Bosworth, K. and P.R. Adamus. 2006. Delineation and Function Rating of Jurisdictional Wetlands on Potentially-developable City-owned Parcels in Juneau, Alaska. Community Development Department, City and Borough of Juneau, AK.

The first document provided technical information (field data, literature synthesis, and technical criteria) that was needed for the first prioritization of Juneau wetlands, which occurred in the second document and was based on estimates of functions and values of all mapped Juneau wetlands. The third document included a limited attempt by ARA, Inc. to update the technical criteria and apply them to several properties owned by the CBJ. Prioritization was based on assigning wetlands to qualitative categories (High, Moderate, Low etc.) rather than using a continuous numeric scale. Local and state agencies were extensively involved during the development of the 1987 and 1997 documents.

2. **Hydrogeomorphic (HGM) Method**

This is the following document:

- Powell, J, D. D'Amore, R. Thompson, T. Brock, P. Huberth, B. Bigelow, and M.T. Walter. 2003. Wetland functional assessment guidebook operational draft guidebook for assessing the functions of riverine and slope river proximal wetlands in coastal Southeast & Southcentral Alaska using the HGM approach. Report to the Alaska Dept. of Environmental Conservation, Juneau, AK.

During the development of this method, data on 18 variables were collected from about 33 streams and wetlands in the Juneau area. The data were used to inform numeric criteria and data forms that can be applied to assess functions of stream-associated wetlands. Data collection requirements associated with the final method are more intensive than for other wetland assessment methods. It appears this method, with its restricted focus on riverine wetlands, has had only limited use since its publication in 2003.

3. **NatureServe Method**

This is represented by the following document:

- Kittel, G. and D. Faber-Langendoen. 2011. Watershed Approach to Wetland Mitigation: A Framework for Juneau, Alaska. Prepared by NatureServe, Arlington, VA.

This method attempts to focus on one aspect of wetlands, their ecological integrity ("condition"). The relationship of this attribute to each wetland function or value (e.g., salmon rearing habitat, recreational use) is unknown. The method is a spinoff of a similar method NatureServe developed in Colorado. There is little in the method's data forms to suggest that it has been modified specifically to address conditions unique to Juneau or Southeast Alaska. Method users employ a combination of GIS-compiled spatial data (e.g., wetland type abundance, position in watershed, roads, rare species) and onsite data (e.g., vegetation, soils, hydrology, stressors) to categorically assess wetland integrity. Users then combine the categories into a single numeric condition score for each wetland. The conversion is based on simply summing the weighted indicators within each group (Landscape, Size, Condition, Vegetation, Hydrology, Soils) without recognition of their potential interactions or relationship to wetland type. Four wetland types are recognized (Estuarine Wetland, Bog/Fen, Emergent, Forested/Shrub) and prioritized based on their local rarity and restorability. Users must be able to identify wetland plants to species. NatureServe applied the method to 12 Juneau-area wetlands in 2010. There appears to have been little or no coordination with or involvement of local agencies.

4. Habitat Equivalency Analysis (HEA)

This is an approach to computing mitigation credits, used experimentally in various parts of the United States by the US Army Corps of Engineers and NOAA. In Southeast Alaska, its use was demonstrated in the following project:

- Houghton, J. and M. Havey. 2010. Proposed Sitka Airport Improvement Projects – Mitigation Plan for Marine Impacts of the Preferred Alternatives. Report to Alaska Dept. of Transportation and Public Facilities and the Federal Aviation Administration.

Although this approach is for marine intertidal habitats it could be applied to wetlands. It is an accounting method, not a standardized technical protocol that anybody can use to assess the functions and values of an area. Relative levels of functions and values of different wetland *types* must be assigned beforehand by a "committee of experts" or less desirably, by a single expert. Doing so assumes that defining those types using just a few features, such as elevation and dominant vegetation, is sufficient to rank them based on all their functions and values, and that then applying those uniform rankings to all wetlands of that type is justified. However, doing that is not supported by current science. Even when the rankings of the types seem correct, the arbitrary basis for the coefficients assigned to each type (e.g., that open water is only 20% as "functional" as kelp beds) is unsupported by research. Either implicitly or explicitly, it requires that multiple functions of each type be combined into a single score or weighting factor that may reflect everything from primary production to fish to seabirds. Many stakeholders were involved in the application of this approach to the Sitka Airport mitigation.

5. Proper Functioning Condition (PFC)

This approach is described in:

- Pritchard, D. (coordinator). 1994. Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas. Technical Reference 1737-11 1994. USDI Bureau of Land Management, Denver, CO.
- Pritchard, D. (coordinator). 1998. A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas. Technical Reference 1737-15 1998. USDI Bureau of Land Management, Denver, CO.

This is a checklist approach that contains no models or formulas to automatically generate a score for an area. A group of resource professionals visits a wetland or stream reach and answers a short series of questions about their impressions of the condition of various natural processes within that unit. It is then up to the group to decide if the assessment unit is in Proper Functioning Condition, Functional-At-Risk, or Nonfunctional. Specific functions and values are not rated. Considerable expertise in interpreting stream geomorphic processes and classification is needed in order to generate consistent ratings. Several partnering agencies in Southeast Alaska are currently developing reference standards for geomorphological features, instream wood, and other attributes of different types of streams in the region; see:
http://www.fs.fed.us/r10/tongass/forest_facts/ct_rev/chantype_revision.shtml

Appendix B. Maps Required to Answer Form OF Questions

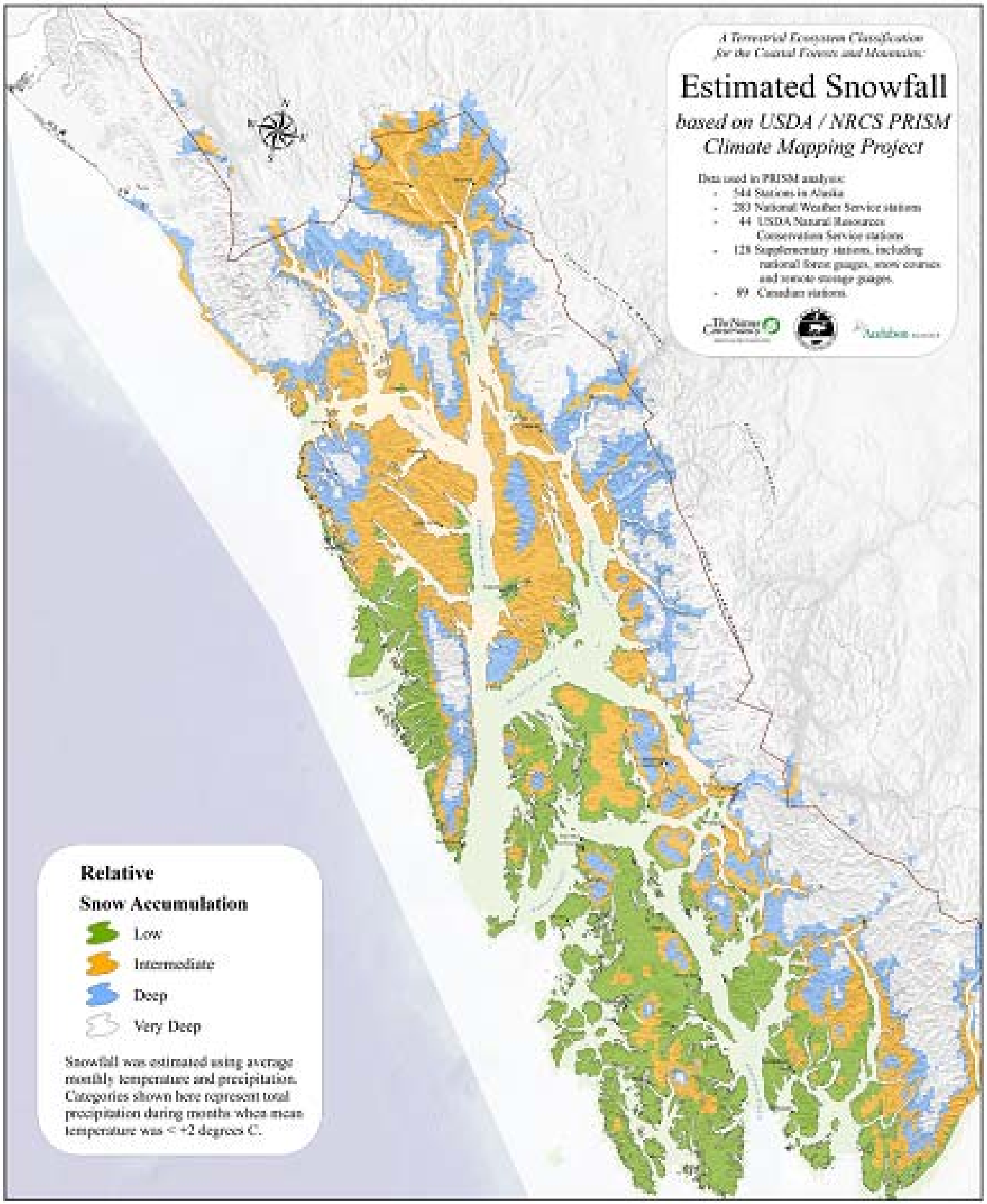


Figure B-1. Estimated snow accumulation (from: Schoen & Dovechin 2007)
Use this for question D21.1 in the Non-tidal WESPAK-SE. Contact Juneau office of The Nature Conservancy for a more readable electronic version of this map.

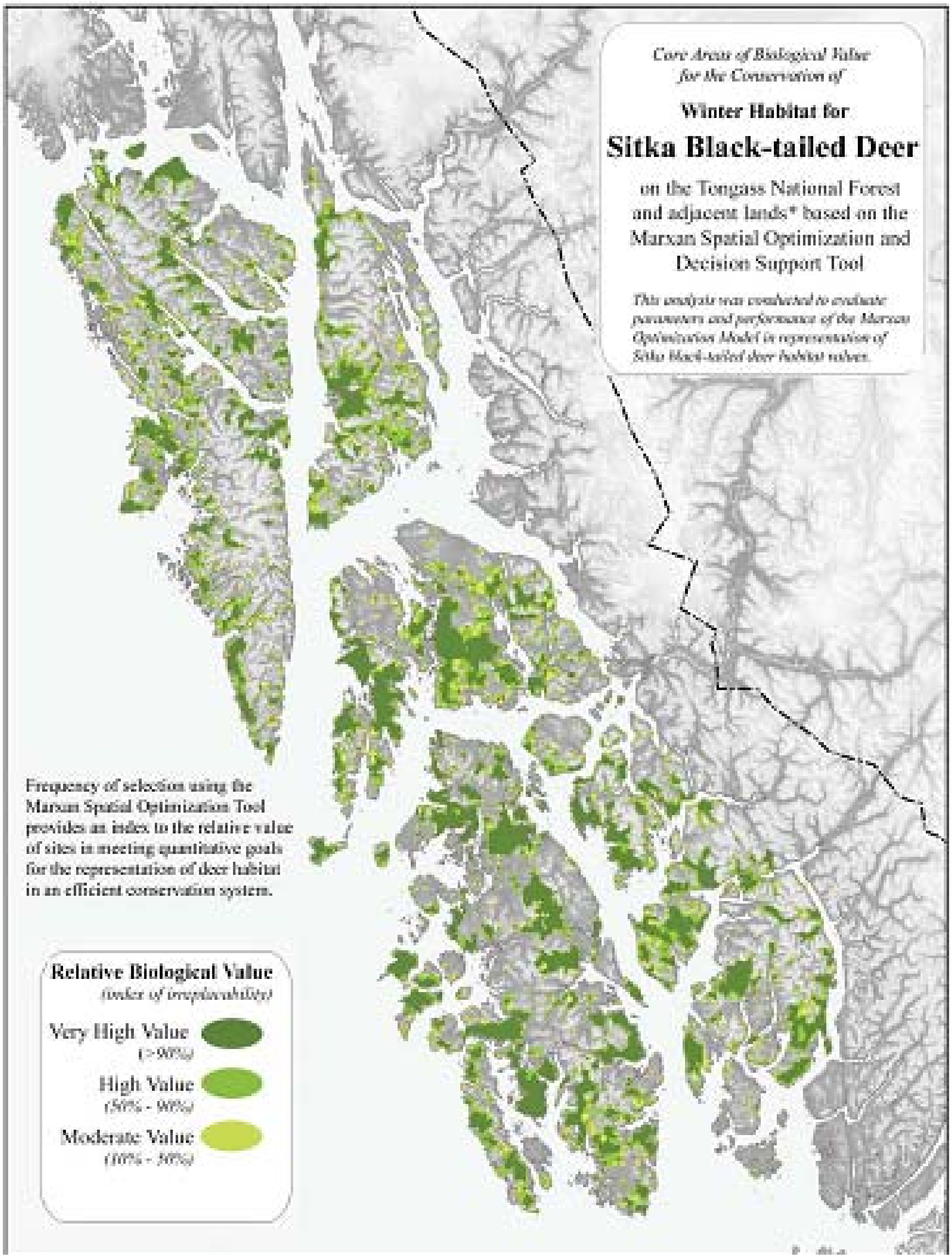


Figure B-2. Wintering Deer Habitat Capability (from: Schoen & Dovechin 2007)
Use this for question D21.2 in the Non-tidal WESPAK-SE. Contact Juneau office of The Nature Conservancy for a more readable electronic version of this map.

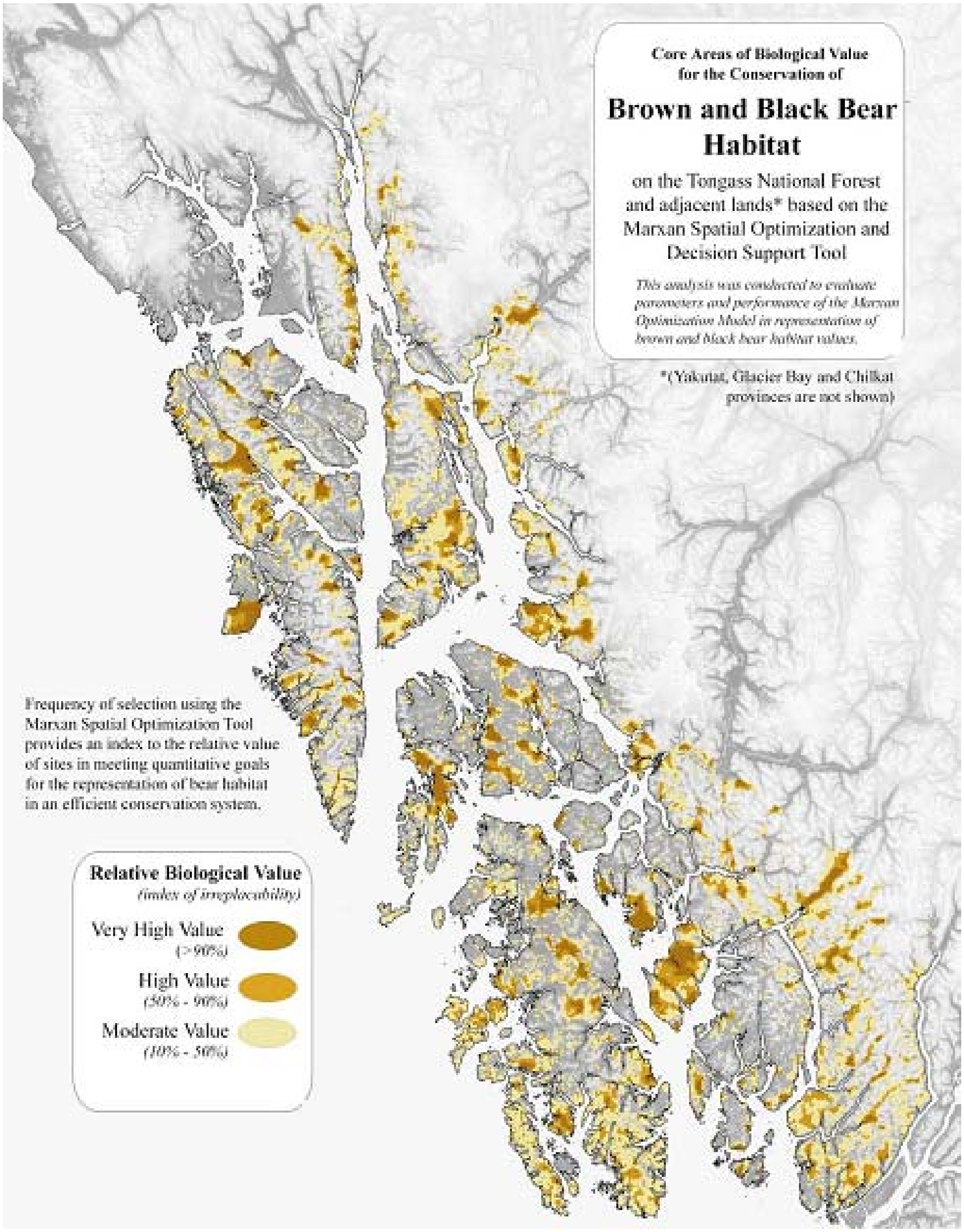


Figure B-3. Bear Habitat Capability (from: Schoen & Dovechin 2007)
Use this for question D32 in the Tidal WESPAK-SE. Contact Juneau office of The Nature Conservancy for a more readable electronic version of this map.

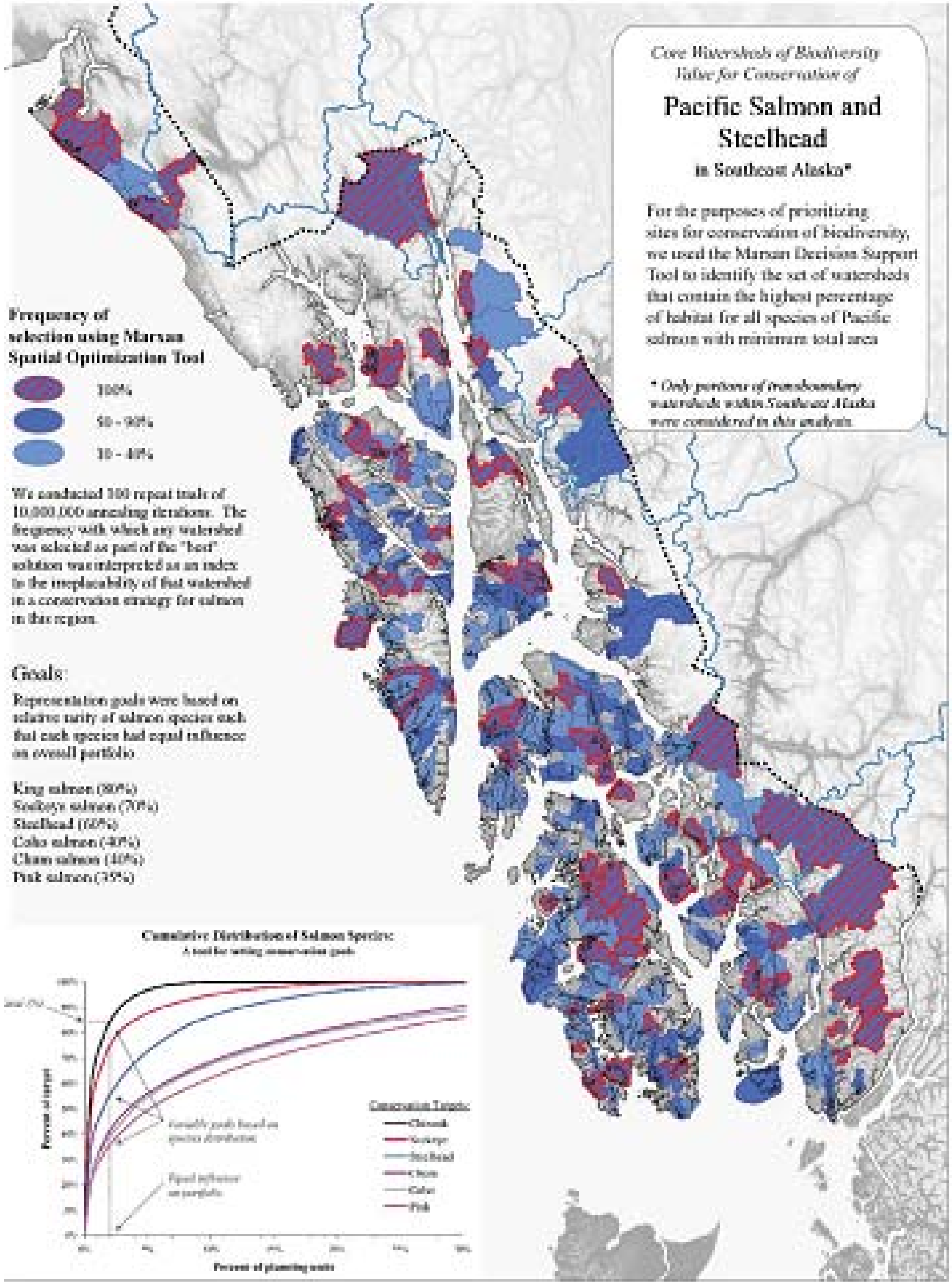


Figure B-4. Salmon watersheds (from: Schoen & Dovechin 2007)

Use this for question D21.3 in the Non-tidal and D33 in the Tidal WESPAK-SE.

Contact Juneau office of The Nature Conservancy for a more readable electronic version of this map.

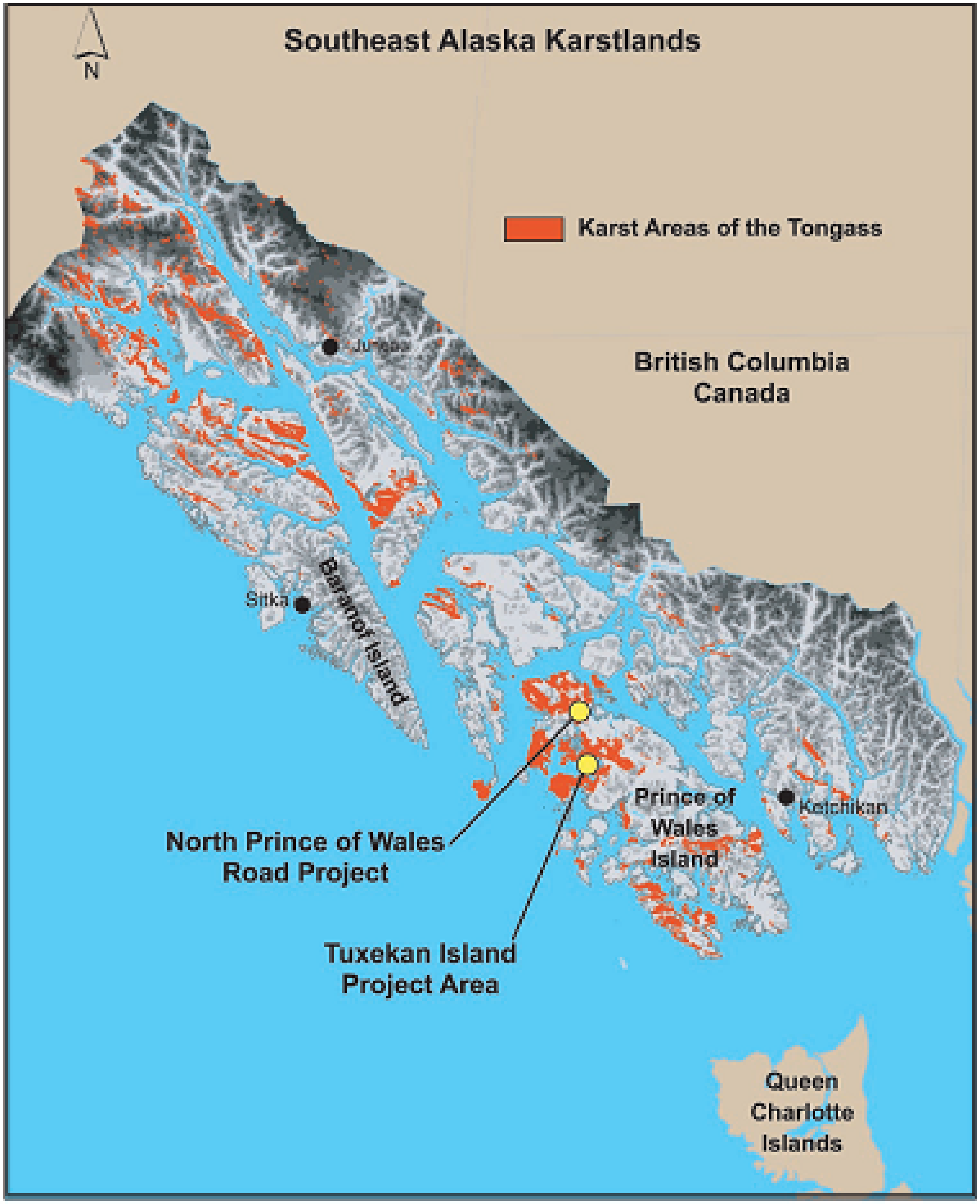


Figure B-5. Karst areas in Southeast Alaska (from: Prussian & Baichtel 2007)
Use this for question D23.1 in the Non-tidal WESPAK-SE.

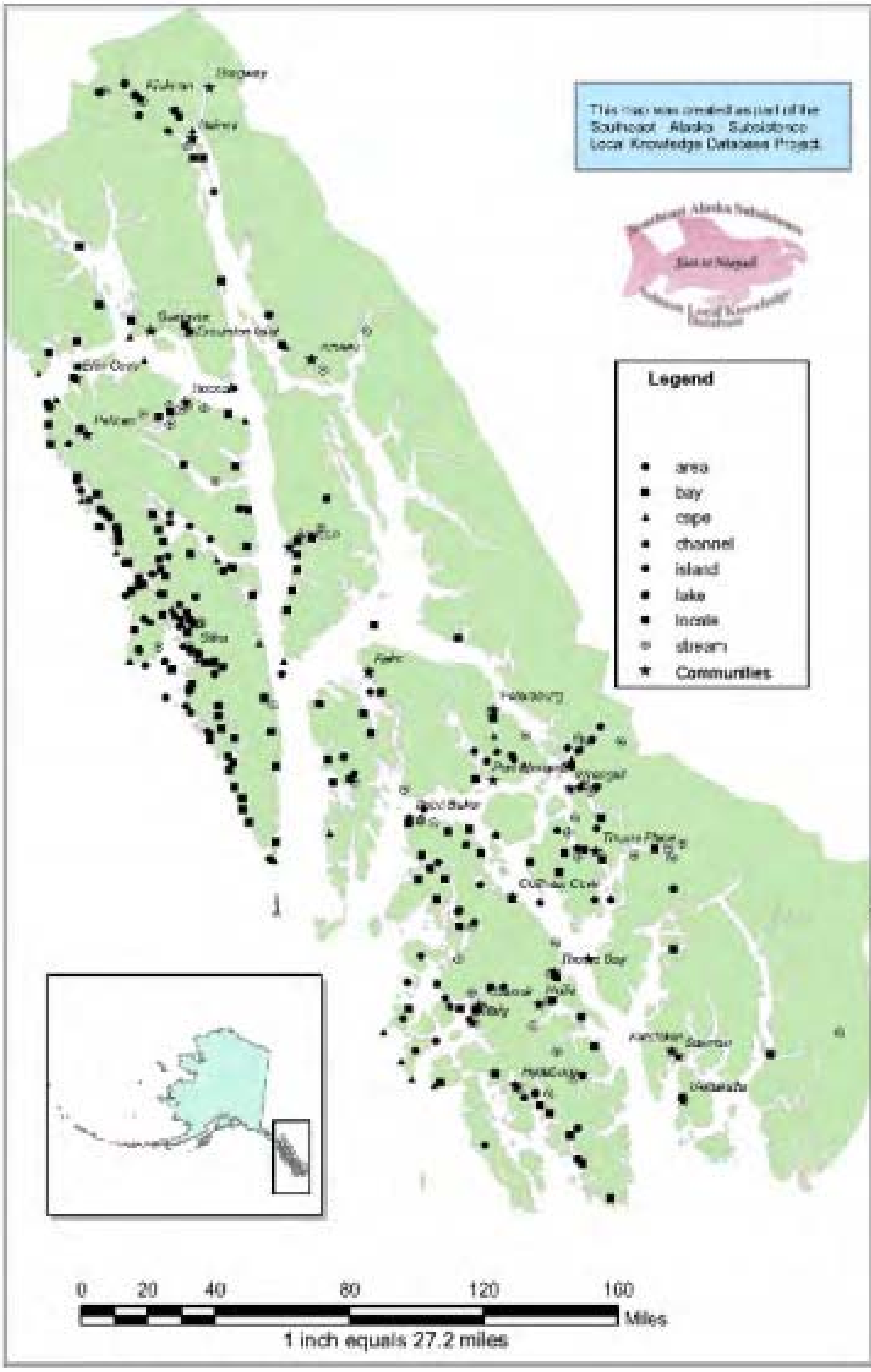


Figure B-6a. Subsistence Fisheries Harvest and Use Areas (from: Brock & Coiley-Kenner 2009)
Use this for question D24 in the Non-tidal and D35 in the Tidal WESPAK-SE. See next page.

Figure B-6b. Identified subsistence fisheries in the Haines, Chilkat, Chilkoot, and Klukwan Rivers, in smaller font. (from: Brock & Coiley-Kenner 2009)

Figure B-6c. Identified subsistence fisheries areas in the Hoonah and Angoon vicinity, in smaller font. (from: Brock & Coiley-Kenner 2009)

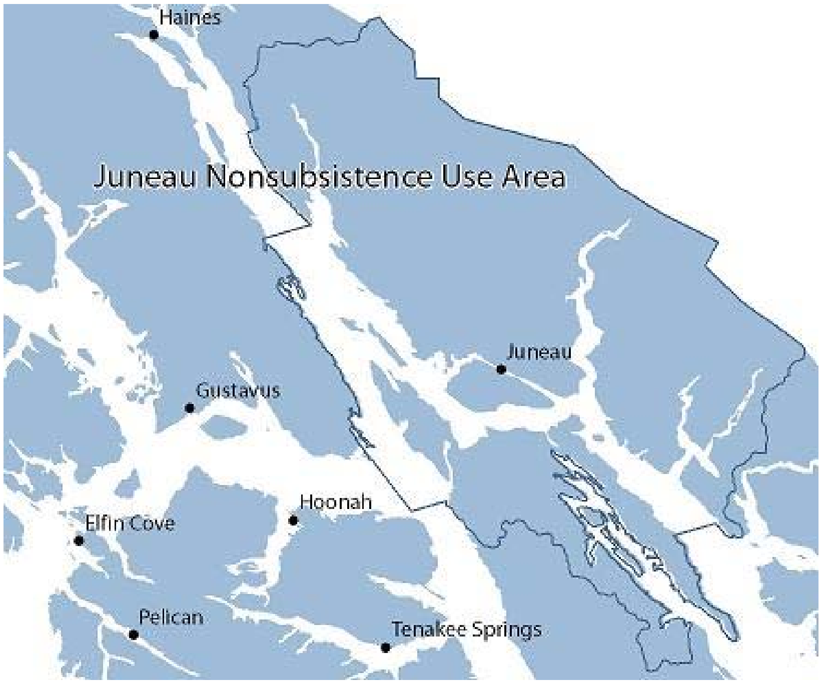


Figure B-5d. Juneau Nonsubsistence Use Area (from:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingSubsistenceByArea.nonSubsistenceUse
Use this for question D24 in the Non-tidal and D35 in the Tidal WESPAK-SE.

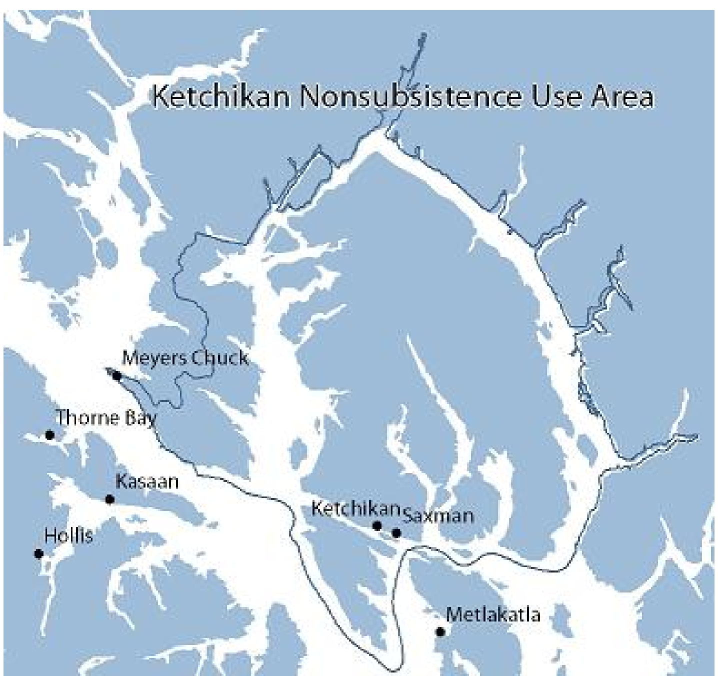


Figure B-5e. Ketchikan Nonsubsistence Use Area

Appendix C. Reference Information Required to Conduct WESPAK-SE Assessments

Table C-1. Growing Degree Days
Use this for Non-tidal data form OF, question D33.

These data were calculated by the author from the 1981-2010 climate normals using a base temperature of 50F °.

Location	**GDD**
Annex Creek	211
Yakutat	291
Elfin Cove	337
Glacier Bay	399
Gustavus	429
Little Port Walter	466
Juneau Airport	519
Petersburg	543
Port Alexander	588
Sitka Airport	590
Haines 40NW	601
Haines Airport	614
Skagway	632
Haines	653
Juneau Downtown	657
Klawock	671
Ketchikan	694
Auke Bay	708
Craig	716
Wrangell	717
Annette	840
Beaver Falls	869

Table C-2. Most Extensive Estuaries Within Their Biogeographic Provinces
(from: Schoen & Dovekin 2007)
Use this for question D30 in the WESPAK-SE Tidal data form OF.

Top-ranked (score=3)

Location	Biogeographic Province	PU_ID
Ahrnklin River Estuary	Yakutat Forelands	428
Alsek Dry Bay / E. Alsek	Fairweather Icefields	1029
Annette - Crab Bay	Revilla Island / Cleveland Peninsula	93
Appleton Cove	E. Baranof Island	336
Bartlet River / Beardslee Is.	Glacier Bay	64
Davidson Glacier	Chilkat River Complex	18
Fish Bay	W. Baranof Island	329
Gambier Bay	Admiralty Island	184
Hidden Inlet	South Misty Fjords	992
Lower Chikamin River	North Misty Fjords	922
Mendenhall Valley	Lynn Canal / Mainland	1027
Neka Bay	E. Chichagof Island	224
Port Bazan	Dall Island Complex	770
Rocky Pass	Kupreanof / Mitkof Islands	492
S Arm Moira Sound	South Prince of Wales Island	808
Salmon Bay Lake	North Prince of Wales Complex	619
Security Bay	Kuiu Island	459
Slocum Arm	W. Chichagof Island	313
Stikine Delta - South	Stikine River / Mainland	569
Taku River	Taku River / Mainland	528
Thoms Lake	Etolin Zarembo Island Complex	550
Warm Chuck Inlet	Outside Islands	659

Second-ranked (score= 2)

Location	Biogeographic Province	PU_ID
Akwe Beach	Yakutat Forelands	439
Baker Is	Outside Islands	667
Berners Bay	Lynn Canal / Mainland	174
Big John Bay	Kupreanof / Mitkof Islands	490
Bobs Bay	Dall Island Complex	750
Cape Spencer	Fairweather Icefields	83
Carroll Cr Revilla	Revilla Island / Cleveland Peninsula	866
Farugut Bay - S. Arm	Stikine River / Mainland	1017
Ferebee River	Chilkat River Complex	48
Gustavus Forelands	Glacier Bay	68
Juneau / Gastineau Channel	Taku River / Mainland	366
Kadashan River	E. Chichagof Island	262
Kitkun Bay	South Prince of Wales Island	793

Location	Biogeographic Province	PU_ID
Klawock Lake / Inlet	North Prince of Wales Complex	716
McHenry Inlet Etolin	Etolin Zarembo Island Complex	543
Nakwasina Passage	W. Baranof Island	345
Pybus Bay	Admiralty Island	198
Saginaw Bay	Kuiu Island	456
Saook Bay	E. Baranof Island	337
Stag Bay	W. Chichagof Island	294
Unuk River	North Misty Fjords	914
Upper Fillmore Inlet	South Misty Fjords	995

Third-ranked (score= 1)

Location	Biogeographic Province	PU_ID
Cannon Beach	Yakutat Forelands	427
Excursion River	Glacier Bay	54
Fools Inlet	Etolin Zarembo Island Complex	552
Hood Bay	Admiralty Island	186
Idaho Inlet	E. Chichagof Island	208
Kadake Cr	Kuiu Island	484
Kelp Bay - South Arm	E. Baranof Island	360
Lower Castle River	Kupreanof / Mitkof Islands	500
Moira Sound - N. Arm	South Prince of Wales Island	797
N Fork Bradfield River	Stikine River / Mainland	591
Port Houghton Salt Chuck	Taku River / Mainland	918
Port Althorp	W. Chichagof Island	206
Port Refugio	Outside Islands	746
Port Stewart	Revilla Island / Cleveland Peninsula	838
Soule River	North Misty Fjords	938
St. James Bay	Lynn Canal / Mainland	117
Staney Estuary	North Prince of Wales Complex	687
Sukoi Inlet / N. Krestof Sound	W. Baranof Island	348
Taiya River	Chilkat River Complex	1
Vesta Bay	Dall Island Complex	766

Table C-3. Least Extensive Estuaries Within Their Biogeographic Provinces
(from: Schoen & Dovekin 2007)
Use this for WESPAK-SE Tidal data form OF, question D31.

Location	Biogeographic Province	PU_ID
916 Lake	E. Chichagof Island	277
Annette - Red Mtn	Revilla Island / Cleveland Peninsula	87
Apex-el Nido	E. Chichagof Island	296
Betton Island	Revilla Island / Cleveland Peninsula	1007
California Cove - Revilla	Revilla Island / Cleveland Peninsula	883
Cann Creek	E. Chichagof Island	297
Cholmondeley - Monie Lake	North Prince of Wales Complex	724
Cholmondeley Sound	North Prince of Wales Complex	790
Edna Bay	North Prince of Wales Complex	638
False Bay	E. Chichagof Island	234
False Island	E. Chichagof Island	274
First No. 2	E. Chichagof Island	231
Flicker Creek	North Prince of Wales Complex	608
Goose View	E. Chichagof Island	248
Gypsum Cr	E. Chichagof Island	236
Holbrook Arm	North Prince of Wales Complex	640
Hoonah	E. Chichagof Island	229
Karheen	North Prince of Wales Complex	658
Kasaan	North Prince of Wales Complex	707
Kasaan Island	North Prince of Wales Complex	727
Kennel Cr	E. Chichagof Island	241
Loon Lakes	E. Chichagof Island	214
Manzanita Bay E Rev	Revilla Island / Cleveland Peninsula	902
Mills Bay	North Prince of Wales Complex	706
Moser Is	E. Chichagof Island	328
Mt Francis	North Prince of Wales Complex	631
Nadzaheen Cove	Revilla Island / Cleveland Peninsula	88
Naukati Bay	North Prince of Wales Complex	670
New Tokeen	North Prince of Wales Complex	653
Pleasant Island	E. Chichagof Island	201
Port Estrella	North Prince of Wales Complex	741
Port Protection	North Prince of Wales Complex	605
Pt. Adolphus	E. Chichagof Island	216
Pt. Cannery	E. Chichagof Island	243
Red Lake	North Prince of Wales Complex	616
S Sukkwan Is	North Prince of Wales Complex	784
Salt Chuck N Karta	North Prince of Wales Complex	701
Sarheen Cove	North Prince of Wales Complex	644
SE Skowl Arm	North Prince of Wales Complex	722

Location	Biogeographic Province	PU_ID
Sea Otter Sound	North Prince of Wales Complex	652
Seal Creek	E. Chichagof Island	238
Settlers Cove SW Rev	Revilla Island / Cleveland Peninsula	1008
Shaheen Creek	North Prince of Wales Complex	690
Shipley Bay	North Prince of Wales Complex	632
Slide Creek	North Prince of Wales Complex	685
South Passage	E. Chichagof Island	266
Squaw Creek	North Prince of Wales Complex	630
Steelhead River	E. Chichagof Island	298
Sunny Cove SE POW	North Prince of Wales Complex	789
Tarn Mountain	E. Chichagof Island	283
Tolstoi Bay	North Prince of Wales Complex	702
Tracodero Bay	North Prince of Wales Complex	735
Trap Bay	E. Chichagof Island	265
Tuxekan NE	North Prince of Wales Complex	654
Twelvemile - Outer Pt	North Prince of Wales Complex	720
Ward Cove	Revilla Island / Cleveland Peninsula	873

Table C-4. Invasive Plants Sometimes Found in Southeast Alaska Wetlands
Use this for Non-tidal question F55.

Scientific Name	Common Name
Capsella bursa-pastoris	Shepherd's-Purse
Cerastium fontanum	Common (Big) Mouse-Ear Chickweed
Cirsium arvense	Canadian Thistle
Elymus repens	Creeping Wild Rye
Fallopia japonica	Japanese Black-Bindweed
Leucanthemum vulgare	Ox-Eye Daisy
Matricaria discoidea	Pineapple-Weed
Phalaris arundinacea	Reed Canary Grass
Phleum pratense	Common Timothy
Poa annua	Annual Blue Grass
Ranunculus repens	Creeping Buttercup
Sonchus arvensis	Field Sow-Thistle
Trifolium dubium	Suckling Clover
Trifolium hybridum	Alsike Clover
Trifolium repens	White Clover

Table C-5. Non-native Plants Sometimes Found in Southeast Alaska Wetlands

Scientific Name of Non-native Species	Common Name
Agrostis capillaris	Colonial Bent
Agrostis gigantea	Black Bent
Agrostis stolonifera	Spreading Bent
Aira caryophyllea	Common Silver-Hair Grass
Alliaria petiolata	Garlic-Mustard
Alopecurus geniculatus	Marsh Meadow-Foxtail
Alopecurus pratensis	Field Meadow-Foxtail
Amaranthus albus	Tumbleweed
Amaranthus retroflexus	Red-Root
Anthemis cotula	Stinking Chamomile
Anthoxanthum odoratum	Large Sweet Vernal Grass
Arrhenatherum elatius	Tall Oat Grass
Atriplex patula	Halberd-Leaf Orache
Bidens frondosa	Devil's-Pitchfork
Brassica juncea	Chinese Mustard
Brassica rapa	Rape
Bromus hordeaceus	Soft Brome
Bromus inermis	Smooth Brome
Bromus vulgaris	Columbia Brome
Calystegia sepium	Hedge False Bindweed
Camelina sativa	Gold-of-Pleasure
Capsella bursa-pastoris	Shepherd's-Purse
Cerastium fontanum	Common (Big) Mouse-Ear Chickweed
Cerastium glomeratum	Sticky Mouse-Ear Chickweed
Chenopodium album	Lamb's-Quarters
Chenopodium leptophyllum	Narrow-Leaf Goosefoot
Cirsium arvense	Canadian Thistle
Cirsium vulgare	Bull Thistle
Collomia linearis	Narrow-Leaf Mountain-Trumpet
Conyza canadensis	Canadian Horseweed
Cotula coronopifolia	Common Brassbuttons
Crepis capillaris	Smooth Hawk's-Beard
Dactylis glomerata	Orchard Grass
Deschampsia danthonioides	Annual Hair Grass
Deschampsia elongata	Slender Hair Grass
Digitalis purpurea	Purple Foxglove
Elymus repens	Creeping Wild Rye
Fallopia convolvulus	Black-Bindweed
Fallopia japonica	Japanese Black-Bindweed
Fallopia sachalinensis	Giant Black-Bindweed
Geranium richardsonii	Richardson's Geranium
Glechoma hederacea	Groundivy

Scientific Name of Non-native Species	Common Name
Gnaphalium uliginosum	Marsh Cudweed
Hesperis matronalis	Mother-of-the-Evening
Holcus lanatus	Common Velvet Grass
Hordeum jubatum	Fox-Tail Barley
Hypericum perforatum	Common St. John's-Wort
Hypochaeris radicata	Hairy Cat's-Ear
Impatiens glandulifera	Ornamental Jewelweed
Lapsana communis	Common Nipplewort
Lepidium densiflorum	Miner's Pepperwort
Lepidium virginicum	Poorman's-Pepperwort
Leucanthemum vulgare	Ox-Eye Daisy
Lolium perenne	Perennial Rye Grass
Lotus corniculatus	Bird's-foot Trefoil
Lupinus polyphyllus	Blue-Pod Lupine
Madia glomerata	Mountain Tarplant
Marrubium vulgare	White Horehound
Matricaria discoidea	Pineapple-Weed
Medicago lupulina	Black Medick
Medicago polymorpha	Toothed Medick
Medicago sativa	Alfalfa
Melilotus officinalis	Yellow Sweet-Clover
Mentha spicata	Spearmint
Microsteris gracilis	Annual-Phlox
Myosotis asiatica	Asian Forget-Me-Not
Myosotis scorpioides	True Forget-Me-Not
Myosotis sylvatica	Woodland Forget-me-not
Nepeta cataria	Catnip
Nymphaea odorata	American White Water-Lily
Persicaria maculosa	Lady's-Thumb
Phalaris arundinacea	Reed Canary Grass
Phalaris canariensis	Common Canary Grass
Phleum pratense	Common Timothy
Plagiobothrys figuratus	Fragrant Popcorn-Flower
Plantago lanceolata	English Plantain
Plantago major	Great Plantain
Poa annua	Annual Blue Grass
Poa compressa	Flat-Stem Blue Grass
Poa pratensis	Kentucky Blue Grass
Poa trivialis	Rough-Stalk Blue Grass
Polygonum aviculare	Yard Knotweed
Polygonum persicaria	Spotted Ladysthumb
Polygonum ramosissimum	Yellow-Flower Knotweed
Polypogon monspeliensis	Annual Rabbit's-Foot Grass
Prunus padus	European Bird Cherry

Scientific Name of Non-native Species	**Common Name**
Puccinellia distans	Spreading Alkali Grass
Ranunculus acris	Tall Buttercup
Ranunculus repens	Creeping Buttercup
Raphanus sativus	Garden Radish
Rosa rugosa	Rugosa Rose
Rubus idaeus	Common Red Raspberry
Rumex acetosella	Common Sheep Sorrel
Rumex crispus	Curly Dock
Rumex longifolius	Door-Yard Dock
Rumex obtusifolius	Bitter Dock
Sagina procumbens	Bird-Eye Pearlwort
Senecio jacobaea	Tansy Ragwort
Senecio vulgaris	Old-Man-in-the-Spring
Sisymbrium altissimum	Tall Hedge-Mustard
Solanum nigrum	European Black Nightshade
Sonchus arvensis	Field Sow-Thistle
Sonchus asper	Spiny-Leaf Sow-Thistle
Sonchus oleraceus	Common Sow-Thistle
Sorbus aucuparia	European mountain-ash
Spergularia rubra	Ruby Sandspurry
Stellaria media	Common Chickweed
Symphytum asperum	Prickly Comfrey
Tanacetum vulgare	Common Tansy
Taraxacum officinale	Common Dandelion
Thlaspi arvense	Field Pennycress
Trifolium dubium	Suckling Clover
Trifolium hybridum	Alsike Clover
Trifolium pratense	Red Clover
Trifolium repens	White Clover
Vaccaria hispanica	Cowcockle
Veronica anagallis-aquatica	Blue Water Speedwell
Veronica arvensis	Corn Speedwell
Veronica chamaedrys	Germander Speedwell
Veronica peregrina	Neckweed
Veronica serpyllifolia	Thyme-Leaf Speedwell
Vicia sativa	Garden Vetch

Table C-6. Uncommon or At-Risk Wetland Plant Species of Southeast Alaska
These are species with a wetland indicator status of OBL, FACW, or FAC; are designated by the Alaska Natural Heritage Program as S1, S2, or S3; and have been reported at least once from the region.

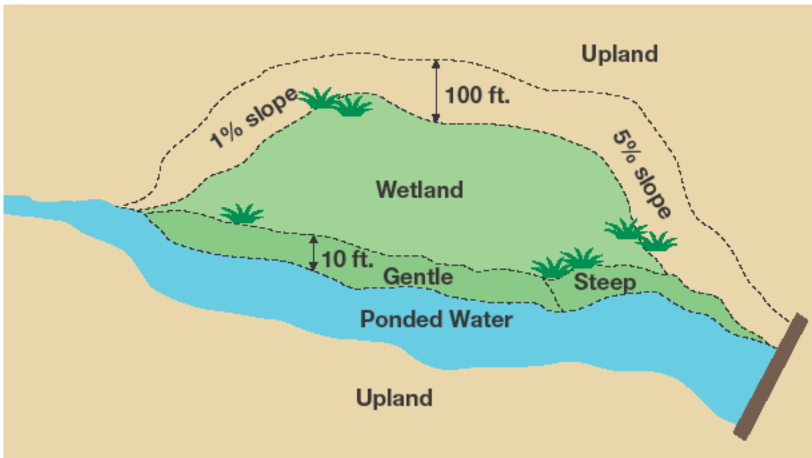
Scientific Name of Uncommon Plant	Wetland Indicator Status 2011	Common Name
Agoseris aurantiaca	FAC	Orange-Flower Goat-Chicory
Agoseris glauca	FAC	Pale Goat-Chicory
Aphragmus eschscholtzianus	FACW	Aleutian-Cress
Arnica mollis	FACW	Cordilleran Leopardbane
Asplenium trichomanes	FAC	Maidenhair Spleenwort
Astragalus robbinsii	FAC	Robbins' Milk-Vetch
Brasenia schreberi	OBL	Watershield
Cardamine bellidifolia	FAC	Alpine Bittercress
Carex atherodes	OBL	Wheat Sedge
Carex athrostachya	FAC	Slender-Beak Sedge
Carex atratiformis	FACW	Scabrous Black Sedge
Carex bebbii	OBL	Bebb's Sedge
Carex crawfordii	FAC	Crawford's Sedge
Carex interior	OBL	Inland Sedge
Carex leptalea	OBL	Bristly-Stalk Sedge
Carex phaeocephala	FAC	Mountain Hare Sedge
Carex stipata	OBL	Stalk-Grain Sedge
Castilleja parviflora	FACW	Small-Flower Indian-Paintbrush
Cirsium edule	FAC	Edible Thistle
Crassula aquatica	OBL	Water Pygmyweed
Crataegus douglasii	FAC	Black Hawthorn
Cryptogramma stelleri	FAC	Fragile Rockbrake
Cypripedium parviflorum	FACW	Yellow Lady's-Slipper
Dulichium arundinaceum	OBL	Three-Way Sedge
Eleocharis kamtschatica	FACW	Kamchatka Spike-Rush
Eleocharis quinqueflora	OBL	Few-Flower Spike-Rush
Erigeron glacialis	FACW	Glacier Fleabane
Eriophorum viridicarinatum	OBL	Tassel Cotton-Grass
Glyceria leptostachya	OBL	Slender-Spike Manna Grass
Hymenophyllum wrightii	FAC	Wright's Filmy Fern
Isoetes occidentalis	OBL	Western Quillwort
Juncus articulatus	OBL	Joint-Leaf Rush
Juncus nodosus	OBL	Knotted Rush
Juncus tenuis	FACW	Lesser Poverty Rush
Lobelia dortmanna	OBL	Water Lobelia
Luzula comosa	FAC	Pacific Wood-Rush
Lycopus uniflorus	OBL	Northern Water-Horehound

Scientific Name of Uncommon Plant	Wetland Indicator Status 2011	Common Name
Maianthemum racemosum	FAC	Feathery False Solomon's-Seal
Maianthemum stellatum	FAC	Starry False Solomon's-Seal
Malaxis paludosa	OBL	Bog Adder's-Mouth Orchid
Mimulus lewisii	FACW	Great Purple Monkey-Flower
Mitella nuda	FAC	Bare-Stem Bishop's-Cap
Mitella trifida	FAC	Pacific Bishop's-Cap
Montia bostockii	FACW	Bostock's Candy-Flower
Myriophyllum verticillatum	OBL	Whorled Water-Milfoil
Penstemon serrulatus	FACW	Cascade Beardtongue
Physocarpus capitatus	FAC	Pacific Ninebark
Piperia unalascensis	FAC	Alaska Rein Orchid
Plantago major	FAC	Great Plantain
Platanthera chorisiana	OBL	Choriso Bog Orchid
Platanthera orbiculata	FAC	Lesser Round-Leaf Orchid
Poa leptocoma	FAC	Marsh Blue Grass
Primula tschuktschorum	FACW	Chukchi Primrose
Ranunculus gelidus	FACW	Arctic Buttercup
Rorippa curvisiliqua	FACW	Curve-Pod Yellowcress
Salix candida	OBL	Sage Willow
Salix hookeriana	FACW	Coastal Willow
Salix planifolia	FACW	Tea-Leaf Willow
Salix prolixa	FACW	Mackenzie's Willow
Salix reticulata	FAC	Net-Vein Willow
Salix setchelliana	FAC	Setchell's Willow
Saussurea americana	FACW	American Saw-Wort
Saxifraga rivularis	OBL	Alpine-Brook Saxifrage
Schizachne purpurascens	FAC	False Melic Grass
Schoenoplectus subterminalis	OBL	Swaying Club-Rush
Spiraea douglasii	FACW	Douglas' Meadowsweet
Thuja plicata	FAC	Western Arborvitae
Tiarella trifoliata	FAC	Three-Leaf Foamflower

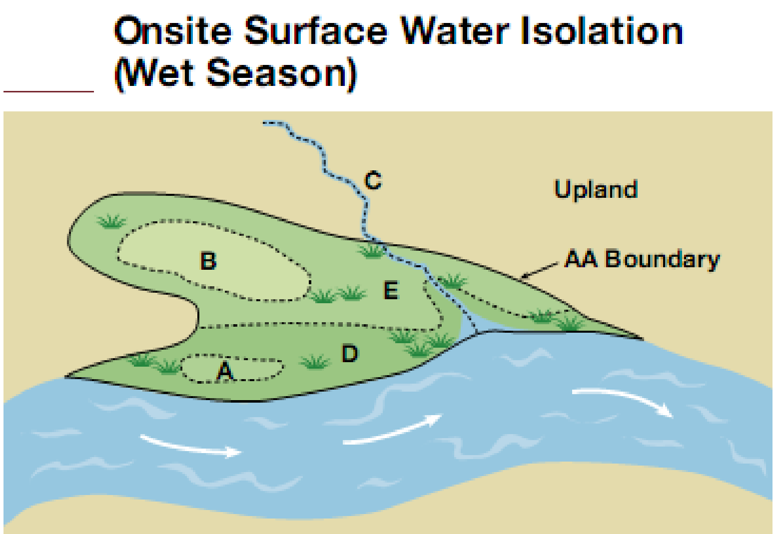
Only a particular subspecies or variety of these is considered uncommon or imperiled:

Scientific Name	Wetland Indicator Status 2011	Common Name
Carex brunnescens ssp. alaskana	FAC	Brownish Sedge
Carex echinata ssp. echinata	OBL	Star Sedge
Erigeron acris ssp. kamtschaticus	FAC	Bitter Fleabane
Pinus contorta var. latifolia	FAC	Lodgepole (Shore) Pine

Appendix D. Illustrations for Assessing Wetland Functions Using WESPAK-SE



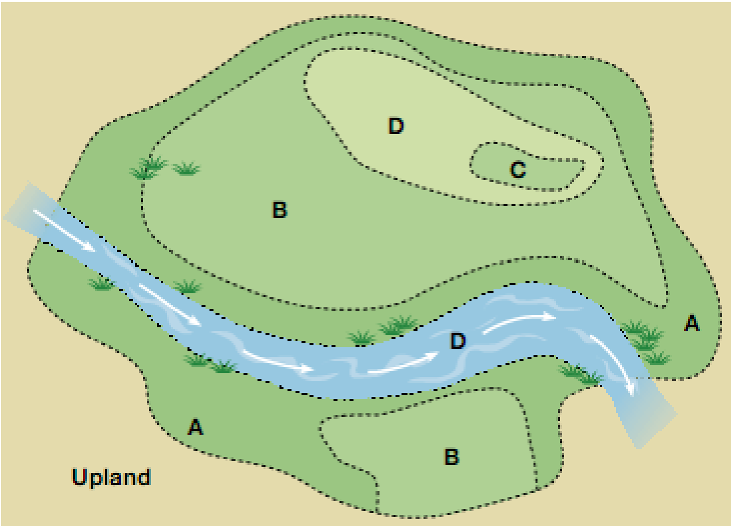
Use this for Non-tidal questions F16 and F64.
In this example, gentle (<5%) slope comprises about 25% of the wetland-upland edge. Steep slope comprises about 25% of the vegetated edge that borders ponded water.



During the dry season, more of the surface water is in pools (A & B) than in the AA's internal channels (C). During the wet season, pool A and area D are flooded by the river, so more of the area within the AA is connected to channels than isolated in pools.

Use this for Non-tidal questions F17 and F18.

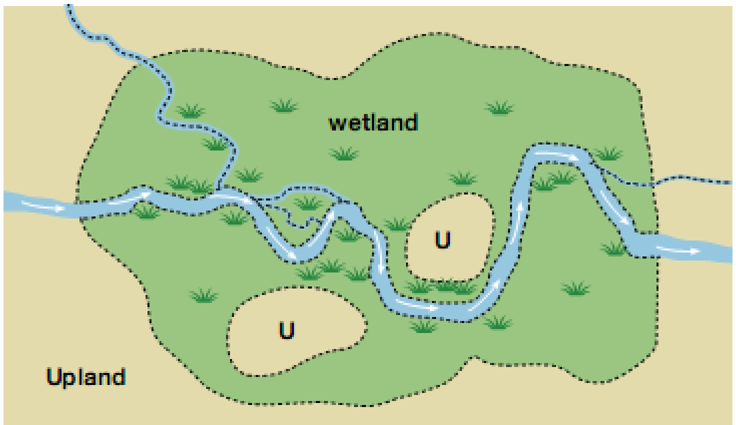
F20	**Predominant Depth Class and Depth Class Distribution**



The depth in most of this AA is Class B during most of the time surface water is present. No depth class comprises > 90% of the AA's inundated area, but Class B comprises > 50%.

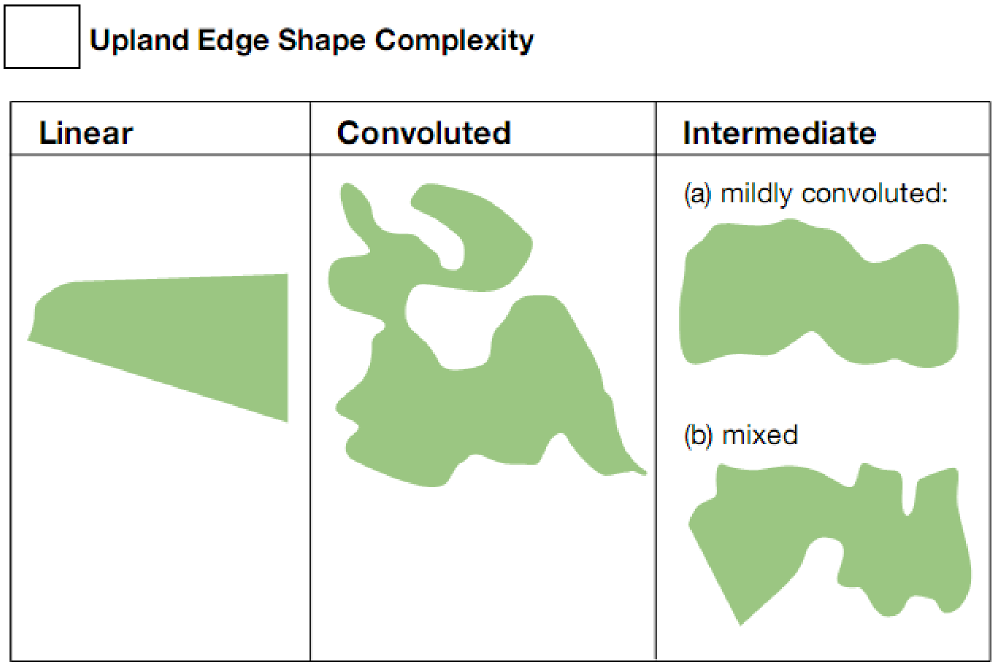
Use this for Non-tidal question 20.

F52	**Throughflow Complexity**

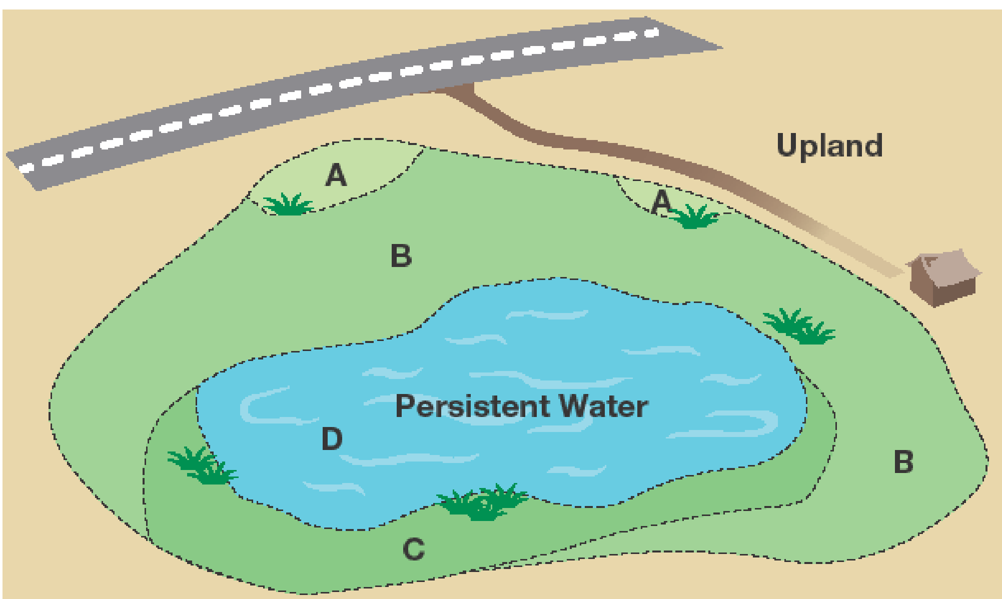


Throughflow complexity in this example is great (sinuous and braided channel, indirect flow path). U = upland inclusion.

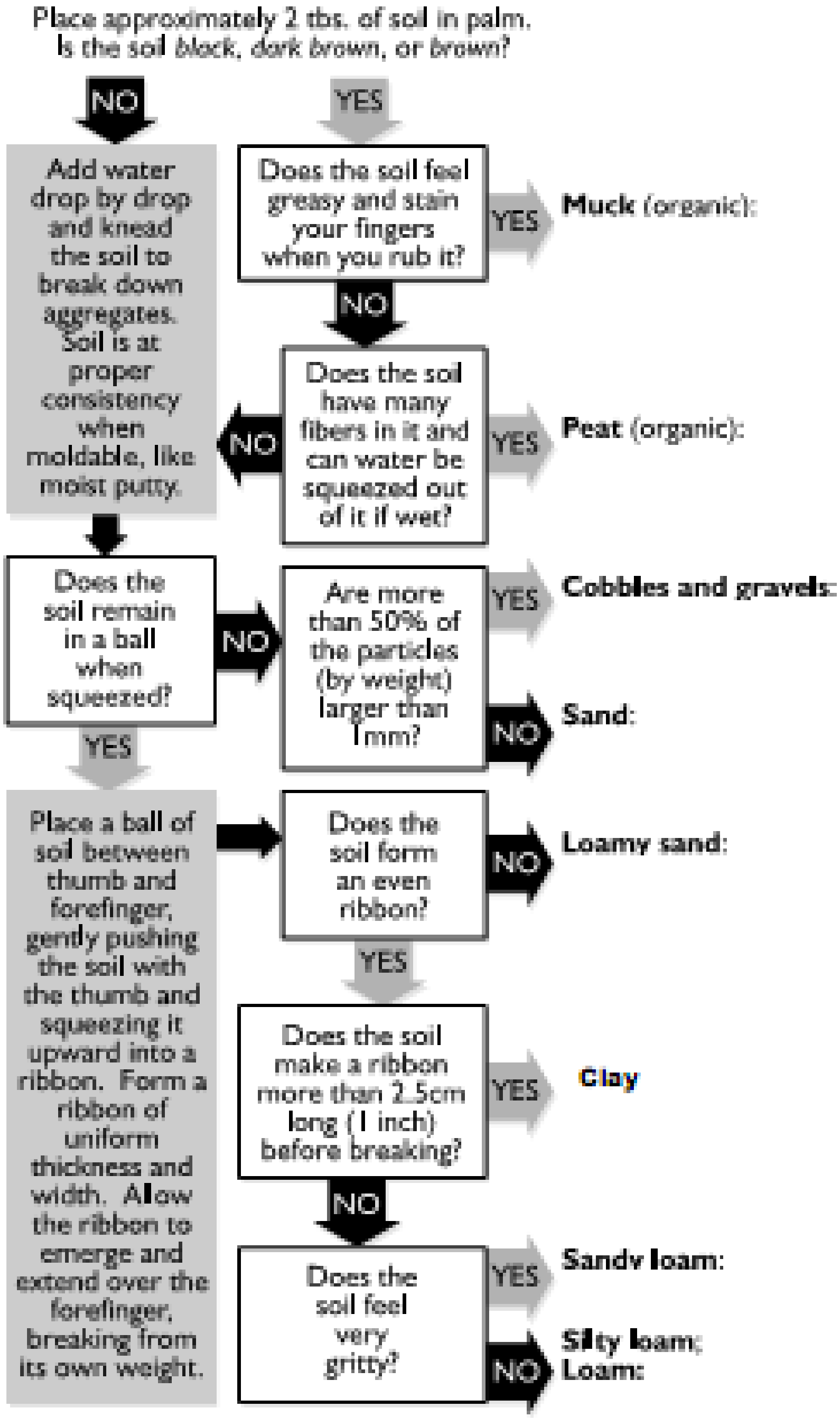
Use this for Non-tidal question F52.



Use this for Non-tidal question D16 and Tidal question F25



Use this for Non-tidal questions F72 and F73 and Tidal questions F30 and F31. Both wetland areas denoted “A” are visited almost daily for several weeks of the year because they are near a road and soil is saturated-only (never any standing water). Area D is almost never visited because water is too deep and inaccessable by boat. Area C is almost never visited because it is too distant from roads and trails, and vegetation is very dense. Area B fits neither category. Although A and B together comprise <5% of the AA, note that an inhabited building is within 300 ft of the AA.



Flow Chart for Identifying Soil Texture (from: Washington Dept. of Ecology 2004)