

ESTUARY ASSESSMENT TRAINING

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This booklet contains excerpts from the publication **Estuary Assessment: Component XII of the Oregon Watershed Assessment Manual**.

The full manual is available as a free download from:

http://www.oregon.gov/OWEB/docs/pubs/OR_wsassess_manuals.shtml#Estuary_Assessment

To obtain a hard copy of the publication, contact:

Publication Request

Oregon Watershed Enhancement Board

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ESTUARY BASICS

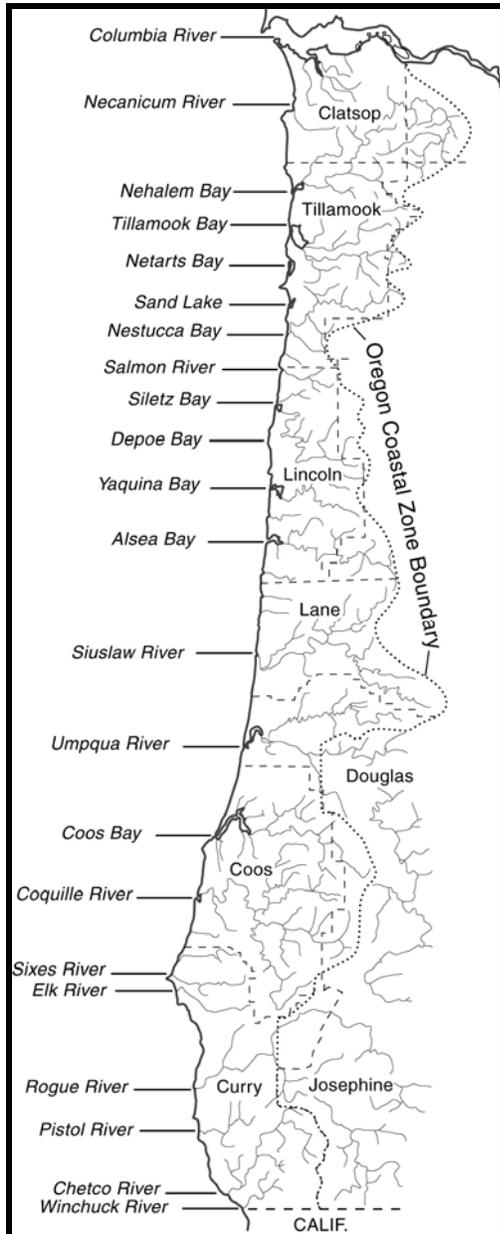


Figure 1: Oregon's Estuaries

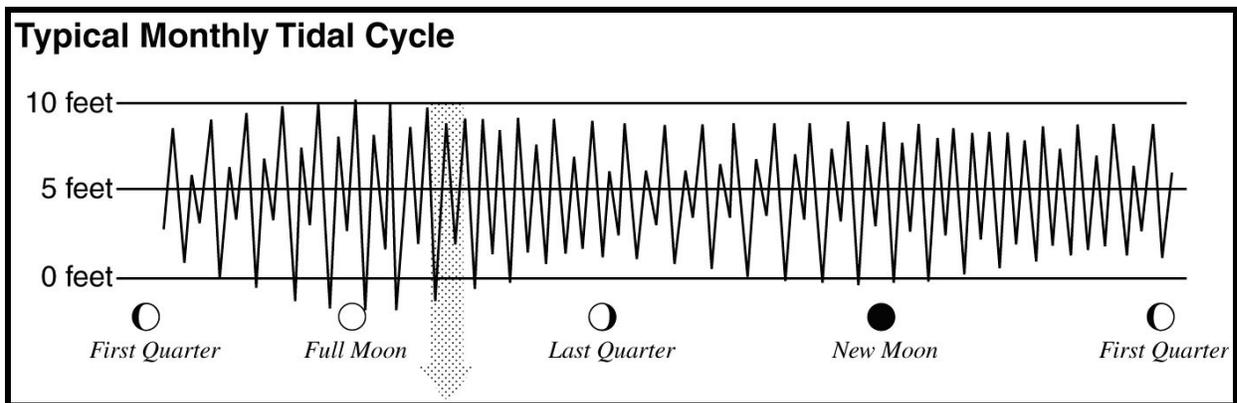


Figure 3: Monthly tidal cycles.

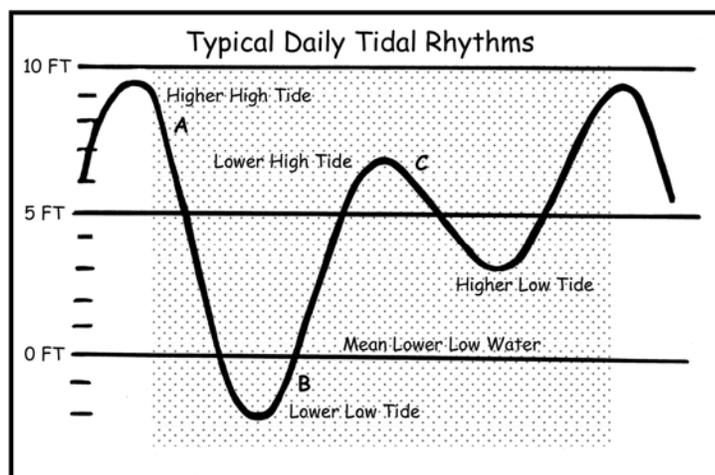


Figure 4: Typical daily tide cycle.

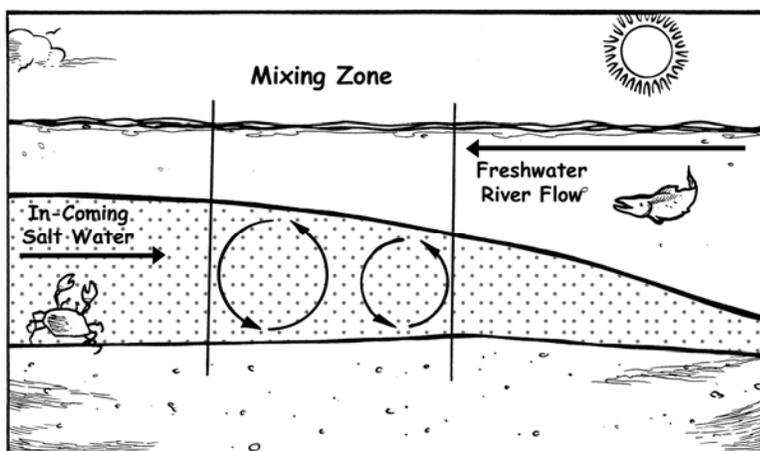


Figure 5: Illustration of the estuary mixing zone

Tidal Terminology

Ebb tide is the outgoing (receding) tide.

Flood Tide is the incoming (rising) tide.

Slack tide when there is no tidal current.

Extreme High Tide (EHT)- The highest projected tide that can occur. It is the sum of the highest predicted tide and the highest storm surge.

Mean Low Water (MLW) - The average of all observed low tides.

Mean Higher High Water (MHHW) – The average height of the higher of the two daily high tides.

Mean High Water (MHW) – The average of all observed high tides, including both the higher high and lower high tides recorded each day.

Mean Low Water (MLW)- The average of all observed low tides, including both the lower low and the higher low tide recorded each day.

Mean lower low water (MLLW) is the average of the lowest of the two daily low tides the elevation is the “zero mark” for measuring tidal elevations.

Extreme Low Tide (ELT) - The lowest estimated tide that has ever occurred.

Elevation Reference systems ("datums")

Several different elevation reference systems are used to describe tides, water levels, and land surface elevations on the Oregon coast. Tidal elevations are measured relative to mean lower low water (MLLW); in this reference system, the MLLW datum is defined as 0 ft elevation, so that (for example) a "tidal elevation" of 8 ft means 8 ft above MLLW. Tidal elevations are established through long-term monitoring by NOAA's National Ocean Service (NOS).

Land elevations are referenced to fixed national survey datums ("geodetic datums" or "absolute elevations") such as the North American Vertical Datum of 1988 (NAVD88) and the older National Geodetic Vertical Datum of 1929 (NGVD29). Geodetic datums use a fixed zero point which does not change with location or time.

Tidal regimes vary with location depending on prevailing winds, currents, and other factors, so the absolute elevation of MLLW varies from place to place. In addition, changing sea levels and land levels (subsidence or uplift) alter the relationships between MLLW and the land surface. Thus, the relationship between tidal elevations (MLLW) and geodetic datums (NGVD29, NAVD88) varies from place to place and over time.

The U.S. Army Corps of Engineers Coastal Geology manual (U.S. Army Corps of Engineers 1995) states that "On project maps and documentation, all tidal datums must be clearly related to the fixed national survey datums." You may need expert assistance to establish these relationships; common methods include combinations of traditional survey methods, Global Positioning System (GPS) data, and calibration to existing USGS benchmarks.

Further information can be found at:

U.S. Army Corps of Engineers, New Orleans District Survey Section, Frequently Asked Questions page,
<http://www.mvn.usace.army.mil/ed/edss/FAQprint.asp>

U.S. Army Corps of Engineers Engineering Manuals, Engineering and Design - Coastal Geology
<http://www.usace.army.mil/publications/eng-manuals/em1110-2-1810/toc.htm>

NOAA Answers page (search for "geodetic benchmarks"): <http://findanswers.noaa.gov/noaa.answers>

ESTUARY ASSESSMENT

Critical questions

1. What was the historic extent of tidal wetlands within the estuary?
2. What alterations have occurred that reduce tidal wetland functions?
3. What restoration and conservation opportunities exist that could help restore impacted tidal wetland functions?

Materials needed

1. Existing studies specific to your estuary.
2. Existing tidal wetland prioritizations for Oregon.
3. USGS topographic maps
4. Head of tide for the mainstem river and for all tributaries
5. Tidal wetlands map
6. The Oregon Estuary Plan Book
7. National Wetlands Inventory (NWI) maps
8. Local Wetlands Inventories reports and maps
9. Oregon Natural Heritage Information Center historic vegetation mapping
10. The Natural Resource Conservation Service (NRCS) soil survey for your area
11. Historic and current aerial photographs
12. Laminated aerial photographs & markers
13. Tide tables
14. Global positioning system
15. Mapping of streams, rivers and other water bodies (hydrography)
16. Field observation and interviews

Sources for Aerial Photographs

New digital orthophoto sources as of 2008 (may not be available for all estuaries):

NAIP 2005 true color orthophotos – 1/2m and 1m pixel size, TIFFs and mosaics
download from: <http://oregonexplorer.info/imagery/>

DLCD/EPA 2005 color infrared orthophotos – high resolution: contact Jeffrey Weber, OCMP Conservation Coordinator, jeff.weber@state.or.us, (971)673-0964

Historic aerial photos. University of Oregon Map and Aerial Photography Library
<http://libweb.uoregon.edu/map/orephoto/index.html> (541)346-4565 or map@uoregon.edu.

U.S. Army Corps of Engineers aerial photography. <https://www.nwp.usace.army.mil/EC/ap.asp>, (503) 808-4820.

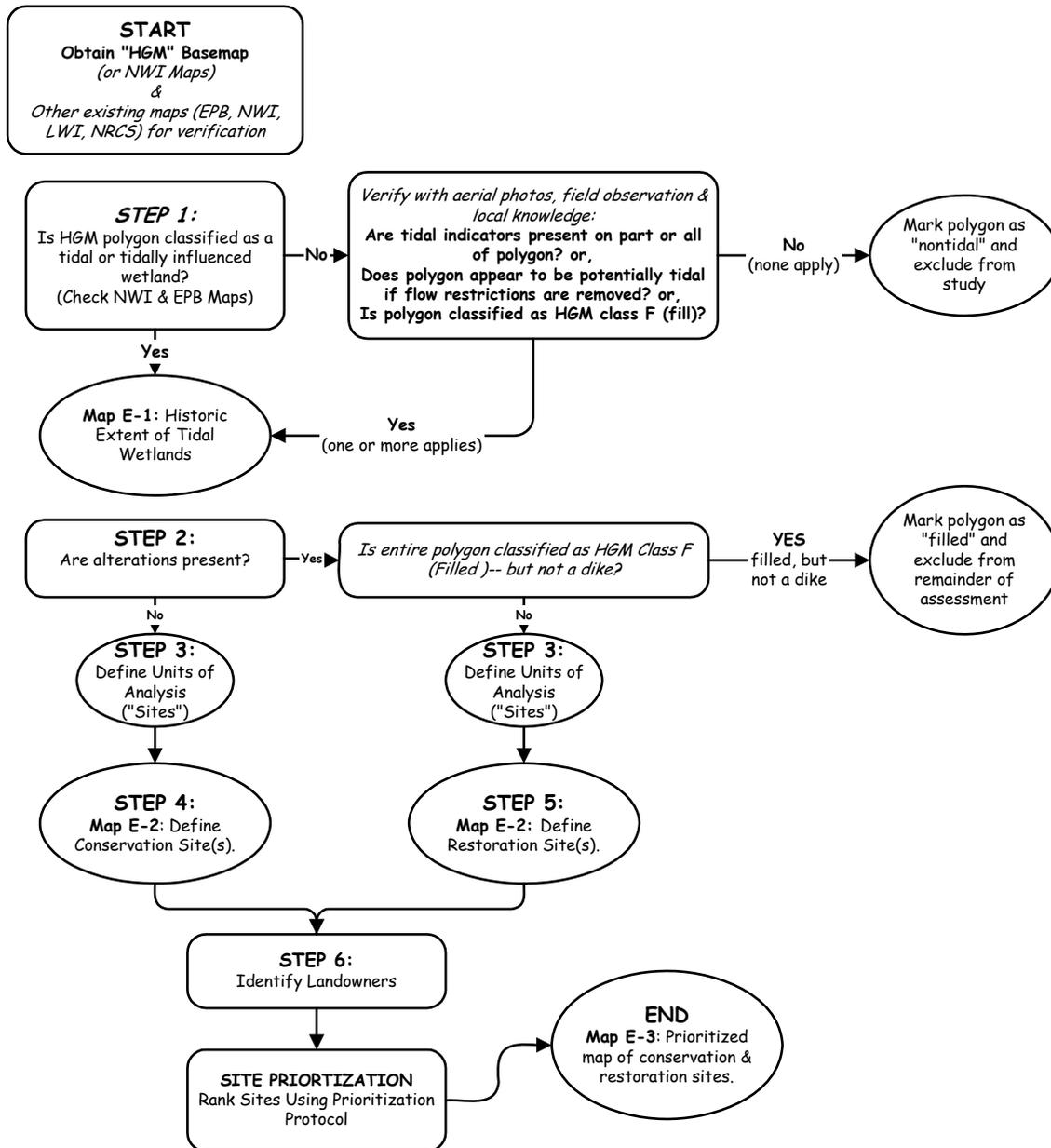
BLM aerial photography. <http://www.blm.gov/nstc/aerial/index.html> 303-236-7991, constance_slusser@blm.gov.

Final Products

Your assessment will produce the following products:

Map E1:	Historic tidal wetlands
Map E2:	Map of tidal wetland restoration and conservation sites
Map E3:	Tidal wetland prioritization
Forms E1-A, E1-B:	Indicators of tidal influence – Parts 1 and 2
Form E2:	Field observations: Hydrology
Form E3:	Field observations: Vegetation
Forms E4-A, E4-B:	Alterations to tidal wetlands – Parts 1 and 2
Form E5:	Conservation sites
Form E6:	Restoration sites
Form E7:	Landowner information
Form E8:	Prioritization scoring
Form E9:	Tidal channel condition scoring

Estuary Assessment flow chart



STEP 1: IDENTIFY THE HISTORIC EXTENT OF TIDAL WETLANDS

HGM map preparation

Table 1. HGM base map classification (Scranton 2004). Classes assessed in this module are in bold.

Class	Class name	Description
MSL	Marine-sourced low marsh	Salt marsh or brackish marsh generally inundated daily. In the HGM guidebook, MSL is equivalent to NWI class E2EMN and EPB class 2.5.11.
MSH	Marine-sourced high marsh	Salt marsh or brackish marsh inundated less than once per day (but usually at least once per month). In the HGM guidebook, MSH is equivalent to the NWI class E2EMP and EPB class 2.5.12.
RS	River-sourced tidal wetland	Marshes and swamps along river channels that are flooded by tides at least once annually and receive little or no marine water.
PF	Potential tidal forested wetland	Forested lands in the upper estuary likely to receive tide-related inundation at least once annually.
RCA	Restoration consideration area	Hydrologically altered areas that may have geotechnical potential for restoration of tidal circulation; also, areas where tidal status could not be determined during the course of Scranton's thesis (Scranton 2004).
F	Fill (filled former tidal wetland)	Areas filled and/or compacted for human use.
W	Open water	Water and tidal channels
NT	Nontidal (palustrine) wetland	Non-tidal wetlands
UN	Unconsolidated sediments	Gravel bars, beaches or dunes
UP	Not wetland	Uplands

General introductory notes

This handout provides a condensed outline of the Estuary Assessment manual. It follows the flow chart on page 8 above. This handout can not be used alone for estuary assessment, since it lacks all instructions on how to characterize sites. Underlined text in this handout is not found in the assessment manual. These additional detailed instructions have been developed for this specific training.

Not a comprehensive GIS instruction course. This handout assumes prior knowledge of GIS; it does not provide all the background needed to conduct GIS analyses. For example, we assume that you know that for a spatial analysis involving two separate spatial datasets, those datasets need to be in the same projection.

Use “endpoint” shapefiles to catch up. Each step in this outline is numbered. If you are having trouble with any step, you can skip that step by opening the corresponding shapefile in the “endpoints” directory, and you will be ready for the next step in the assessment.

Recommended approach. Although this method provides specific instructions for every step of the assessment, it is still important to evaluate the logic and appropriateness of your results. Keep notes on your methods and observations so others can interpret your work. For example, if several of your data sources show a site as diked, but the most recent aerial photos show that the dike has been removed, your final results should show the site as undiked, and your notes should describe the discrepancy. Also remember that even though some steps in this procedure may seem unnecessary (or are even skipped) during the training, all steps are necessary when performing an actual assessment.

Backups, filename conventions, and error-checking. As you work, save your work frequently. Edits to shapefiles and changes to your map document have to be saved separately – saving one doesn’t save the other. After you edit a shapefile, view the results graphically and re-check the number of polygons and total area to make sure no unwanted changes occurred. Right-click the “Area” field and use “Calculate geometry” to calculate areas, then use “Statistics” to check total area.

Preventing selection errors. As you characterize Map E1 polygons, you will often be making selections based on characteristics of other layers. For interactive selection, make sure you have set selectable layers correctly. Before geoprocessing, make sure only desired selections are in place; most geoprocessing steps act only on selected features unless otherwise specified. In properties for the MapE1 shapefile, set selection properties so that selected polygons are symbolized with a solid color rather than an outline -- this will make your selection easier to see. Consider the results you are trying to achieve and use your judgment to determine whether your selection achieved the desired results. Check your work frequently; examples of ways to check include by switching the selection to see which polygons were NOT selected, and using “Zoom to selected features” to see if there are unintended selections.

Create Map E1

HGM base layer

Step 1a: Save the HGM base layer as a new shapefile named “MapE1_[date1-time1].”

Retain polygons classified as MSL, MSH, RS, PF, RCA, and Fill.

Delete HGM polygons in the following classes:

NT: Nontidal wetland (“Palustrine”)

UN: Unconsolidated

W: Water (BUT: retain water polygons that are contained inside tidal wetlands)

UP: Upland

Save the revised shapefile with a new date-time stamp: “MapE1 [date2-time2].” Continue this process of saving after each step throughout the assessment.

Identify “likely tidal” areas

HGM base layer

Step 1b: Polygons classified as MSH and MSL in the HGM base layer can be assumed to be tidal wetlands. For these polygons, enter “Y” in Column 6. For all other HGM classes, enter “N” in Column 6.

Estuary Plan Book

Step 1c: If any part of an HGM polygon is shown as emergent, scrub-shrub or forested tidal wetland in the Estuary Plan Book habitat map (habs.shp), enter “Y” in Column 7, and record the EPB habitat type code(s) in Column 8. If an HGM polygon is not shown on the EPB map, enter “N” in Column 7.

You can transfer EPB attributes to your base layer polygons by hand (by viewing the underlying EPB polygons for each HGM polygon) or by using “spatial join” in ArcMap (ArcToolbox/ Analysis/ Overlay/ Spatial Join). If you use Spatial Join, set a join merge rule with a comma delimiter and place the results in a new data column. Note that transferring attributes by hand often produces better results than an automated join, because doing the work by hand requires more careful inspection and application of judgment.

National Wetlands Inventory (NWI)

Step 1d: Record all of the underlying NWI classifications for each HGM polygon in Column 9, including any modifiers. Omit NWI classes that are not assessed (RB, UB, AS, OW). (Classes assessed are emergent [EM], scrub-shrub [SS] and forested [FO]). Refer to Appendix E2 for NWI classification details. Some HGM polygons may be classified as upland on the NWI map; if so, enter “U” in Column 9.

You can transfer NWI attributes to your base layer polygons by hand (by viewing the underlying NWI polygons for each HGM polygon) or by using “spatial join” in ArcMap (ArcToolbox/ Analysis/ Overlay/ Spatial Join). See “Estuary Plan Book” above for details. If you use a spatial join, create a new field to hold the join results, then edit the results to delete NWI classes that are not assessed (RB, UB, AS, OW), and copy the edited results to Column 9.

Step 1e: If any of the underlying NWI codes for a polygon indicate tidal influence (code begins with E, or code contains a tidal water regime modifier code of R, S, T, or V) enter “Y” in Column 10. If

any of the underlying NWI codes have the modifier “h,” indicating diking, enter “Y” in Column 10. If none of the above apply, enter “N” in Col. 10.

Local Wetlands Inventory (if any)

Step 1f: If available, enter wetland classification from a Local Wetlands Inventory (LWI) in place of the NWI classification for steps 1c-1e above, noting the data source as “LWI.”

Summarize “likely tidal” areas from HGM, EPB and NWI

Step 1g: Assign a “tidal score” of 10 in Column 22 for any polygon with a value of “Y” in Columns 6, 7 or 10, and record their tidal status as “Y” in Column 23.

Proceed to **Historic vegetation type** (next step). For polygons marked “Y” in Column 23, you can skip the rest of Step 1 and move directly to Step 2 (**Assess alterations to tidal wetlands**). For polygons marked “N” in Column 6, 7, and 10, you need to continue with the rest of Step 1 to determine the likelihood that the polygon is or was once a tidal wetland.

Analyze other tidal status indicators

1- Historic vegetation type

This analysis of historic vegetation type uses 1:24,000 scale GIS data. These data are available from the Oregon Natural Heritage Information Center (ORNHIC) as described in the full Estuary Assessment manual. Note that the ORNHIC website and the Oregon Geospatial Enterprise Office offer a 1:100,000 scale historic vegetation layer, which is NOT recommended for this analysis as it is much less accurate than the 1:24,000 scale layer.

Step 1h: Use the historic vegetation data to locate areas of historic tidal marsh (coded “WSM”). Find HGM polygons that intersect the historic tidal marsh: First select the WSM polygons in the historic vegetation layer, then use Toolbox/Data Management Tools/Layers and Table Views/Select by Location to find HGM polygons that intersect the historic vegetation “WSM” polygons. For these HGM polygons, enter “Y” in Column 11 and assign these polygons a score of 10 in Column 22 and enter “Y” in Column 23.

Step 1i: Use the historic vegetation data to locate areas of historic swamp (see table below for swamp codes). Find HGM polygons that intersect the historic swamps; for these HGM polygons, enter “Y” in Column 13. For these polygons, check Columns 6, 7, 10 and 11; if none are marked ‘Y,’ enter “Y” in Column 3 (field check required).

Table 2. List of forested and scrub-shrub wetland types contained in the ORNHIC historic vegetation layer.

Description (ORNHIC field VEG_TEXT)	Abbreviation (ORNHIC field VEG_ABB)
Ash-alder-willow swamp	FALW
Red alder swamp	FL
Sitka spruce swamp	FSL
Crabapple swamp	HC
Brush fields or thickets on bottoms or wet terraces	HD
Shrub swamp, composition unknown	HSS
Willow swamp	HW
Sitka spruce swamp with scattered spruce and dense shrub understory	OFSL
Mixture of shore pine swamp and undifferentiated "marsh"	WSP
"Swamp," composition unknown	WSU

2- Soil survey mapping

[You may skip this step for polygons marked "Y" in Column 6, 7, 10 or 11.]

Step 1j: If any of your HGM polygons contain any of the following soil types, enter "Y" and list the tidally influenced soil types in a new column "soils_all." Otherwise, enter "N" in this column.

- ▶ Bragton
- ▶ Chetco
- ▶ Coquille and variants
- ▶ Fluvaquents-histosols complex (also found in nontidal areas)
- ▶ Brallier and variants
- ▶ Clatsop
- ▶ Coquille-Clatsop complex
- ▶ Langlois

3- Historic and current aerial photograph interpretation

[You may skip this step for polygons marked "Y" in Column 6, 7, 10 or 11.]

Check the available aerial photographs for indicators of tidal influence. (In a full implementation of the assessment, you would gather and consult a sequence of historic aerial photographs, not just current ones).

Step 1k: Active channels: If you see active tidal channels in the aerial photos, enter "Y" in Column 15, and record the year of the photo in which you saw the channels. If you do not see active tidal channels in any year's photos, enter "N" in this column. If you are uncertain, mark "Q" in Column 15, and also mark "Y" in Column 3.

Step 1L: Remnant channels: For each HGM polygon where you saw remnant channels in the aerial photos, enter "Y" in Column 16, and record the year of the photo in which you saw the channels. If you did not see remnant channels in any of the photos, enter "N" in Column 16. If you are uncertain, mark "Q" in Column 16, and also mark "Y" in Column 3.

Step 1m: Sitka spruce dominant: For each HGM polygon where you saw dominant Sitka spruce in an aerial photograph, enter “Y” and the year of the photo in Column 17. If you entered “Y” in Column 17 but entered “N” in Columns 6 through 16, you should also mark “Y” in Column 3.

4- Field observation and local knowledge

[You may skip this step for polygons marked “Y” in Column 6, 7, 10 or 11.]

Step 1n: At this point in your assessment, HGM polygons which lack clear evidence of tidal influence should be marked “Y” in Column 3 to indicate that a field check is needed. HGM polygons without clear evidence of tidal influence are those that have “N” entries in Columns 6, 7, 10, 11, 13, 14, 15, 16 and 17 (or possibly “Y” in Column 17 but “N” in all other columns). If any of these polygons are not marked “Y” in Column 3, enter “Y” in that column now. In the next few paragraphs, these polygons will be referred to as “field-check polygons.”

(a) Landowner contacts and other local knowledge

Step 1o: If the landowner or other source confirms that the site is flooded by the tides, enter “Y” in Column 18. If local knowledge fails to confirm tidal influence, leave Column 18 unmarked; you should check other indicators for these areas.

(b) Prepare for field visits

See assessment manual.

(c) When and where to visit

See assessment manual.

(d) Tidal inundation

Step 1p: If a field-check polygon is inundated at high tide, but not at low tide, mark “Y” in Column 19 and record the details in Form E2. For any polygon where you observe tidal inundation, you can skip the rest of this section, because you have confirmed that the site is tidally influenced. If you do not observe tidal inundation, go on to the next two steps (**Tidal channels**).

(e) and (f) Tidal channels – all sites

*[You may skip this step if you confirmed that the site has **Tidal inundation**, above.]*

Step 1q: If your field work provides evidence of tidal fluctuation in water levels within any interior channel in a field-check polygon, enter “Y” in Column 20 and record the details in Form E2.

(g) Tidal channel mouths – culverted or tidegated sites

*[You may skip this step if you confirmed that the site has **Tidal inundation**, above.]*

Step 1r: Enter “Y” in Column 20 if you see evidence of tidal fluctuation at the mouth of a restricted channel, or “N” if you see no such evidence. Also enter your observations in Form E2; mark the location of your observations on your aerial photo laminates, and record GPS coordinates.

Step 1s: Special situation: Offsite tidal restrictions affecting multiple HGM polygons. For all HGM polygons affected by an offsite restriction (e.g. a river mouth tide gate), mark the location of the offsite restriction on your aerial photograph, enter “Q” for “questionable” in Columns 19 and 20, and use other indicators.

(h) Vegetation

*[You may skip this step if you confirmed that the site has **Tidal inundation**, above.]*

Step 1t: For field-check polygons, record your vegetation observations in Form E3. If brackish-tolerant plants are dominant within the wetland, mark the area on your aerial photo laminates with the code “BV,” and enter “Y” in Column 21. [See Appendix E3 for a list of brackish-tolerant plants.]

5- Summarize tidal indicators

Step 1u: Enter “Y” in Column 4 for all polygons that you have field-checked. For any polygon which has Column 3 marked ‘Y’ but Column 4 is marked ‘N’ or blank, enter “Q” in Column 23. These are polygons that need to be field-checked but have not been field-checked; their tidal status remains unknown.

Step 1v: If Column 6, 7, 10, 11 or 19 is marked “Y,” enter “10” in Column 22. Otherwise, add up the number of “Y” or “Q” entries in Columns 13-21 and write the result in Column 22. Fill in Column 23 as follows (but don’t change prior entries in this column):

Col. 22 total	Col. 23 entry
3-10	Y
1-2	Q
0	N

Finalize Map E1, Historic Extent of Tidal Wetlands

Step 1w: After completing Steps 1a-1v, you may have discovered additional NWI polygons or other areas that have strong indicators of current or historic tidal influence, but which are missing from the HGM layer. Add these features into your Map E1 shapefile using the ArcToolbox Union or Merge tools as appropriate. Enter data in each column, following Steps 1a-1v above. For each of these added features, assign a unique polygon number in Column 1 (making sure your polygon numbers are outside the range of the HGM polygons). Enter “none” in the column “HGM Class” and enter your data source (e.g., “from NWI”) in the column “Classifica.”

Step 1x: Delete the polygons for which Column 23 is marked “N” for “Nontidal.” Save your revised layer as MapE1_FINAL_[date].shp.

STEP 2: ASSESS ALTERATIONS TO TIDAL WETLANDS

Site-specific alterations

The purpose of this section is to locate the following types of alterations within your Map E1 polygons:

- Dikes
- Ditches
- Restrictive culverts and tide gates
- Road and railroad embankments, bridges, and other structures crossing tidal wetlands
- Earthen dams and other channel blockages
- Channel armor/riprap
- Dredged material disposal/ditching sidecast
- Logging and driftwood removal
- Grazing
- Invasive species
- Fill

You will use existing GIS data to locate mapped alterations, then use aerial photograph interpretation and field visits to find unmapped alterations.

HGM base layer

Examine all polygons classified as “Fill” (HGM Class F) in Map E1 to separate dikes from filled and developed infrastructure areas. Long, narrow fill polygons downslope of broader HGM polygons are often dikes. Other Class F polygons upslope from broader HGM polygons are less likely to be dikes.

Step 2a: Class F polygons which are not dikes and are developed (with houses, roads, or other infrastructure) can now be eliminated from Map E1, since this method does not address such developed areas. For these polygons, enter “Y” in Column 24 and indicate your information source (HGM) in Column 25.

Step 2b: For Class F polygons which are dikes but are not otherwise developed, enter “Y” in Column 26 for all affected polygons, and show the data source as “HGM” in Column 27. Confirm these observations in the next steps, using USGS topographic maps and NWI data. Note that a single dike often affects several HGM polygons. If you are not sure which polygons are affected by a dike, ask local experts for help.

Some linear areas classified as “Fill” in the HGM base layer may be natural levees. Natural levees are high areas along riverbanks resulting from sediment deposition during flood flows (see **Dikes** below for details); they are most prominent in upper estuaries. If you are uncertain whether the linear HGM fill you see is a dike or a natural levee, enter “Q” for “questionable/unknown” in Column 26, and enter “Y” in Column 38 (to indicate that a field check is needed). If you have not yet conducted field visits to check for tidal indicators, copy this “Y” to Column 3.

USGS topographic maps

Step 2c: If the USGS topographic map shows a dike or levee protecting one or more of your Map E1 polygons, enter “Y” in Column 26 for all affected polygons, and show the data source (“USGS”) in the adjacent column(s). If you had already marked the polygon as diked based on the HGM classification, just add “USGS” to the list of data sources for diking in Column 27.

NRCS soil survey mapping

Step 2d: Using the soil survey, locate soil map units coded as “protected” (indicating the mapping unit is behind a dike). For any affected polygons, enter “Y” in Column 26 and enter the information source (“NRCS”) in the adjacent column. If you have already entered “Y” in Column 26, just add “NRCS” to the list of data sources for diking in the Column 27.

Oregon Estuary Plan Book (EPB)

Step 2e: Check each polygon in Map E1 for EPB codes indicating diked tidal wetlands (2.5.11D, 2.5.12D, 2.5.13D, and 2.5.14D). For each polygon with such a code, enter “Y” in Column 26 and show the data source (“EPB”) in the adjacent column. If you have already entered “Y” in Column 26, just add “EPB” to the list of data sources.

The Estuary Plan Book also shows designated dredged material disposal (DMD) sites within some estuaries. For each Map E1 polygon that has a designated DMD site, enter “Y” in Column 28 and show the source of the information in the adjacent column as “EPB.”

National Wetlands Inventory (NWI)

Using the list of NWI codes from Step 1d, check each polygon for underlying NWI mapping with the following codes indicating alterations:

d = Partially drained/ditched

h = Diked/Impounded

s = Spoil (i.e., fill material in the wetland resulting from excavation elsewhere)

x = Excavated

Step 2f: For each alteration mapped in the NWI, enter “Y” for the affected Map E1 polygon(s). Use the appropriate column (Column 26 for diking, Column 28 for spoil, Column 30 for ditching, Column 32 for excavation), and show the data source in the adjacent column as “NWI.”

Other maps

See assessment manual.

Aerial photograph interpretation and field observation

Aerial photograph interpretation

General instructions: starting at the downstream end of your estuary, check each Map E1 polygon for the alterations listed at the beginning of Step 2. (See steps below for specific instructions for

each alteration type.) First, use the aerial photographs to verify the alterations you have marked in your Map E1 attribute table; this will also help calibrate your aerial photograph interpretation skills. When you see an alteration in an aerial photograph of a Map E1 polygon, mark the appropriate column in your Map E1 attribute table. Show the source of information as “aerial” and show the year of the photo. If you are not sure of your interpretation, enter “Y” in Column 38 (to indicate that a field check is needed).

Field observation

General instructions: For all polygons where you have entered “Y” in Column 38, conduct a field check and/or seek further local information. Ask specifically about the features and alterations you marked “Q” in the Map E1 attribute table, but also ask for general information about the area.

For polygons with alterations, enter “Y” in the appropriate column (see steps below) and record your data source (“field check” or “local knowledge”) in the adjacent column. If you are still uncertain about an alteration after the field check, enter “Q” in the appropriate column, and enter “Y” in Column 38. Enter “Y” in Column 4 for the polygons you have field-checked.

Instructions for specific alteration types

Ditches / Dredged channels

Step 2g: Channel alterations assessed in this manual include both ditches and dredging of natural channels. For polygons with channel dredging or ditching, enter “Y” in Column 30.

Restrictive culverts

Step 2h: For all polygons that may be affected by a restrictive culvert, enter “Y” in Column 34 and indicate the source of your information in the adjacent column (“aerial [year]” or “field check”). If you have not field checked the location, enter “Q” in Columns 34 and 36, because it is generally not possible to distinguish restrictive culverts from tide gates in aerial photos; enter “Y” in Column 38; and seek further information.

Tide gates

Step 2i: For every Map E1 polygon affected by a tide gate -- whether onsite or offsite -- enter “Y” in Column 36, and indicate the source of your information in the adjacent column. If you are uncertain whether a particular polygon is affected by a tide gate, enter “Q” in Column 36, and also enter “Y” in Column 38, because you will need to verify this information.

Roads/railroads

Step 2j: For each Map E1 polygon affected by a road or railroad crossing the wetland, enter “Y” in Column 39, and indicate the source of your information in the adjacent column. If the road or railroad crossing acts as a dike, enter “Y” in Column 26 as well.

Earthen dams or other tidal channel blockages

Step 2k: For each polygon where you observe a man-made dam or blockages, enter “Y” in Column 41 and indicate your data source in the adjacent column. (Beaver dams are not considered alterations.)

Earthen dams constructed in major channels sometimes act as dikes, affecting several different Map E1 polygons. If a dam completely blocks tidal flow to all upstream polygons, enter “Y” in Column 26 for all of those polygons.

Channel armoring/riprap

Step 2L: For each polygon where you observe channel armoring and riprap along the margins of the polygon, enter “Y” in Column 43 and indicate the source of your information in the adjacent column. If the channel armor consists of a road or railroad, enter “Y” in Column 39 as well. In many of these cases, the road also acts as a dike; if so, also enter “Y” in Column 26. If you are uncertain whether a particular polygon has channel armoring or riprap, enter “Q” in Column 43, and enter “Y” in Column 38.

Spoil/Dredge material disposal

Step 2m: For each Map E1 polygon where you observe DMD or other spoil disposal, enter “Y” in Column 28 and indicate your data source in the adjacent column. If you are uncertain whether a particular polygon has received dredge material, enter “Q” in Column 28, and enter “Y” in Column 38. It is especially important to obtain local knowledge for this investigation by consulting resource professionals, landowners and port authorities, as it can be challenging to identify DMD sites.

Logging and driftwood removal

Step 2n: Check your study area for former spruce swamp areas (marked “Y” in Column 13 and classified in the ORNHIC mapping as FSL or OFSL; or marked “Y” in Column 17). If spruce are no longer present, record the likelihood that the area has been logged by entering “Y” in Column 45. Show your data source in the adjacent column.

Grazing

Step 2p: For each Map E1 polygon where you observe grazing, enter “Y” in Column 47 and indicate your information source in the adjacent column. If you are uncertain whether a particular polygon is grazed, enter “Q” in Column 47, and enter “Y” in Column 38.

Invasive species

Check Map E1 polygons for the following invasive species of special concern to emergent, scrub-shrub and forested tidal wetlands:

Smooth cordgrass (*Spartina alterniflora*)
Saltmeadow cordgrass (*Spartina patens*)
Purple loosestrife (*Lythrum salicaria*)
Reed canarygrass (*Phalaris arundinacea*)

Japanese knotweed (*Polygonum cuspidatum*)
Giant knotweed (*Polygonum sachalinense*)

Step 2q: For any Map E1 polygon where you observe invasive species (or where others report their presence), enter “Y” in Column 49, indicate your information source in Column 50, and list the species observed in Column 51.

STEP 3: DEFINE UNITS OF ANALYSIS (“SITES”)

Create Map E2

Step 3a: Export your entire Map E1 shapefile to a new shapefile called Map E2, using the same naming conventions described in **Backups and filename conventions** above (save as “Map E2_[date].shp”).

Exclude Map E1 polygons that are filled and developed

Step 3b: Delete polygons marked “Y” in Column 24, unless they are dikes without houses or other permanent structures. These filled and developed areas will be excluded from the remainder of this assessment.

Lump adjacent Map E1 polygons that have similar levels of alteration

Step 3c: Referring to aerial photos and your Map E1 attribute table, group adjacent Map E1 polygons that have a similar level of alteration. Assign a unique site number (Project ID code) to each group of polygons in Column 2 (“2_PROJ_ID”).

Split Map E1 polygons where the level of alteration is strikingly different within a polygon

Step 3d: Referring to aerial photos and your Map E1 attribute table, split Map E1 polygons that have internal areas with noticeably different levels of alteration. Assign unique site numbers in Column 2 (“2_PROJ_ID”) to these polygons, or group them with other adjacent polygons as appropriate.

Step 3e: Edit your Map E2 shapefile to merge all polygons with the same site number (same number in Column 2, “2_PROJ_ID”).

Step 3f: In the column 5_HGM_CDS, list all of the underlying HGM classes for each site. You can do this by using a spatial join; see step 1c for details.

Step 3g: In the column 53_ALTERS, for each site, list all of the alterations shown in Columns 25 through 51 for the underlying Map E1 polygons. (This prevents loss of the information gathered during Steps 2a-2r.) You can enter the alterations as shown in the table below, or use the abbreviations:

Alteration	Abbreviation
Dike	Y
Ditch	D
Restrictive culvert	C
Tide gate	T
Road/Railroad crossing	R
Dam	M
Channel armor/riprap	A
Dredged material disposal / ditching sidecast	S
Logging	L
Grazing	G
Fill	F

Finalize your site map

Step 3h: After completing all merge and split operations that define your project site, export the finalized shapefile with the name “MapE3_[date-time].”

STEPS 4 AND 5: IDENTIFY CONSERVATION AND RESTORATION SITES

Step 4-5: Categorize your sites into restoration and conservation sites by considering the alterations listed in Column 53. Enter the results in Column 54, “54_RESTCON.” Enter “REST” for restoration sites (more disturbed sites) and “CON” for conservation sites (relatively undisturbed sites).

STEP 6: IDENTIFY LANDOWNERS

Step 6: Enter landowner information for each site in a spreadsheet using Form E7 as a model.

IV. SITE PRIORITIZATION

Critical question

1. *Where will restoration and conservation opportunities offer the highest ecological benefits?*

Materials needed

- Products of Steps 1 through 6 above (Maps E1, E2, E3; Forms E2, E3, and E7).
- Data sources used in Steps 1-6 above (many will be used again in this step)
- Land ownership information

- Land use planning documents
- Field observation and interviews

Final products

This prioritization will produce:

- **Map E3 attribute table** containing scores for 6 prioritization criteria and a total score
- **Map E3:** Final tidal wetland prioritization map

General instructions

For each criterion (except channel condition, which is already on a scale of 1 to 5), use the following formula to rescale scores to a scale of 1 to 5. The formula is available in the text file “formulas.txt” in your “workshop data” folder.

$$(((\text{site value} - \text{min}) / (\text{max} - \text{min})) * 4) + 1$$

ECOLOGICAL CRITERIA

Table 3. Summary of ecological prioritization criteria

Factor	Data source	Description	Levels and scoring
Size of site	Map of sites	Size in hectares or acres. You may choose to omit sites under 1 ha (2.5 A) in size.	Convert full range of values for study area to scores of 1 (smallest) to 5 (largest).
Tidal channel condition	Aerial photograph interpretation and field observation; Forms E4-A and E4-B	Look for visible tidal flow restrictions, ditching, dikes, and remnant channels.	See scoring matrix (Table 4). This score is doubled in the final total score.
Wetland connectivity	National Wetlands Inventory, Estuary Plan Book Habitat types mapping	Total area of wetlands and eelgrass beds within 1 mile of site, excluding the site itself.	Convert full range of values for study area to scores of 1 (smallest area) to 5 (largest area).
Salmonid diversity	ODFW salmonid distribution data	Number of salmon stocks spawning upstream of site <i>in the stream system on which the site is located</i> (main stem or tributary), including areas of historic use.	Convert full range of values for study area to scale of 1 (lowest # stocks) to 5 (highest # stocks).
Historic wetland type	Oregon Natural Heritage Program historic vegetation mapping and ranking	Percentage of site area that was historically tidal swamp (ranked by ORNHIC as critically imperiled) or other tidal swamp.	Convert full range of values for study area to scores of 1 (smallest percentage) to 5 (largest percentage).
Diversity of current vegetation classes	National Wetlands Inventory/Air photo interpretation	Number of Cowardin vegetation classes (emergent, scrub-shrub, forested wetlands) mapped on site, excluding classes mapped on <10% of site area.	One Cowardin class: score = 1 Two Cowardin classes: score = 3 Three Cowardin classes: score = 5
TOTAL SCORE			Add all 6 criteria scores, doubling the tidal channel condition score (maximum possible score = 35; minimum possible score = 7)

Size of site

Step P1: Use “Calculate geometry” to update site size. First sort the sites by area and record the maximum and minimum size. Then use the formula below to calculate the scaled score for size of site, and enter it in the column 3_SIZE_SCO:

$$\text{Score} = (((\text{site size} - \text{min size}) / (\text{max size} - \text{min size})) * 4) + 1$$

Tidal channel condition

Step P2: Use the four columns TCC_TX, TCC_TG, TCC_D, and TCC_RC to enter data on tidal connections, tide gates, ditching and remnant channels, following the scoring matrix below. Calculate the tidal channel condition score in the field 4_CHAN_SCO. No rescaling is needed for this criterion.

Table 4. Tidal channel condition scoring reference chart.

	Tidal exchange		Tide gate location		Ditching		Remnant channels	
	Condition description	Score						
Highly altered condition	None	1	Offsite	1	Heavy	1	None	1
Medium alteration level	Restricted	3	Onsite	3	Some	3	Some	3
Least-altered condition	Full	5	None	5	None	5	Many*	5

*or: channels are undisturbed; or site is an existing restoration site

Wetland connectivity

Step P3: Using your Sites overlay, draw a 1-mile diameter buffer around the outside edge of each site, but excluding the site itself. Use the Buffer Wizard: On top ArcMap menu bar, choose Tools/Customize/Commands tab/Categories: Scroll down to Tools, hold buffer wizard and drag it below the tool dropdown menu..) Add the Project ID (Site #) to each buffer by hand, since it is not retained in the buffer process. (Buffer Geoprocessing tool can retain this field if use it as the join field in buffer operation; but that tool can't exclude the site itself.) Output from this process is Buffer_MapE3.shp (available as a prepared layer in your “endpoints” folder).

Step P4: In the NWI layer, select polygons in classes EM, SS, and FO. Export the selected features to NWI_EMSSFO.shp (available as a prepared layer in your “endpoints” folder).

[Note: The next step in the assessment is to locate aquatic bed wetlands within the Estuary Plan Book layer, or another data source. These wetlands are then added to the NWI wetlands, forming an EPB+NWI layer, which is then intersected with the Step P4 buffer. However, since there are no aquatic bed wetlands mapped in the EPB within the 1 mile buffer for Coalbank Slough, we will skip this step for this workshop.

Step P5: Intersect the NWI_EMSSFO layer with the buffer layer; output is NWI_inMapE3Buffer.shp (available as a prepared layer in your “endpoints” folder).

In the intersection layer, use “calculate geometry” to update the column called “area.” (Do not use the column “Acres,” which is left over from an earlier input layer.) Then summarize areas of the merged wetlands within site buffers: Summarize field = Proj_ID; summary statistic = Sum of Area for the merged wetlands. Output is a summary table named Area_NWI_EPB_buff.dbf.

Step P6: Join the summary table Area_NWI_EPB_buff.dbf to MapE2. Copy the contents of the Sum of Area field to the field 5_WCON_SZ. Remove the join.

Step P7: Sort the site map by 5_WCON_SZ and record the maximum and minimum values. Calculate the wetland connectivity score using the formula below, and enter the results in the field 6_WCON_SCO:

$$(((\text{site value}-\text{min})/(\text{max}-\text{min}))*4)+1$$

Salmonid diversity

Step P8: Using the ODFW salmonid distribution maps, locate stream reaches classified as “spawning and rearing areas” (“Usetype 1”) or “historic use” (Usetype 4). For each of your sites, count the number of different salmonid stocks with spawning/rearing or historic use in stream reaches that are either directly adjacent to the site, or upstream of the site. Enter this number in the field 7_NSTOCKS. Calculate the salmonid diversity score using the formula below, and enter the results in the field 8_NSAL_SCO:

$$(((\text{site value}-\text{min})/(\text{max}-\text{min}))*4)+1$$

Historic wetland type

Step P9: Intersect the ONHP historic vegetation mapping with MapE2 (producing the layer MapE3_histveg_Intersect), then extract the forested categories* from the intersection output shapefile (export to shapefile “MapE3_histforest.shp). Summarize the area of these polygons by site (HistForest_summ.dbf) and join the summary table to MapE2, joining by project ID. Copy the Sum of Area field to the field 9_SWMP_SZ, then rescale to obtain the historic wetland type score, entering the results in the field 10_SWP_SCO.

*For this example basin, we use all areas mapped as forested in the historic vegetation map, since the historic mapping in this area does not explicitly map forested wetlands in tidal areas. In estuaries where the historic vegetation mapping shows forested wetlands in tidal areas, only those wetland types should be used. See the full Estuary Assessment manual for details.

Diversity of current vegetation classes

Step P10: Using the list of Cowardin classes, determine how many classes (of the assessed classes EM, SS and FO) are found within each site. Enter the score in the field 12_CWD_SCO, using the conversion below:

Number of Cowardin classes	Score
1	1
2	3
3	5

2. COMBINED SCORING

Calculating the combined score

Step P11: For the total ecological prioritization score, add all six scores, but multiply the channel condition score by two:

$$\text{Combined ecological score} = (\text{site size score}) + 2(\text{channel condition score}) + (\text{wetland connectivity score}) + (\text{salmon diversity score}) + (\text{historic wetland type score}) + (\text{current vegetation diversity score}).$$

Equivalent formula in field calculator is [3_SZ_SCO] + (2 * [4_CHAN_SCO]) + [6_WCON_SCO] + [8_NSAL_SCO] + [11_SWP_SCO] + [12_CWD_SCO]. This formula is available in the text file “formulas.txt” in your “workshop data” folder.

Enter the combined score in the field 13_TOT_SCO.

Priority groups

Step P12: Sort your sites by combined ecological score, in decreasing order. Roughly divide the sites into 3 to 5 similar-sized “priority groups,” depending on your total number of sites. To do this, look for natural groupings of scores, keeping in mind that the total scores can range from 7 to 35.

Export your final prioritization map as “MapE3_[date-time].shp.” This is the final outcome of your prioritization. **(In an actual assessment, you would need to create metadata for this map.)**

3. SUPPLEMENTAL ANALYSES

Number and type of landowners

Step S1: Intersect the landowner layer with Map E3 to determine the ownership for each site. Visually inspect the results to determine number of landowners for each site. Enter the results in the field 15_N_OWNRS.

Enter the land ownership type in the field 16_OWN_TYP, using the categories in Table 7 below.

Table 7. Land ownership categories

Land ownership category	Description/examples
Tribe	Tribal lands
Federal	USFS, BLM, USFWS, etc.
State	OR Dept. of State Lands, ODFW, Game Commission, etc.
County	County lands
Port	Port lands
City	City and school district lands
Private Industrial	Industrial timber lands or other large-scale private industrial operations
Private Non-Industrial	Private lands other than industrial (residential, small business, etc.)
Mixed	Any combination of the above types

Land-use regulations

See Assessment Manual.

Native American cultural history and archaeological sites

See Assessment Manual.

Synthesis of supplemental analyses

See Assessment Manual.

IX. GLOSSARY

Accretion: The accumulation of sediment, deposited by natural fluid flow processes.

Aquatic bed: A wetland dominated by plants that grow principally on or below the surface of the water. In Oregon estuaries, aquatic beds are generally dominated by algae or eelgrass, so aquatic beds may also be called algal beds or eelgrass beds.

Berm: Another term for a dike (see dike).

Brackish marsh: Another term for tidal marsh; implies moderate salinity (see **salinity zones**).

Breach: A natural or deliberate break in a dike.

Dike: Manmade structure along a river built to protect the adjacent lands from flooding by high water. Many dikes are built on top of natural levees.

Dredging: Excavation of the bottom or shoreline of a water body

Ebb tide: Falling (outgoing) tide; occurs twice a day in Oregon.

Embankment: An artificial bank or dike built to hold back water or to carry a roadway.

Emergent wetland: A wetland dominated by erect, rooted, nonwoody vegetation such as grasses and sedges. Tidal emergent wetlands are often called tidal marshes.

Estuary: A semi-enclosed coastal body of water which has a free connection with the open sea and, within which, seawater mixes and usually is measurably diluted with freshwater from land runoff (Pritchard 1967). In Oregon, the regulatory definition of an estuary includes estuarine water, tidelands, tidal marshes, and submerged lands, and extends upstream to the head of tidewater (except in the Columbia River estuary, where the regulatory definition stops well short of the head of tide).

Estuarine wetland: Tidal wetland (defined below).

Flood tide: Incoming (rising) tide. Flood tide occurs twice a day in Oregon.

Forested wetland: A wetland dominated by woody vegetation more than 6m (20 ft) tall. Tidal forested wetlands are often called tidal swamps.

Freshwater tidal wetland: A wetland where the water regime is influenced by the tides, but salinity is less than 0.5 ppt (parts per thousand).

Geographic Information System (GIS): A computerized mapping system that stores and allows the user to manipulate spatially referenced data.

Geomorphology: That study of the form of the Earth, its surface configuration, the distribution of land, water, etc., and the history of geologic changes through the interpretation of these topographic forms.

HGM: Hydrogeomorphic. Used in the context of the hydrogeomorphic method for functional assessment of wetlands. This module uses a map of tidal wetlands and potential tidal wetlands (Scranton 2004) developed for Volume 3 of the HGM Guidebook for Tidal Wetlands of the Oregon Coast (Adamus et al. 2005b). The map is referred to as the **HGM map**. Areas mapped in the HGM map are referred to as **HGM polygons**.

HGM map: See **HGM** above.

HGM polygon: See **HGM** above.

Intertidal: The zone between the high and low water marks.

Levee: A barrier constructed to block water flow; in tidelands, often consists of a long, narrow embankment built to block tidal flow (see **dike**). Also see **natural levee** below.

Marsh: A wetland characterized by nonwoody, low-growing vegetation (usually grasses, rushes, sedges, and some broadleaved herbs).

Mud flat: An intertidal area without vegetation, with a substrate of unconsolidated sediment, mostly silt and clay. Mud flats are exposed only at low tide.

Natural levee: A narrow strip of higher ground along a river bank, resulting from sediment deposition during flood flows. Natural levees, by definition, are not man-made. However, they are sometimes built up for flood protection purposes, in which case they qualify as dikes.

Neap tide: A tide of relatively small range, occurring when the moon is at quarter.

Pier: A structure extending into the water to serve as a landing place for boats, or for recreational activities.

Piling: A thick wooden or metal pole driven into a channel bottom or sea bed to provide support or protection.

Piping: Erosion of subterranean channels by water moving through soil.

Range of tide: The difference in height between consecutive high and low waters. Also called the “tidal range.”

Riprap: Broken rock used to protect structures, foundations, etc. from wave action, erosion by currents, or slumping.

Marine salinity zone: See salinity zones below.

Salinity zone: The geographic area of an estuary where surface waters are characterized by a particular salinity range. Several classification systems exist for salinity zones. For Oregon estuaries, the zones include the **marine** salinity zone (>30 ppt), the **brackish** salinity zone (0.5 to 30 ppt), and **freshwater** zone (less than 0.5 ppt). A more precise classification includes subdivisions of the brackish salinity zone: oligohaline (0.5-5 ppt), mesohaline (5-18 ppt), and polyhaline (18-30 ppt) (Cowardin *et al.* 1987).

Salinity: Number of grams of salt per thousand grams of sea water, usually expressed in parts per thousand.

Salt marsh: Another term for tidal marsh; implies high salinity.

Scrub-shrub wetland: A wetland dominated by woody vegetation less than 6m (20 ft) tall. Tidal scrub-shrub wetlands are often called tidal swamps.

Seawall: A structure built along the coastline to prevent erosion and wave damage. Earth is held against the shore side of the structure.

Sediment: Fine-grained fragments of soil, rock, or organic material which are carried by water or air and deposited away from their source.

Sheet flow: Movement of water in a shallow, broad layer across the surface of a wetland (not confined to channels).

Slack water (slack tide): The period of low water velocity between flood and ebb tides, when the tidal current reverses.

Slough: A water body characterized by low flow, often with a muddy bottom, edged by marshes and other wetlands.

Spring tide: A tide of relatively large range, occurring when the moon is new or full. The word “spring” does not refer to the season of the year; spring tides occur during every month of the year.

Staff gauge: A long rod marked at intervals, for measuring water level.

Subsidence: Sinking of the soil surface.

Swamp: A forested or scrub-shrub wetland.

Tidal channel: For this module, defined as any channel in which water levels are influenced by the tides. Some tidal channels carry both tidal flow and drainage from the watershed; others carry only tidal flow. The latter are called “blind channels.”

Tidal flat: An area inundated by all high tides and exposed only at low tide. Some tidal flats have extensive growth of algae or seagrass; others are bare mud.

Tidal marsh: An emergent tidal wetland.

Tidal swamp: A scrub-shrub or forested tidal wetland.

Tidal waters: Waters that rise and fall in a predictable and measurable rhythm or cycle due to the gravitational pull of the moon and sun.

Tidal wetland: A vegetated wetland that is periodically inundated by tidal waters. Tidal wetlands include emergent, scrub-shrub, and forested wetland types.

Tide gate (or tidegate): A device to prevent tidal flow into a tidal channel. Usually a hinged flap hung on the downstream end of a culvert set into a dike or riverbank. Each rising tide pushes the flap closed against the culvert’s end, stopping tidal inflow.

Tide gauge: A device for measuring or recording the rise and fall of the tides.

Tide staff: A staff gauge for reading the height of the tide. A “fixed staff” is secured in place; a “portable staff” can be moved from place to place.

Tide tables: Tables showing times and heights of daily high and low tides.

Unconsolidated: Used to refer to sediment grains that are loose, separate, or unattached to one another.

Upland: An area that is not wetland.

Water table: The upper surface of the zone of saturation in soil.

Wetland: An area characterized by soil saturation that occurs often enough to influence soil development and plant communities.

Abbreviations:

BLM	Bureau of Land Management
DOQ	Digital Orthoquadangle
DSL	Department of State Lands
EPB	Estuary Plan Book
GIS	Geographic Information System
GPS	Global Positioning System
HGM	Hydrogeomorphic
LWI	Local Wetlands Inventory
MHHW	Mean higher high water
MHW	Mean high water
MLLW	Mean lower low water
MLW	Mean low water
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
ODA	Oregon Department of Agriculture
ODFW	Oregon Department of Fish and Wildlife
ORNHIC	Oregon Natural Heritage Program
PDF	Portable Document Format (copyright Adobe Inc.)
SWCD	Soil and Water Conservation District
USGS	U.S. Geological Survey

Appendix E2. Tidal Wetland Classifications

Oregon Estuary Plan Book habitat classification

This page lists major habitat classes and subclasses. Combinations may also be mapped, such as 2.3.9/10 (mixed seagrass and algal bed) or 2.3.10(3) (algal bed on mud).

1. Subtidal habitats

1.1 Unconsolidated bottom

- 1.1.1 Sand
- 1.1.2 Sand/Mud (mixed)
- 1.1.3 Mud
- 1.1.4 Shell
- 1.1.6 Cobble/Gravel

1.2 Rock Bottom

- 1.2.7 Boulder
- 1.2.8 Bedrock

1.3 Aquatic Bed

- 1.3.9 Seagrass Bed
- 1.3.10 Algal Bed

2. Intertidal habitats

2.1 Shore

- 2.1.1 Sand
- 2.1.2 Sand/Mud (mixed)
- 2.1.3 Mud
- 2.1.4 Shell
- 2.1.5 Wood Debris/Organic
- 2.1.6 Cobble/Gravel
- 2.1.7 Boulder
- 2.1.8 Bedrock

2.2 Flat

- 2.2.1 Sand
- 2.2.2 Sand/Mud (mixed)
- 2.2.3 Mud
- 2.2.4 Shell
- 2.2.5 Wood Debris/Organic
- 2.2.6 Cobble/Gravel

2.3 Aquatic Bed

- 2.3.9 Seagrass
- 2.3.10 Algal

2.4 Beach/Bar

- 2.4.1 Sand
- 2.4.2 Sand/Mud (mixed)
- 2.4.3 Mud
- 2.4.6 Cobble/Gravel

2.5 Tidal Marsh

- 2.5.11 Low Salt Marsh
- 2.5.11 D Diked Low Salt Marsh
- 2.5.12 High Salt Marsh
- 2.5.12 D Diked High Salt Marsh
- 2.5.13 Fresh Marsh
- 2.5.13 D Diked Fresh Marsh
- 2.5.14 Shrub
- 2.5.14 D Diked Shrub

HGM classification key for Oregon's tidal wetlands

This key (excerpted from Adamus 2006) is used to place Oregon's tidal wetlands into the appropriate HGM subclass.

1. Tidal forces cause the wetland to be flooded with surface water at least once annually, during most years. Excluded are wetlands whose water level or soil saturation may be influenced by tidal fluctuations but which lack a regular (at least annual) surface connection to tidal waters. Plant species that typically characterize upland habitats are absent or nearly so, and some wetland species that are present may be characteristically tolerant of brackish as well as fresh salinity conditions. Channels, if present, are often narrow, winding or branched, and deeply incised as a result of tidal action. Regardless of the wetland's salinity, it is located downriver from the recognized head-of-tide of its associated estuary. Drift logs and growth of trees and moss often mark the upper boundary of annual flooding, i.e., the transition to non-tidal wetland or upland.

YES: *Estuarine Fringe HGM Class. go to #2*

NO: *other wetland classes; the HGM guidebook is not applicable.*

2. Tidal forces cause the wetland to be flooded at least once annually with saline or brackish surface water originating partly or wholly from the ocean (i.e., marine-sourced). Often located within or along the fringes of a major estuarine embayment or a slough off the embayment. Typically located within zones classified as "Marine" or "Brackish" on maps published by Hamilton (1984), the National Estuarine Inventory (1986, 1988), and/or as "Estuarine" on maps of the National Wetlands Inventory. The wetland and/or its immediate receiving waters may have one or more of the following indicators suggestive of marine water: barnacles, stranded seaweed, salt marsh plant species (halophytes, e.g., *Salicornia*, *Triglochin*, *Distichlis*, *Plantago maritima*), springtime minimum salinities of >5 ppt, or a preponderance (in adjacent flats) of rounded sediment particles indicative of marine-derived sediments.

YES: *Marine-sourced, go to #3*

NO: *River-sourced Tidal Fringe Wetland (RS)*

3. All of the wetland is inundated at high tide at least once during the *majority of days during each month of the year*. This may be indicated by a combination of direct observation of tidal inundation, predominance of plant species characteristic of "low marsh" marine environments in Oregon, absence of woody plants, and/or by reference to data on local tidal range paired with precise measurements of elevation and tidal fluctuations relative to an established geodetic benchmark. Less definitively, a boundary between low and high marsh may be evidenced by a vertical break in the marsh surface or by accumulations of fresh wrack (seaweed, plant litter).

YES: *Marine-sourced Low Tidal Fringe Wetland (MSL)*, commonly called "low marsh"

NO: *Marine-sourced High Tidal Fringe Wetland (MSH)*, commonly called "high marsh"

Additional categories in HGM map (Scranton 2004)

The HGM map used as a base layer for this module (Scranton 2004) contains two other wetland mapping categories that are important to this assessment, but which are not included in the key above. They are “Potential Tidal Forested Wetland” (PF) and “Restoration Consideration Area” (RCA). Adamus (2006) provides the following definitions of those categories:

PF = Wooded nearshore areas that may be flooded by tides at least once annually

RCA = Restoration consideration areas, i.e., nontidal wetlands at about the same elevation as tidal waters and which, in some cases, might have been tidal wetlands prior to blockage by dikes, roads, etc.

Our observations indicate that some of the areas mapped by Scranton as “RCA” may be hydrologically modified as described above, but others appear to be hydrologically connected to tidal waters and were designated RCA because the degree of tidal influence could not be determined during Scranton’s thesis work. Many of these areas are in landscape positions and at elevations where it is quite challenging to determine the degree of current or former tidal influence. The methods described in Step 1 of this module (**Identify the historic extent of tidal wetland**), particularly the section **Field observation and local knowledge**, are key to determining tidal influence in these RCA areas.

Scranton (2004) provided details on the methods used to map the PF and RCA areas. The following three paragraphs are excerpted from Scranton (2004):

Potential Tidal Forested Wetland (PF). This classification includes lands currently covered by woody vegetation that are suspected of experiencing tide-related inundation at least once annually, but for which definitive field data are lacking. This includes wetlands labeled E2F* or E2S* by the NWI, as well as wetlands that NWI labeled PSS* or PFO* and which adjoin tidal channels and apparently are not diked. It also includes wetlands coded 2.5.14* by ODFW in the Oregon Estuary Plan Book. These are mostly relict spruce swamps and willows existing near their physiological threshold for salinity. Many probably became established in tidal zones due to fresher hillslope seepage. However the classification label “potential” was derived also as a result of the inability to interpret true hydrology remotely through the canopy. This classification needs to be refined in future work to reclassify these polygons as Tidal Forested Wetlands, Forested Wetlands or Upland Forest.

Restoration Consideration Areas (RCA): Due to the uncertainty of response in terminology the classification of “Restoration Consideration Areas” was changed from its original classification, Potential Tidal Wetlands. This classifies lands, which could not be accurately classified based on existing remote sensing data or lands that are presently defined as upland or non-tidal wetland areas by other sources, which deserve closer scrutiny as possible candidates for restoration of tidal circulation. These areas were identified based solely on coarse-scale geotechnical information from available data sets. No on-site feasibility investigations were conducted, and sociopolitical factors were not

considered. These are generally lands that are diked or may have been partially filled or ditched for agricultural or commercial purposes.

RCAs were identified primarily by reviewing digital elevation information, NWI and ODFW habitat maps, the hydric soils layer from NRCS and other historical sources. Rigid criteria were not developed to identify and map these areas systematically. Rather, mapping employed considerable judgment and consequently the results are very approximate, but err on the side of over-approximation based on the “precautionary principle” of resource management (Cican-Sain 1998). Unknown portions of the RCAs are palustrine wetlands or riparian uplands that never experienced tidal flooding, due to naturally-formed barriers.

Appendix E3. Wetland Plants Tolerant of Brackish Water

This table shows a list of common plant species tolerant of brackish water that are found in Oregon's tidal marshes and tidal swamps. Many of these species are also found in freshwater wetlands. However, if a wetland is dominated only by brackish-tolerant species, it is likely to have brackish water.

Species	Abbreviation	Common name
<i>Argentina egedii</i>	ARGEGE	Pacific silverweed
<i>Atriplex patula</i>	ATRPAT	Saltbush
<i>Carex lyngbyei</i>	CARLYN	Lyngbye's sedge
<i>Cotula coronopifolia</i>	COTCOR	Brass buttons
<i>Cuscuta salina</i>	CUSSAL	Saltmarsh dodder
<i>Deschampsia caespitosa</i>	DESCES	Tufted hairgrass
<i>Distichlis spicata</i>	DISSPI	Seashore saltgrass
<i>Eleocharis palustris</i>	ELEPAL	Creeping spikerush
<i>Eleocharis parvula</i>	ELEPAR	Spikerush
<i>Festuca rubra</i>	FESRUB	Red fescue
<i>Galium trifidum</i>	GALTRI	Small bedstraw
<i>Glaux maritima</i>	GLAMAR	Sea-milkwort
<i>Grindelia stricta</i>	GRISTR	Gumweed
<i>Hordeum brachyantherum</i>	HORBRA	Meadow barley
<i>Jaumea carnosa</i>	JAUCAR	Fleshy jaumea
<i>Juncus balticus</i>	JUNBAL	Baltic rush
<i>Juncus gerardii</i>	JUNGER	Mud rush
<i>Lilaeopsis occidentalis</i>	LILICC	Lilaeopsis
<i>Lonicera involucrata</i>	LONINV	Black twinberry
<i>Malus fusca</i>	MALFUS	Pacific crabapple
<i>Picea sitchensis</i>	PICSIT	Sitka spruce
<i>Plantago maritima</i>	PLAMAR	Seaside plantain
<i>Rumex maritimus</i>	RUMMAR	Golden dock
<i>Salicornia virginica</i>	SALVIR	Pickleweed
<i>Schoenoplectus (Scirpus) maritimus</i>	SCIMAR	Seacoast bulrush
<i>Spergularia canadensis</i>	SPECAN	Canada sandspurry
<i>Spergularia macrotheca</i>	SPEMAC	Beach sandspurry
<i>Spergularia marina</i>	SPEMAR	Saltmarsh sandspurry
<i>Symphotrichum (Aster) subspicatum</i>	SYMSUB	Douglas' aster
<i>Trifolium wormskioldii</i>	TRIWOR	Springbank clover
<i>Triglochin maritimum</i>	TRIMAR	Seaside arrowgrass

Training Overview

All sessions will be held at the SOCC Business Development Center, 2455 Maple Leaf Street, North Bend, OR (across from the airport). The Wednesday field trip will leave from the BDC.

Session	Time	Topics covered
Session 1 Tuesday 6/10/08, 1 pm - 2 pm Estuary basics and the estuary assessment process <i>(based on EAM Chaps. 2 & 3)</i>	1 hr	<ol style="list-style-type: none"> Welcome and introductions, registration and program overview. Estuary Basics Overview of the Estuary Assessment Method
Session 2 Tuesday 6/10/08, 2 pm - 5 pm Introduction to GIS; Identification of historic extent <i>(EAM Chap. 3)</i>	3 hrs	<ol style="list-style-type: none"> Review of GIS Develop Map E1 (Map of Historic Extent)
Session 3 Wednesday 6/11/08, 8 am - 10am Identifying alterations <i>(EAM Chap. 3)</i>	2 hrs	<ol style="list-style-type: none"> Develop Map E2 (Site Map) <i>(classroom)</i>
Session 4 Wednesday 6/11/08, 10 am - 2 pm Field reconnaissance and ground-truthing <i>(EAM Chap. 3)</i>	4 hrs	<ol style="list-style-type: none"> Refine Map E2 (Site Map) <i>(field)</i>
Session 5 Wednesday 6/11/08, 2 pm - 4 pm Defining and characterizing sites <i>(EAM Chap. 3)</i>	2 hrs	<ol style="list-style-type: none"> Refine Map E2 (Site Map) <i>(classroom)</i>
Session 6 Thursday 6/12/08, 8 am - noon Prioritizing sites for restoration and conservation <i>(EAM Chaps. 4, 5 & 6)</i>	4 hrs	<ol style="list-style-type: none"> Create Map E3 (Prioritization) Restoration opportunities associated with specific alterations Linking the EAM to other assessment modules
Session 7 Thursday 6/12/08, 12:30 pm - 2:30 pm Monitoring tidal wetlands before and after restoration <i>(EAM Chap. 7)</i>	2 hrs	<ol style="list-style-type: none"> Types of monitoring How monitoring relates to rapid assessment Monitoring science

Field trip timeline, Estuary Assessment Training
June 11, 2008 Transportation via First Stop Bus Co. (Joe @ 267-3104) Fax: 888-4924

DEPART 10 AM – RETURN 2 PM

Time (approximate)	Destination and activity
10 AM	Board bus Depart SOCC Business Development Center, 2455 Maple Leaf Dr., North Bend
10:25	Arrive East Bay Road (via Allegany Hwy/Coos River bridge) <i>Field session #1 (about 40 minutes)</i>
11:10	Board bus
11:15	Depart East Bay
11:40	Arrive Green Acres <i>Field session #2 (about 40 minutes)</i>
12:25	Board bus
12:30	Depart Green Acres
12:50	Arrive old KCBY Station @ Coalbank Slough <i>Field session #3 (about 20 minutes)</i>
1:10	Board bus
1:15	Depart KCBY station
1: 20 (tentative stop)	Arrive Bicketts @ Coalbank Slough <i>Tentative field session #3 (about 45 minutes)</i>
	Board bus
	Depart Bicketts
1:20	Arrive Casey's @ lower parking lot behind saddle shop on Southwest Blvd. <i>Field session #3 (about 45 minutes)</i> <i>(alternative field session #4)</i>
2:00	Board bus Return to SOCC Business Development Center

Welcome!

Oregon Estuary Assessment Training

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www.GreenPointConsulting.com
Laura@GreenPointConsulting.com
brophy1@onid.orst.edu

Welcome!

- Why we're here
- Where we're coming from
- Your experiences and interests
- Goals for the workshop
- Handouts
- Workshop format and Q&A

Agenda for this workshop

Tuesday 6/10:

- Estuary Basics
- Estuary Assessment Overview

Wednesday 6/11:

- Identification of estuary alterations
- Field trip (ground-truthing)
- Site definition and characterization

Thursday 6/12:

- Site prioritization
- Monitoring tidal wetlands

What is the Oregon Estuary Assessment Method?

- Assessment of all tidal wetlands from ocean to head of tide



Emergent



Scrub-shrub



Forested

- Excludes mudflats, eelgrass beds, open water
- Excludes filled lands (but includes diked)
- Method applies to OR estuaries S of the Columbia

Watershed context

Other components of the Oregon Watershed Assessment Manual:

- Historical conditions
- Channel types and modifications
- Hydrology
- Riparian/wetlands
- Sediment sources
- Water quality
- Fish habitat

• "Action Planning" is generally the next step after Assessment

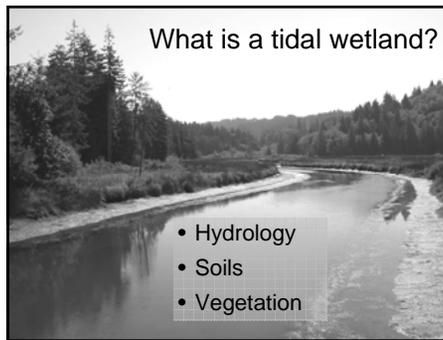
• Estuary Assessment Method includes prioritization for action planning

Why assess tidal wetlands?

- Inadequate existing data
- Development pressure
- Highly altered landscape
- Valuable ecological functions
 - Habitat
 - Food web
 - Water quality protection
 - Flood/storm protection



What is a tidal wetland?

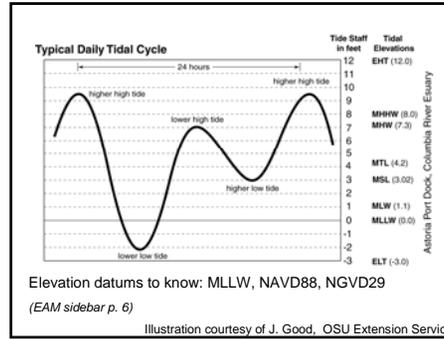
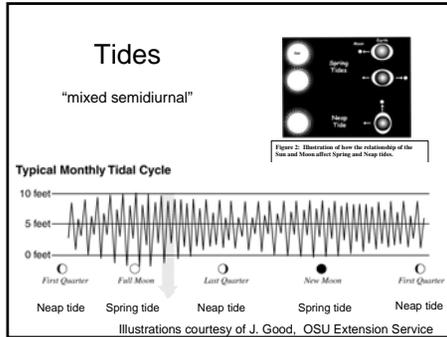


- Hydrology
- Soils
- Vegetation

Hydrology

- Water level is affected by tides
- Surface inundation occurs regularly
- Water may be salt, brackish or fresh
- Many sites also have freshwater inflows
- River flooding and nontidal inputs important in upper estuary

Estuary Basics



Soils

- Saturation
- Salinity
- Organic matter
- Texture

Tidal wetland vegetation (emergent to forested)

I. Emergent: "Tidal marsh"

Low marsh

High marsh



Estuary Basics



Tidal wetland vegetation

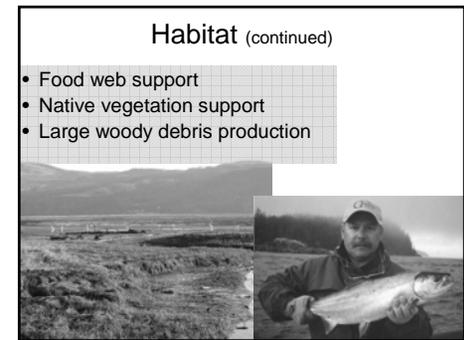
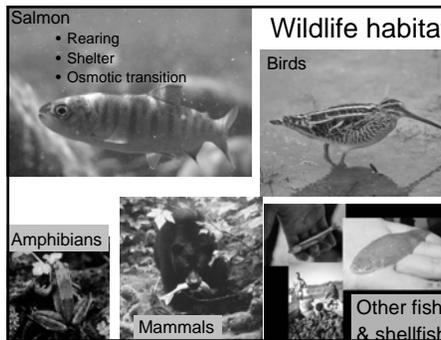
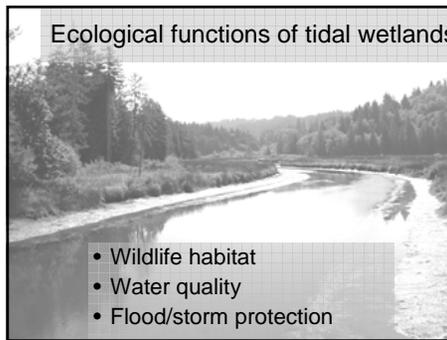
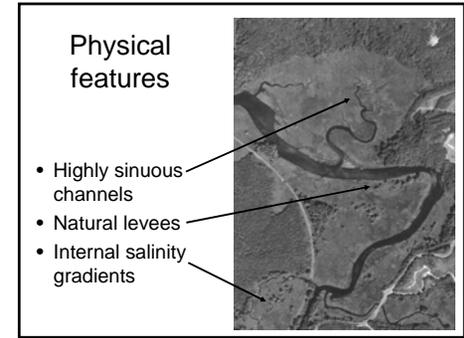
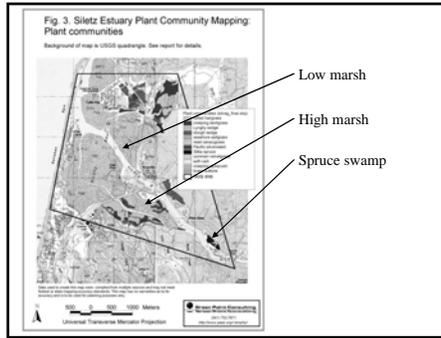
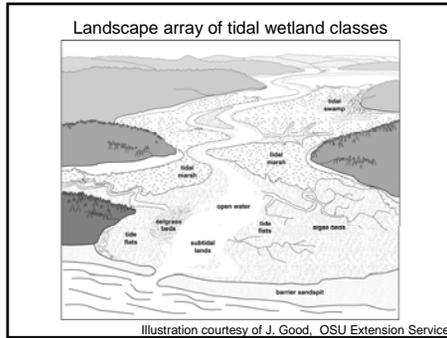
II. Scrub-shrub and forested:
"Tidal swamp"

Scrub-shrub

Forested



Estuary Basics



Water quality

- Nutrient processing
- Sediment stabilization
- Pollutant processing and removal
- Water temperature moderation



Floodwater detention

Flood/storm protection

Shore stabilization & buffering

More information:
Adamus [HGM](#)
[Guidebook](#) Vol. 2, 2006



Alterations to tidal wetlands

- Dikes
- Ditches
- Restrictive culverts
- Tide gates
- Road and railroad crossings
- Dams and other channel blockages
- Channel armor/riprap
- Logging and driftwood removal
- Grazing
- Invasive species
- Fill (incl. dredged material disposal)



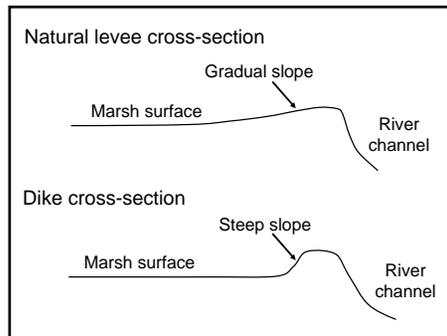

Diking

Goals:

- Exclude tidal flow
- Dispose of dredged material
- Agricultural use

Unintended consequences:

- Soil subsidence
- Impoundment
- Freshwater wetland
- Invasive plants
- Sedimentation
- Offsite effects

Ditching

Goal:

- Drainage

Unintended consequences:

- Reduced habitat area
- Altered channel profile
- Warmer water
- Altered speed of flow
- Sedimentation/scouring
- Offsite effects



Tide gates / restrictive culverts

Goal:

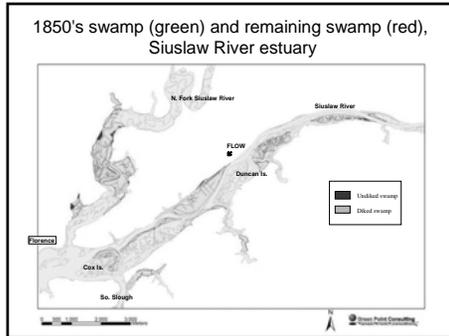
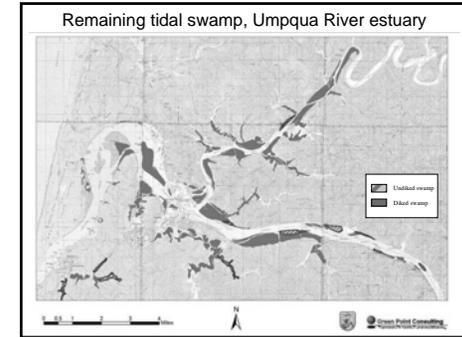
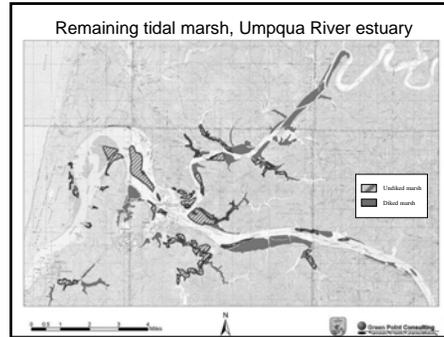
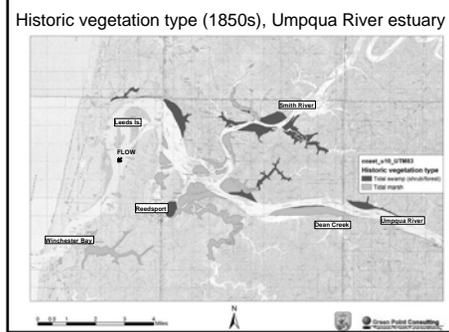
- Eliminate tidal flow
- Exclude salt water

Unintended consequences:

- Passage barrier
- Impoundment
- Altered flow velocities
- Scouring ("turbulence pools")
- Sedimentation
- Offsite effects

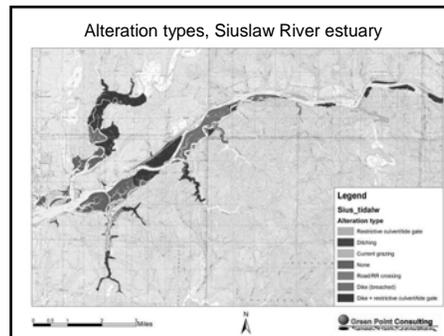
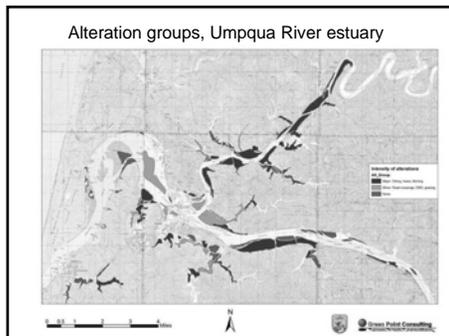
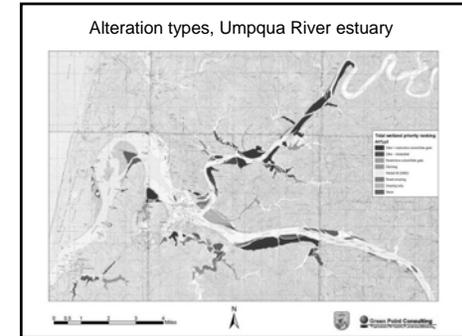


Estuary Basics



Tidal wetland loss/conversion estimates

- Oregon:
 - 70-80% of tidal marshes
 - >> 90% of tidal swamps
- Washington
 - 70% of tidal wetlands in Puget Sound area
- California:
 - 90% of tidal wetlands statewide



**Estuary Assessment and Prioritization:
The Oregon Method**

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The Oregon Estuary Assessment Method

- Developed during 2004-2005
- Based on field work, literature review
- Developed, tested & completed in 5 of 11 major estuaries S of Columbia
- Peer-reviewed
- Manual available from OWEB:
http://www.oregon.gov/OWEB/docs/pubs/OR_wsassess_manuals.shtml#Estuary_Assessment

Tidal wetland assessments & prioritizations completed by GPC & co-authors

Estuary Assessment chapter in Oregon Watershed Assessment Manual

What is assessed and prioritized?

- All tidal wetlands from ocean to head of tide

- Excludes mudflats, eelgrass beds, open water
- Excludes filled lands (but includes diked)
- Method applies to OR estuaries S of the Columbia

Why assess tidal wetlands?

- Inadequate existing data
- Highly altered landscape
- Development pressure
- Valuable ecological functions
 - Habitat
 - Food web
 - Water quality protection
 - Flood/storm protection

Why prioritize the resources?

- Extensive losses (~70%)
- Urgent need for action
- Limited funding
- Grant requirements

Key elements of the method

1. Focus on wetland functions
2. Involves the local community
3. Immediate practical use

1. Focus on wetland ecology

- Landscape approach
- Characterize controlling factors ("drivers")
- Prioritization addresses multiple functions
- Non-regulatory

2. Involves the local community

- Local watershed group involvement
- Incorporates local knowledge
- Can use GIS or paper maps
- Attention to detail needed

3. Immediate practical use

- Useful tools (maps, tables, site descriptions)
- Establishes a baseline
- Easily updated as conditions change
- Provides a basis for immediate action
- Improves chances of funding projects



Steps in the method

1. Assessment
 - Historic extent
 - Alterations
 - Current conditions
2. Prioritization
 - Ecological factors
3. Supplementary analyses
 - Land ownership
 - Land use zoning

Existing data sources

- Map of existing and "potential" tidal wetlands (Scranton 2004)
- National Wetland Inventory
- Estuary Plan Book
- Local Wetland Inventories
- Existing literature
- Head of tide data
- Historic vegetation maps
- NRCS Soil Survey maps



New data development

- Aerial photograph interpretation
 - Alterations
 - Vegetation type
 - Hydrology



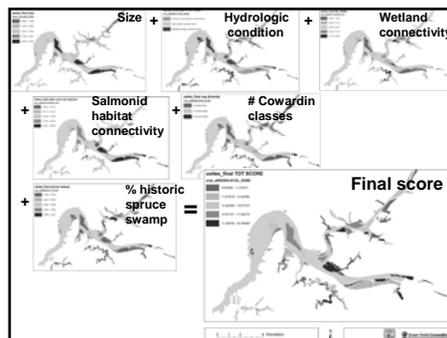
New data development

- Field reconnaissance and local input
 - Ground-truthing
 - Site details
 - Local involvement vital



Prioritization criteria

1. Site size
2. Tidal channel condition
3. Wetland connectivity
4. Number of salmon stocks
5. Historic wetland type
6. Diversity of vegetation classes



Post-prioritization feasibility analysis

- Land ownership
 - Type of owner
 - Number of owners
- Land use zoning/planning
 - City/county Comprehensive Plans
 - Estuary Management Plans



2. Optional further analyses

- Economics
- Community perceptions
- Salmon habitat
- Historic vegetation



Summary

- Straightforward, user-friendly approach
- Extensively reviewed and tested
- Detailed yet comprehensive
- Landscape-scale analysis
- Community-based
- Facilitates rapid action
- Establishes baseline conditions



Next step: Computer Lab

GIS experience (PC groupings)

- Versions: 9.x, 8.x, 3.x
- ArcCatalog
- Tasks:
 - Edit attribute table
 - Change selection symbol
 - Set interactive selection method
 - Calculate areas
 - Intersect layers
 - Select by graphics
 - Select by location
 - Buffer
 - Spatial join
 - Merge or divide features

Site-scale Monitoring for Tidal Wetland Restoration



Steps in restoration

1. Preliminary site evaluation
 2. **Monitoring design**
 3. **Baseline monitoring**
 4. Restoration design
 5. Restoration implementation
 6. **Post-restoration monitoring**
 7. Adaptive management
- Note: Steps are often iterative**



Step 1

Preliminary evaluation of project site

- Bring in experts!
- Landscape setting and ecology
 - Elevation range and topography
 - Tidal range
 - Salinity regime
 - Freshwater flow
 - Plant communities
 - Wetland status
- Alterations and land use history



Landscape Setting "Big Picture"

- Ecological setting
 - Location in estuary (geomorphology)
 - Back-barrier, finger, fringe
 - Use Adamus as guide
 - Offsite tidal restrictions
 - Possible nearby reference sites
- Cultural setting
 - Land use patterns and history
 - Current land use issues
 - Community perceptions



Step 2

Development of monitoring program

- Based on project goals
- Incorporates expert technical advice
- Science-driven
- Uses appropriate reference sites
- Establishes monitoring priorities



Step 3

Baseline monitoring

- Conducted at project and reference sites
- Identifies physical site constraints
- Contributes to project design
- Establishes methods and initial conditions for future evaluation



Step 4

Restoration design

- Uses an interdisciplinary team approach
- Seeks "lessons learned" from other practitioners
- Uses results from baseline monitoring
- Ties tightly to project goals
- Uses "design template" from reference sites
- Recognizes constraints
- Allows for adaptive management



Step 5



Restoration implementation

This is another workshop!

Step 6

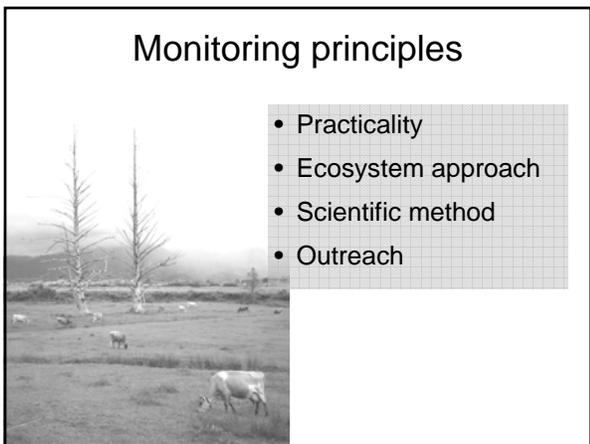
Post-restoration monitoring

- Conducted at project and reference sites
- Continues baseline monitoring methods
- Ties results to project goals
- Tracks and adapts to restoration trajectory
- Enables adaptive management
- Involves community
- Addresses landscape scale issues









Monitoring principles 1.

- Practicality
 - Focus on project goals
 - Streamline for efficiency
 - Recognize constraints
 - Prioritize!
- Ecosystem approach
 - Uses conceptual model
 - Process-oriented
 - Landscape perspective
 - Adequate duration



Monitoring principles 2.

- Scientific method
 - Hypothesis-driven
 - Statistically valid
- Outreach
 - Team approach
 - Consistent methods
 - Collaboration is key



Constraints

- Short timelines
- Tightly defined project goals
- Access / landowner concerns
- Funding



Monitoring program stages

- Planning
- Design
- Implementation
- Outreach



Planning

- Define project goals
- Develop conceptual model
- Define measurable project objectives



Design

- Choose monitoring parameters
- Choose monitoring and analysis methods
- Set frequency, timing and duration



Implementation

1. Implement baseline monitoring
2. Analyze results
3. Feed results into project design
4. Implement followup monitoring
5. Analyze results
6. Feed results into adaptive management



Steps apply even under constraints

- Short timelines:
 - Single-season baseline data
 - Followup still important
- Tightly defined project goals
 - Performance standards
 - Funding requirements



Steps apply even under constraints

- Access / landowner concerns
 - Information vital to success
 - Enhanced public perception
- Funding
 - Hierarchy of monitoring parameters
 - Monitor "drivers" for efficiency
 - Future funding depends on evaluation of results



Planning a monitoring program Steps 1-4

- Define project goals
- Develop conceptual model
- Define measurable project objectives
- Select monitoring parameters to address objectives



Planning Step 1.

- Define project goals

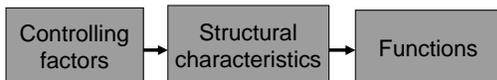
Examples:

- Restore native tidal swamp
- Reduce downstream sedimentation
- Improve juvenile salmon foraging habitat

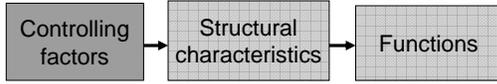
Planning Step 2.

- Develop conceptual model

Basic framework:

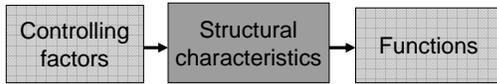


Conceptual model example



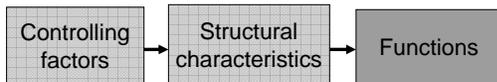
- Examples:
- Landscape setting
 - Salinity
 - Tidal exchange
 - Freshwater flow
 - Sedimentation
 - Soil characteristics

Conceptual model example



- Examples:
- Elevation
 - Tidal inundation regime
 - Depth to groundwater
 - Channel salinity
 - Soil salinity, organic matter, texture
 - Channel morphology
 - Water temperature
 - Plant community interspersion

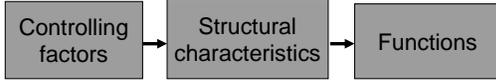
Conceptual model example



- Examples:
- Support native veg
 - Provide fish habitat
 - Provide bird habitat
 - Produce and export organic matter
 - Detain sediment

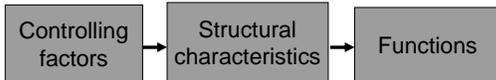
Planning Step 3.

- Define measurable project objectives
 - Based on goals and conceptual model



Planning Step 4.

- Select monitoring parameters
 - Based on project objectives
 - Include controlling, structural and functional parameters



Planning Example 1, Steps 1-2.

- Project goal: Restore native tidal swamp
- Controlling factors (examples)
- Tidal exchange
 - Salinity
 - Freshwater flow
 - Sediment deposition
 - Soil chemistry
 - Herbivory

Planning Example 1, Step 3.

Project goal: Restore native tidal swamp

Potential measurable objectives:

- Frequency of tidal flooding similar to reference site
- Plant communities similar to reference site
- Increased area of native plant communities
- Soils similar to native tidal swamp
- Increased sediment accretion rate

Planning Example 1, Step 4.

Project goal: Restore native tidal swamp

Potential monitoring parameters

Objective	Monitoring parameters
Tidal flooding similar to reference site	•Water levels (tide gauge) •Site elevations
Plant communities similar to reference site	•% cover of native species •Shrub/tree stem density
Increased area of native plant communities	•Mapped area of native-dominated communities
Soils similar to reference site	•% organic matter, texture, pH
Increased sediment accretion	•Sediment accretion rate

Planning Example 2, Steps 1-2

Project goal:
Reduce downstream sedimentation

Controlling factors (examples):

- Frequency of combined tidal / riverine flooding
- Structure of vegetation
- Density of vegetation
- Flow velocities

Planning Example 2, Step 3.

Project goal: Reduce downstream sedimentation

Measurable objectives:

- Increased sediment accretion rate
- Increased frequency of overbank flooding
- Increased shrub stem density
- Increased herbaceous vegetation cover

Planning Example 2, Step 4.

Objective	Monitoring parameters
Increased sediment accretion	•Sediment accretion rate
Increased tidal/riverine flooding	•Water levels (tide gauge) •Site elevations
Increased shrub stem density	•Shrub stems/hectare
Increased cover of herbaceous vegetation	•% cover of herbaceous species in monitoring plots

Note the monitoring parameters in common between the two very different project goals:

Monitoring parameter	Project goal	
	Restore native tidal swamp	Decrease downstream sedimentation
Water levels	✓	✓
Site elevations	✓	✓
Shrub stem density	✓	✓
Sediment accretion rate	✓	✓

- Parameters in common are controlling factors ("drivers")
- These are high priority monitoring parameters for many projects

Unique role of vegetation monitoring

Vegetation is a:

- Controlling factor
 - Sediment trapping/accretion
 - Bank stabilization
- Structural attribute
 - Habitat interspersion, vertical structure
- Functional attribute
 - Biomass productivity
 - Direct uptake of nutrients
- *High priority integrative monitoring parameter because it is a good indicator of environmental conditions*

Selection of reference sites for restoration project

1. Conduct preliminary biological evaluation:
 - Ecological setting
 - Landscape position (slope, aspect, estuary zone)
 - Elevation range and topography
 - Tidal range and salinity regime *inside and outside dike*
 - Freshwater flow
 - Alterations and land use history
2. Select least-disturbed reference sites
 - Match project site's ecological setting

Monitoring data ⇔ design template

Hypothetical restoration project (*not actual data*)

Attribute	Project site	Reference site
Tidal inundation frequency	None	Once daily (HHT)
Groundwater level (July)	-25"	-2"
Channel sinuosity	1.0	2.5
Channel width:depth ratio	6:1	2:1
Elevation range	6-8.5' MLLW	7-9.5' MLLW
# Cowardin classes	1	3
% native species	15%	75%
Channel water salinity	8 PSU	15 PSU

How monitoring data influence restoration design

Design decisions:

- Dike breach vs. dike removal
 - Need site elevations, water levels, channel measurements
 - Affects flooding regime, velocities, accretion rates
- Channel restoration method (active/passive)
 - Need site elevations
 - Affects flooding regime, fish access
- Locations and types of plantings
 - Need elevations, salinities, soils data, reference veg data
 - Affects wildlife habitat, accretion rates, soil characteristics

Post-project monitoring

- Include both reference & restoration sites
- Compare restoration to reference
- Compare baseline to subsequent years
- Were objectives achieved?
- Analyze restoration trajectory
- Be aware of system-wide change
- Practice adaptive management

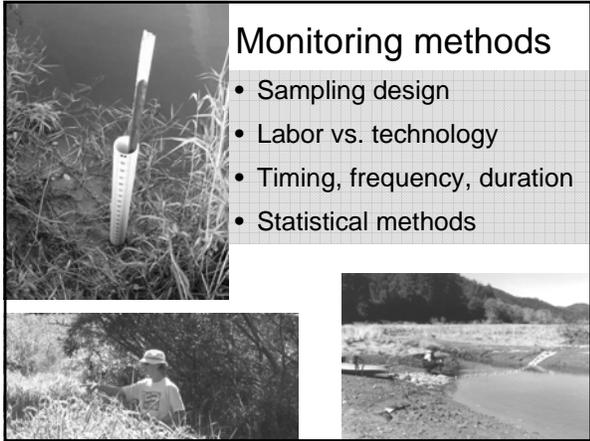


Top priority monitoring parameters*

- Hydrology
 - Water levels (tide gauge)
 - Salinity
 - Tidal and freshwater flow patterns
 - Groundwater levels (in upper estuary)
- Topography
 - Elevations (including channel depths)
 - Channel length and sinuosity
- Habitats and substrates
 - Plant communities
 - Habitat class area and interspersion
 - Soil characteristics
- Parallel monitoring at reference sites



**Recommended in national and regional guidance; adjust for your project goals and site characteristics*



Monitoring methods

- Sampling design
- Labor vs. technology
- Timing, frequency, duration
- Statistical methods

What about “rapid assessment”(HGM)?

- Goals differ:
 - Monitoring: Understand drivers, assist design
 - HGM: Score functions; regulatory emphasis
- Approach differs:
 - Monitoring: Can address any project goal
 - HGM: Addresses a defined suite of site functions
- Field methods and outcomes differ:
 - Monitoring: Repeated observation, produces many kinds of data, including design parameters criteria
 - HGM: Single visit, produces function scores
- HGM assessment does **NOT** substitute for monitoring

Selected monitoring references

(EAM p. 86)

- Rice et al., 2005. Monitoring Rehabilitation in Temperate North American Estuaries.
- Zedler, J.B. (Ed.), 2001. Handbook for Restoring Tidal Wetlands.
- Simenstad et al., 1991. Estuarine Habitat Assessment Protocol.
- Thayer et al. 2005. Science-Based Restoration Monitoring of Coastal Habitats, Volume 2.
- Thom and Wellman, 1996. Planning Aquatic Ecosystem Restoration Monitoring Programs.

Rapid functional assessment:

- Adamus 2006. Hydrogeomorphic Assessment Guidebook for Tidal Wetlands of the Oregon Coast. (3 volumes)