Historical Habitat Change in the Lower Columbia River and Estuary

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Lower Columbia Estuary Partnership

Presented to the Landscape Planning Workshop,
March 21, 2013
Skamania Lodge
One of 28 estuaries in EPA’s National Estuary Program
- Network of community based programs working to protect and restore the water quality and ecological integrity of estuaries of “National Significance”

Bi-State – Federal Partnership:
- OR, WA, US EPA

3 Program Areas
- Habitat Restoration, Ecosystem Monitoring, Stewardship
Project development, coordination of partner projects

CCMP targeted actions and goals
- Restore ecosystem structure and function through restoring natural habitat diversity; key to restoring diversity of salmon life history strategies
- 19k acres restored/protected by 2014

Restoration Prioritization Strategy
- Framework for conducting landscape scale restoration using a strategic approach, rather than opportunistic
Funded by EPA

Incorporates a variety of data, including:
- Historical Habitat Change
- Juvenile Chinook salmon Habitat Suitability Index
- Priority lower Columbia tributaries (OR/WA Recovery Plans)
- Suitable and available habitats for:
  - Tule Chinook, Columbia White Tailed Deer, migratory birds
- Priority Contaminant Clean-up Sites

Draft Report Available on EP website

http://www.estuarypartnership.org/habitat-restoration-strategy
Assumption: Historical habitat diversity played a key role in supporting a diversity of salmon life history strategies

Cited as key task for ecosystem restoration approach


Why another analysis?

Availability of improved data sets (current and historical) allowing for better comparison and greater detail
Habitat Change Overview

► **Objectives**
  Compare pre-Anglo European landscape to present landscape in the LCRE floodplain.
  Quantify changes, set targets for recovery of ‘priority’ habitats
  Use CREEC Hydro-geomorphic Reaches as basis for analysis

► **Methods**
  GIS overlay of existing historical and present data
Habitat Change Data Requirements

**Temporal/Spatial**

Complete data coverage of LCRE floodplain (mouth to Bonneville) for both ‘Current’ and ‘Historical’ periods

Historical period: pre Anglo European settlement (prior to diking/agriculture)

**Accuracy**

Good spatial alignment (Historical is primary concern)

High confidence in the predicted habitat types

For most prior LCRE change analysis efforts, the above conditions have typically not ALL been met
### Previous Studies of LCRE Historical Habitats

<table>
<thead>
<tr>
<th>Author &amp; Year</th>
<th>Report</th>
<th>Spatial Extent</th>
<th>Historical Period (Data Source)</th>
<th>Current Period (Data Source)</th>
<th>Primary Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas 1983 (CREDDP)</td>
<td>CREST/ LCEP</td>
<td>RM 0 – 43</td>
<td>1880s (OC &amp;GS)</td>
<td>1980 (Thomas)</td>
<td>spatial (H,C)</td>
</tr>
<tr>
<td>Graves/Christy 1995</td>
<td>CREST/ LCEP</td>
<td>RM 0 – 102</td>
<td>1880s (OC &amp;GS)</td>
<td>1991 (aerial photo)</td>
<td>spatial (H,C)</td>
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<tr>
<td>OR GAP 1999</td>
<td>PSU/ LCEP</td>
<td>RM 0 – 146</td>
<td>Late 1800s (GLO)</td>
<td>1993 (LandSAT)</td>
<td>spatial (H)</td>
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<td>NOAA-CCAP 1994</td>
<td>NOAA</td>
<td>RM 0 – 146</td>
<td>1989 (LandSAT)</td>
<td>1993 (LandSAT)</td>
<td>temporal (H,C)</td>
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<td>Garano 2003</td>
<td>LCEP</td>
<td>RM 0 – 146</td>
<td>1992 (LandSAT)</td>
<td>2000 (LandSAT)</td>
<td>temporal (H)</td>
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<tr>
<td>Burke 2004 – 2006</td>
<td></td>
<td>RM 0 – 43</td>
<td>1880s (OC &amp;GS)</td>
<td>2000 (LandSAT)</td>
<td>spatial (H)</td>
</tr>
</tbody>
</table>

OC&GS: Office of Coast and Geodetic Survey  
GLO: General Land Office  
C: current data source  
H: historical data source
Historical Landscape Reconstruction: T-sheets

**US Coast & Geodetic Survey Topographic Sheets (T-sheets)**
Survey maps of nearshore zone, created from 1850 – 1890 for the coastal US.

Paper/cloth sheets scanned and georeferenced by NOAA
Accuracy assessment by Daniels, R.C. and R.H. Huxford. 2001

Columbia River Sheets:
- Mapped to RM 129 (Rooster Rock). 27 sheets total.
- Survey period predates most diking and draining of tidal wetlands (Tidal Marshes of the United States. Nesbit, 1885)
Historical Landscape Reconstruction: T-sheets

Scanned T-Sheet example:
SHORE AND SEA BOUNDARIES

WITH SPECIAL REFERENCE
TO THE INTERPRETATION AND USE
OF COAST AND GEODETIC SURVEY DATA

BY
AARON L. SHALOWITZ, LL.M.
Special Assistant to the Director

In Two Volumes

Publication 10–1

U.S. DEPARTMENT OF COMMERCE
Luther H. Hodges, Secretary
COAST AND GEODETIC SURVEY
H. Arnold Kari, Director
Historical Landscape Reconstruction: T-sheets

From Shalowitz – Shore and Sea Boundaries Volume II Part 2, Chap 4 (1964)

Analysis and Interpretation of Topographic Surveys

From a study of successive topographic and hydrographic surveys, the progressive development of a marsh area with relation to the tide can be traced. This is important in determining ownerships of a past date, especially where the land has become bare at high water either through natural processes or through artificial development.

446. THE LOW-WATER LINE

A feature on topographic surveys which frequently assumes significance for purposes other than charting is the low-water line. One reason for this is that in some of the states the tidelands (lands between high and low tide) are subject to alienation by the state. Many of the grants to such lands were made years ago prior to waterfront improvements, and it frequently becomes important to know where the low-water line was located at the time of the grant or as close thereto as possible. The hydrographic and topographic surveys of the Bureau often provide the only authentic evidence available. In using these surveys, it is essential that a proper understanding be had of the method of surveying such line, the accuracy with which it is determined, and any other information that would tend to throw light on its delineation on the survey sheet.

446.1 How Determined

Both to the hydrographer and the topographer, the low-water line is one of the most uncertain and difficult features to delineate. Unlike the high-water line, it is actually visible but momentarily to the topographer. If located by the hydrographer it must generally be accomplished when the height of the tide is well above low water, making it difficult to develop readily its many irregularities. It was, therefore, recognized at a very early period in the work of the Coast Survey that the determination of the low-water line must be left for its final delineation to both parties, “everyone to work according to his best knowledge, and compare afterwards.”

22. This statement on marsh formation is paraphrased from testimony given by B. S. Patton, while Chief of the Chart Division (Inter Director) of the Bureau, in the case of East Ruming Co. vs. City of New York, 165 N.E. 497 (1928). Involved was the question whether under a deed from the Crown conveying land, including all marshes and creeks, the land of the plaintiff was included in a grant as meadows or marshes. Material on tidal marshes can be found in Annual Report of the U.S. Coast Survey 82-86 (1869); in Nisbet, TIDAL MARNES OF THE UNITED STATES, Misc. Special Report No. 7, U.S. Department of Agriculture (1853); and in Johnson, THE NEW ENGLAND-ACADIAN SHORELINE 517-521 (1929).

37. In Oakland v. Boston, 29 P. ad 177 (1924), the Supreme Court of California defined the “line of ship channel” as the line of “ordinary low tide.”

38. Although riparian ownership in this country extends generally to high-water mark, in a few states it extends to low-water mark. In Massachusetts, for example, by virtue of a 1641-1647 ordinance, the title of the owner of land bounded by tidewater extends to low-water mark where the sea does not ebb beyond 200 rods (656 feet). Commonwealth v. Alger, 61 Mass. 55, 67-81 (1853).


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Historical Landscape Reconstruction: T-sheets

From Shalowitz – Shore and Sea Boundaries Volume II Part 2, Chap 4 (1964)

Analysis and Interpretation of Topographic Surveys

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444. INNER EDGE OF MARSH

On many of the early topographic surveys, the inner or landward limits of the marsh (the line separating the marsh from the fast land) are shown variously by “a continuous line, a dotted line, or by a continuous line with short hachures at right angles to it, by long hachures or ends of the parallel lines significant of marsh areas.” The Bureau has always interpreted such line as indicating merely the dividing line between the marsh land and the fast or upland, and not as representing any particular tidal elevation other than that inshore of this line the land is bare at all stages of the tide. Generally, it may be considered as the limit of penetration of the highest tides, but, as has been noted previously, in certain stages of marsh development it may coincide with the high-water line (see 4432).

The detail with which the line was surveyed depended largely upon its accessibility. Not being a feature readily seen by the mariner the tendency was towards generalization. Where the dividing line between the two characteristics of land was inaccessible, as where the upland was heavily wooded or overgrown, or where marsh faded imperceptibly into meadow, the dividing line was altogether omitted and the transition shown by the appropriate conventional symbol.

Notwithstanding its use on some of the early surveys, the representation of the inner edge of the marsh by a definite line was never a requirement until the publication of the Topographic Manual of 1928 when it was made permissive by the instruction that “The inner edge of the marsh (the limit of submergence at high water) when clearly defined may be drawn by a line distinctly lighter than the high-water line.” The parenthetical phrase used here should be considered as a very general definition of the “inner edge of the marsh” and not as referring to an exact tidal plane (see 4432).

29. From letter of F. G. Donn, field office man, to the chairman of the topographical conference convened in 1832 by the Superintendent of the Coast Survey (see 465), Annual Report, U.S. Coast and Geodetic Survey (Part II) 610 (1832).

30. In all references to the inner edge of marsh or fast land in the early manuals, the discussion deals with the indexing of the topographic sheet (by appropriate conventional symbols) and not with the surveying aspect. But it may be concluded that there was no intention that the dividing line be located with great accuracy and detail the value of which would be vitiated by a generalization in the final indexing. Annual Report, U.S. Coast Survey 218 (1856), and U.S. Coast Survey 218, op. cit. supra note 25, at 66. Occasionally, however, as a result of the judgment of the individual topographer, the inner edge of the marsh was very carefully delineated. For example, on Register No. T-1594 (1874), the dividing line between the inner edge of the salt marsh and the outer edge of the fresh marsh is shown by a continuous fine black line. A note in the early correspondence (Jan. 2, 1875) states that Care was taken to delineate exactly the division line between salt and fresh water marsh, a point that may be of future value in land disputes.

31. SWANSON (1928), op. cit. supra note 3, at 5. But at page 93 it is stated that “Neither the inner border of a marsh nor a shoal covered at high tide has a distinct continuous line to mark its limits, each being represented in its proper form and within its area by its conventional symbol only.”

32. SWANSON (1928), op. cit. supra note 3, at 94.

33. Annual Report, U.S. Coast Survey 218, 230 (1856). Appended to this report, as Sketch No. 35, is a composite drawing of the eastern end of Deer Island and shows the method of representing such marsh areas. (See fig. 49.)

34. Field Memorandum No. 1 (1938), supra note 23, at 241.

35. SWANSON (1928), op. cit. supra note 25, at 343.

36. See, for example, Descriptive Report for Register No. T-5976 (1949). There have been instances where such marsh formations have been enclosed by a dotted or pecked line (see Register No. T-1115 (1865)). This is interpreted to be a cartographic expedient rather than a distinction from those areas shown without such enclosing line (see contemporary hydrographic survey Register No. N-1064 (1869), and representation on recent topographic survey of same area, Register No. T-5976 (1949)).

Shore and Sea Boundaries

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This practice of using a definite line for the inner edge of the marsh was reversed in 1938 by Field Memorandum No. 1, supra note 23, at 242, which provides in part that “The edge of high ground at the back of the marsh, mangrove and cypress areas shall be indicated by symbols only . . . and not by a fine line.” The practice in 1949 was to show the inshore limits of marsh by a broken blue line on planimetric and topographic manuscripts, but by conventional symbols on shoreline manuscripts.  

445. MARSH AREAS MOSTLY FLOODED AT HIGH WATER

A feature frequently encountered on topographic surveys is a marsh representation (with solid or broken horizontal rulings), without a solid bounding line. This is interpreted to indicate that there existed no well-defined edge at high water which the topographer could consider the dividing line between land and water. What he saw was a marshy area mostly flooded at high water. Such formations are characteristic of marsh in the early stages of development and may be found contiguous to a well-defined marsh or outside the high-water line. The elevation of the ground in such cases is below high water and usually below low water, although scattered tufts of grass may be found in places protrude above high water.  

The earliest reference to such formations was contained in the treatise on the planetable published in the Annual Report of 1869. They were referred to as “grassy shoals” and “grass upon flats, or shoals covered at high tide,” and were described as “always found in water scarcely agitated by waves or currents.” They were to be shown on the finished topographic sheet without a “distinct continuous line to mark their limits, each being represented in its proper form and within its area by its conventional sign only, but the shape should be well and correctly defined.” This practice is still continued on planetable surveys and on photogrammetric surveys.  

The same collateral sources mentioned in 4433 should be examined for additional information regarding the condition of such marsh areas with respect to the tidal plane.  

37. SWANSON (1928), op. cit. supra note 25, at 340, 343.
Analysis and Interpretation of Topographic Surveys

Figure 41.—Mapping an Alaska shoreline with the planetable. The planetabler constructs his map as he surveys. The rodman on the point of rocks is holding a telemeter rod and the observer is measuring its distance and direction from the planetable.

4113. Mapping the Shoreline

In mapping the shoreline, the topographer set up his instrument at some commanding point where he could see the beach for 400 or 500 yards. The rodman walked along the beach setting up his rod at short intervals and particularly wherever there was a change in direction. The topographer deter-
Historical Landscape Reconstruction: T-sheets

Chronology of T-Sheet Symbols (From Shalowitz, 1964)

Figure 45.—Topographic symbols used in France in 1775.

Surveys due to difficulty of securing complete uniformity where field parties are scattered over a wide area. Such was not the case with the published charts, since they were prepared in one central office where close supervision could be exercised.

In this chronology, no attempt is made to reproduce all the symbols or plates that were in use during any given period, but rather to provide continuity without duplicating identical symbols. This has been accomplished through the use of explanatory notes and cross-references. All the references to annual reports and other publications of the Bureau are those for which at least file copies are available, and it would be possible to reproduce these symbols should this become of importance in a particular situation.

461. Earliest Published Symbols (Circa 1840)

The earliest reference to conventional symbols in the topographic literature of the Coast Survey is found in the instructions for topographic work, issued

Figure 47.—Conventional symbols used in 1860.
Historical Landscape Reconstruction: T-sheets

Chronology of T-Sheet Symbols (From Shalowitz, 1964)

Analysis and Interpretation of Topographic Surveys

![Symbols](image)

**Figure 50.**—Conventional symbols used in 1865.

The final drawing was done by one familiar with the character of the ground. On
Historical Landscape Reconstruction: T-sheets

Chronology of T-Sheet Symbols (From Shalowitz, 1964)

- Shoreline Low Water
- Rocky Shores
- Eroded Banks
- Sand and Shingle
- Sand Dunes
- Oak
- Deciduous and Undergrowth
- Pine
- Palmetto
- Mangroves
- Cacti
- Salt Marsh
- Cypress Swamp
- Salt Pond
- Fresh Marsh and Fresh Pond
- Orchard
- Oyster Bed
- Rice Dikes and Ditches
- Weeded Marsh
- Curves of equal elevation and intermediate curves
- Submerged Marsh
- Basil Grass
- Kelp

Figure 51.—Conventional symbols used in 1892.

Figure 52.—Conventional symbols used in 1892.
T-Sheet Digitization: Jennifer Burke, Univ. of WA. 2006-2010

Extended work of Thomas (1983) and Graves/Christy (1995)
- Increased spatial extent (RM 42/105 to RM 129)
- Modified classification (increased detail)

Difficulties
- Multiple surveyors using slightly different mapping conventions
- Quality of scanned images
GIS Reconstruction of T-Sheet Data
Historical Landscape Reconstruction: T-sheets

Edge Matching Adjoining Digitized T-Sheets (LCEP)

Sheet 1455 + digitized features

Digitized features overlay

Sheet 1495 + digitized features

Edge-matched features based on reference data
Historical Landscape Reconstruction: T-sheets

Edge Match Reference Data
Historical Landscape Reconstruction: GLO maps

- Maps and Field Notes from General Land Office Cadastral Survey
- Same survey period as T-sheets (late 1800s)
- Digitized by John Christy (Oregon Natural Heritage Program, 1999)
- Fill gaps in T-sheet data
Historical Landscape Reconstruction: Final Coverage

Spatial Extent of Historical Data Sources
- UW WET lab interpretation (307,800 acres)
- Christy T-Sheet interpretation (87,000 acres)
- Graves T-Sheet interpretation (6,600 acres)
- Area of Analysis (Approx. Extent of Historic Floodplain)
Present Day Landscape: LCEP 2010 Data Set

- **LCEP 2010 High Resolution Land Cover Data Set**

  Funded by Bonneville Power Administration

  Part of Columbia R. Estuary Ecosystem Classification

  Classification scheme adopted from 2000 LCEP LandSAT TM classification (Garano)

  High resolution (0.25 acre) *segmented* approach based on:

  - 2009 NAIP, 2010 LiDAR, 2007-2008 LandSAT

  Improved estimates for tidal/fluvial and diking extents based on recent LiDAR and WSE data
Present Day Landscape: LCEP 2010 Data Set

Segmented vs. Raster Land Cover Data Comparison

2010 LCEP High Resolution (NAIP)  
2000 LCEP 30m (LandSAT)
Present Day Landscape: LCEP 2010 Data Set

Derivation of Tidal/Non-Tidal/Diked Designation for Wetlands Habitats:

1) Compare Approximate 1 Year Water Surface Elevation Data to LiDAR Derived DEM (tidal vs. non-tidal)

2) Add levee and point barrier information (tidal vs. diked)
Present Day Landscape: LCEP 2010 Data Set

Cover Classes:
- Coniferous Upland Forest
- Deciduous Upland Forest
- Coniferous Wetland Forest - Non Tidal
- Coniferous Wetland Forest - Tidal
- Coniferous Wetland Forest - Diked
- Deciduous Wetland Forest - Non Tidal
- Deciduous Wetland Forest - Tidal
- Deciduous Wetland Forest - Diked
- Shrub-Scrub Upland
- Shrub-Scrub Wetland - Non Tidal
- Shrub-Scrub Wetland - Tidal
- Shrub-Scrub Wetland - Diked
- Herbaceous Upland
- Herbaceous Wetland - Non Tidal
- Herbaceous Wetland - Tidal
- Herbaceous Wetland - Diked
- Aquatic Beds
- Agriculture
- Tree Farms
- Bare
- Mud
- Sand
- Rock
- Urban - Impervious
- Open Space Developed
- Water
<table>
<thead>
<tr>
<th>Normalized Class</th>
<th>Code</th>
<th>T-Sheet Classes (Burke)</th>
<th>T-Sheet Classes (Graves/Thomas)</th>
<th>GLO Classes (Christy)</th>
<th>2010 Classes (LCEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbaceous Tidal WL</strong></td>
<td>HWT</td>
<td>- Marsh: tidal</td>
<td>- Marsh: tidal</td>
<td>- Tidal marsh: salinity undifferentiated</td>
<td>- Herbaceous Tidal WL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Submerged Marsh: Tidal</td>
<td></td>
<td>- Marsh: unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Wapato Marsh</td>
<td></td>
</tr>
<tr>
<td><strong>Herbaceous Non-tidal WL</strong></td>
<td>HWNT</td>
<td>- Marsh: floodplain, upland</td>
<td></td>
<td>- Seasonally or perennially wet prairie</td>
<td>- Herbaceous Non-tidal WL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Submerged Marsh: floodplain</td>
<td></td>
<td>- Marsh/Wet Meadow, unknown</td>
<td>- Herbaceous Diked WL</td>
</tr>
<tr>
<td><strong>Shrub-Scrub Tidal WL</strong></td>
<td>SWT</td>
<td>- Shrub-Scrub Marsh: Tidal</td>
<td>- Willow Swamp: Tidal</td>
<td>- Willow Swamp</td>
<td>- Shrub/Scrub Tidal WL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Swamp: unknown</td>
<td></td>
</tr>
<tr>
<td><strong>Shrub Scrub Non-tidal WL</strong></td>
<td>SWNT</td>
<td>- Shrub Scrub Marsh: floodplain</td>
<td></td>
<td>- Wetland: unknown</td>
<td>- Shrub/Scrub Non-tidal WL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Shrub/Scrub Diked WL</td>
</tr>
<tr>
<td><strong>Forested Tidal WL</strong></td>
<td>FWT</td>
<td>- Wooded Marsh: Tidal</td>
<td>- Spruce Swamp: Tidal</td>
<td>- Sitka Spruce Swamp</td>
<td>- Coniferous Tidal WL Forest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Cottonwood Swamp: Tidal</td>
<td>- Deciduous Tidal WL Forest:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Ash Swamp</td>
<td></td>
</tr>
<tr>
<td><strong>Forested Non-tidal WL</strong></td>
<td>FWNT</td>
<td>- Wooded Marsh: Floodplain, Upland</td>
<td></td>
<td>- Black Cottonwood Riparian</td>
<td>- Coniferous Non-tidal WL Forest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Red Alder – Mixed Conifer Riparian</td>
<td>- Coniferous Diked WL Forest</td>
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<td></td>
<td></td>
<td></td>
<td>- Red Alder swamp</td>
<td>- Deciduous Non-tidal WL Forest</td>
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<td></td>
<td></td>
<td></td>
<td>- Mixed Riparian</td>
<td>- Deciduous Diked WL Forest</td>
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<td></td>
<td></td>
<td></td>
<td>- Riparian Sitka Spruce Forest</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>- Mixed Riparian</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>- Black Cottonwood Riparian</td>
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</tbody>
</table>
## Cover Class Crosswalk

<table>
<thead>
<tr>
<th>Normalized Class</th>
<th>Code</th>
<th>T-Sheet Classes (Burke)</th>
<th>T-Sheet Classes (Graves/Thomas)</th>
<th>GLO Classes (Christy)</th>
<th>2010 Classes (LCEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbaceous non-wetland</strong></td>
<td>H</td>
<td>- Grass: upland, floodplain</td>
<td></td>
<td>- Prairie, wet and dry undifferentiated - Upland and xeric prairie</td>
<td>- Herbaceous non-wetland</td>
</tr>
<tr>
<td><strong>Shrub-Scrub non-wetland</strong></td>
<td>S</td>
<td>- Shrubs: upland, floodplain</td>
<td></td>
<td>- Doug Fir (Savannah) - Rose or briar thickets - Brush fields or thickets on slopes and ridges - Brush, composition unknown - Brush fields or thickets on bottoms or wet terraces</td>
<td>- Shrub/Scrub non-wetland</td>
</tr>
<tr>
<td><strong>Forested non-wetland</strong></td>
<td>F</td>
<td>- Mixed Forest: upland, floodplain - Pine: upland, floodplain - Woodland: upland, floodplain</td>
<td></td>
<td>- Doug Fir - Doug Fir/White Oak - White Oak - Sitka Spruce - Doug Fir/White Oak (Woodland) - Doug Fir (Woodland)</td>
<td>- Coniferous Forest - Deciduous Forest</td>
</tr>
<tr>
<td><strong>Tidal Sand/Mud Flats</strong></td>
<td>TF</td>
<td>- Sand flat, tidal</td>
<td>- Tidal Flats, - Shallows</td>
<td></td>
<td>- Sand - Mud</td>
</tr>
<tr>
<td><strong>Agriculture</strong></td>
<td>AG</td>
<td>- Orchard: upland, floodplain - Cultivated: upland, floodplain</td>
<td></td>
<td></td>
<td>- Agriculture - Tree Farms</td>
</tr>
<tr>
<td>Normalized Class</td>
<td>Code</td>
<td>T-Sheet Classes (Burke)</td>
<td>T-Sheet Classes (Graves/Thomas)</td>
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</tr>
</tbody>
</table>
| **Developed**    | D    | - Dwellings: upland, floodplain  
|                  |      | - Road: upland, floodplain  
|                  |      | - Levee: upland, floodplain  
|                  |      | - Overwater Structure: floodplain  |                     |                   |
| **Water**        | W    | - Riverine/Estuarine: tidal  
|                  |      | - Open Water: upland, floodplain  
|                  |      | - Stream/river: upland, floodplain  | - Deep Water  
|                  |      | - Medium/Shallow Water  | - Water Bodies  
|                  |      |                              | - Seasonally Flooded Lake  |
| **Other**        | O    | - Barren: upland, floodplain  
|                  |      | - Sand: floodplain  
|                  |      | - Sand Flat: floodplain  
|                  |      | - Rocky bluff: upland  
|                  |      | - Eroded Bank: upland  |
| **Unclassified** | UNC  | - Unclassified  |                     |                   |                   |
Change Analysis Results

Historical Reconstruction: Distribution of Tidal Wetland Habitats

- **Wooded Tidal Wetland**
- **Herbaceous Tidal Wetland**
- **Tidal Flat**
- **Water**
- **Not Analyzed or Unclassified**
Change Analysis Results, cont’d

Current Landscape: Distribution of Tidal Wetland Habitats

- Wooded Tidal Wetland
- Herbaceous Tidal Wetland
- Tidal Flat
- Water
- Not Analyzed or Unclassified
Change Analysis Results, cont’d

Change in Tidal Wetlands, Reach A,B,C

- Yellow: Wooded TWL, unchanged
- Green: Herbaceous TWL, unchanged
- Orange: Changed TWL type
- Light green: Gained herbaceous TWL
- Dark green: Gained wooded TWL
- Light blue: Herbaceous TWL, lost
- Purple: Wooded TWL, lost
Change Analysis Results, cont’d

Change in Tidal Wetlands, Reach C,D,E
### Change Analysis Results, cont’d

<table>
<thead>
<tr>
<th>Historic:</th>
<th>Ag</th>
<th>D</th>
<th>F</th>
<th>H</th>
<th>HWNT</th>
<th>HWT</th>
<th>O</th>
<th>S</th>
<th>TF</th>
<th>UNC</th>
<th>W</th>
<th>WWNT</th>
<th>WWT</th>
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<th>percent loss</th>
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<td>(497)</td>
<td>(360)</td>
<td>(46)</td>
<td>(45)</td>
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<td>(6)</td>
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<td>(110)</td>
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<tr>
<td>% overall cover present (excluding Water):</td>
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<td>26</td>
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Change Analysis Results, cont’d

Legend (Highlighting Key Loss Scenarios For Reach)
- Other Change Scenario
- Forested to Ag
- Forested to Developed
- Forested to Forested WL, NT
- Forested WL to Ag
- Herb to Ag
- Herb WL T to Ag
- SS to Ag
- Present Day Water
- Unclassified Historical
- Reach E, Not Analyzed

Comparison of Historic vs. Present Acreages for Land Cover Types

Land Cover Change Matrix

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<th>FROM LANDSCAPE</th>
<th>ag</th>
<th>dev</th>
<th>forest</th>
<th>forest WL</th>
<th>NT</th>
<th>Tidal WL</th>
<th>Tidal NT</th>
<th>other</th>
<th>shrub, WL, NT</th>
<th>shrub, T</th>
<th>wet</th>
<th>pro</th>
<th>wa</th>
<th>water</th>
<th>woody/wetland</th>
<th>Historical Acres</th>
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<td>3751</td>
<td>66%</td>
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Total Acres in Reach (Water + Floodplain): 38,015
Total Acres Covered by Analysis: 25,121 (66% of Total)

Historical Land Cover Change, 1880s to 2010: Lower Columbia River, Reach E
Application

Priority Habitats By Hydrogeomorphic Reach (as identified by LCEP Science Work Group)

Rules:

- Identify habitats which historically comprised >10% of total cover for the Reach
  - Include habitats which suffered >25% loss
    - Prioritize by severity of loss

- Include ‘rare’ habitats (those which historically comprised <10% cover within the Reach)
<table>
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<tr>
<th>Reach</th>
<th>Priority Habitats</th>
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<td>A</td>
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</tr>
<tr>
<td>B</td>
<td>wooded tidal WL</td>
</tr>
<tr>
<td>C</td>
<td>wooded tidal WL</td>
</tr>
<tr>
<td>D</td>
<td>herbaceous tidal WL</td>
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<td>E</td>
<td>herbaceous</td>
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<td>G</td>
<td>forested</td>
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<tr>
<td>H</td>
<td>wooded WL</td>
</tr>
</tbody>
</table>
Next Steps

Determine Target acreages for recovery/protection by Reach
  - Identify ‘recoverable’ habitat types
    Consider: habitat type, effects of climate change, etc.
  - Distribution based on public/private ownership

Role of Habitat Change Within Landscape Planning Framework
  - Include as additional statistic for site analysis
  - Other ideas??
Acknowledgements

Jennifer Burke – Digitization and explanation of historical T-Sheet Data

John Christy – Digitization of historical GLO data

Amy Borde, Heida Diefenderfer, Nikki Sather (PNNL) : cover class crosswalk

LCEP Science Work Group (Bernadette Graham Hudson, Jim Brick, Cindy Studebaker, Dan Roix, Tom Murtagh, Cathy Roberts) : Process Review