Landscape Planning Framework for Restoration and Protection of Juvenile Salmon Habitat using the Columbia River Estuary Ecosystem Classification

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NCER
5th National Conference on Ecosystem Restoration
The Spirit of Cooperation

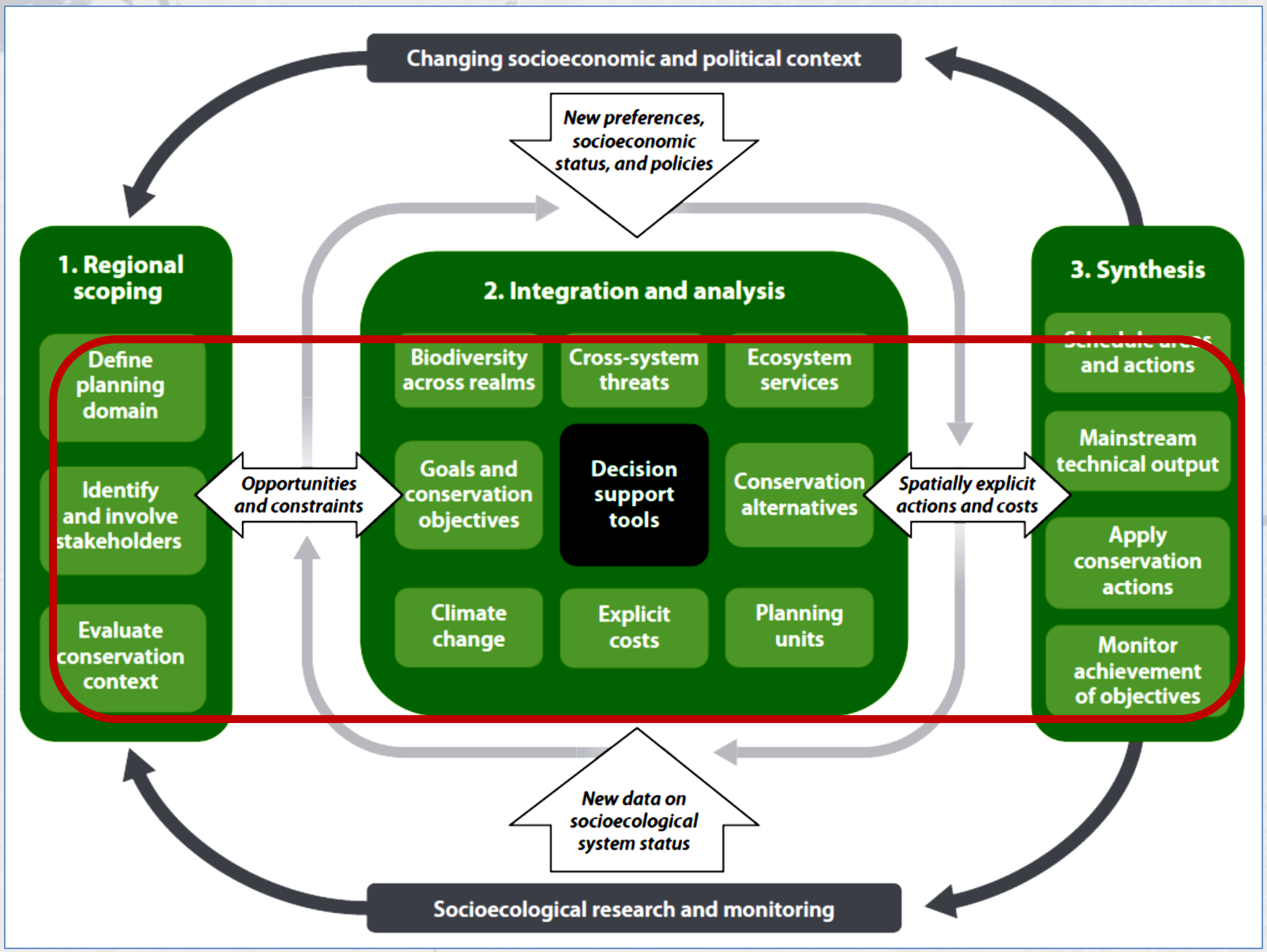
Spatial Planning for Conservation

Contemporary conservation planning draws on seven sets of ideas (below) intended to safeguard the persistence of biodiversity in a conservation area network. **Planning for persistence requires, at the very least, incorporation of rules of spatial configuration that take these ideas into account**.

1. Biogeographical theory
2. Metapopulation dynamics
3. Successional pathways
4. Spatial autoecological requirements
5. Source-sink population structures
6. Effects of habitat modification
7. Species as evolutionary units

Sarkar *et al.* 2006. Biodiversity Conservation Planning Tools: Present Status and Challenges for the Future. *Annu. Rev. Environ. Resour.* **31**:123-159.

Decision Support Tools for Spatial Planning Restoration/Conservation



Álvarex-Romero *et al.* 2011. Integrated Land-Sea Conservation Planning: The Missing Links. *Annu. Rev. Ecol. Evol. Syst.* **42**:381-409.

Viable Salmon Populations (VSP)

VSP principles are the foundation of ESA planning of Pacific salmon recovery (McElhany *et al.* 2000), encapsulating the importance of evolutionary processes:

1. Abundance (A)
2. Growth rate/productivity (P)
3. **Spatial structure (SS)**
4. Diversity (D)

Although seldom considered, the spatial structure of estuarine rearing habitats used by different juvenile salmon Evolutionarily Significant Units (ESU) and life histories during seaward migration should be an equally important conservation focus.

McElhany *et al.* 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Tech. Memo NMFS-NWFSC-42.

Problem Statement

- Many restoration initiatives do not necessarily need to be spatially specific; however, when addressing critical habitat of endangered migratory species, our approaches need to more strategic than merely *ad hoc*, random acts of opportunistic restoration
- Particularly for anadromous salmon, with their diverse life histories that contribute to population resilience
- Columbia River salmon even more challenging, with 13 endangered ESU (5 Chinook ESU of particular issue for habitat restoration in estuary)
- Good general evidence for benefit of estuarine restoration to salmon, but need to be more attentive to different estuarine rearing habitat requirements over space and time by different genetic stocks

Objectives and Approach of Landscape Planning Framework

- Supported by Columbia River "action agencies" BPA and USACE in ESA salmon recovery in the Basin
- Develop scientific guidance to support proactive identification of estuarine habitat restoration and protection needs of different genetic and life histories of Columbia River Chinook salmon
- Advance a spatially-explicit understanding of juvenile Chinook salmon habitat requirements based on variation in dynamic ecosystem processes along estuary continuum
- Use Columbia River Estuary Ecosystem Classification ("*Classification*") as background for Juvenile Salmon Estuarine Habitat Landscape Planning Framework (Landscape Planning Framework; LPF)

Columbia River Estuary Ecosystem Classification

- Hierarchical space/time structure
- Initial concept document (USGS OFR 2011-1228)
- geodatabase completed July 2013
- summary report and “users guide” (USGS PP) anticipated December 2013-January 2014

1—*Ecosystem Province*

2—*Ecoregion*

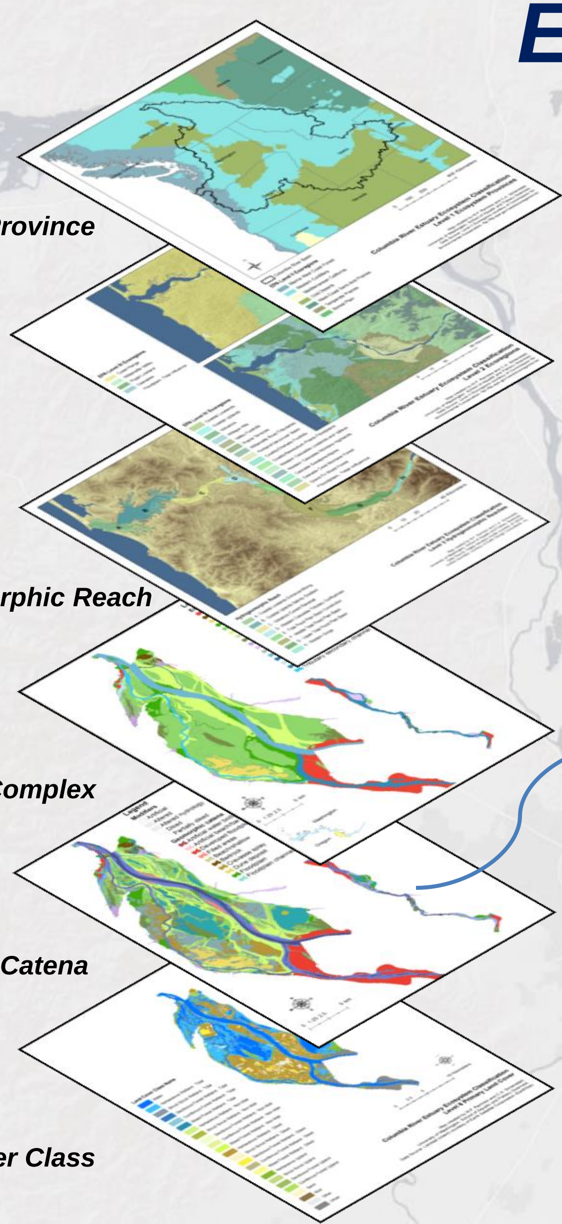
3—*Hydrogeomorphic Reach*

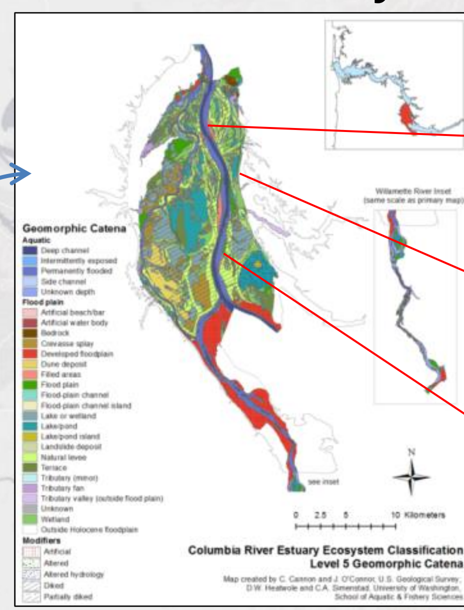
4—*Ecosystem Complex*

5—*Geomorphic Catena*

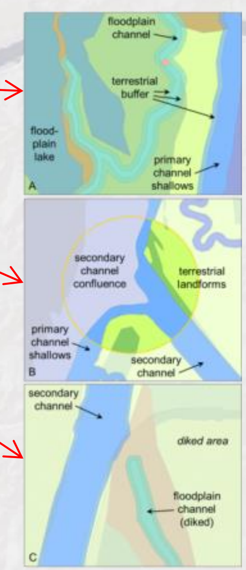
Subcatena = “ecosystems”

6—*Primary Cover Class*

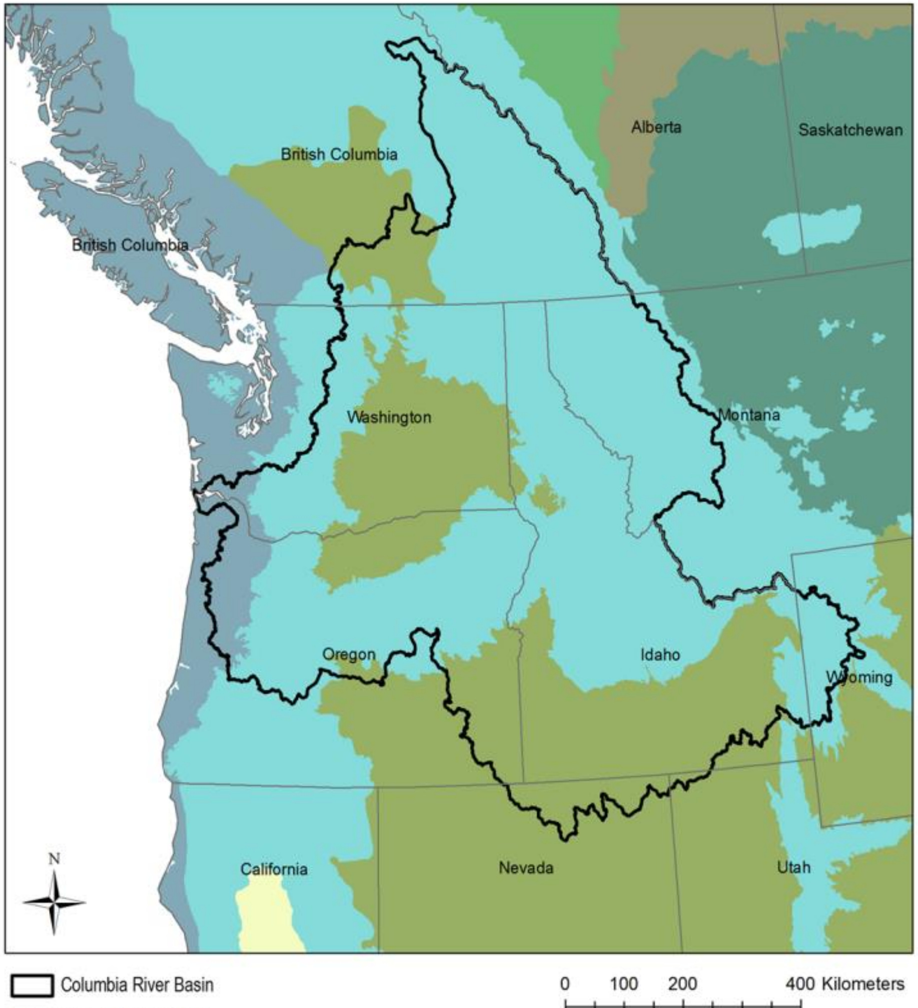




Fish Habitat Catena



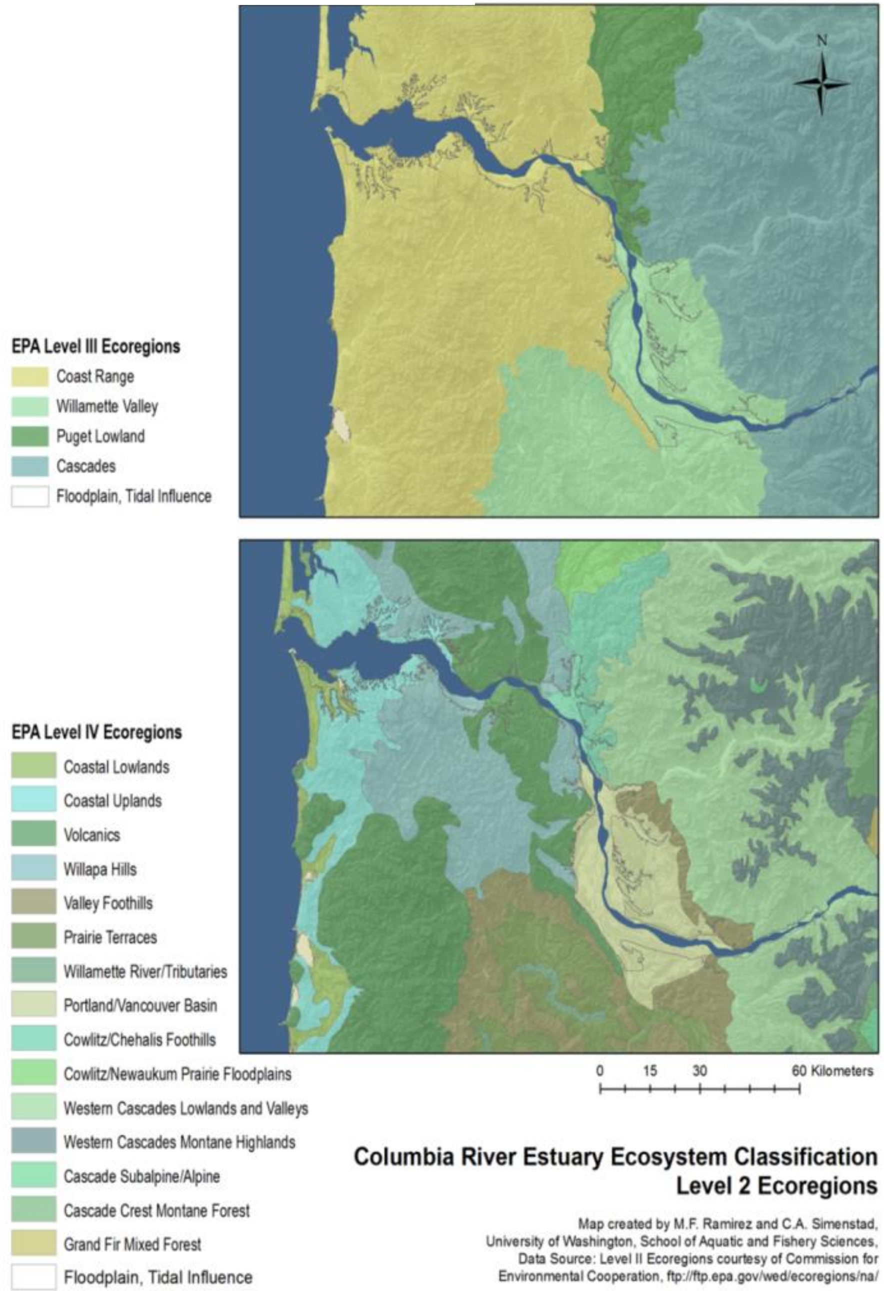
Level 1 — *Ecosystem Province*



Columbia River Estuary Ecosystem Classification
Level 1 Ecosystem Provinces

Map created by M.F. Ramirez and C.A. Simenstad, University of Washington, School of Aquatic and Fishery Sciences, Data Source: Level II Ecoregions courtesy of Commission for Environmental Cooperation, ftp://ftp.epa.gov/wed/ecoregions/na/

Level 2 — *Ecoregions*



Columbia River Estuary Ecosystem Classification
Level 2 Ecoregions

Map created by M.F. Ramirez and C.A. Simenstad, University of Washington, School of Aquatic and Fishery Sciences, Data Source: Level II Ecoregions courtesy of Commission for Environmental Cooperation, ftp://ftp.epa.gov/wed/ecoregions/na/

Development of fish habitat catena (FHC)

- Based on combinations of *Classification* classes that distinguish variability in juvenile salmon estuarine habitat
- Juvenile, ocean-type Chinook salmon habitat requirements
  - Direct FHC
  - Indirect FHC
  - Supporting drainage
- Guiding principles for restoration and conservation

Juvenile Salmon Habitat Factors

❑ Habitat Selection

- Direct opportunity (access)
  - depth
  - temperature
  - velocity
  - salinity
  - turbidity
- Indirect attractants/deterrents
  - prey availability
  - perceived predation threat

❑ Habitat Capacity

- Direct support
- Indirect factors
  - water quality (e.g., dissolved oxygen)
  - competitors
  - predators
  - food web processes

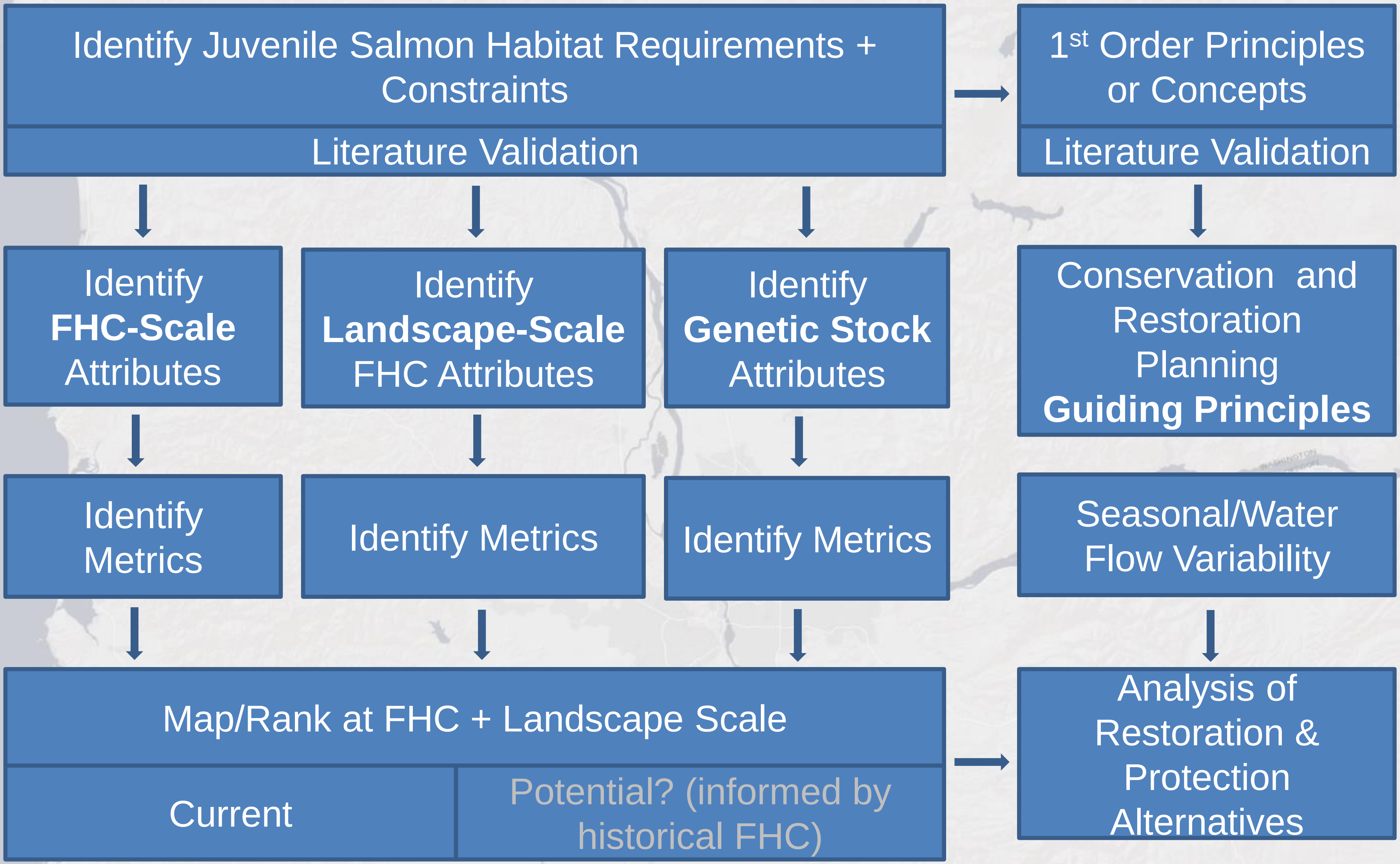
❑ Factors

- fish size
- seasonality
- genetic stock

❑ Fish Habitat Catena (FHC)

- categorize (based on *Classification* catena and subcatena classes)
- characterize “habitat quality”
- map distribution
- Identify variability in use by unique genetic stocks

Process and Scales of Analyses



Fish Habitat Catena

Fish Habitat Catena (FHC) integrate three+ levels of the Classification that capture multiple scales and categories of ecosystem structure and processes:

(1) eight ***hydrogeomorphic reaches*** embody formative geologic and tectonic processes that created the existing estuarine landscape and capture the influence of the resulting physiography on interactions between fluvial and tidal hydrology and geomorphology across 230 km of the estuary;

(2) 21 ***ecosystem complexes*** comprise broad landforms created predominantly by geologic processes during the Holocene; and,

(3) 36 ***geomorphic catenae*** (and 40 ***subcatenae***) that represent distinct geomorphic landforms, structures, and ecosystems most likely to change over short time periods

Level 3 —
Hydrogeomorphic Reach

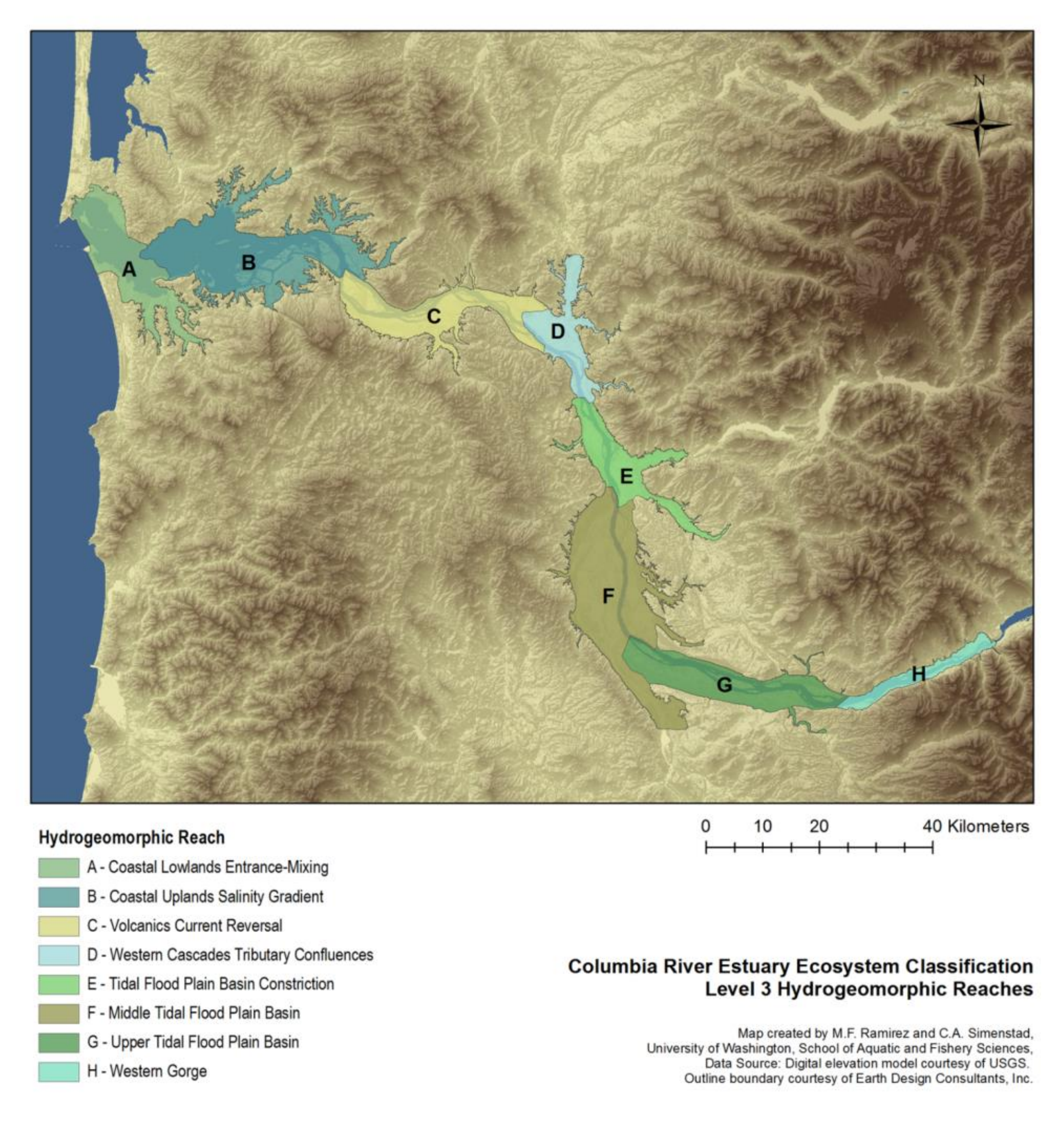
Division or adjustment to the up- or downstream boundaries of the EPA Level IV Ecoregions based on spatial data indicating marked transitions in large-scale hydrogeomorphic and tidal-fluvial forcing, including:

(a) maximum (historic) salinity intrusion;

(b) transitions in maximum flood (pre-regulation) tide level;

(c) the upstream extent of current reversal; and

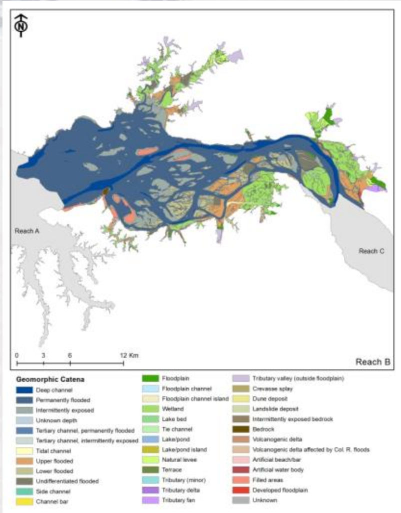
(d) convergences with major tributaries and slough systems.

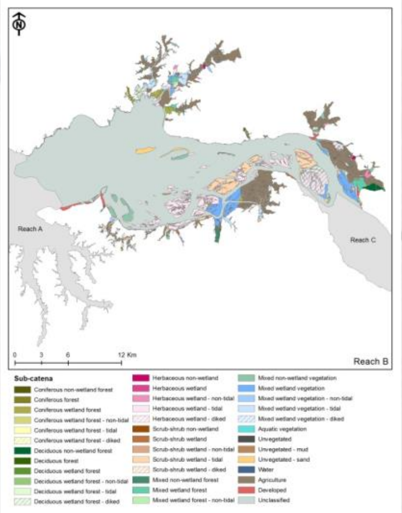


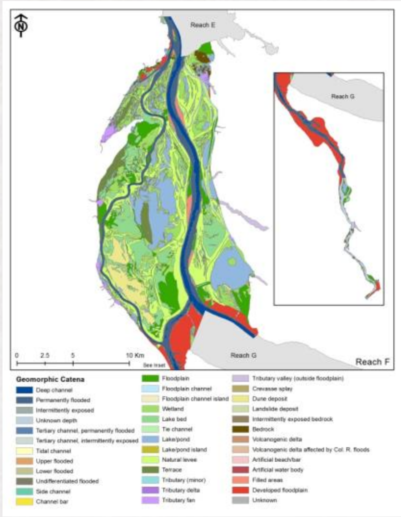
Merging *Classification* Geomorphic Catena and Subcatena to FHC

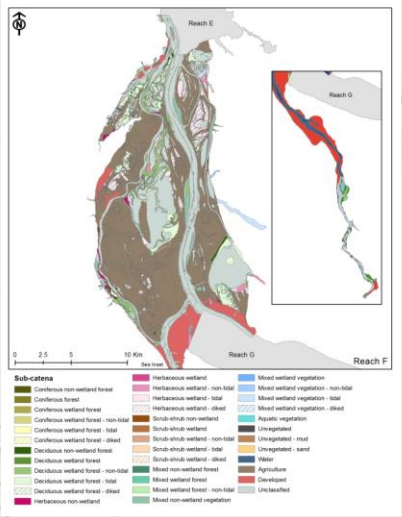
Catena

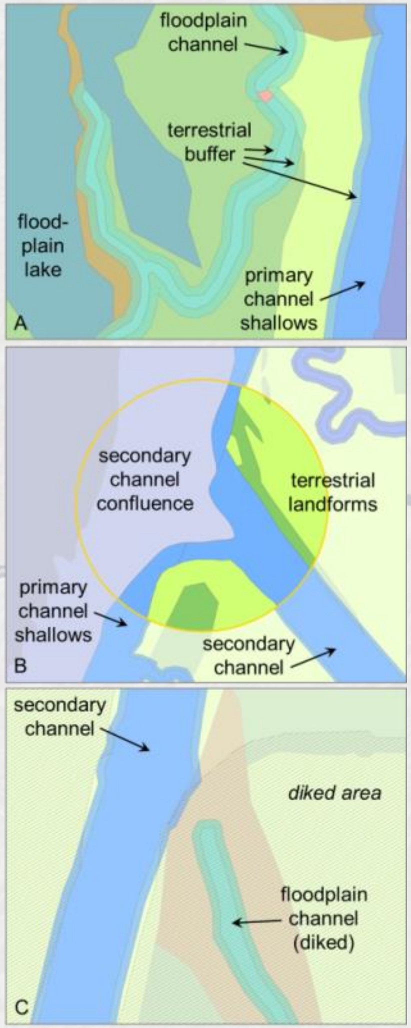
Subcatena



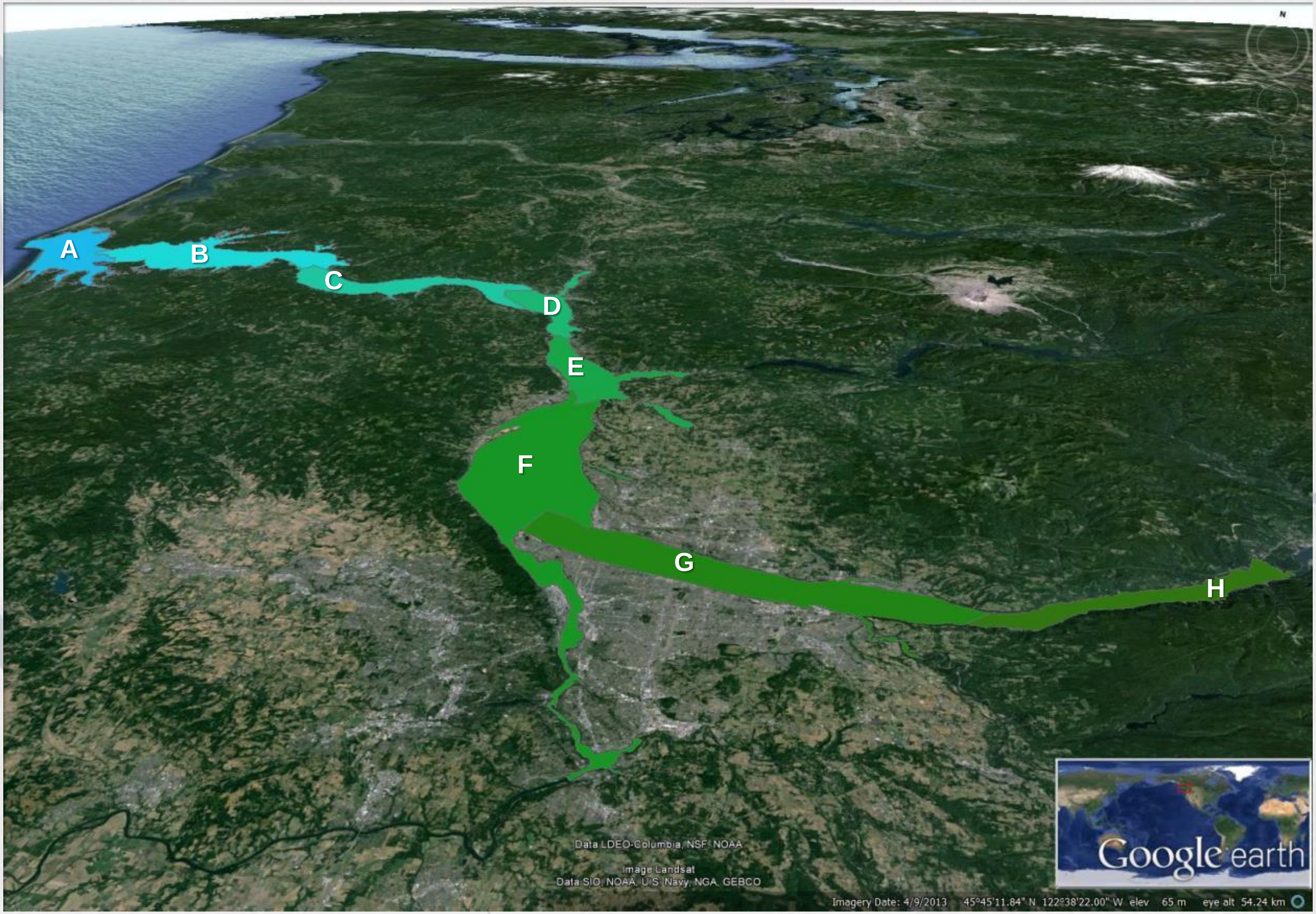




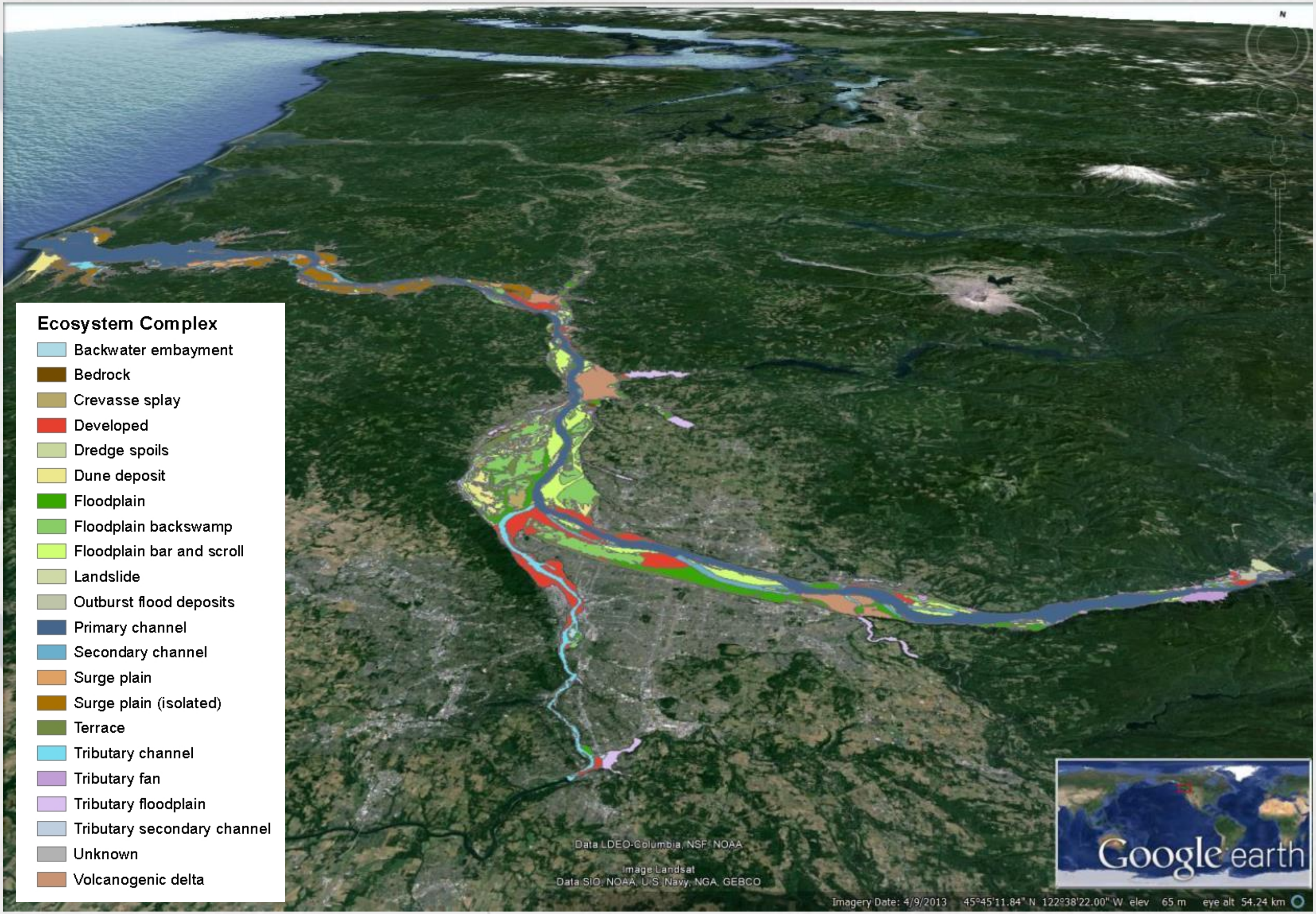




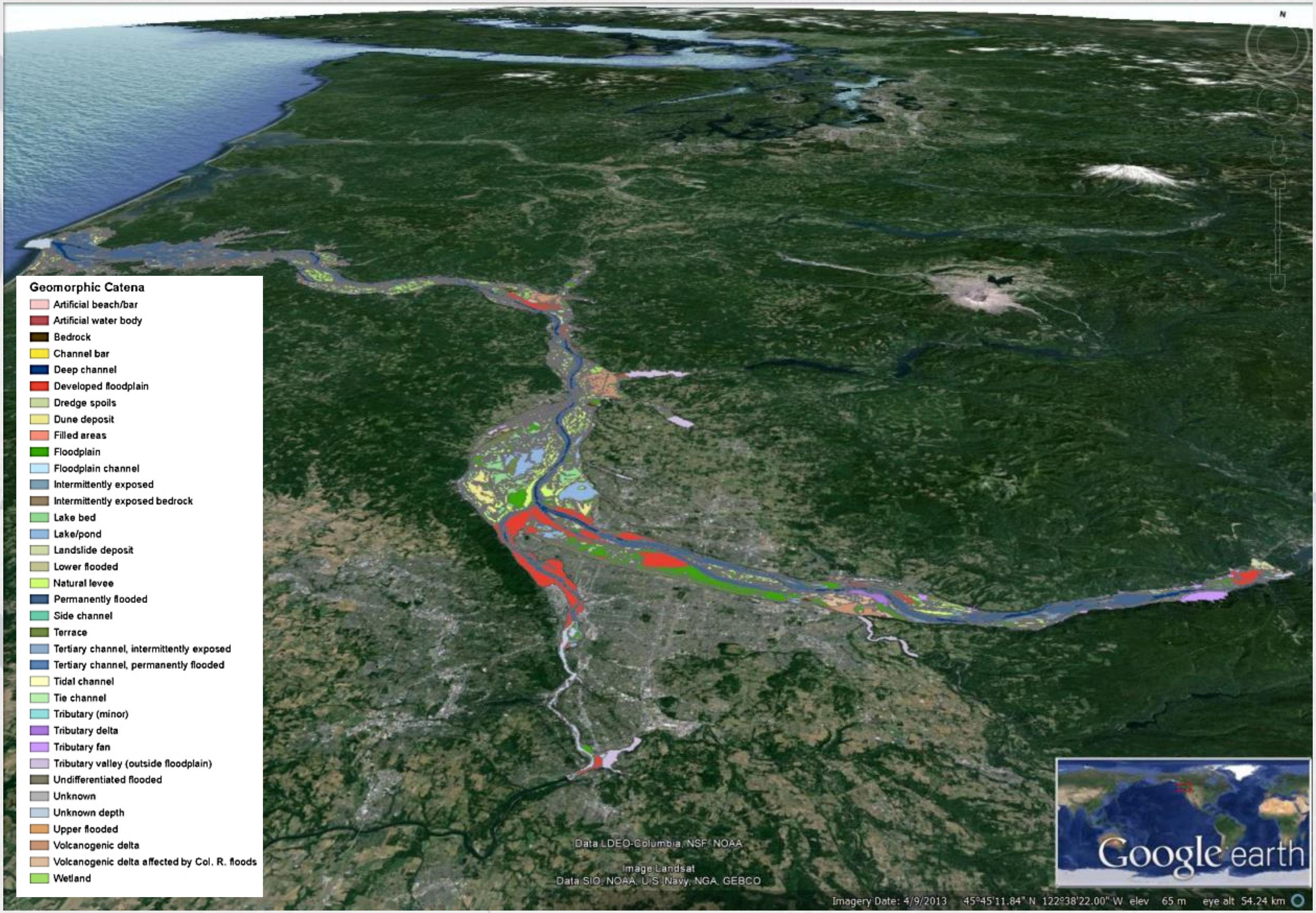
Level 3-Hydrogeomorphic Reach



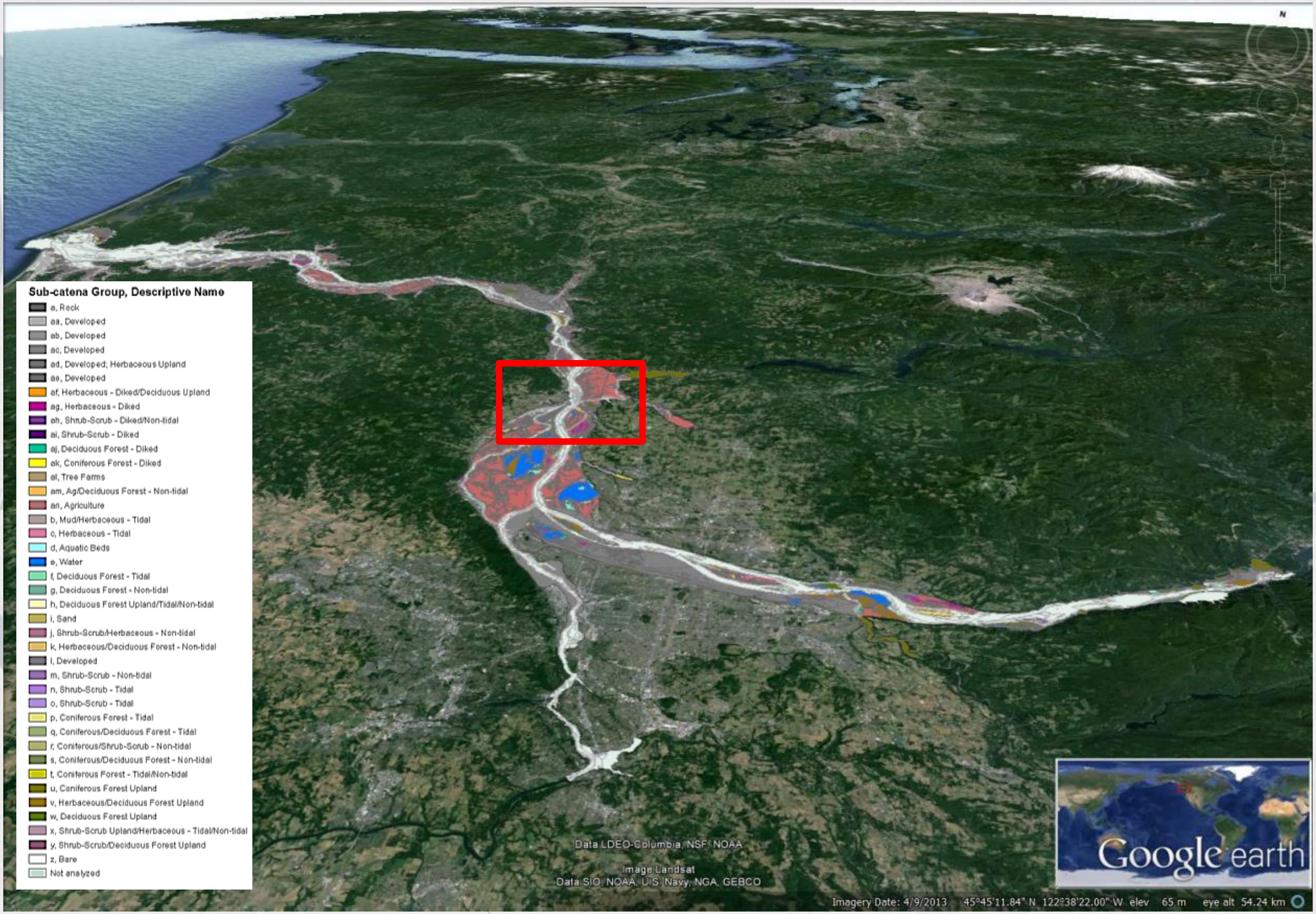
Level 4-Ecosystem Complex



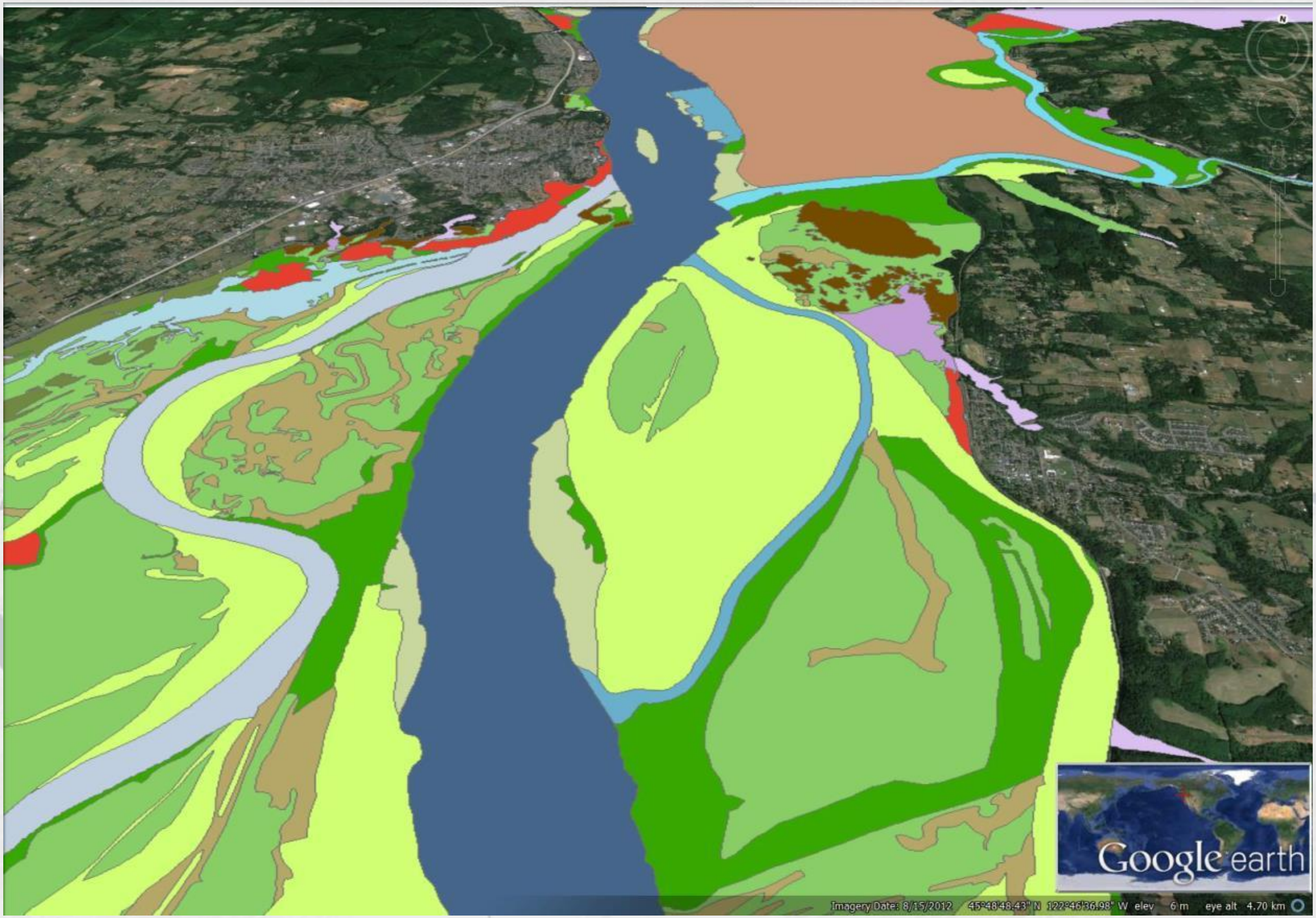
Level 5-Geomorphic Catena



Level 5+ Subcatena

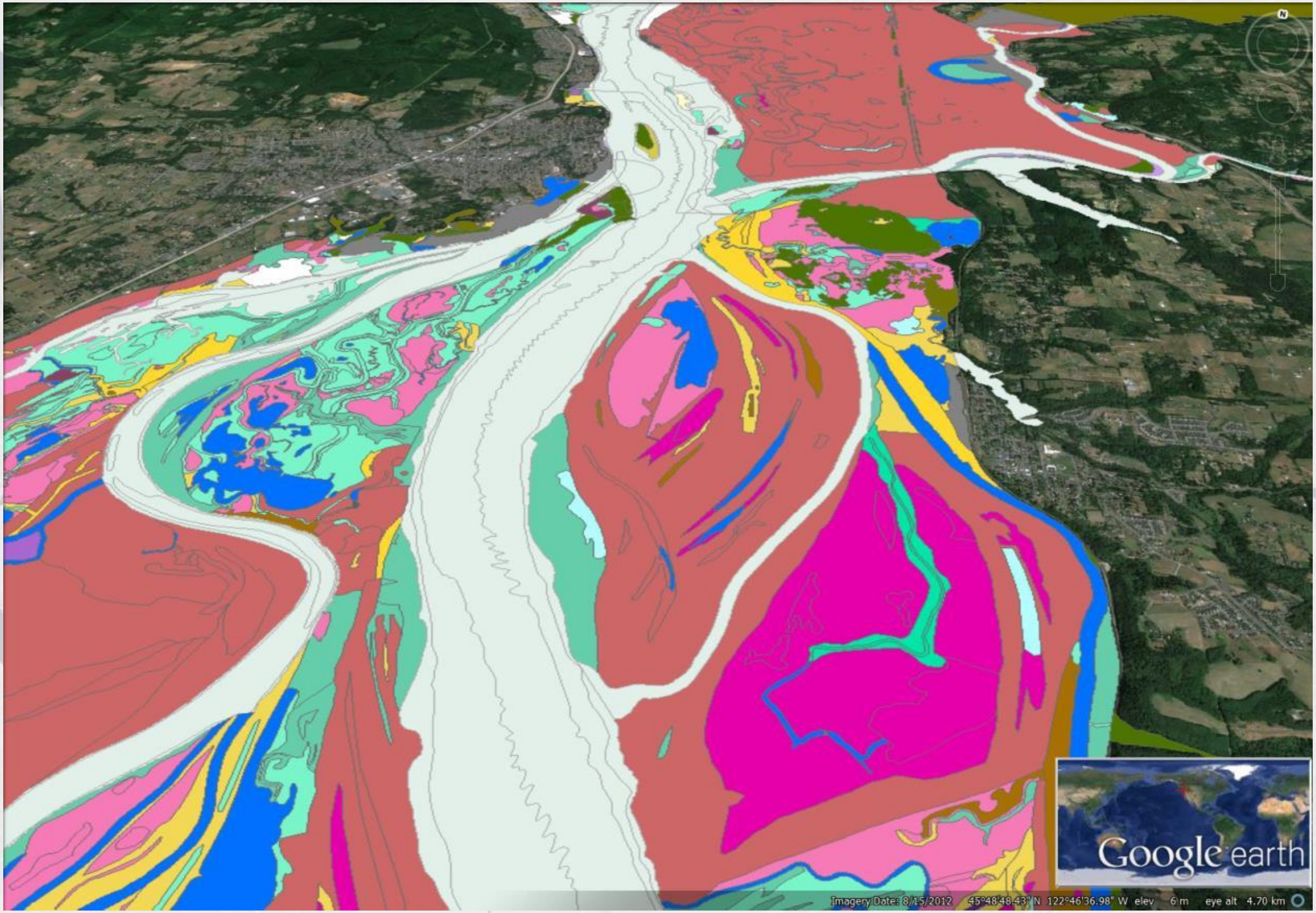


Level 4-Ecosystem Complex

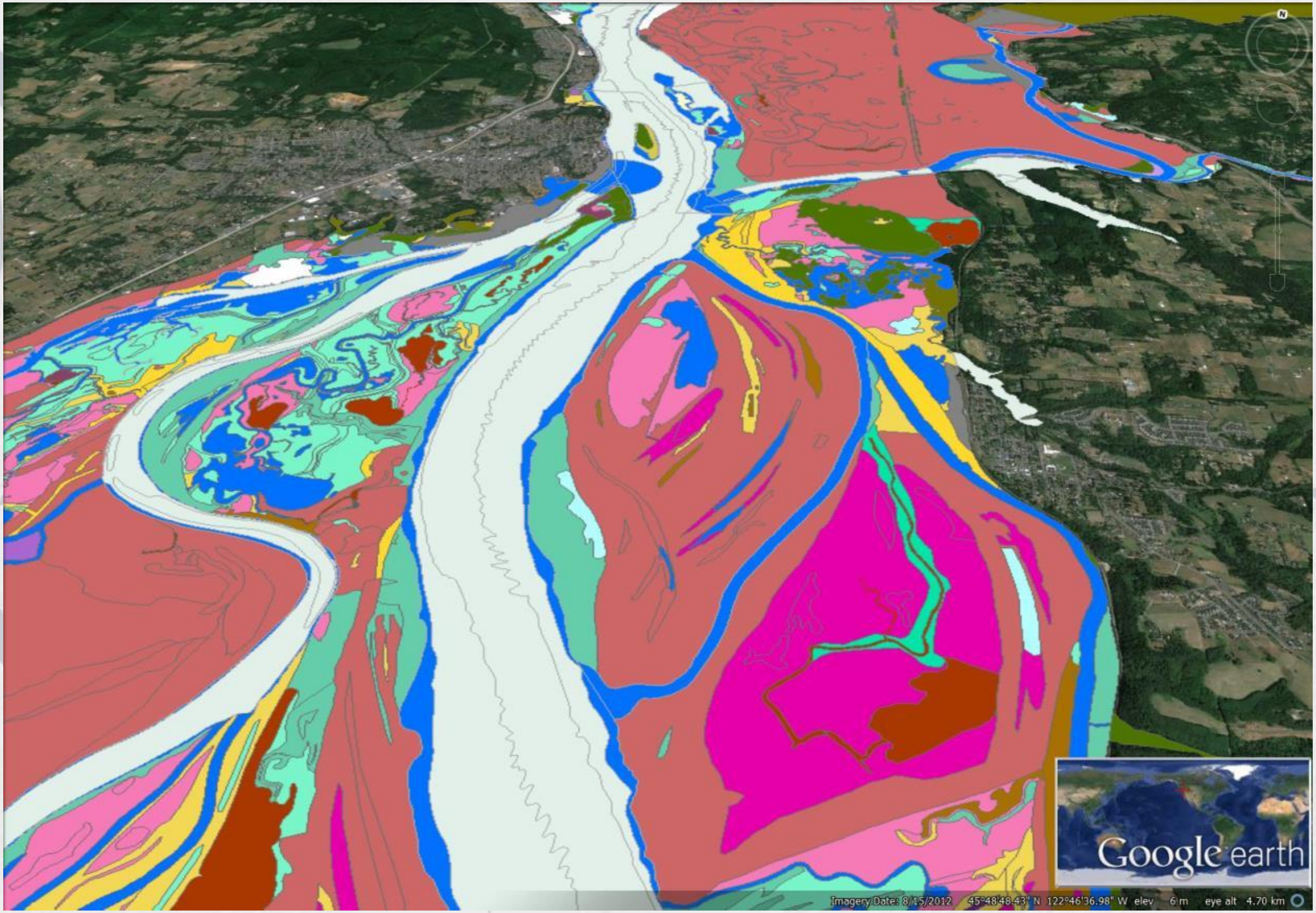


Level 5-Geomorphic Catena

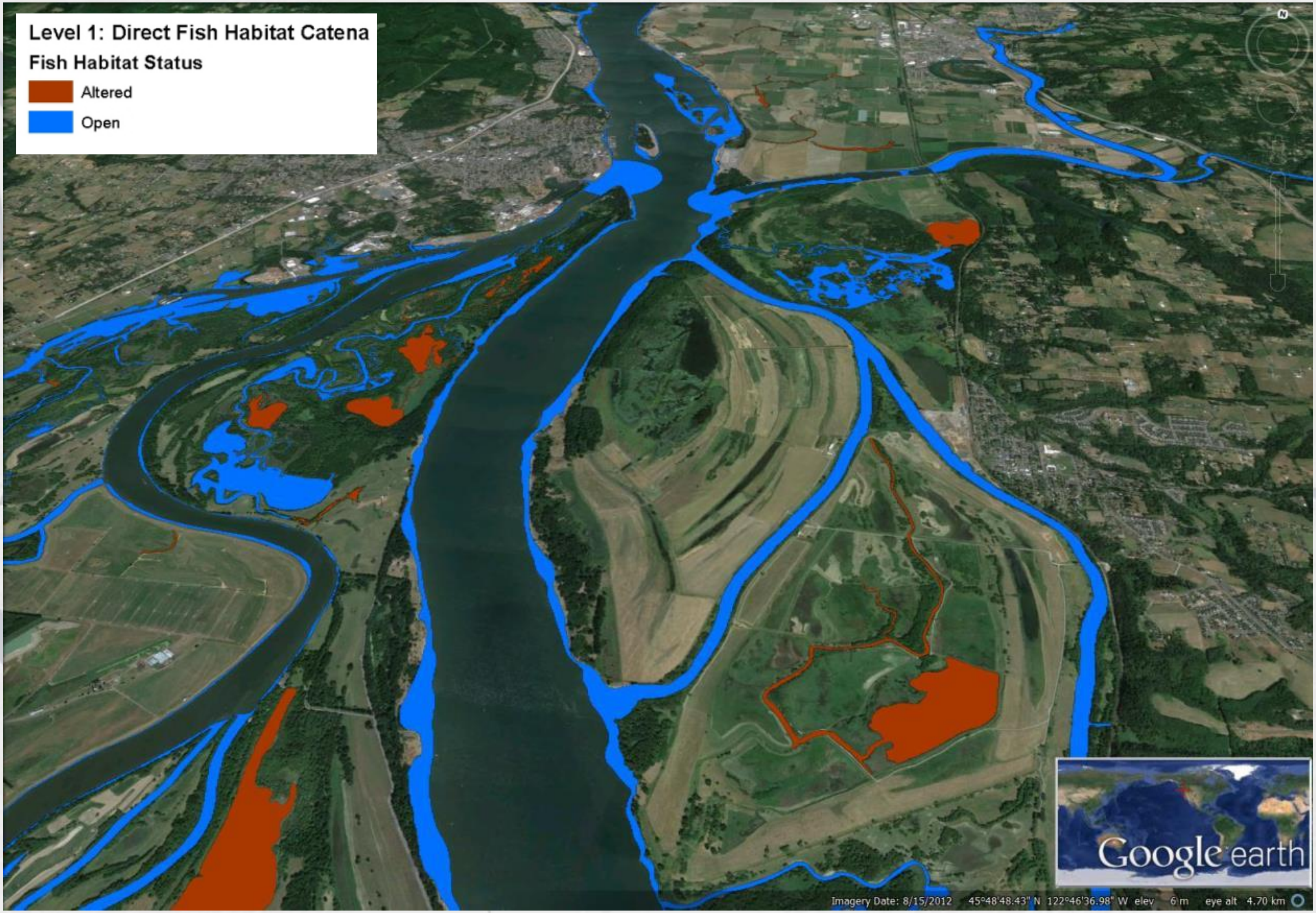
Level 5+ Subcatena



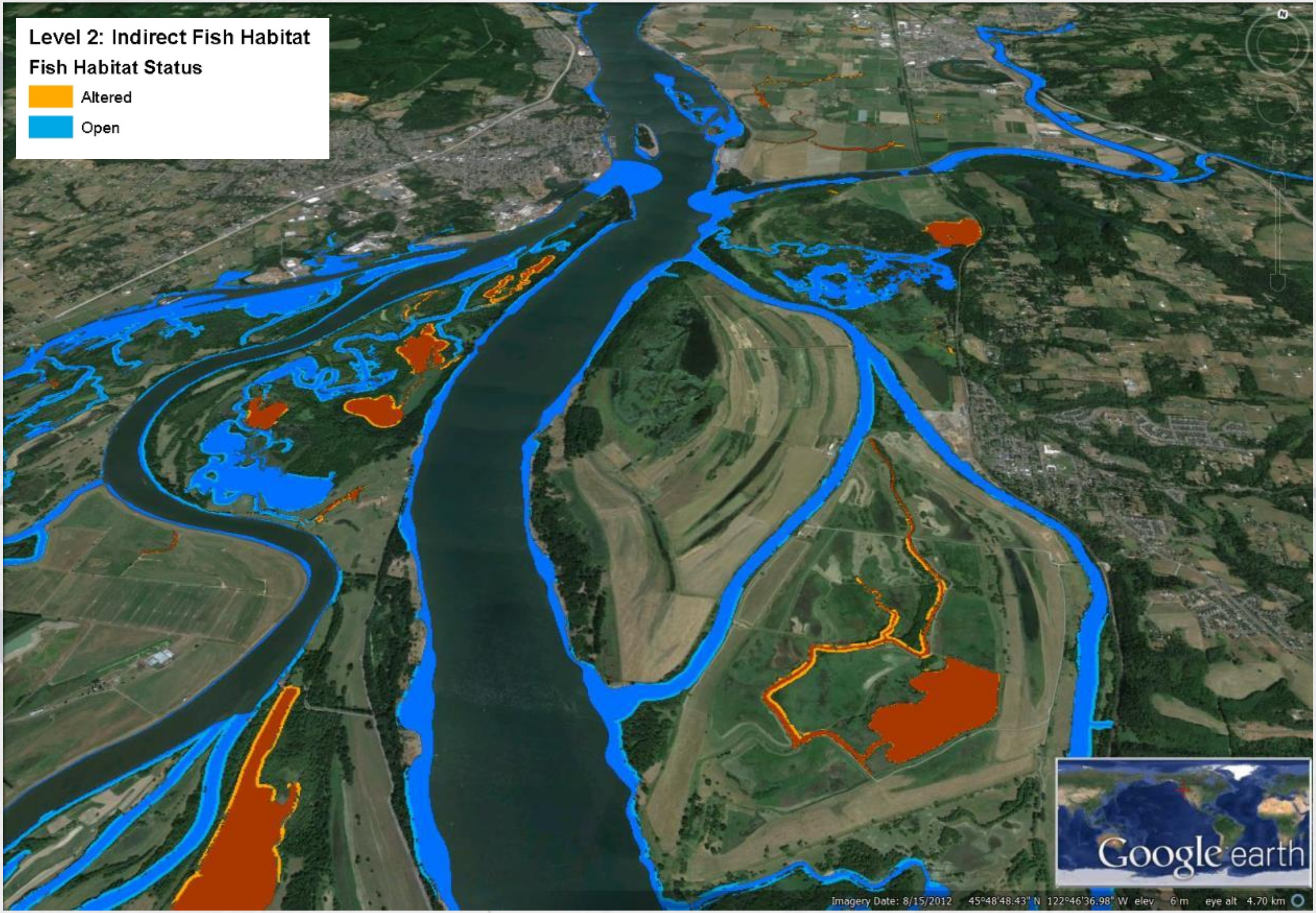
Subcatena + Direct FHC



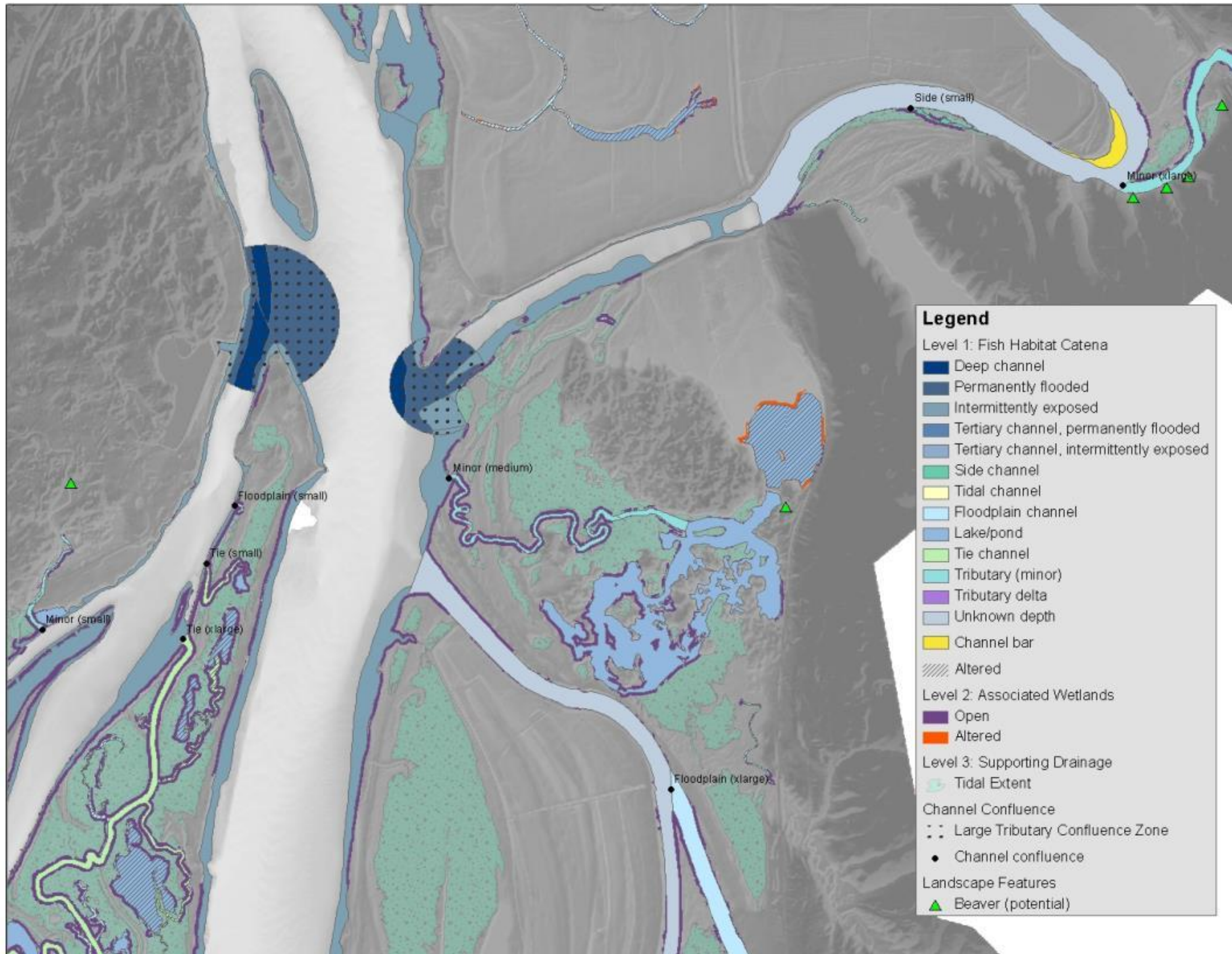
Direct FHC (Available, Altered)



Direct + Indirect FHC



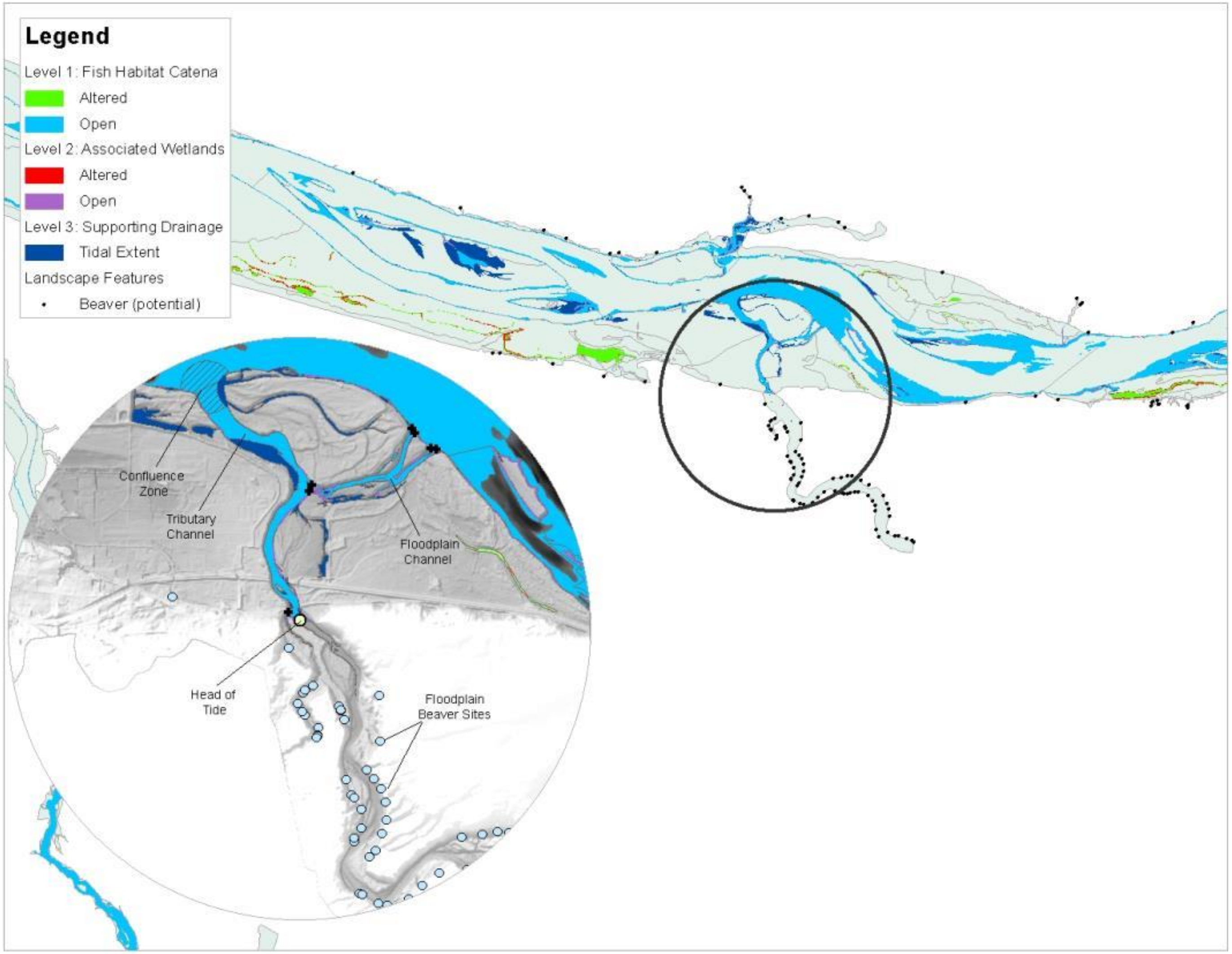
Examples of Fish Habitat Catena in the Columbia River Estuary



Variability in Fish Habitat Catena in the Columbia River Estuary

Examples of Fish Habitat Catenae:

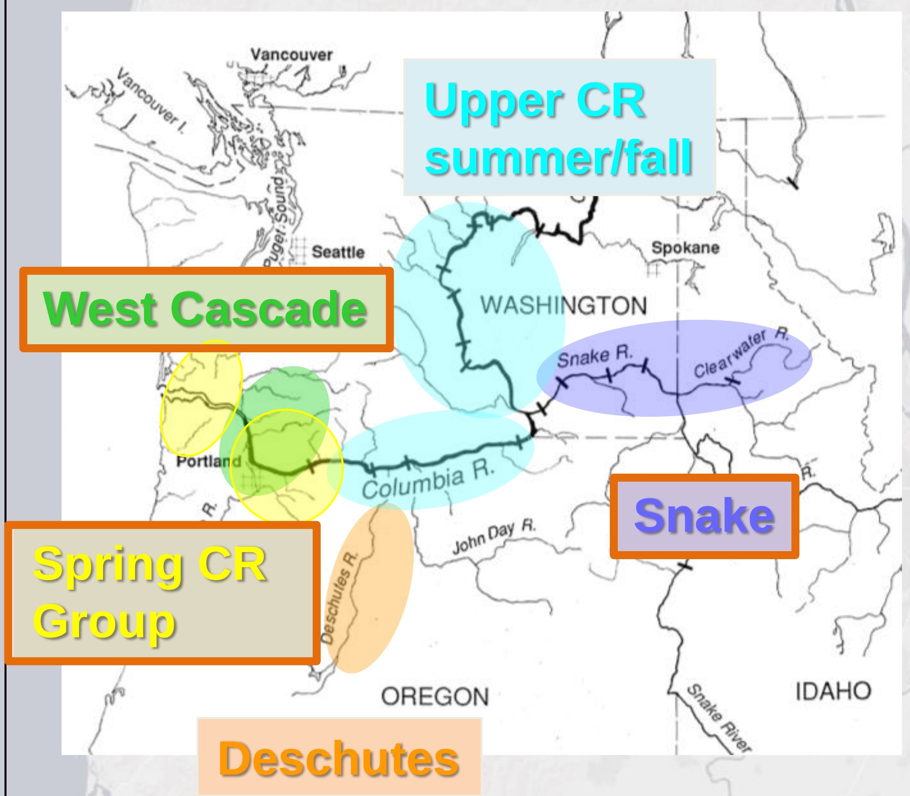
1. Tributary sub-estuary, Reach B
2. Mainstem island, Reach C
3. Tributary delta, Reach G



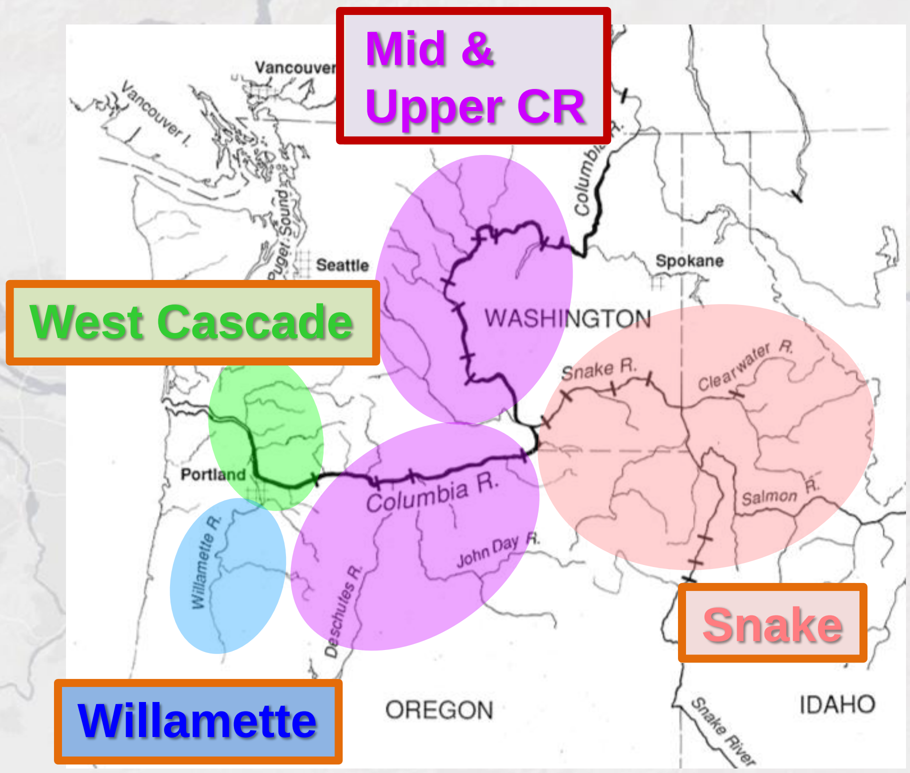
Why Does Genetic Stock Matter?

genetic stock groups resolved with Genetic Analysis of Pacific Salmon (GAPS) microsatellite loci

Fall Run

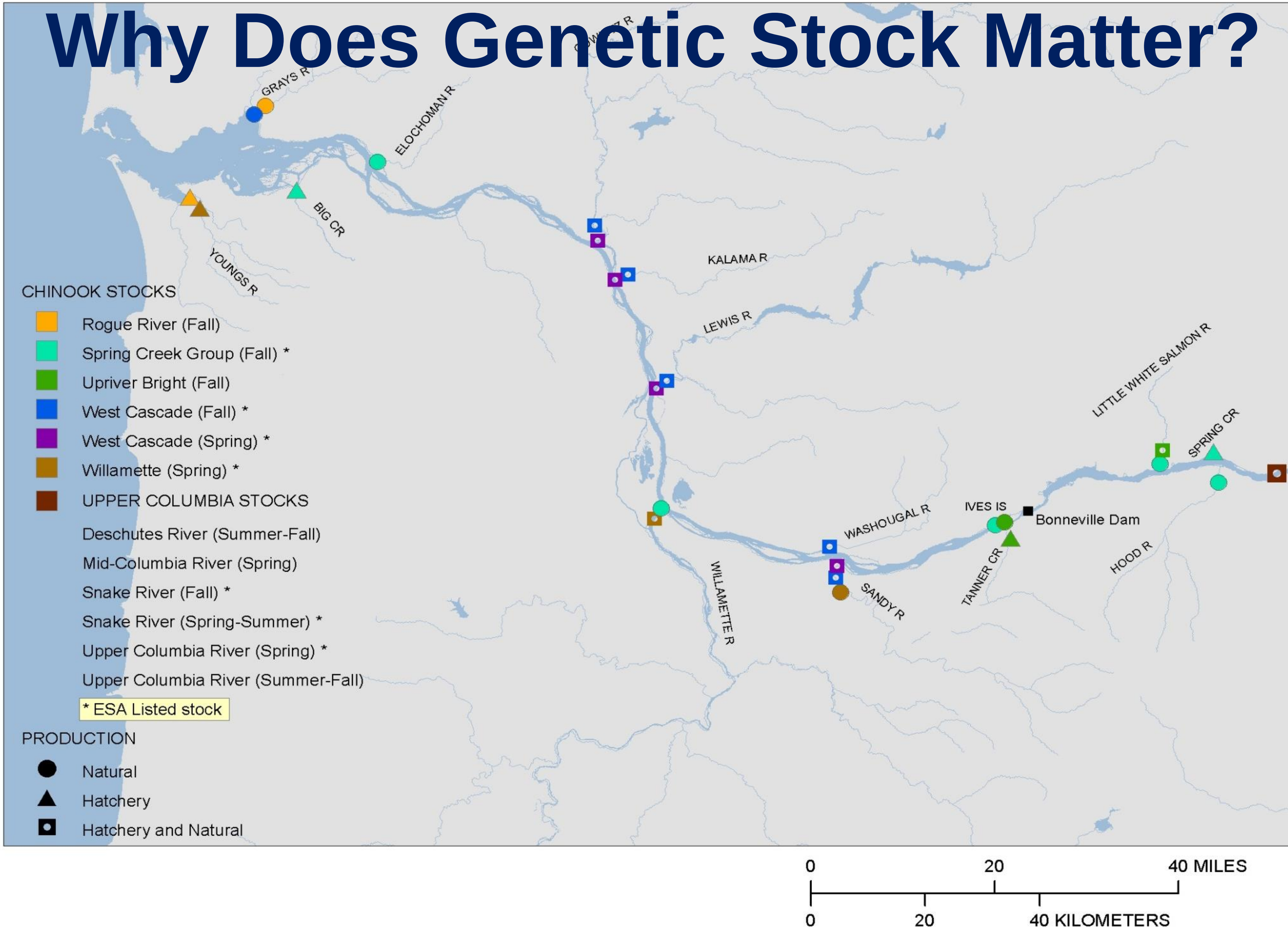


Spring Run



Source: D. Teel; NOAA-NWFSC

Why Does Genetic Stock Matter?



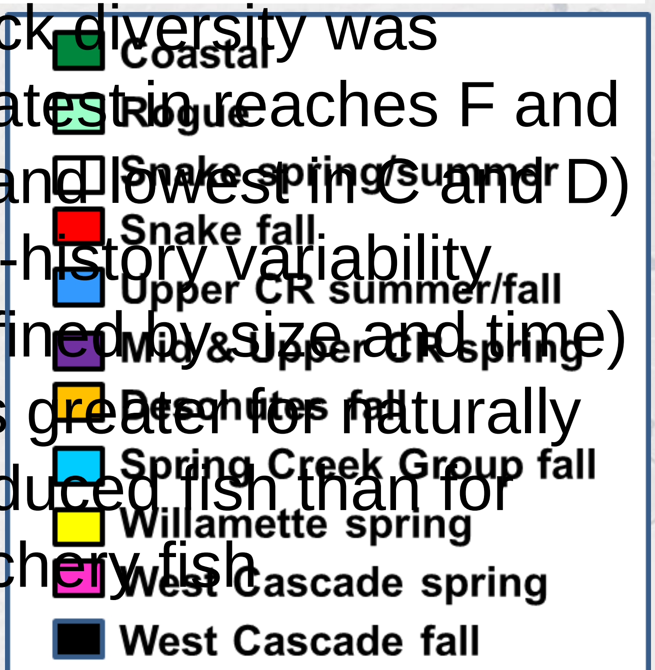
Source: D. Teel; NOAA-NWFSC

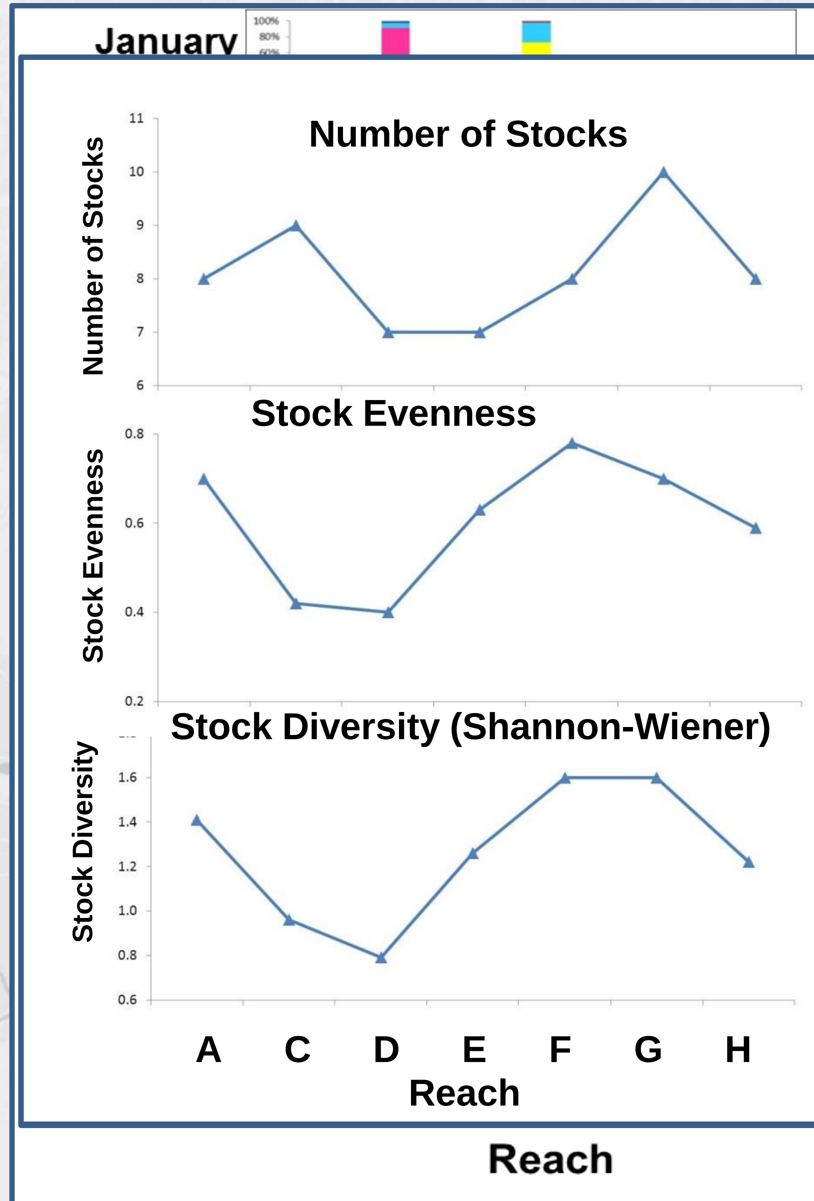
Why Does Genetic Stock Matter?

- 11 genetically distinct stocks of Chinook reared in shallow water habitats
- Stock composition varied seasonally and by life-history type in all reaches

- Stock proportions differed among reaches: overall and also within temporally and for each life-history type

- Stock diversity was greatest in reaches F and G (and lowest in C and D)
- Life-history variability (defined by size and time) was greater for naturally produced fish than for hatchery fish





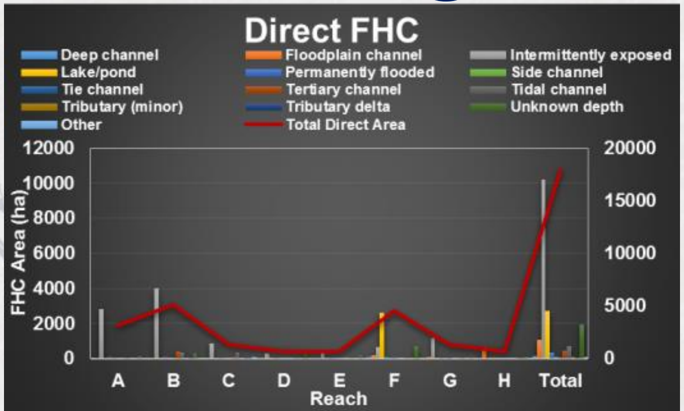
Source: D. Teel; NOAA-NWFSC

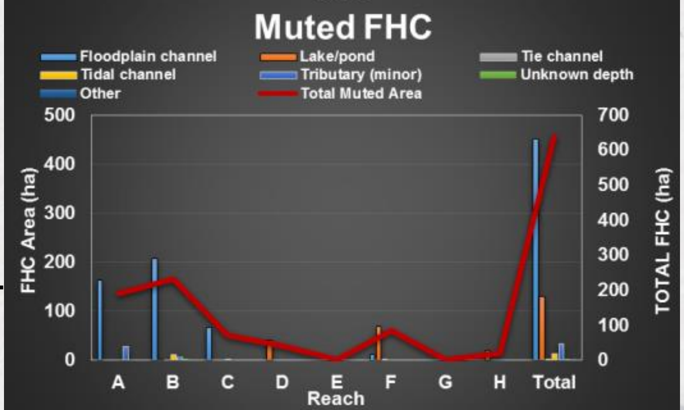
Quantifying Fish Habitat Catena at Multiple Scales

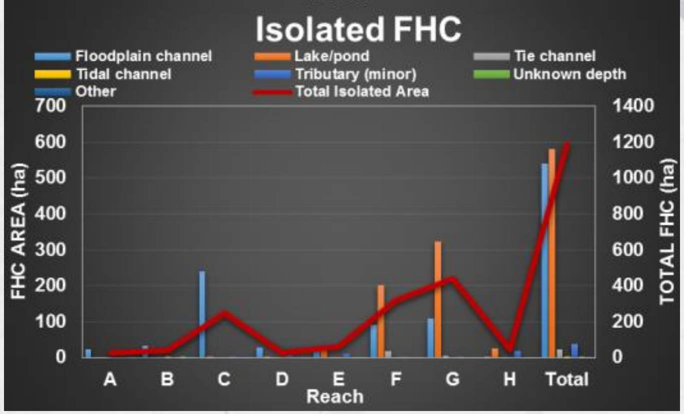
- Apply landscape metrics as quantitative measures of spatial structure or arrangement of FHC at all appropriate scales: landscape-, reach-, ecosystem complex- or local-scale
- Select metrics to characterize habitat “quality”
  - Select metrics for FHC according to guiding principles
  - Analyze fish habitat metrics (using FRAGSTATS)
- Landscape Distribution and Arrangement
  - Analyze FHC metrics at landscape scale
  - What constitutes the available fish habitat ‘continuum’?
  - What constitutes potentially restorable muted/isolated FHC?
  - How can restoration and preservation be complementary?
- Reach-, Ecosystem Complex- and Local Scale
  - Prioritization, design, monitoring

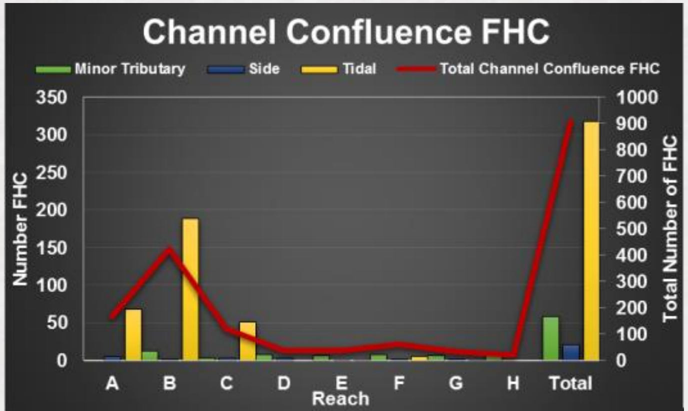
Spatial Planning FHC Baseline

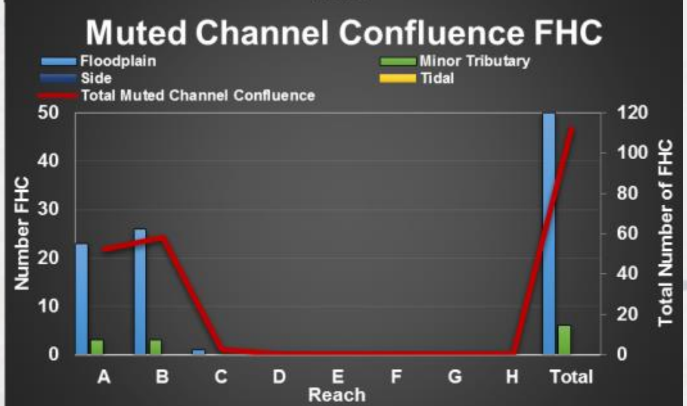
- <u>Direct:</u> channel margin (intermittently exposed) and lake/pond; B & F
- <u>Muted and isolated:</u> floodplain channel and lake/pond; A-B & F or C, F-G
- <u>Direct confluences:</u> tidal channel; A-C
- <u>Muted confluences:</u> few above reaches A-B
- much fewer potential beaver FHC above reaches A-C

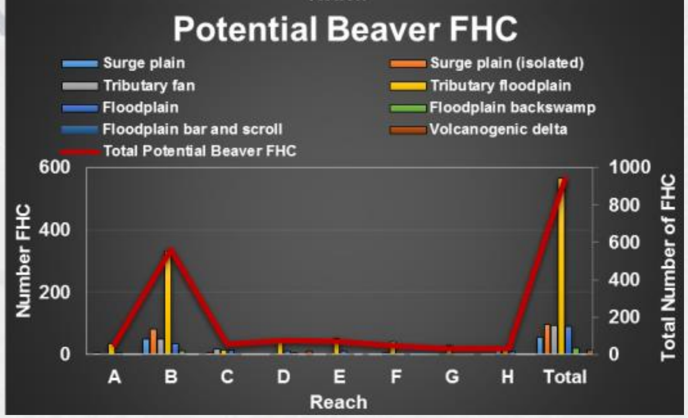






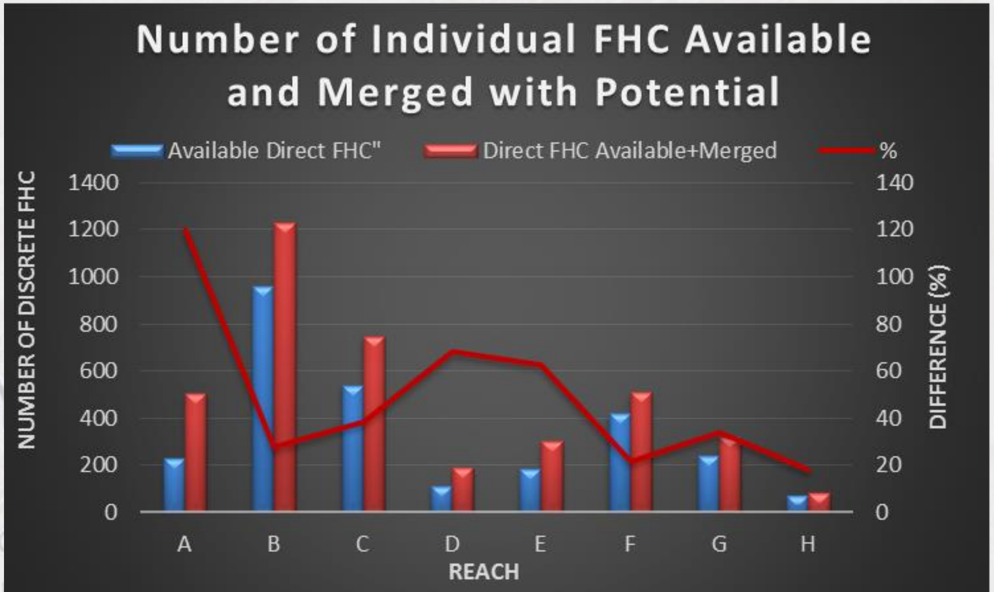


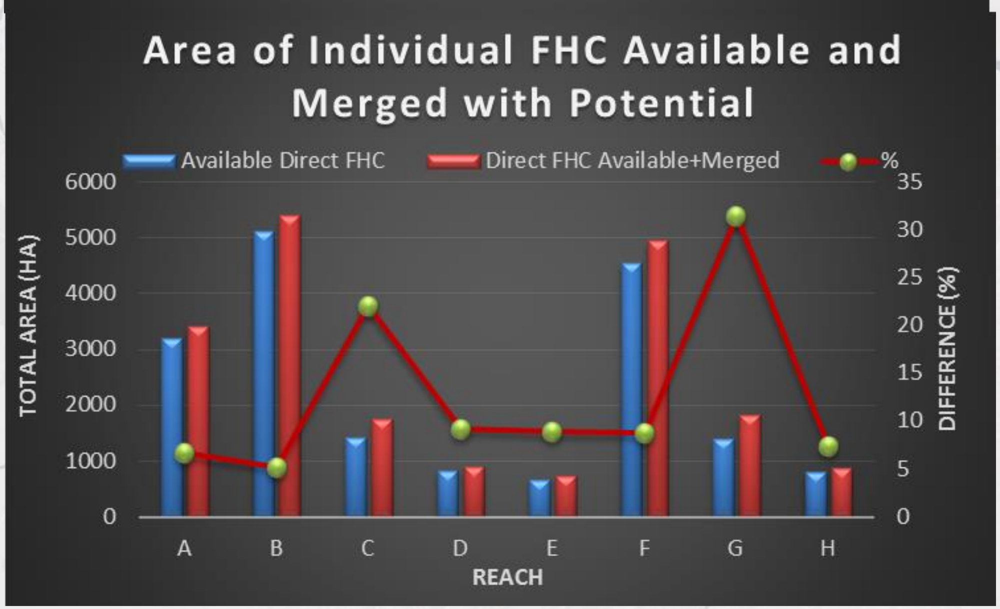




Spatial Planning Landscape Metrics

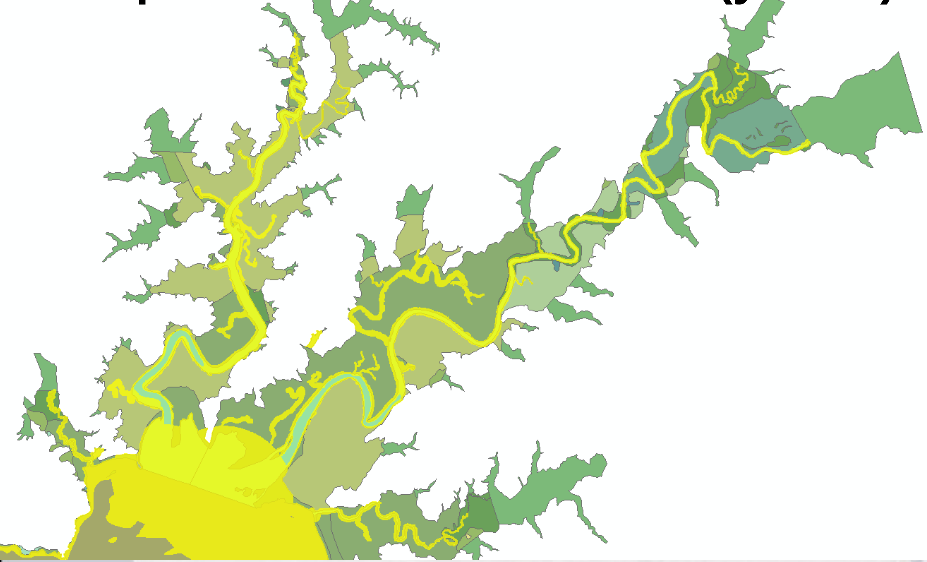
- ❑ Number of direct FHC could be expanded by restoration of muted and isolated FHC in reaches A and D-E
- ❑ Total area of direct FHC available would benefit most from restoration actions in reaches C and G



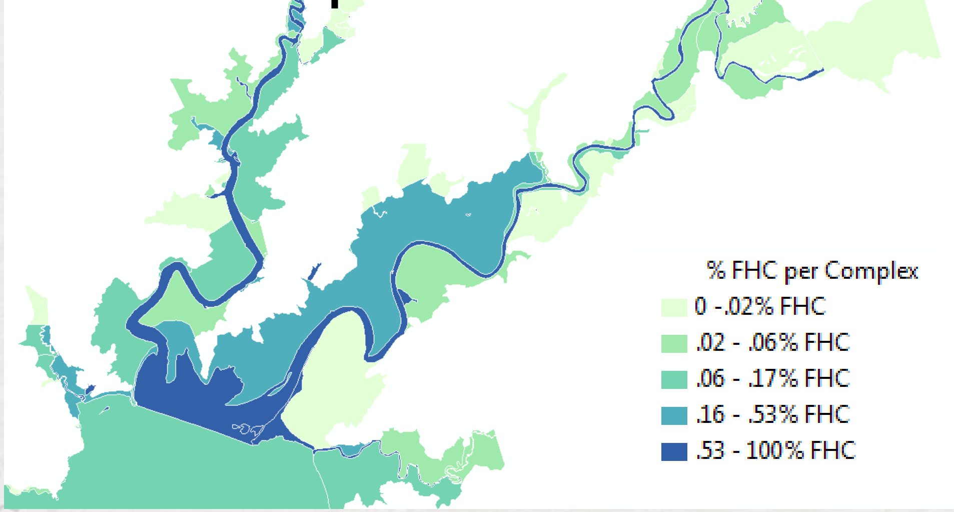


Grays River Tributary Estuary Example

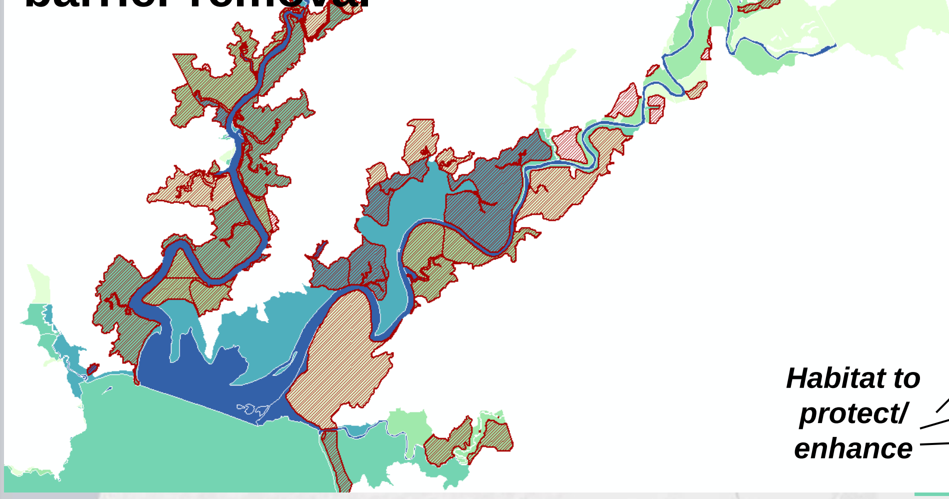
Complexes with FHC overlaid (yellow)



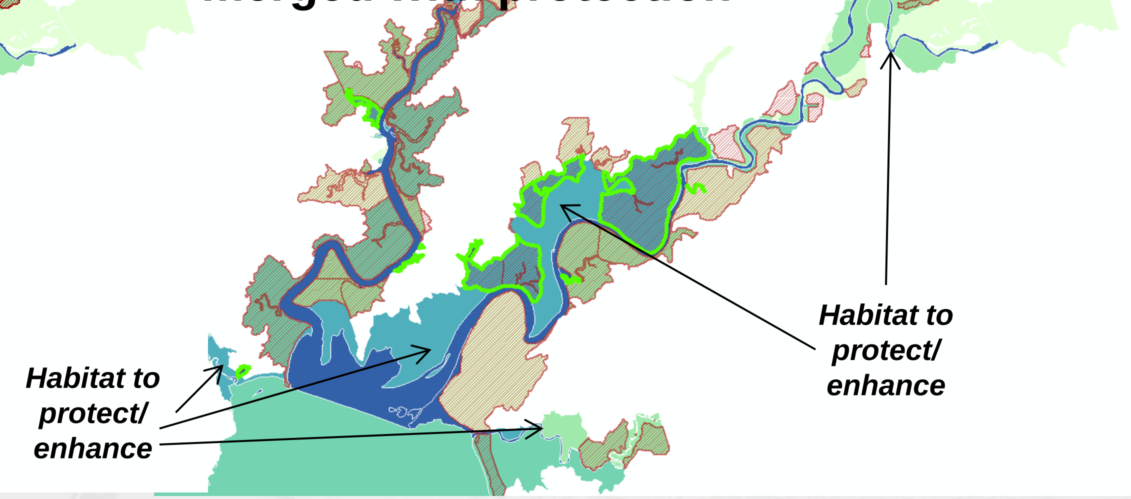
% FHC per ecosystem complex, classified in quartiles



Muted/isolated FHC ➔ where fish habitat access could be restored by barrier removal



Green = muted/isolated FHC that could yield high % of FHC if restored when merged with protection



Analysis of Wolf Bay using Fish Habitat Catena:

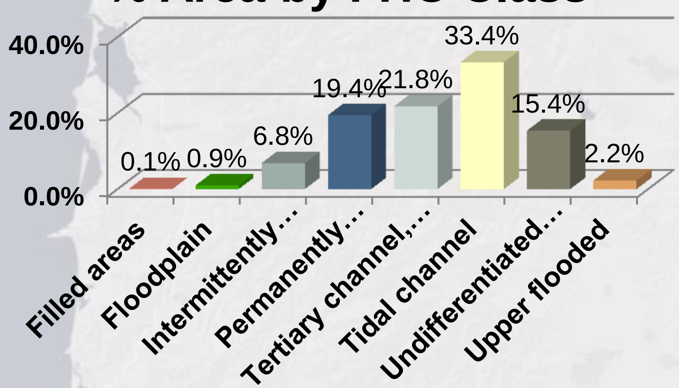
- Located in Reach B
- Not affected by muted/isolated FHC
  - Mostly a protection project with some enhancement thrown in
- Occurs within a complex with a relatively high concentration of FHC (27%)

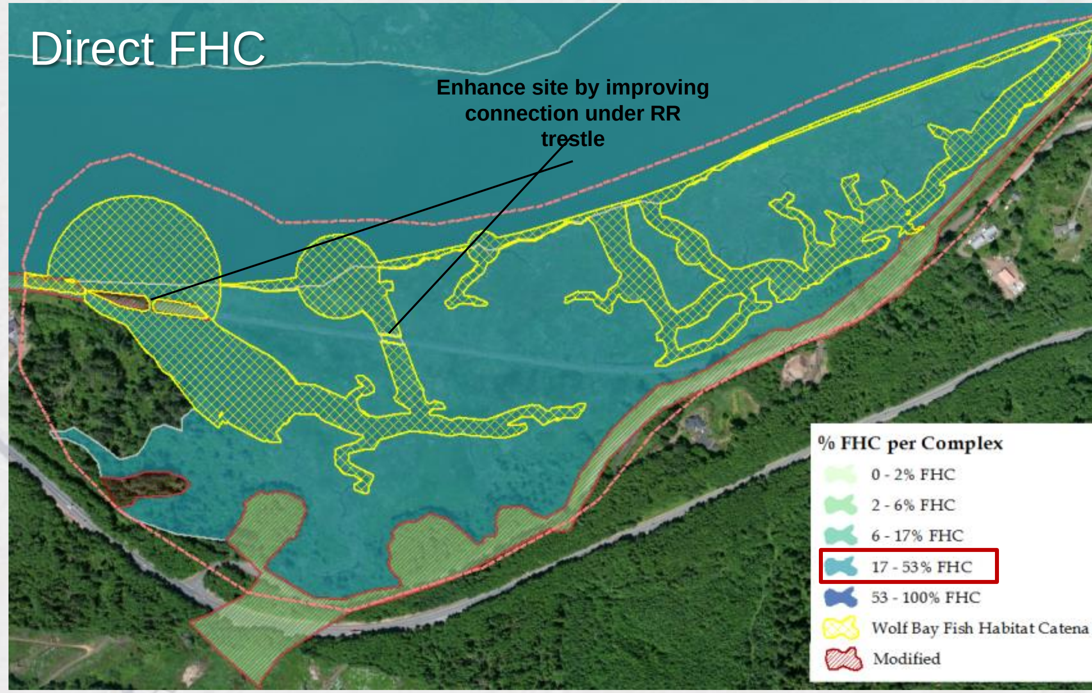
Wolf Bay METRICS

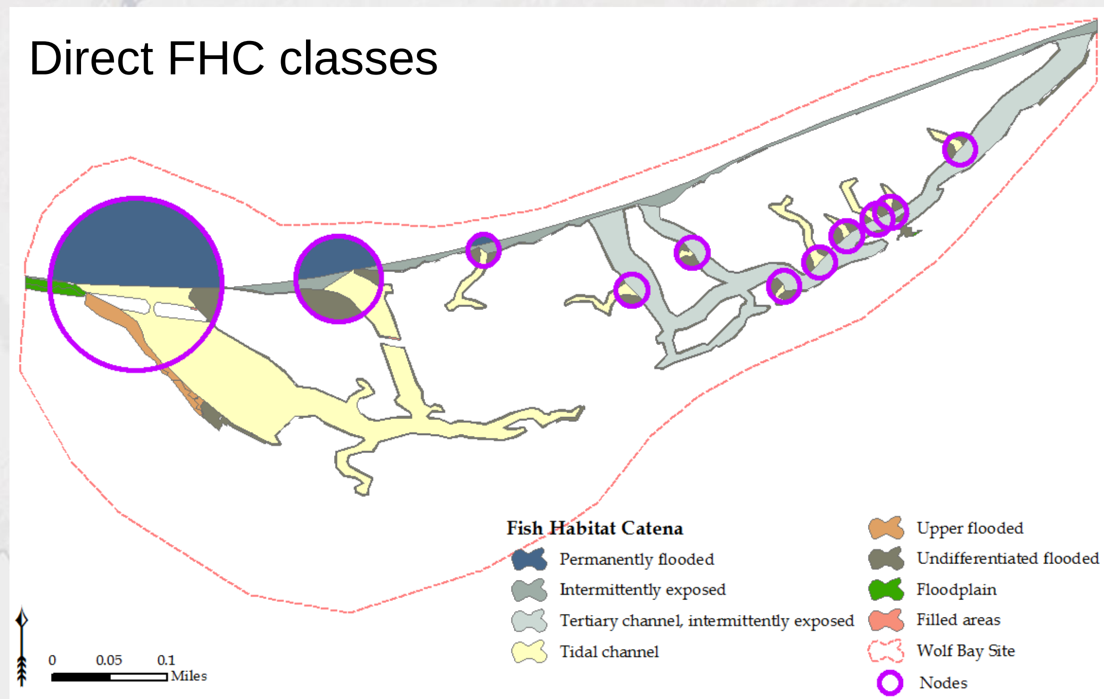
	Site	Reach B	Increase/Value
Total FHC Area	144399.80	56920324.38	0.25%
% FHC Area	23.92%	15.48%	Site has *high % FHC occurrence* compared to Reach B total
Total Edge	10725.90	1398622.80	0.77%
Edge Density	742.79	245.72	Site has *high edge density* compared to Reach B total
# Patches	126	19467	0.65%
Patch Density	8.73	3.42	Site has *high patch density* compared to Reach B total
# Nodes	11	190	5.79%
Node Density	0.18	0.01	Site has *high node density* compared to Reach B total

Reach B Total area: ***367593567.78***
Wolf Bay site area: ***603644.11***
(All areas in sq meters and distances in meters)

% Area by FHC Class







Where From Here?

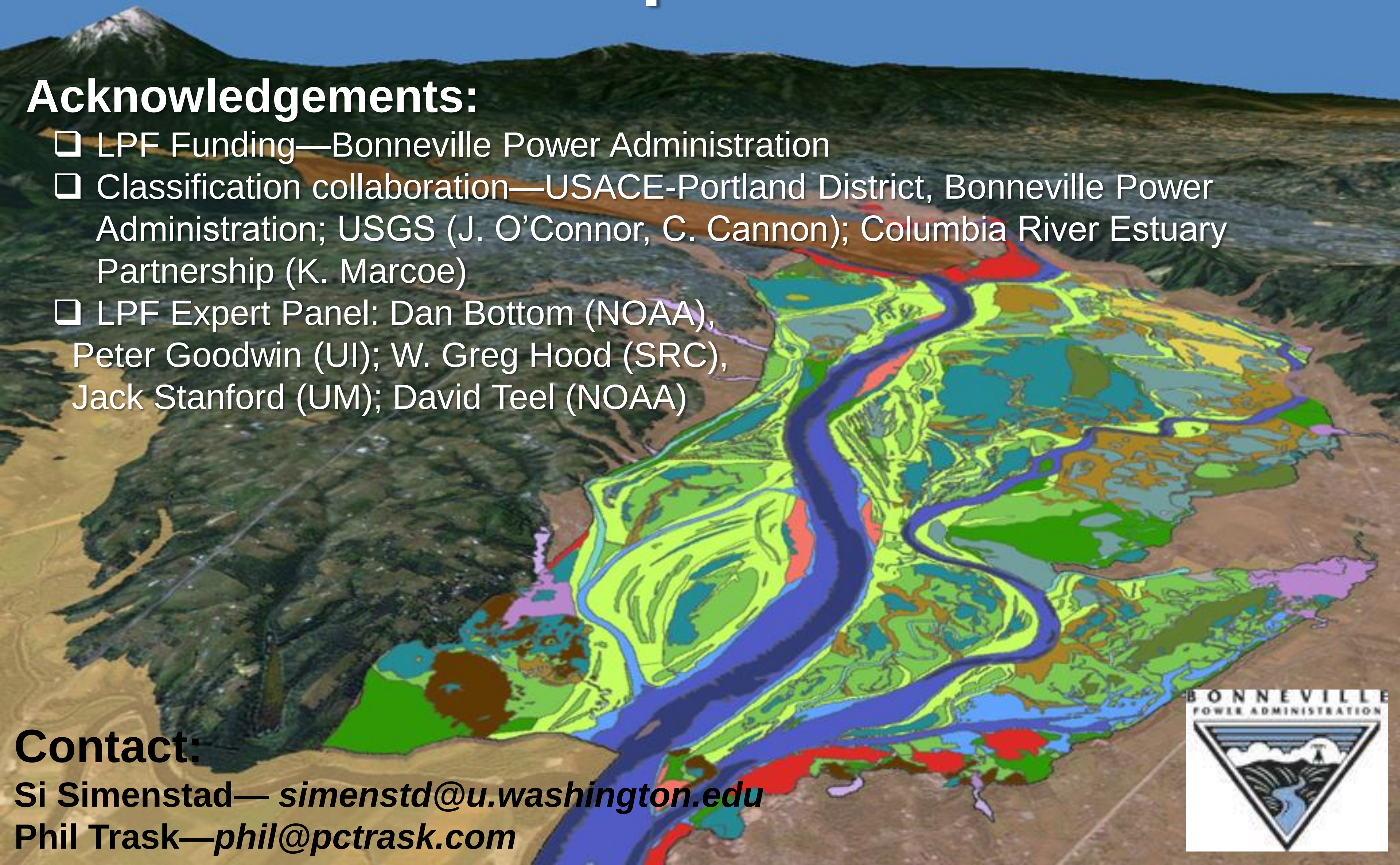
Landscape Planning Framework is still a work in progress!

- Incorporate other datasets as available:
  - temperature? predators? DO? prey availability/value
- Historic change:
  - What FHC landscape did Columbia River salmon evolve with? How much has the baseline shifted?
- Inundation modeling:
  - How does change in flooding regime change FHC? What ESU juvenile salmon benefit/not?
  - What flow regulation options? CRT?
  - What does climate change foretell?
- Dissemination of geodatabase and publication

Summary

- Landscape Planning Framework provides a potentially viable tool for more strategic planning restoration and conservation of estuarine habitat for Pacific salmon
- Directly applicable to Columbia River estuary; extendable methodology?
- Not a ranking, but provides spatial data for salmon life history modeling and for prioritization in other 'models' to make critical decisions about not only what restoration and preservation actions might involve, but also where and how they should optimally be deployed
- When addressing recovery planning of anadromous species such as Pacific salmon, we should be obligated to place proactive spatial planning ahead of convenience

Thank You!........questions?



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- LPF Expert Panel: Dan Bottom (NOAA), Peter Goodwin (UI); W. Greg Hood (SRC), Jack Stanford (UM); David Teel (NOAA)

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