Uniqueness of NW Natural Rivers (Naiman)

- "Pristine temperate rain forests on geologically young terrain"
  - LWD
  - Riparian corridors encourage biodiversity
  - Adaptations of organisms to highly fluctuating environments
  - Ease of invasion by invasive plants
  - Extent of water movement in subsurface channels

Uniqueness of NW Natural Rivers (Naiman)

- Number & variety of river channels
  - Diversity of habitats fosters diversity of species & life history strategies
- Assisted by regional & seasonal climate variations
  - Elevation, temperature, rainfall, river flow
  - Highly variable but seasonally predictable
- LWD lasts as long as 7000 years
  - Affects channel configuration & flow
  - Creates diverse habitats & biota

Original River Conditions (Montgomery)

- Rivers changed in prehistory
  - Glaciation
  - Since then:
    - Small
    - Relatively short-lived
    - Or confined to only some basins
  - Within the adaptability of diverse & abundant salmon populations
    - Even as local stocks occasionally crashed or disappeared

Original River Conditions (Montgomery)

- Rivers today "tamed and sanitized"
  - Even those that have been restored
  - Montgomery (Ch. 10) uses Nisqually & Skagit Rivers as case studies
    - Lower reaches reserved for tribe by treaty
    - Relatively undisturbed
    - Study role of log jams

Wood in Rivers

- "Grand old cottonwoods" growing on flood plain
  - Fall into river through natural bank erosion
  - Large enough to remain in place when other logs float downstream
  - Stack up into log jams
- Log jams divert flow
  - Create side channels that once were the main channel
  - 2000 logs/mile, 90% in jams

Wood in Rivers

- Create complex web of channels
  - Deepest pools are under & around biggest log jams
    - Both main & side channels
  - Both side channels & pools have reduced flow areas
    - Also overhanging & submerged logs for cover
- Made rivers impassable to boats

Flood Plain Rivers

- Comparison to "virgin" rivers
  - Hoh & Queets on Olympic Peninsula
  - Almost all "juveniles" in side channels
    - Main stem used for migration & spawning
    - 10 times more fish in side channels
  - In flood plain today:
    - Streams with side channels have 2–3 times more fish
    - Streams in forests have 3–4 times more fish
    - Compared to rural, urban, or agricultural streams

The Skagit River

- Rapids & deep pools
  - Skagit pools "full of fish"
  - Log jams backed up flood waters during high flows
- Perennial wetlands in flood plain
  - Ideal summer rearing habitat
  - Slow-water refuges during winter floods
  - Creates wide, flat valley floor

Wetland Functions (Kruckeberg)

- Flood water absorption & storage
- Reservoir in time of drought
- Nurseries for fish
- Habitat for migratory birds & wildlife
- Cycling of nutrients—aid productivity
  - Comparable to tropical rain forest
  - Exceeding crop land

History of the Habitat

- Ancestral tribal population ~50,000
  - Used wood & rivers and harvested fish
  - No significant alteration of salmon habitat
- 1840's first local white settlements
  - Subsistence logging & milling
- 1870's railroads
  - Logging & milling for trade
  - Cleared coastal & lowland areas first

History of the Habitat

- By 1900 widespread farming
  - Vegetables, berries, etc. on river deltas
  - Dairy cattle in foothills
- Farming impacts
  - Stream diversion for irrigation
  - Removal of riparian vegetation
  - Increased stream temperatures
  - Nutrients, chemicals, sediments in runoff
  - Diking, draining, filling of wetlands
    - 72% loss of Skagit nearshore marsh habitat

Removing the Wood

- Rivers were main transportation corridor
  - Before logging cleared roads
  - Goal was a straight, clear, single channel
- 1877 settlers dismantled Skagit logjam
  - Wetlands began to dry up
- Army Corps of Engineers clearing 1880
  - Peaked 1890–1910
  - 3,000 12-15 foot logs/year from Skagit River
  - 150,000 from five rivers over 100 years

Today We Know

- 1st scientific warning Henry Froelich (OSU) 1973
  - Ignored; salmon needed “clean highways”
- Big trees
  - Stabilize banks, provide cover, create LWD
- Log jams
  - Provide cover & deep pools
  - Divert river source to form side channels
  - Cause river channel to meander & migrate across flood plain

Natural Log Jams

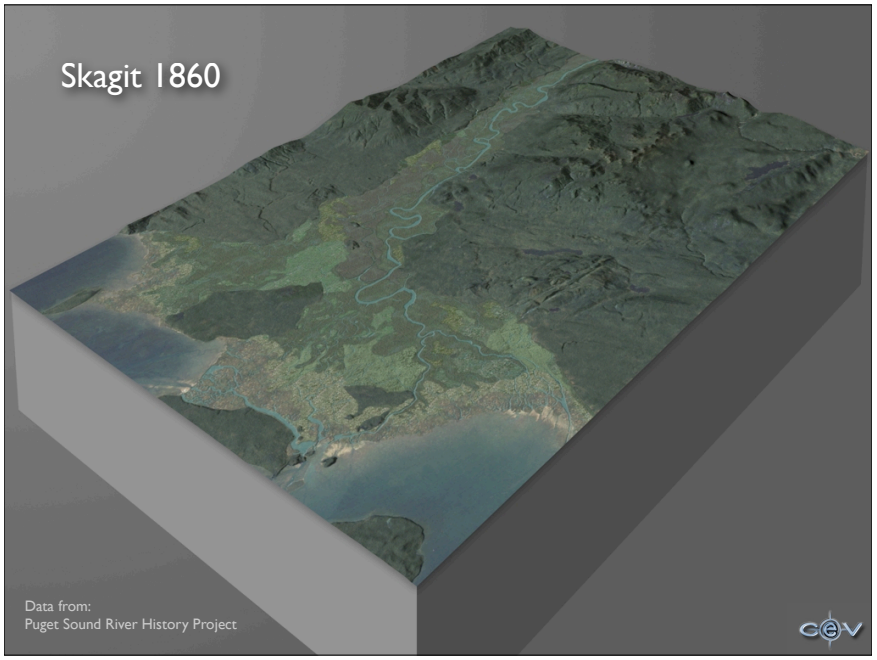
- www.2steger.de/michael/canada/40a_Stein_Valley_Traverse.htm

The Skagit River

- Settlers ditched & drained flood plains
  - Plugged side channels, built levees/dikes
  - To create rich farm land
  - By 1930’s only scattered wetlands remained
  - Greatly reduced habitat for “juveniles”
- Clearing of small streams followed rivers
  - Often used dynamite
  - “Splash damming” to transport logs to rivers
    - Deadly for salmon
  - Large rivers transport to mills

Channelizing Rivers

- Levees & dikes
  - Dikes confine still waters
  - Levees confine moving waters
- Levees speed flow & prevent flooding
  - Push flooding further downstream
  - Necessitate more building downstream
- Encourage building on flood plain
  - More property damage from major floods
  - Especially if levees fail
  - Insurance & rebuilding costs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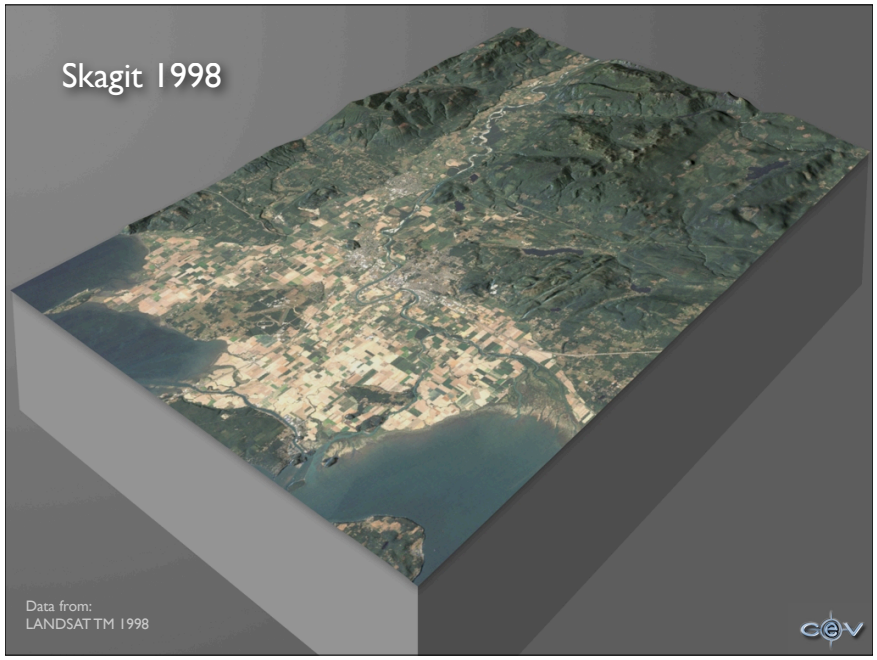
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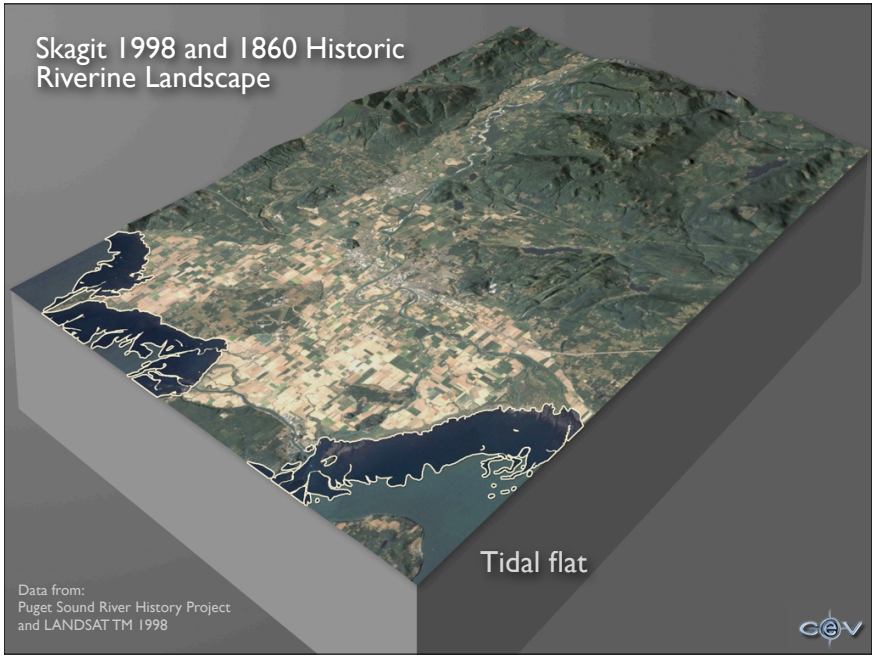
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Riverine Landscape
Tidal flat
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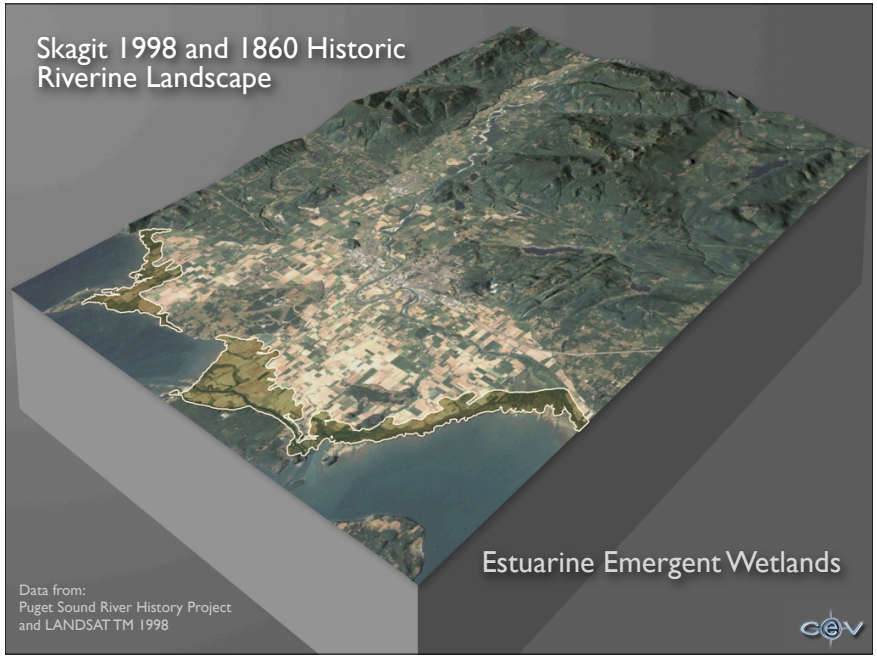
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Riverine Landscape
Estuarine Emergent Wetlands
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Skagit 1998 and 1860 Historic
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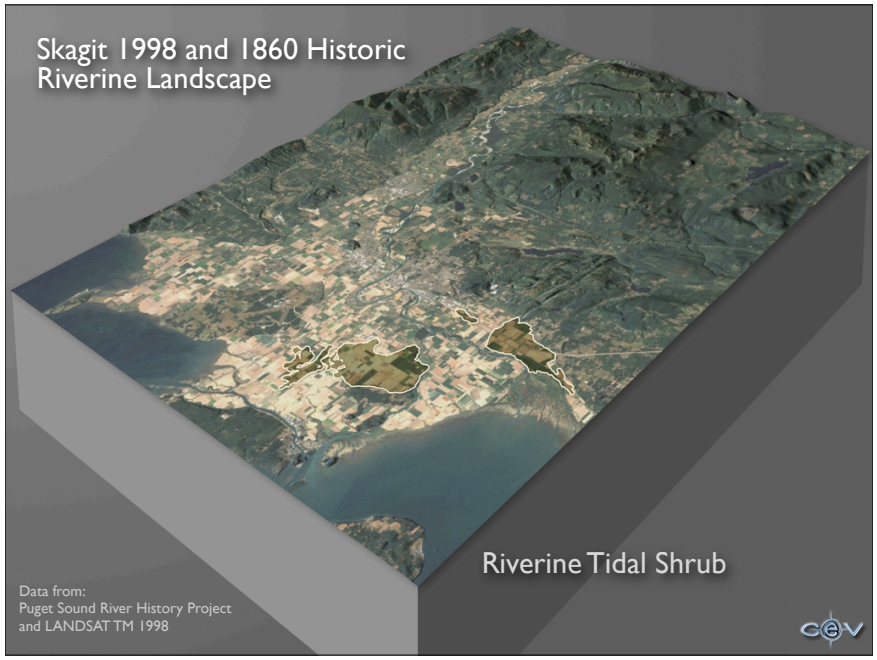
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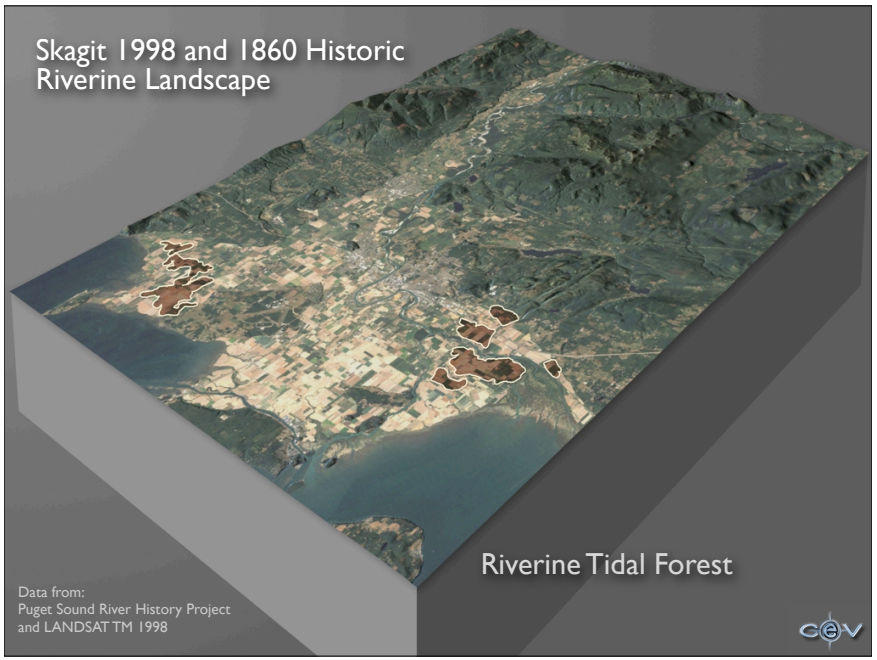
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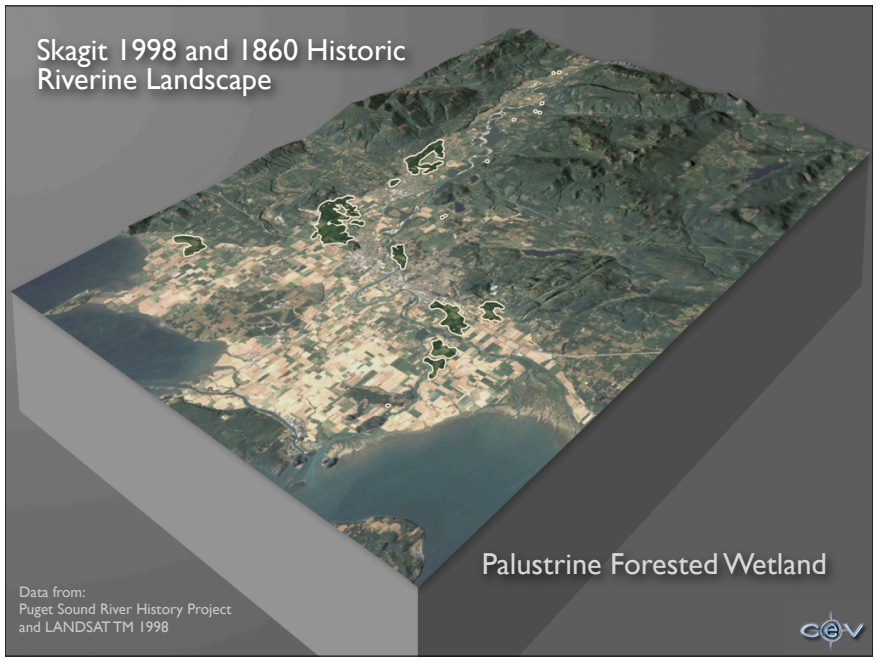
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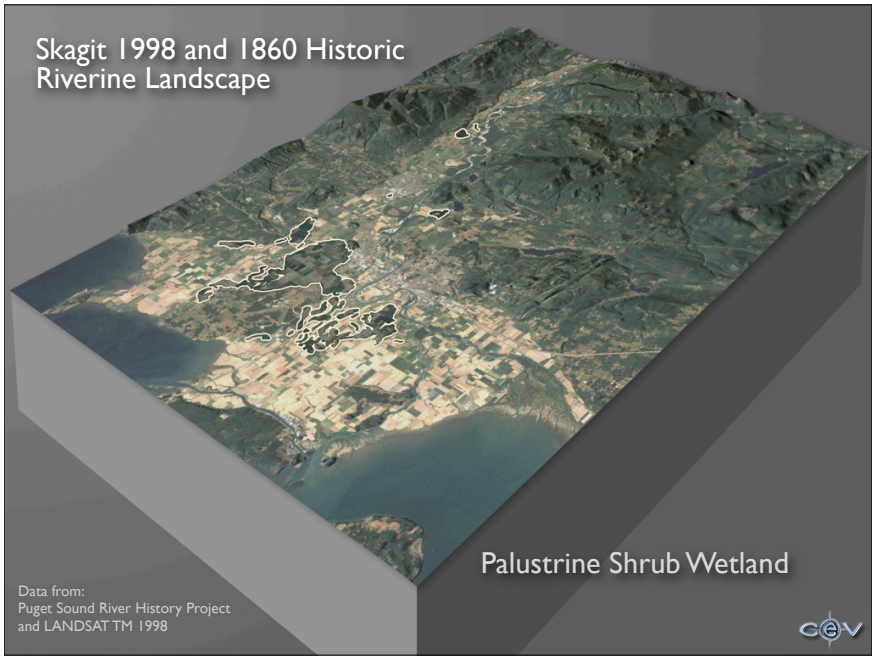
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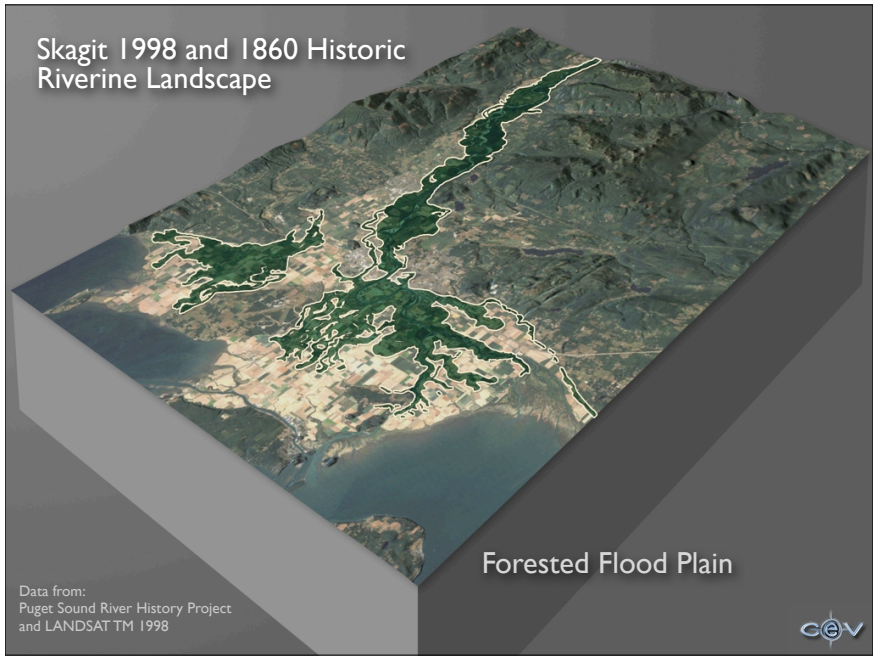
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Riverine Landscape
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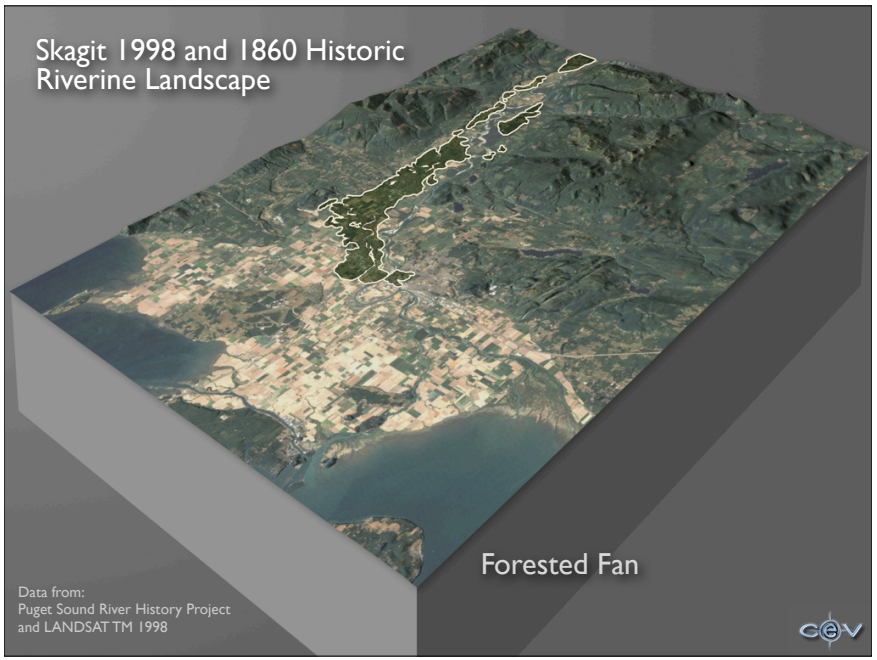
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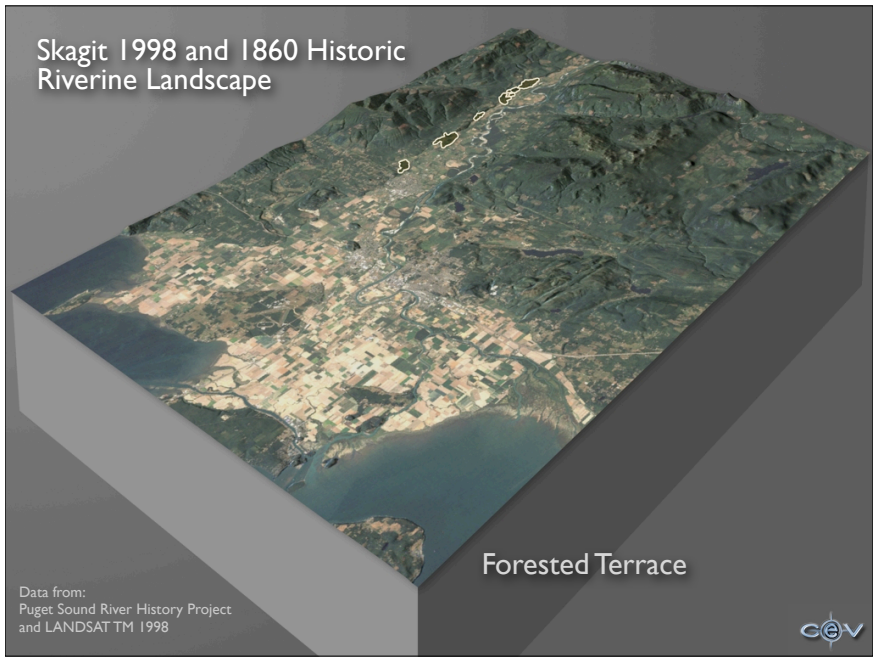
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Forested Terrace
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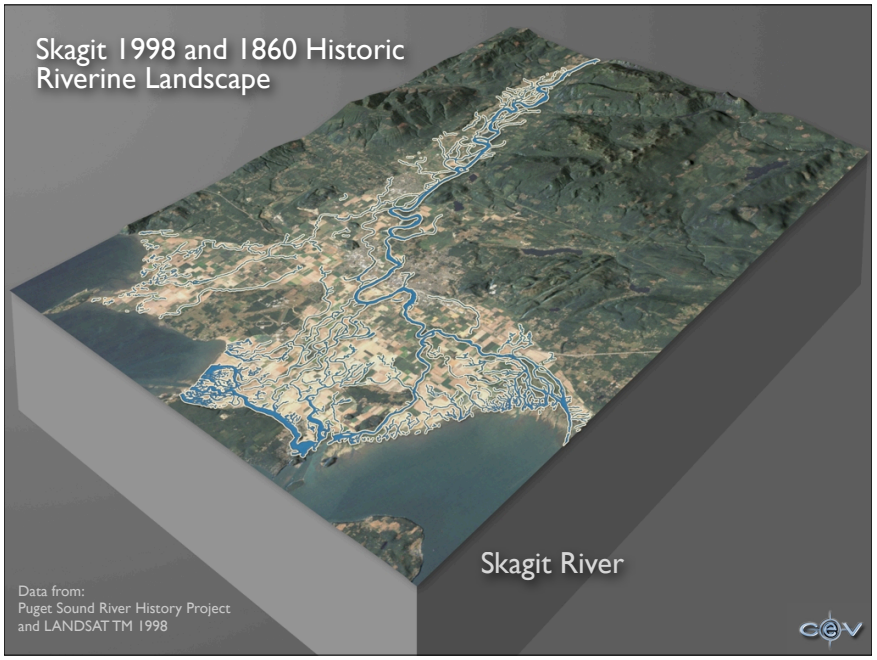
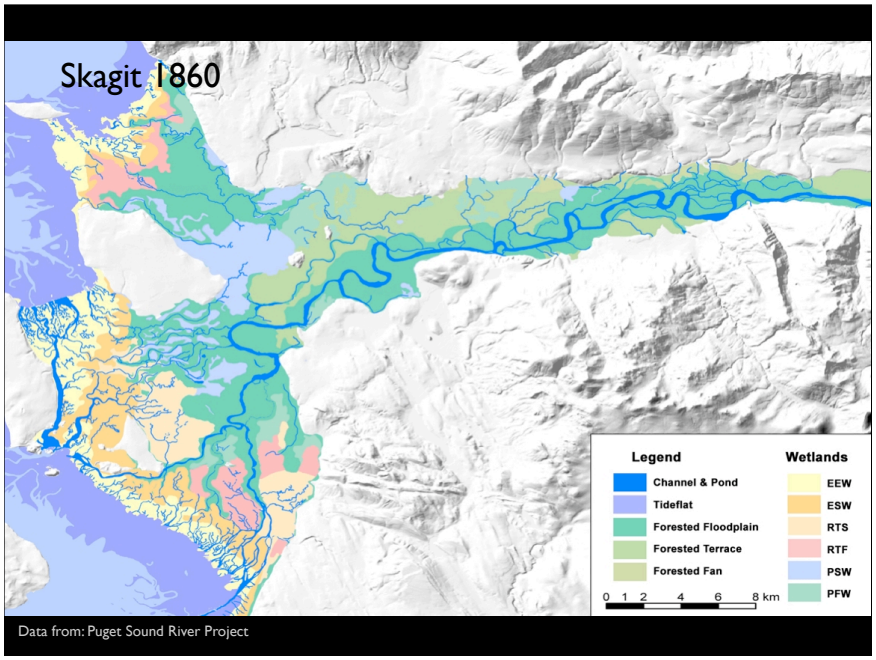
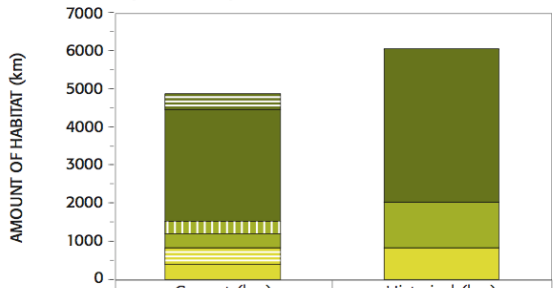




Shared Strategy Figure 3.10 **Estimated amount of Chinook rearing habitat in the Puget Sound region**



	Current (km)	Historical (km)
Freshwater habitat - modified	406.89	0.00
Freshwater habitat	2924.79	4011.35
Estuary habitat - modified	333.69	0.00
Estuary habitat	361.09	1186.91
Nearshore habitat - modified	440.82	0.00
Nearshore habitat	396.90	837.71

Notes: This graph depicts current and historical estimates of juvenile rearing habitat in the Puget Sound Region. Rearing habitat is divided into three habitat types: freshwater, estuary and nearshore. Current habitat is further divided into modified and unmodified amounts.

Logging Impacts

- Riparian forests were the first ones cut
  - Easiest to reach & transport
  - Largest trees were most desirable
    - But also most beneficial for habitat
- Clearcutting most efficient way of removing logs
  - Skidding & roadbuilding stripped soil
  - Roots rotted did not hold remaining soil
  - Erosion of soil & debris into streams
- Pioneer mentality & economic necessity

Splash Dams & Impacts

- Logs cut in winter floated down rivers
  - Flow was high enough
- Splash dams used to move logs in summer
  - When flow was normally lower
  - 1st built 1881
  - Dams created retention ponds
    - Logs skidded into pond
  - Periodically gates opened to flush logs downstream

Splash Dams & Impacts

- Splash dam on the Coquille River circa 1912. (Coos County Historical Museum)

bluebook.state.or.us/cultural/scenic/scenic/work/logsplash.htm

Splash Dams & Impacts

- Dams persisted despite impacts
  - Impoundments for log ponds, power production & irrigation
    - Disrupted natural flow
    - Blocked up- & downstream fish passage
  - Logjams cleared using dynamite
    - Log impacts killed fish & eggs
  - Floods scoured out gravel
    - Logs eroded banks & silted up bottom
  - Hatcheries to mitigate effects early 1900's
  - Not eliminated until 1960's

Sawmills & Impacts

- Mills typically sited at river mouths
  - Tribes protested impacts on salmon 1850's
  - Dumped tons of sawdust into streams
    - Carried downstream on winter floods
      - Suffocated eggs & killed prey
      - Clogged gills of juveniles & adults
- Dumping banned by Territorial Legislature
  - Banned 1876 but poorly enforced
  - Practice continued for 50 more years

Sawmills & Splash Dams

- Dams persisted despite impacts
  - Blocked up- & downstream passage
  - Hatcheries built to mitigate effects of splash dams early 1900's
  - LLWD no longer helped retain gravel
  - Scoured out by floods
  - Impoundments for log ponds, power production & irrigation

More Logging Impacts

- Loss of gravel
- Siltation
- Higher stream temperatures
- Artificial log jams
  - Created by dumping of small trees
  - Block fish passage
  - Prompted laws against log dumping & requiring stream-clearing 1950's - 1970's
  - But also cleared out "good wood" LWD

Skokomish River

- "Poster Child" for impacts of:
  - "misguided forest practices, river management & land use"
  - Typical natural river just overtops banks every year or two
    - Little significant impact on humans
  - Skokomish has large floods several times per year
  - 1929 Cushman Dam built
    -

Skokomish River

- Causes of Skokomish floods
  - 1929 Cushman hydroelectric dam built
    - Reduced downstream flow
    - Reduced ability to transport sediment
  - Clearcutting in watershed
    - Heavy erosion & sediment into streams
    - 6 feet shallower 1950–1990
    - Frequent overflowing

Impacts on Salmon Species

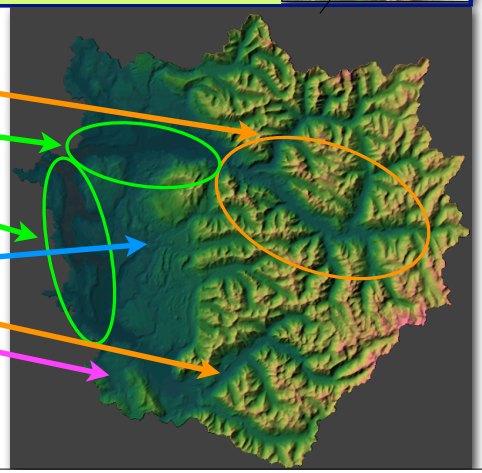
- Least affected
  - Chum & pink
    - Spend shortest time in streams as fry & parr
    - 1–4 months
  - Sockeye rear in lakes
    - Less vulnerable to human impacts
- Most affected
  - Chinook & coho
  - Spend longest time in streams as fry & parr
  - 1-2 years

The Snohomish Watershed Today

- Still 75% forest or wilderness
  - 5% agricultural
  - Better hydrologic & riparian function
  - Better sediment conditions than other PS basins
  - 1856 square miles
  - 1700 rivers & tributaries
- Projected human population growth 59% 2000–2030

The Snohomish Watershed Today

- Skykomish
  - Upper
  - Lower
- Snoqualmie
  - Mainstem
  - Tolt R.
  - Upper
  - Raging R.



The Snohomish Watershed Today

- Skykomish River basin
  - Upper reaches steep with boulders & rapids
    - Some glacial sources, source of gravel
  - Gold Bar to Monroe less steep
    - Gravel is deposited
    - Channel braided & more stable
    - Channel is more armored
      - Isolated from off-channel habitat
    - Still good spawning areas

The Snohomish Watershed Today

- Snoqualmie River basin
  - Tolt & Raging major upper tributaries
    - Best spawning habitats at their mouths
    - Tolt a source of gravel but not glacial
  - Mainstem through Carnation & Duvall
    - Farmland & rural
    - River banks straightened & hardened

The Snohomish Watershed Today

- Mainstem Snohomish River
  - Confluence of Skykomish & Snoqualmie
    - 21 miles to multi-threaded delta on Puget Sound
    - Under tidal & salt water influence
  - Upper reach
    - Broad valley with prime farmland
    - Spawning habitat for chinook
    - Holding & rearing habitat for several salmonids
  - Lower reach
    - Portions straightened & armored
    - Loss of side channels & LWD

Snohomish Watershed Salmon

- Habitat for all species
  - Threatened chinook & declining coho
- Chinook habitat
  - Snohomish & lower Skykomish & Snoqualmie mainstems
    - Considered degraded to moderately degraded
  - Skykomish (larger) & Snoqualmie separate spawning populations
  - “Backbone” of PS chinook populations along with Skagit & Stillaguamish

Snohomish Watershed Salmon

- Coho habitat
  - Inhabit smaller tributaries
  - More abundant than chinook
  - Hundreds of miles of high-quality habitat in middle & upper reaches
    - Largest population of wild coho in Puget Sound

Snohomish Watershed Mainstem Conditions

- 82% of off-channels sloughs & ponds disconnected
- 74% loss of flood plain wetlands
- 44 miles of dikes wall off flood plain
- Several thousand acres of wetland disconnected
- Little riparian forest, LWD & logjams
- Stream bank erosion
- Culverts block fish passage

Snohomish Watershed Mainstem Restoration

- Dike setback
  - Allows some channel migration & side-channel & wetland formation
  - But still protects property
- Plant trees & native vegetation
- 10-year goals (2015)
  - 10.4 miles of river-edge habitat
  - 256 acres of riparian habitat
  - 41 logjams
  - 167 acres off-channel habitat

Snohomish Watershed Mainstem Restoration

- General priorities for habitat
  - Protect the best remaining habitat
  - Restore those habitat areas that are still functioning
  - Restore severely impaired non-functioning habitat where feasible
- Land-use regulations alone will not be sufficient
  - Active participation & stewardship by land owners is essential

"Hot Spots" in the Snohomish Watershed

- Dams & reservoirs on the S. Fork Tolt River, Sultan River
  - Domestic water supply
  - Also withdrawals from Pilchuck River in summer
- Snoqualmie Falls & Sunset Falls (Skykomish)
  - Natural fish-passage barriers
  - Fish now transplanted above Sunset Falls

"Hot Spots" in the Snohomish Watershed

- Mainstem Snoqualmie
  - Diking, bank hardening, channelizing, ditching & draining for agriculture
  - Channel little changed for 50 years
  - Cut-off side channels &"oxbows"
  - 81% loss of flood plain wetlands
  - Loss of riparian vegetation & LWD
  - Cattle access: Bank erosion & pollution
  - Spawning limited to a few sites with gravel
  - Excessive temperatures (>18˚C) in summer

"Hot Spots" in the Snohomish Watershed

- Mainstem Snoqualmie
  - Cattle impact

How to Manage Rivers?

- Leave & restore riparian forest buffers
  - How wide to make them?
  - Loss of developable land
  - Restore LWD & allow trees to fall into streams
    - Obstacle & hazard to boating
- Allow for migration of channel
  - Very difficult unless flood plain is abandoned
    - Buildings & roads
  - Also requires wider forest buffers

Snohomish Watershed Recovery Plan

- Snohomish Salmon Recovery Forum
  - State Dept. Fish & Wildlife
  - Tulalip Tribe
  - County & city governments
  - Farmers, businesses, non-governmental organizations, concerned citizens
  - About 100 restoration projects already completed
  - Balance conservation, economic gain, private property, health & safety

Snohomish Watershed Salmon Goals

- Chinook populations 1999–2003
  - Steep decline since late 1970's
  - About 1200 wild spawners on Snoqualmie
    - About 5.7% of historic numbers
    - 2245 if hatchery fish included
    - Goal of 25,000
  - About 1700 wild spawners on Skykomish
    - About 3.4% of historic numbers
    - 4100 if hatchery fish included
    - Goal of 39,000

Snohomish Watershed Salmon Trends

- Mainstems
  - Focus of restoration efforts (with estuary)
  - Cities of Monroe, Sultan, Gold Bar, Duvall, Carnation near quality spawning grounds
  - Forecast 10% loss of forest cover, 4% increase in impervious cover over 25 years
- Tributaries
  - 44 streams have low-flow problems
  - Increased water demand as population grows 40% by 2020 (Tolt Reservoir)