Geomorphic Context for Recovery of Willamette Salmon and Steelhead Associated with the Willamette Project

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Overview and Key Questions

What are the expected spawning and rearing patterns once fish passage is improved at dams?

Are geomorphic conditions adequate for recovery?

Where are physical habitat conditions most limiting recovery?

What can we realistically do about these limitations?

What do we need to know to better manage the system?

Spawning

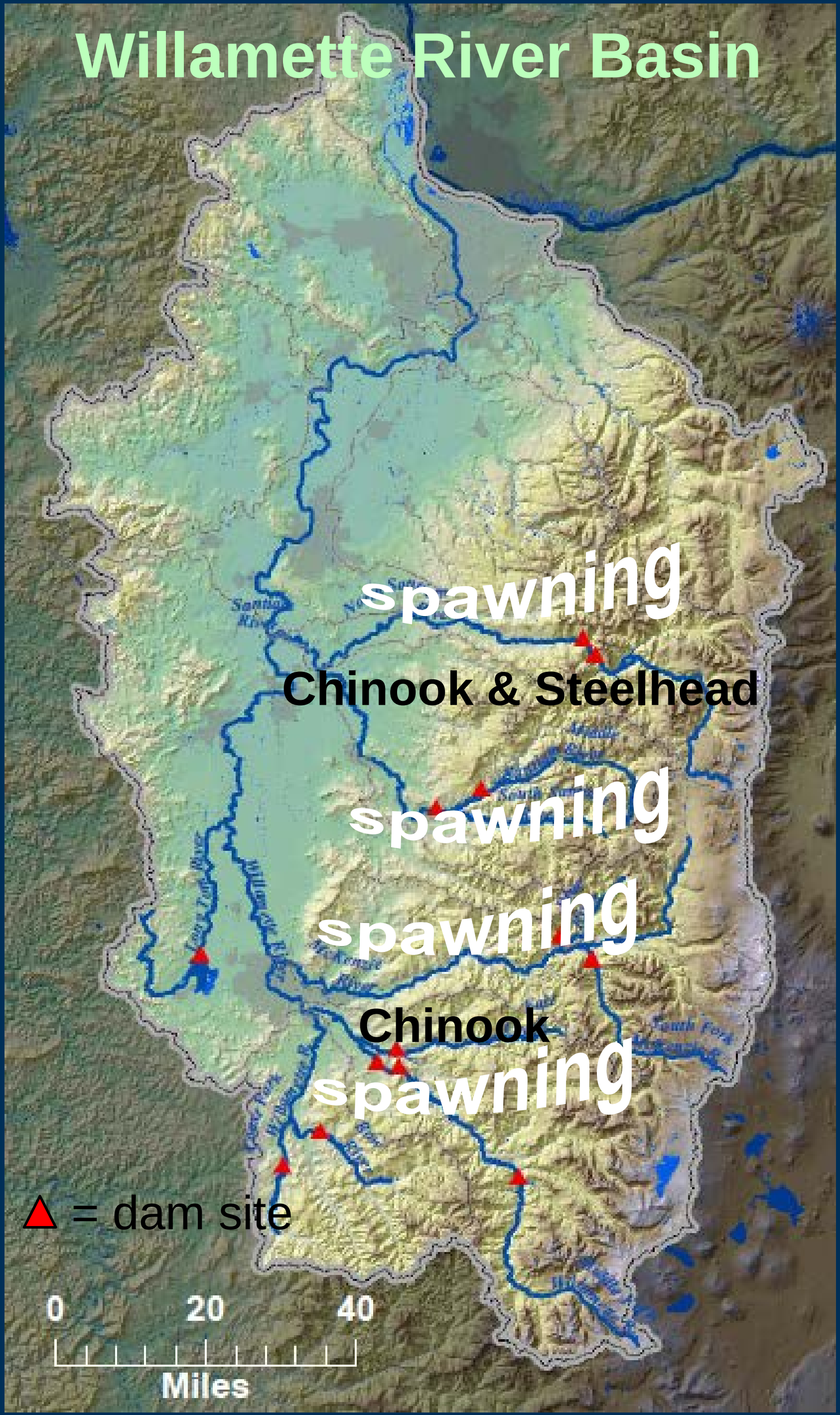
Historically, many spring Chinook and winter steelhead spawned upstream of where Willamette Project dams now exist

(Craig and Townsend, 1946; Mattson, 1948)

- Typically in riffles, glides or pool tail outs containing a mix of gravel and cobble with adequate depth (≥ 30 cm) and velocity (50 to 150 cm/s)

(Healey, 1991)

Photo courtesy Freshwaters Illustrated



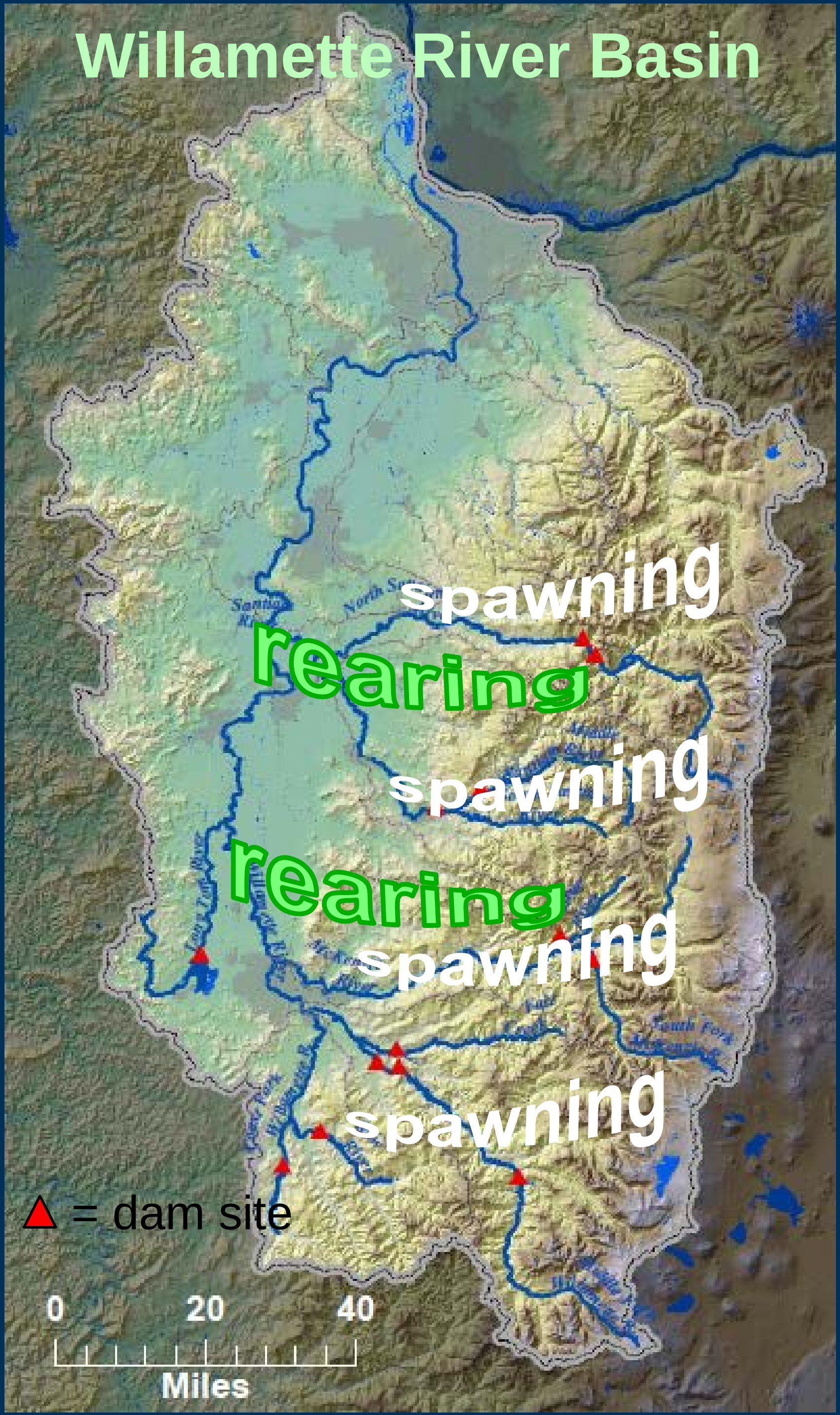
Rearing

Chinook rear along river margins, flood plains, and lower reaches of natal and non-natal streams

(Craig and Townsend, 1946)

Steelhead often rear in riffles and also deep pools with relatively high velocities

(e.g. Bisson et al. 1988)



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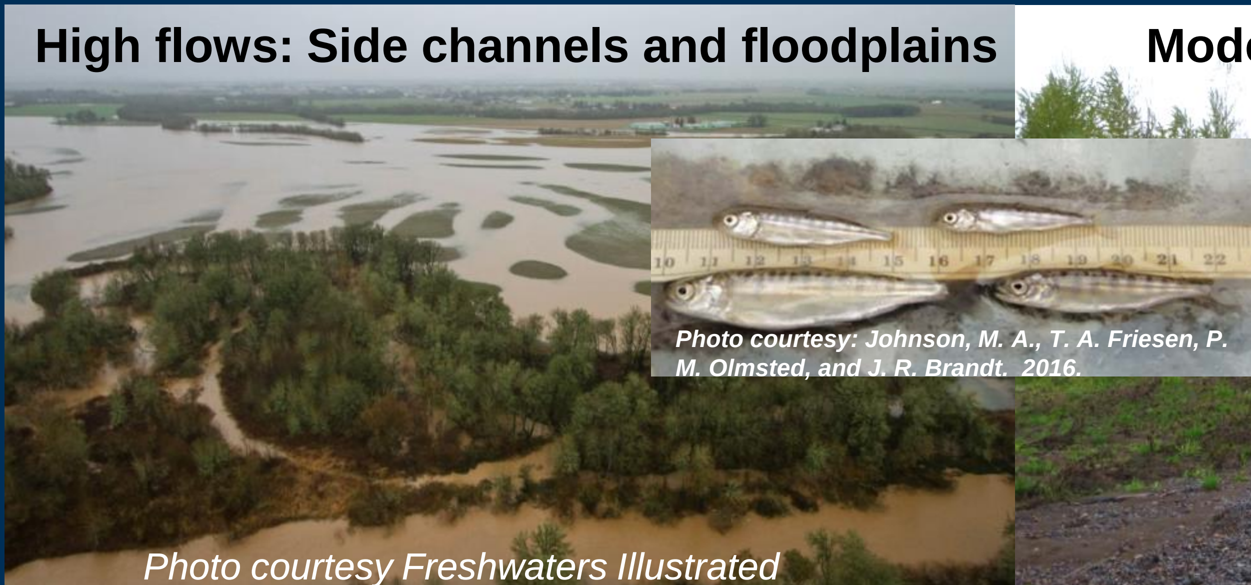
Rearing



- Juvenile habitat preferences change as they grow and with stream size

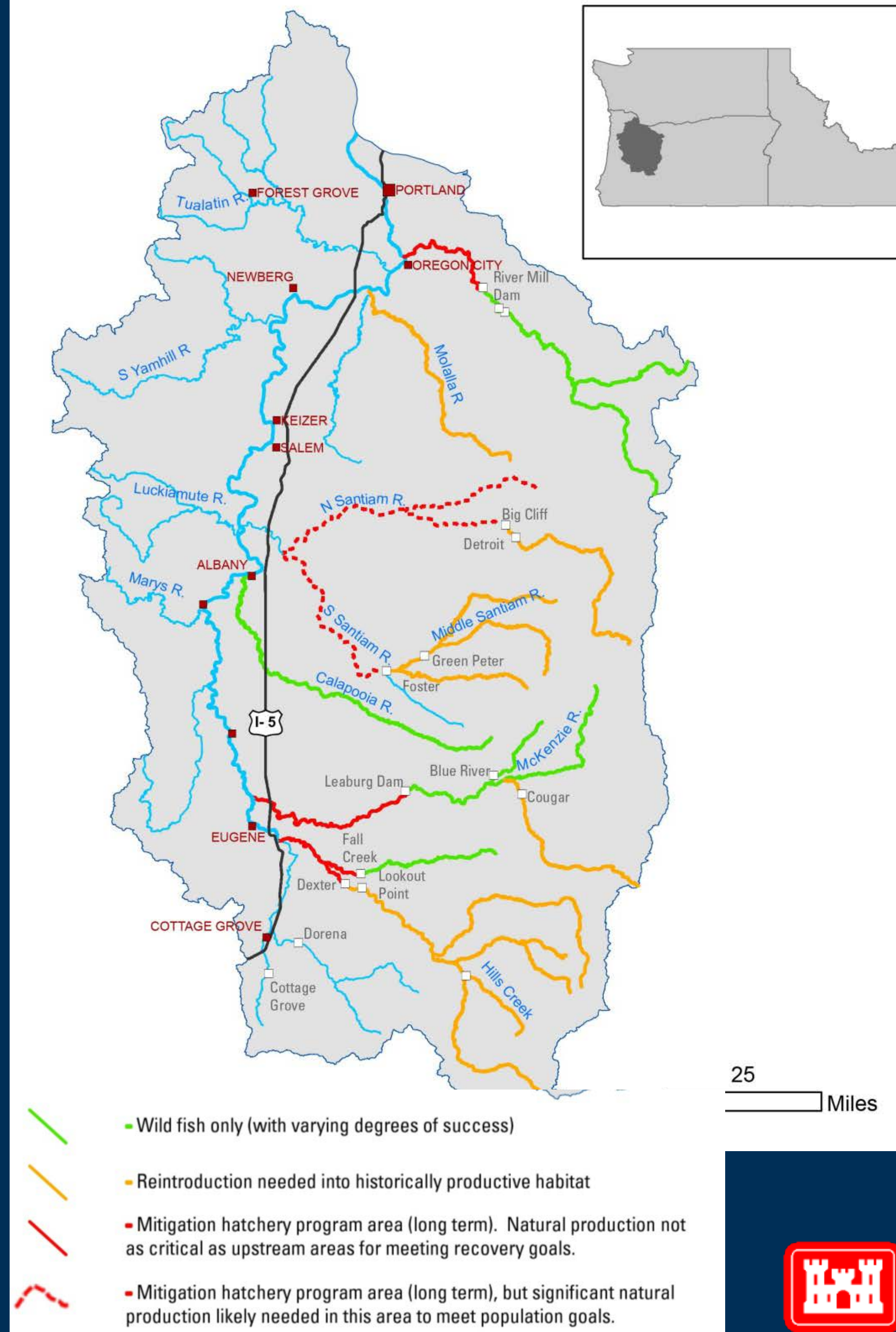
(e.g. Everest and Chapman 1972; Friesen et al. 2004, 2007 Schroeder et al. 2016)

Willamette Salmon and Steelhead Recovery Approach

Wild fish above dams, maintain hatchery area below (“Split-Basin” strategy)

Highest priority - address direct impacts of dams:

- Restore adult access and spawning
- Reduce adult pre-spawning mortality
- Reduce juvenile migration mortality
- Improve habitat attributes by adjusting
    - flows,
    - water temperatures
    - sediment loads,
    - large wood recruitment



NMFS Biological Opinion, 2008
ODFW/NMFS Recovery Plan, 2011

Willamette Salmon and Steelhead Recovery Approach

Above dams, most juveniles will likely rear in reservoirs, and emigrate in spring (CH & ST) or fall (CH). *(Monzyk et al. 2014; Johnson et al. 2016)*

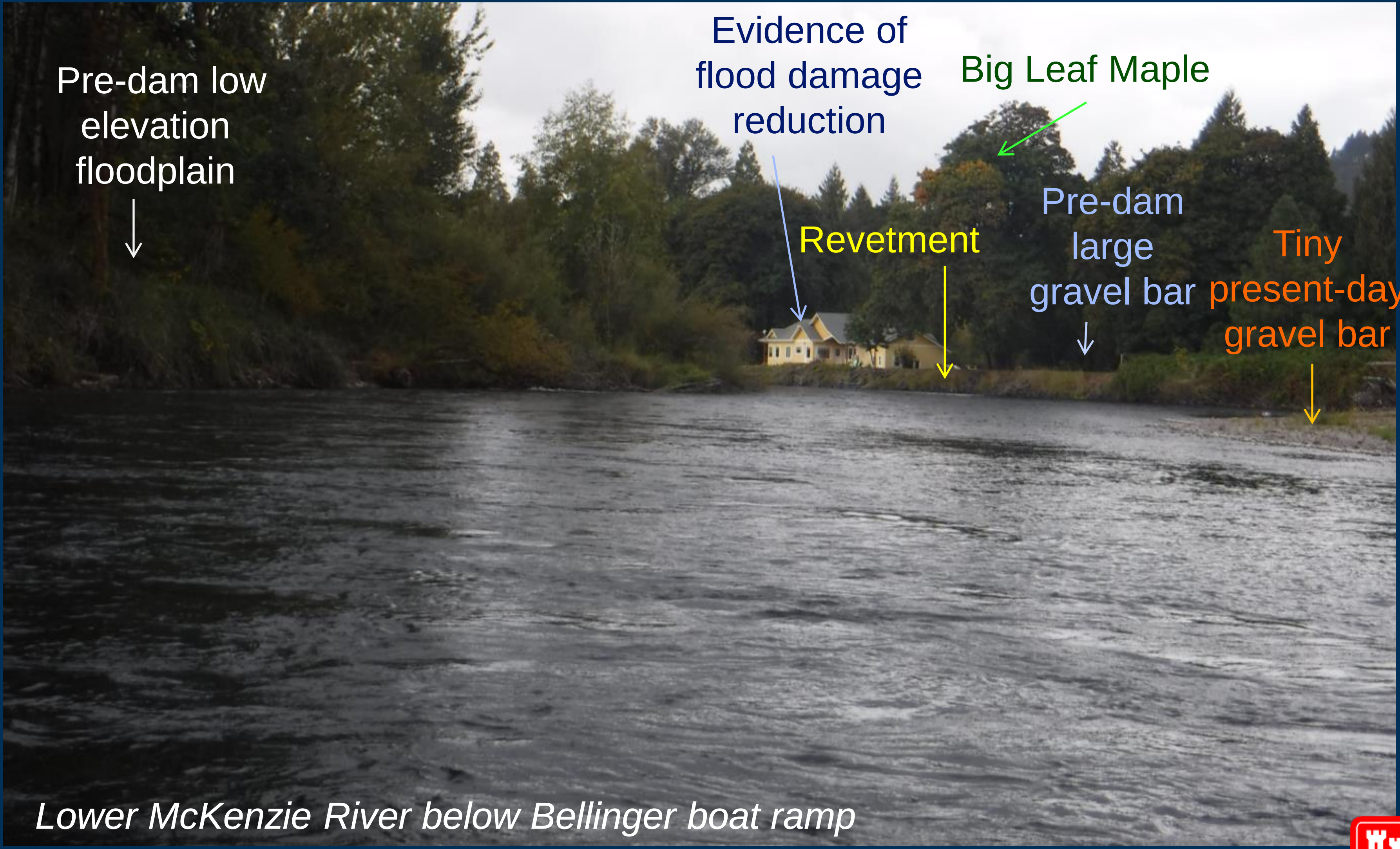
Juveniles originating below dams depend on lower river areas to rear

Productivity of the basin can be substantially increased by the contribution of fish with dispersive life histories (over 50%)

Schroeder et al. 2016

USGS

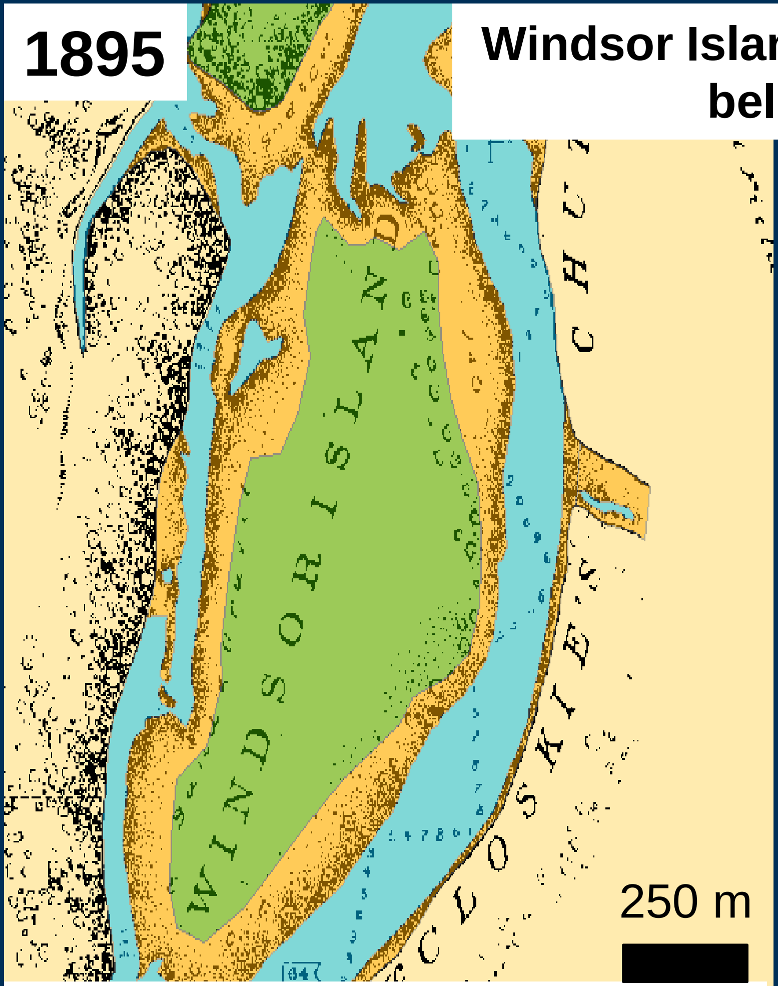
Aquatic habitats below dams critical for productivity and life-history diversity



Geomorphic process, channel features and habitat availability

Reductions in bed-material supply, peak flows, bank erodibility and large wood create a more stable present-day river system.

Windsor Island, Willamette River below Salem



USACE navigational maps. Wetted channels and forested islands mapped by PNWERC. Gravel bars mapped by Gabe Gordon, USGS (provisional mapping, subject to revision)

2016 active channel mapping by Gabe Gordon, USGS (provisional mapping, subject to revision) from NAIP imagery.

Present-day geomorphic framework of salmon-bearing streams below USACE dams

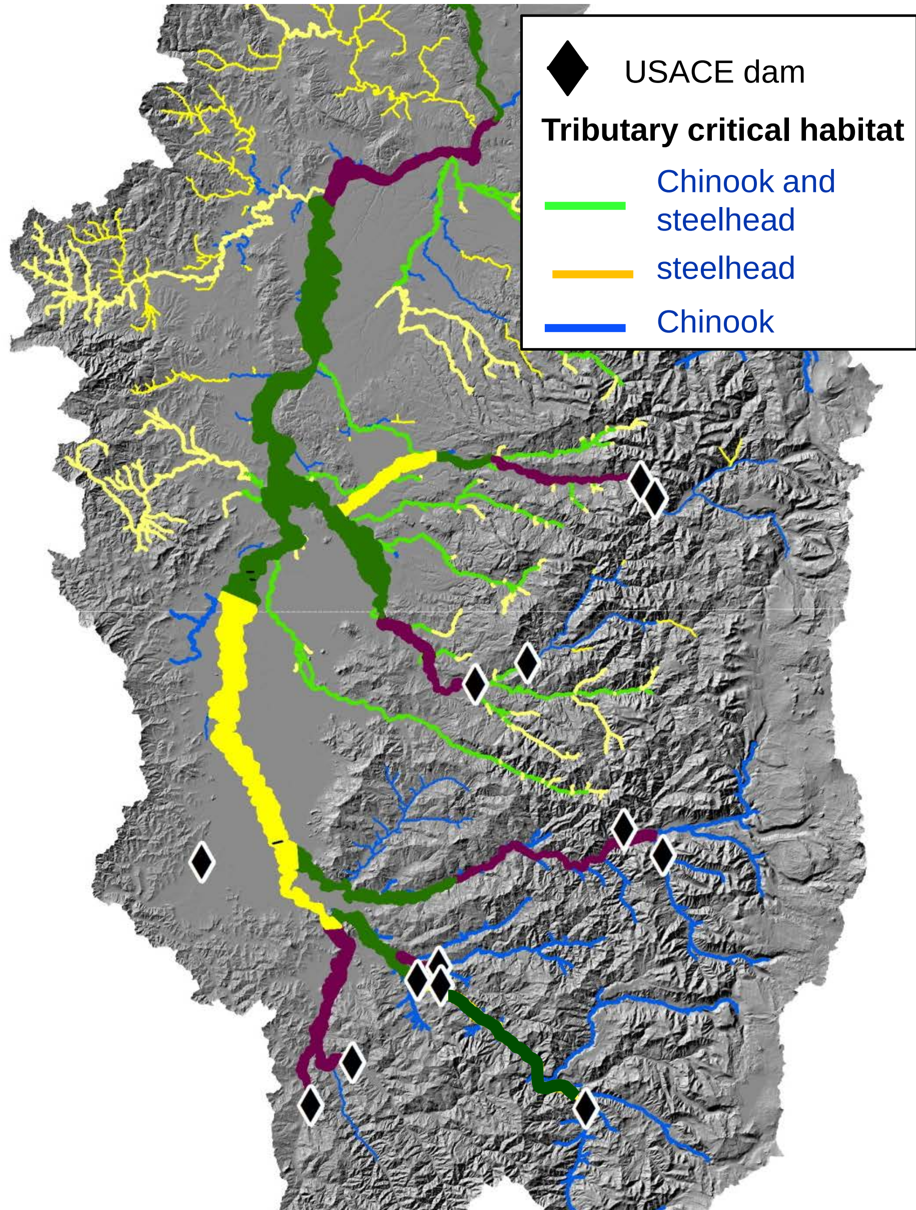
<u>Presently dynamic reaches</u>
(Diverse channel features, active habitat formation)
Upper Willamette
North Santiam

<u>Historically dynamic, presently stable</u>
(Habitat formation limited, many relict features)
Middle Fork
McKenzie
S. Santiam
Mainstem Santiam
Middle Willamette
Lower Willamette

<u>Bedrock reaches</u>
Below dams; Newberg Pool

Geomorphic reaches from Wallick and others, 2013; Critical habitat from NOAA

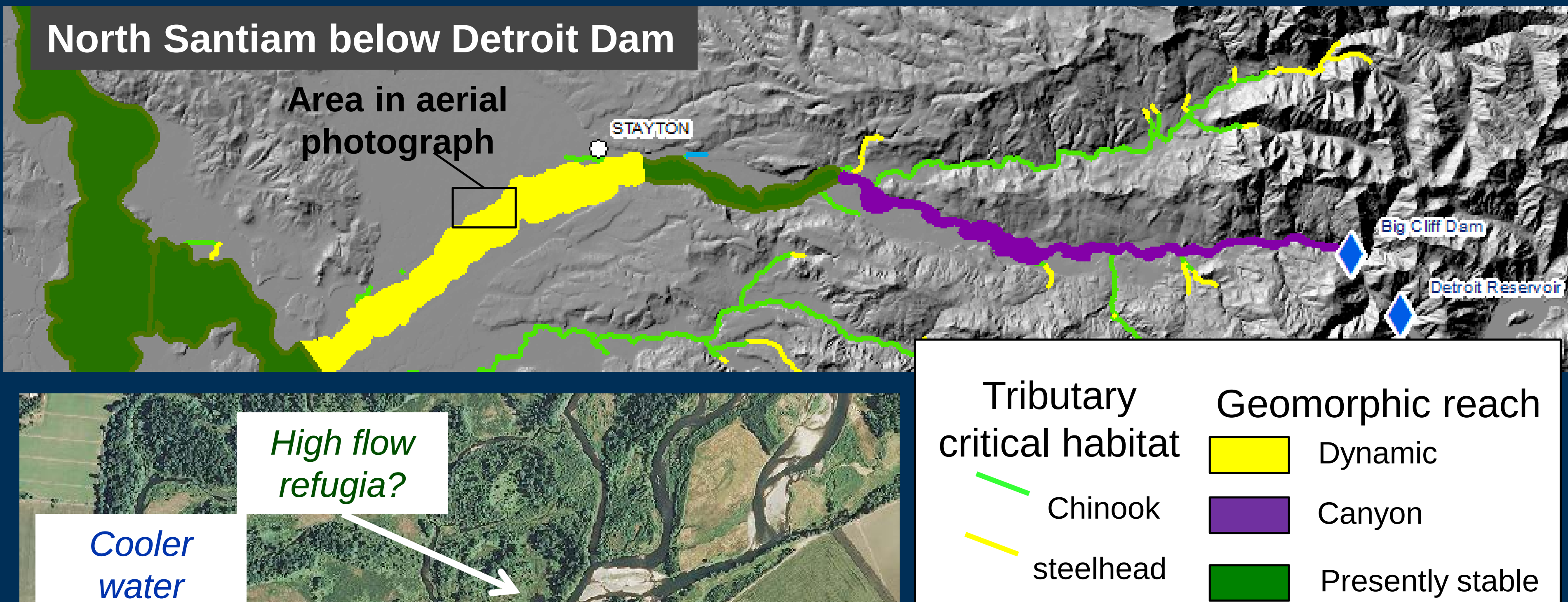
Chinook, steelhead and geomorphic classification of Willamette Basin Rivers

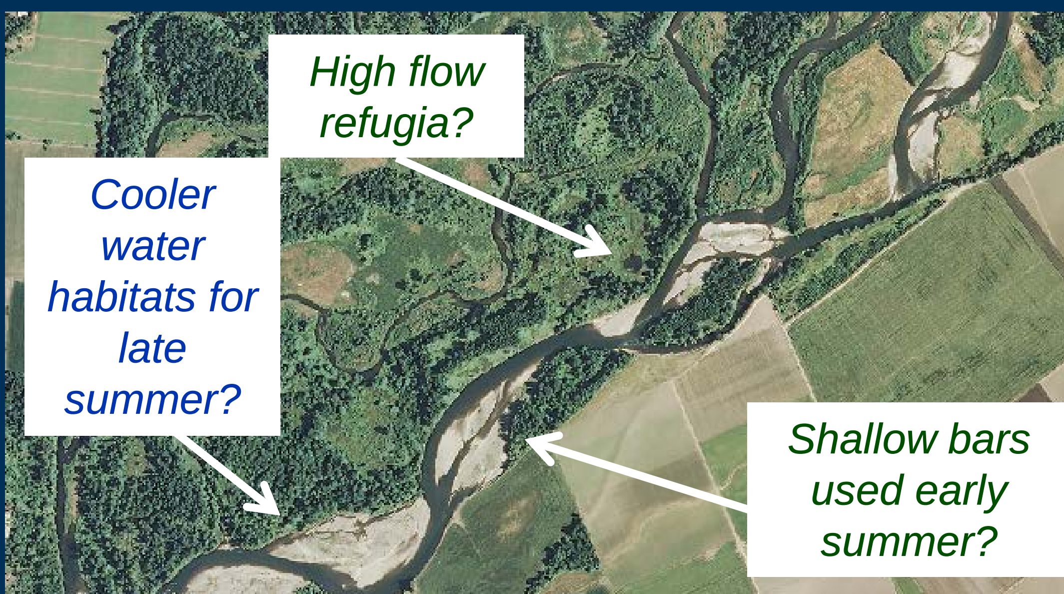


Presently dynamic reaches: example from North Santiam

"Significant natural production likely needed to meet population recovery goals"

NMFS Biological Opinion, 2008, ODFW/NMFS Recovery Plan, 2011

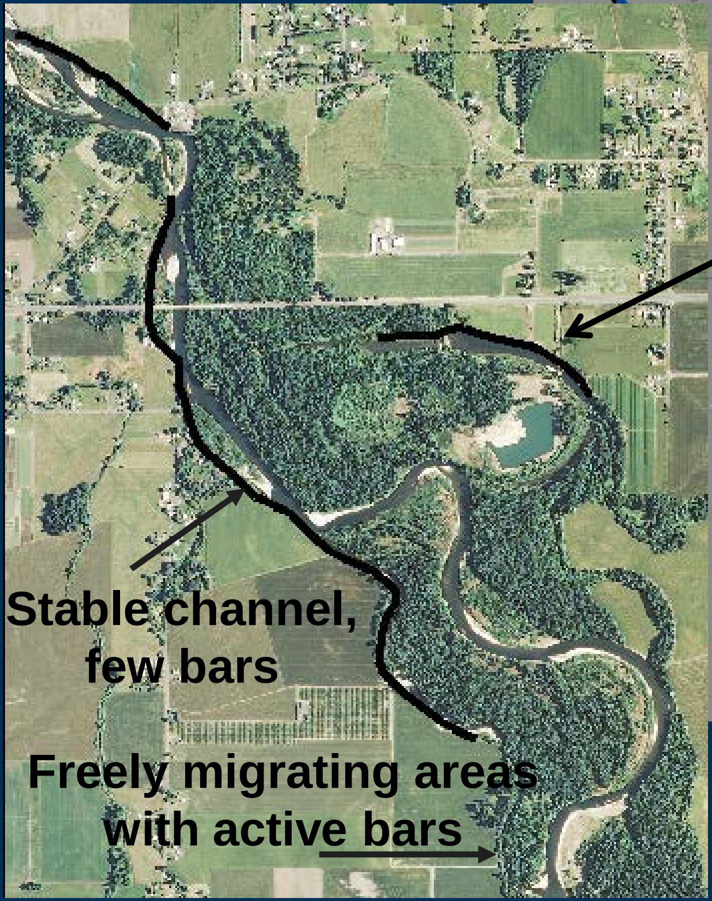


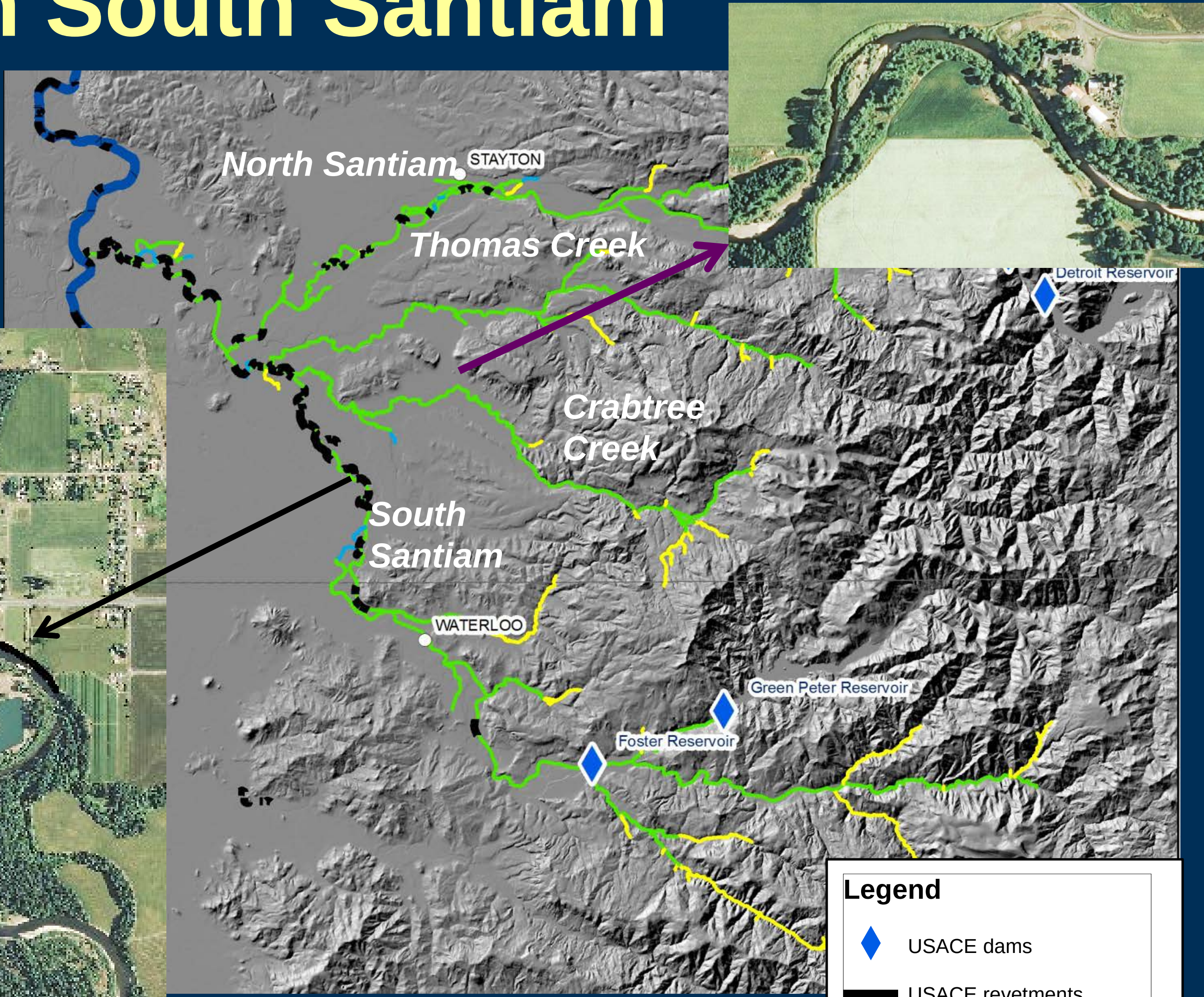


Restoration efforts by Confederated Tribes of the Grande Ronde on the North Santiam River will help expand the corridor of active habitat formation

Habitats on presently stable reaches: example from South Santiam

Wild steelhead spawn and rear in the lower South Santiam Sub-basin below Foster Dam and in tributaries including Thomas and Crabtree Creeks





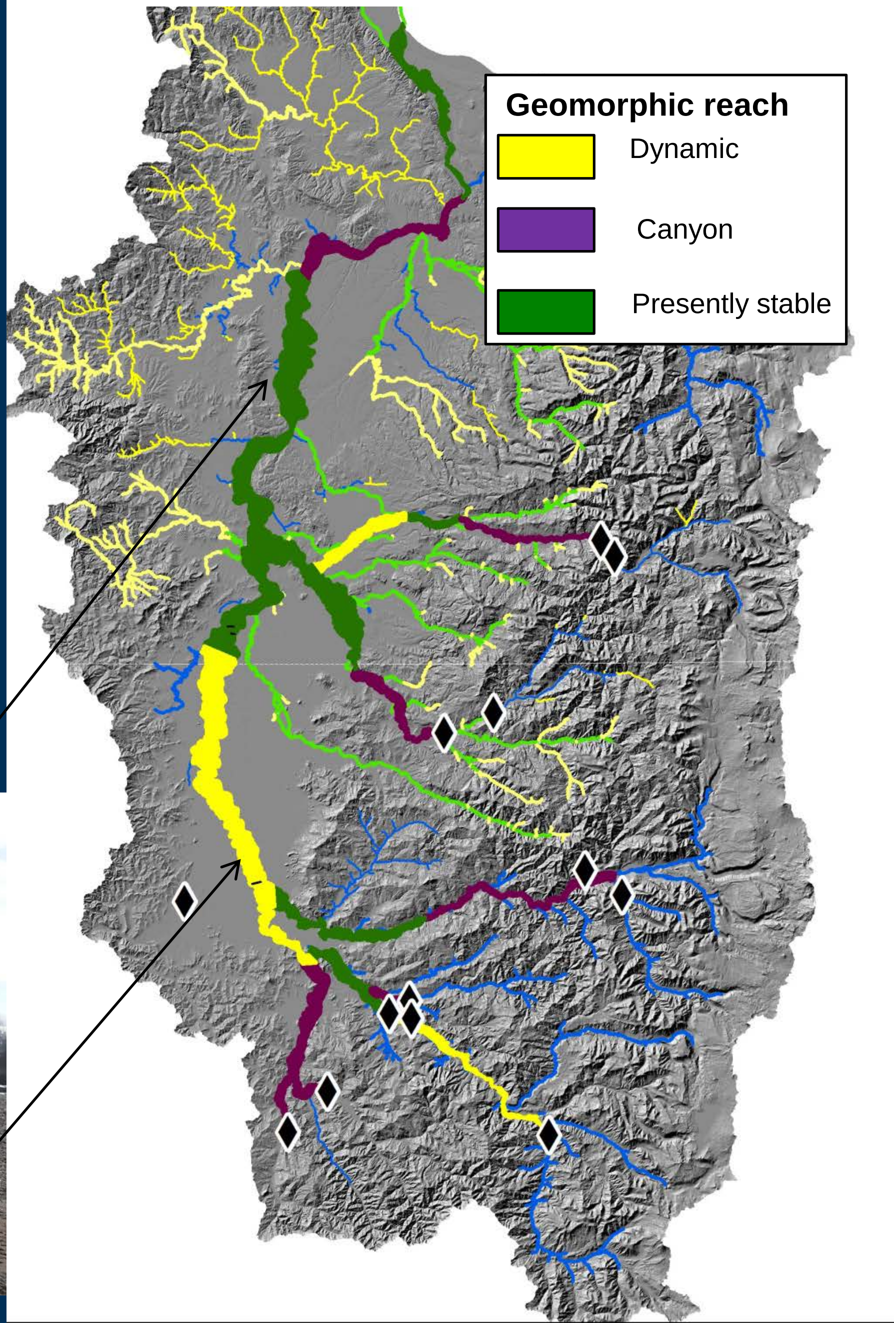
Much of South Santiam River and Santiam River flanked by revetments

When and where are habitat limitations most influencing recovery?

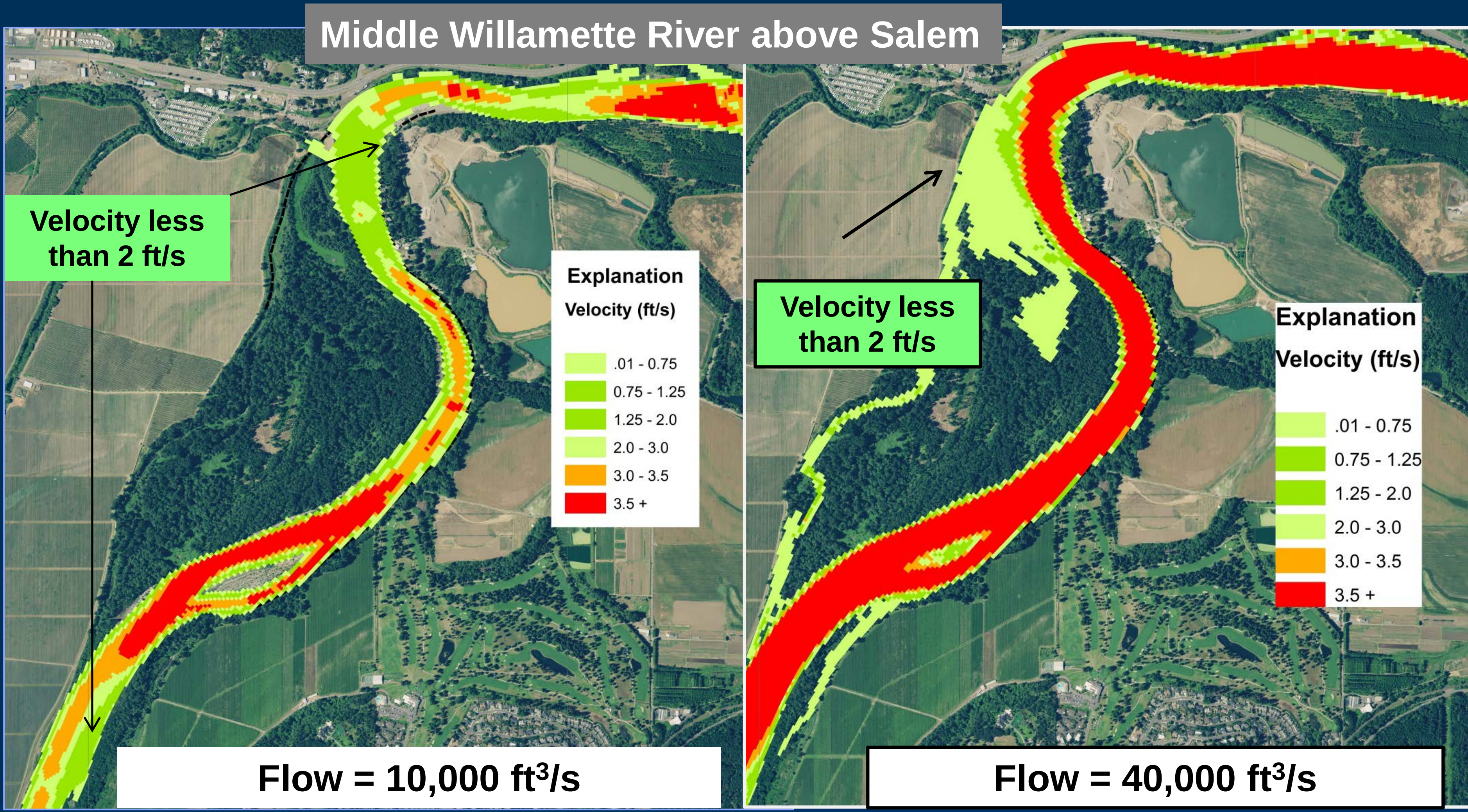
Middle Willamette River near Independence,
photo by Norman Buccola, USACE

Upper Willamette River near Eugene

Critical habitat and geomorphic classifications of Willamette Basin



Rearing habitat availability varies with channel morphology and streamflow



Preliminary , uncalibrated 2D hydraulic model results using Delft3D FM on Willamette River between Independence and Salem. Modeling by James White, USGS

Linking place, process and strategy to address habitat limitations

Dynamic areas where habitat forming processes intact:

?

- Flows to inundate and maintain channel and thermal diversity
- Land conservation to minimize future losses

Stable areas where habitat-forming processes (currently) inactive:

?

- Flows to inundate existing features
- Direct enhancement to address barriers and key gaps
- Restore channel dynamics?

Throughout floodplain:

- Restore floodplain forest

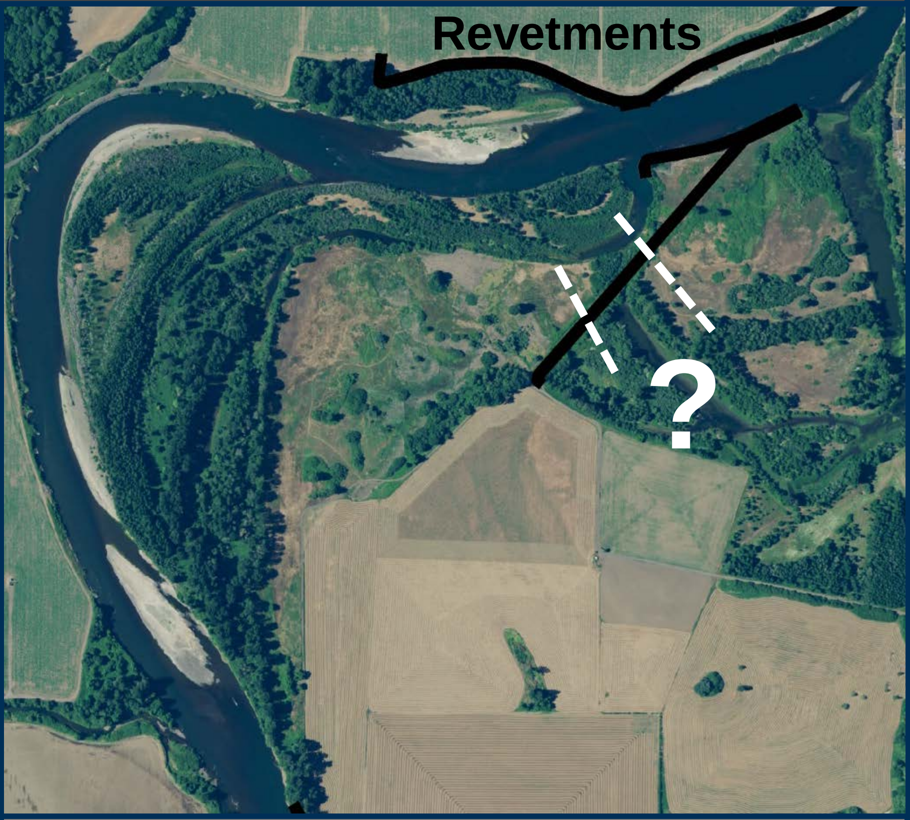
USGS

Sources: WAHWG, 2015; HTT, 2015; WWMP, 2017

Photos courtesy Freshwaters Illustrated

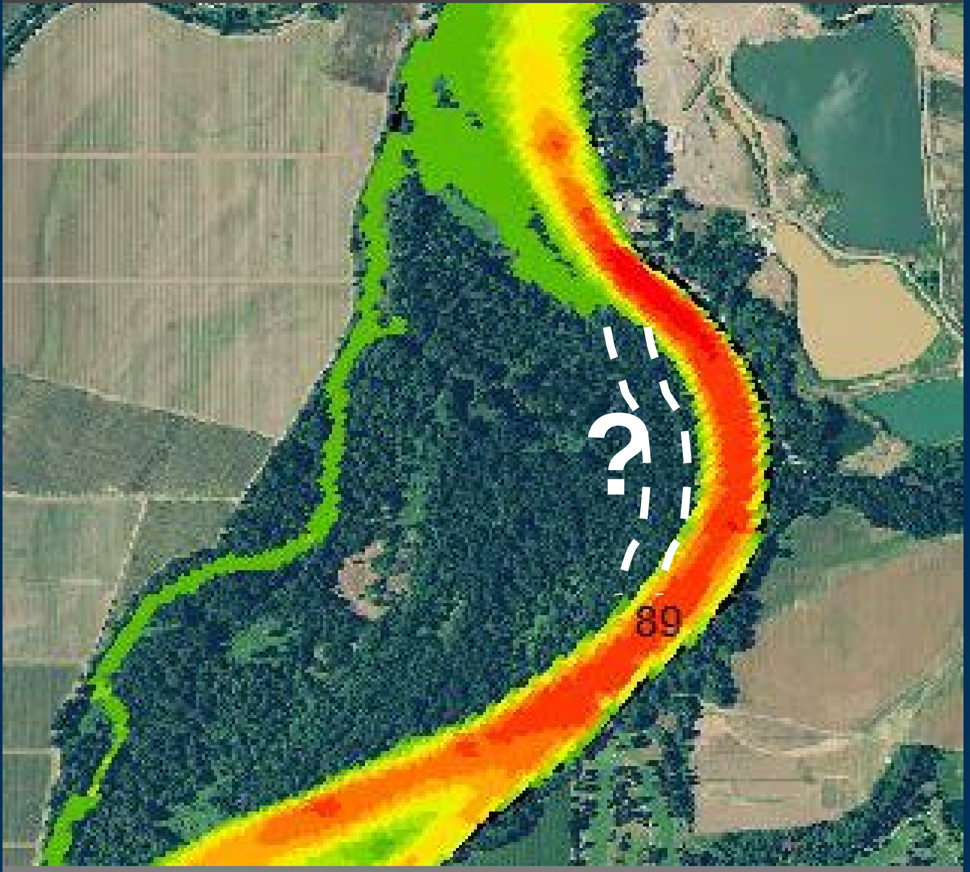
Potential strategies for increasing habitat complexity through channel dynamism

USFWS's Snag Boat Bend, Upper Willamette River, near Peoria



USACE revetments limit inundation and scour of off-channel features and are potential candidates for future modification.

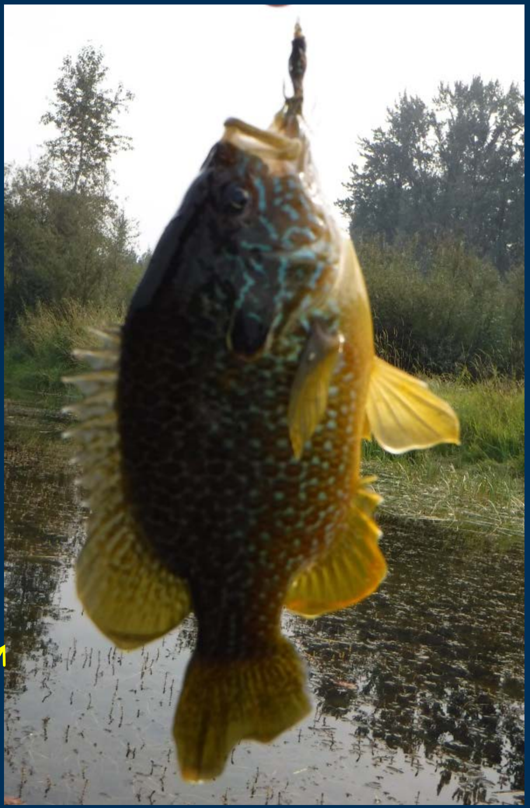
ODFW's Gail Acherman Wildlife Area, Middle Willamette River, near Salem



Lack of disturbance transformed former bare gravel bar to mature floodplain. Preliminary modeled inundation and velocity at 40,000 cfs by James White, USGS

Even dynamic reaches can have challenges

In most years, much of Willamette River exceeds 18° C from late June through August, Rounds and others, in prep.



Summary and Discussion

Downstream reaches may be critical for life history diversity, *even with access to habitat above Willamette dams provided*

River habitat conditions below dams are substantially altered

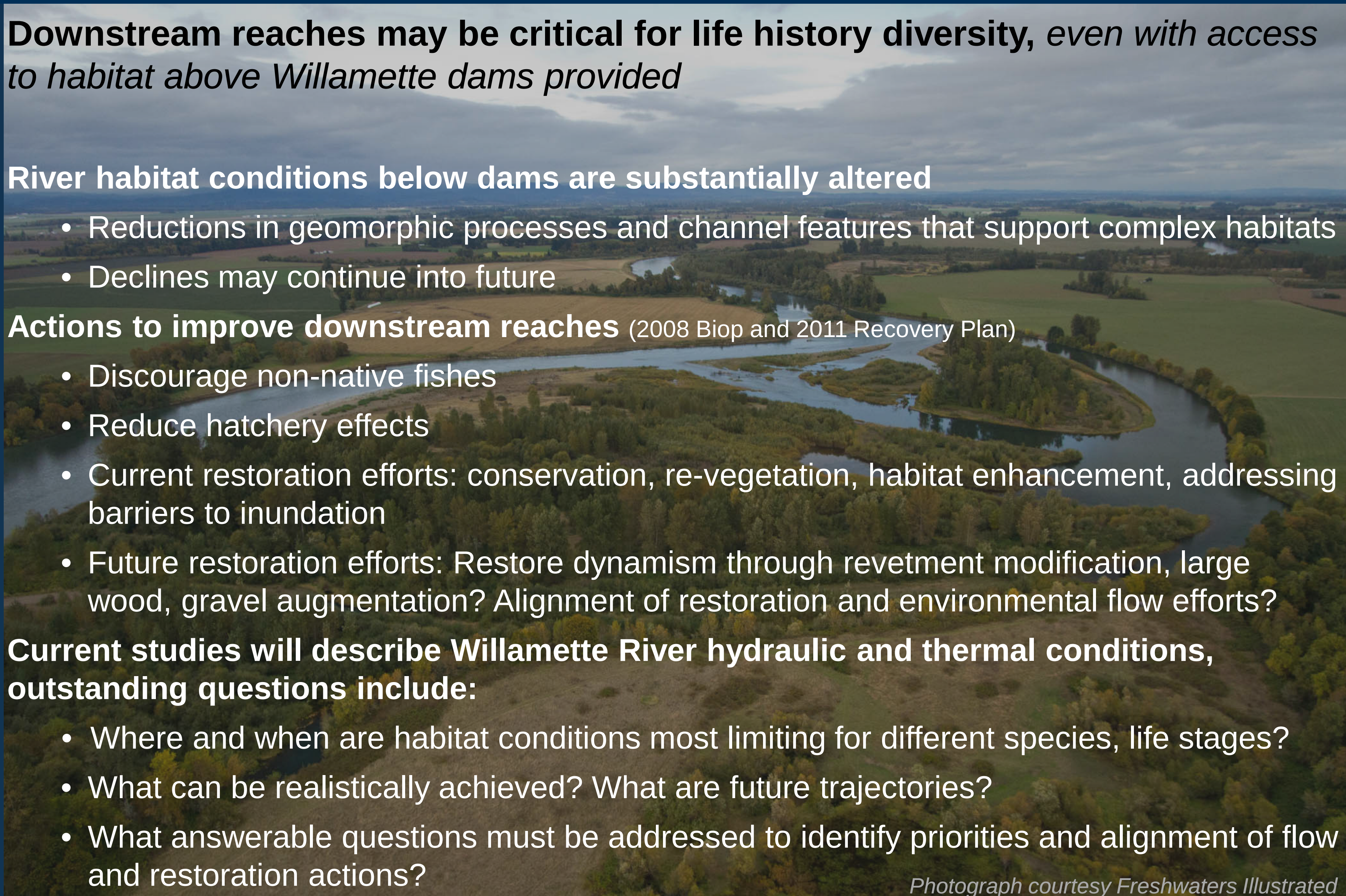
- Reductions in geomorphic processes and channel features that support complex habitats
- Declines may continue into future

Actions to improve downstream reaches (2008 Biop and 2011 Recovery Plan)

- Discourage non-native fishes
- Reduce hatchery effects
- Current restoration efforts: conservation, re-vegetation, habitat enhancement, addressing barriers to inundation
- Future restoration efforts: Restore dynamism through revetment modification, large wood, gravel augmentation? Alignment of restoration and environmental flow efforts?

Current studies will describe Willamette River hydraulic and thermal conditions, outstanding questions include:

- Where and when are habitat conditions most limiting for different species, life stages?
- What can be realistically achieved? What are future trajectories?
- What answerable questions must be addressed to identify priorities and alignment of flow and restoration actions?



Photograph courtesy Freshwaters Illustrated

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Photo courtesy Freshwaters Illustrated

Extra slides

Responses to extreme reductions in flooding and gravel transport

Middle Fork Willamette River, September 2012

Gravel supply vs transport

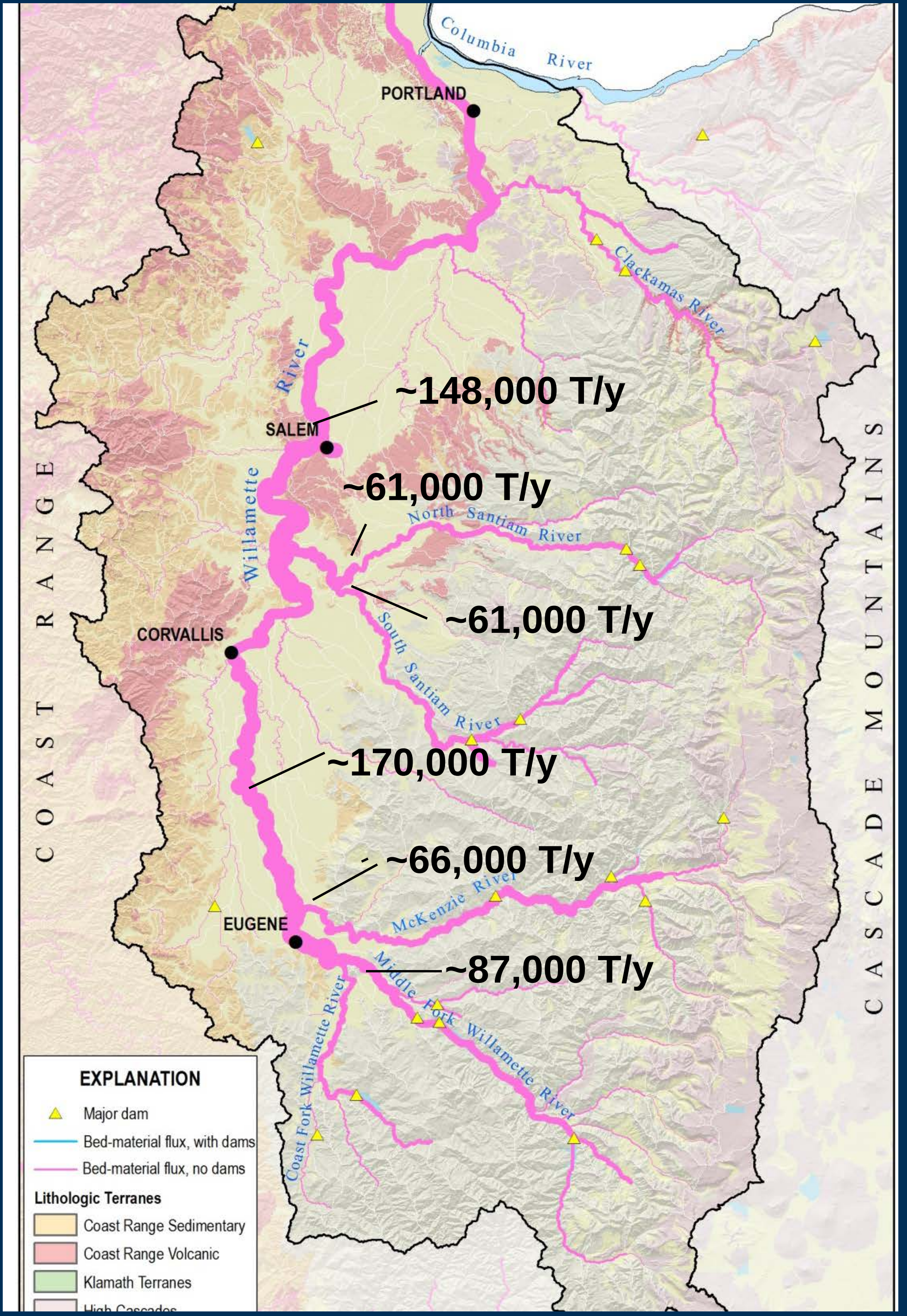
Supply:
Gravel volume & characteristics

Transport Capacity:
Amount of gravel a river can carry

Pre-dam gravel transport

Bed-material transport without dams
(width of pink line corresponds to flux)

Flux estimated from geology and slope; accounts for in-channel attrition



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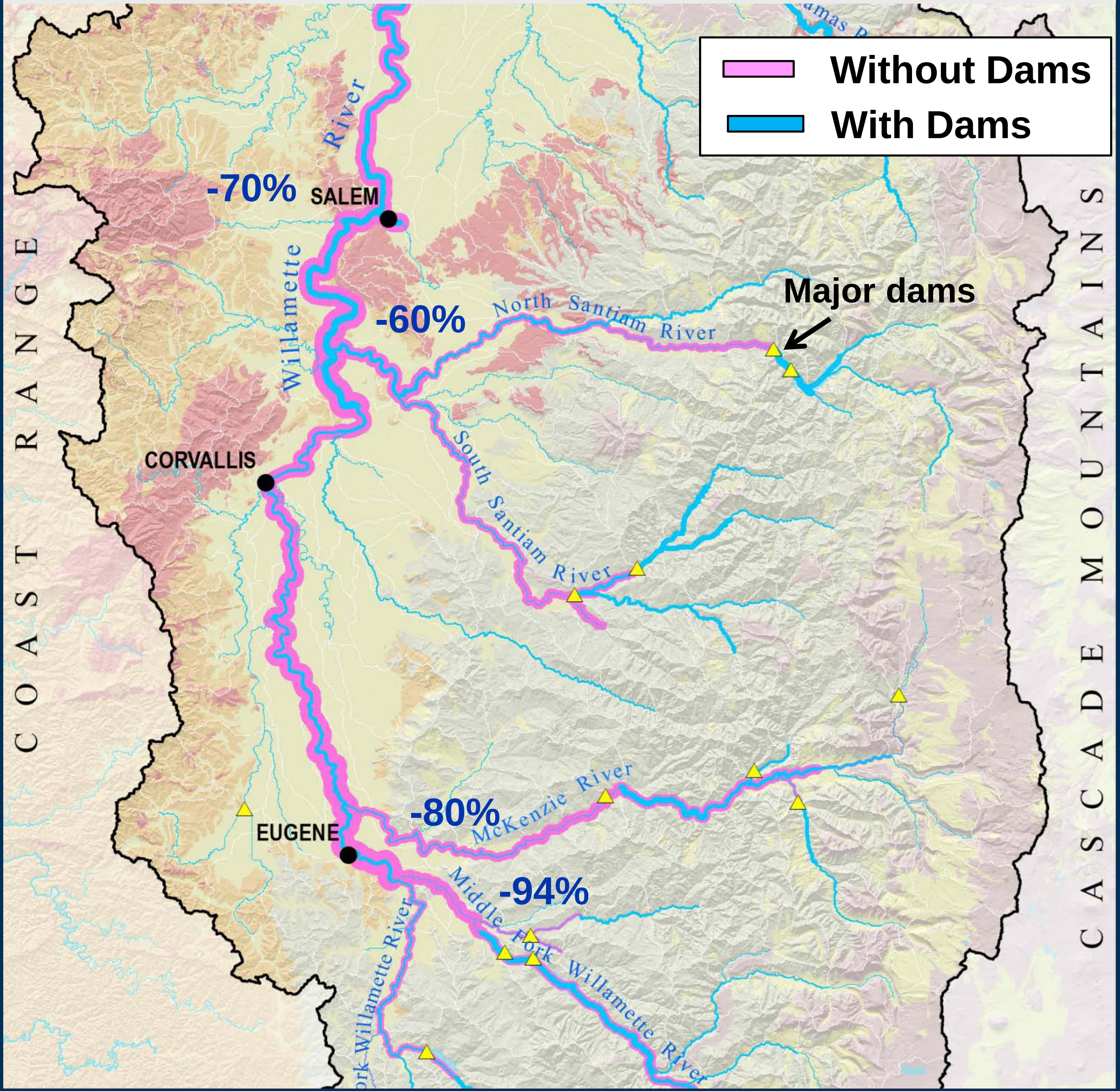
Map prepared by JoJo Mangano from relations presented in O'Connor et al., 2014

Changes in Gravel Supply

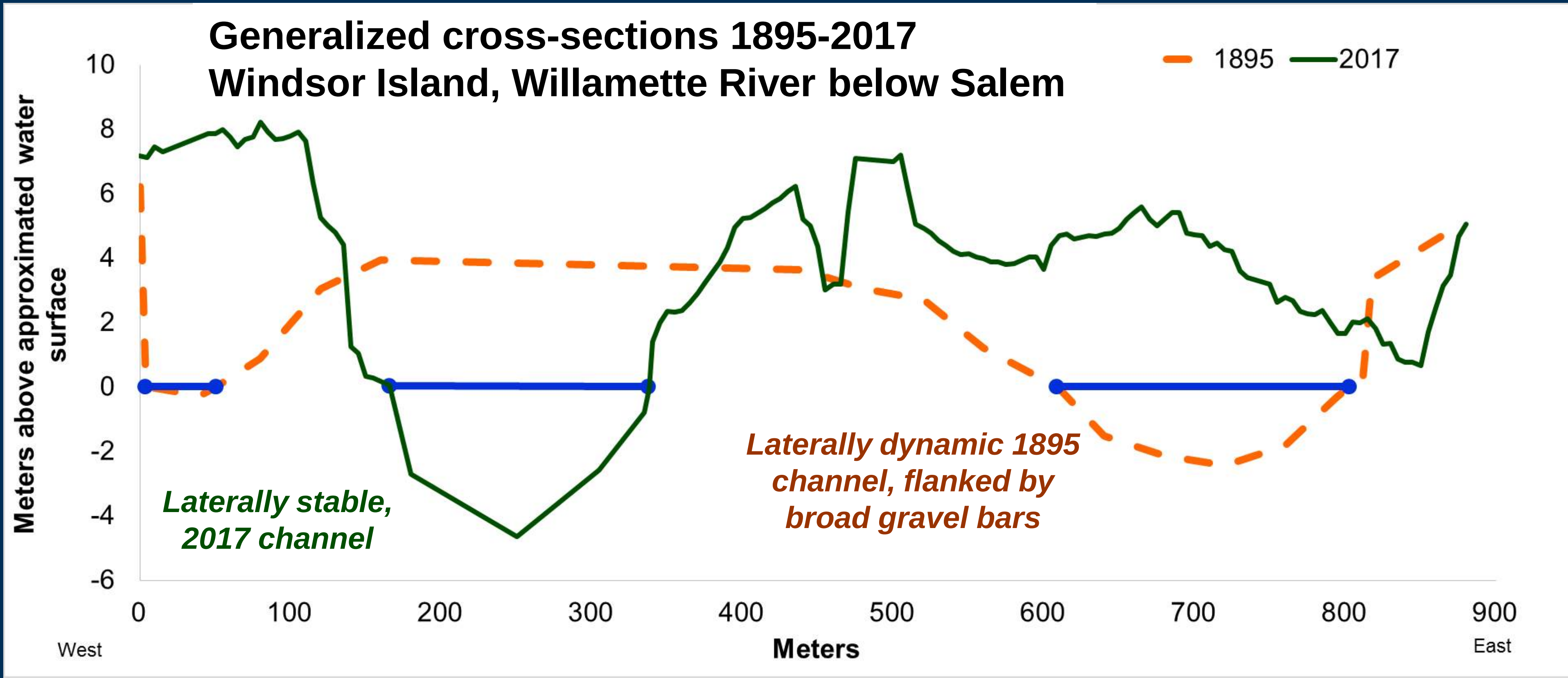
Upstream dams result in ~2/3 reduction in bedload flux at Salem

Produced by JoJo Mangano, from O'Connor et al., 2014

Bed-Material Flux, with sediment trapping

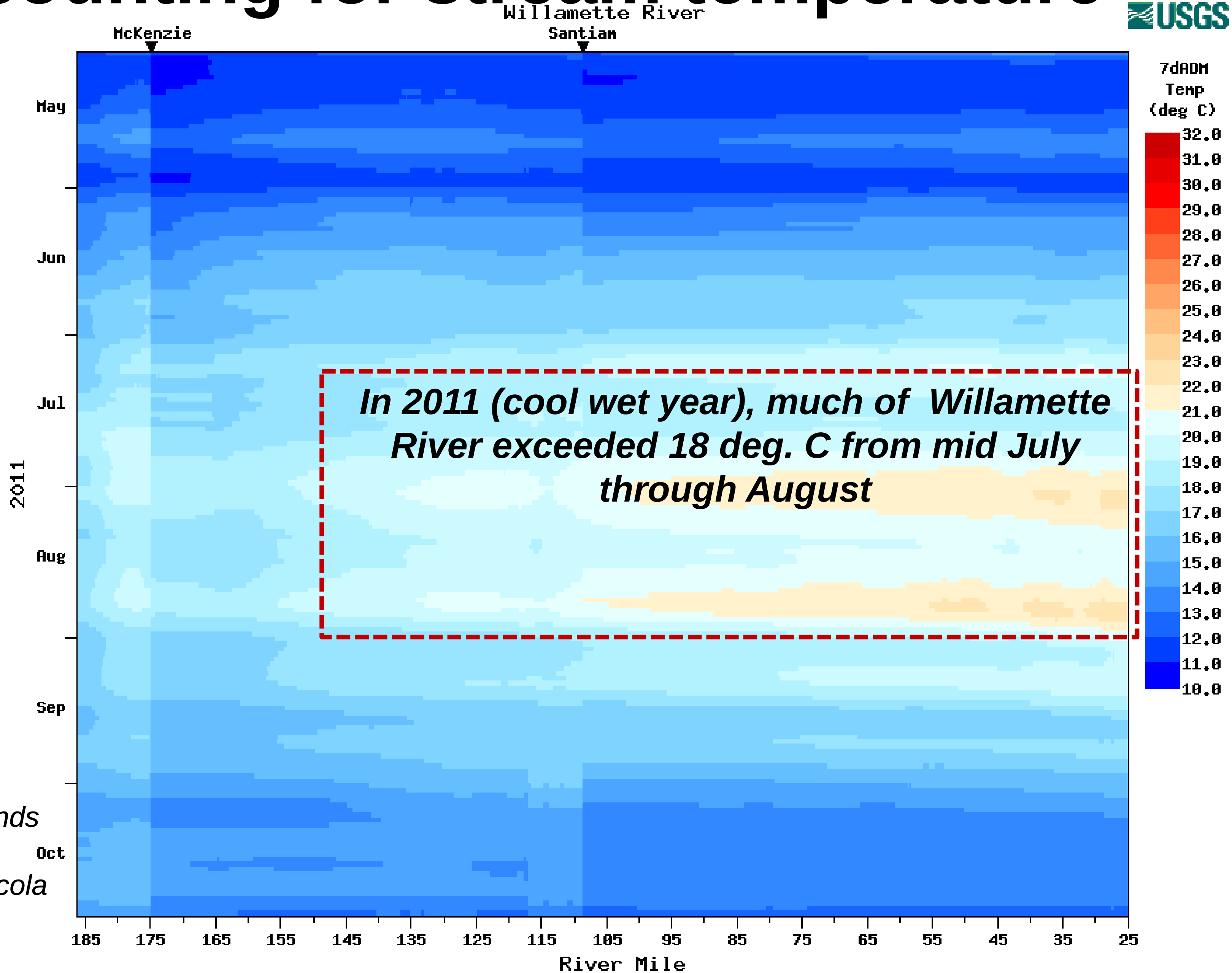


Geomorphic process, channel features and habitat availability

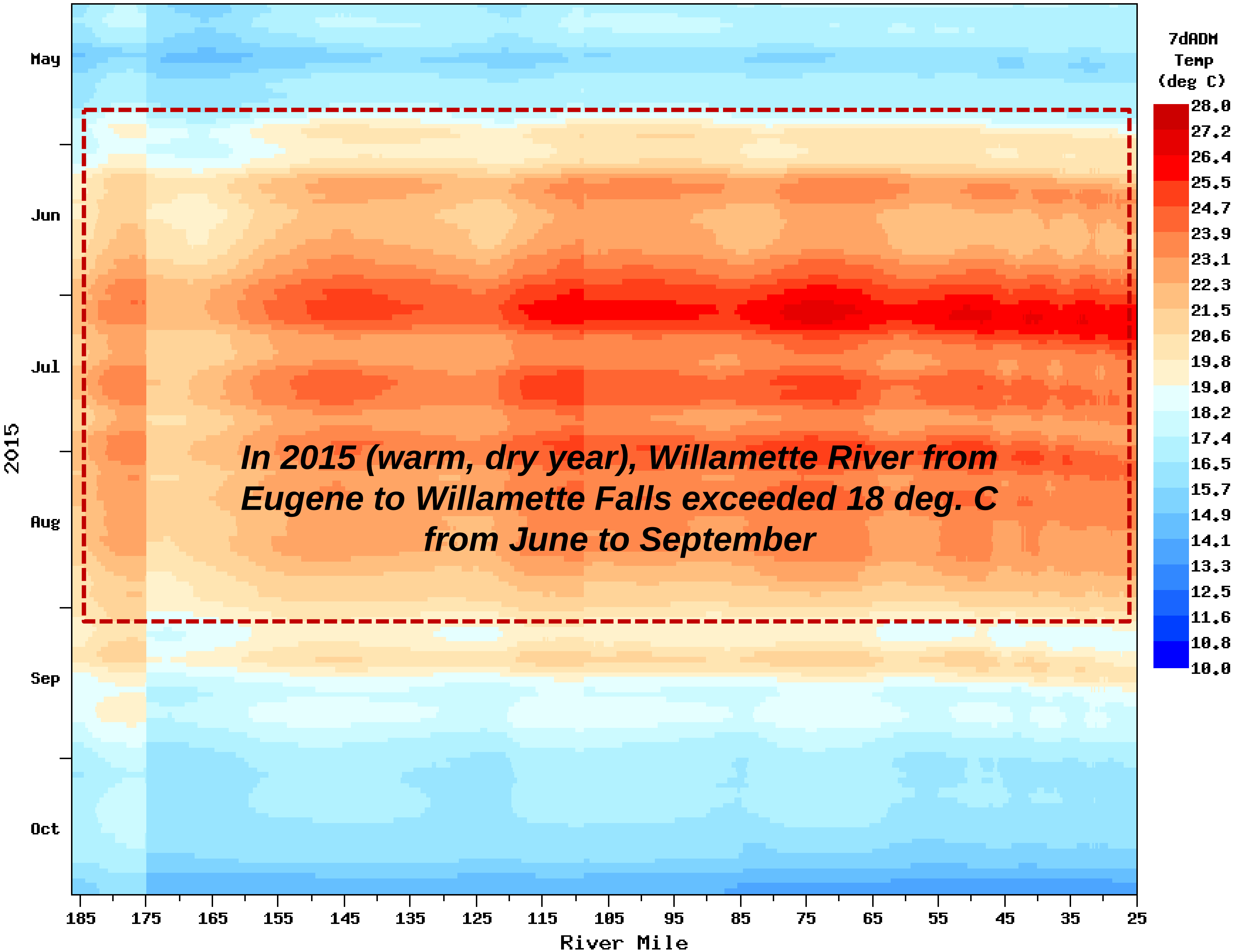


2017 topography from provisional topo-bathy lidar by QSI, Inc. and USGS boat-based surveys; 1895 topography from USACE navigational charts. Provisional data and analyses, subject to revision. Prepared by Gabe Gordon, USGS.

Accounting for stream temperature



Provisional temperature modeling by Stewart Rounds (USGS), Norman Buccola (USACE)



In 2015 (warm, dry year), Willamette River from Eugene to Willamette Falls exceeded 18 deg. C from June to September
7dADM
Temp
(deg C)
28.0
27.2
26.4
25.5
24.7
23.9
23.1
22.3
21.5
20.6
19.8
19.0
18.2
17.4
16.5
15.7
14.9
14.1
13.3
12.5
11.6
10.8
10.0
May
Jun
Jul
Aug
Sep
Oct
2015
185
175
165
155
145
135
125
115
105
95
85
75
65
55
45
35
25
River Mile