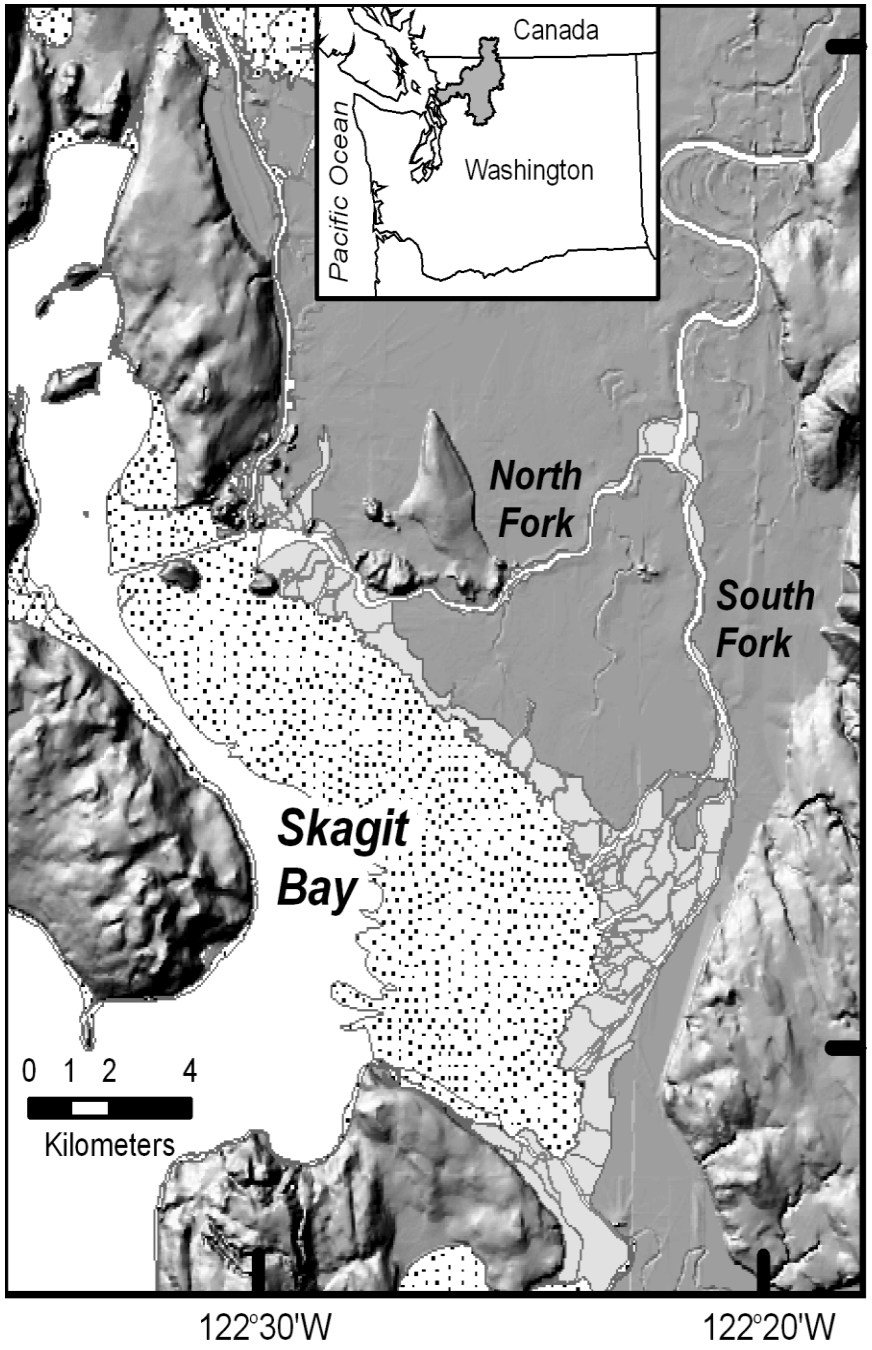
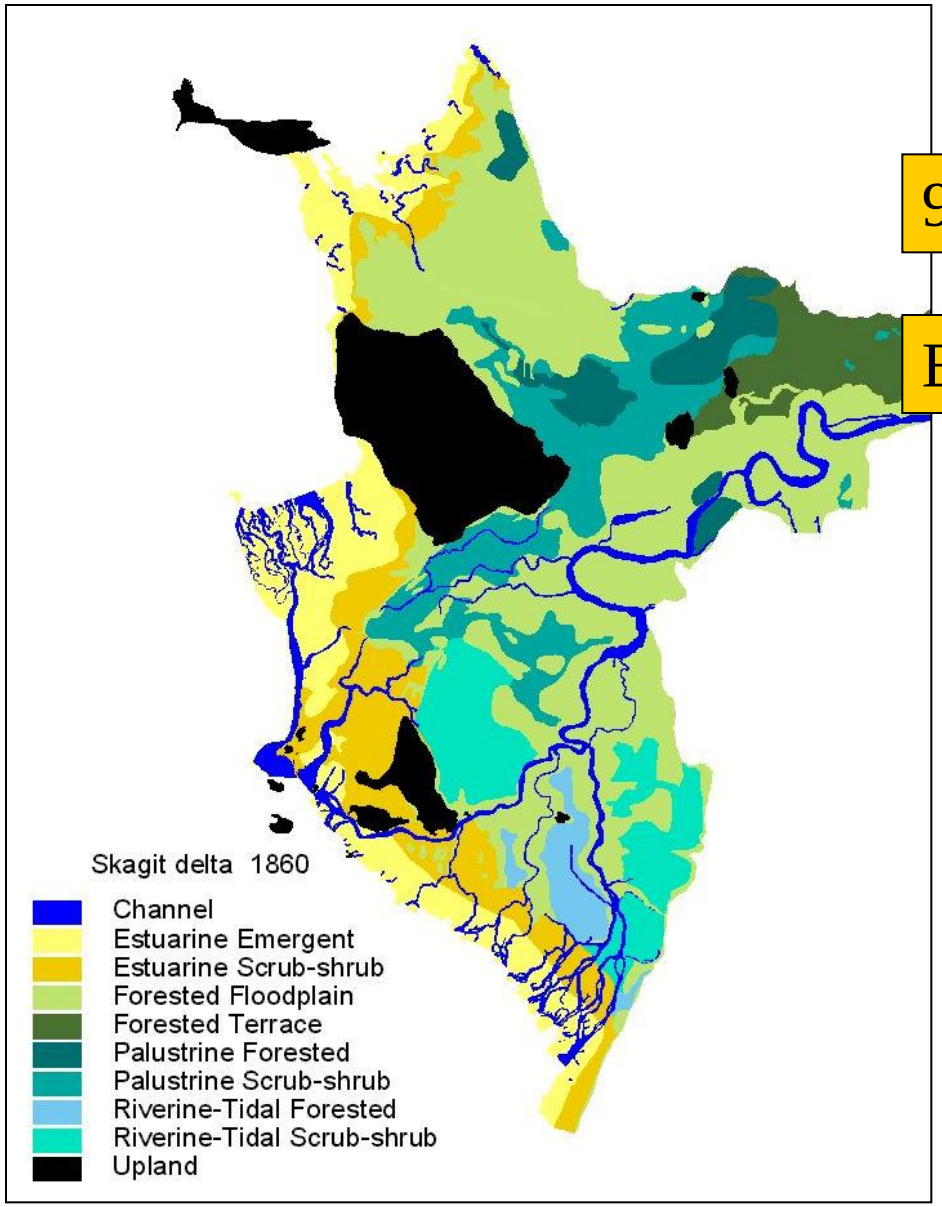
Beaver in tidal marshes: Dam effects on low-tide channel pools and fish use of estuarine habitat

W. Gregory Hood
Skagit River System Cooperative

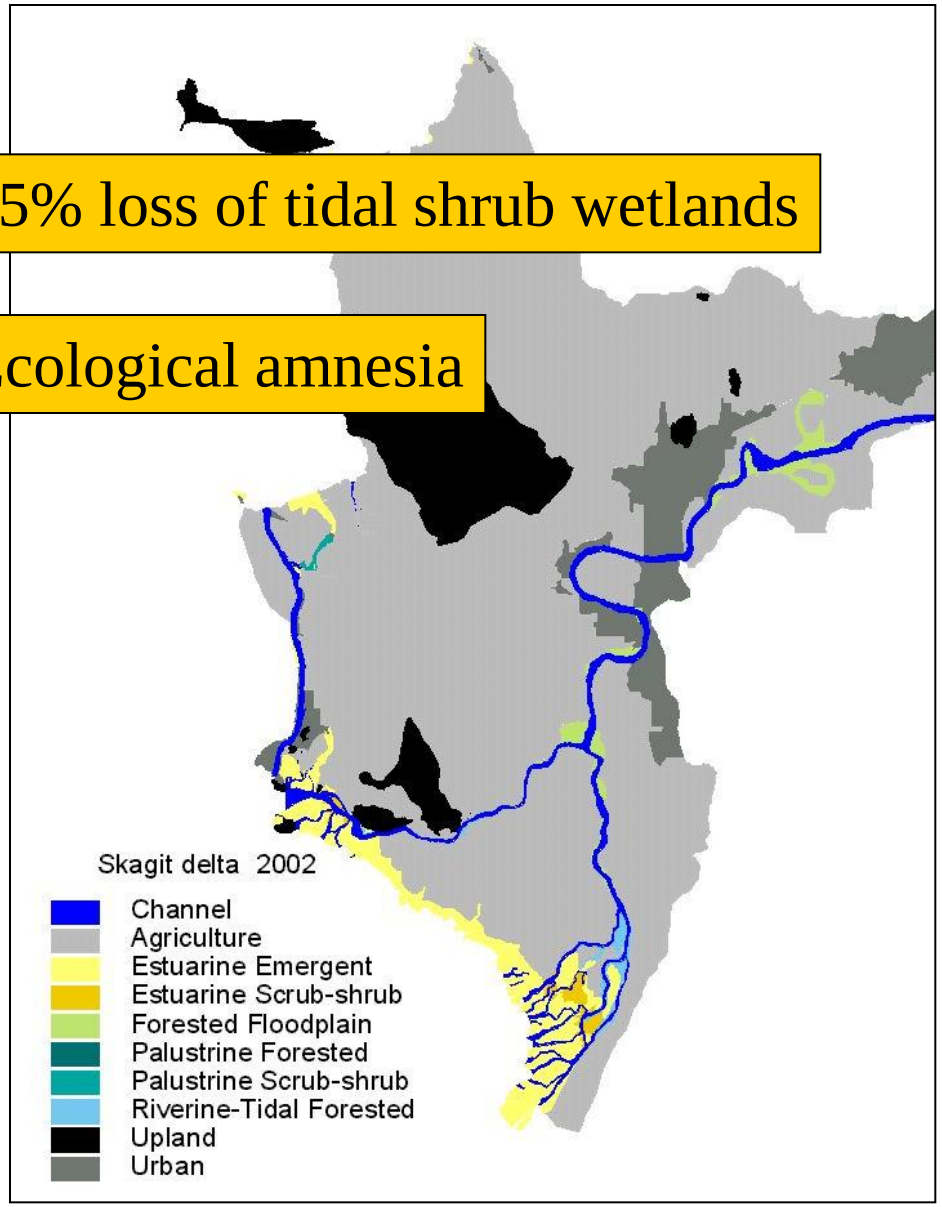

Canada
Pacific Ocean
Washington
North Fork
South Fork
Skagit Bay
0 1 2 4
Kilometers
48°28'N
48°18'N
122°30'W
122°20'W

Skagit Historical and Current Deltas



95% loss of tidal shrub wetlands

Ecological amnesia



B. Collins 2001 (University of Washington)

W. G. Hood, unpublished (Skagit System Cooperative)

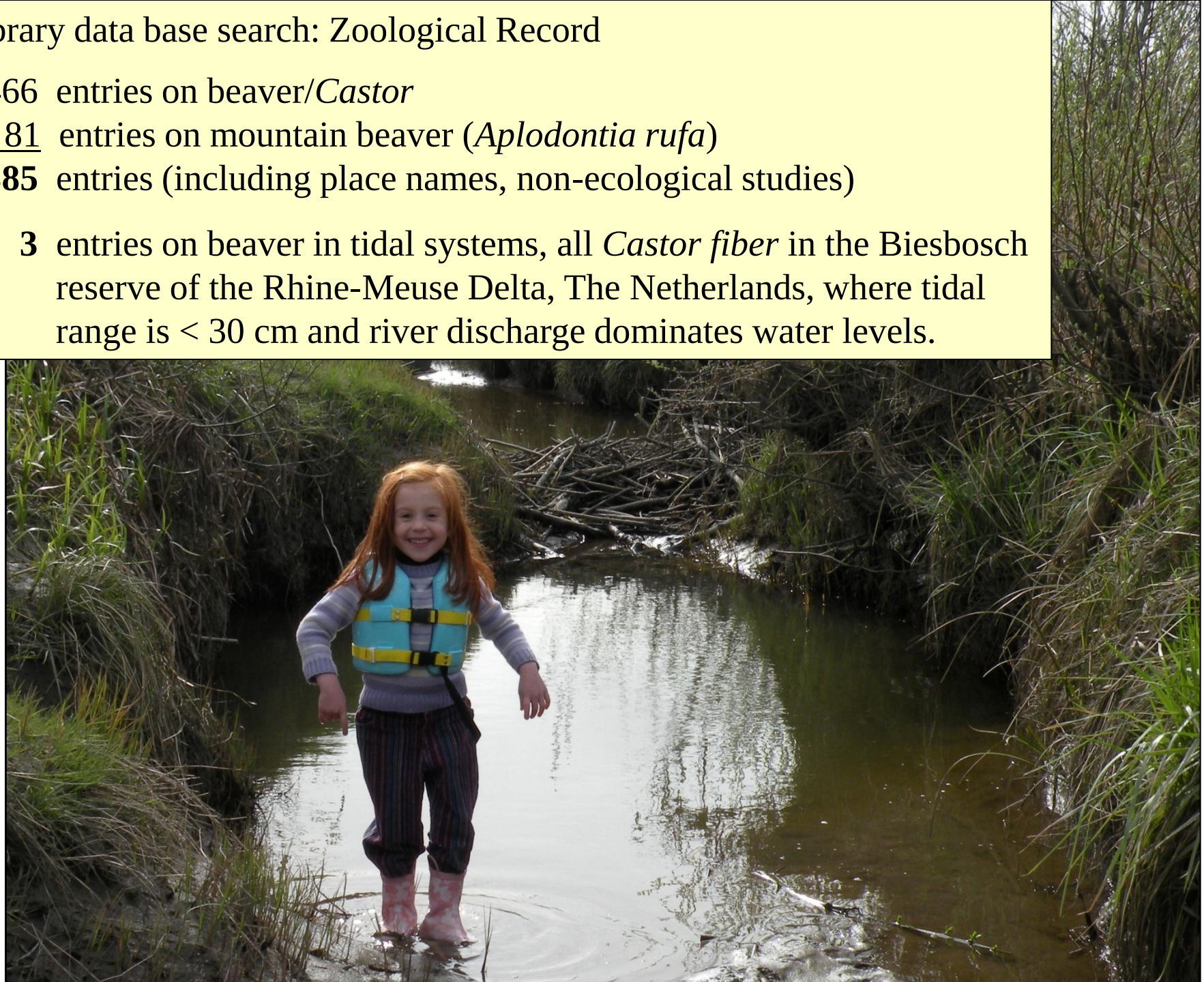
Library data base search: Zoological Record

1466 entries on beaver/*Castor*

- 81 entries on mountain beaver (*Aplodontia rufa*)

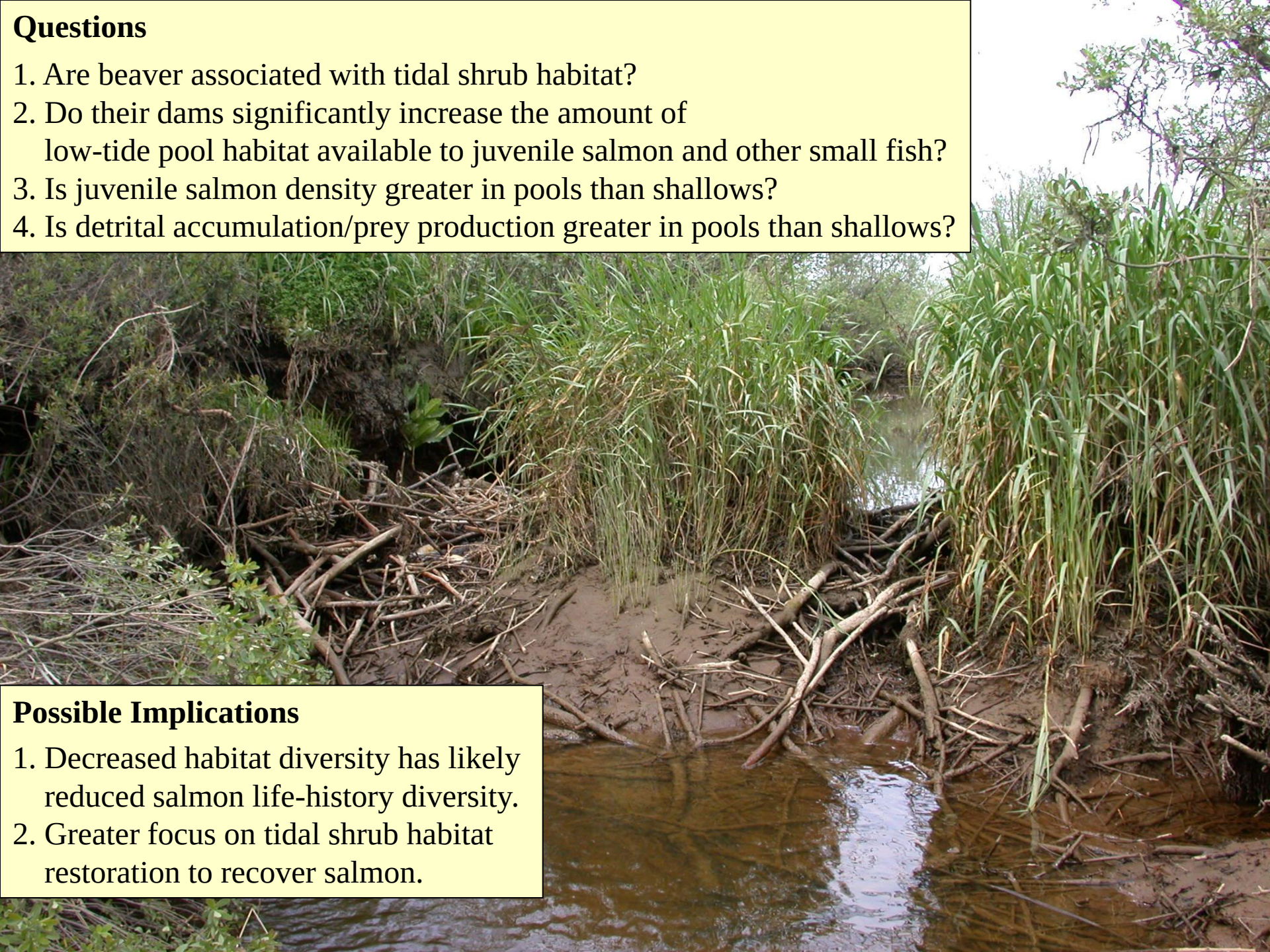
1385 entries (including place names, non-ecological studies)

3 entries on beaver in tidal systems, all *Castor fiber* in the Biesbosch reserve of the Rhine-Meuse Delta, The Netherlands, where tidal range is < 30 cm and river discharge dominates water levels.



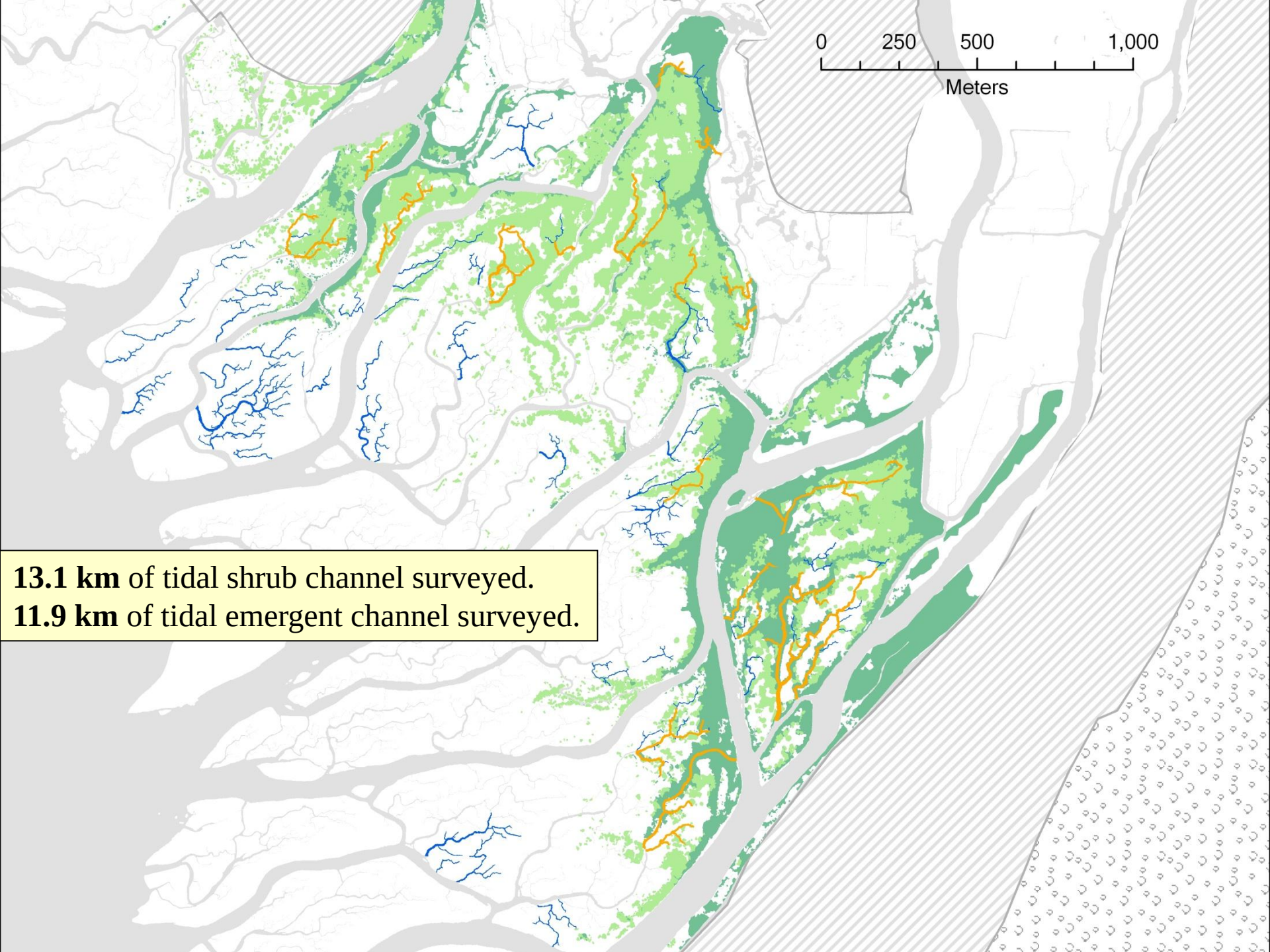
Questions

1. Are beaver associated with tidal shrub habitat?
2. Do their dams significantly increase the amount of low-tide pool habitat available to juvenile salmon and other small fish?
3. Is juvenile salmon density greater in pools than shallows?
4. Is detrital accumulation/prey production greater in pools than shallows?

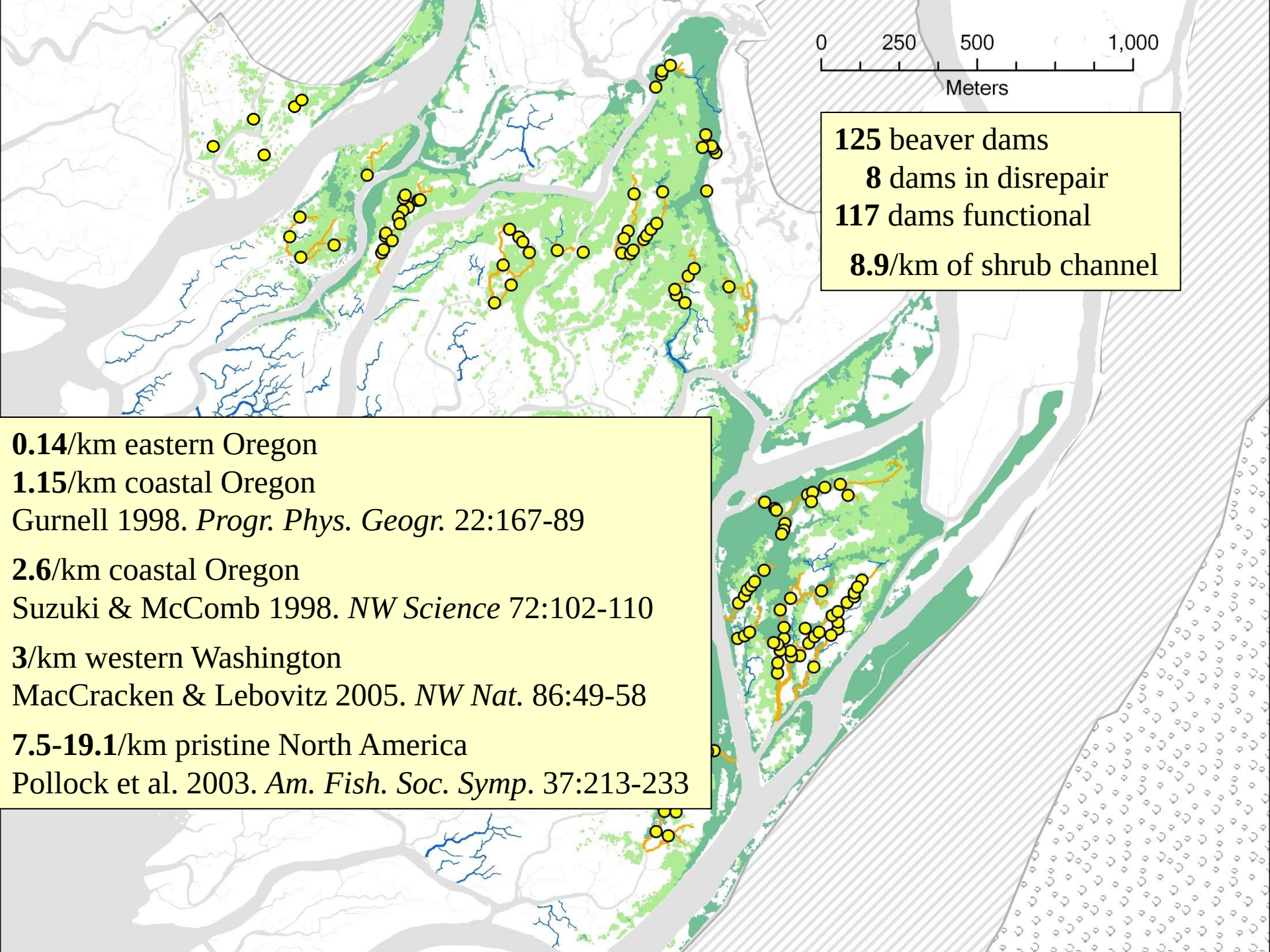


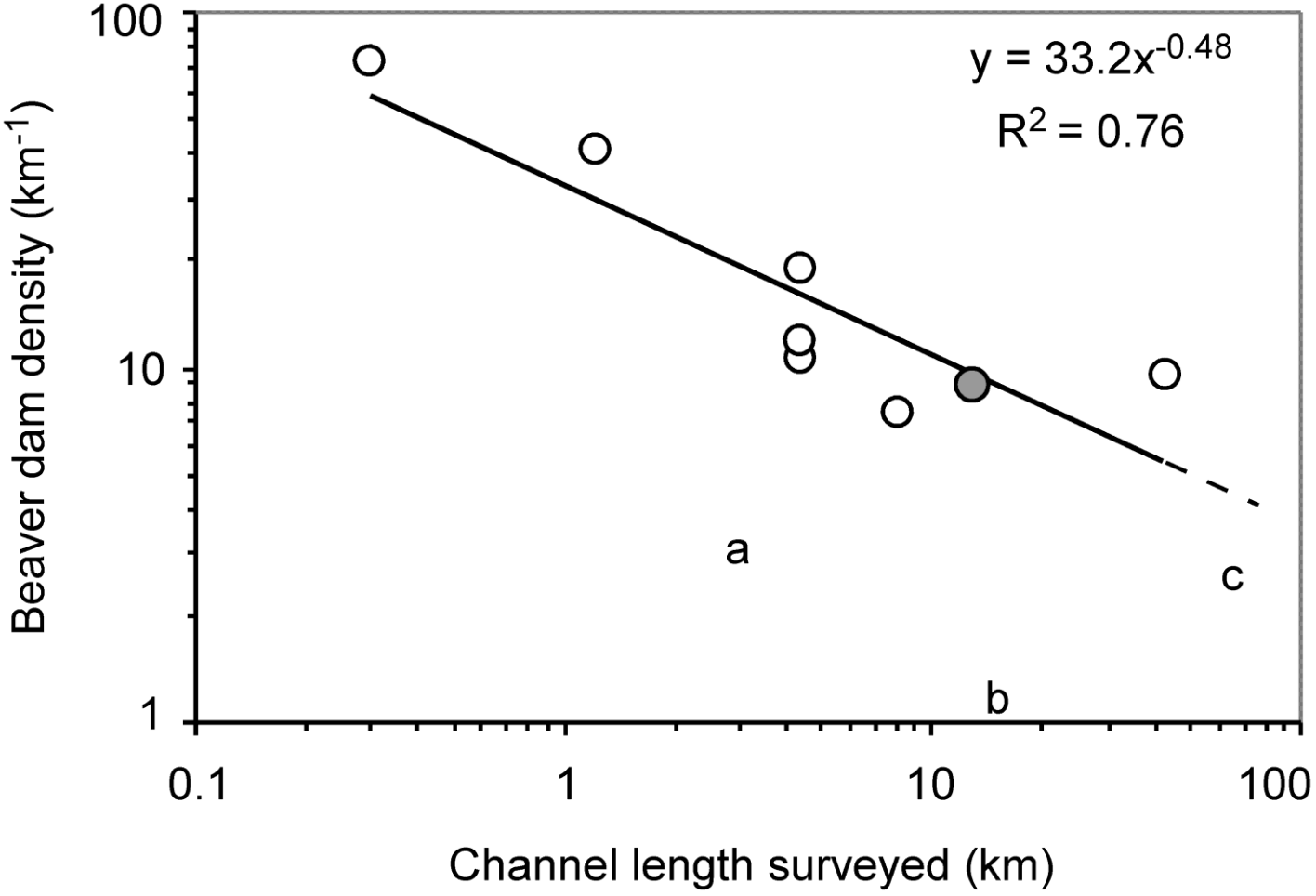
Possible Implications

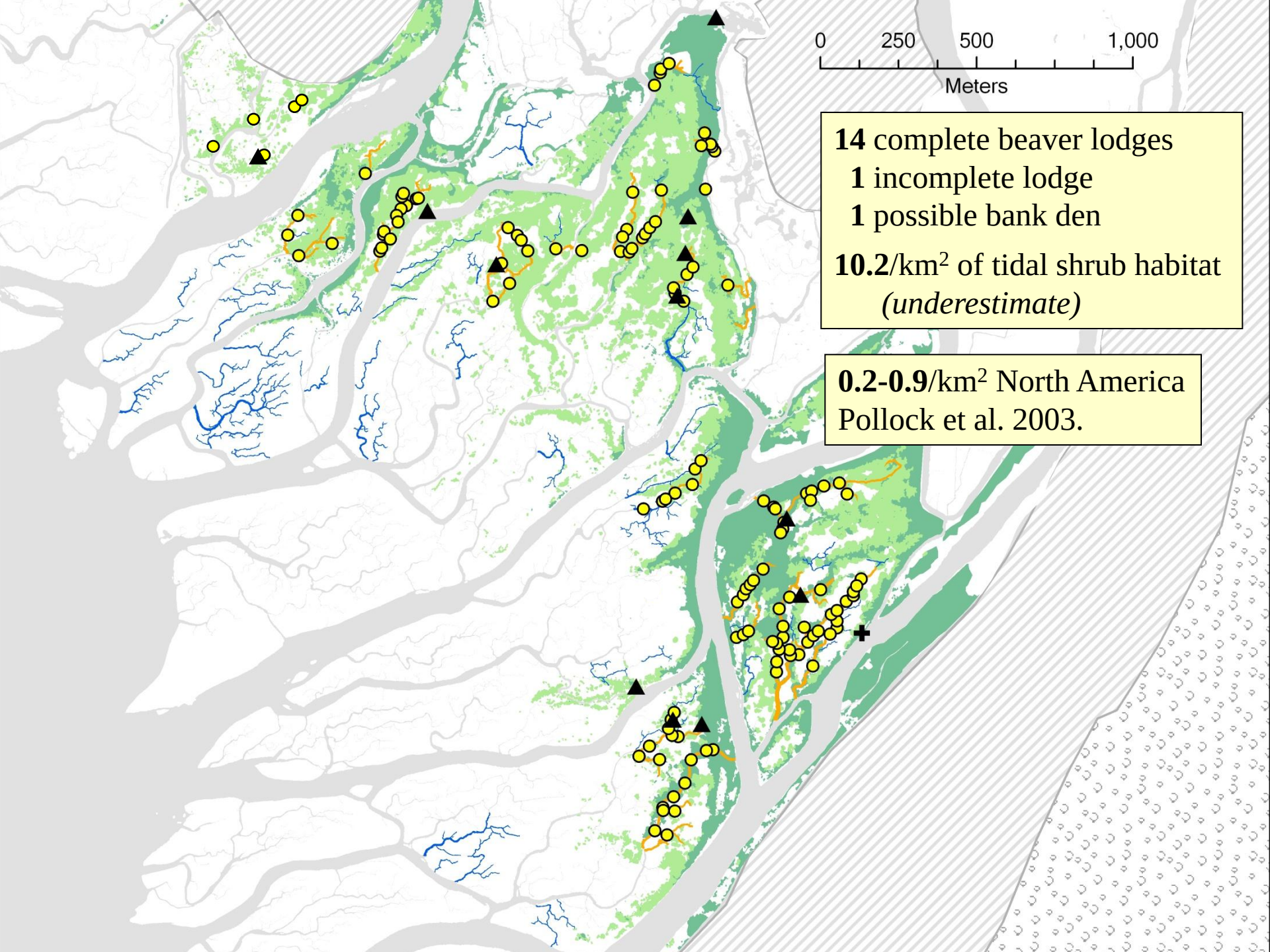
1. Decreased habitat diversity has likely reduced salmon life-history diversity.
2. Greater focus on tidal shrub habitat restoration to recover salmon.

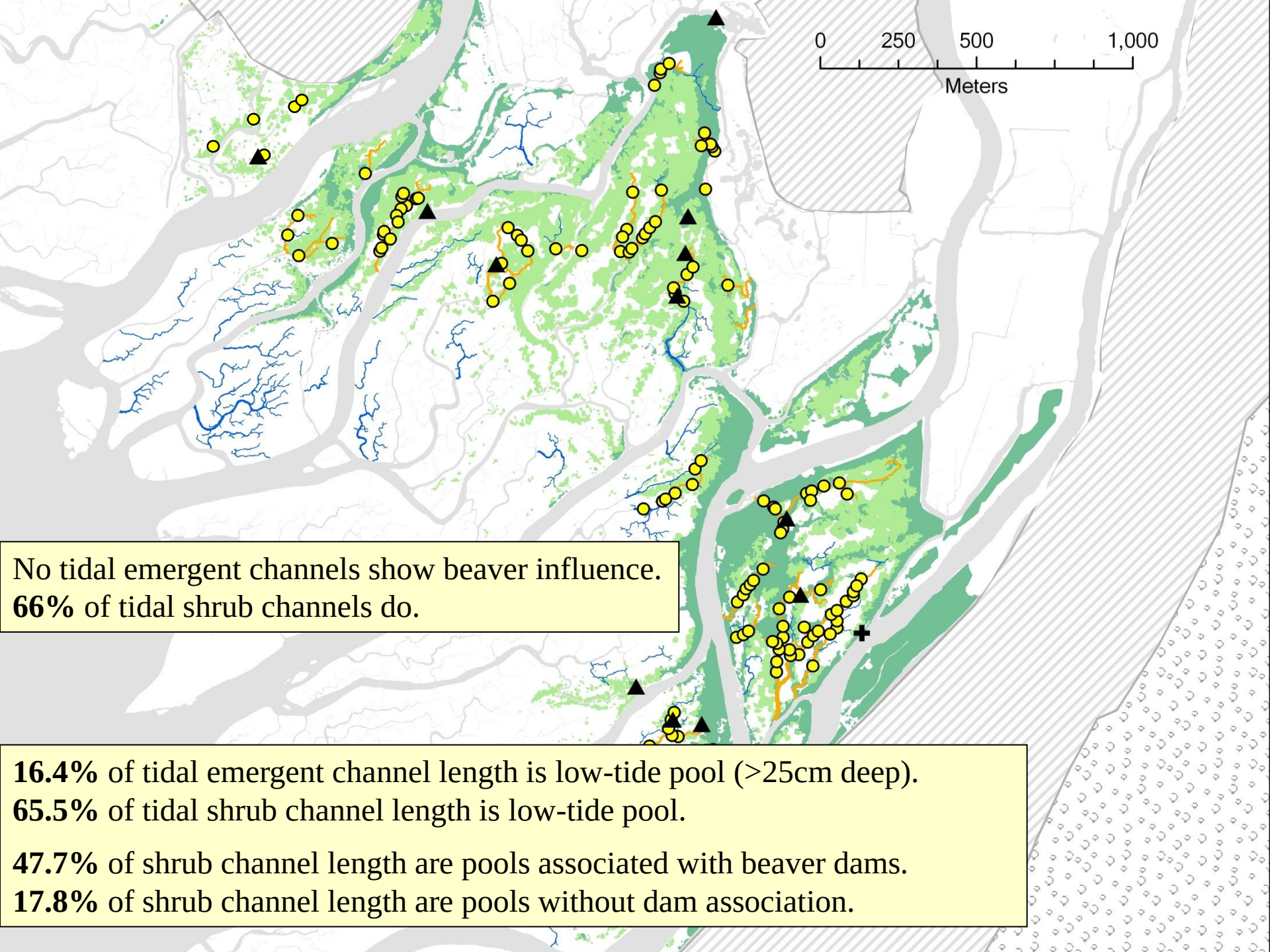


13.1 km of tidal shrub channel surveyed.
11.9 km of tidal emergent channel surveyed.


0
250
500
1,000
Meters
125 beaver dams
8 dams in disrepair
117 dams functional
8.9/km of shrub channel
0.14/km eastern Oregon
1.15/km coastal Oregon
Gurnell 1998. Progr. Phys. Geogr. 22:167-89
2.6/km coastal Oregon
Suzuki & McComb 1998. NW Science 72:102-110
3/km western Washington
MacCracken & Lebovitz 2005. NW Nat. 86:49-58
7.5-19.1/km pristine North America
Pollock et al. 2003. Am. Fish. Soc. Symp. 37:213-233


100
10
1
Beaver dam density (km-1)
y = 33.2x-0.48
R2 = 0.76
a
b
c
0.1
1
10
100
Channel length surveyed (km)

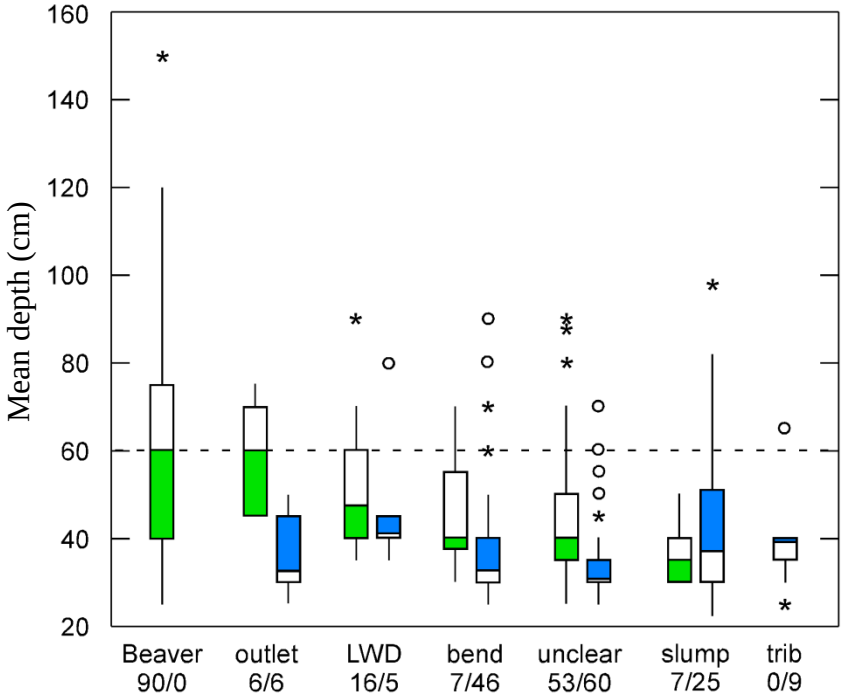

0
250
500
1,000
Meters
14 complete beaver lodges
1 incomplete lodge
1 possible bank den
10.2/km2 of tidal shrub habitat
(underestimate)
0.2-0.9/km2 North America
Pollock et al. 2003.



No tidal emergent channels show beaver influence.
66% of tidal shrub channels do.

16.4% of tidal emergent channel length is low-tide pool (>25cm deep).
65.5% of tidal shrub channel length is low-tide pool.

47.7% of shrub channel length are pools associated with beaver dams.
17.8% of shrub channel length are pools without dam association.

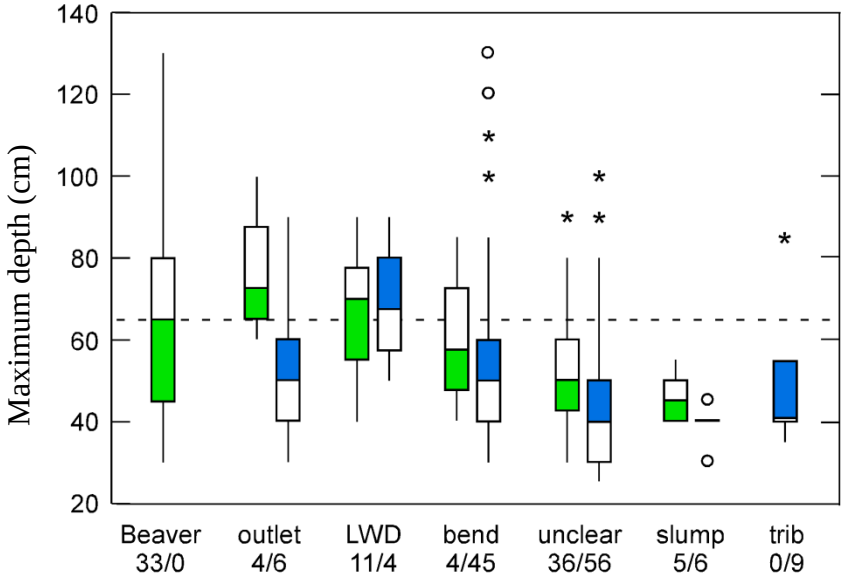


Beaver pools vs. all others

$\bar{x}$ = 60.8 cm 45.5 cm

t = 5.05, df = 144

p < 0.0001

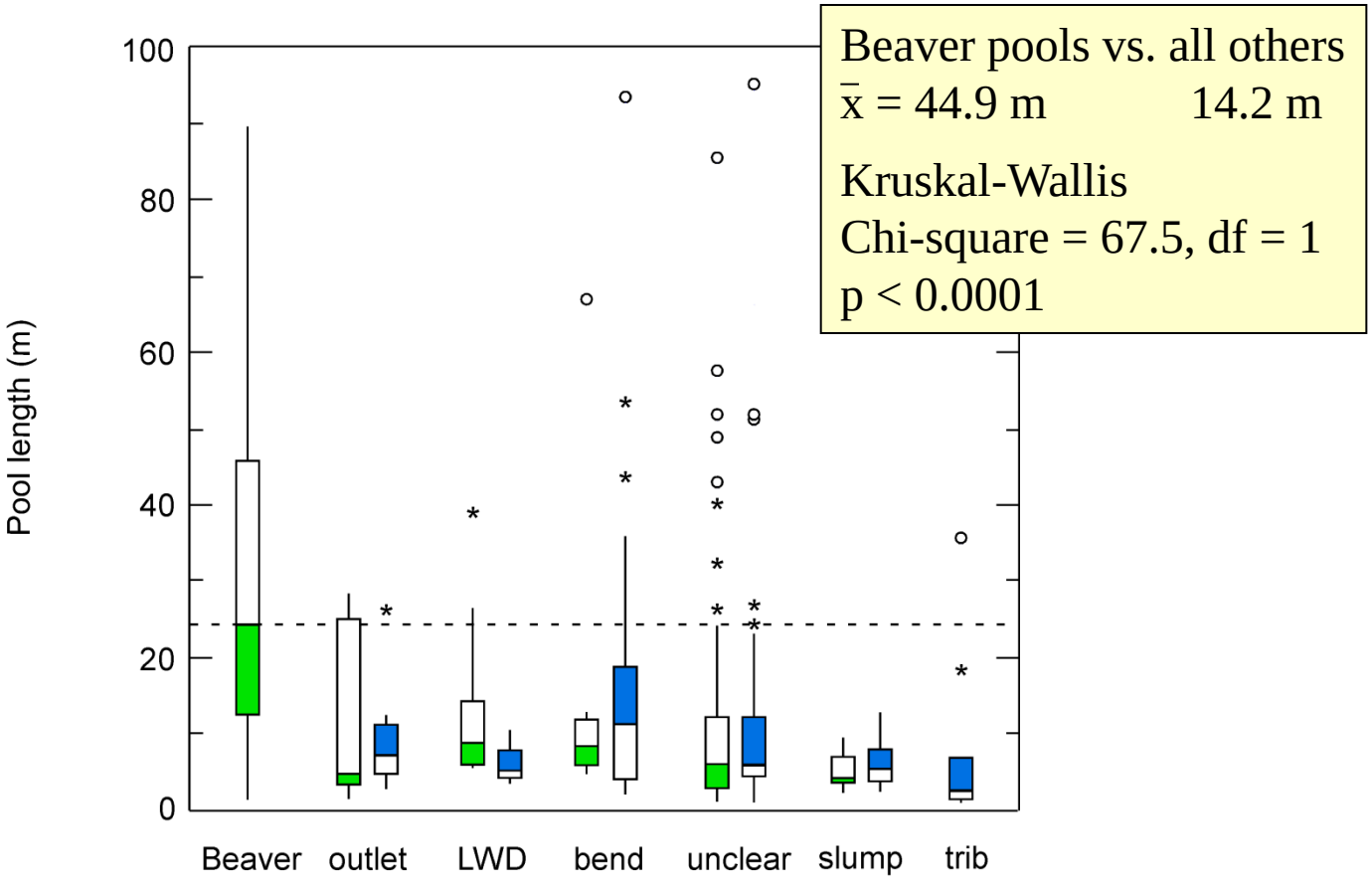


Beaver pools vs. all others

$\bar{x}$ = 65.5 cm 56.2 cm

t = 2.03, df = 49

p < 0.05


Beaver pools vs. all others
x̄ = 44.9 m 14.2 m
Kruskal-Wallis
Chi-square = 67.5, df = 1
p < 0.0001
Pool length (m)
100
80
60
40
20
0
Beaver
outlet
LWD
bend
unclear
slump
trib

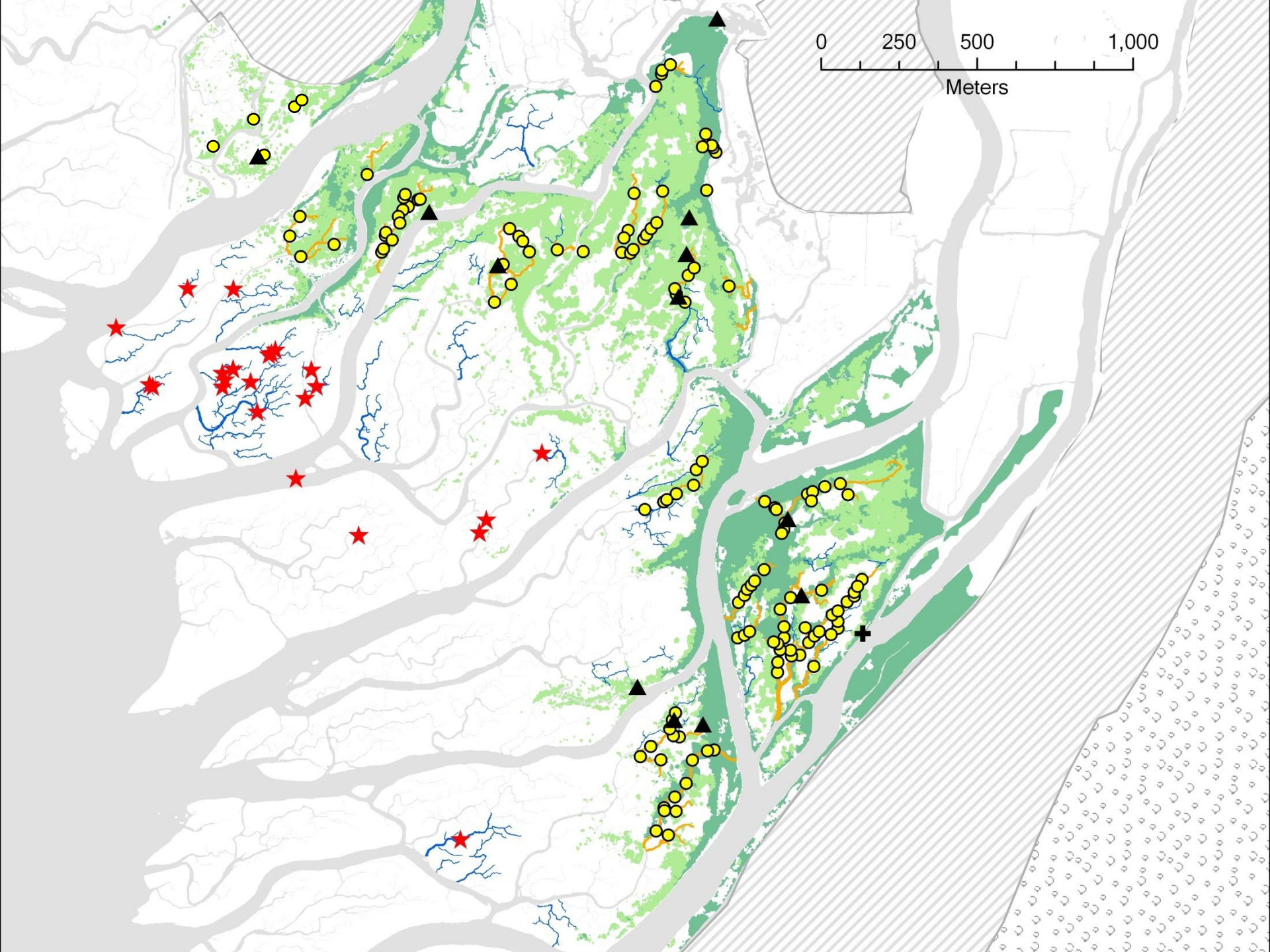
Fish Patterns

Chinook density was **3.2 x** higher in pools than shallows (per volume), ss = em.
Stickleback density was **2.2 x** higher in pools than shallows (per volume), ss = em.
Prickly sculpin densit was **7.5 x** higher in pools than shallows (per volume), ss = em.
River lamprey only present in pools.

Chum salmon were almost exclusively abundant in em-pools, rarely elsewhere.
Staghorn sculpin were mostly in the emergent zone, pools or shallows.

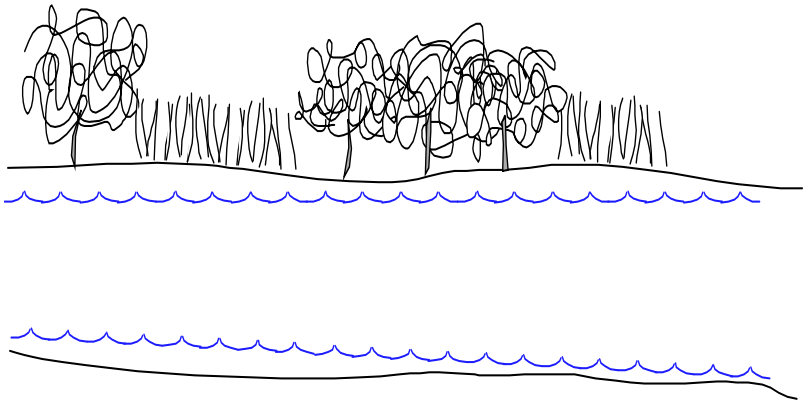
Seines in ss-channels were generally full of detritus.

Seines in em-channels were generally very clean.

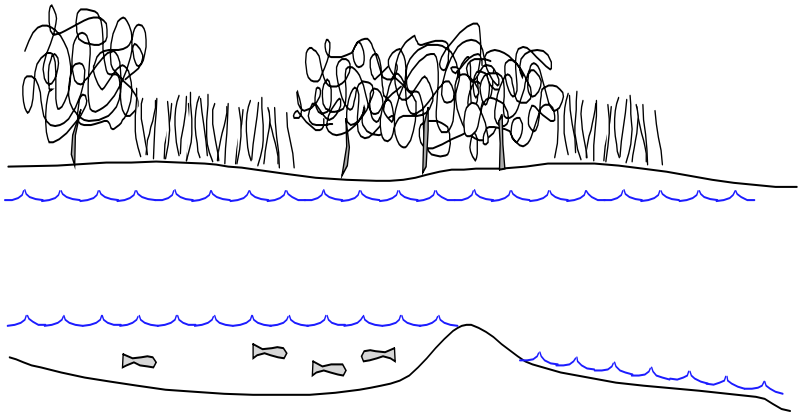

0
250
500
1,000
Meters

Frequency of occurrence (%, upper cell values) and density (m^{-3}, lower cell values in italics) of fish sampled in tidal channel segments at low tide.

Species	Shrub Pools	Shrub Shallows	Emergent Pools	Emergent Shallows
Three-spine Stickleback *Gasterosteus aculeatus*	**100.0** ***57.0***	**72.2** ***44.3***	**100.0** ***47.0***	**33.3** ***3.9***
Chinook Salmon *Oncorhynchus tshawytscha*	**55.6** ***0.36***	5.6 *0.20*	**50.0** ***0.48***	5.6 *0.06*
Chum Salmon *O. keta*	11.1 *0.03*	5.6 *0.03*	**50.0** ***0.83***	5.6 *0.06*
Coho Salmon *O. kisutch*	11.1 *0.07*	5.6 *0.07*	16.7 *0.63*	0 *0*
Prickly Sculpin *Cottus asper*	**61.1** ***0.37***	5.6 *0.20*	**44.4** ***1.17***	0 *0*
Staghorn Sculpin *Leptocottus armatus*	11.2 *0.07*	5.6 *0.08*	**38.9** ***1.21***	**16.7** ***0.74***
Starry Flounder *Platichthys stellatus*	11.2 *0.02*	11.2 *0.29*	11.2 *0.30*	5.6 *0.38*
River lamprey *Lampetra ayresi*	**27.8** -	0 -	**22.2** -	0 -



vs.

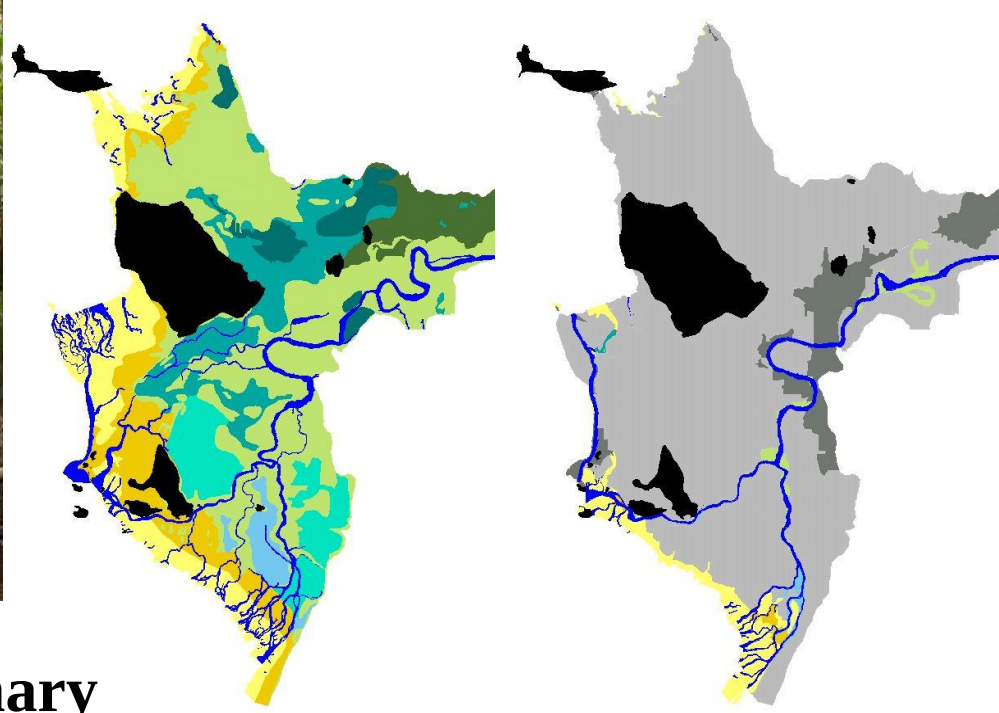


Upstream river management

LWD → Sweetgale Willow et al. → beaver → (4x) low-tide pools → (3x) fish (salmon)

Climate change
(sea-level rise, salinity)

Predation refuge
Detritus trapping
Prey production?



Summary

[1] We don't know as much as we think we do, e.g., we need to cure our ecological amnesia to understand what needs to be restored and why.

[2] Tidal shrub habitat in the PNW is generally missing from the landscape, with likely impacts to Chinook productivity. Estuarine habitat restoration should include greater focus on this missing habitat, other missing habitat types, and on the landscape and its structure generally.

[3] Other historical habitat types and their often unknown ecological functions and linkages are also missing from the modern landscape, e.g., surge plains, flood plains, pocket estuaries.