Estimating spring Chinook spawning and rearing capacity in the Upper Willamette River
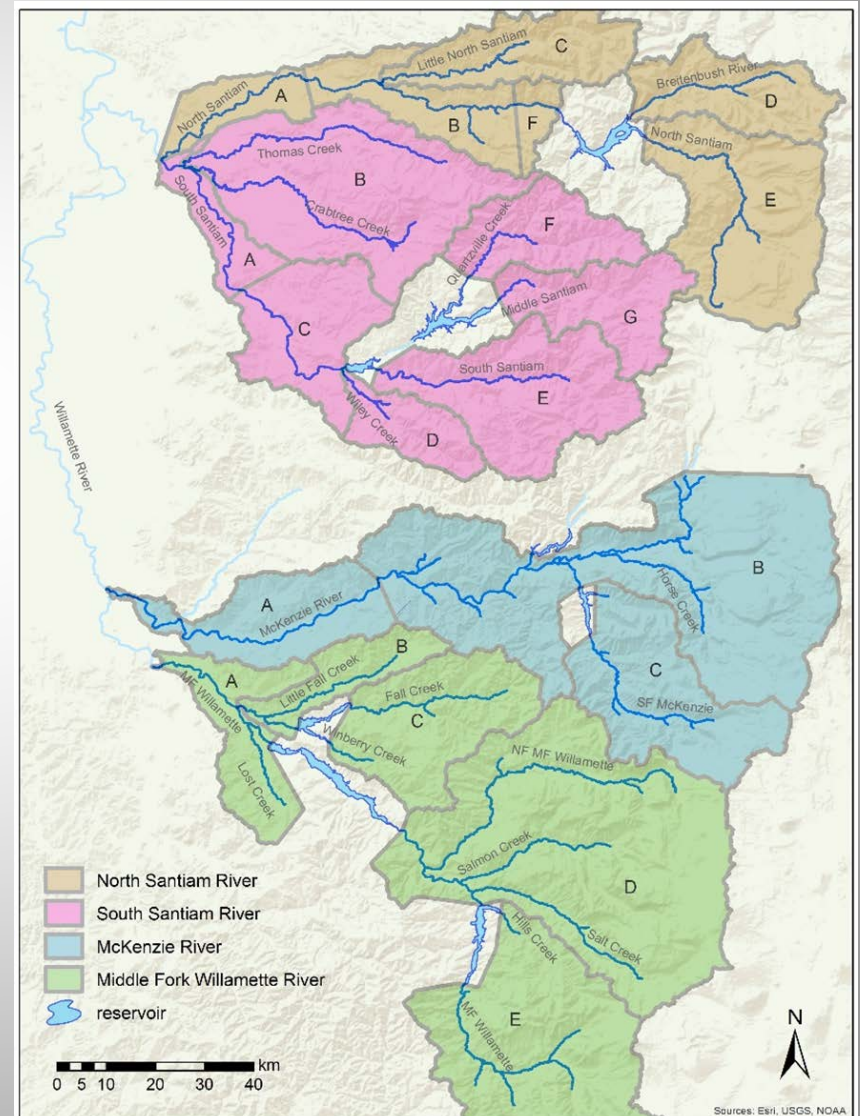
Morgan Bond, Tyler Nodine, Tim Beechie, Rich Zabel

NOAA Northwest Fisheries Science Center

WFSR, Corvallis, OR, Feb. 2017

Habitat based capacity to support life-cycle modeling

- Life-cycle modeling determines spatial extent

- Spawning capacity

- Rearing capacity (parr)

- Reservoir capacity

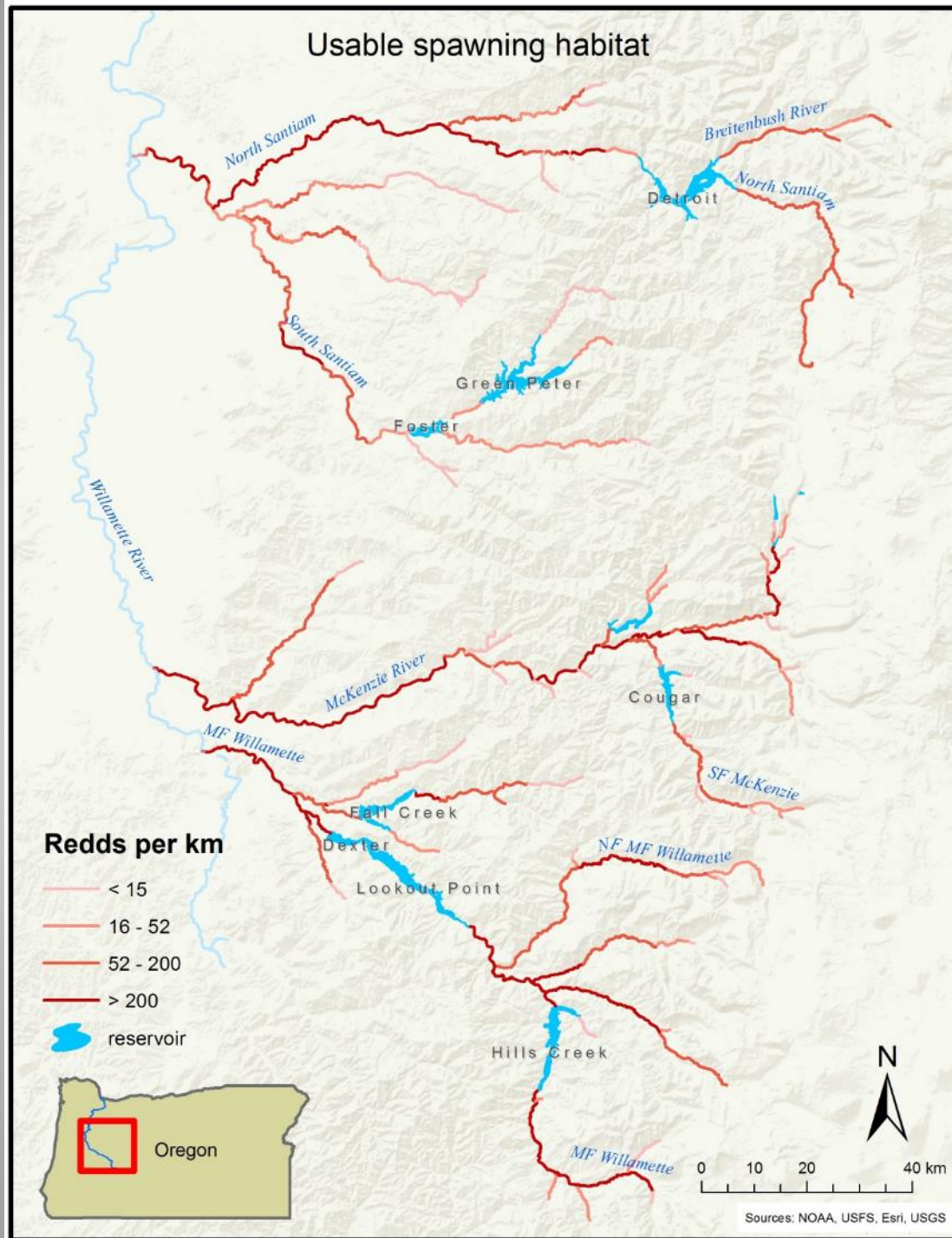# Upper Willamette R. spawning capacity

Spawning capacity above and below impoundments

- StreamNet (useable extent)
- ODFW fish passage barrier dataset
- Model stream width (Beechie and Imaki 2014)

How much habitat?

- Pre-dam gravel surveys (Bureau of Fisheries)

% Useable

- Redd size and redd defense
- NorWeST modeled stream temperatures (USFS, Isaak et al.)

% Spawn condition
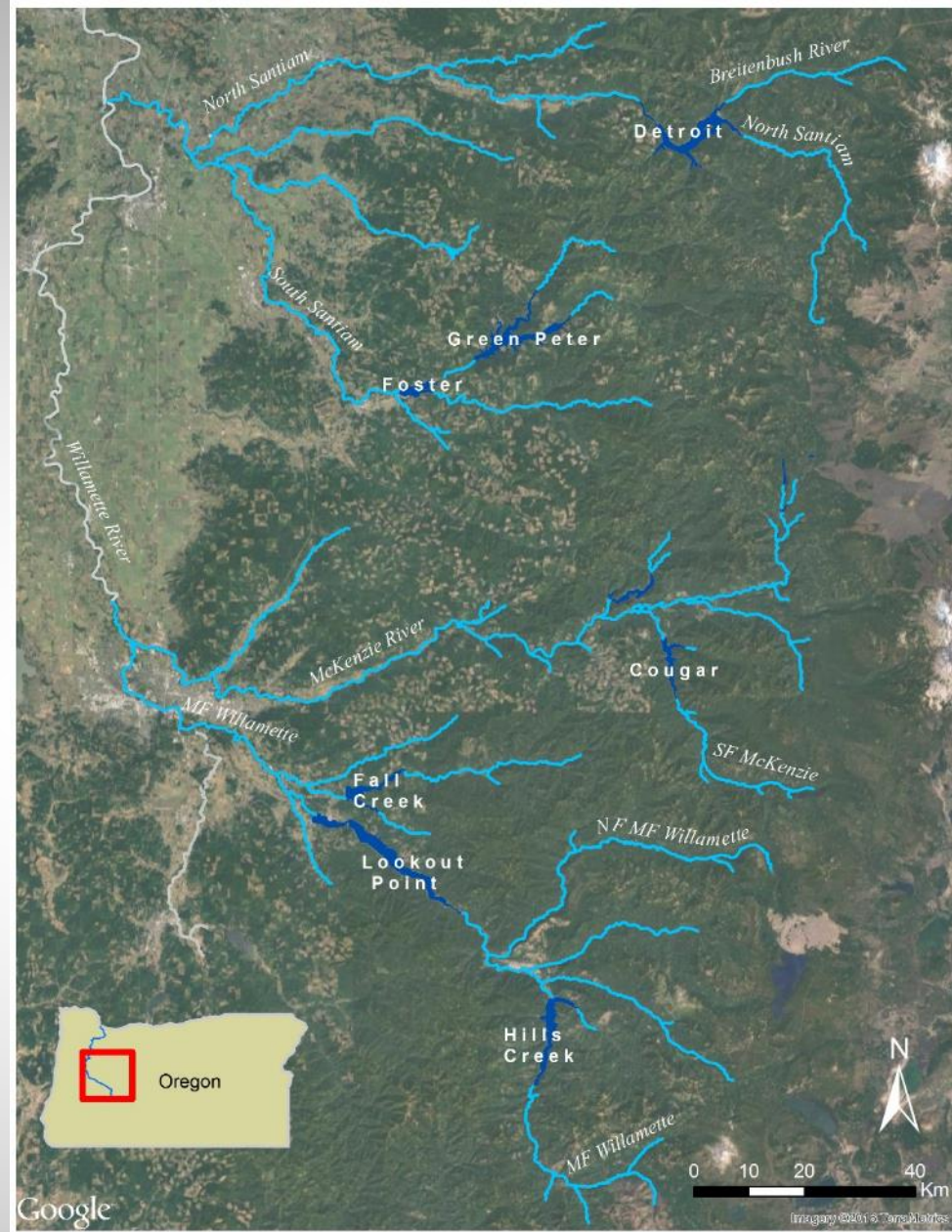
Substrate capacity:
76,000 redds
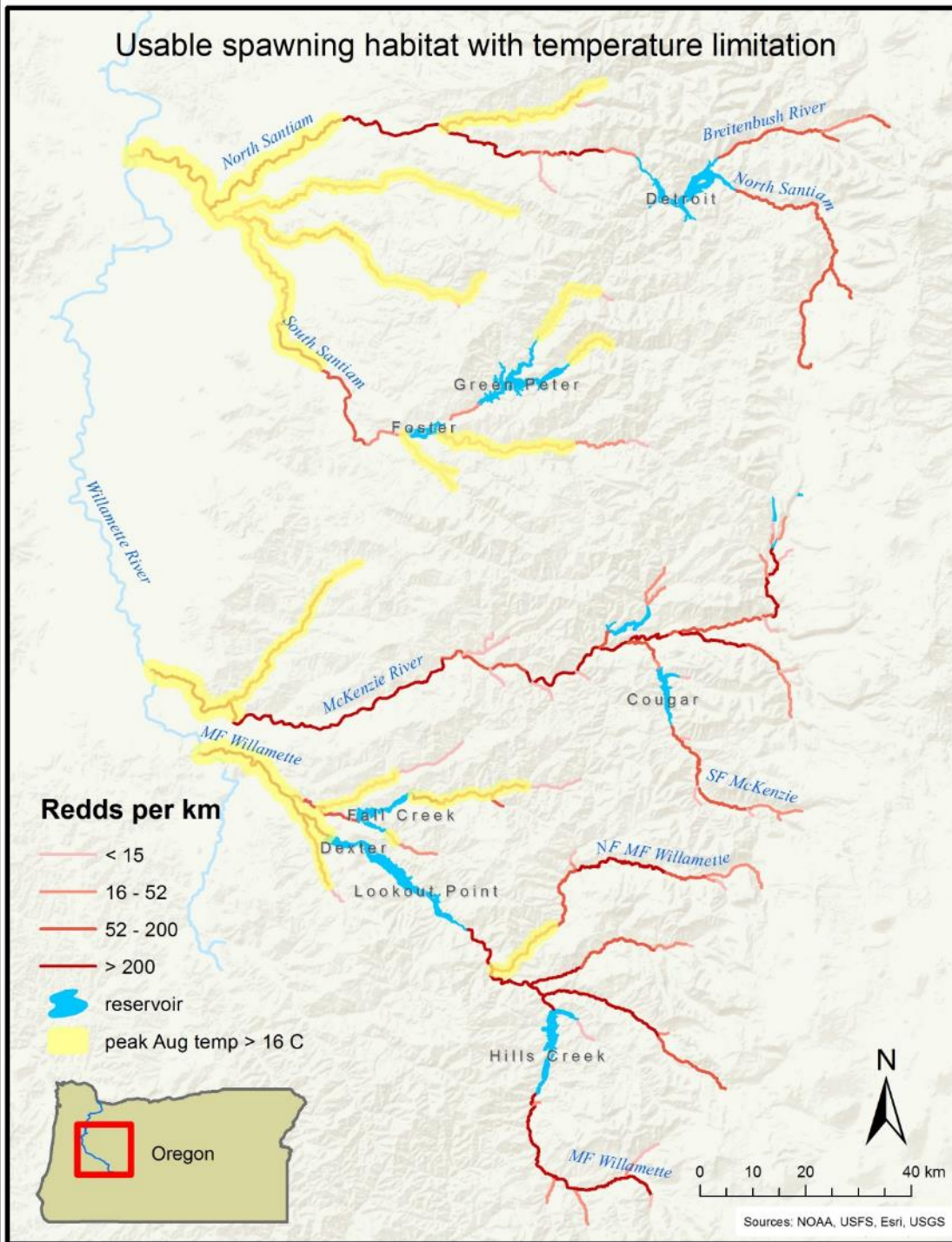

Usable spawning habitat

Substrate capacity:
76,000 redds

Current temperature limited capacity:
52,000 redds

2080 projected stream temperature capacity:
38,000 redds

Usable spawning habitat with temperature limitation

Redds per km

— < 15
— 16 - 52
— 52 - 200
— > 200
🟦 reservoir
🟨 peak Aug temp > 16 C

Oregon

N

0 10 20 40 km

Sources: NOAA, USFS, Esri, USGS

Caveats

- Coarse scale of substrate survey (400 m – 2700 m reaches)

- "Usable" substrate hard to quantify

- Behavior

Future directions

- Model redd survey data

- Functional response of spawning behavior and temperature

- Spatially explicit temperature (IR)

Estimating large scale juvenile salmon rearing capacity : a geomorphic approach

Parr rearing capacity

- How much rearing habitat is available?
 - Separate wetted area into habitats useful for parr…..
  - But still estimable!
1. Measure habitats throughout the CRB
   1. Satellite imagery
   2. Stratified random site selection for to include modified and unmodified sites
2. Model side channel habitat
   1. Contemporary area
   2. Historical area
- Apply fish capacity fish densities to habitats at several spatial scales

NHD stream network

- Prior success identifying channel types (Beechie and Imaki 2014)

- Can we use similar information to estimate habitat area?
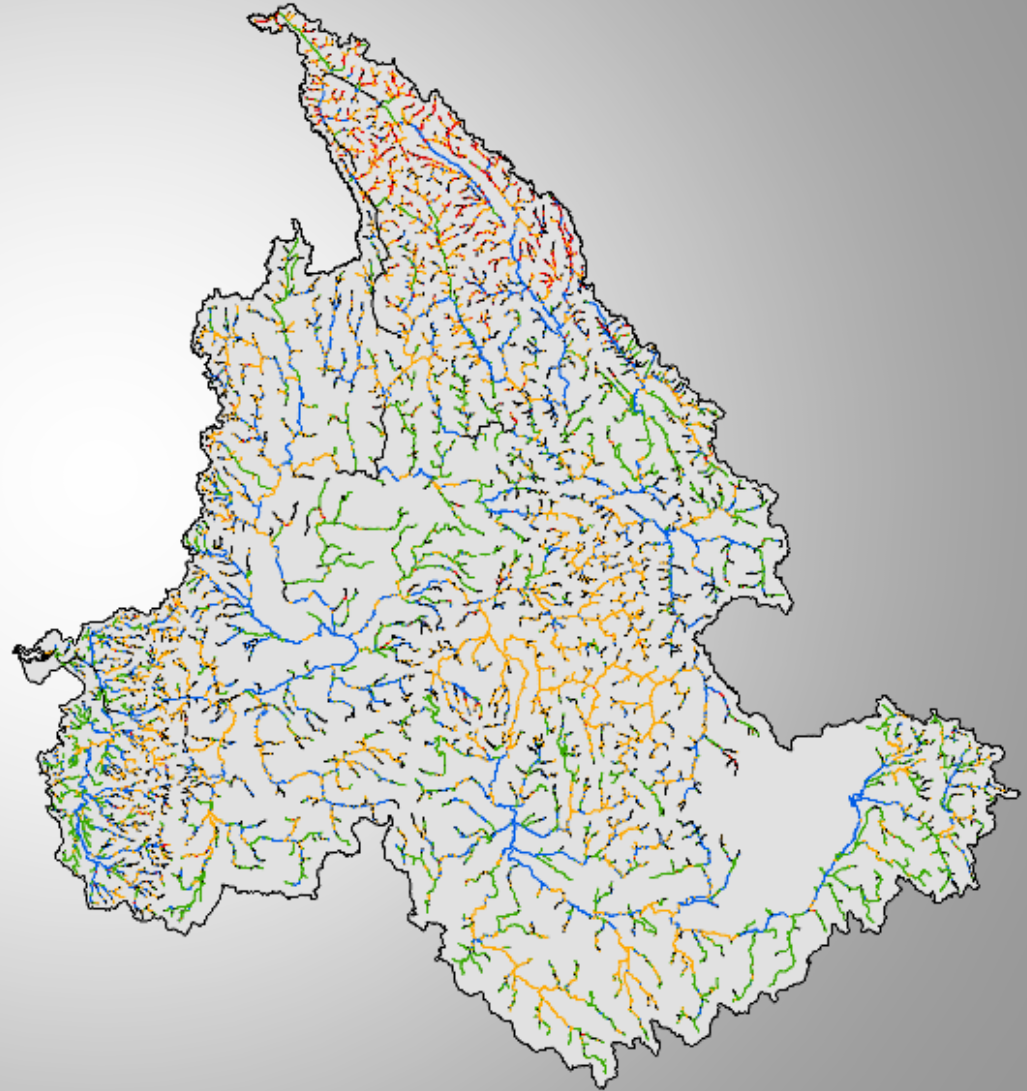
Fish habitat not represented by NHD
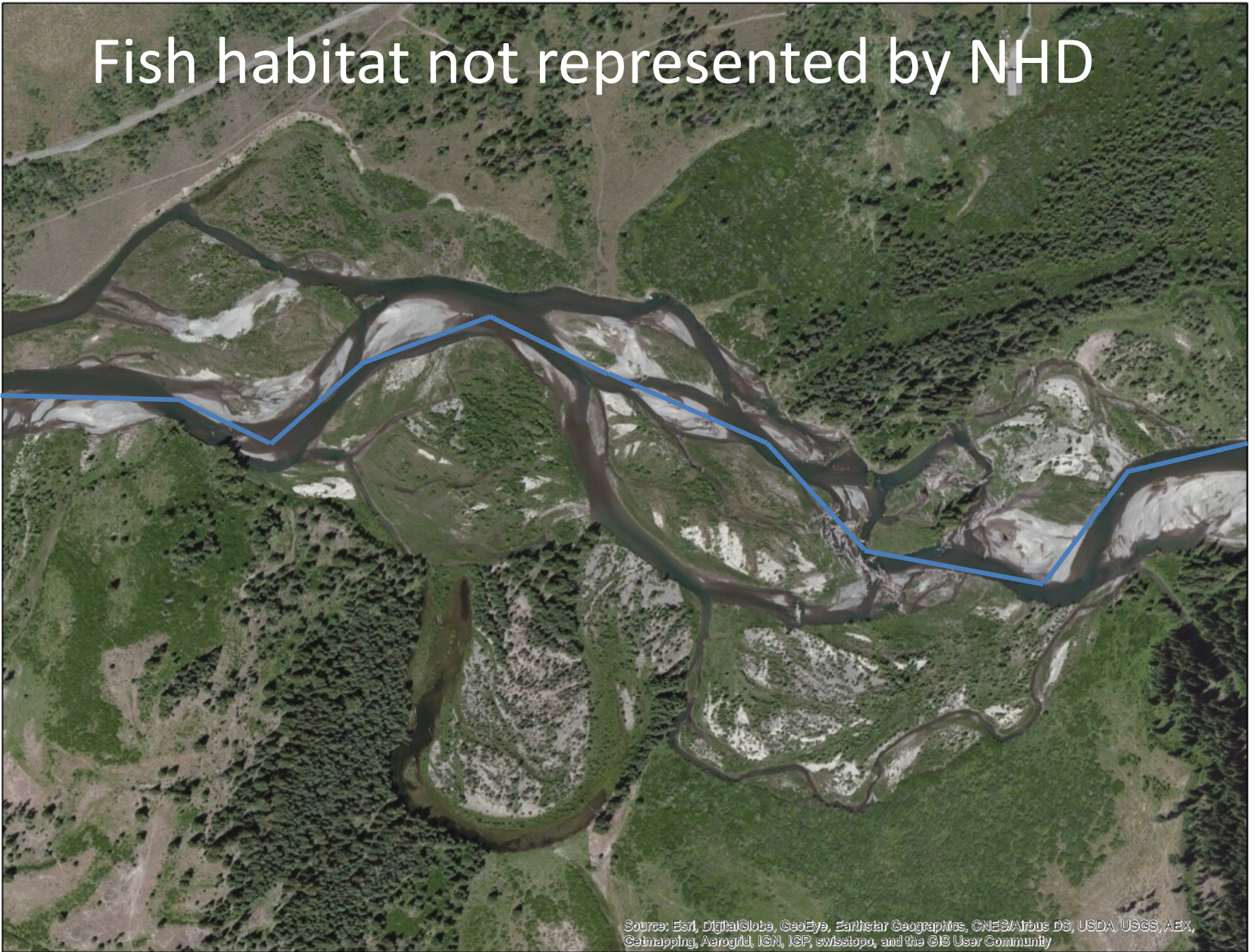
Stratified sampling

- 2093 sites
- Stratified by:
  - land cover
  - BFW category
  - Channel type (Beechie and Imaki)
- From satellite imagery:
  - Width of main channel
  - Widths of all wetted habitats
    - Side channels
    - Sloughs
    - Oxbows
    - Blind channels
    - Ditches
- 3 transects per 200 m segment
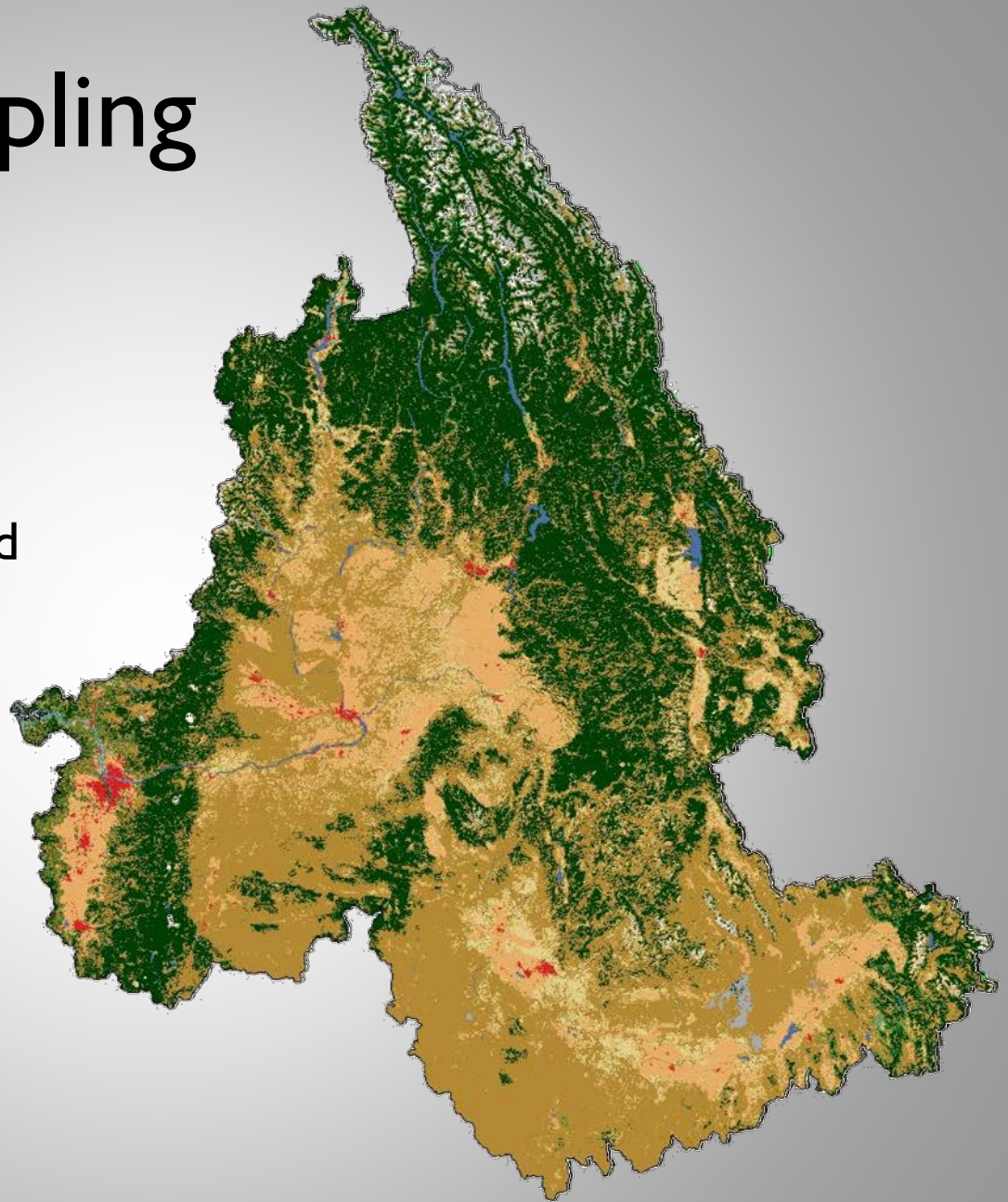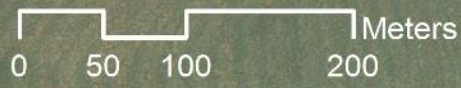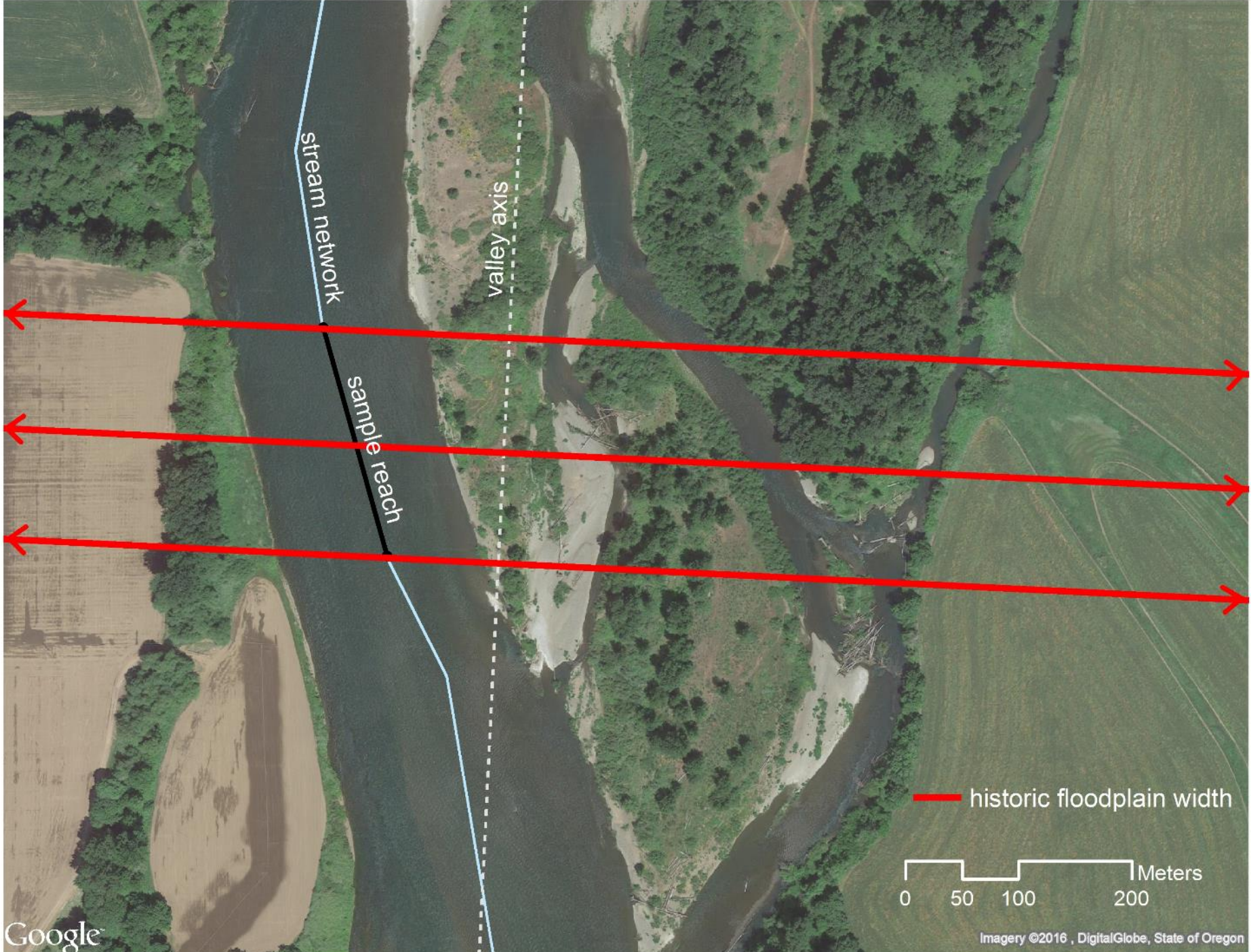
stream network

valley axis

sample reach

— historic floodplain width

0   50   100   200 Meters

Google

Imagery ©2016 , DigitalGlobe, State of Oregon

current floodplain width

historic floodplain width

Meters
0   50   100   200

Google

Imagery ©2016, DigitalGlobe, State of Oregon

mainstem wetted width
current floodplain width
historic floodplain width

Meters
0   50   100   200

Google

Imagery ©2016 , DigitalGlobe, State of Oregon

side channel width

mainstem wetted width

current floodplain width

historic floodplain width

Meters
0   50   100   200

Google

Imagery ©2016 , DigitalGlobe, State of Oregon

How much off channel habitat is there?

- 2093 sites (~1% of CRB)
  - Side channel
    - 24% of measured wetted area.
    - 35% of channel segments have multi-thread channels
  - Other off channel
    - Sloughs, disconnected oxbows, blind channels
    - 2% of wetted area
    - Found at only 46 sites

Can we model side channels?

- Random forest: Similar to decision trees
  - Build an ensemble of many shallow trees
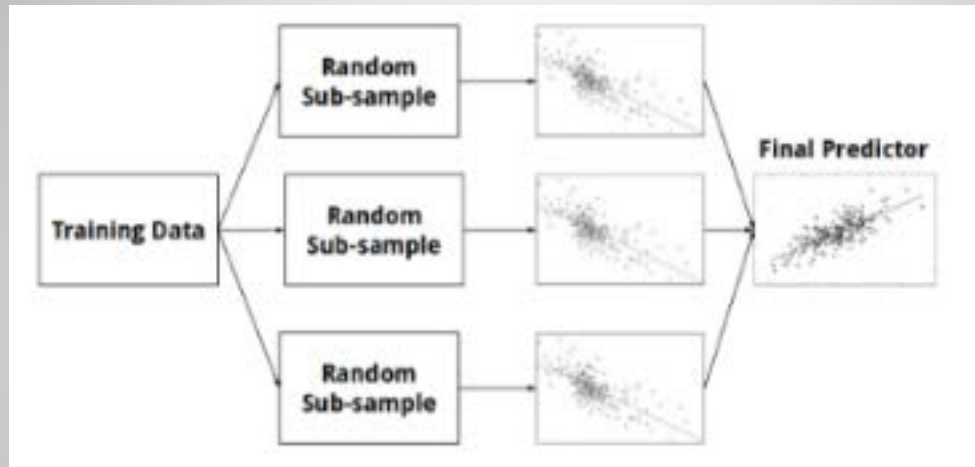
  - Hurdle model approach: first estimate the presence of side channels
    - Split sites into 80/20% Training/Testing datasets
    - Cross-validation
    - Predict side channel as "0" or "1"
  - Estimate side channel amount in sites with "1"

Side channel presence

- Predictors:
  - Current floodplain width
  - Sediment accumulation
  - Discharge
  - Average elevation
  - Bankfull width
  - Slope
  - Sinuosity
  - Ecoregion
  - Land use

- 74% balanced accuracy in predicting side channel presence
- $R^2 = 0.47$ for side channel amount
- Historical floodplain/land use for historical side channels
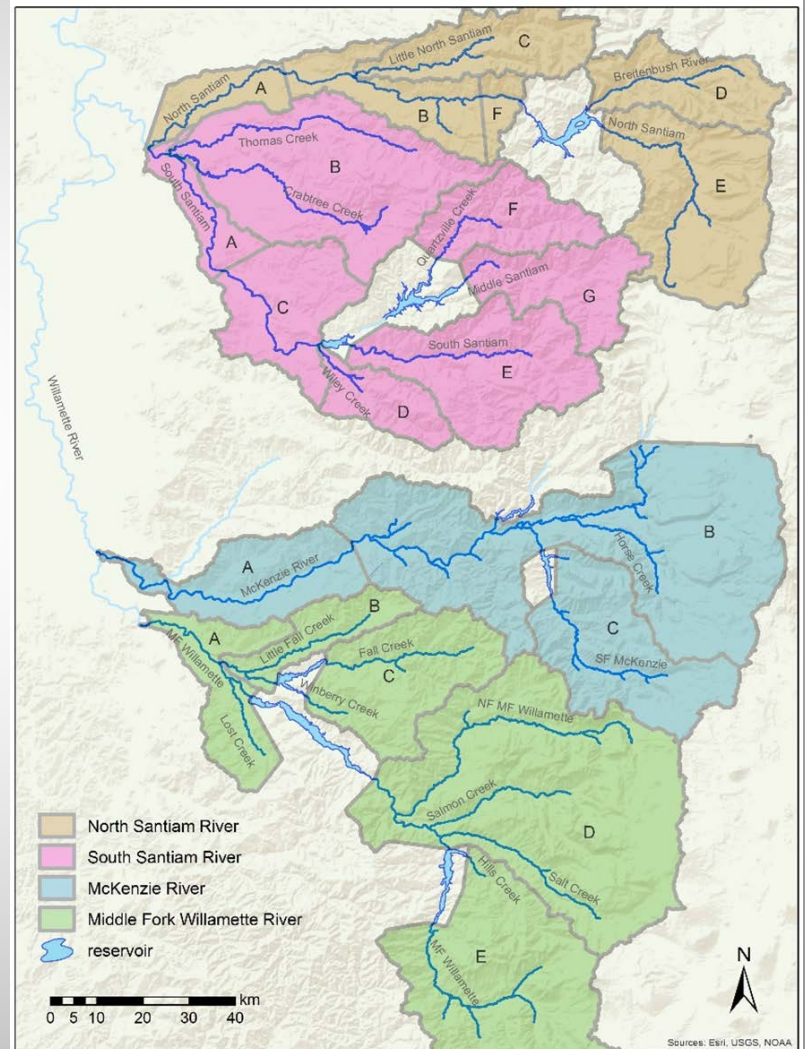- Separate model for mainstem bank and bar habitat

Habitat area (Chinook)

Tributary	Reach ID	Habitat area (Hectares)				
		All	Bank and bar	Current side channel	Historical side channel	% Loss
North Santiam River	A	389.7	177.8	163.8	177.9	7.9
	B	208.0	104.7	72.0	82.6	12.8
	C	77.2	38.2	24.6	24.9	1.3
	D	58.3	30.3	14.9	14.9	0.1
	E	116.7	58.7	35.1	36.0	2.8
	F	36.0	17.9	13.2	13.2	0.0
South Santiam River	A	190.3	89.5	75.7	84.5	10.4
	B	188.5	125.1	14.5	30.8	53.1
	C	138.1	82.7	29.3	53.1	44.8
	D	14.6	9.8	0.0	0.0	0.0
	E	104.4	50.4	36.3	38.6	5.9
	F	62.9	31.1	21.0	21.2	1.2
	G	18.7	8.9	6.7	6.7	0.0
McKenzie River	A	481.6	201.1	225.2	234.9	4.1
	B	564.9	273.4	202.0	205.5	1.7
	C	71.6	38.1	17.2	17.8	3.3
Middle Fork Willamette	A	214.6	94.5	91.1	94.4	3.5
	B	54.9	37.3	1.6	10.9	85.3
	C	61.7	35.0	10.1	10.2	0.6
	D	410.1	199.9	137.0	141.7	3.3
	E	121.4	57.7	39.2	39.2	0.0

Legend:
- North Santiam River
- South Santiam River
- McKenzie River
- Middle Fork Willamette River
- reservoir

Sources: Esri, USGS, NOAA

Applying fish to habitat (spring Chinook parr)

- Habitat expansion:
  - Fish densities fish/m^2 (Beechie et al. unpublished):
    - Bank: 0.88
    - Bar: 0.47
    - Mid-channel: 0.001
    - Side channel: 0.60

- Quantile regression: CHaMP/ISEMP interior CRB electrofishing surveys

- 5200 per hectare: Thorson et al. 2014, Idaho snorkel surveys

Parr capacity (Chinook)

Tributary	SLAM Reach	Mainstem	Current side channel	Historical side channel	< 8 m BFW streams	Historical expansion total	Current expansion total	Quantile regression total	5200 per hectare total
					Summer parr (Chinook)				
North Santiam River	A	338,494	982,654	1,067,430	90,214	1,496,138	1,411,362	1,329,852	2,026,183
	B	216,283	431,824	495,376	50,468	762,126	698,574	750,539	1,081,561
	C	98,037	147,596	149,477	22,133	269,646	267,765	438,986	401,667
	D	87,905	89,397	89,505	461	177,871	177,763	383,148	302,948
	E	154,582	210,331	216,281	581	371,445	365,494	770,511	606,883
	F	36,489	79,252	79,153	0	115,641	115,741	169,237	187,342
South Santiam River	A	177,923	454,419	506,925	12,176	697,023	644,517	736,770	989,357
	B	333,844	86,742	184,961	61,076	579,880	481,662	1,292,097	980,112
	C	183,124	175,988	318,641	33,053	534,819	392,165	810,361	717,977
	D	31,153	0	0	19,122	50,275	50,275	105,281	75,819
	E	123,929	217,984	231,741	0	355,669	341,913	533,864	542,839
	F	76,587	125,855	127,440	0	204,027	202,442	348,808	327,070
	G	22,148	40,134	40,134	0	62,282	62,282	106,481	97,471
McKenzie River	A	387,841	1,351,047	1,409,518	120,431	1,917,790	1,859,319	1,726,496	2,504,357
	B	609,805	1,212,236	1,233,229	172,942	2,015,976	1,994,983	2,956,819	2,937,293
	C	109,772	103,109	106,634	55,725	272,131	268,607	421,262	372,349
Middle Fork Willamette River	A	196,752	546,896	566,621	148,643	912,015	892,290	904,782	1,115,951
	B	105,771	9,655	65,541	41,908	213,221	157,334	279,037	285,390
	C	108,053	60,648	61,008	17,703	186,764	186,404	313,436	320,775
	D	494,297	821,971	850,196	76,879	1,421,372	1,393,147	2,204,039	2,132,312
	E	160,255	235,413	235,464	97,815	493,535	493,483	812,878	631,282
Total		4,053,044	7,383,151	8,035,275	1,021,329	13,109,648	12,457,524	17,394,680	18,636,937
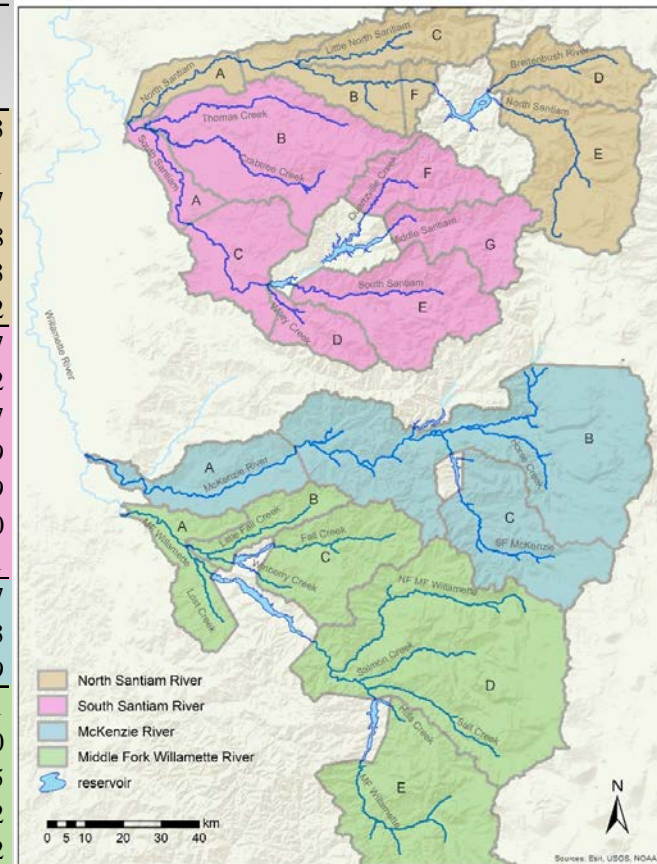
Caveats

- Does not take into account side channel number (one large or many small?)
- Does not account for mainstem hydromodified banks
- Literature review of habitat-specific fish densities varies widely

Future directions

- Riparian model
  - Buffer, tree height, species
- Improved floodplains / land use assessment
- Migration to higher resolution NHD network