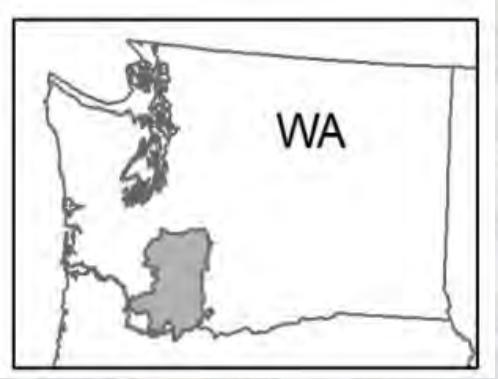
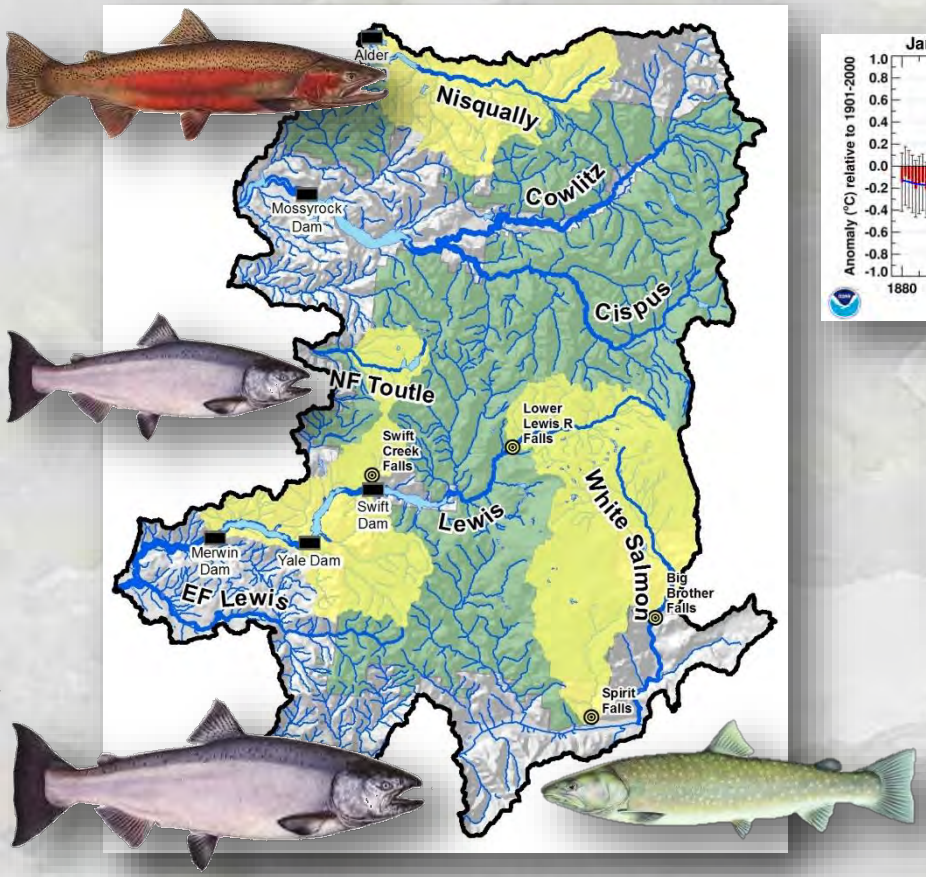
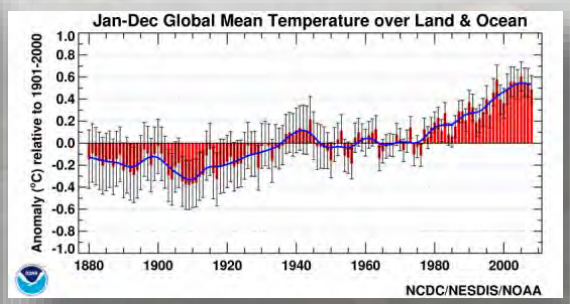
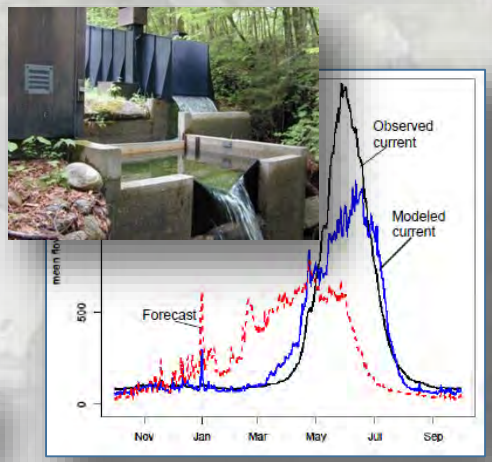
Southwest Washington Adaptation Partnership: Effects of Climate Change on Fisheries

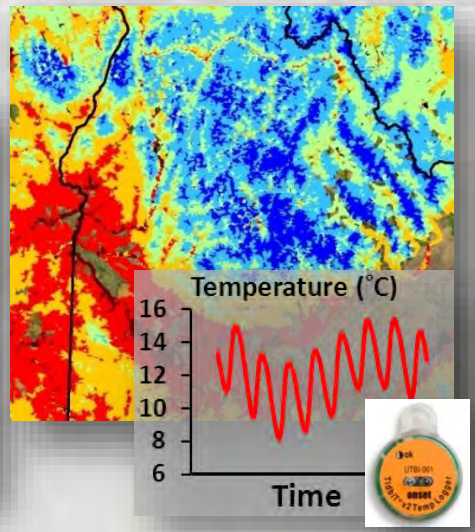
Ruth Tracy, Baker Holden, Dona Horan, Jessica Hudec, John Chatel, Dan Isaak







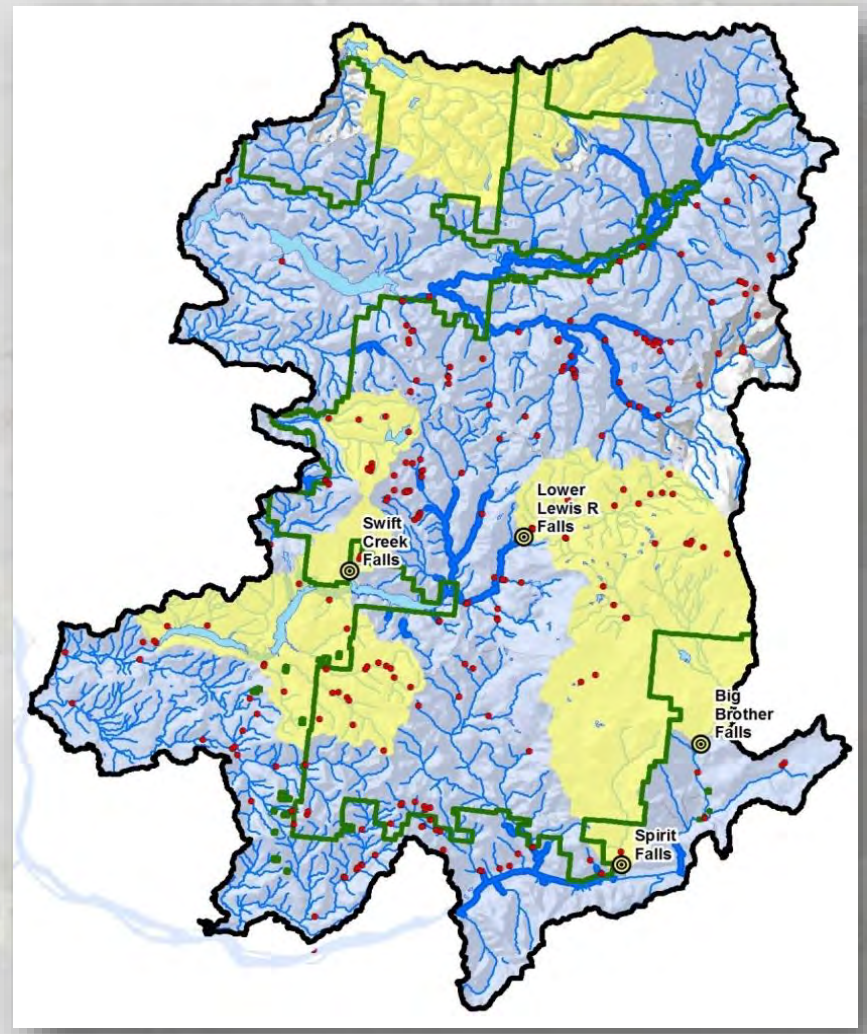




Climate Factors Relevant to…

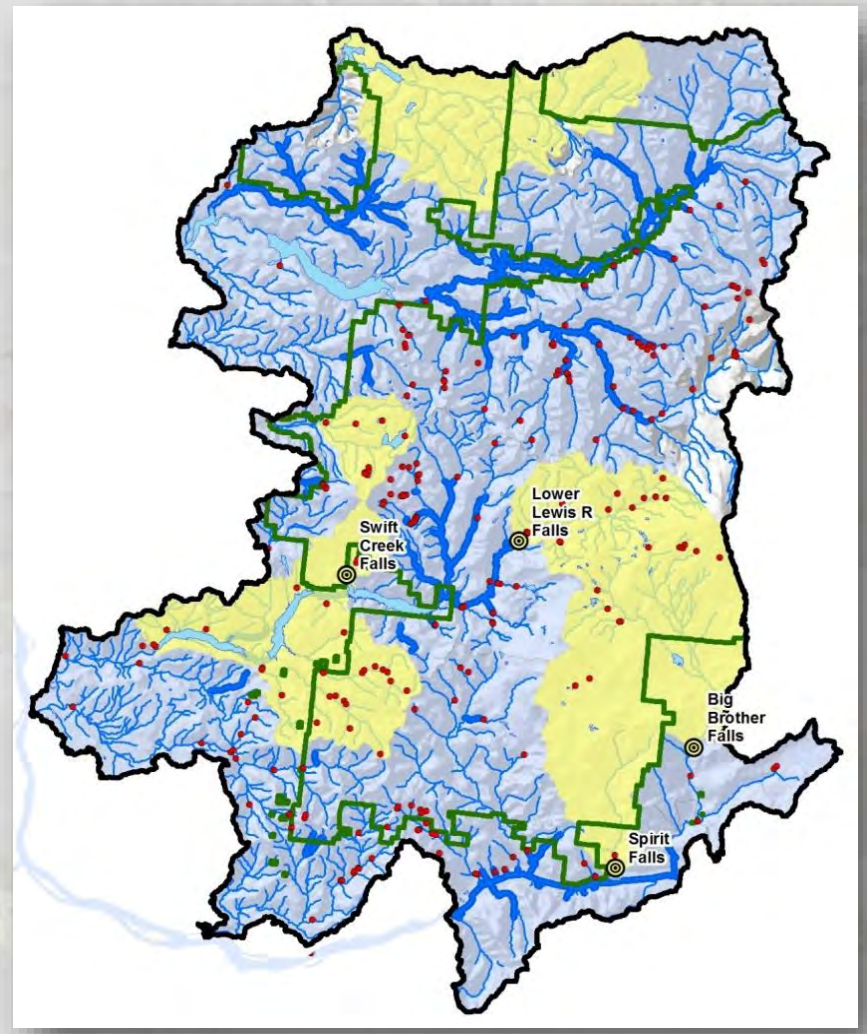
Chinook salmon

- ESA listed as threatened
- Populations require fluvial connectivity to ocean
- Ocean cycles strongly affect freshwater abundance
- Fall spawner & eggs incubate overwinter



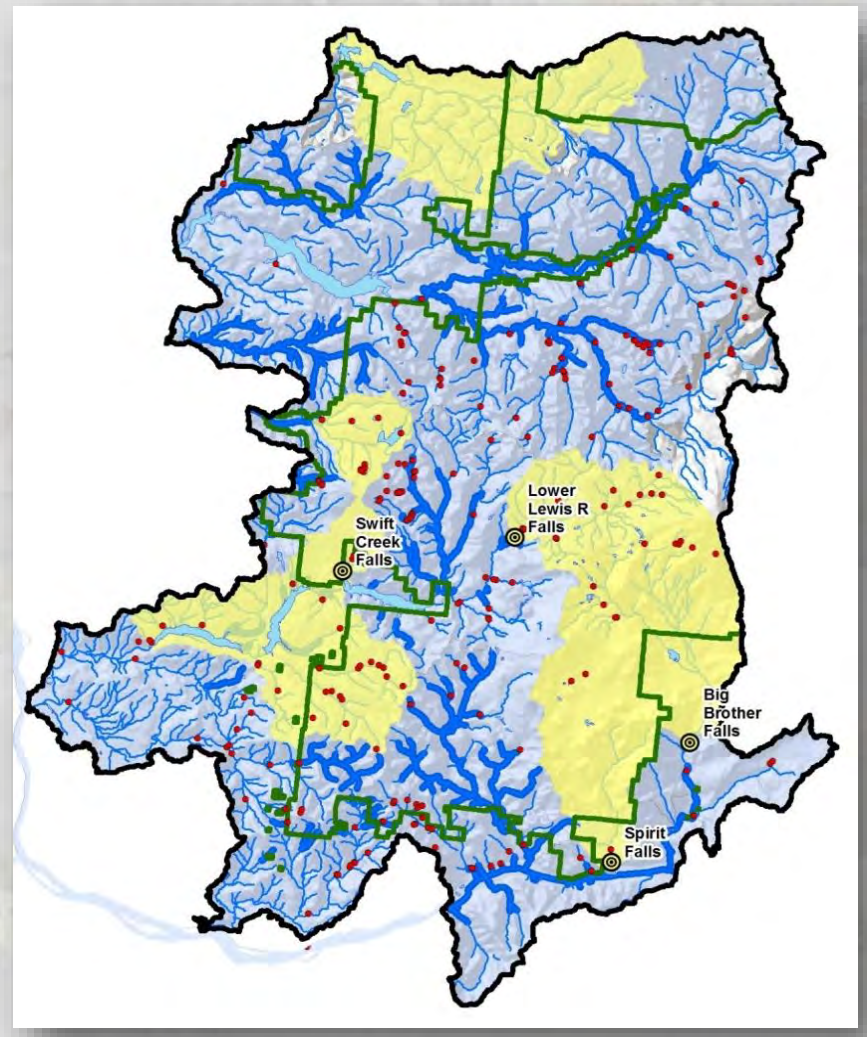
Species of Concern… Coho salmon

- ESA listed as threatened
- Populations require fluvial connectivity to ocean
- Ocean cycles strongly affect freshwater abundance
- Fall spawner & eggs incubate overwinter



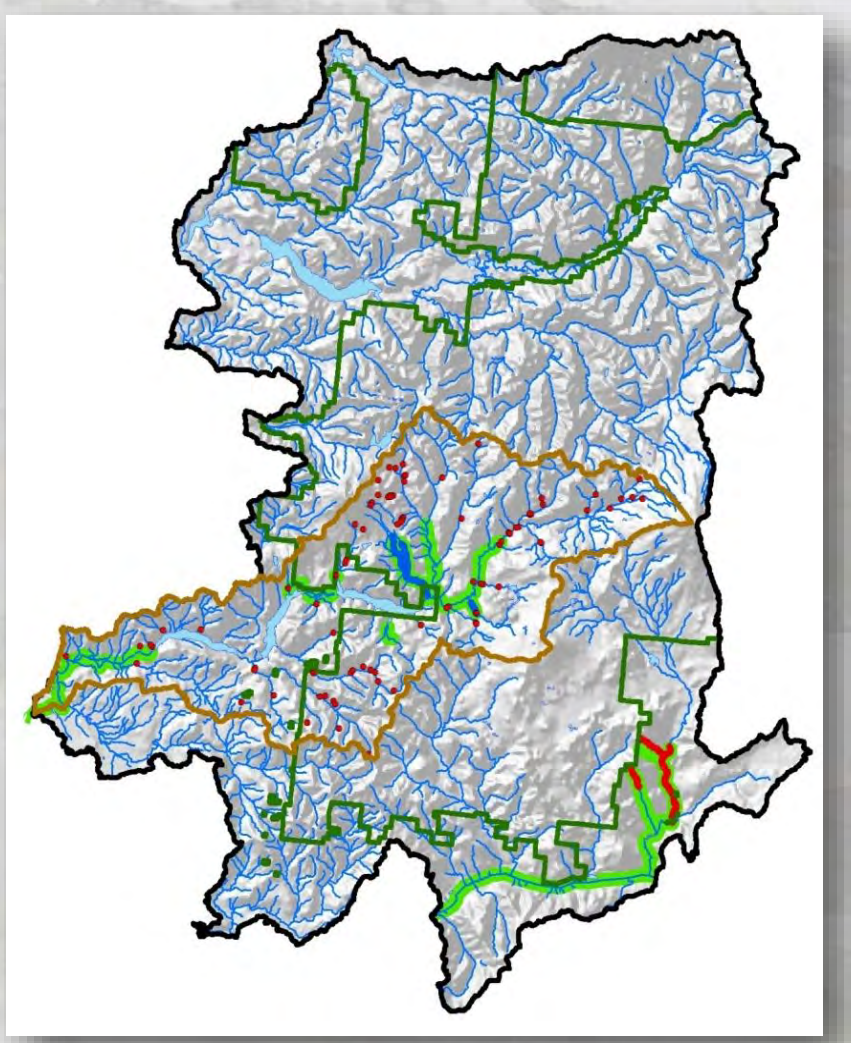
Species of Concern… Steelhead

- ESA listed as threatened
- Populations require fluvial connectivity to ocean
- Ocean cycles strongly affect freshwater abundance
- Relatively warm thermal niche – unsuitably cold upstream areas could serve as refugia
- Spring spawner after peak flows
- Natal habitats occur in small streams susceptible to disturbance

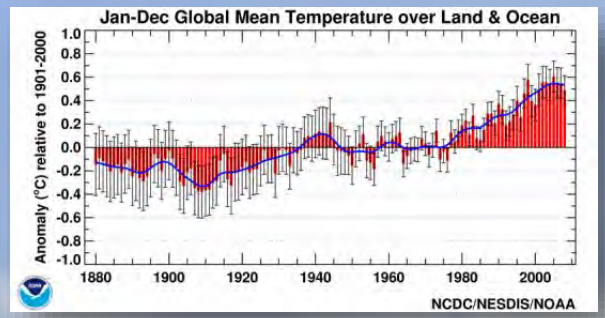


Species of Concern… Bull trout

- ESA listed as threatened
- Cold thermal niche constrains populations to high-elevation refugia
- Extant populations occupy ~20 kilometers of stream
- Habitats & populations are fragmented & isolated
- Occurs in small streams that are susceptible to disturbance
- Spawns in fall & eggs incubate overwinter

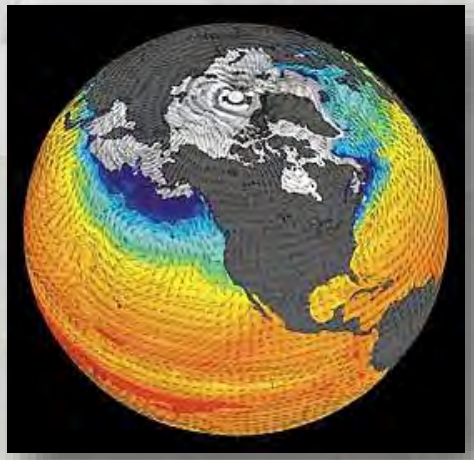


Taking Climate into the Water Where Fish Live…

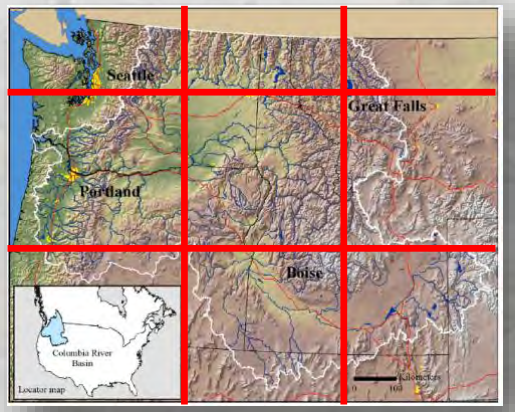


Taking Climate into the Water Where Fish Live…

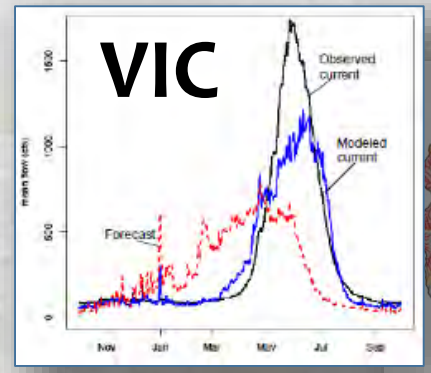
Climate model (air temp & precip)

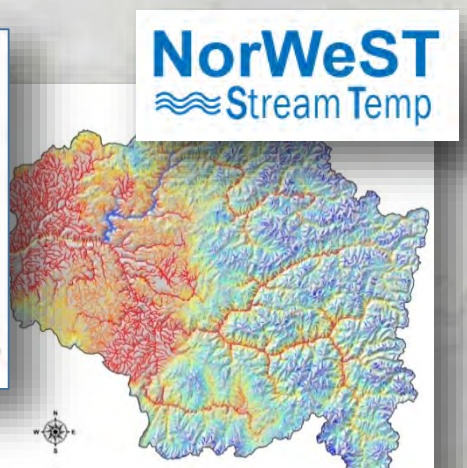


Regional patterns

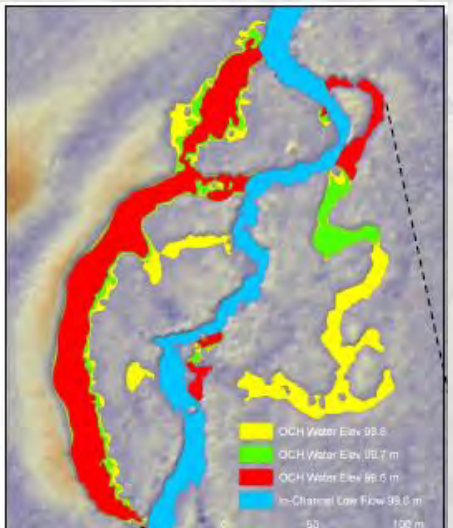


Stream temperatures & flow



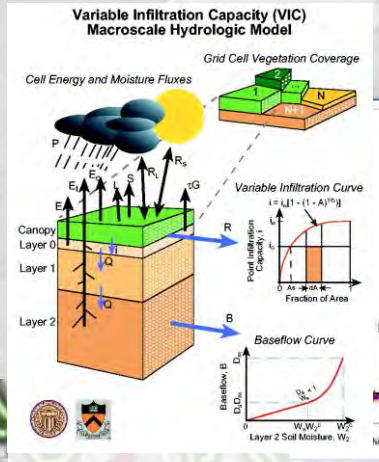


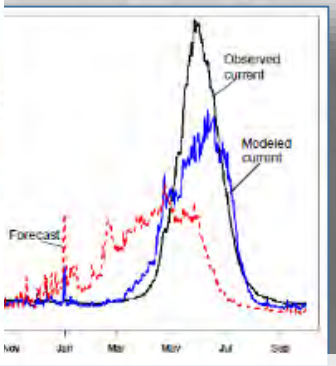
Stream reach patterns



GIS Data for Stream Flow & Temperature Scenarios Downloaded from Websites

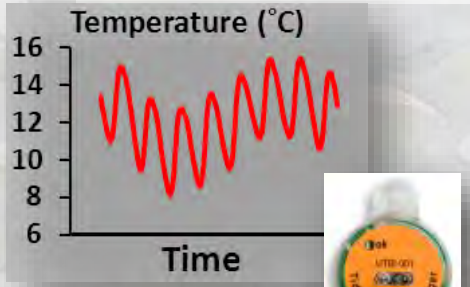
VIC Streamflow Scenarios

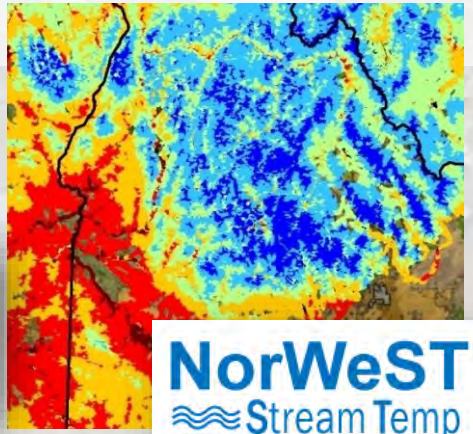




Google "Stream flow Metrics"

Google "NorWeST stream temp"





NorWeST Stream Temp

Isaak et al. 2010. *Ecol. Apps.* **20**:1350-1371

Isaak et al. 2012. *Climatic Change* **113**:499-524.

Luce et al. 2014. *Wat Res Res* DOI: 10.1002/2013WR014329

Ver Hoef et al. 2006. *Environ Ecol Stat* **13**:449-464.

Ver Hoef & Peterson. 2010. *Journal Am Stat Ass* **105**:6–18.

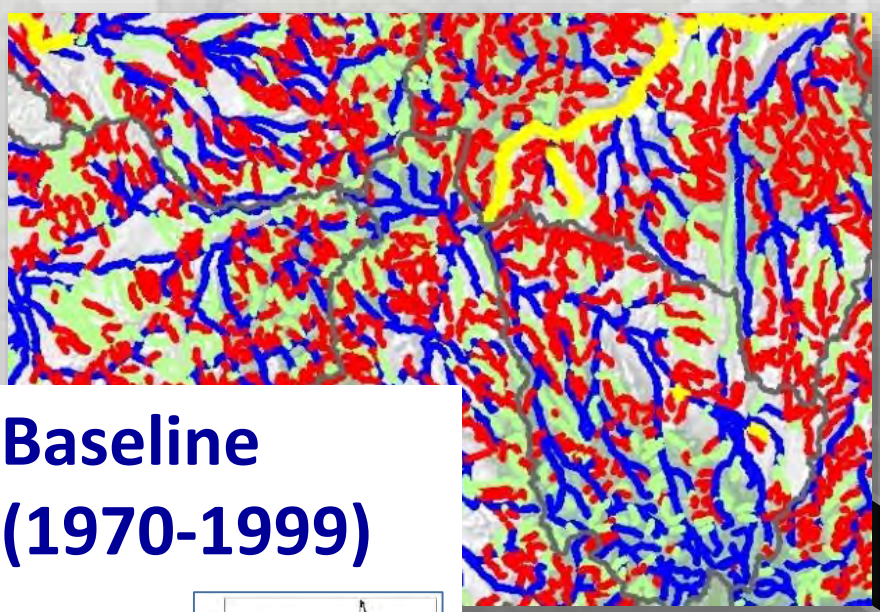
Liang et al. 1994. *J. Geophys Res* **99**:14415–14428.

Wenger et al. 2010. *Water Res Res* **46**:W09513.

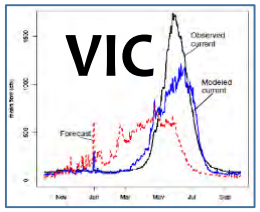
Safeeq et al. 2014. *Hydrology and Earth System Sciences* **11**:3315-3357.

Stream Hydrography Base Layer

1:100,000 NHDPlus



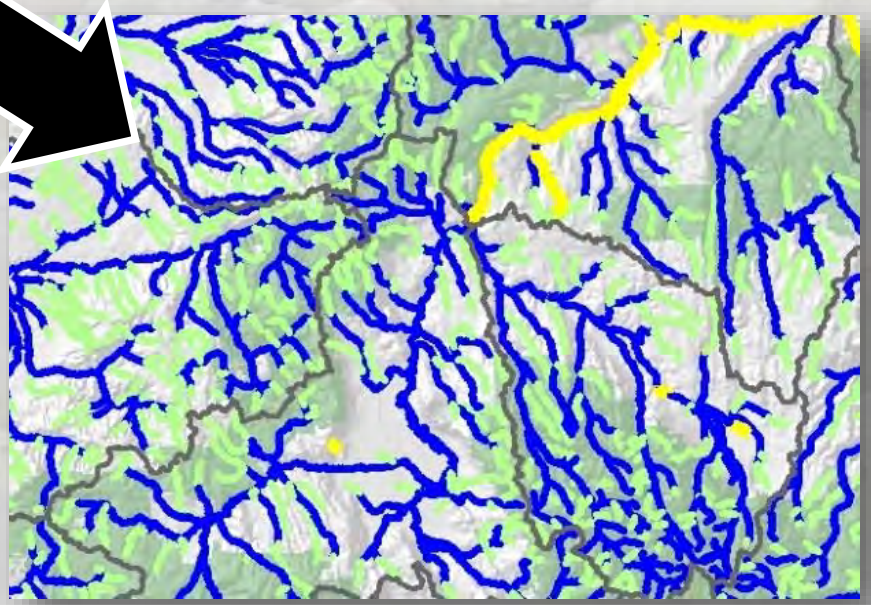
Baseline (1970-1999)



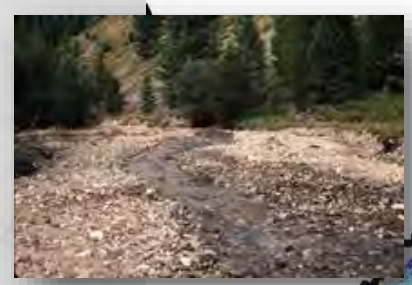
>0.006 m^3/s summer flow

<15% slope

Deleted intermittent channels



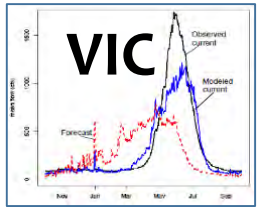
~65% network reduction

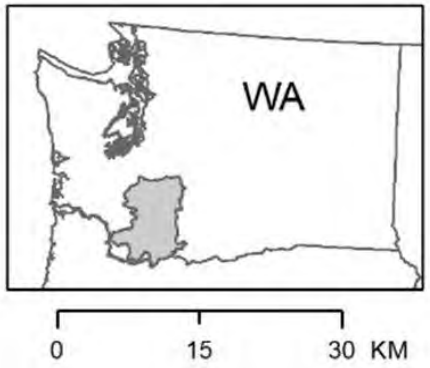


1980s

Mean Summer Flow (cms)

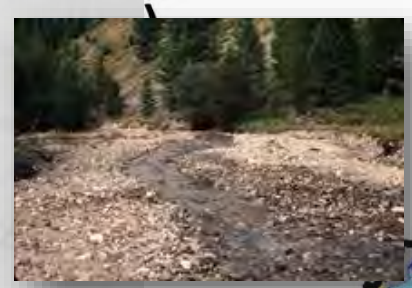
- < 0.006
- 0.006 - 0.034
- 0.034 - 0.085
- > 0.085
- Forest Lands
- Lake





Non-FS lands: 2,104 km of streams

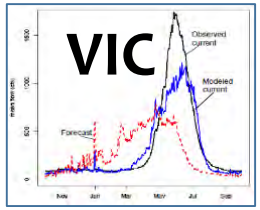
USFS lands: 2,389 km on FS lands

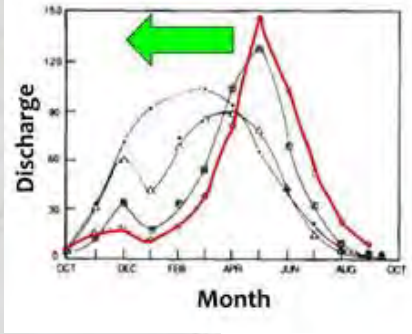


2080s

Mean Summer Flow (cms)

- < 0.006
- 0.006 - 0.034
- 0.034 - 0.085
- > 0.085
- Forest Lands
- Lake

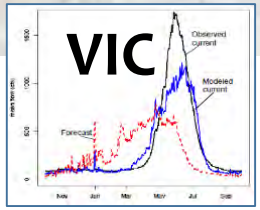


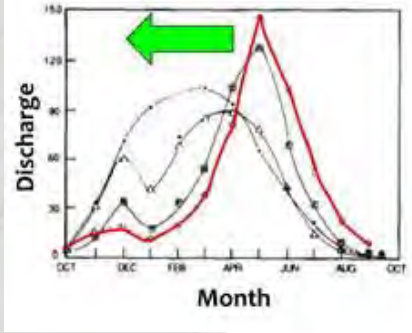


1980s

Median flow date

- < 150
- 150 - 160
- 160 - 170
- 170 -180
- > 180
- Forest Lands
- Lake

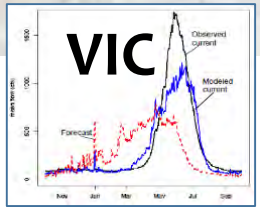


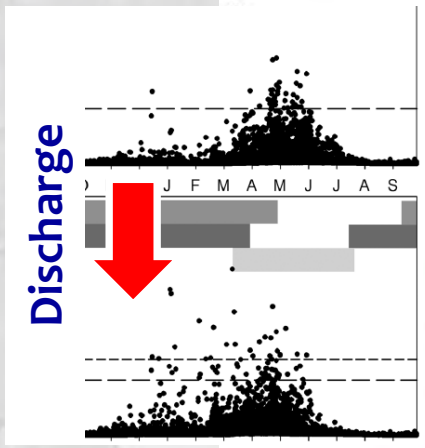


2080s

Median flow date

- < 150
- 150 - 160
- 160 - 170
- 170 -180
- > 180
- Forest Lands
- Lake





1980s

Winter high flow days

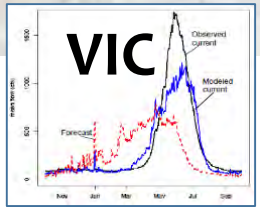
< 1

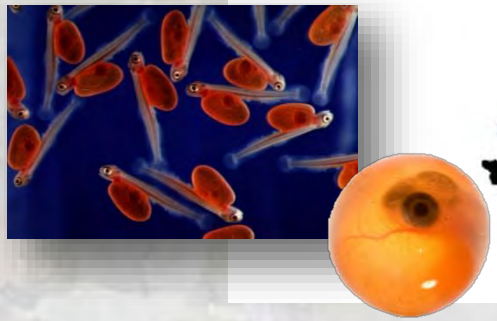
1 - 4

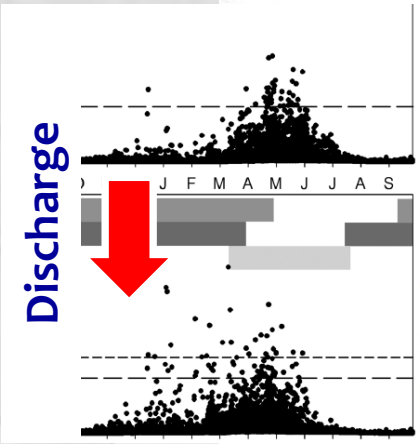
> 4

Forest Lands

Lake







2080s

Winter high flow days

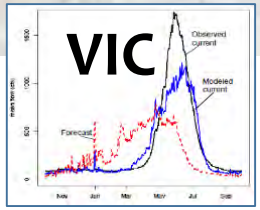
< 1

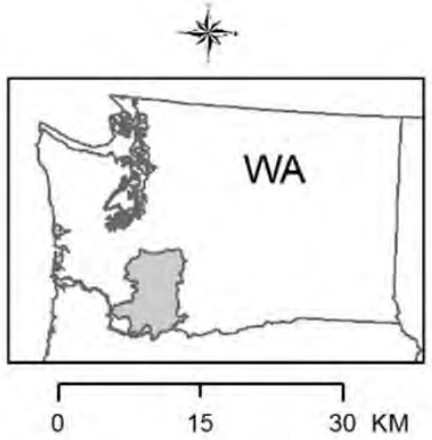
1 - 4

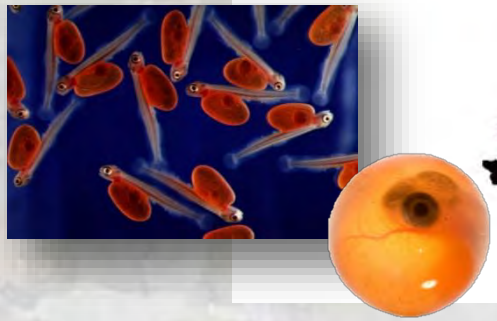
> 4

Forest Lands

Lake



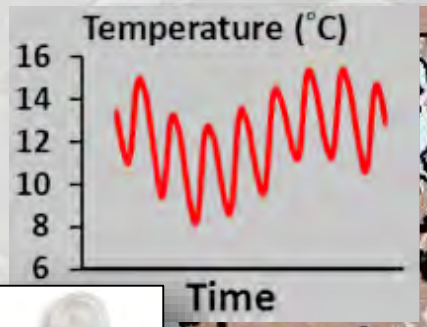




Stream Flow Statistics for A1B Warming Scenario

		All lands		USFS lands	
Flow metric	**Climate period**	**Water year day**	**Days Advance**	**Water year day**	**Days Advance**
Median flow date	1980s	158	-	165	-
	2040s	142	-16 days	144	-21 days
	2080s	134	-24 days	133	-32 days
		Number of days	**Days increase**	**Number of days**	**Days increase**
Winter high flow days	1980s	11.0	-	9.3	-
	2040s	13.0	2.0	12.3	3.0
	2080s	14.0	3.0	13.8	4.5
		ft^3/s	**% change**	**ft^3/s**	**% change**
Mean summer flow	1980s	94.8	-	59.0	-
	2040s	57.0	-39.9	32.7	-44.6
	2080s	40.0	-57.8	20.7	-64.9
Mean annual flow	1980s	186.9	-	91.2	-
	2040s	193.0	3.3	94	3.1
	2080s	194.1	3.9	94.5	3.6

Stream Temperature Database & Scenarios



NorWeST Stream Temp

IDAHO POWER.

NEZ PERCE TRIBE TREATY OF 1855

IDAHO FISH & GAME

HENRY'S FORK FOUNDATION

KOOTENAI TRIBE OF IDAHO

KALISPEL TRIBE OF INDIANS

FOREST SERVICE USDA

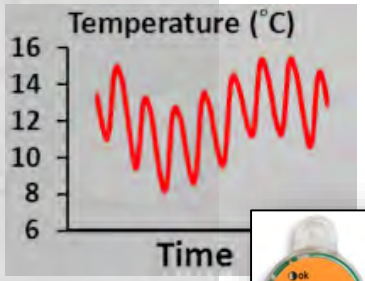
U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY

USGS science for a changing world

NOAA Fisheries

SHOSHONE BANNOCK FISH AND GAME



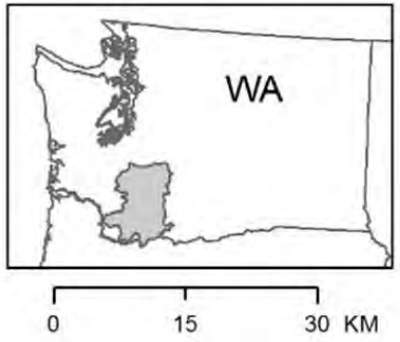
1980s

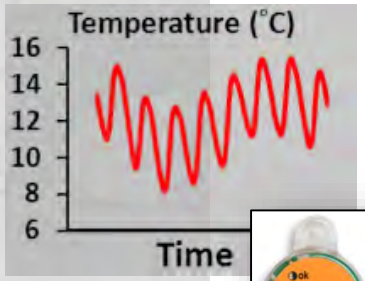
NorWeST Stream Temp

August Mean Temp (°C)

- < 8
- 8 - 11
- 11 - 14
- 14 - 17
- 17 - 20
- > 20

Mean August Stream Temperature = 11.5°C





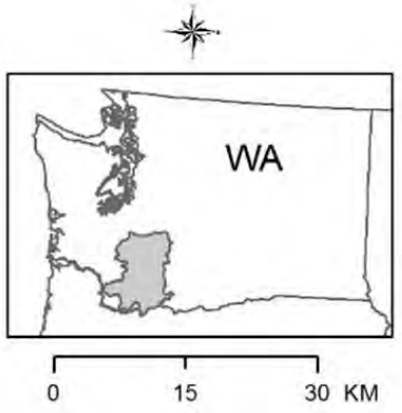
2080s

NorWeST Stream Temp

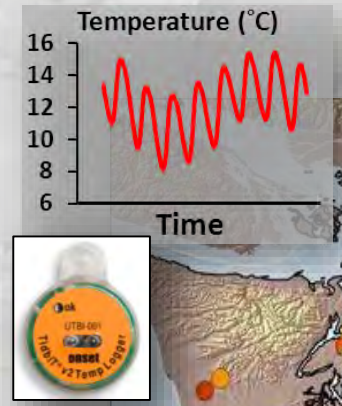
August Mean Temp (°C)

- < 8
- 8 - 11
- 11 - 14
- 14 - 17
- 17 - 20
- > 20

Increase = 2.17°C



Slow Stream Warming Rates 1968-2011



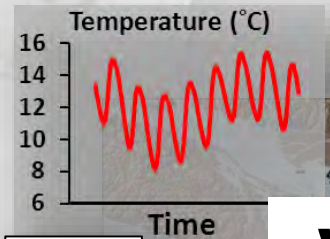
923 sites in NorWeST database with >10 year records

+0.10°C/decade since 1968

< 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
> 0.9

Isaak et al. 2016. Slow climate velocities of mountain streams portend their role as refugia for cold-water biodiversity. *Proc. Nat. Acad. Sciences* doi:/10.1073/pnas.1522429113

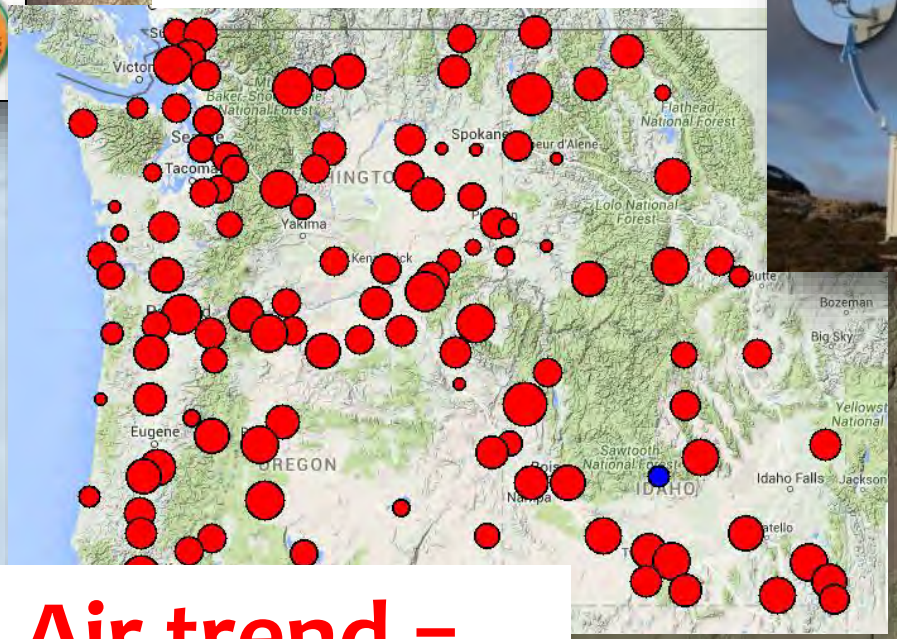
Slow Stream Warming Rates 1968-2011



923 sites in NorWeST database with >10 year records

+0.10°C/decade since 1968

Weather Stations



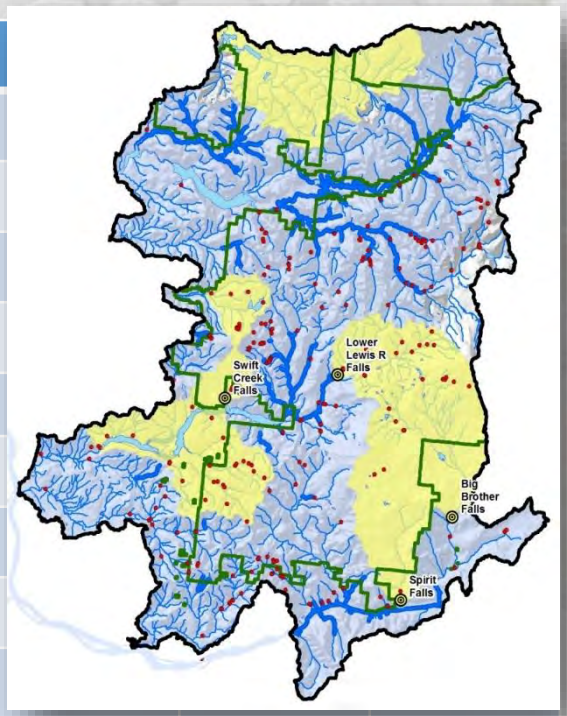
Air trend = 0.21°C/decade

Isaak et al. 2016. Slow climate velocities of mountain streams portend their role as refugia for cold-water biodiversity. *Proc. Nat. Acad. Sciences* doi:/10.1073/pnas.1522429113

Changes Within Coho Habitat

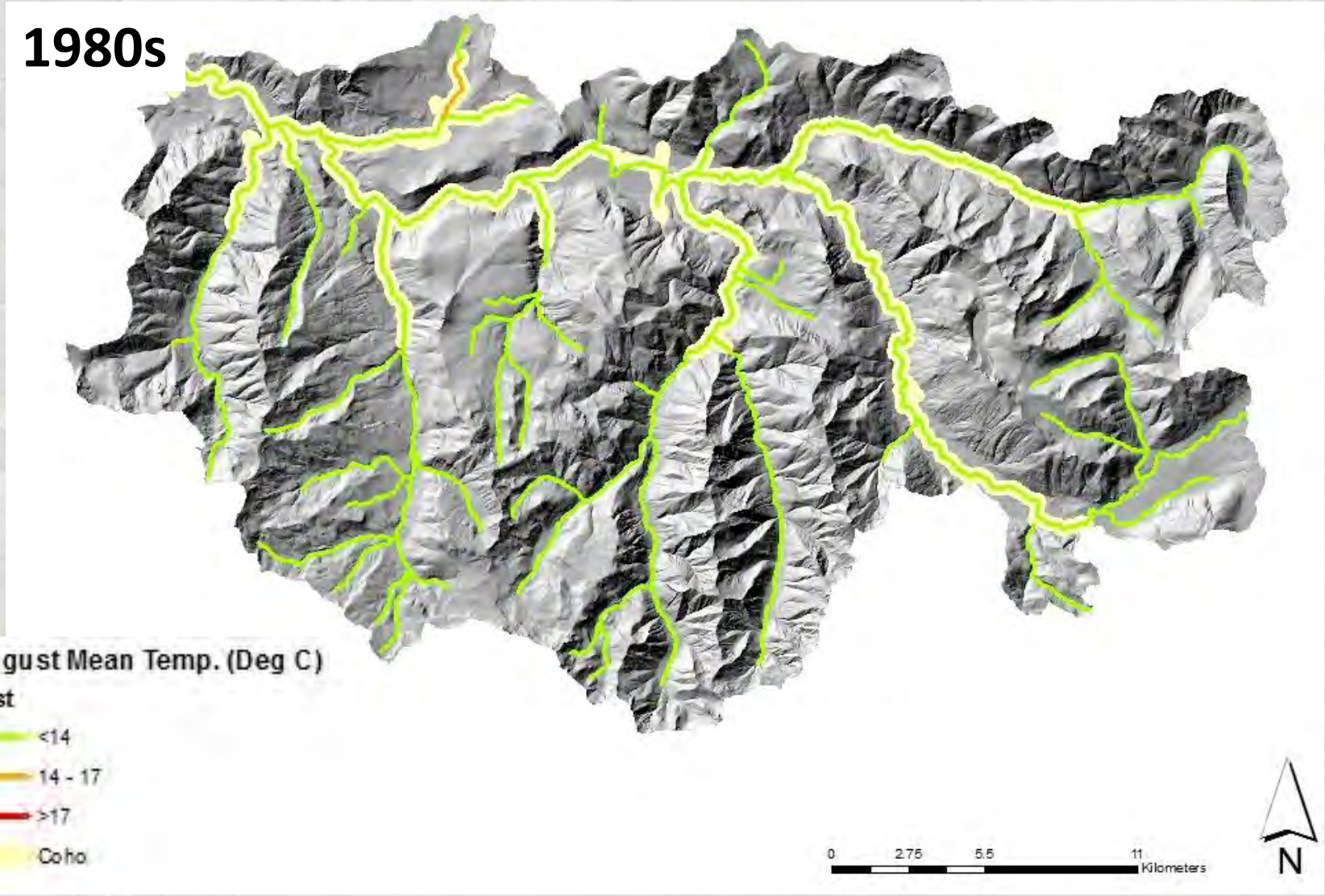
584 River Kilometers of Habitat

		Number of high flow days					
Stream metric	**Period**	**<5**	**5-10**	**>10**			
Winter 95% flow	1980s	80 (14%)	162 (28%)	343 (59%)			
	2040s	37 (6%)	27 (5%)	521 (89%)			
	2080s	-	40 (7%)	545 (93%)			
			m^3/s				
		<0.034	**0.034-0.085**	**>0.085**			
Summer flow	1980s	2.4 (1%)	41 (6%)	541 (93%)			
	2040s	4.6 (1%)	53 (9%)	526 (90%)			
	2080s	6.6 (1%)	55 (9%)	523 (89%)			
				Stream kilometers			
		<8	**8-11**	**11-14**	**14-17**	**17-20**	**>20**
August temperature	1980s	6.1 (1%)	73 (13%)	351 (60%)	107 (18%)	6 (1%)	40 (7%)
	2040s	-	30 (5%)	215 (37%)	284 (49%)	11 (2%)	45 (8%)
	2080s	-	18 (3%)	118 (20%)	375 (64%)	26 (5%)	46 (8%)



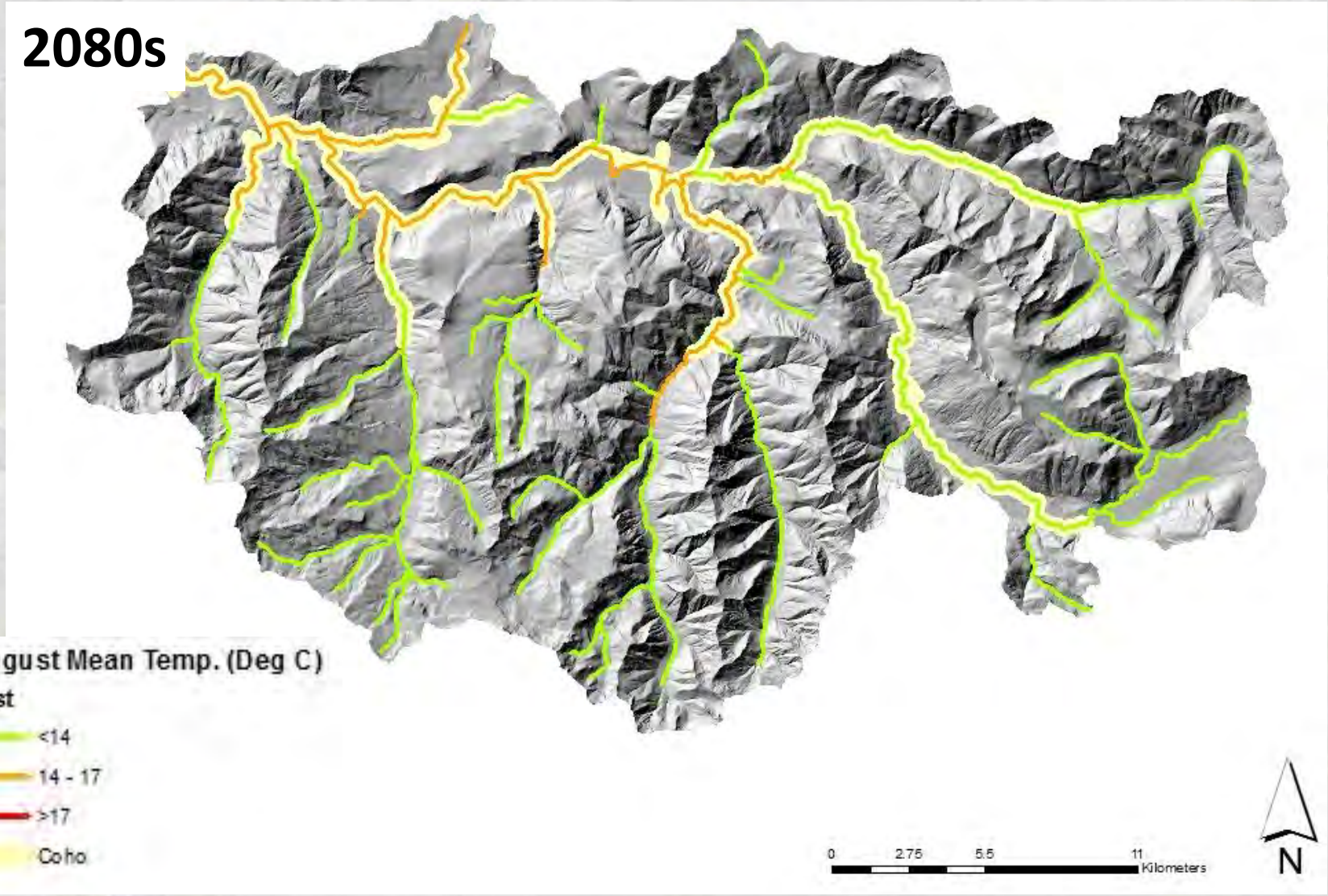
Changes Within Coho Habitat

August Temperatures within Cispus River



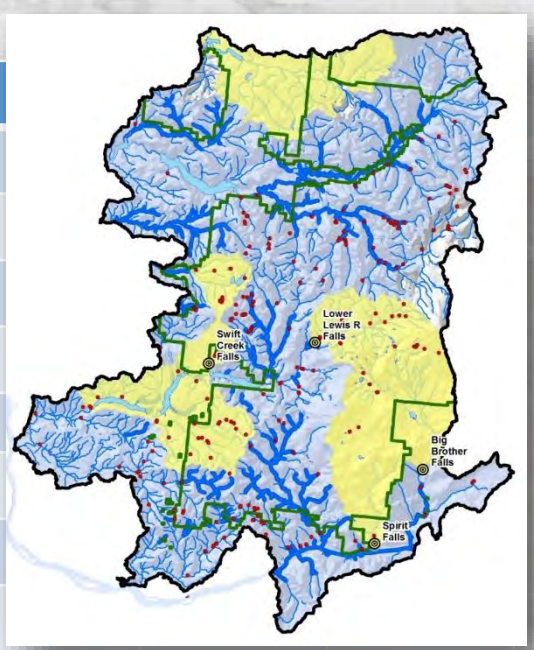
Changes Within Coho Habitat

August Temperatures within Cispus River



Changes Within Steelhead Habitat

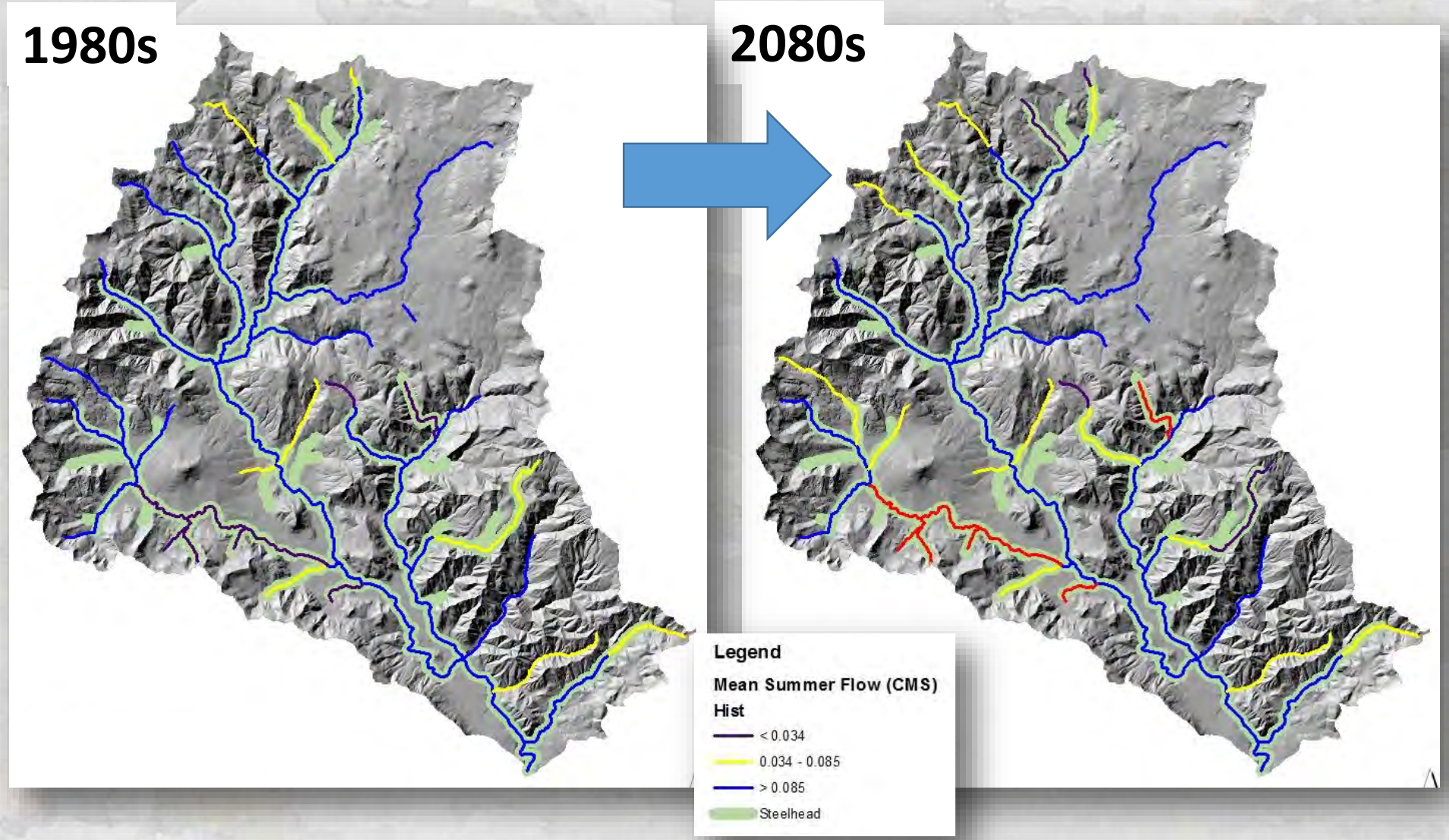
901 Kilometers of Habitat



		Number of high flow days					
Stream metric	**Period**	**<5**	**5-10**	**>10**			
Winter 95% flow	1980s	106 (12%)	160 (18%)	635 (70%)			
	2040s	37 (4%)	52 (6%)	812 (90%)			
	2080s	-	40 (4%)	861 (96%)			
			m^3/s				
		<0.034	**0.034-0.085**	**>0.085**			
Summer flow	1980s	8.7 (1%)	94 (10%)	799 (89%)			
	2040s	30 (3%)	119 (13%)	752 (83%)			
	2080s	33 (4%)	127 (14%)	741 (82%)			
			Stream kilometers				
		<8	**8-11**	**11-14**	**14-17**	**17-20**	**>20**
August temperature	1980s	14 (2%)	167 (18%)	564 (63%)	108 (12%)	8 (1%)	40 (4%)
	2040s	4 (1%)	58 (6%)	423 (47%)	359 (40%)	12 (1%)	45 (4%)
	2080s	3 (0%)	29 (3%)	269 (30%)	520 (58%)	34 (4%)	46 (5%)

Changes Within Steelhead Habitat

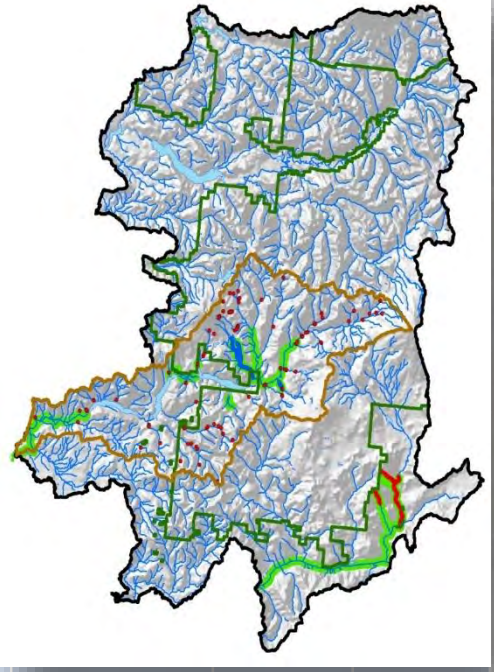
Summer Flows within the Wind River



Changes Within Bull Trout Habitat

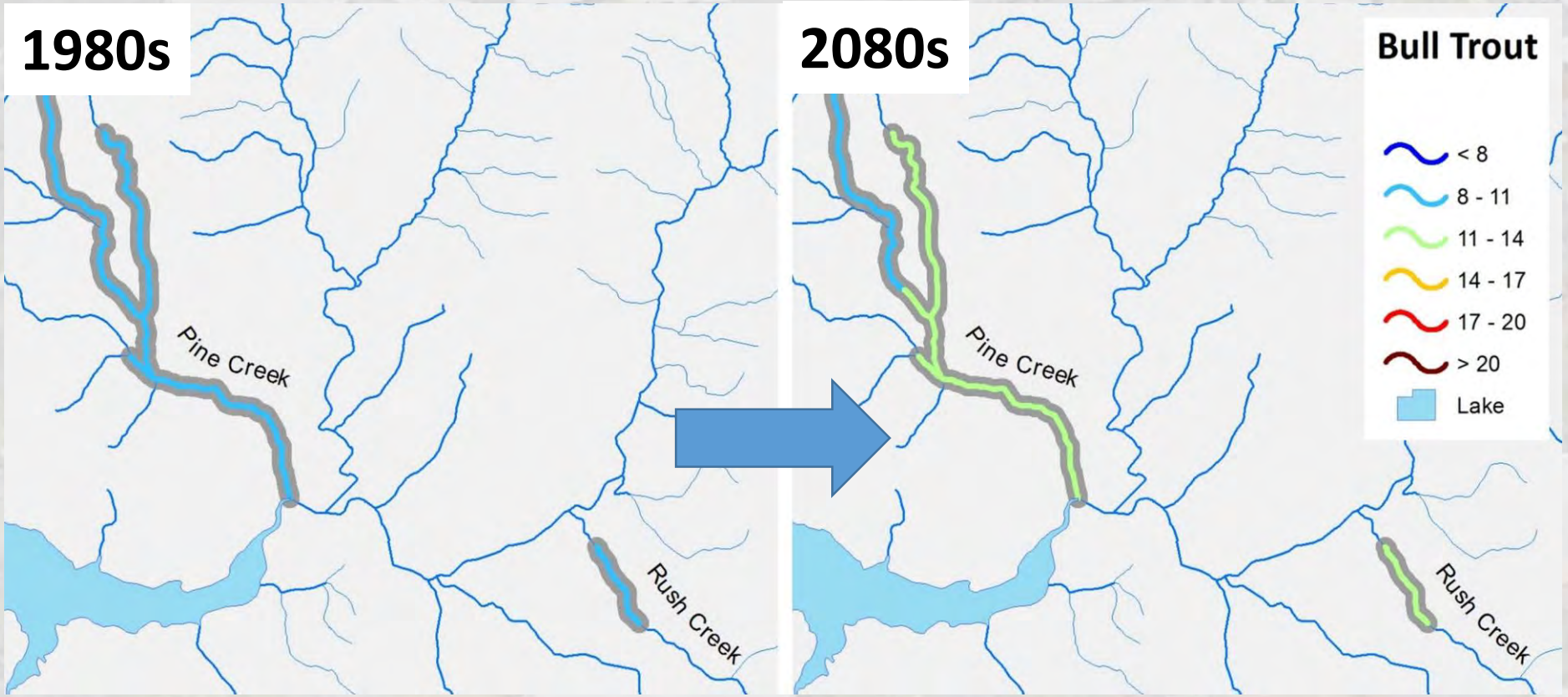
20 Kilometers of Natal Habitat

		Number of high flow days					
Stream metric	**Period**	**<5**	**5-10**	**>10**			
Winter 95% flow	1980s	-	2 (10%)	18 (90%)			
	2040s	-	-	20 (100%)			
	2080s	-	-	20 (100%)			
			m^3/s				
		<0.034	**0.034-0.085**	**>0.085**			
Summer flow	1980s	-	4 (20%)	16 (80%)			
	2040s	-	4 (20%)	16 (80%)			
	2080s	-	4 (20%)	16 (80%)			
			Stream kilometers				
		<8	**8-11**	**11-14**	**14-17**	**17-20**	**>20**
August temperature	1980s	-	20 (100%)	-	-	-	-
	2040s	-	8 (40%)	12 (60%)	-	-	-
	2080s	-	6 (30%)	14 (70%)	-	-	-



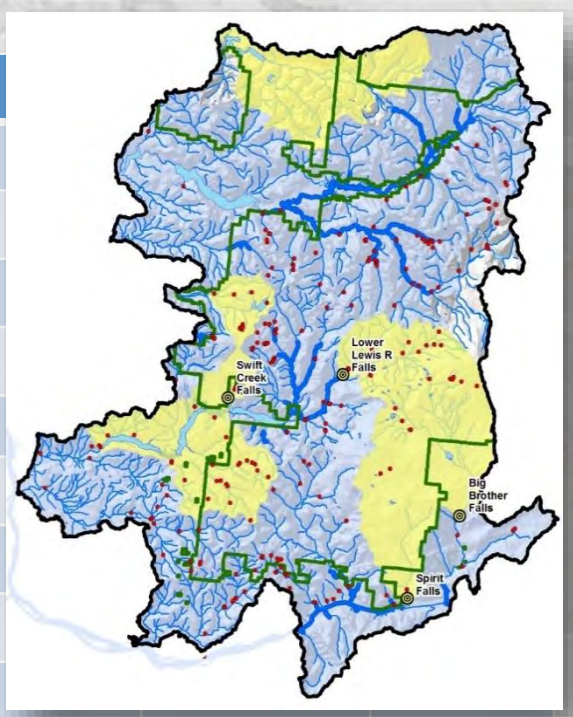
Changes Within Bull Trout Habitat

August Temperatures within Pine & Rush Creeks



Changes Within Chinook Habitat

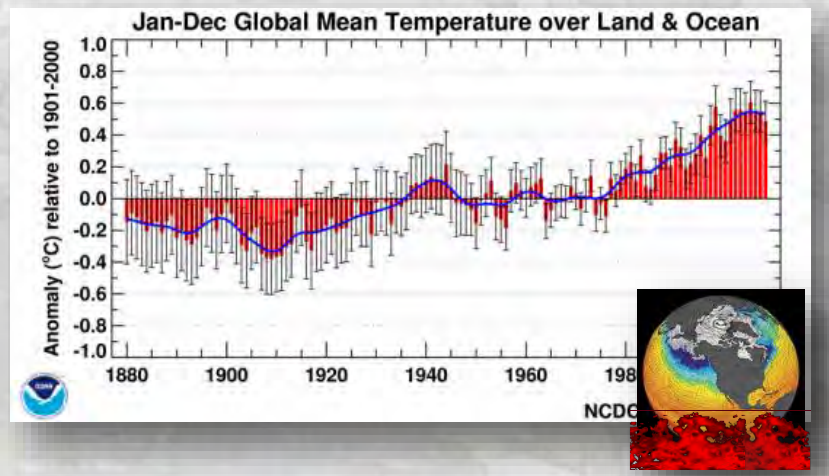
359 River Kilometers of Habitat

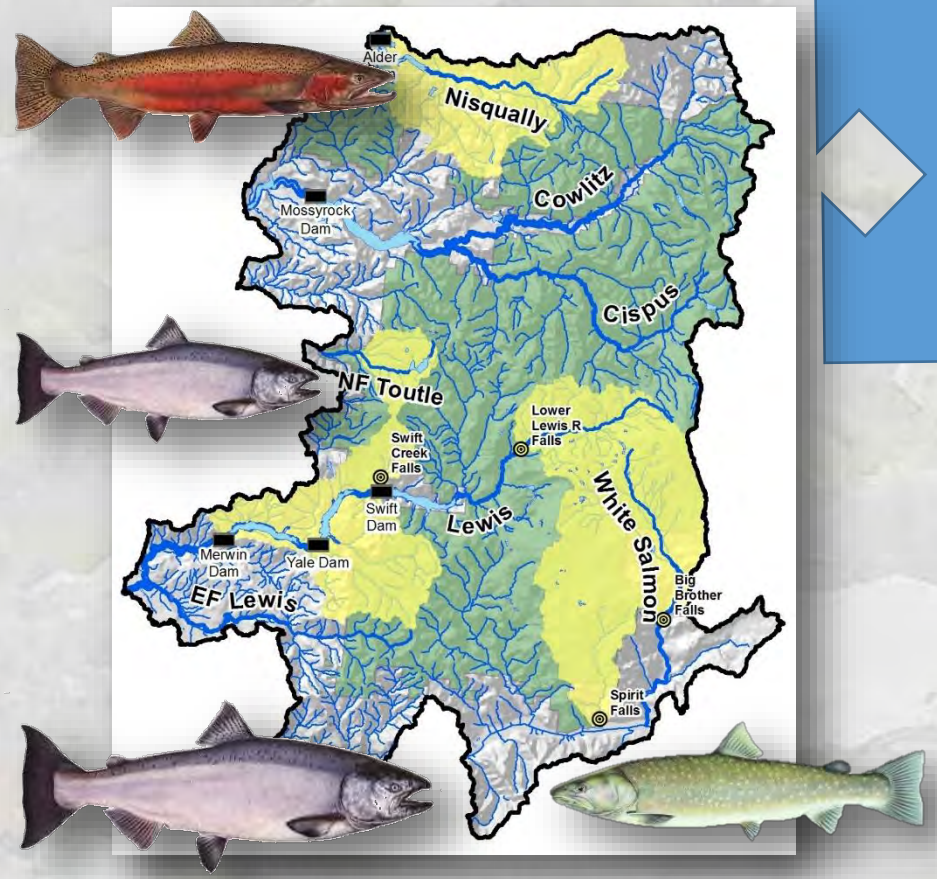


		Number of high flow days					
Stream metric	**Period**	**<5**	**5-10**	**>10**			
Winter high flow days	1980s	65 (18%)	139 (39%)	155 (43%)			
	2040s	26 (7%)	23 (6%)	310 (86%)			
	2080s	-	26 (7%)	333 (93%)			
			m^3/s				
	-	**<0.034**	**0.034-0.085**	**>0.085**			
Summer flow	1980s	-	9.8 (3%)	349 (97%)			
	2040s	-	20 (6%)	339 (94%)			
	2080s	-	21 (6%)	338 (94%)			
			Stream kilometers				
		<8	**8-11**	**11-14**	**14-17**	**17-20**	**>20**
August temperature	1980s	4.1 (1%)	45.4 (13%)	241 (67%)	39 (11%)	6 (2%)	24 (7%)
	2040s	-	20 (6%)	133 (37%)	167 (46%)	12 (3%)	28 (8%)
	2080s	-	9 (2%)	83 (23%)	223 (62%)	15 (4%)	29 (8%)

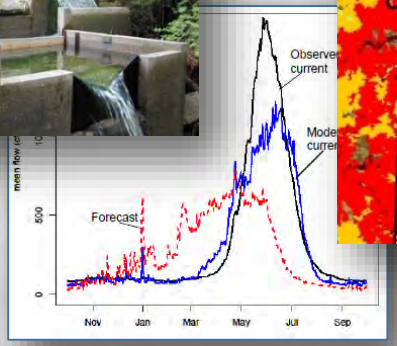
Fish Climate Vulnerability
What matters?

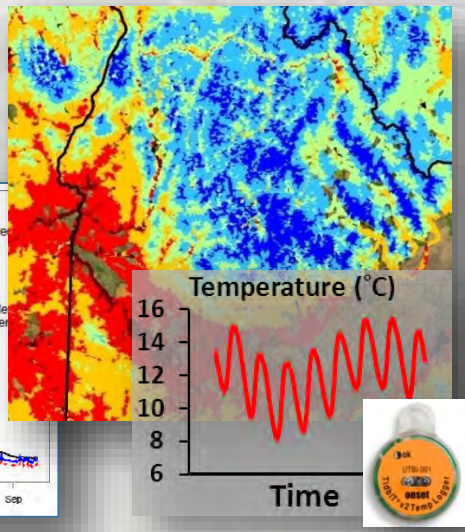
1) species considered
2) stream location
3) climate factor



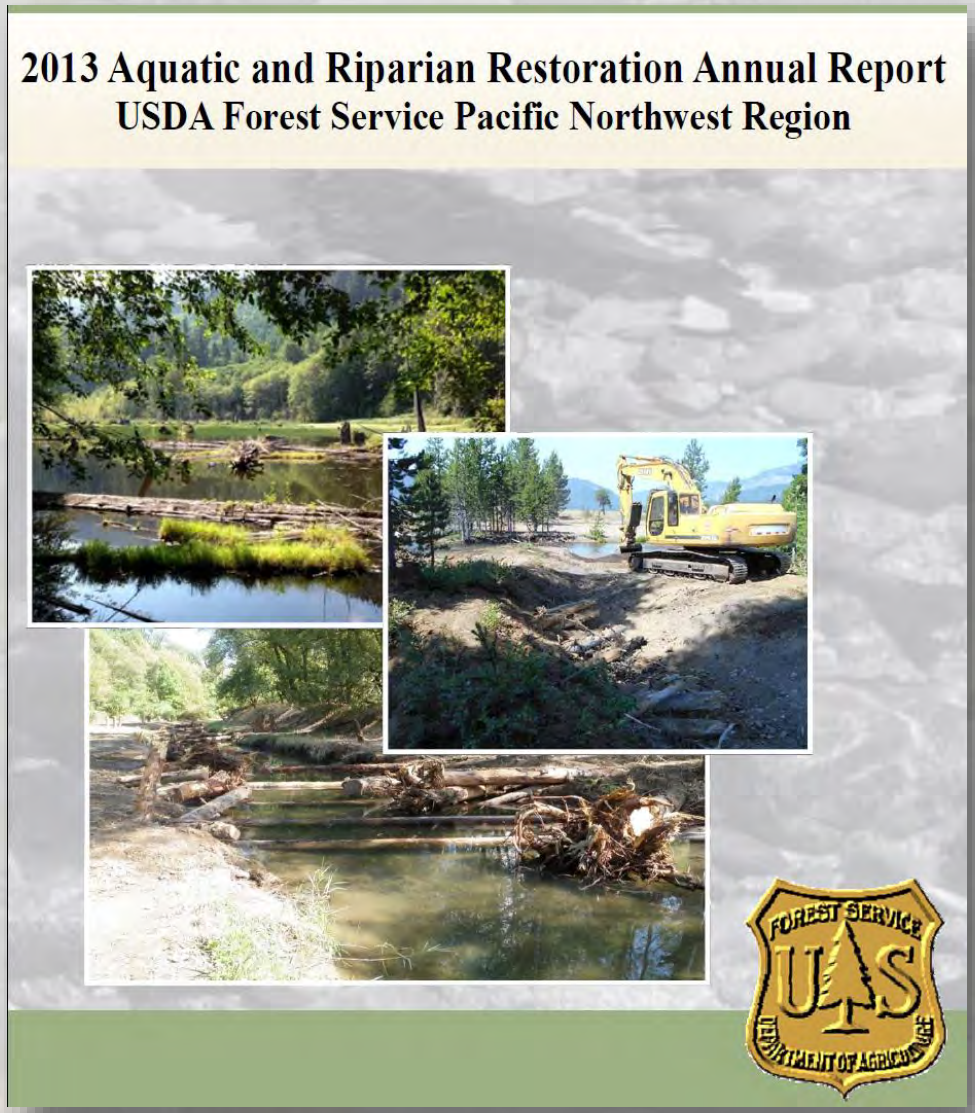


Where do vulnerabilities meet "on-the-ground" opportunities?





Climate Vulnerability Could Provide a Context for Prioritizing Stream Restoration Efforts…



- Modifying road culverts…
- Maintaining/restoring flow…
- Maintaining/restoring riparian…
- Restoring channel form/function…
- Non-native species control…
- Large woody debris…

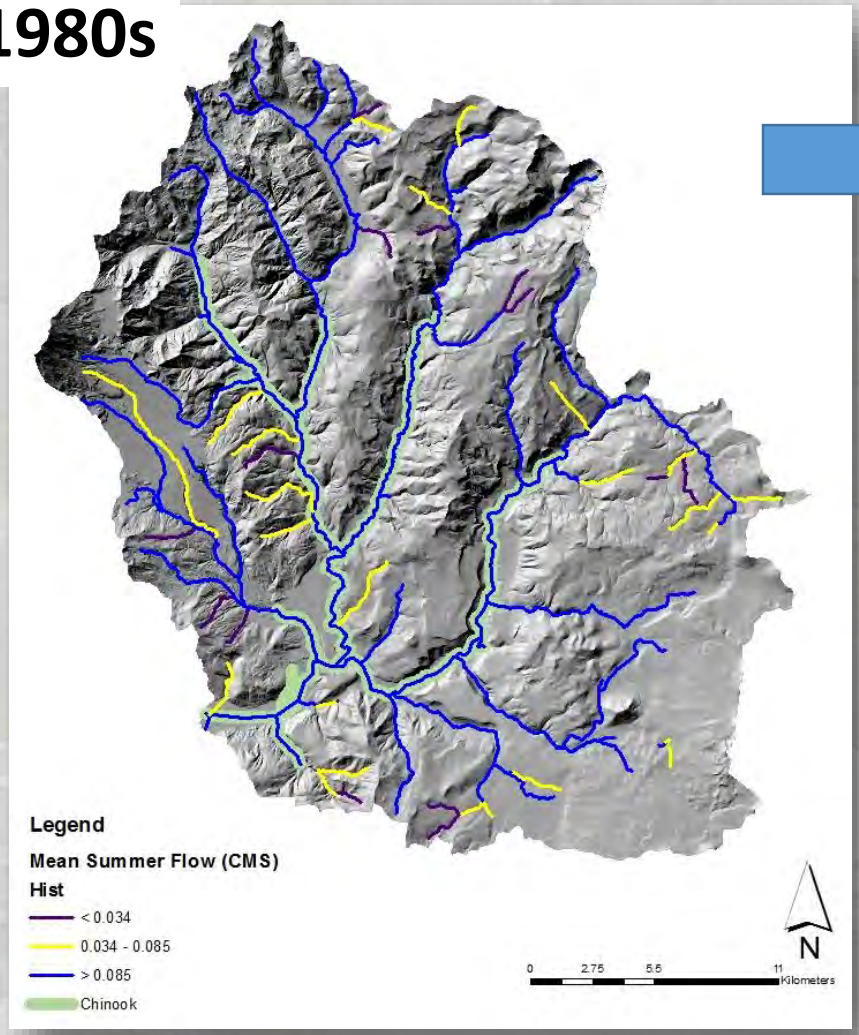
Before → **After**


Global Warming Is ...
NOT COOL!
The End

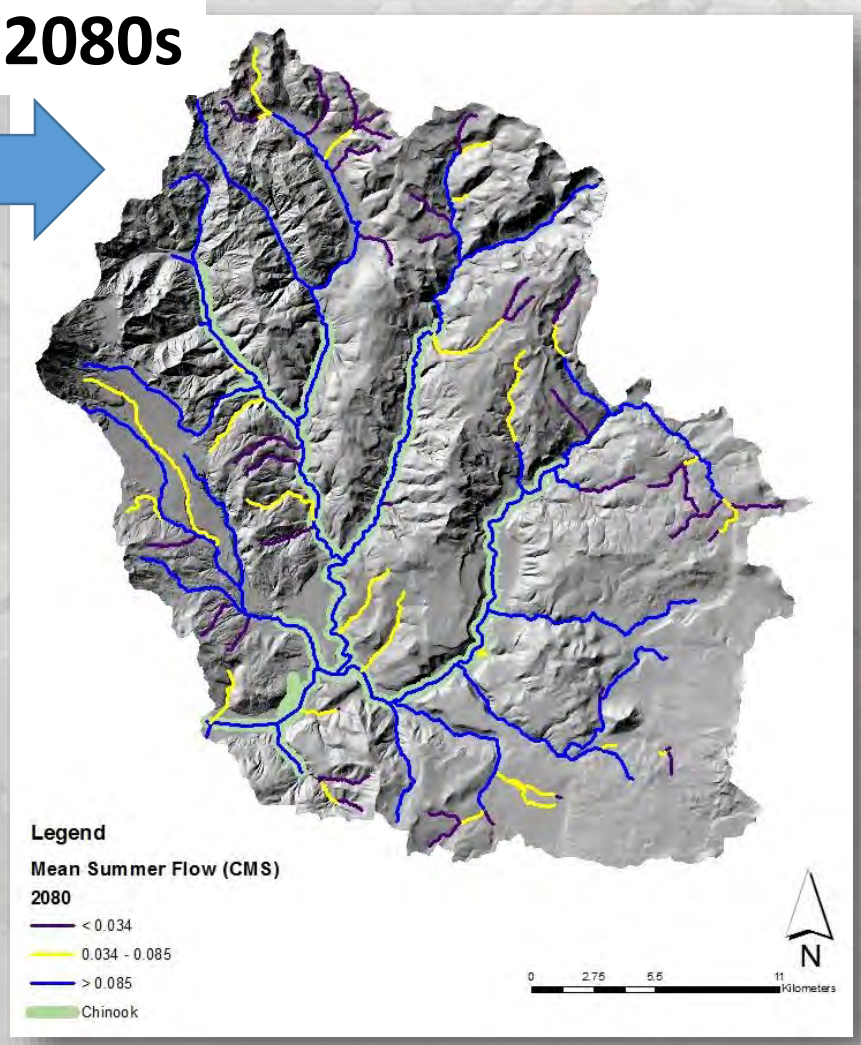
Changes Within Chinook Habitat

Summer flows in Lewis River

1980s

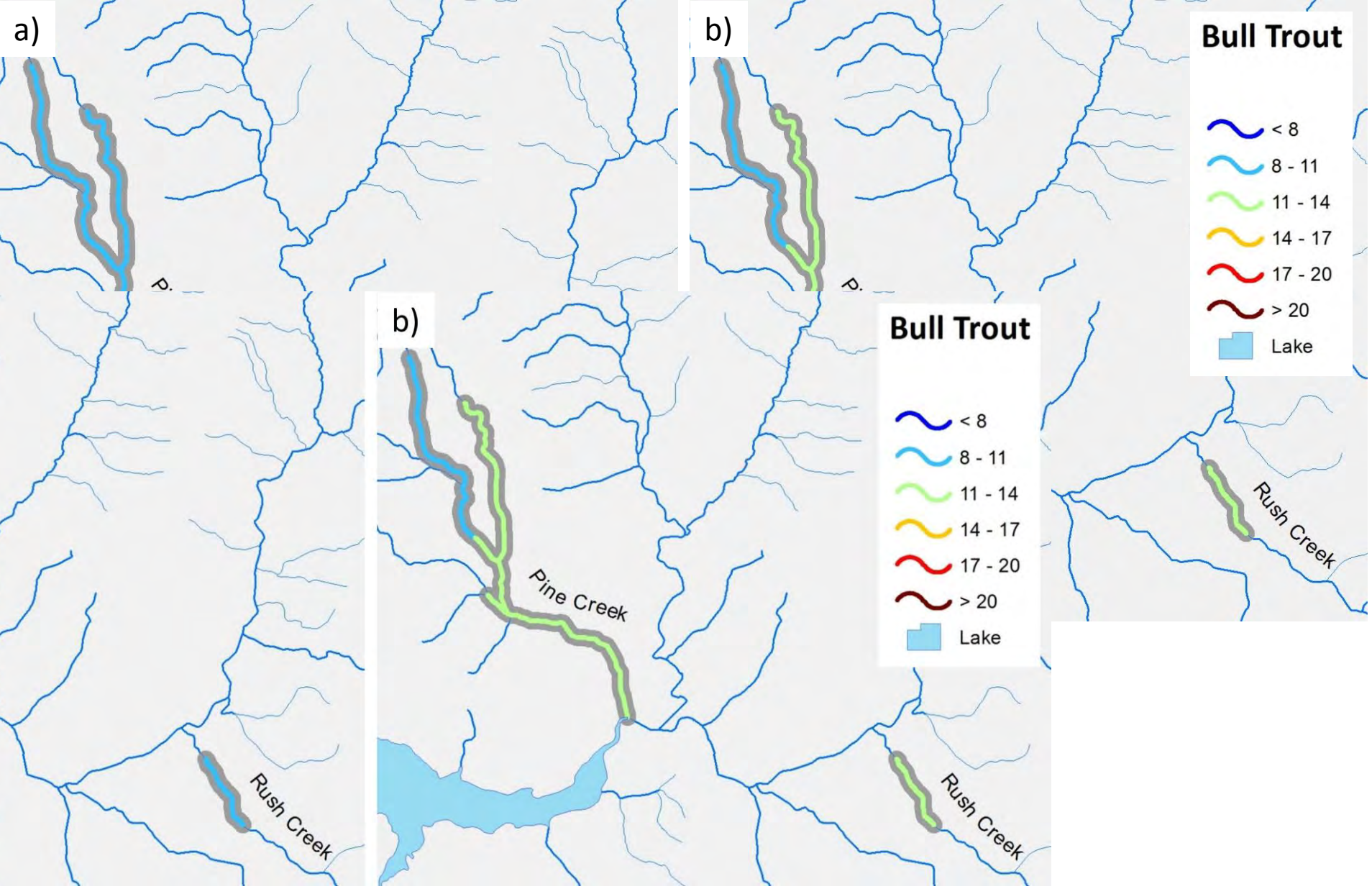


2080s



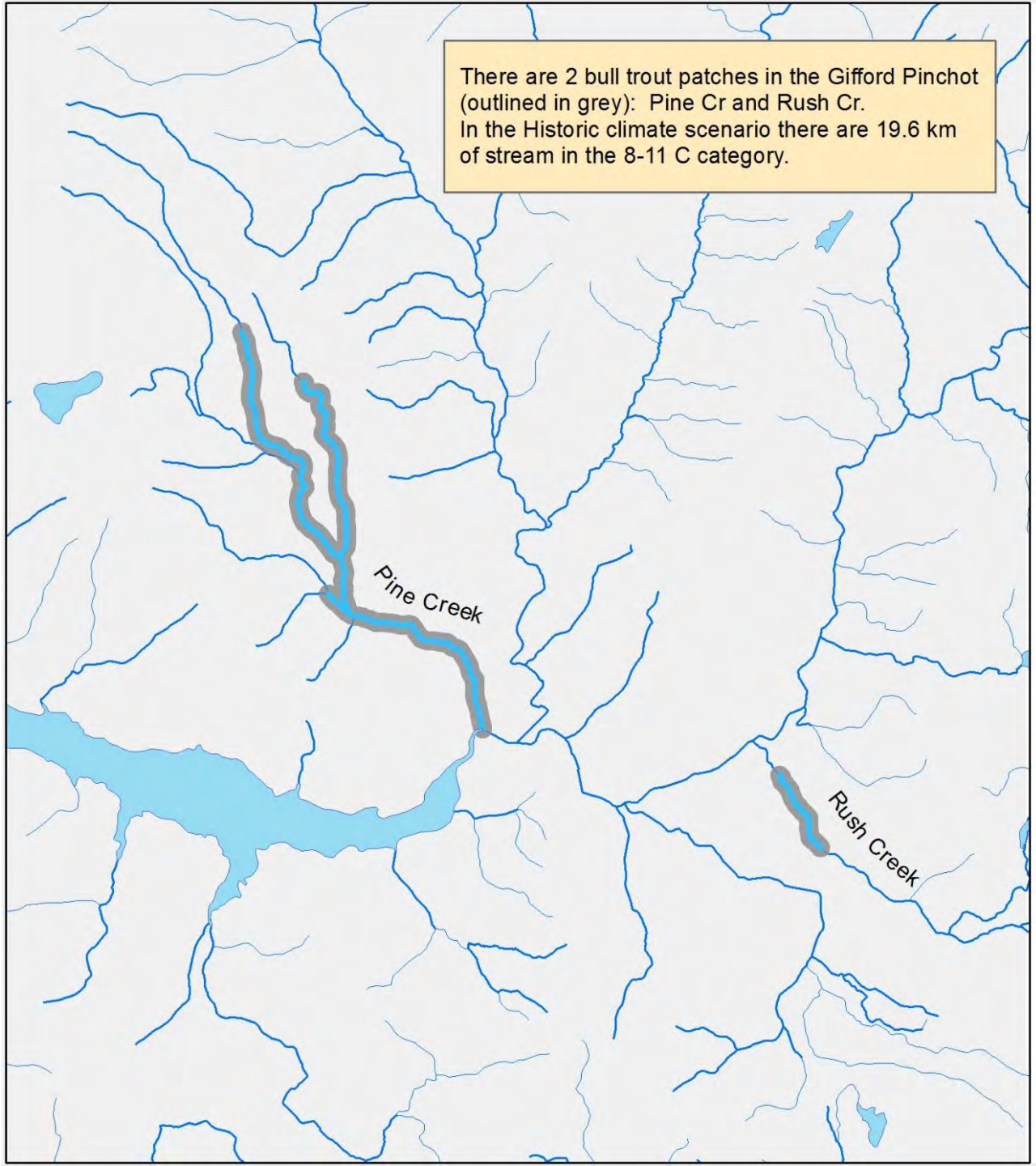
Forest Datasets Were Key to The Quality of This Assessment…

& Will Be Key to Improving Assessments in *Future* Decades…


a)
b)
Bull Trout
< 8
8 - 11
11 - 14
14 - 17
17 - 20
> 20
Lake
Pine Creek
Rush Creek

1980s

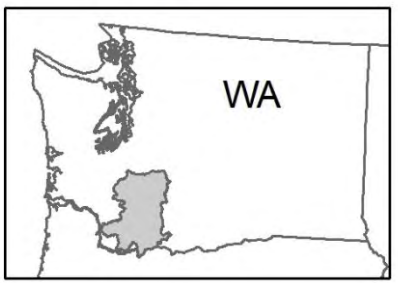
There are 2 bull trout patches in the Gifford Pinchot (outlined in grey): Pine Cr and Rush Cr.
In the Historic climate scenario there are 19.6 km of stream in the 8-11 C category.



Bull Trout

- < 8
- 8 - 11
- 11 - 14
- 14 - 17
- 17 - 20
- > 20
- Lake

All perennial streams <15% slope & mean summer flow >0.006 cms



2040s

In the 2040 climate scenario there are 7.4 km of stream in the 8-11 C category and 12.2 km of stream in the 11-14 C category.

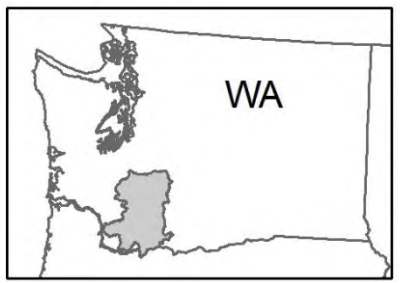
Bull Trout

- < 8
- 8 - 11
- 11 - 14
- 14 - 17
- 17 - 20
- > 20
- Lake

Pine Creek

Rush Creek

All perennial streams <15% slope & mean summer flow >0.006 cms



2080s

In the 2080 climate scenario there are 5.4 km of stream in the 8-11 C category and 14.2 km of stream in the 11-14 C category.

Pine Creek

Rush Creek

Bull Trout

- < 8
- 8 - 11
- 11 - 14
- 14 - 17
- 17 - 20
- > 20
- Lake

All perennial streams <15% slope & mean summer flow >0.006 cms