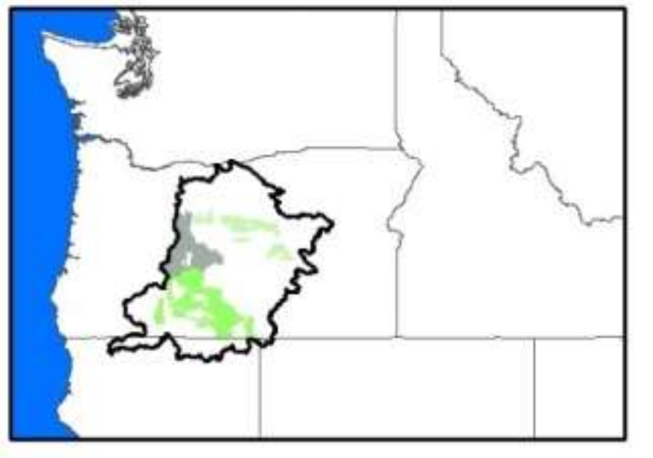
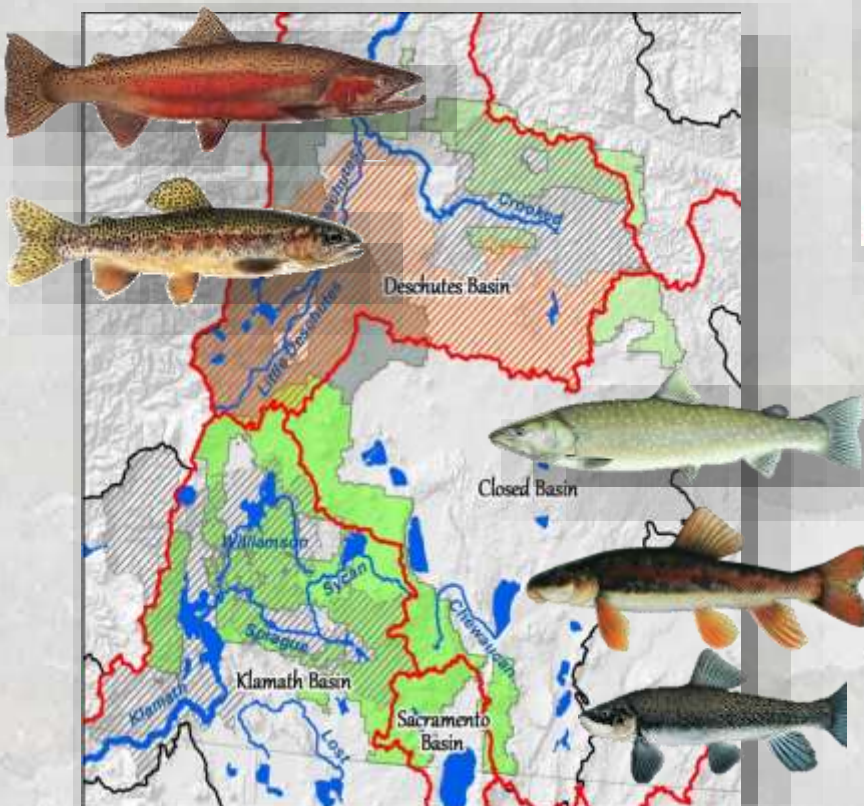
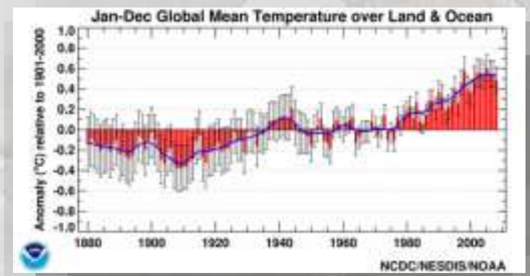
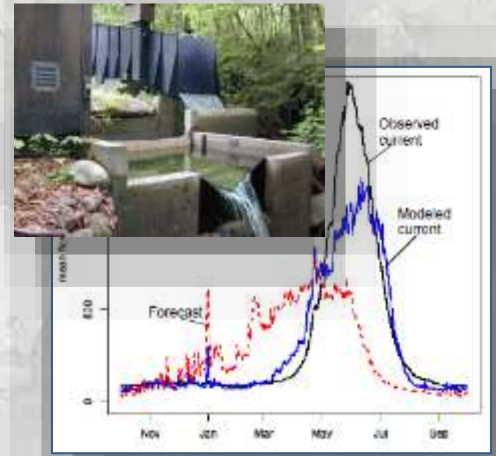
South Central Oregon Adaptation Partnership: Effects of Climate Change on Fisheries

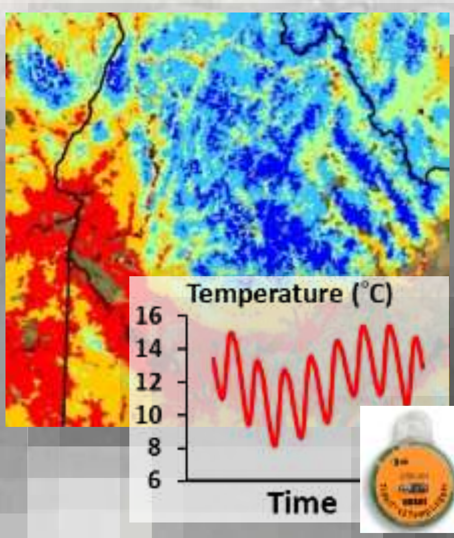


John Chatel, Jennifer Mickelson, Phillip Gaines, Terry Smith, Dona Horan, Dan Isaak





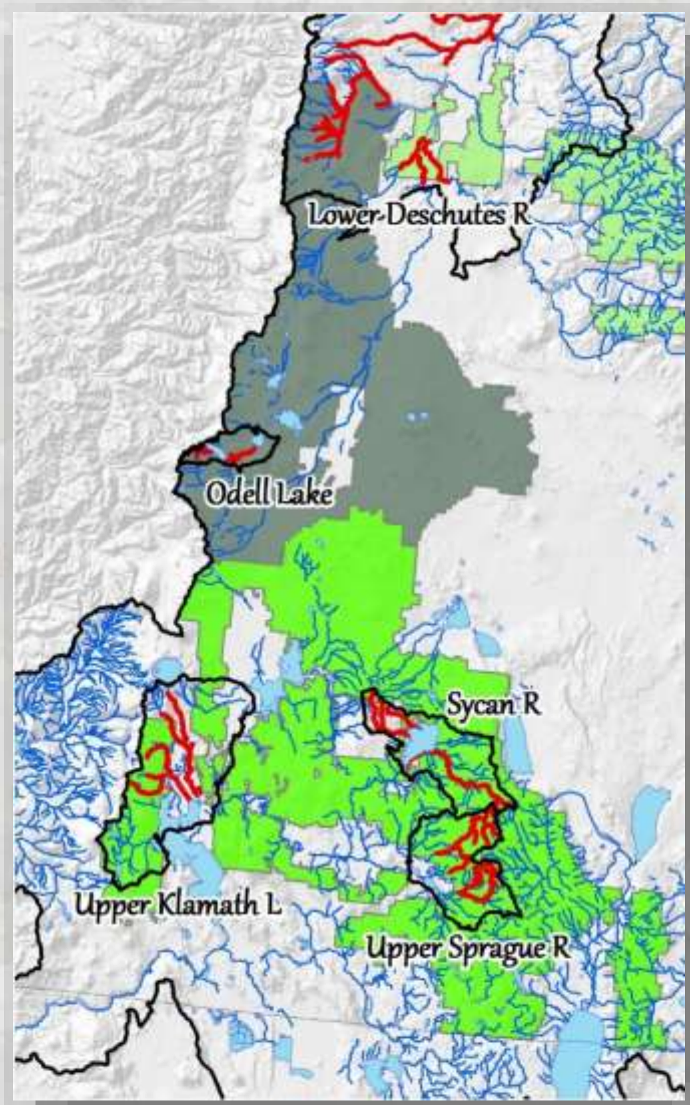




Species of Concern… Bull trout

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

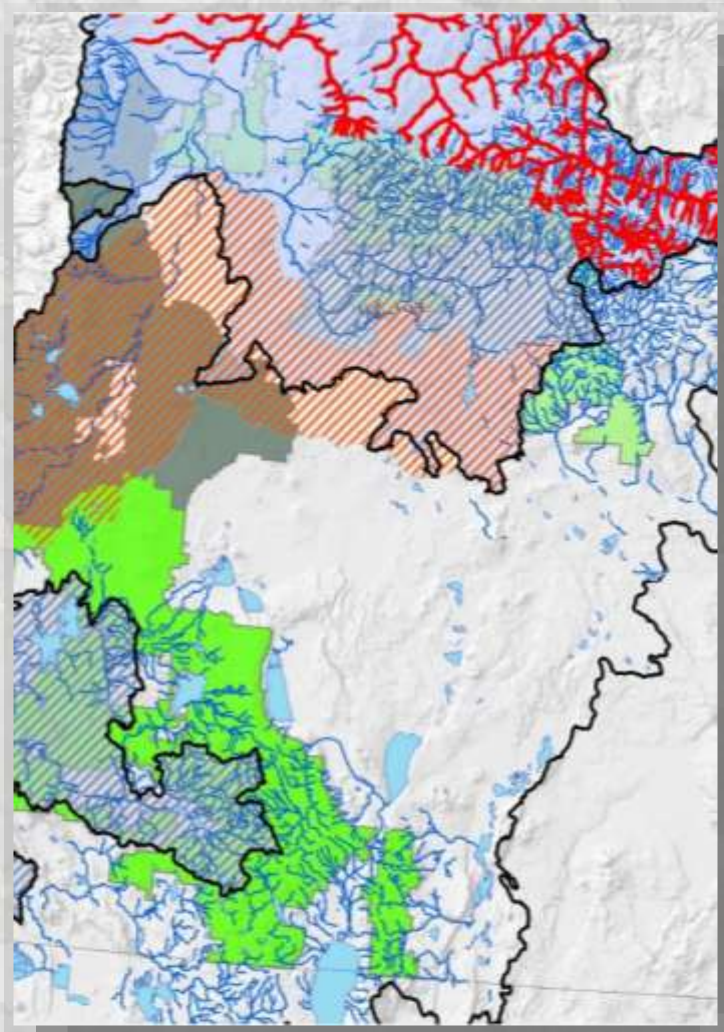
Critical habitat



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

Critical habitat

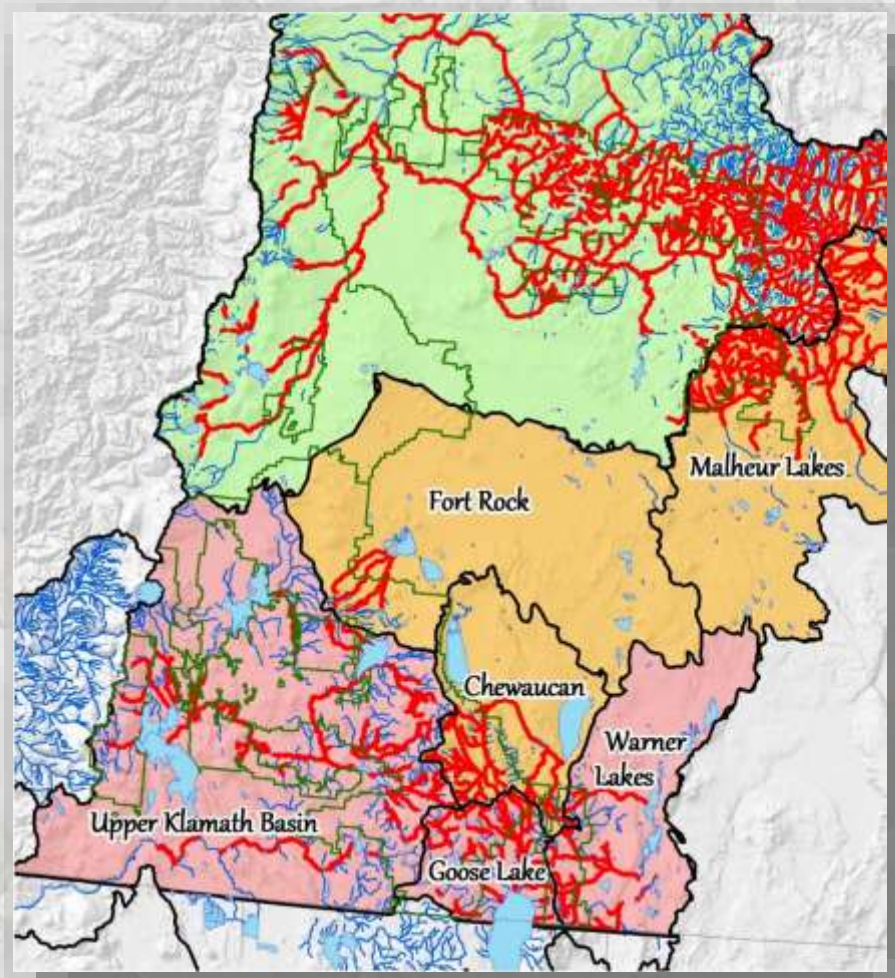


Species of Concern…

Redband trout

- Not ESA listed, but Regional Forester considers to be "sensitive species"
- Non-anadromous version of steelhead
- 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

Stream Habitats



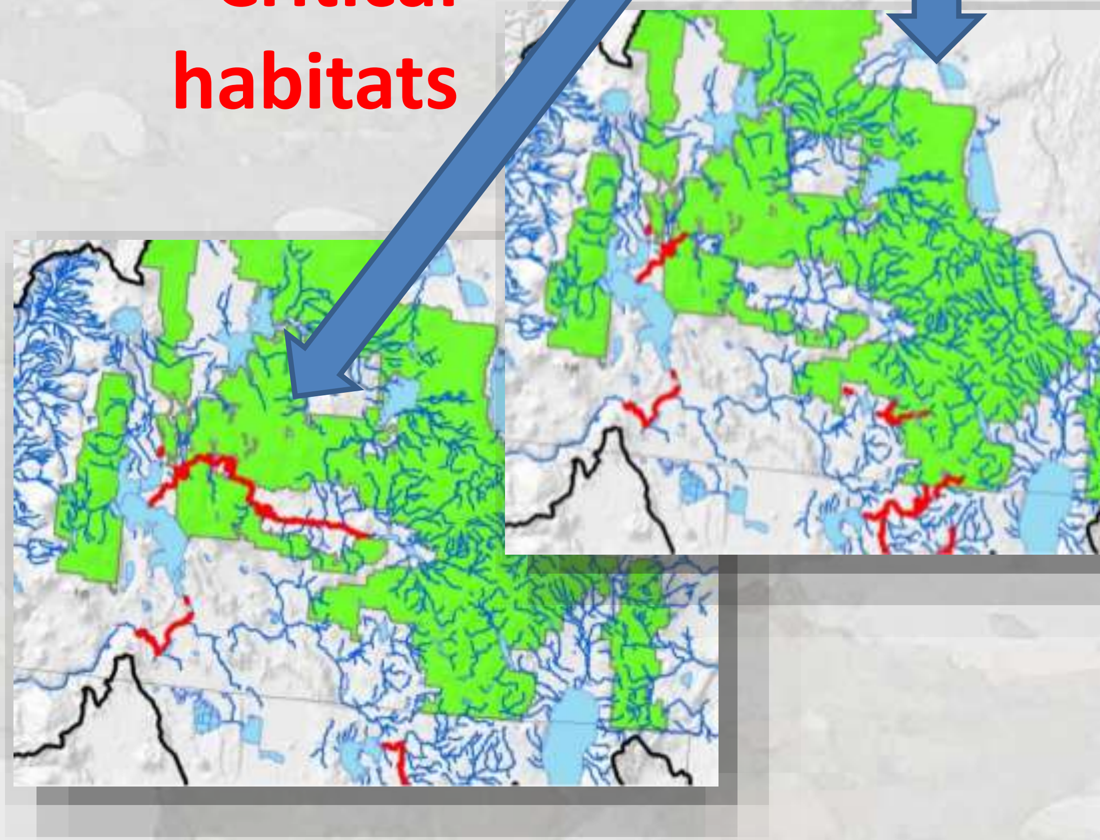
Species of Concern…

Lost River Sucker

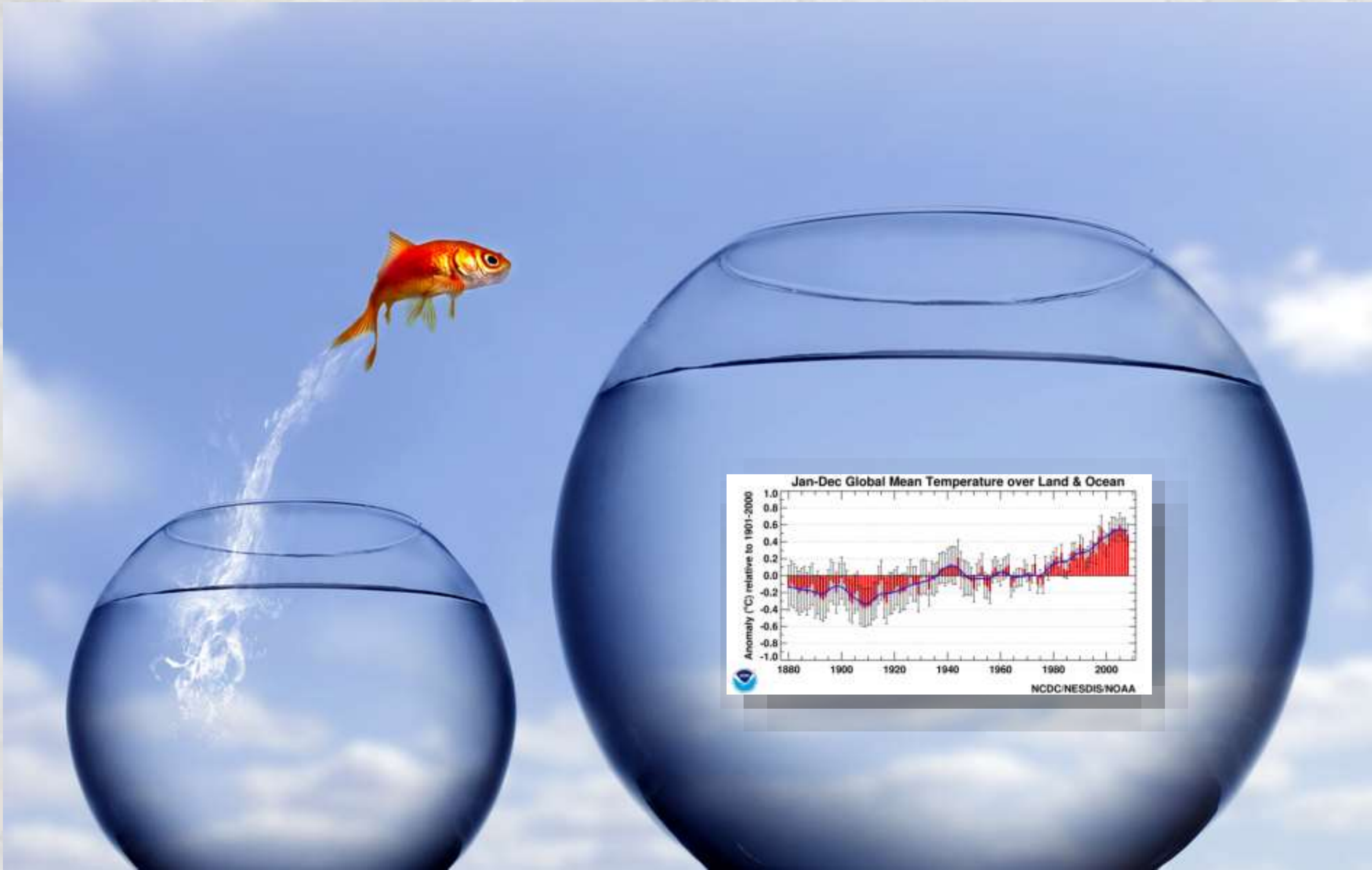
Shortnose Sucker

- ESA listed as endangered
- Endemic species
- Main habitats are lakes but use inflowing streams for spawning
- Distribution on FS lands limited to ~40 kilometers of stream on the Fremont-Winema NF

Critical habitats

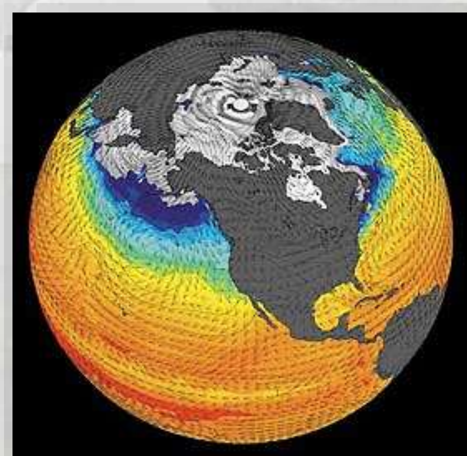


Taking Climate into the Water Where Fish Live…

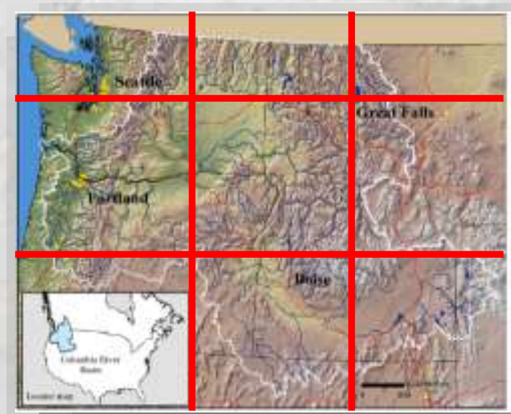


Taking Climate into the Water Where Fish Live…

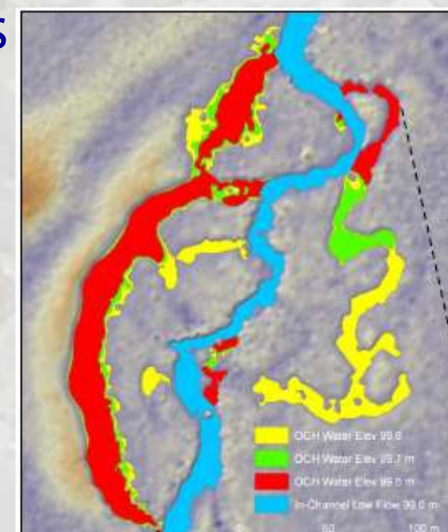
Climate model (air temp & precip)



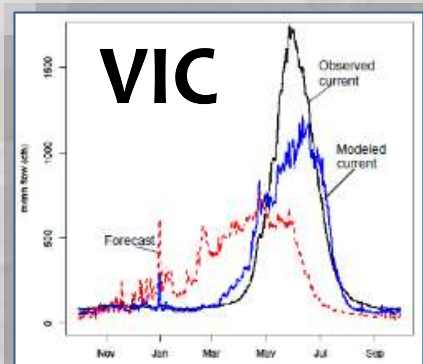
Regional patterns



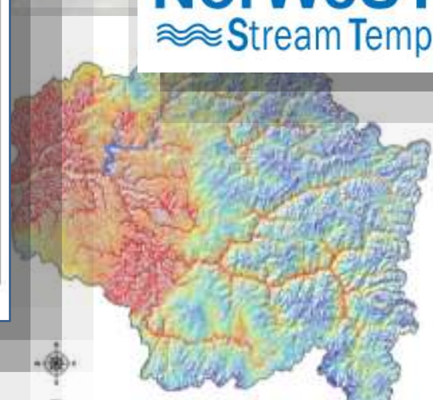
Stream reach patterns



Stream temperatures & flow

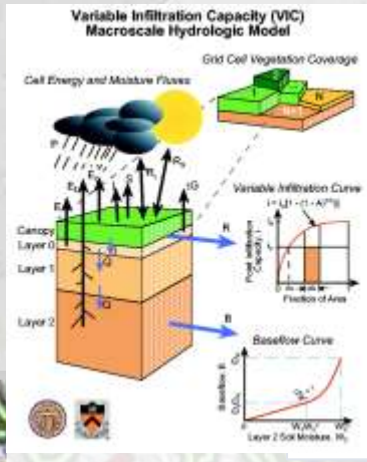


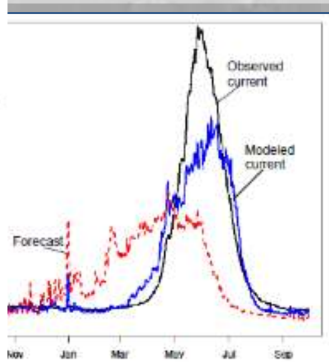
NorWeST Stream Temp



GIS Data for Stream Flow & Temperature Scenarios Downloaded from Websites

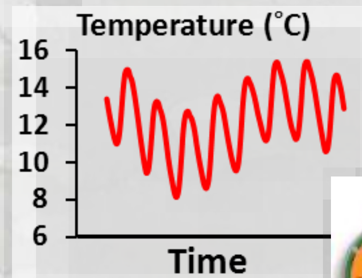
VIC Streamflow Scenarios

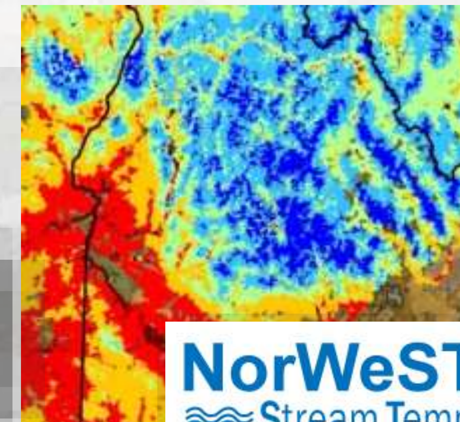




Google "Stream flow Metrics"

Google "NorWeST stream temp"





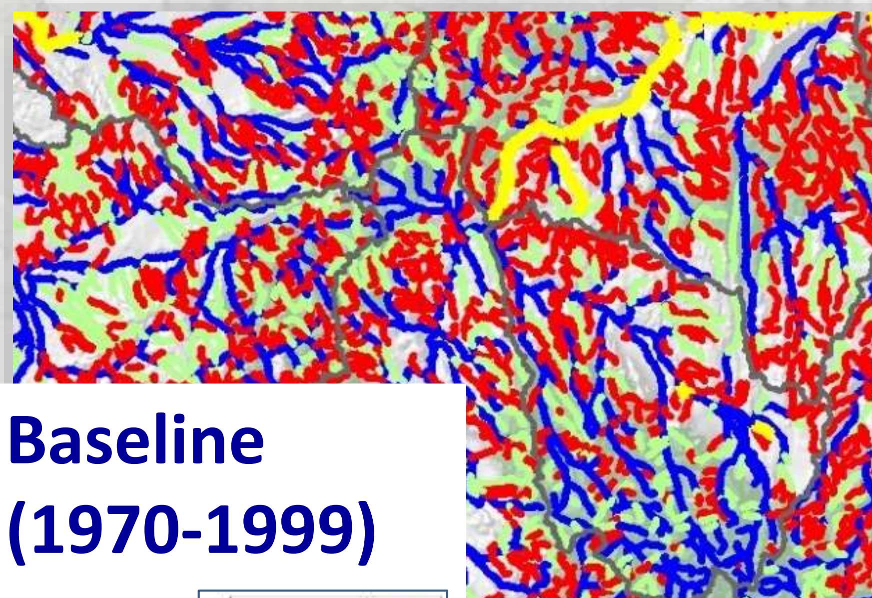
NorWeST
Stream Temp

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.

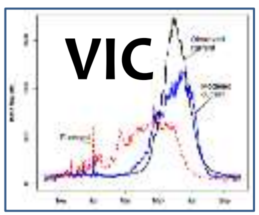
Liang et al. 1994. *J. Geophys Res* **99**:14415–14428.
Wenger et al. 2010. *Water Res Res* **46:**W09513.
Safeeq et al. 2014. *Hydrology and Earth System Sciences* **11:**3315-3357.

Stream Hydrography Baseline for Fish

1:100,000 NHDPlus



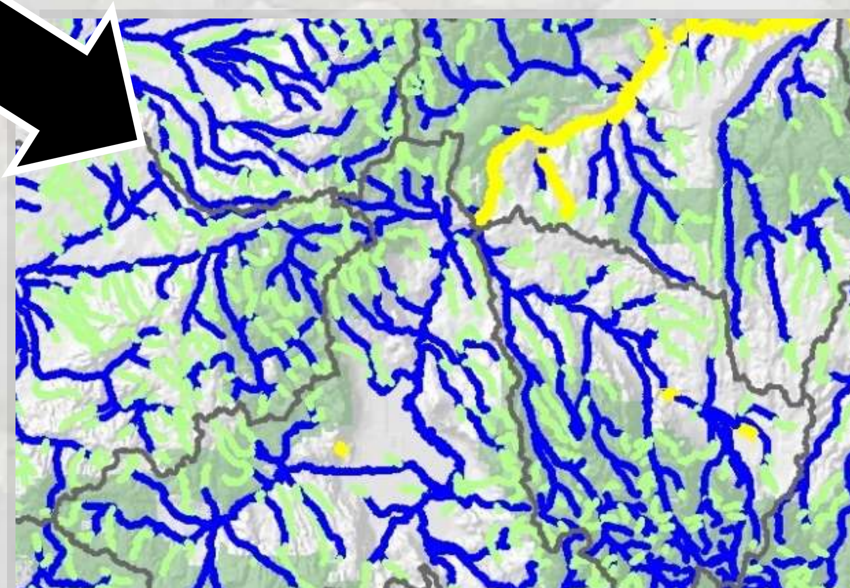
Baseline (1970-1999)



>0.2 cfs summer flow

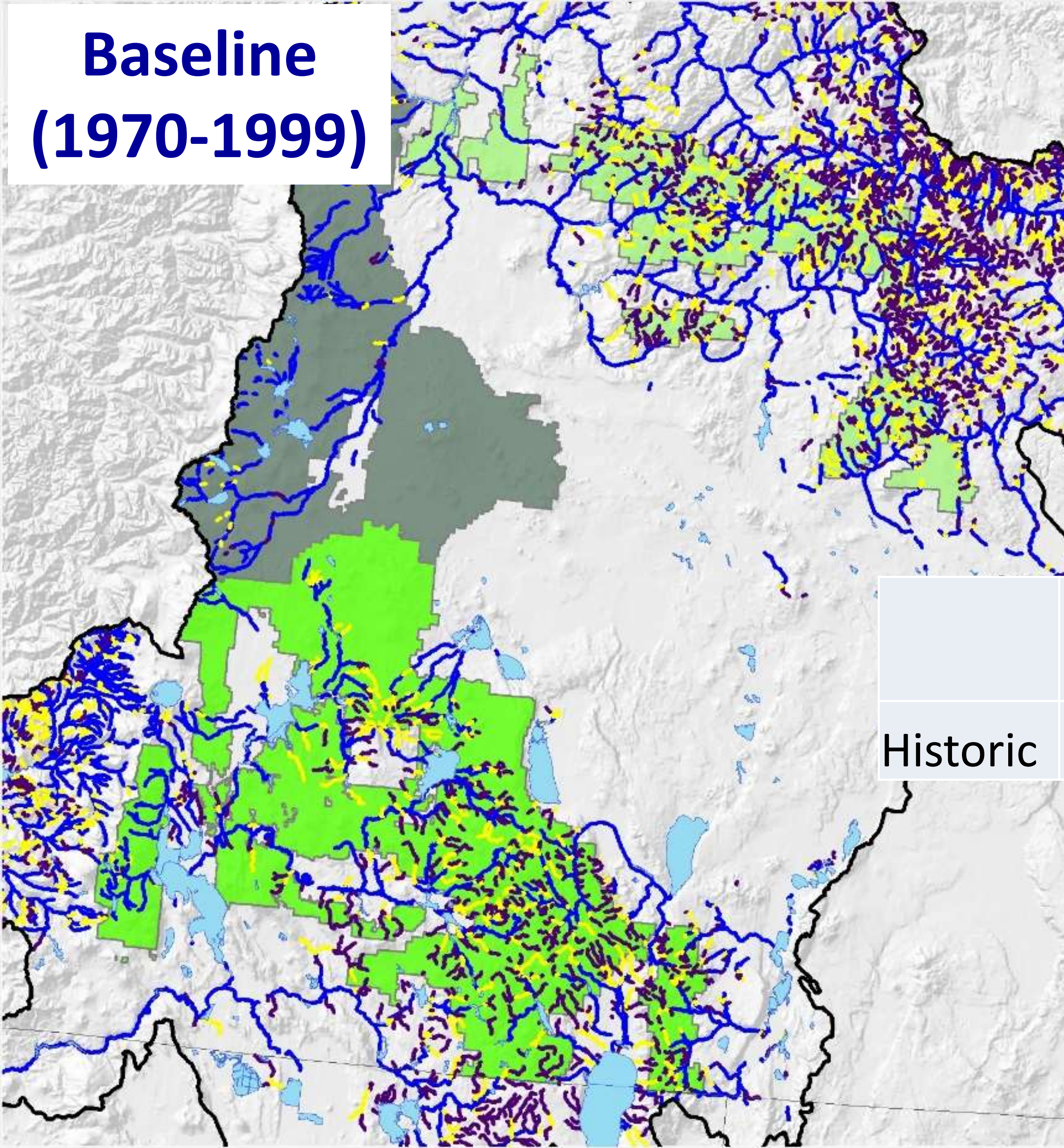
<15% slope

Deleted intermittent channels



~65% network reduction

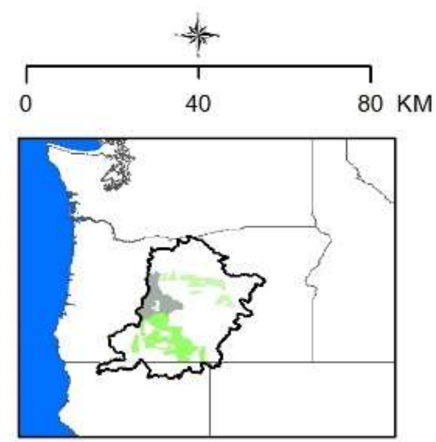
Stream Fish Hydrography



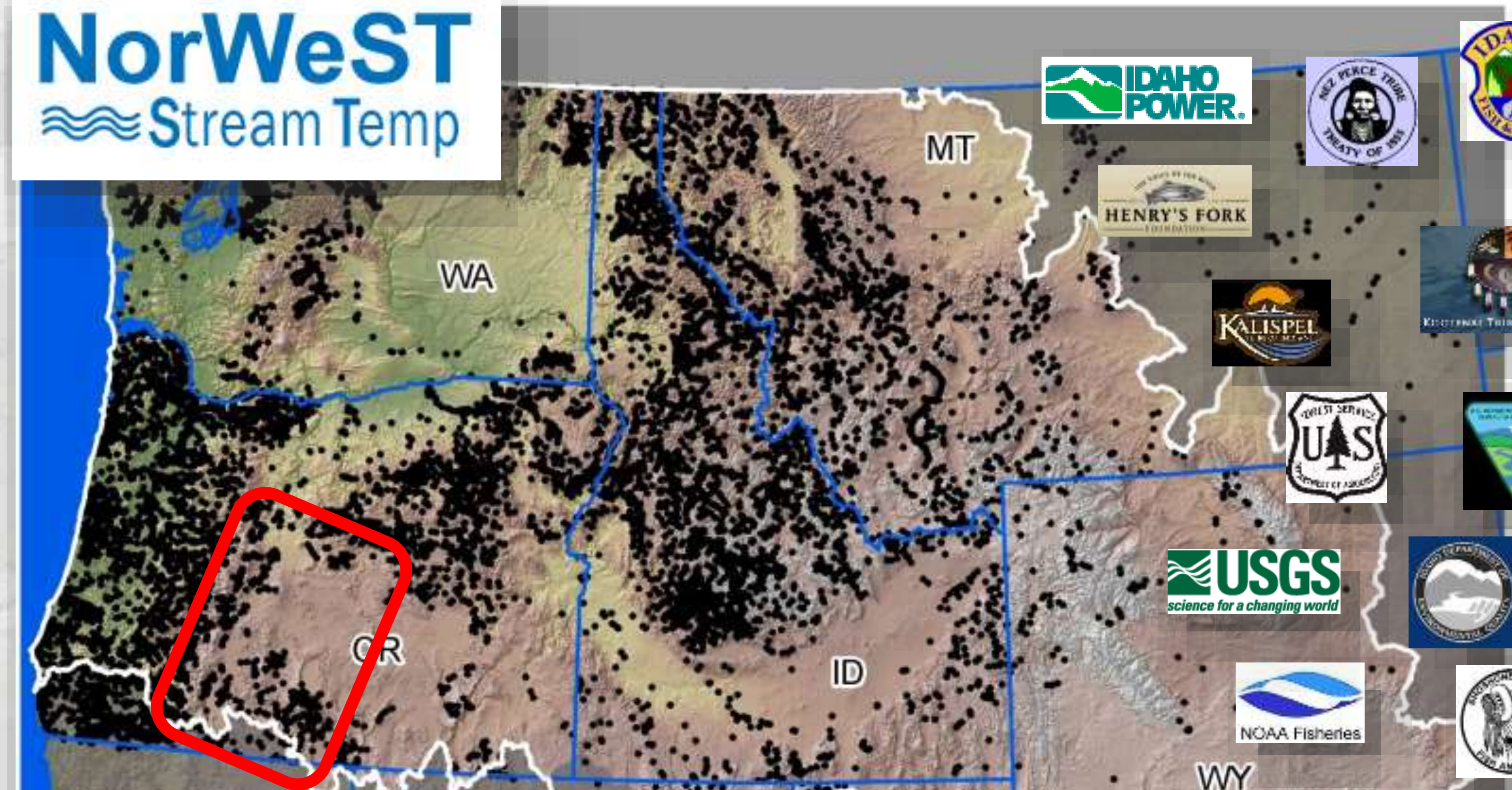
Mean Summer Flow (cms)

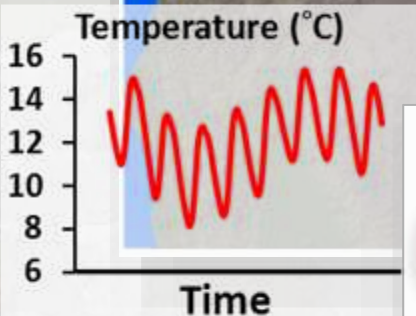
- 0.000285 - 0.034000
- 0.034001 - 0.085000
- 0.085001 - 163.571635
- Ochoco NF
- Deschutes NF
- Fremont-Winema NF
- Lake (>1 Sq Km)

	All Streams	USFS Streams
Historic	19,161 km	4,968 km



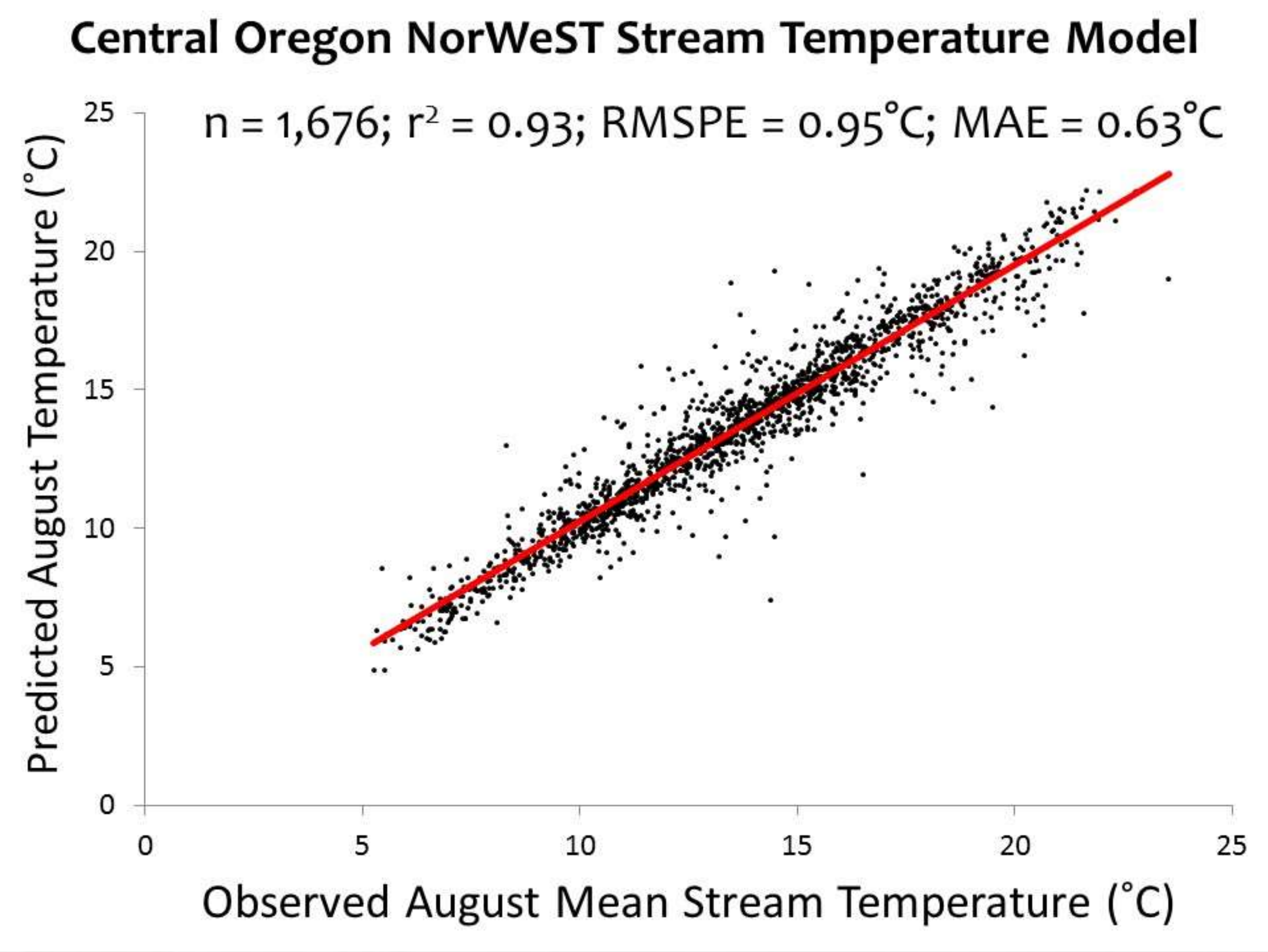
Stream Temperature Database





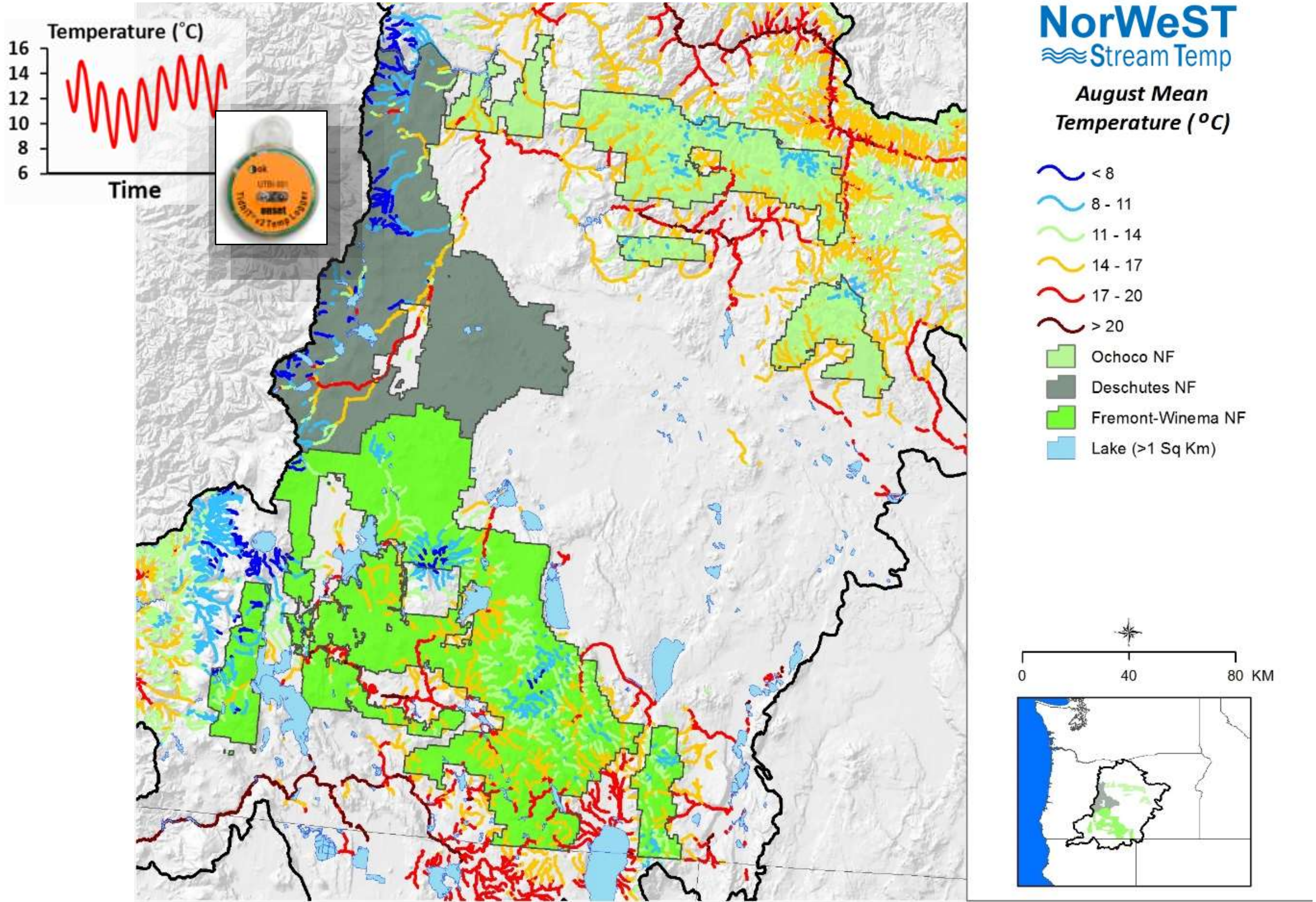
Data from all agencies &…

NorWeST Temperature Model Accuracy



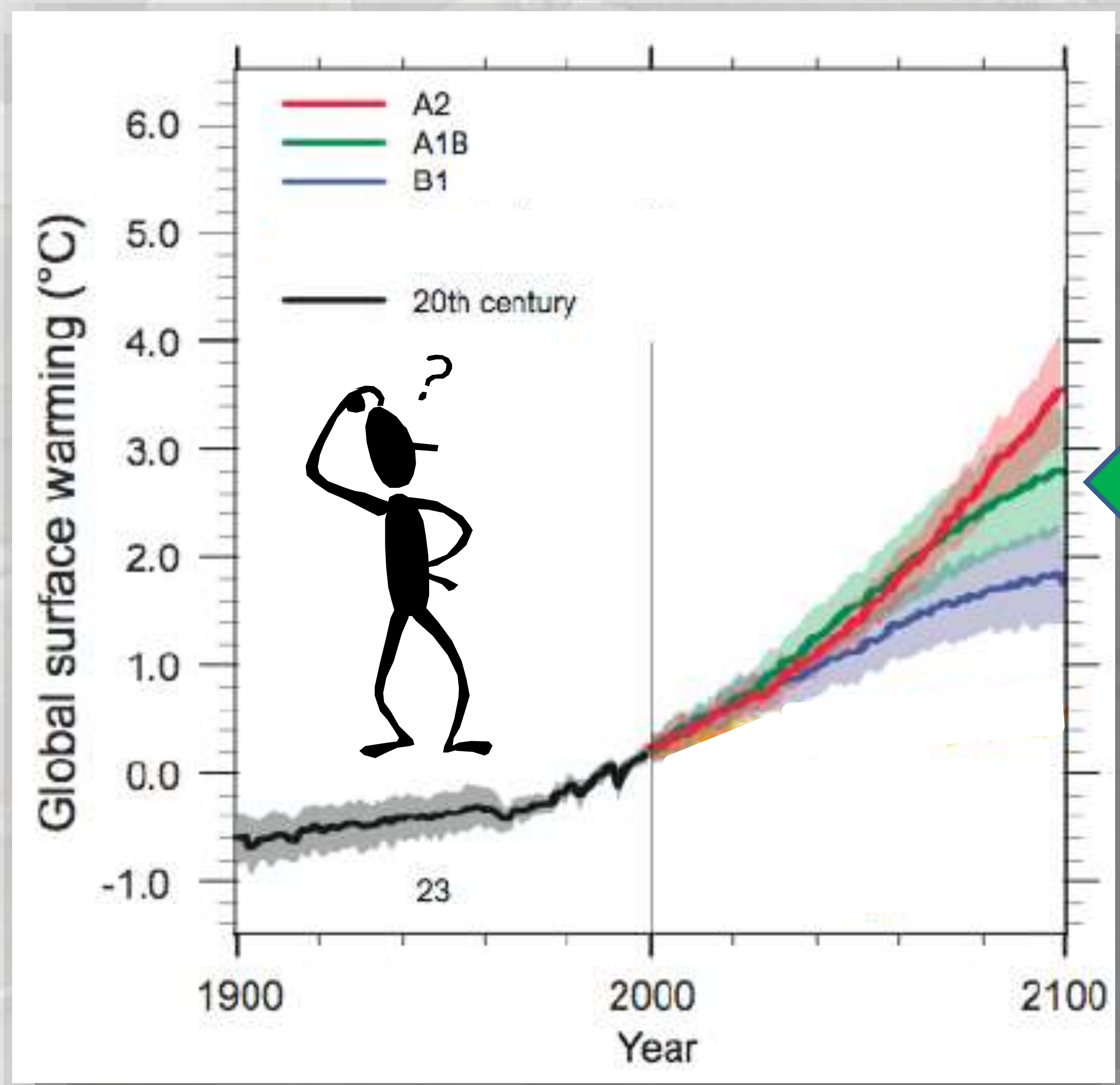
Stream Temperature Baseline

Baseline (1970-1999)



Future Climate Scenarios

A1B 10 GCM Ensemble from CIG



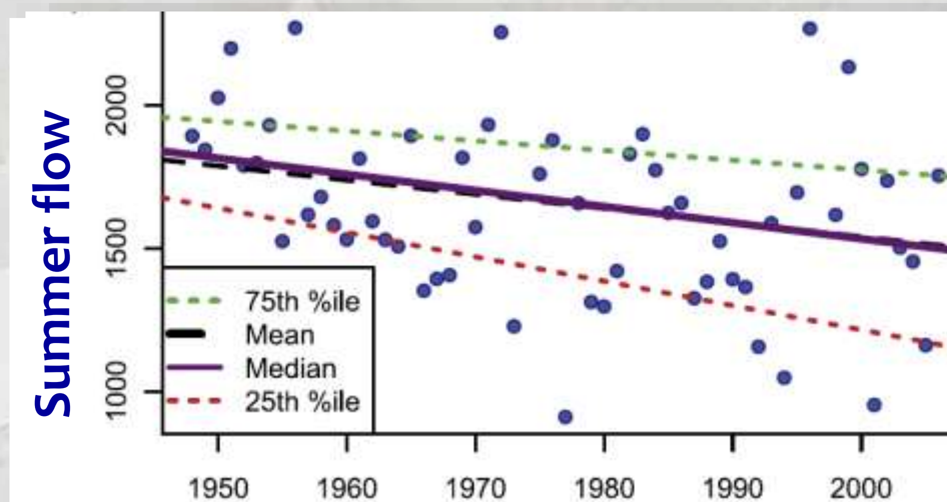
A1B ~RCP 6.0

- Historic baseline (1970-1999)
- 2040s (2030-2059)
- 2080s (2070-2099)

Changes in Mean Summer Flows - Summary

		All lands		**USFS lands**
Baseline (1970-1999)		-		-
2040s (2030-2059)		-20.0%		-31.3%
2080s (2070-2099)		-29.5%		-47.1%

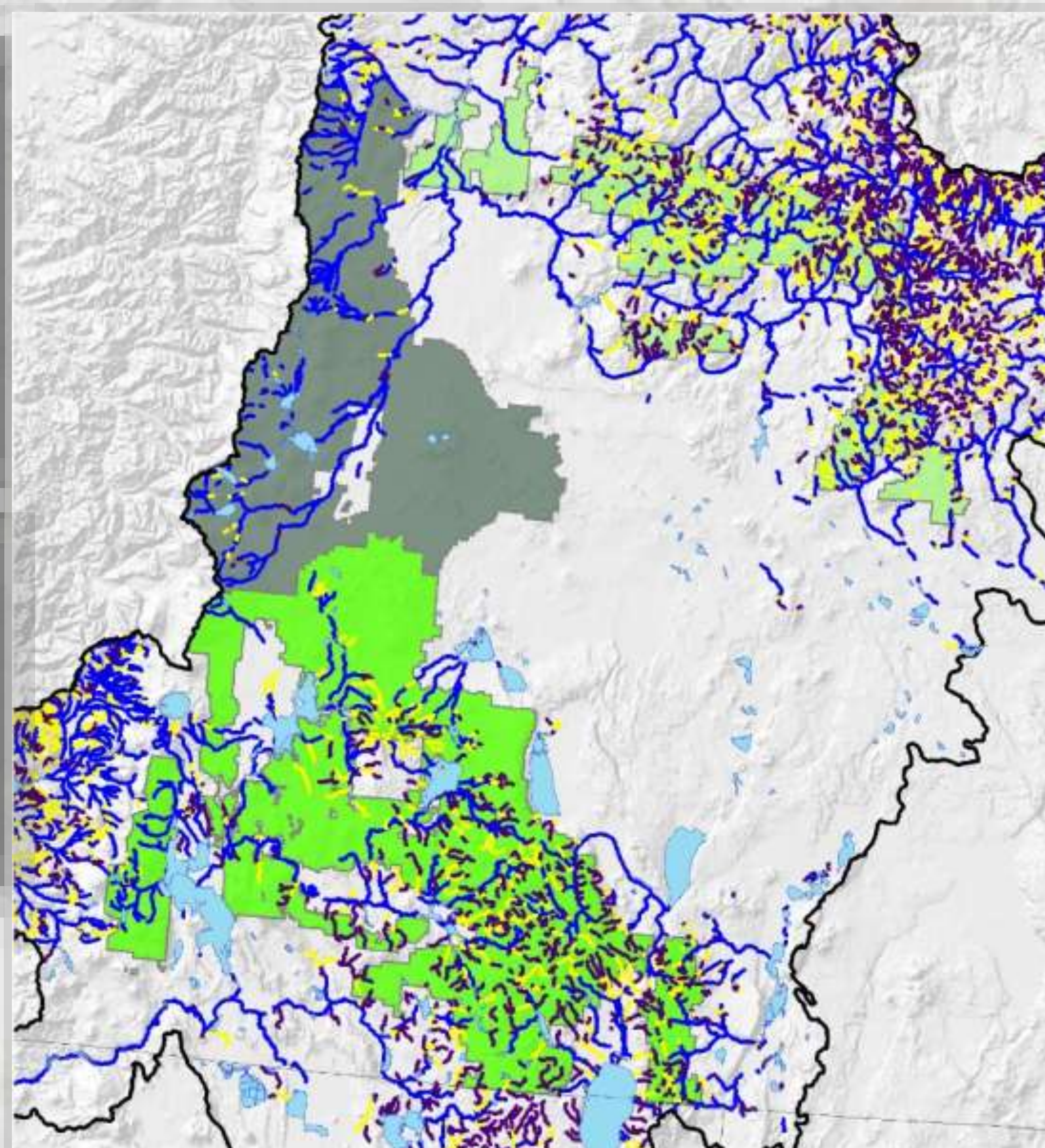
*VIC projections as modified by Safeeq et al. (2014)



Mean Summer Flows – 1980s

Mean Summer Flow (cms)

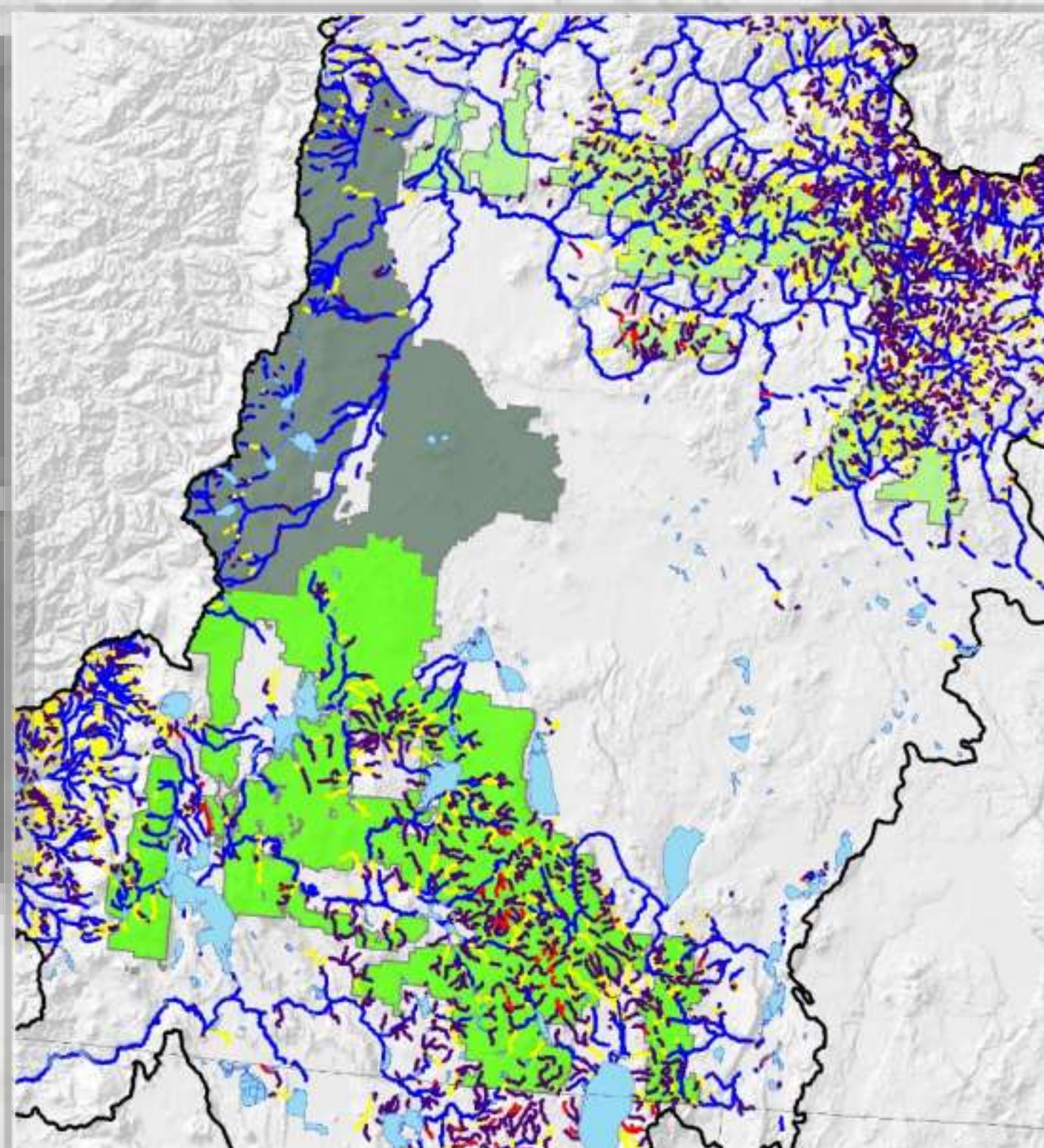
- < 0.006
- 0.006 - 0.034
- 0.034 - 0.085
- > 0.085



Mean Summer Flows – 2080s

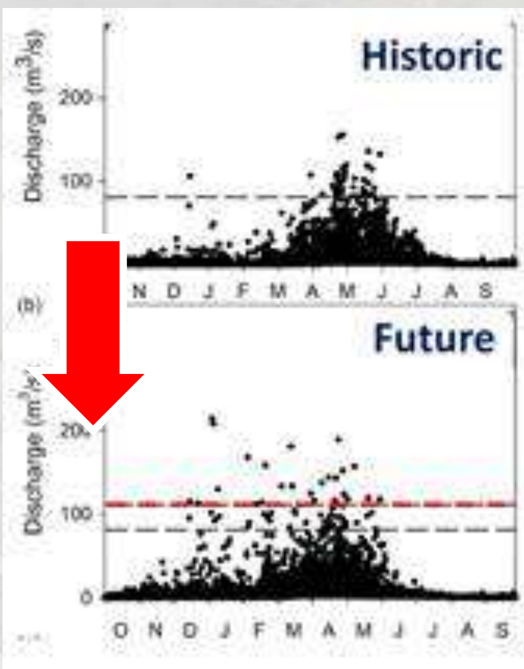
Mean Summer Flow (cms)

- < 0.006
- 0.006 - 0.034
- 0.034 - 0.085
- > 0.085



Changes in Winter High Flows - Summary

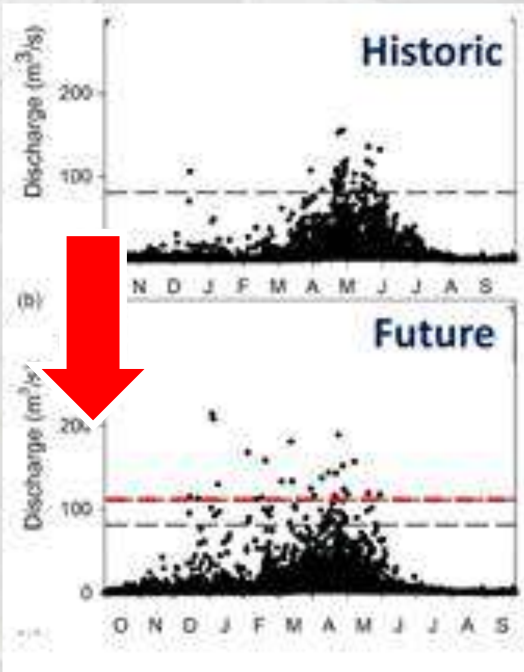
Winter95 flow metric	All lands		USFS lands	
	Number of Days	Days Increase	Number of Days	Days Increase
Baseline (1970-1999)	10.5	-	9.8	-
2040s (2030-2059)	12.4	1.9	12.6	2.8
2080s (2070-2099)	13.2	2.7	13.8	4



Infrastructure impacts

Fall spawner egg & juvenile mortality

Winter High Flow Days – 1980s

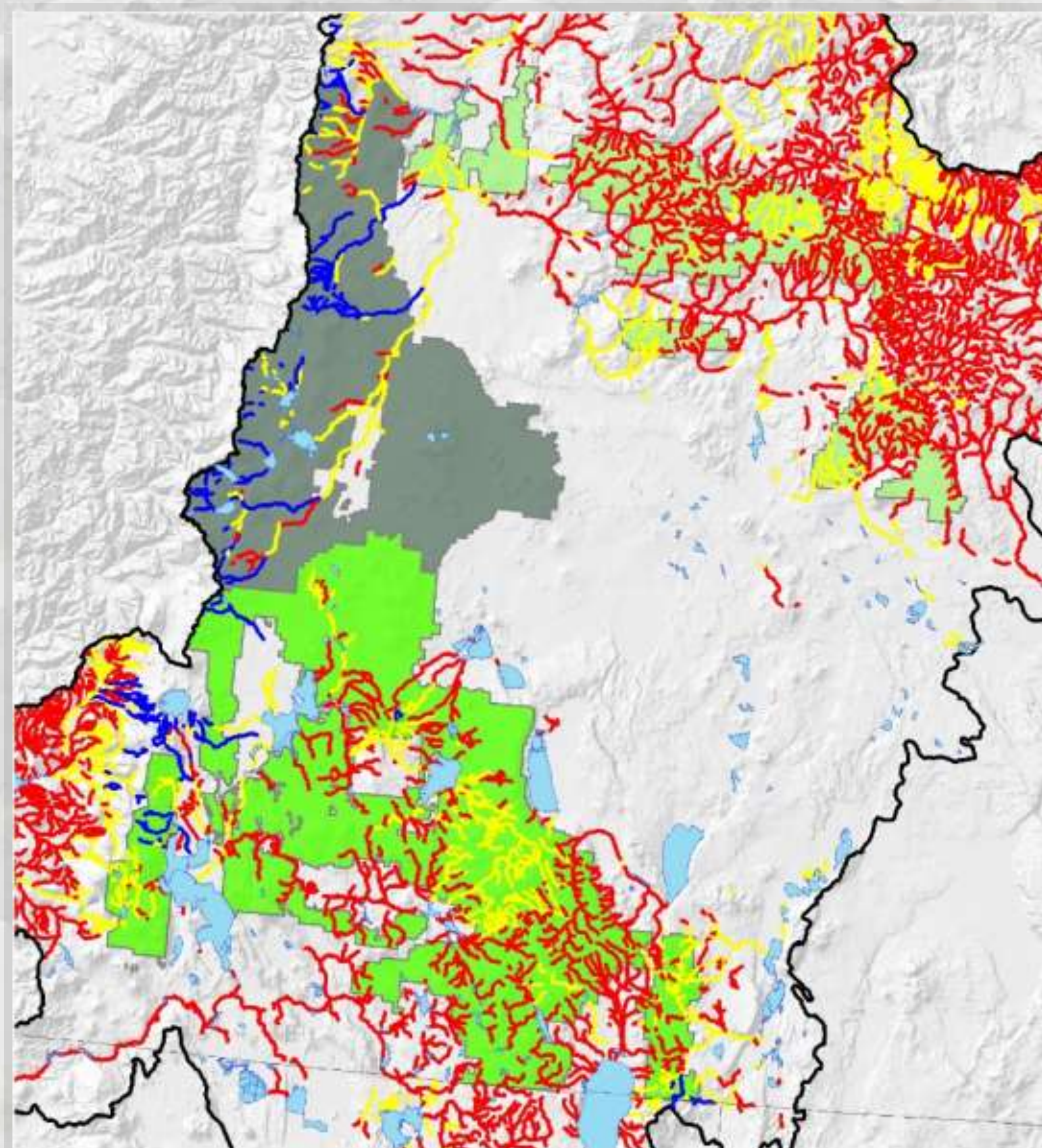


Number of days that winter flow is among highest 5% for the year

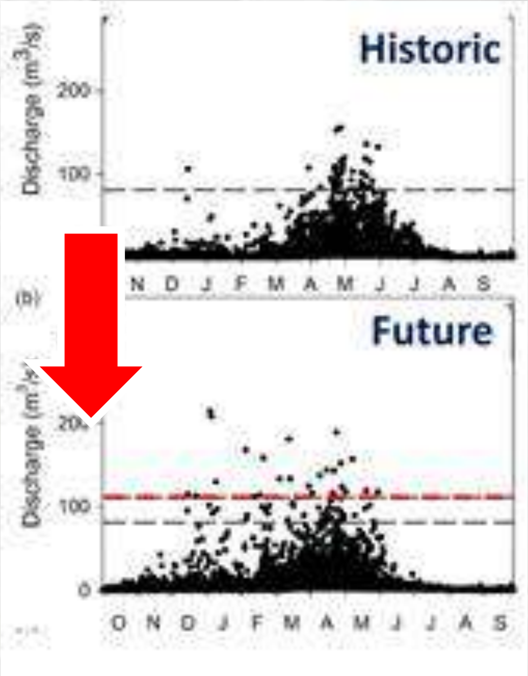
< 5

5 - 10

> 10



Winter High Flow Days – 2080s

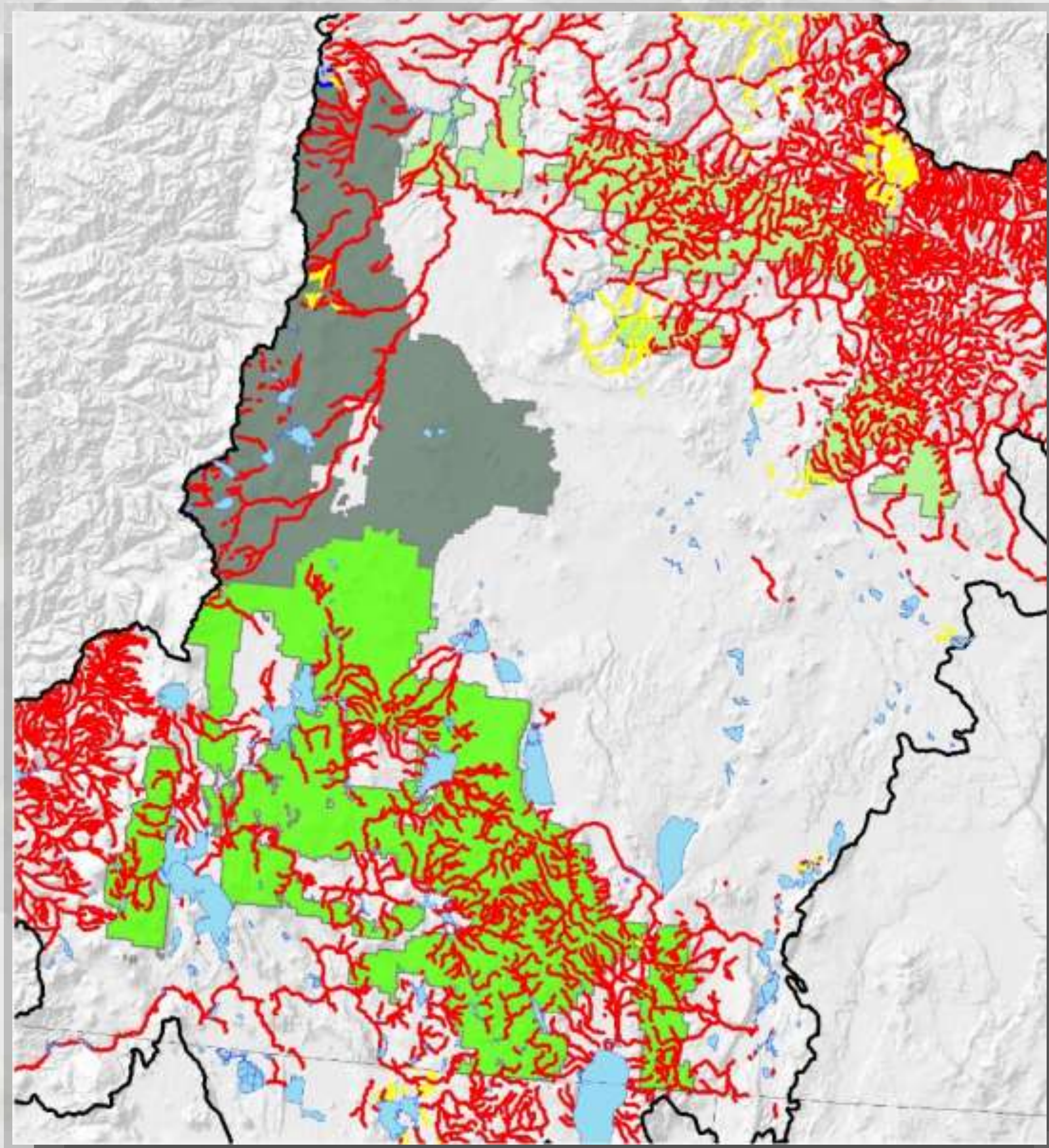


Number of days that winter flow is among highest 5% for the year

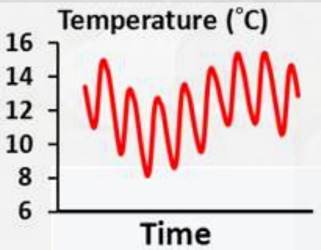
< 5

5 - 10

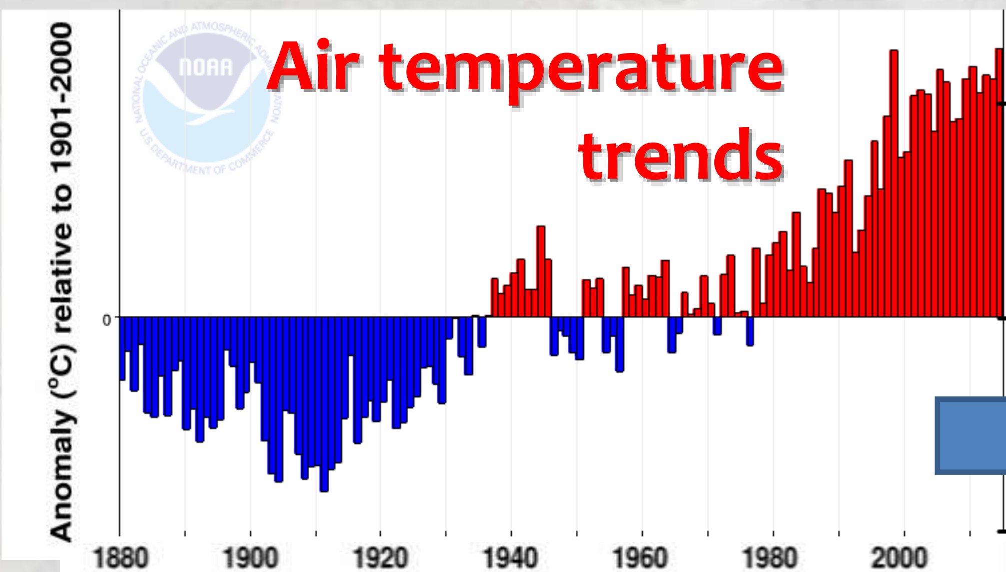
> 10

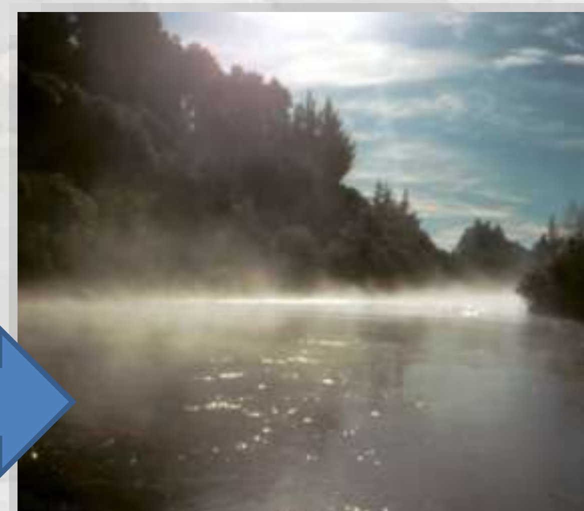


Changes in Summer Stream Temperature

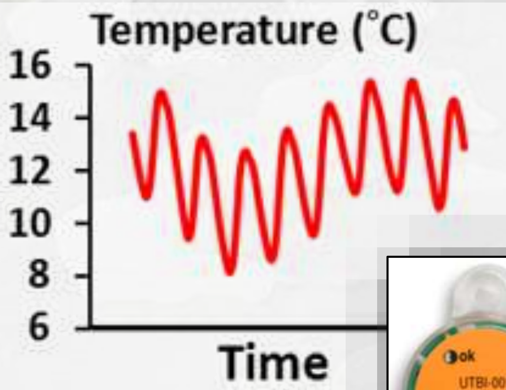


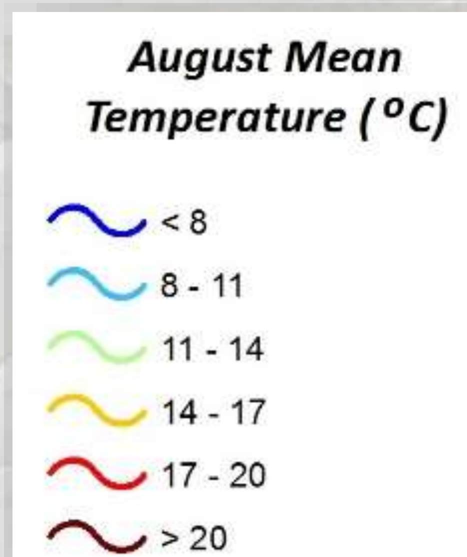
	All lands	USFS lands
Baseline (1970-1999)	-	-
2040s (2030-2059)	1.3°C	1.2°C
2080s (2070-2099)	2.2°C	2.0°C

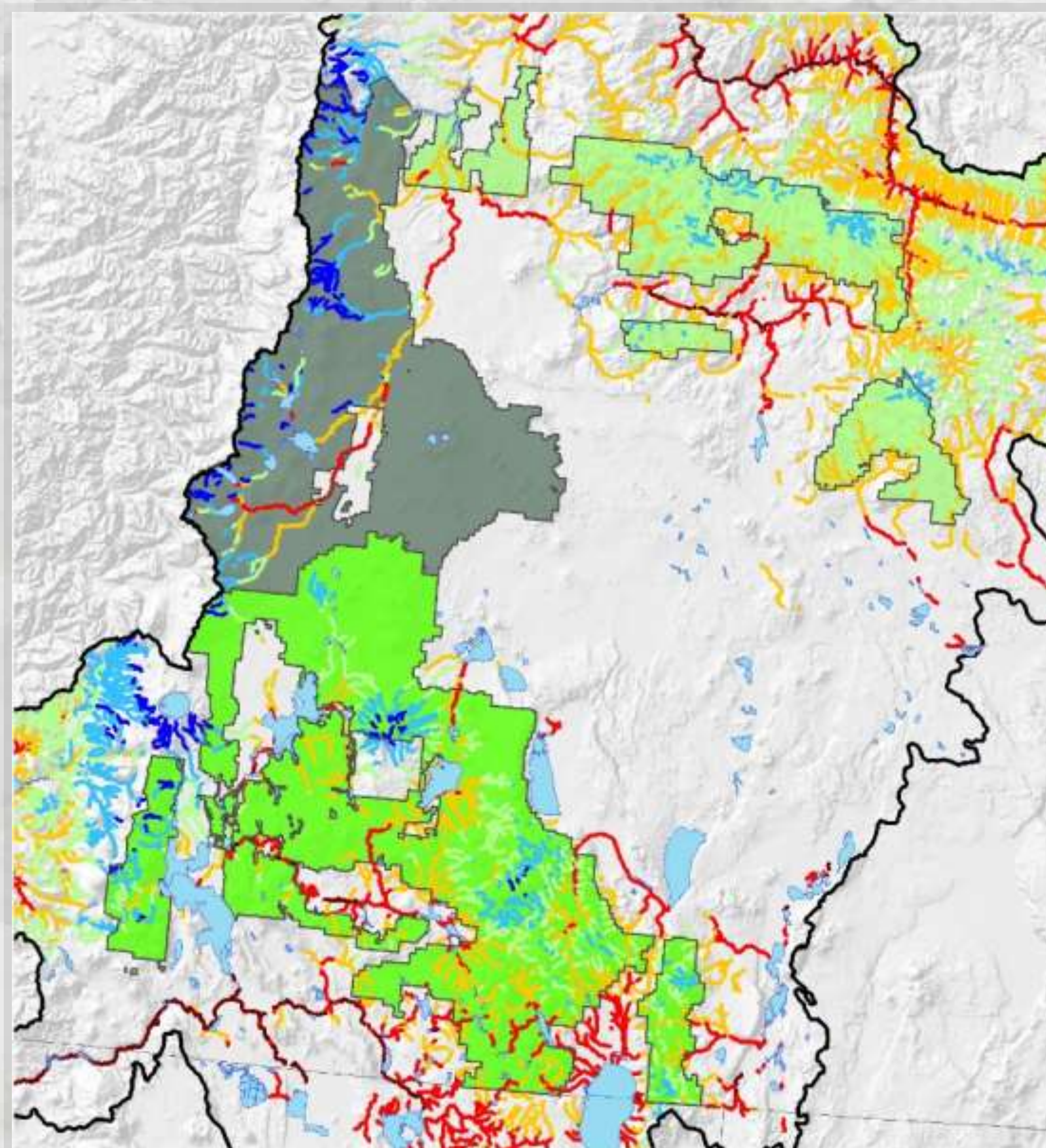




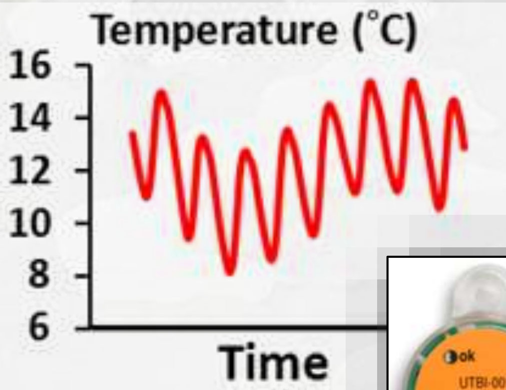
Summer Stream Temperature – 1980s

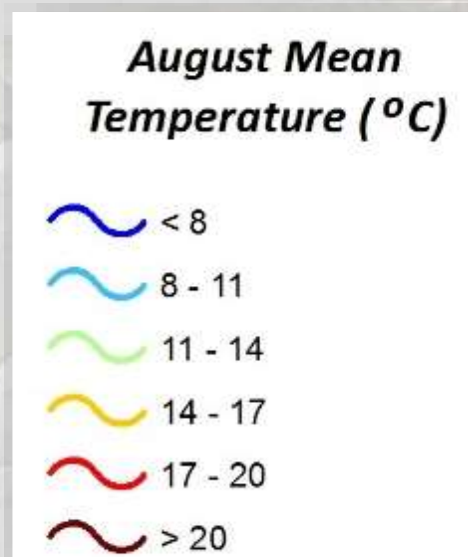


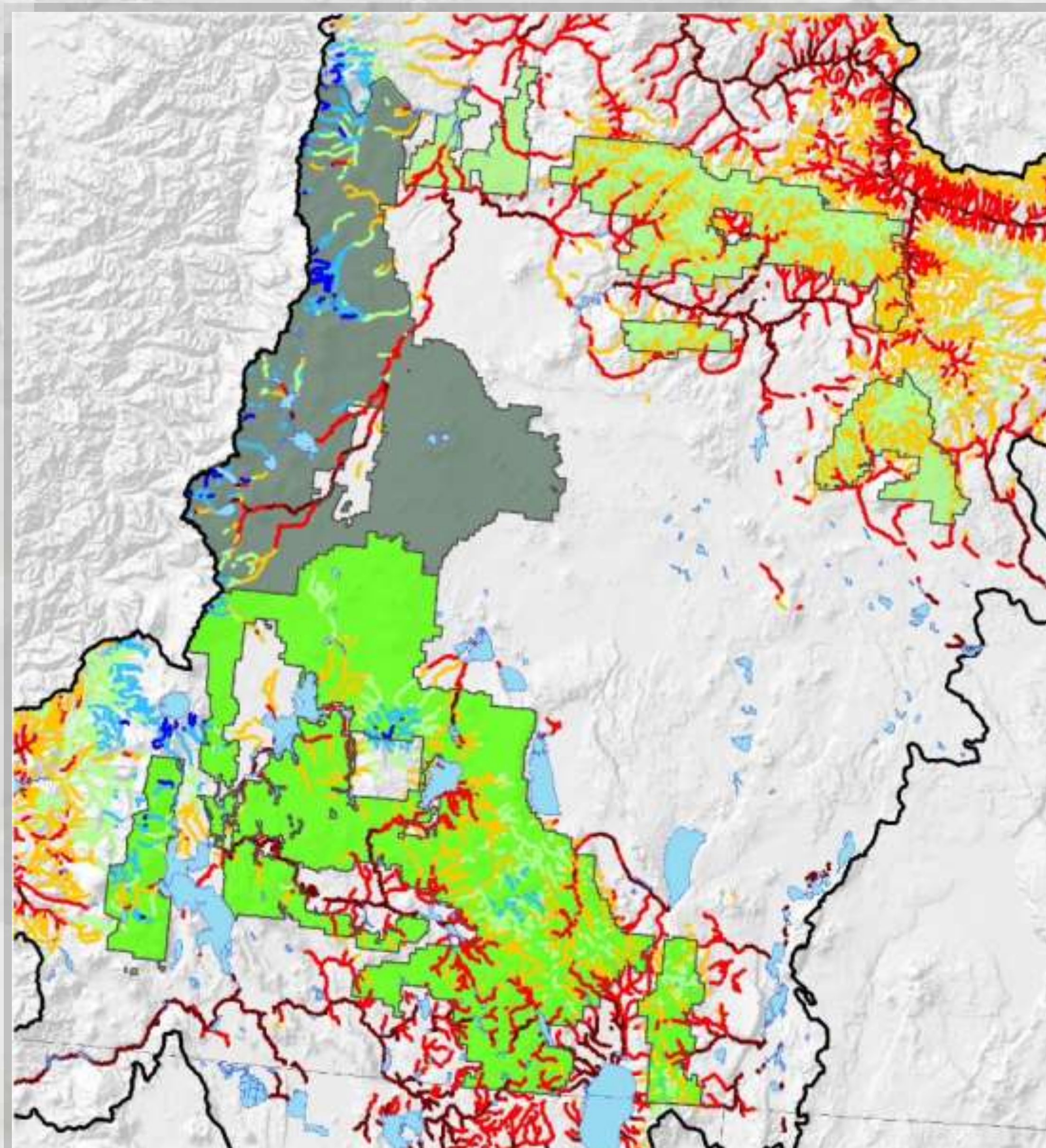




Summer Stream Temperature – 2080s

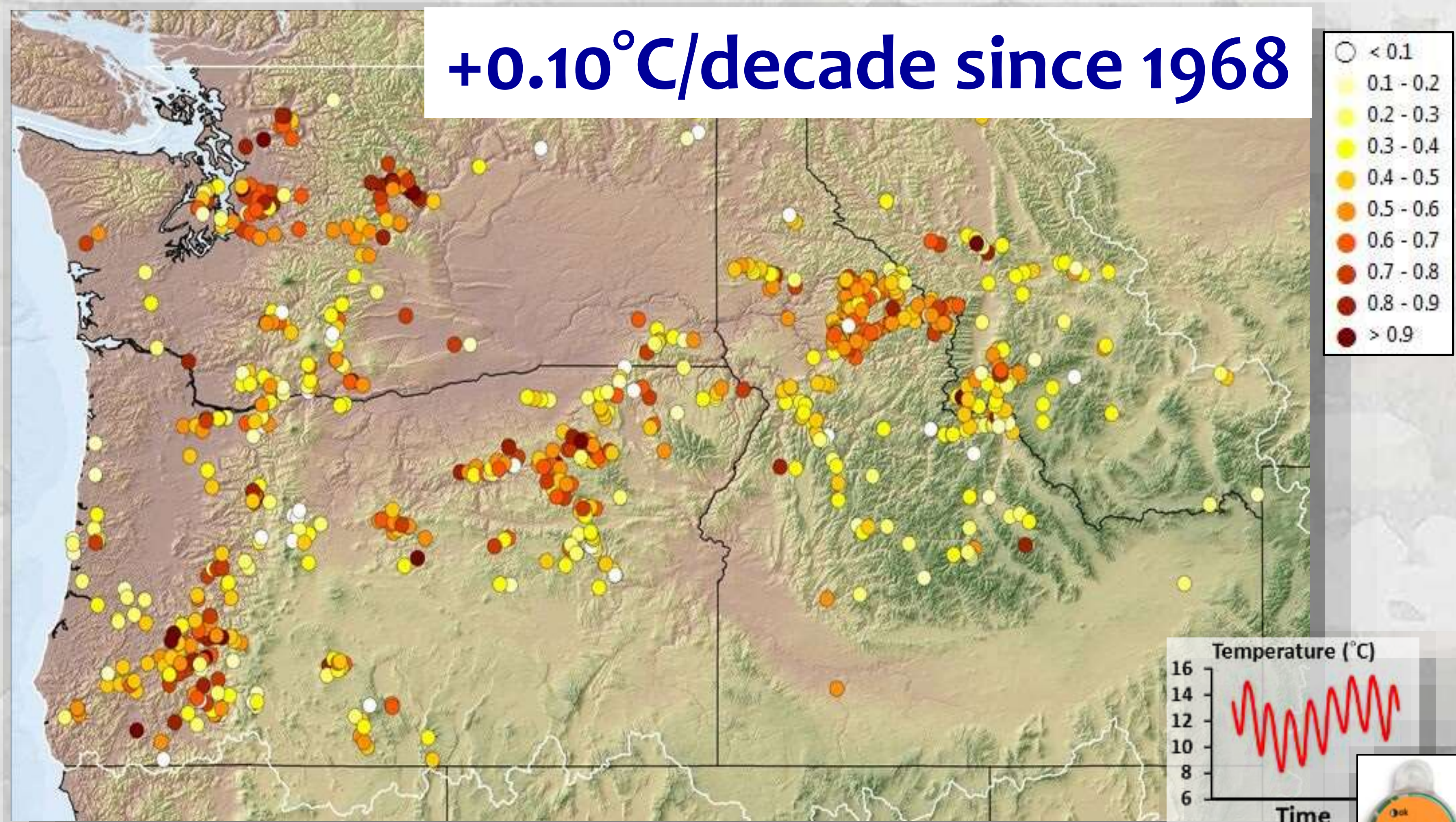






Heterogeneity in Stream Warming Rates

923 sites in NorWeST database with >10 year records

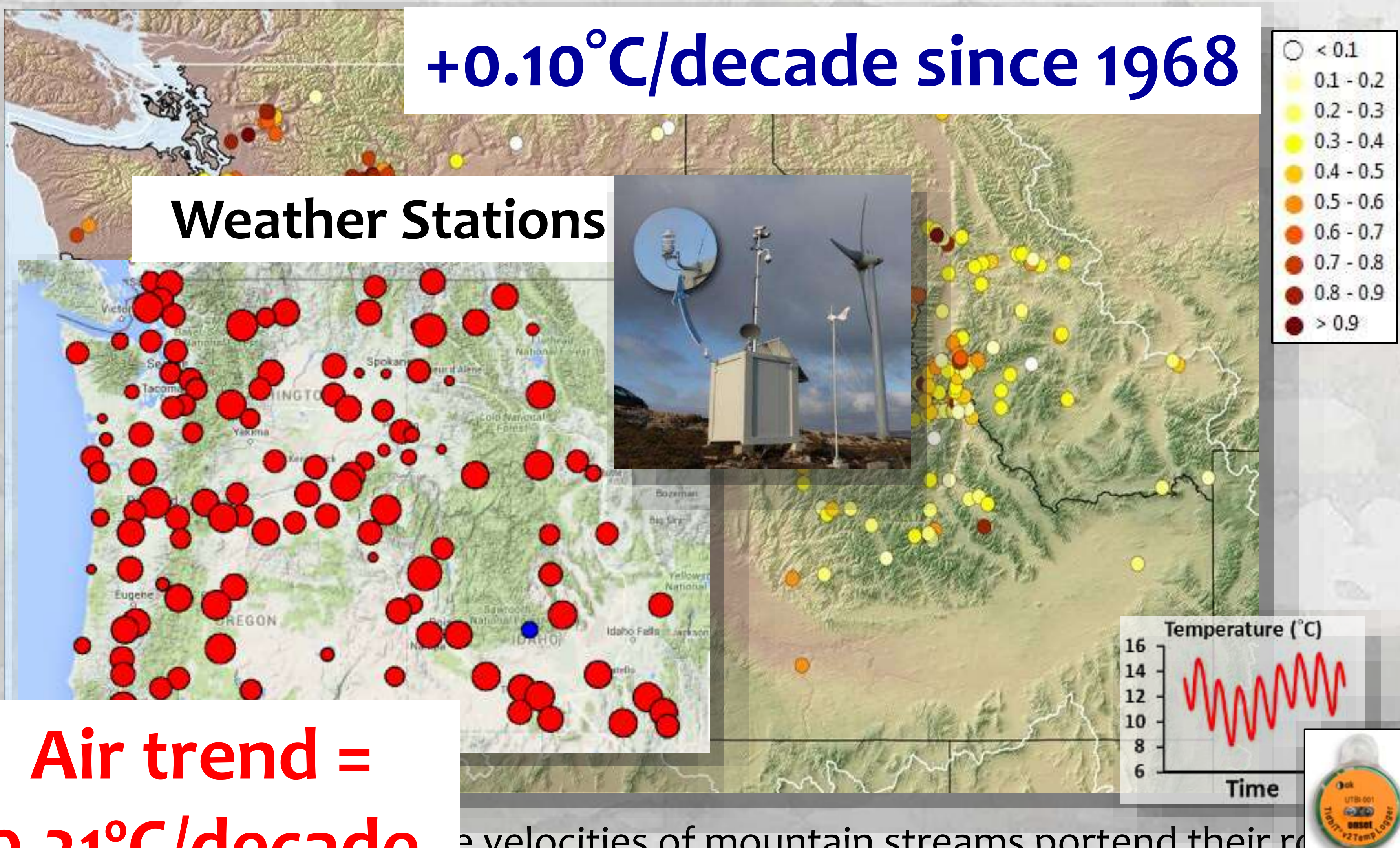


Isaak et al. 2016. Slow climate velocities of mountain streams portend their r
refugia for cold-water biodiversity. *Proc Nat Acad Sci*

Heterogeneity in Stream Warming Rates

923 sites in NorWeST database with >10 year records

+0.10°C/decade since 1968



Air trend = 0.21°C/decade

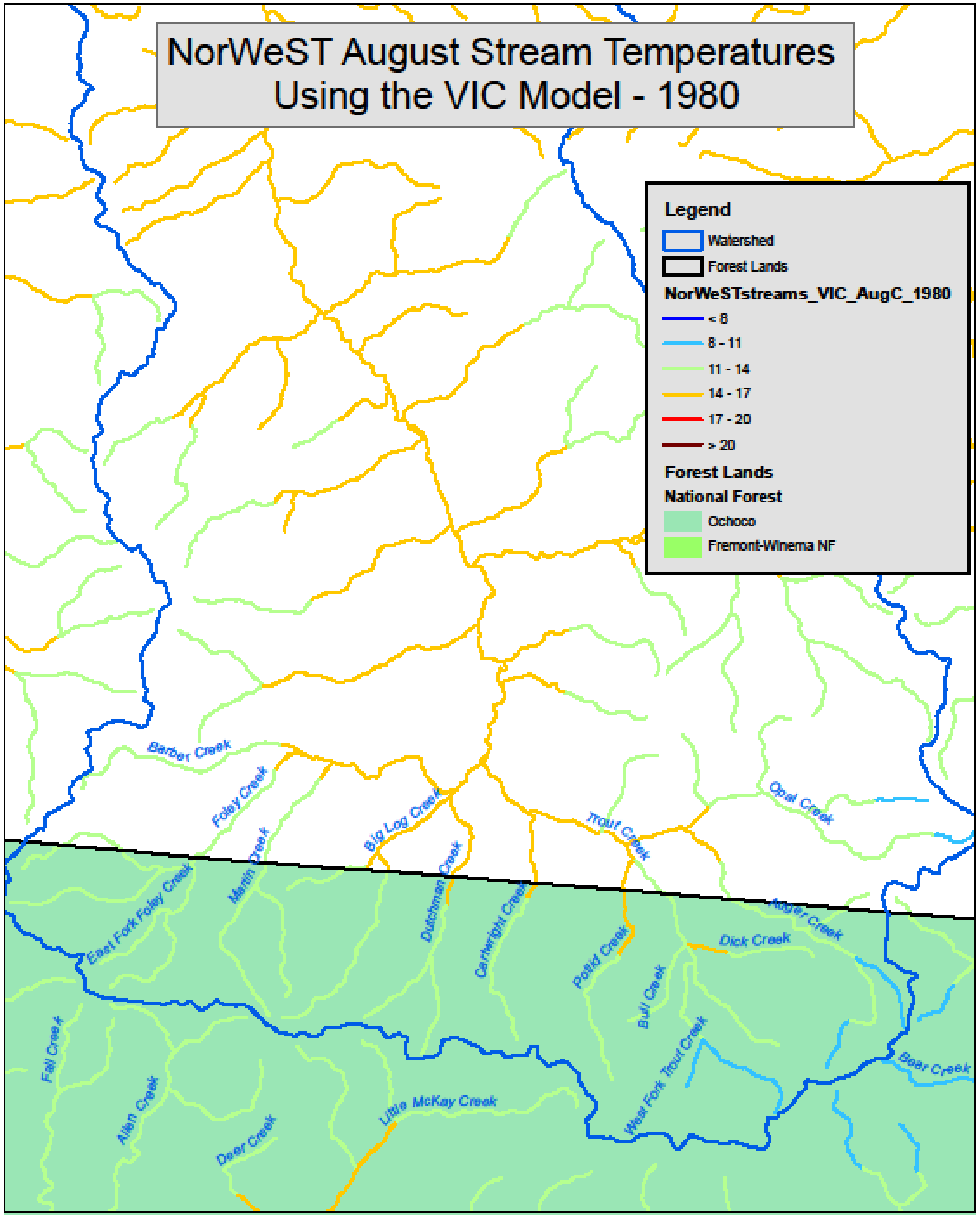
...e velocities of mountain streams portend their r...
...er biodiversity. *Proc Nat Acad Sci*

Effects to Mid-Columbia River Steelhead

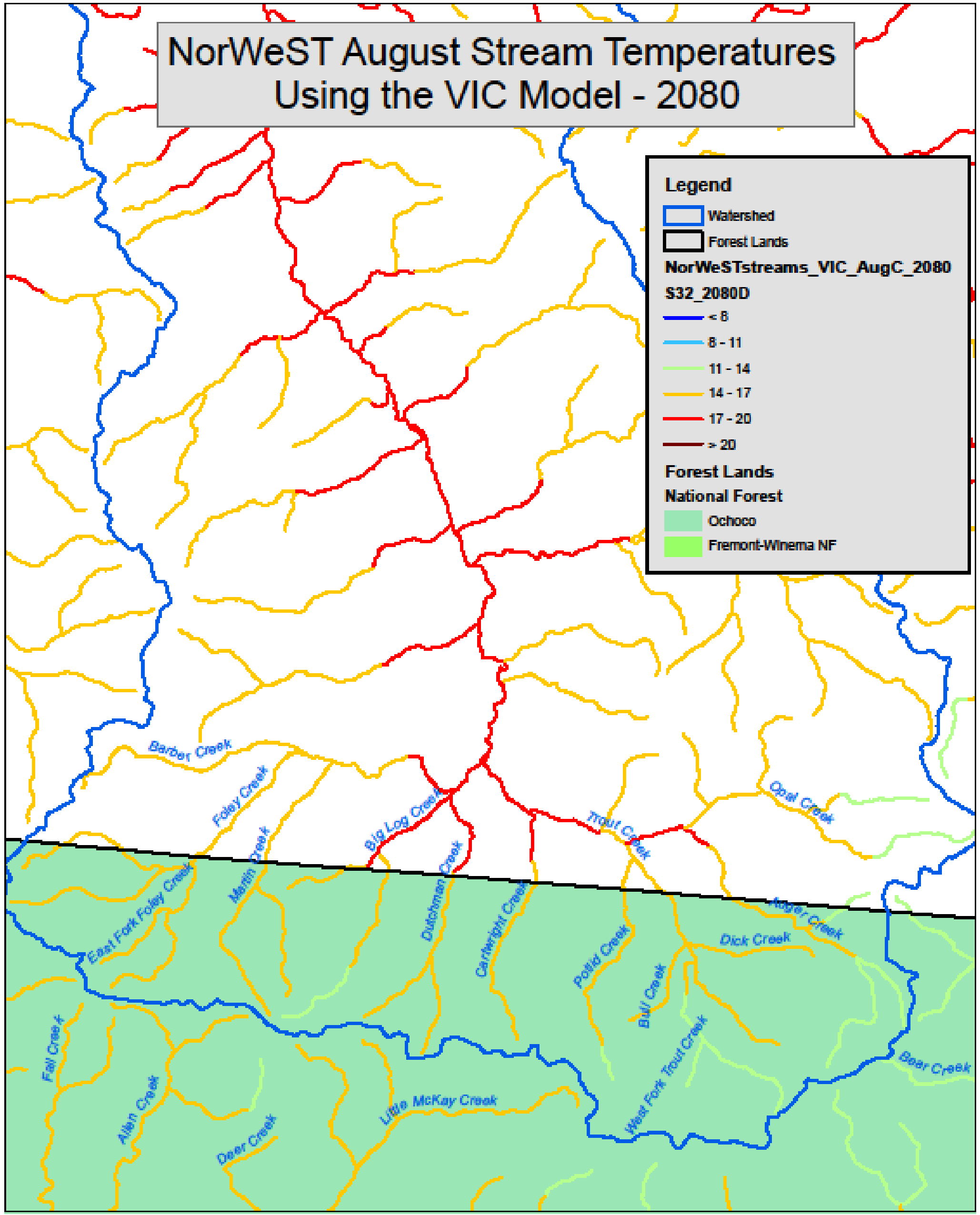
Cascades Eastern Slope Tributaries & John Day River

- **Largest Risk - Increases in summer stream temperature**
- **Models predict stream temperatures outside optimal range – increase of 37% and 33% respectively**
- **Reduction in available habitat, some of which is already in a degraded condition**
- **Winter peak flows & summer flow mostly maintained**

		Number of high flow days					
Stream metric	Period	<5	5-10	>10			
Winter 95% flow	1980s	0.1%	24%	76%			
	2040s	0	12%	88%			
	2080s	0	9%	91%			
			m^3/s				
		<0.034	0.034-0.085	>0.085			
Summer flow	1980s	9%	14%	77%			
	2040s	10%	14%	76%			
	2080s	11%	14%	75%			
					Stream kilometers		
		<8	8-11	11-14	14-17	17-20	>20
August temp	1980s	0.4%	6%	19%	38%	26%	11%
	2040s	0.1%	2%	12%	29%	39%	18%
	2080s	0	1%	8%	23%	39%	29%


NorWeST August Stream Temperatures
Using the VIC Model - 1980
Legend
Watershed
Forest Lands
NorWeSTstreams_VIC_AugC_1980
< 8
8 - 11
11 - 14
14 - 17
17 - 20
> 20
Forest Lands
National Forest
Ochoco
Fremont-Winema NF
Barber Creek
Foley Creek
Big Log Creek
Trout Creek
Opal Creek
Martin Creek
East Fork Foley Creek
Dutchman Creek
Cartwright Creek
Pollid Creek
Dick Creek
Auger Creek
Bull Creek
West Fork Trout Creek
Bear Creek
Fall Creek
Allen Creek
Deer Creek
Little McKay Creek

NorWeST August Stream Temperatures Using the VIC Model - 2080

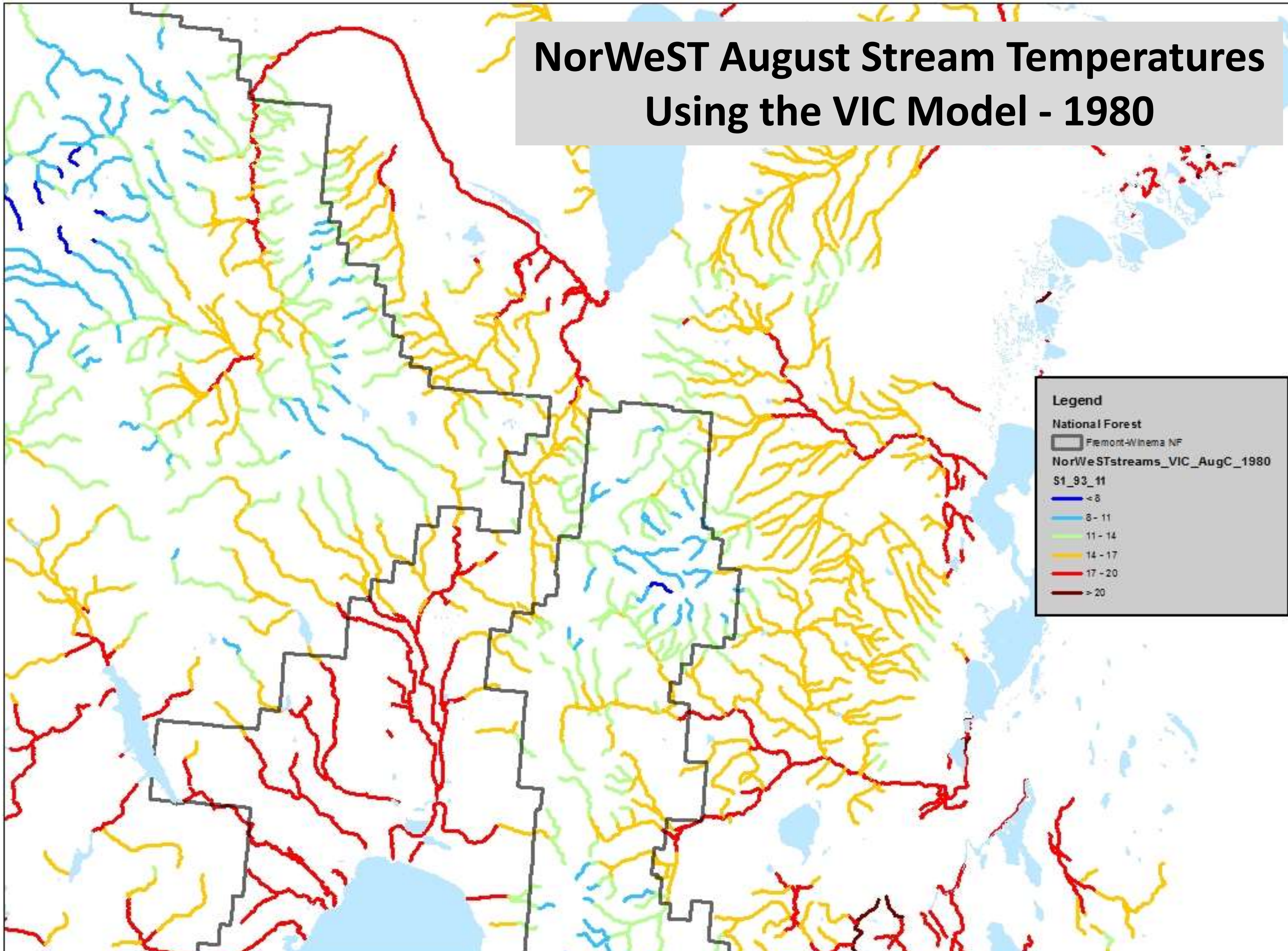


Effects to Redband Trout

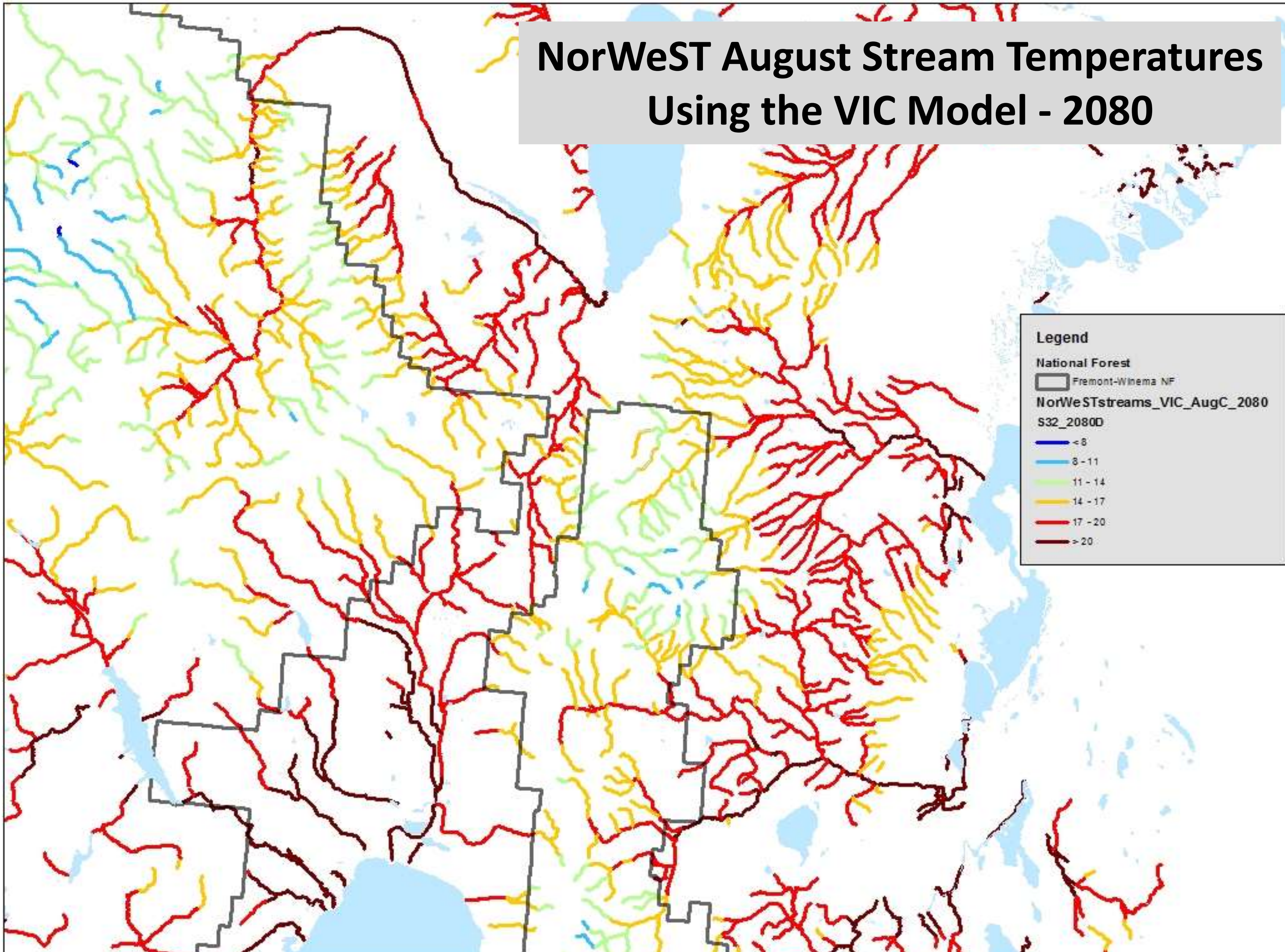
Throughout Analysis Area

- **Largest Risk - Increases in summer stream temperature**
- **Summer base flows mostly maintained**
- **Models predict that by 2040 the majority of the redband occupied streams will experience more than 10 days with the highest 5% winter peak flows**

		Number of high flow days					
Stream metric	Period	<5	5-10	>10			
Winter 95% flow	1980s	0.1%	26%	73%			
	2040s	0	2%	98%			
	2080s	0	1%	99%			
			m^3/s				
		<0.034	0.034-0.085	>0.085			
Summer flow	1980s	17%	20%	63%			
	2040s	21%	20%	59%			
	2080s	23%	20%	56%			
				Stream kilometers			
		<8	8-11	11-14	14-17	17-20	>20
August temp	1980s	1%	8%	29%	38%	21%	4%
	2040s	1%	4%	19%	38%	29%	9%
	2080s	1%	5%	15%	35%	28%	16%


NorWeST August Stream Temperatures
Using the VIC Model - 1980
Legend
National Forest
Fremont-Winema NF
NorWeSTstreams_VIC_AugC_1980
S1_93_11
< 8
8 - 11
11 - 14
14 - 17
17 - 20
> 20

NorWeST August Stream Temperatures Using the VIC Model - 2080

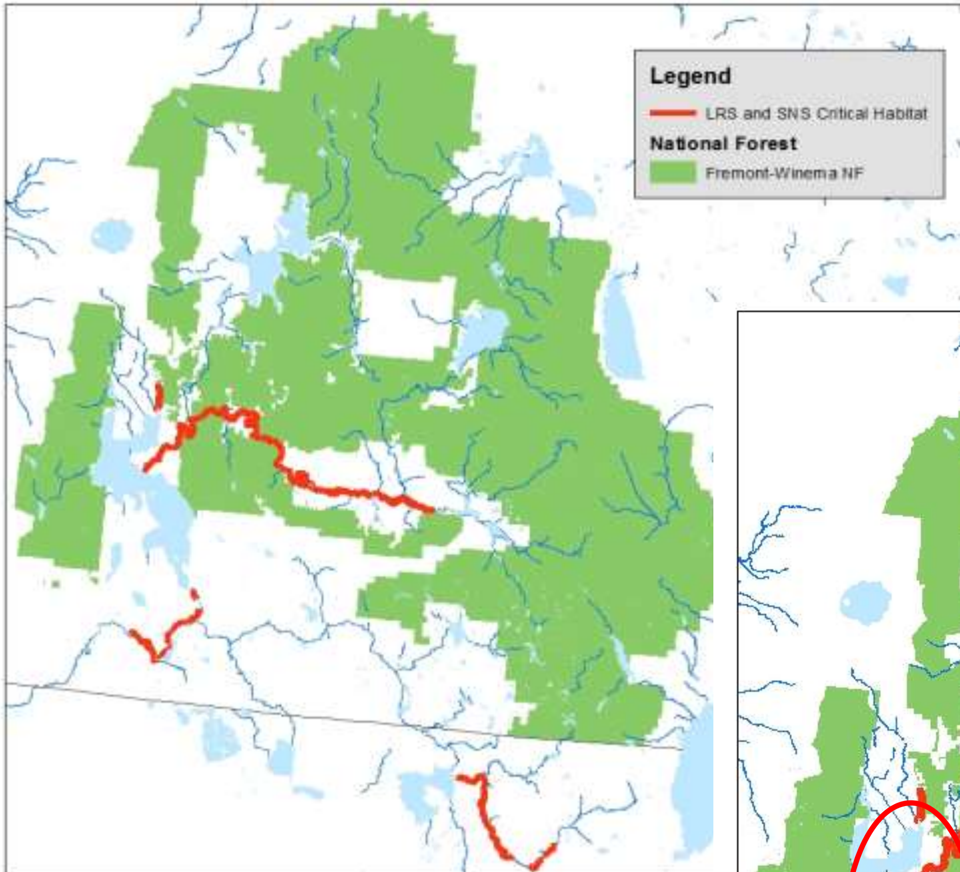


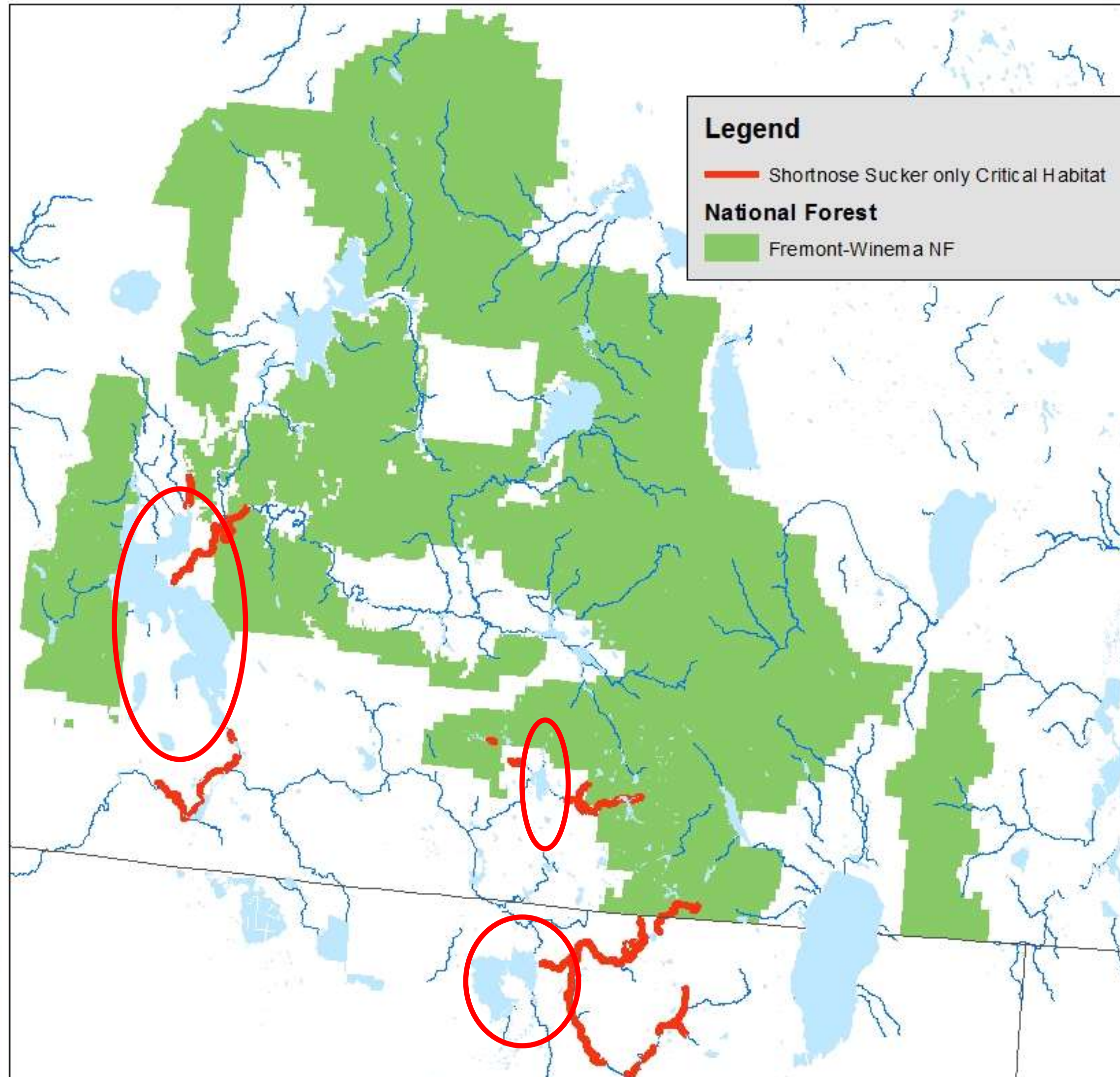
Effects to Lost River Sucker and Shortnose Sucker

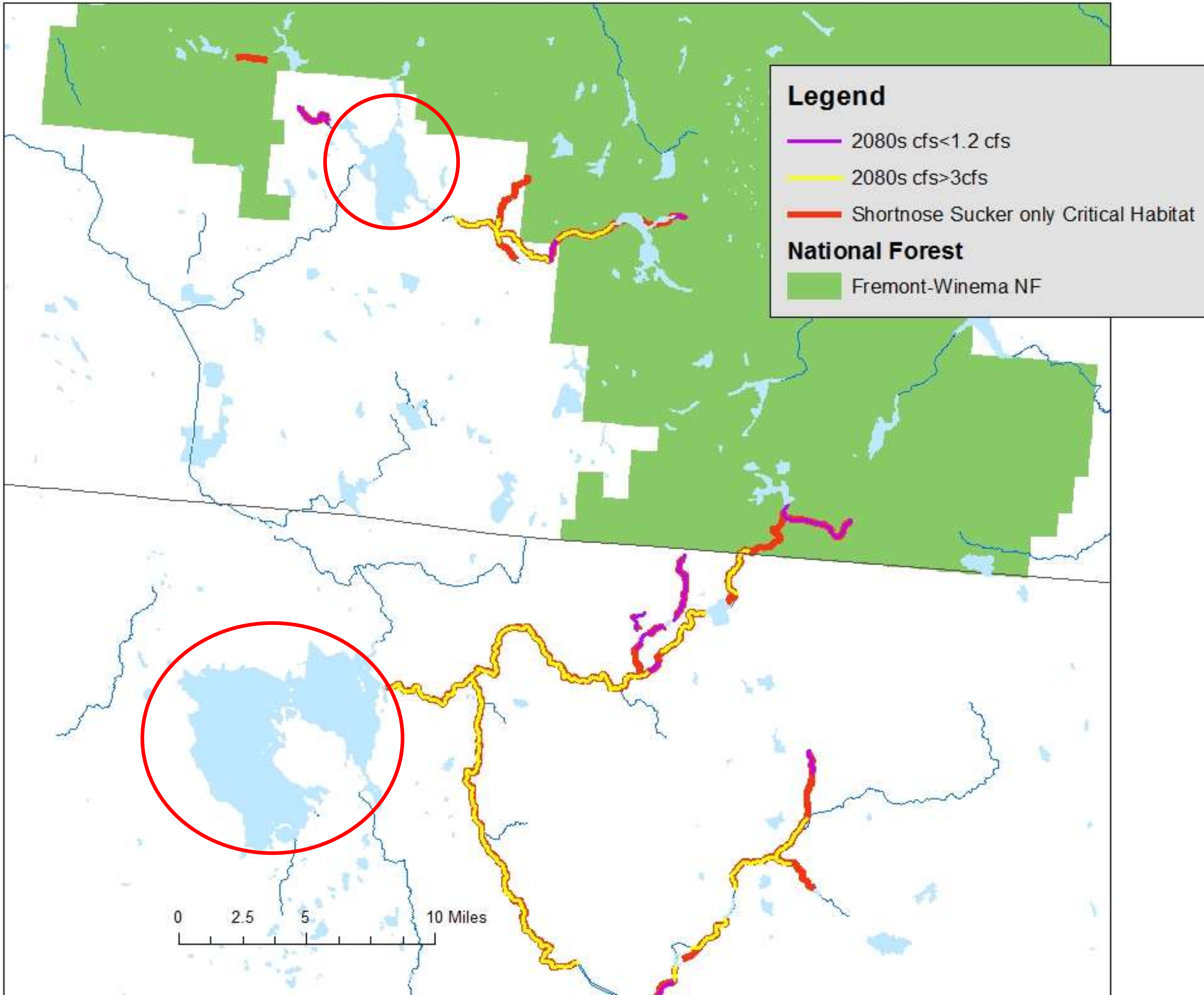
Upper Klamath Lake and Lost River Basin Recovery Units

- **Largest Risk on National Forest streams – Loss of stream flow**
- **Winter peak flows and summer flow remain similar to current modeled conditions**
- **Extensive modification of historic habitat, intermittent flows, isolation and increasingly limited access between lake habitats and stream spawning habitats.**

		Number of high flow days					
Stream metric	Period	<5	5-10	>10			
Winter 95% flow	1980s		5%	95%			
	2040s			100%			
	2080s			100%			
			m^3/s				
		<0.034	0.034-0.085	>0.085			
Summer flow	1980s	8.5%	8.5%	83%			
	2040s	11%	8%	82%			
	2080s	13%	7%	80%			
				Stream kilometers			
		<8	8-11	11-14	14-17	17-20	>20
August temp	1980s			3%	8%	66%	23%
	2040s			1%	5%	45%	49%
	2080s				4%	18%	78%


Legend
LRS and SNS Critical Habitat
National Forest
Fremont-Winema NF


Legend
Shortnose Sucker only Critical Habitat
National Forest
Fremont-Winema NF


Legend
2080s cfs<1.2 cfs
2080s cfs>3cfs
Shortnose Sucker only Critical Habitat
National Forest
Fremont-Winema NF
0
2.5
5
10 Miles

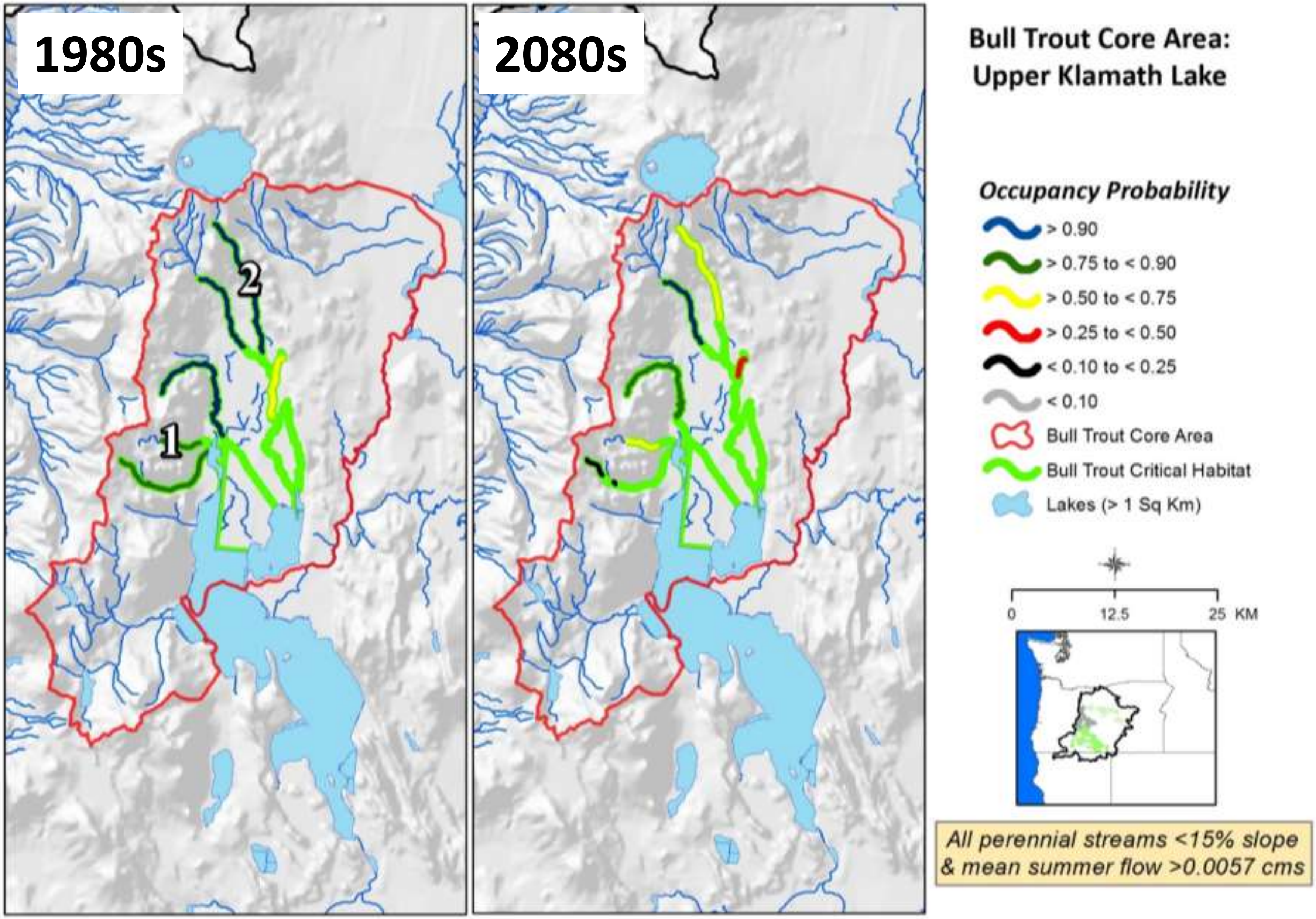
Effects to Bull Trout

Odell Lake

- **Largest Risk – Increase in winter peak flows**
- **Models predict the highest 5% winter peak flows are expected to increase by 100% by 2080**
- **Summer stream temperatures not expected to increase significantly, but 10% estimated reduction in headwater summer bull trout habitat**
- **Core area already has a small population, fragmented habitat and limited spawning habitat**
- **Changes put population at high risk – reduction in available habitat, direct redd effects, reduced headwater habitat availability**

		Number of high flow days					
Stream metric	Period	<5	5-10	>10			
Winter 95% flow	1980s	100%	0	0			
	2040s	11%	67%	22%			
	2080s	0	0	100%			
		m^3/s					
		<0.034	0.034-0.085	>0.085			
Summer flow	1980s	0	12%	88%			
	2040s	12%	10%	78%			
	2080s	12%	10%	78%			
		Stream kilometers					
		<8	8-11	11-14	14-17	17-20	>20
August temperature	1980s	85%	0	15%			
	2040s	85%	0	0	15%		
	2080s	85%	0	0	15%		

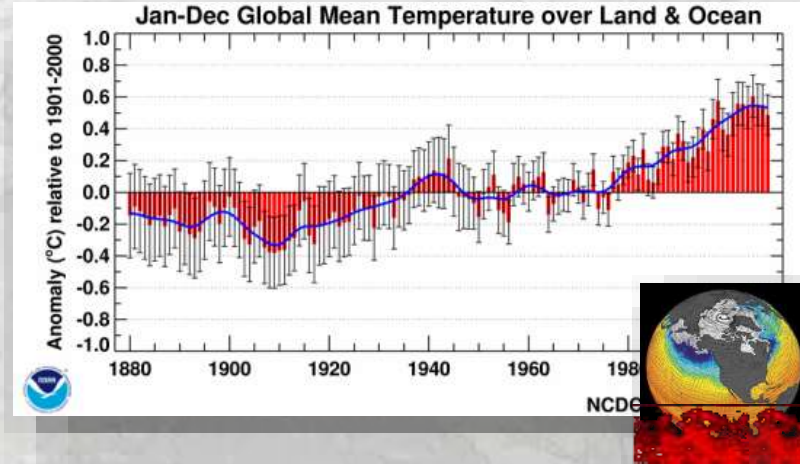
Bull Trout Habitat

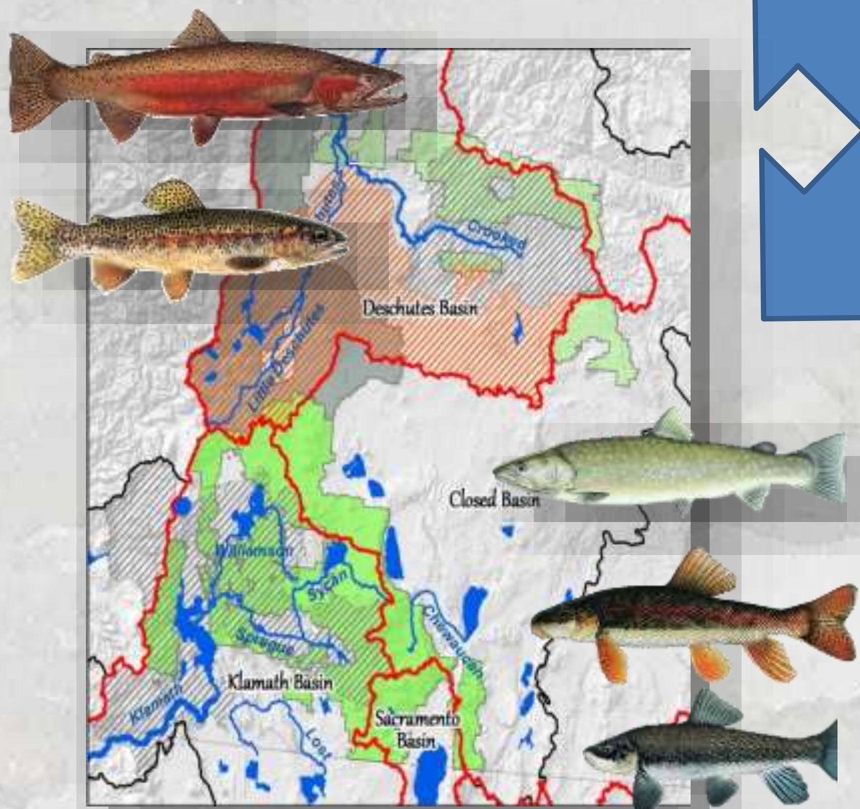


Fish Climate Vulnerability

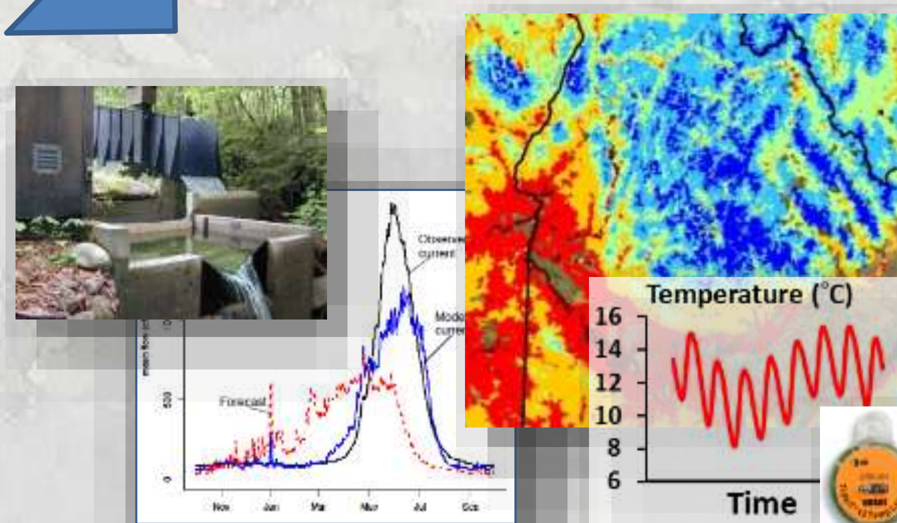
<u>What matters?</u>

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

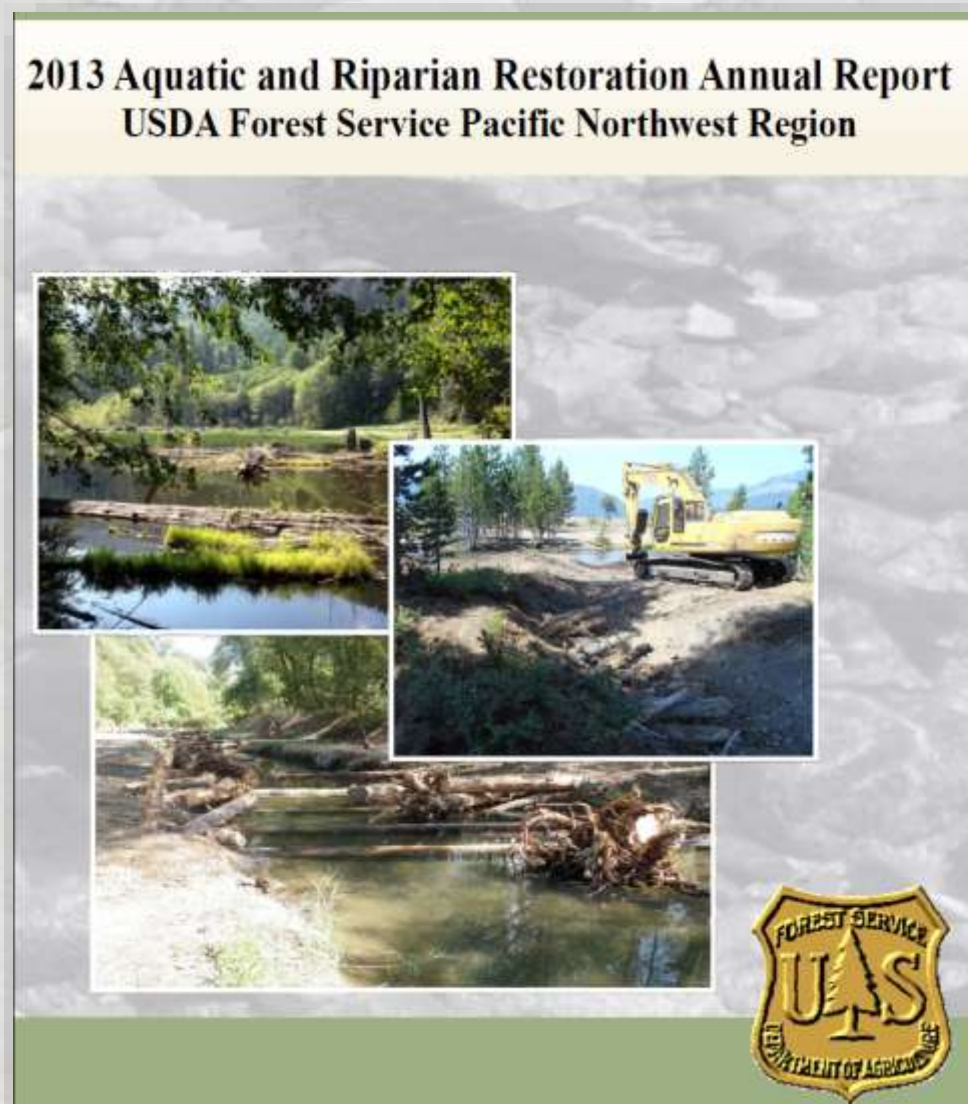




Where do vulnerabilities meet "on-the-ground" opportunities?



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

Forest Datasets Were Key to The Quality of This Assessment…

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

Global Warming Is ... NOT COOL!

The End