Climate Change Impacts on Columbia Basin Tribal Lands: Past-Present-Future

January 16, 2024

EOC3 Climate Conversation series

YAKAMA NEZ PERCE WARM SPRINGS UMATILLA

Kyle Dittmer, P.H. **(AIH 07-1699)**

Hydrologist – Meteorologist

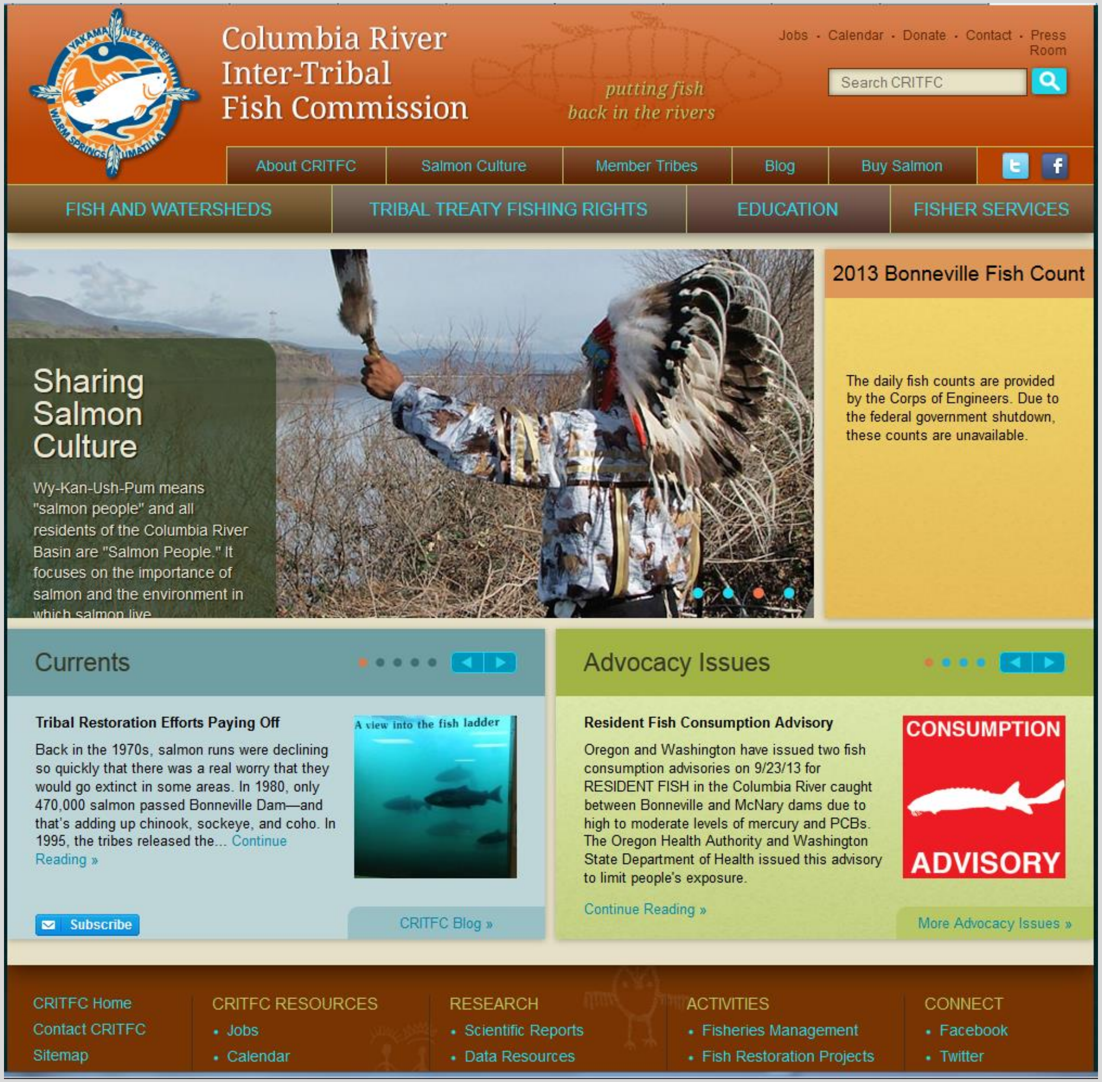
Columbia River Inter-Tribal Fish Commission
Portland, Oregon, USA

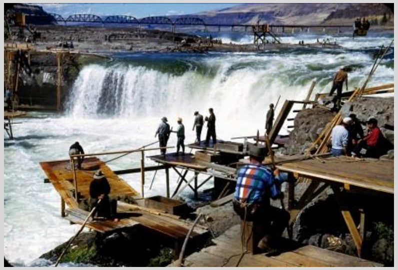
Professor of Natural Sciences

Multnomah University, Portland, Oregon

MULTNOMAH UNIVERSITY

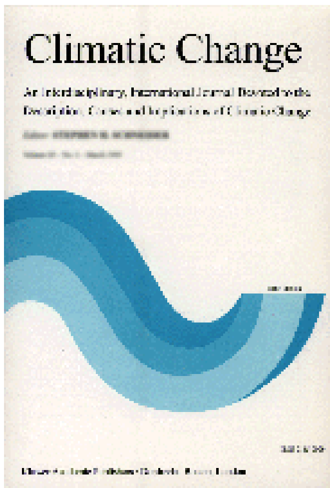
Columbia River Inter-Tribal Fish Commission - CRITFC



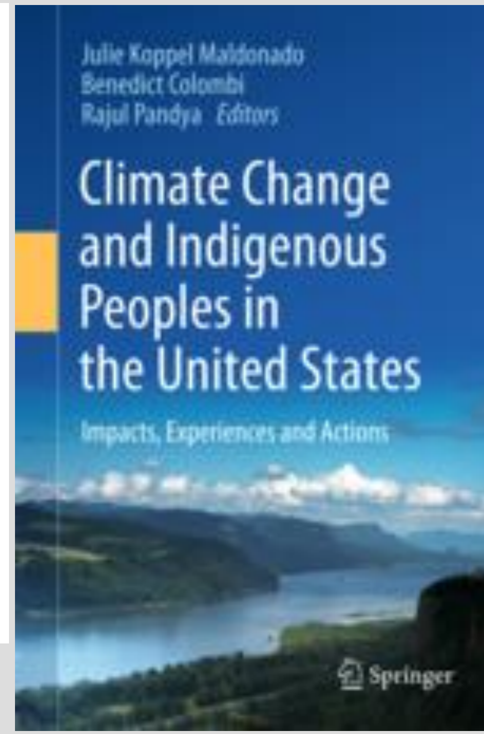


CRITFC website, http://www.critfc.org

Tribes and Climate Change



Climatic Change is dedicated to the totality of the problem of climatic variability and change – its descriptions, causes, implications and interactions among these. The purpose of the journal is to provide a means of exchange between those working on problems related to climatic variations but in different disciplines. Interdisciplinary researchers or those in any discipline, be it meteorology, anthropology, agricultural science, astronomy, biology, chemistry, physics, geography, policy analysis, economics, engineering, geology, ecology, or history of climate, are invited to submit articles, provided the articles are of interdisciplinary interest. This means that authors have an opportunity to communicate the essence of their studies to people in other climate related disciplines and to interested laypersons, as well as to report on research in which the originality is in the combinations of (not necessarily original) work from several disciplines. The journal also includes vigorous editorial and book review sections.



ARTICLE WENT PUBLIC (ON-LINE) ON APRIL 17, 2013! ☺

http://link.springer.com/article/10.1007/s10584-013-0745-0

THE CLIMATE THAT WAS…

Introduction…Methods

- Goal: (1) Assess how river flow has changed on Columbia Basin tribal lands over the last 100 years, (2) Possible climate change impacts on region's water resources and salmon.
- Tributary Flow: US Geological Survey stream data for 32 basins. Flow data were naturalized (no irrigation effects) for 19 basins. Research study Goals (and calculated metrics):

  (1) Shift in Seasonal Flow Fraction (i.e., Spring-Summer vs. Fall-Winter)

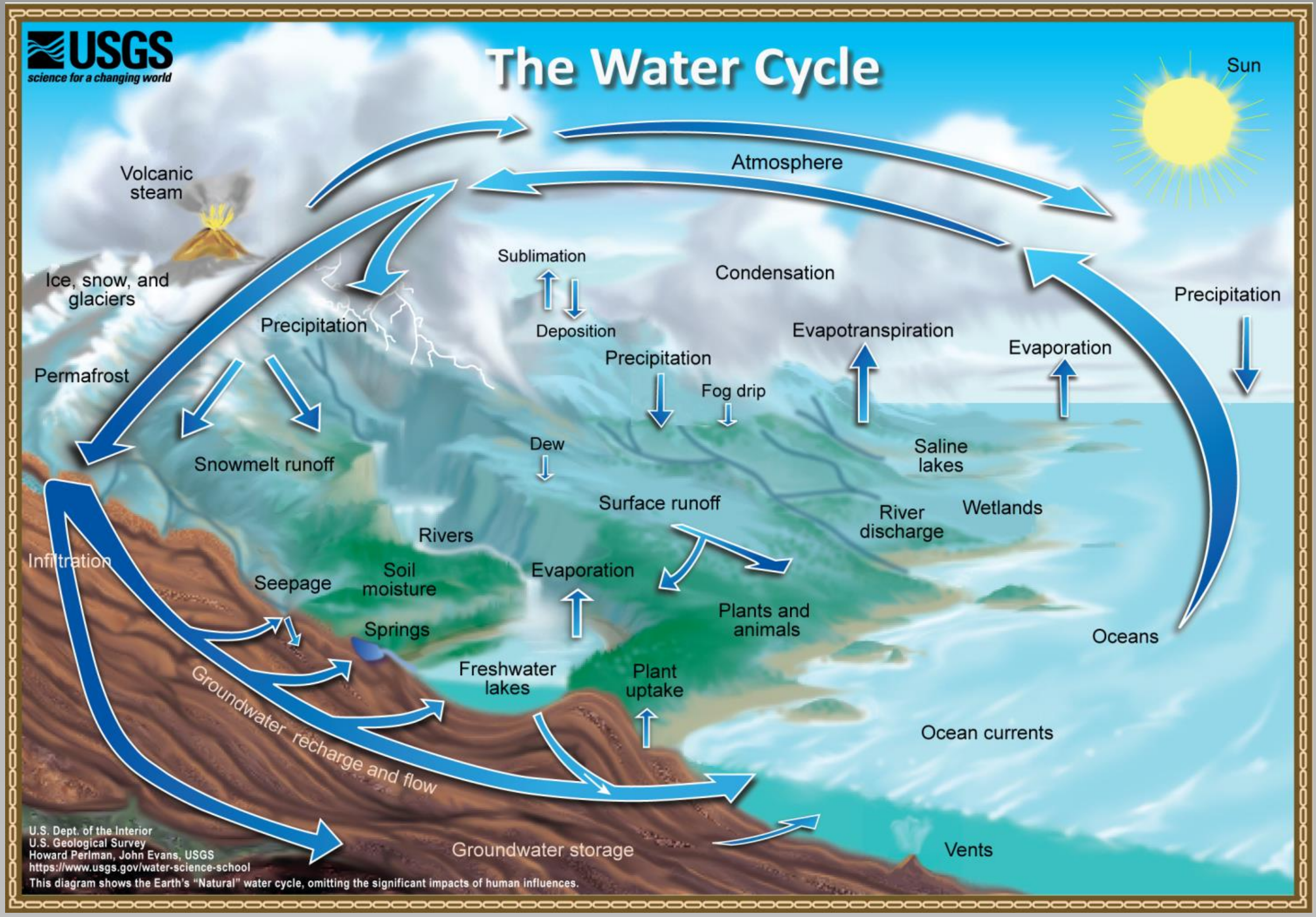
  (2) Shift in median (50th percentile) annual flow Center Timing

  (3) Shift in Spring Flow Onset (i.e., start of the spring snowmelt)

  (4) High Flow/Flood Flow (autumn-winter)

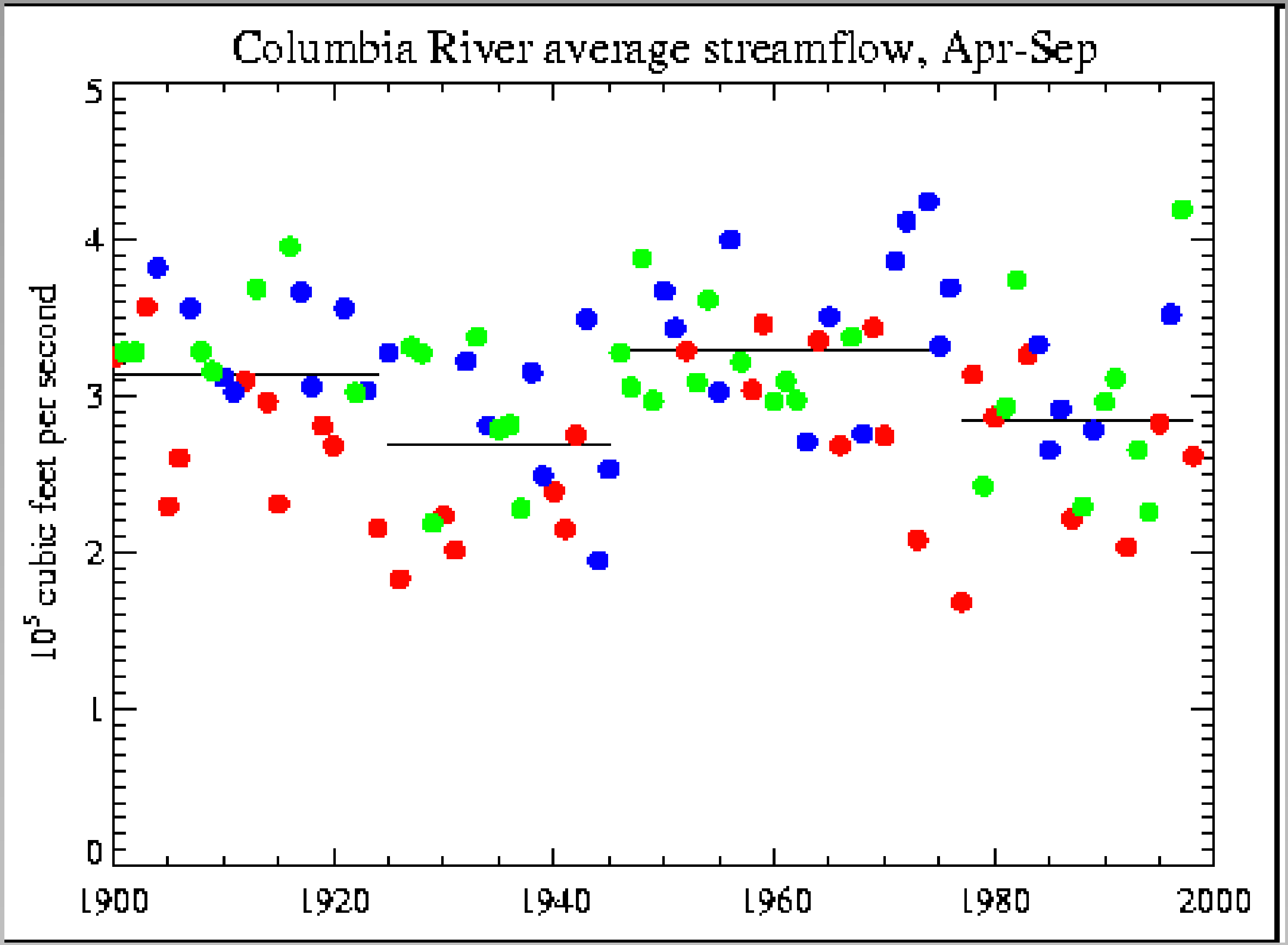
  (5) Low Flow (summer-autumn)
- Student "t-test", Mann-Kendall trend statistical tests were used.
- GIS data: Climate change risk for land below elevation 4000 feet?

The Water Cycle – Watersheds and Climate



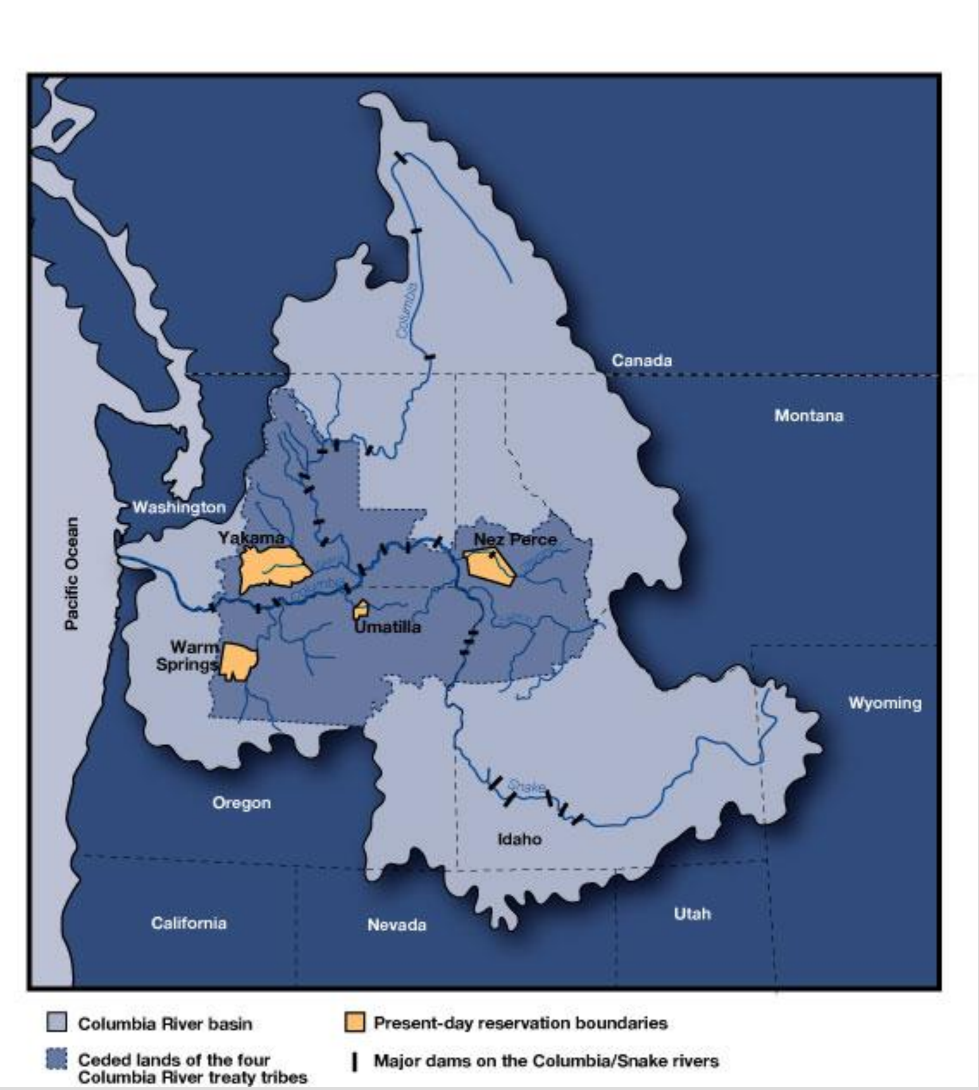
Source: https://www.usgs.gov/media/images/natural-water-cycle-jpg

Climate Variability and Streamflow in the PNW



Source: Climate Impacts Group, University of Washington, Seattle

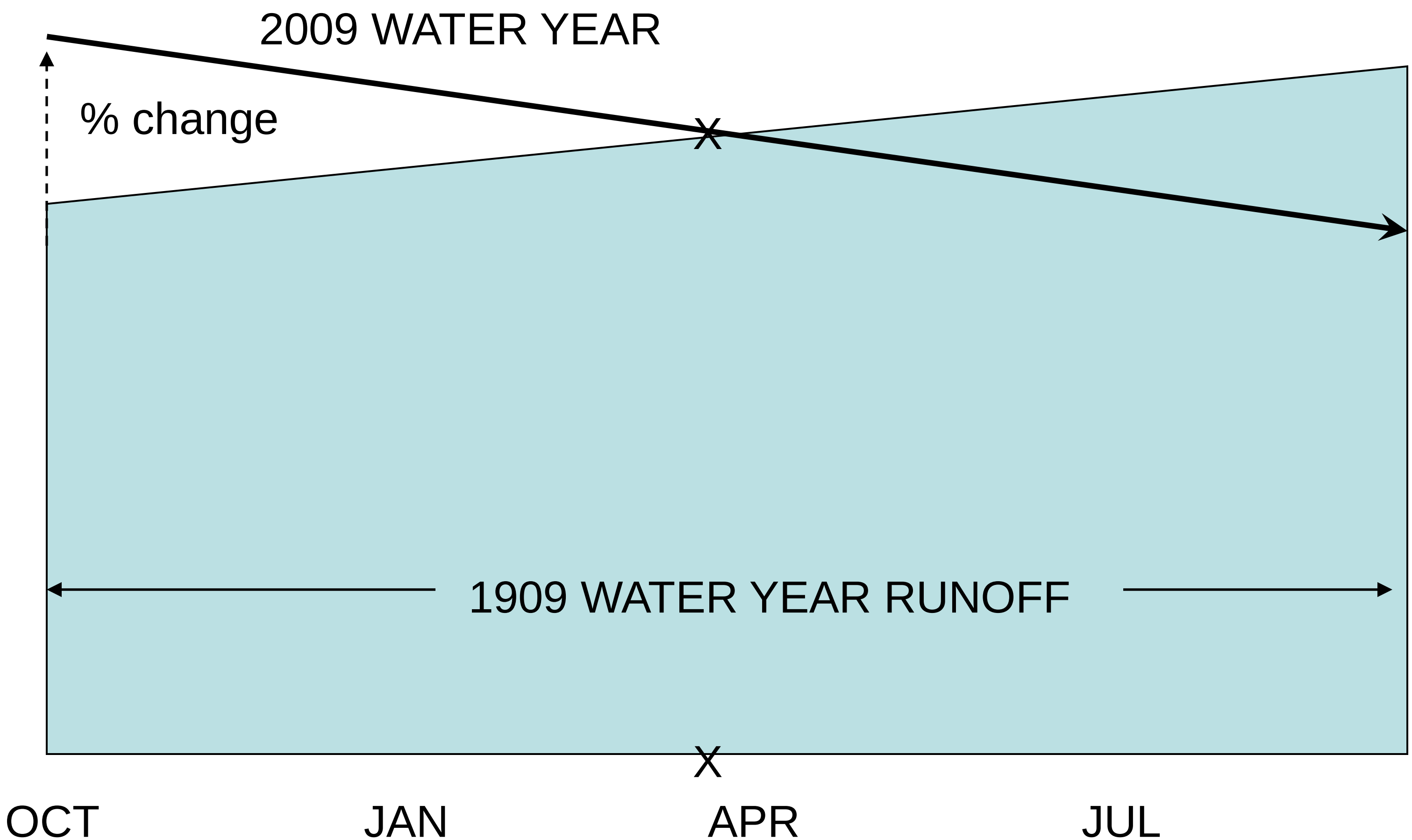
Location Map



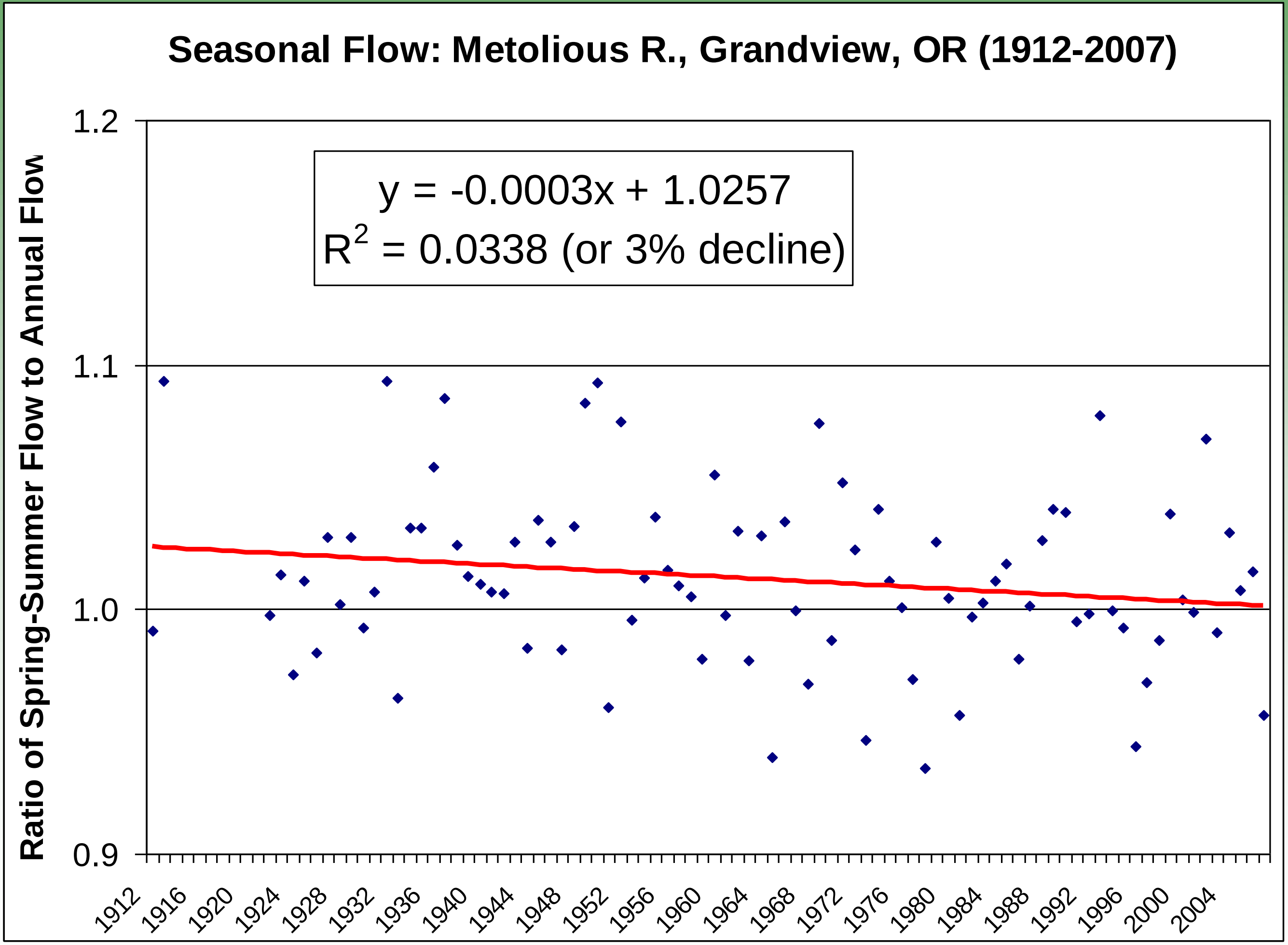
Seasonal Flow Fraction

SFF = Ratio of SPRING and SUMMER FLOW to ANNUAL FLOW

(e.g., Autumn-Winter vs. Spring-Summer volumes)

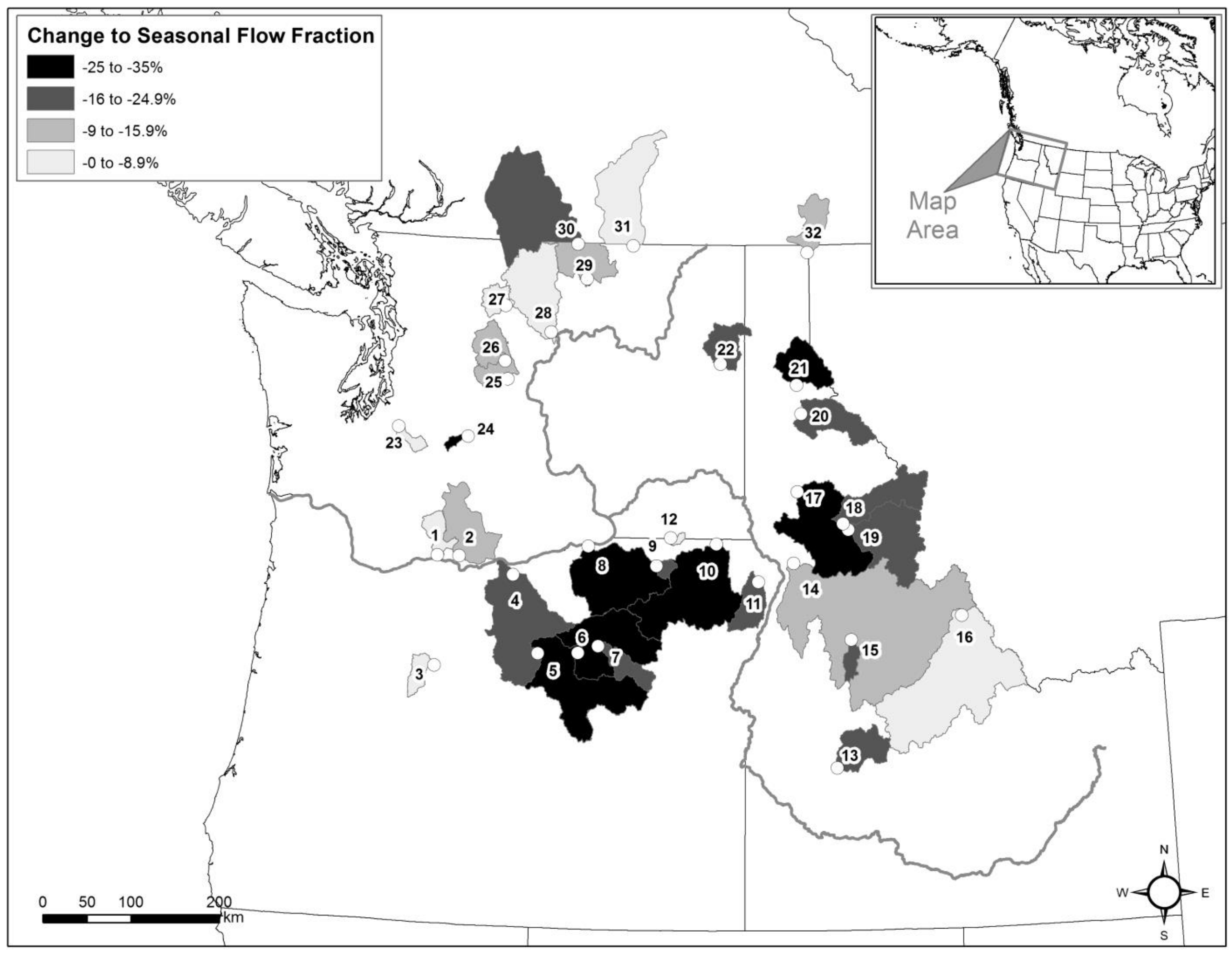


Seasonal Flow Fraction: Metolius Basin (Deschutes)



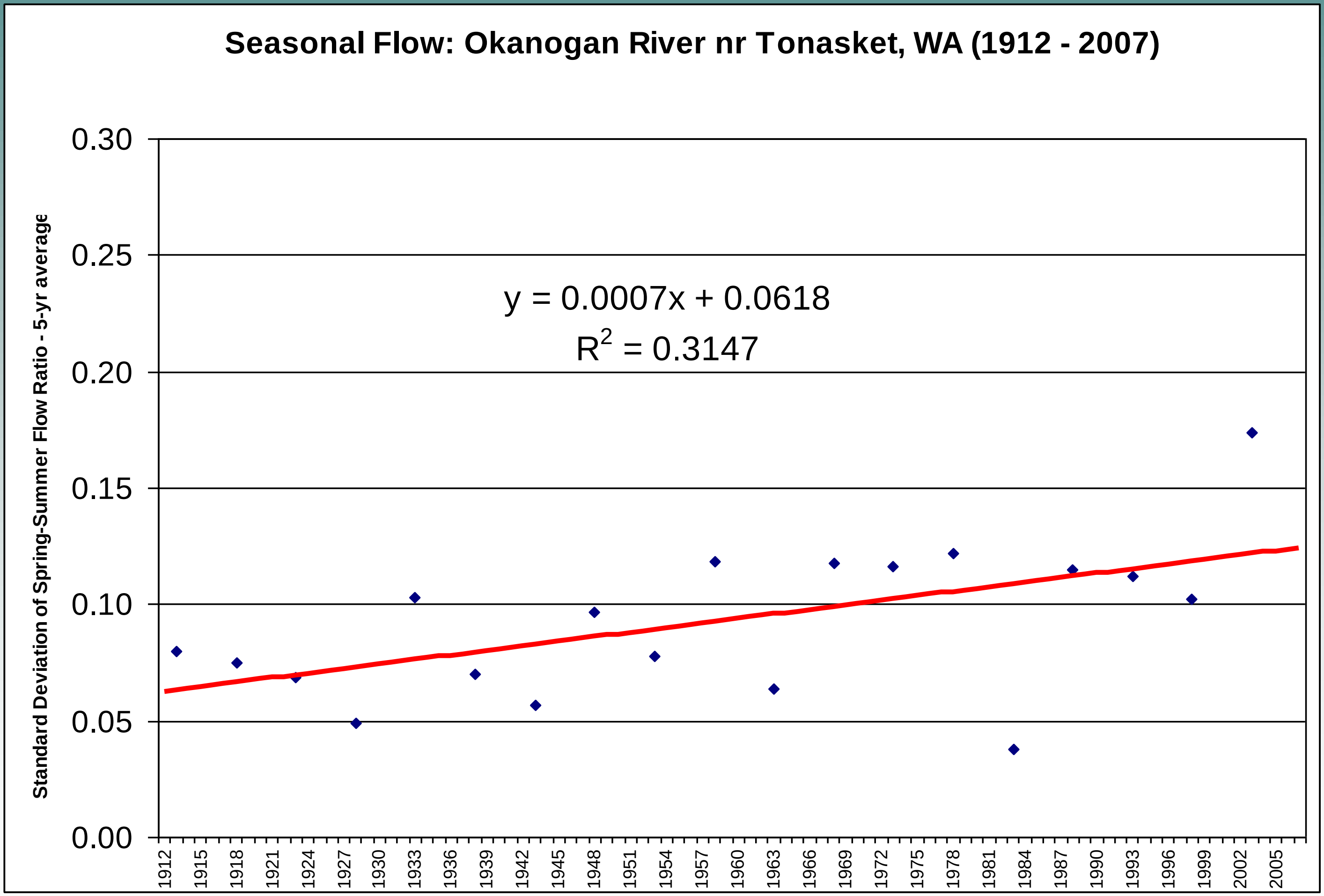
Source: Dittmer (2013)

Seasonal Flow Fraction:
spring-summer vs. autumn-winter



Source: Dittmer (2013)

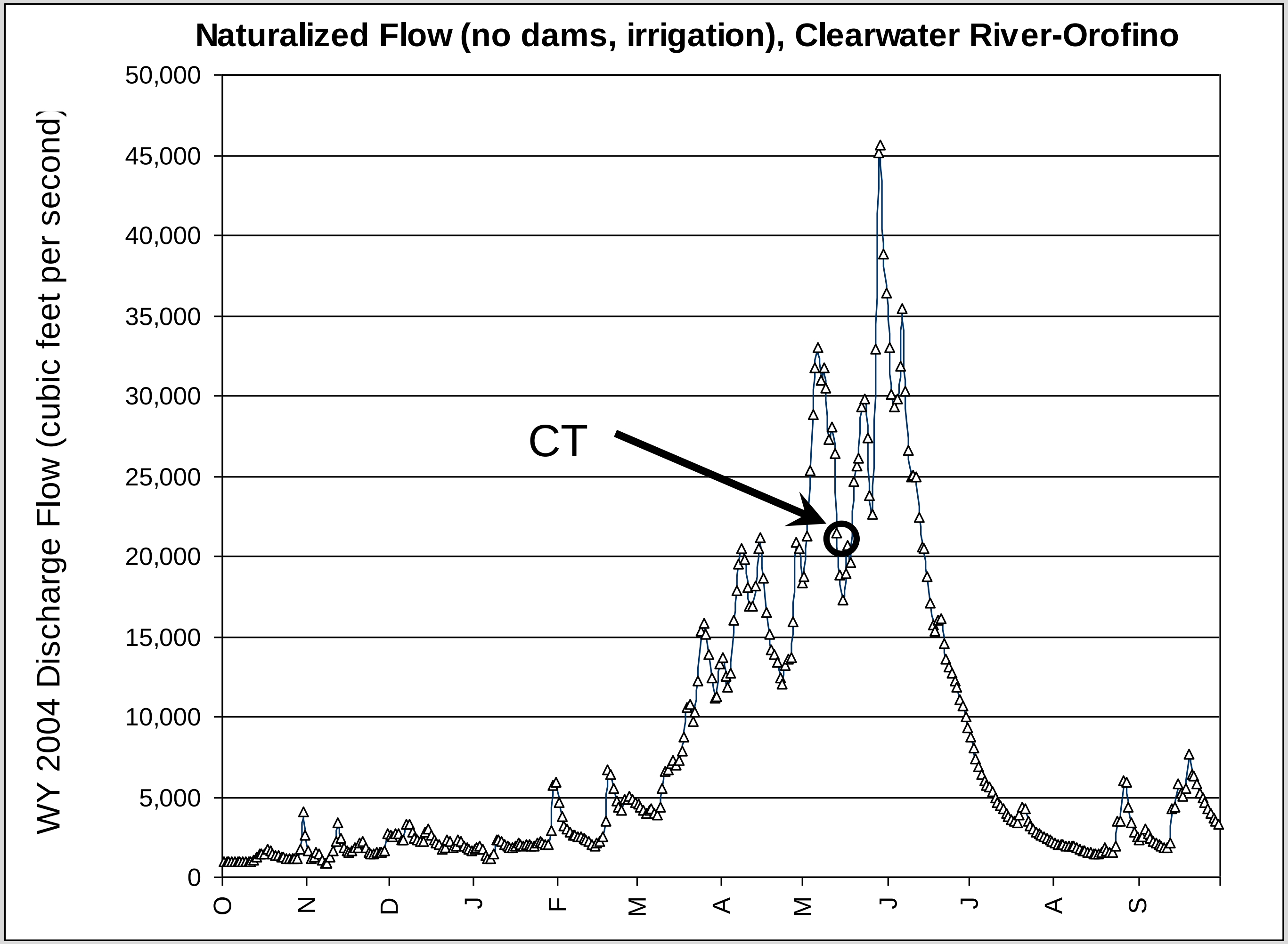
Seasonal Flow Fraction: Standard Deviation



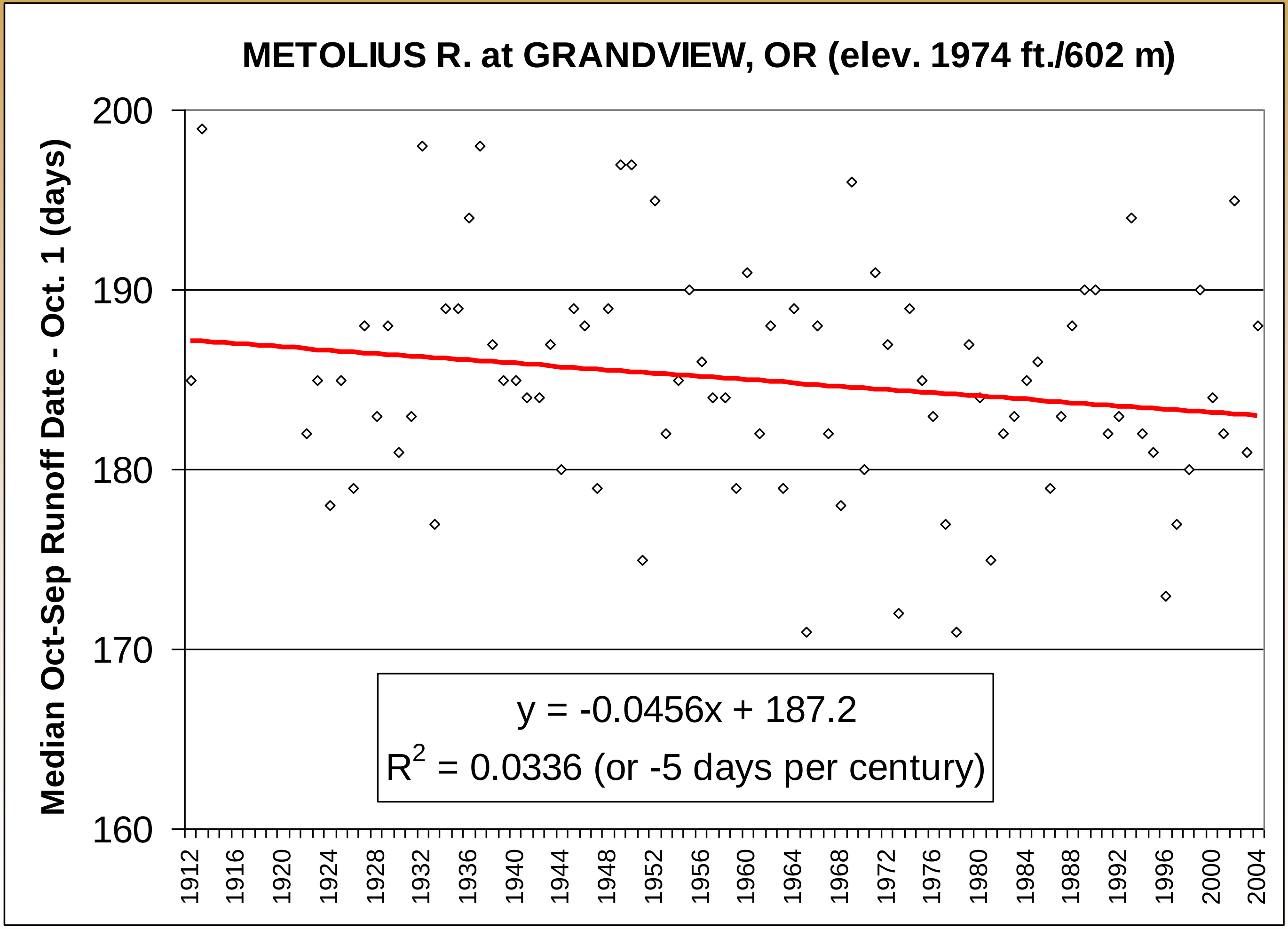
Source: Dittmer (2013)

Center-of-mass Timing

CT = MID-POINT (50%) OF WATER YEAR RUNOFF

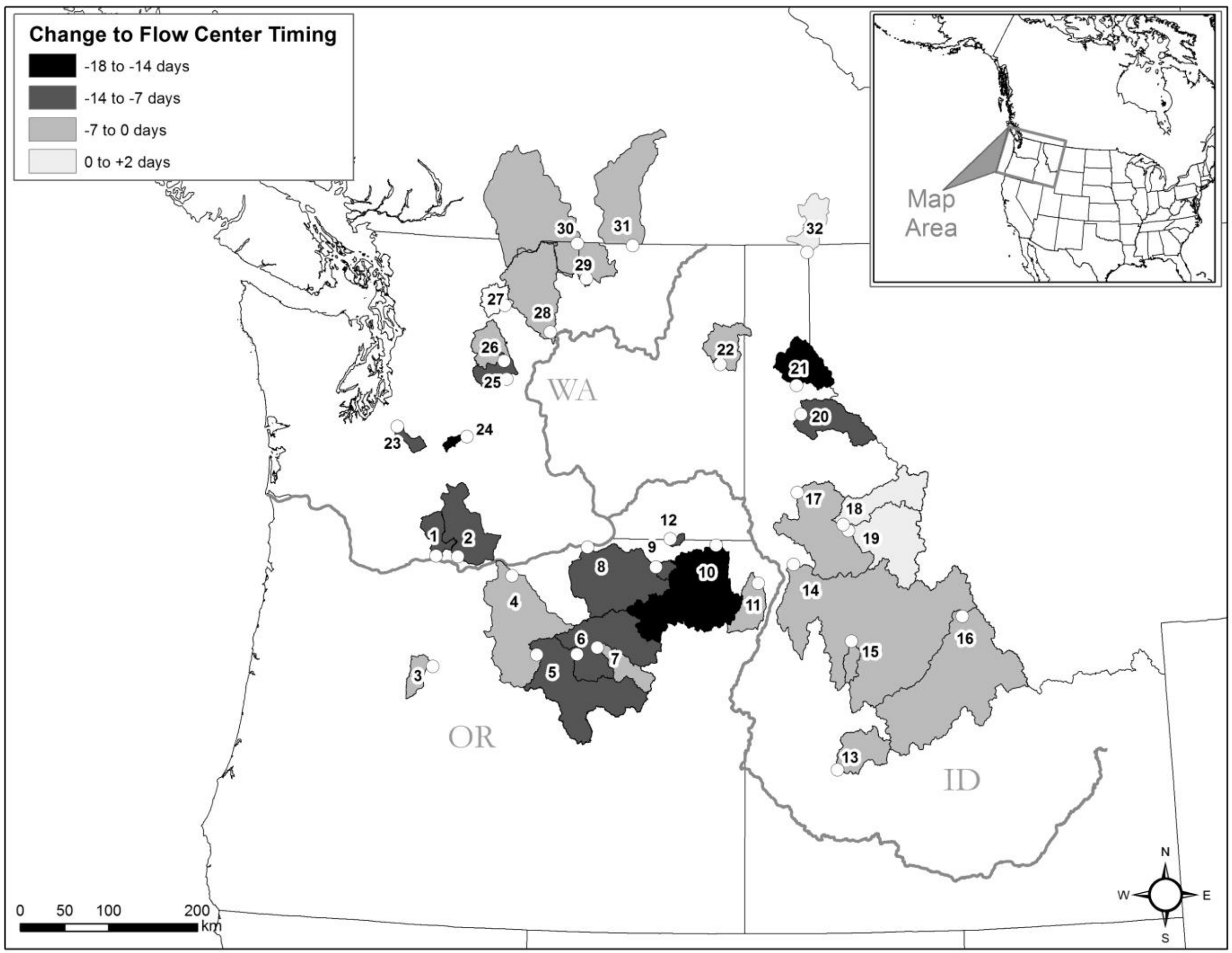


Snowmelt timing (CT): Metolius Basin (Deschutes)



Source: Dittmer (2013)

Snowmelt timing (CT):
Mid-point of seasonal runoff

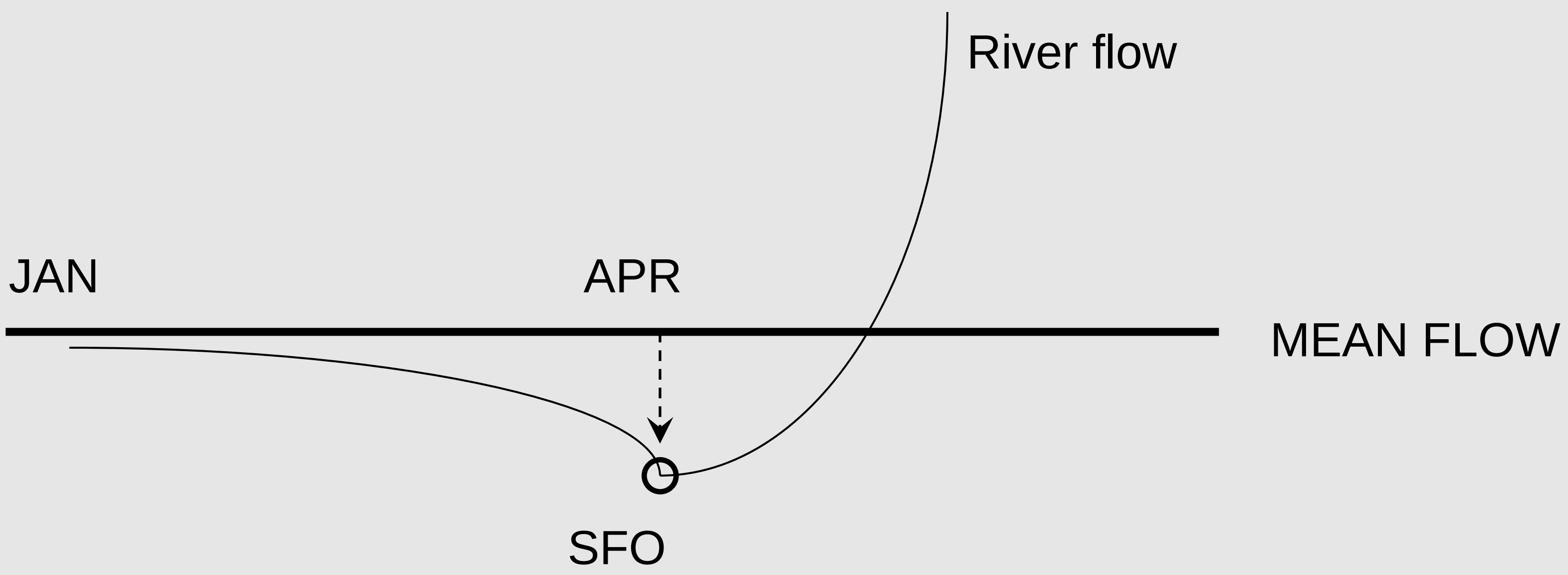


Source: Dittmer (2013)

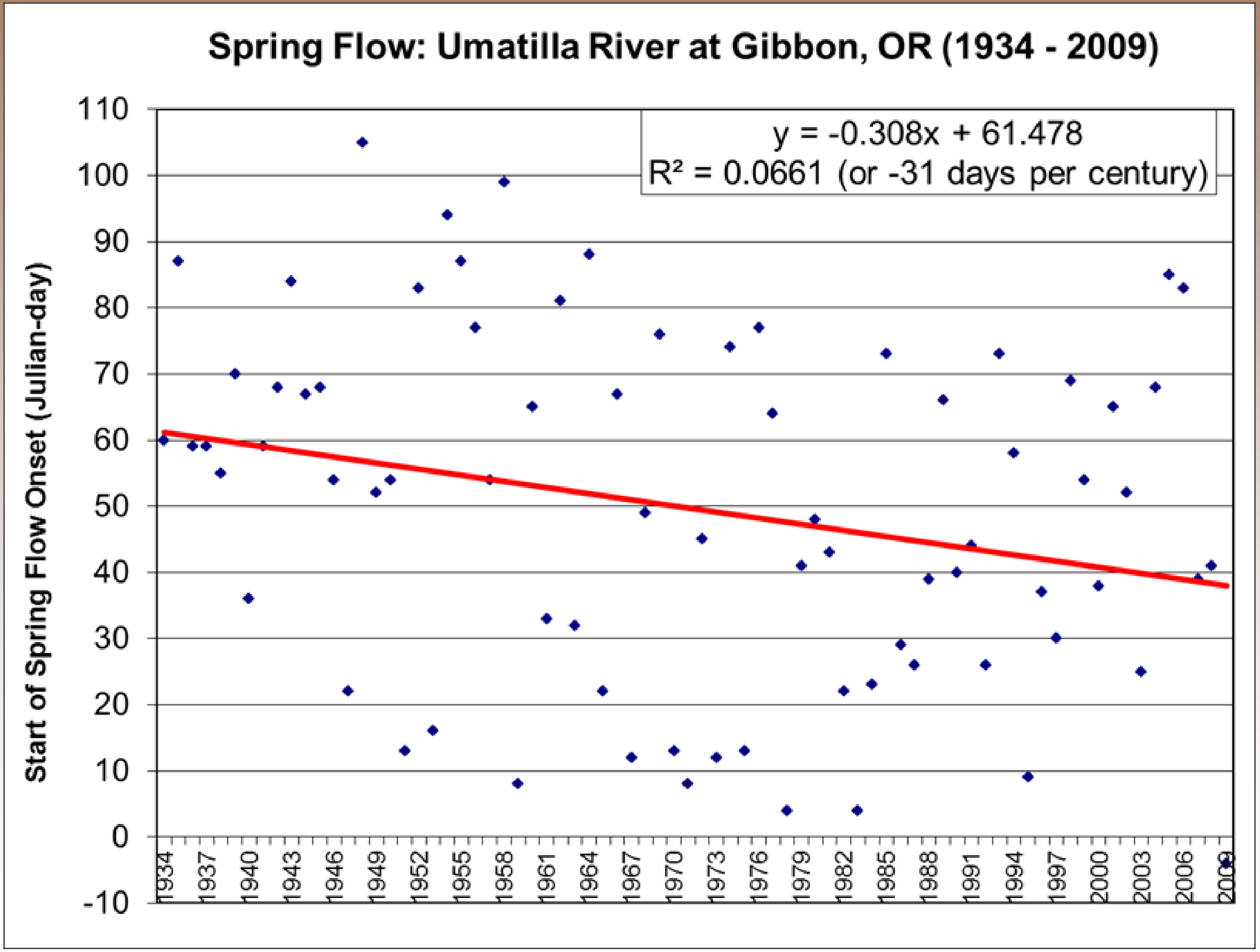
Spring Flow Onset

SFO = CUMULATIVE NEGATIVE DEPARTURES

FROM THE MEAN FLOW ARE AT A ***MINIMUM***

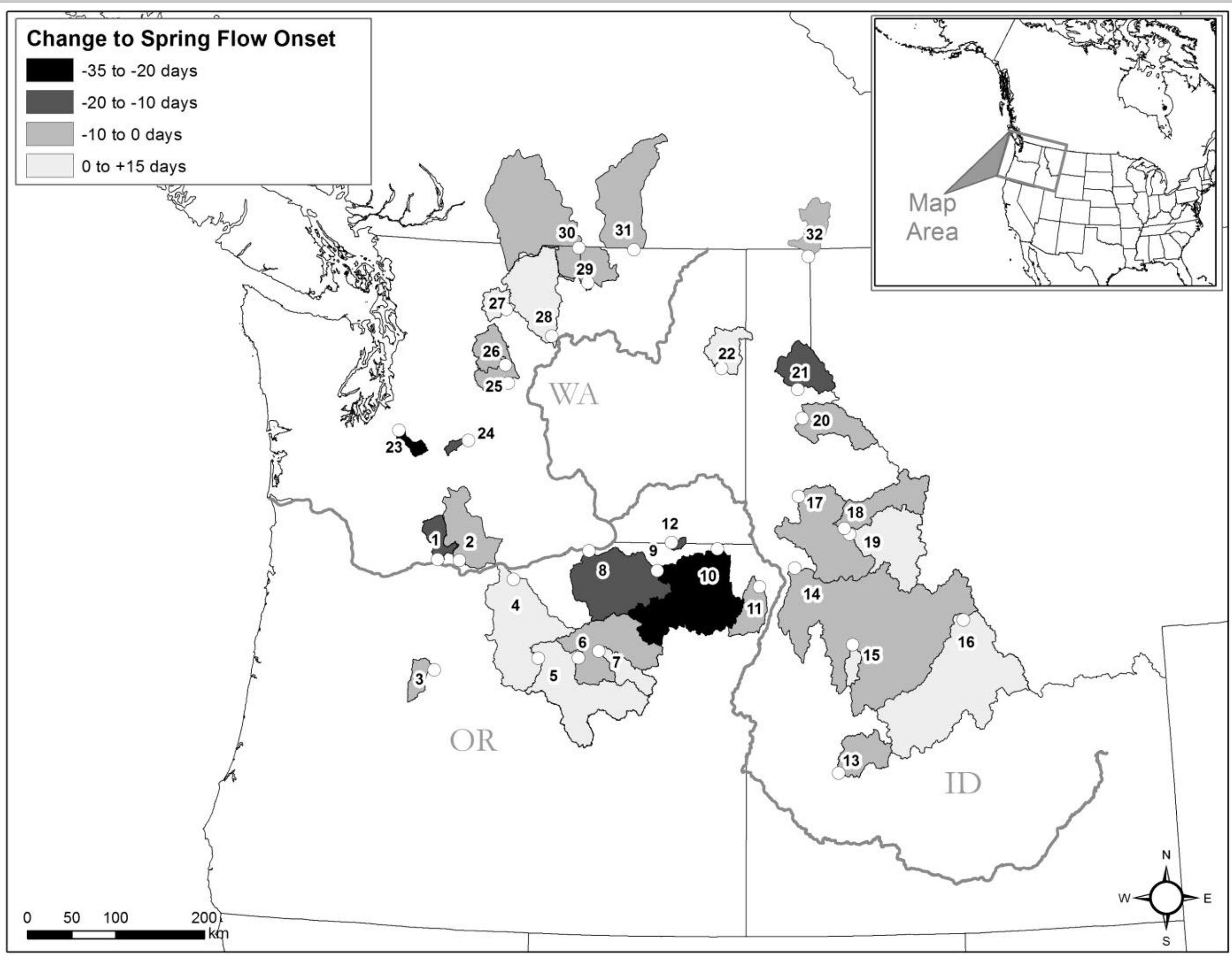


Spring Flow Onset: Umatilla Basin (at Gibbon)



Source: Dittmer (2013)

Spring Flow Onset (SFO):
start date of the seasonal snow-melt



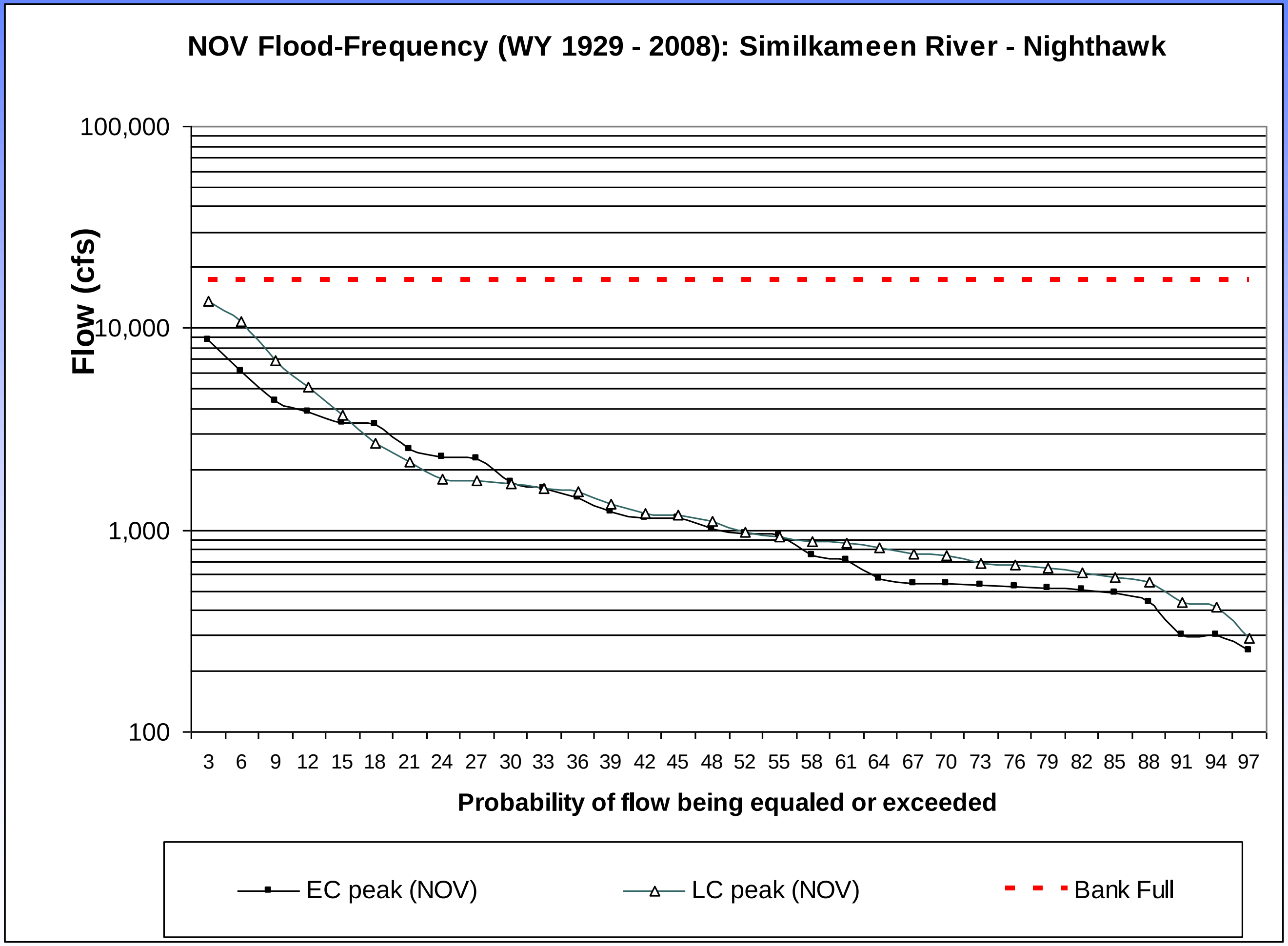
Source: Dittmer (2013)

Statistics…SFF, CT, SFO

			SFF		Mann -	CT		Mann -	SFO		Mann -
t-test 3-year moving average	Figure 1		LC vs. EC	W-C	Kendall	LC vs. EC	W-C	Kendall	LC vs. EC	W-C	Kendall
River - Gauge Location	labels	USGS Gage #	(p-value)	(p-value)	(alpha)	(p-value)	(p-value)	(alpha)	(p-value)	(p-value)	(alpha)
White Salmon	1	14123500	**0.052**	0.194	none	**0.038**	0.232	< 0.1	0.174	0.309	none
Klickitat	2	14113000	**0.008**	**0.012**	< 0.1	**0.029**	**0.061**	< 0.1	0.634	0.205	none
Metolius	3	14091500	**0.046**	**0.050**	none	**0.021**	**0.044**	none	0.496	0.500	none
John Day - McDonald	4	14048000	**0.047**	**0.086**	none	0.248	0.267	none	0.750	0.922	none
John Day - Service Crk.	5	14046500	**0.059**	**0.061**	none	0.293	0.242	none	0.566	0.806	none
John Day - Monument	6	14046000	**0.054**	**0.056**	none	0.865	0.210	none	0.870	0.683	none
John Day - Ritter	7	14044000	0.110	**0.094**	none	0.691	0.719	none	0.610	0.755	none
Umatilla - Umatilla	8	14033500	**0.018**	0.158	< 0.1	**0.002**	**0.008**	< 0.05	**0.073**	0.257	< 0.1
Umatilla - Gibbon	9	14020000	**0.056**	**0.043**	none	**0.056**	**0.054**	none	**0.011**	**0.004**	< 0.05
Grande Ronde	10	13333000	**0.006**	**0.002**	< 0.05	**0.044**	**0.005**	< 0.05	**0.048**	**0.001**	< 0.05
Imnaha	11	13292000	**0.001**	**0.000**	< 0.01	0.349	0.121	none	0.945	0.252	none
Mill Creek	12	14013000	**0.099**	0.206	none	0.221	0.569	none	0.169	0.356	none
Boise	13	13185000	**0.003**	**0.003**	< 0.01	0.233	0.111	none	0.527	0.136	none
Salmon - Whitebird	14	13317000	**0.012**	**0.013**	< 0.05	0.441	0.422	none	0.499	0.759	none
Johnson Creek	15	13313000	**0.015**	**0.014**	< 0.05	0.733	0.537	none	0.209	0.735	none
Salmon - Salmon	16	13302500	0.288	**0.037**	none	0.854	0.365	none	**0.015**	**0.029**	none
Clearw ater	17	13340000	**0.002**	**0.001**	< 0.01	0.545	0.185	none	0.515	0.593	none
Lochsa	18	13337000	0.104	**0.032**	< 0.00	0.647	0.862	none	0.654	0.638	none
Selw ay	19	13336500	**0.035**	**0.007**	< 0.05	0.407	0.925	none	**0.096**	0.522	none
St. Joe	20	12414500	**0.044**	**0.023**	< 0.05	0.594	0.212	none	0.611	0.445	none
Coeur D'Alene	21	12413000	**0.026**	**0.010**	< 0.1	**0.020**	**0.011**	< 0.05	**0.096**	**0.022**	< 0.1
Little Spokane	22	12431000	**0.089**	**0.081**	none	**0.049**	**0.002**	< 0.1	0.840	0.829	none
Puyallup	23	12093500	0.549	0.609	none	0.523	0.863	none	**0.026**	**0.047**	< 0.1
American	24	12488500	**0.010**	**0.003**	< 0.05	**0.089**	**0.024**	< 0.1	0.419	0.463	none
Wenatchee - Peshastin	25	12459000	**0.040**	**0.007**	none	0.327	**0.038**	none	0.785	0.429	none
Wenatchee - Plain	26	12457000	**0.071**	**0.018**	none	0.481	0.103	none	0.639	0.646	none
Stehekin	27	12451000	0.457	0.113	none	0.385	0.586	none	**0.030**	0.146	< 0.1
Methow	28	12449950	0.101	0.119	none	0.717	0.714	none	0.433	0.724	none
Okanogan	29	12445000	0.161	0.104	< 0.1	0.842	0.721	none	0.898	0.754	none
Similkameen	30	12442500	**0.064**	**0.009**	< 0.05	0.821	0.453	none	0.511	0.644	none
Kettle - Ferry	31	12401500	0.370	0.190	none	0.943	0.316	none	0.862	0.189	none
Moyie - Eastport	32	12306500	0.424	**0.100**	< 0.1	0.331	0.884	none	0.509	0.863	none
Average:			**0.11**	**0.08**		**0.40**	**0.34**		**0.45**	**0.46**	
Maximum			0.55	0.61		0.94	0.93		0.94	0.92	
Minimum			0.01	0.00		0.09	0.02		0.03	0.05	
Bold: p = 0.05 - 0.1		Bold-shade: p < 0.05									

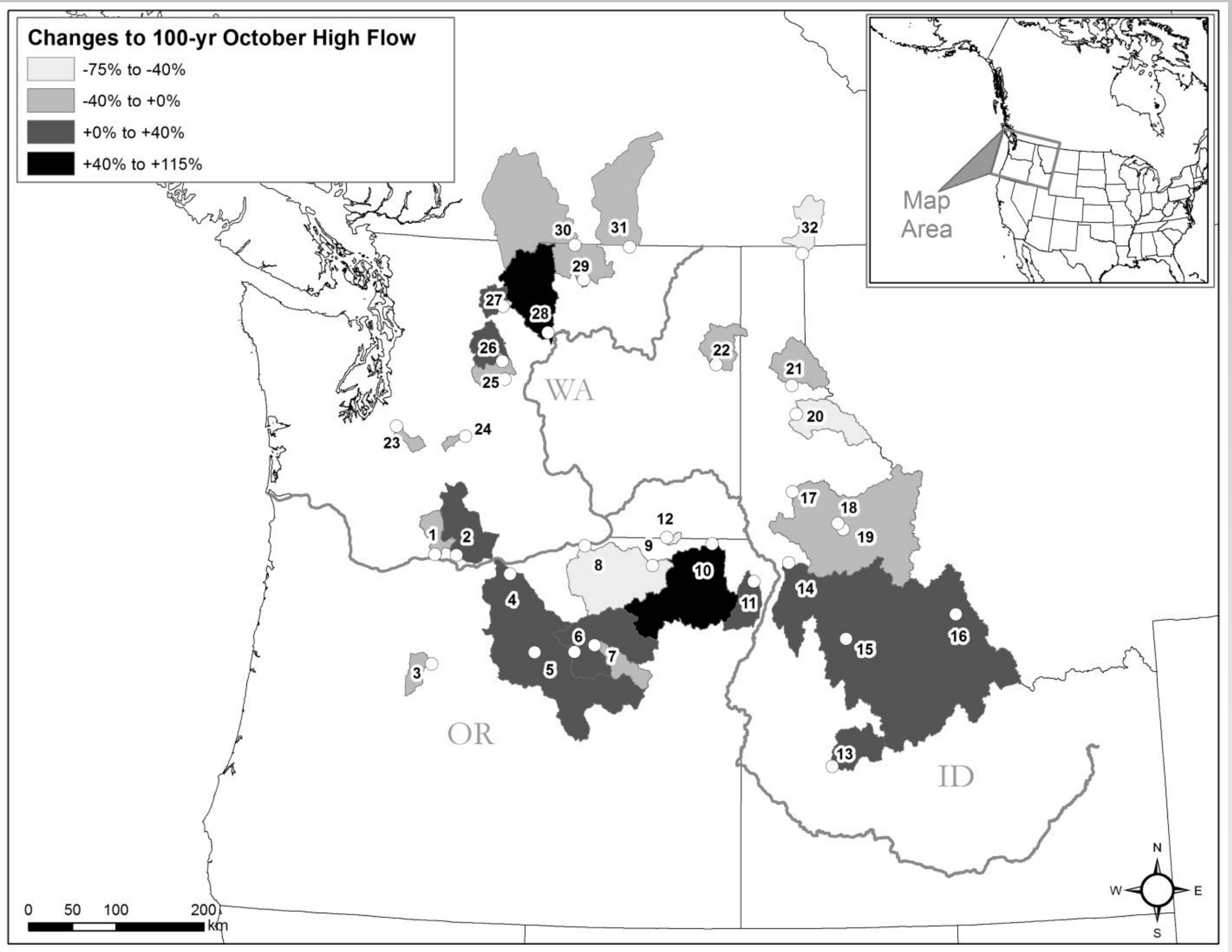
Source: Dittmer (2013)

High Flow events: Similkameen Basin (at Nighthawk)



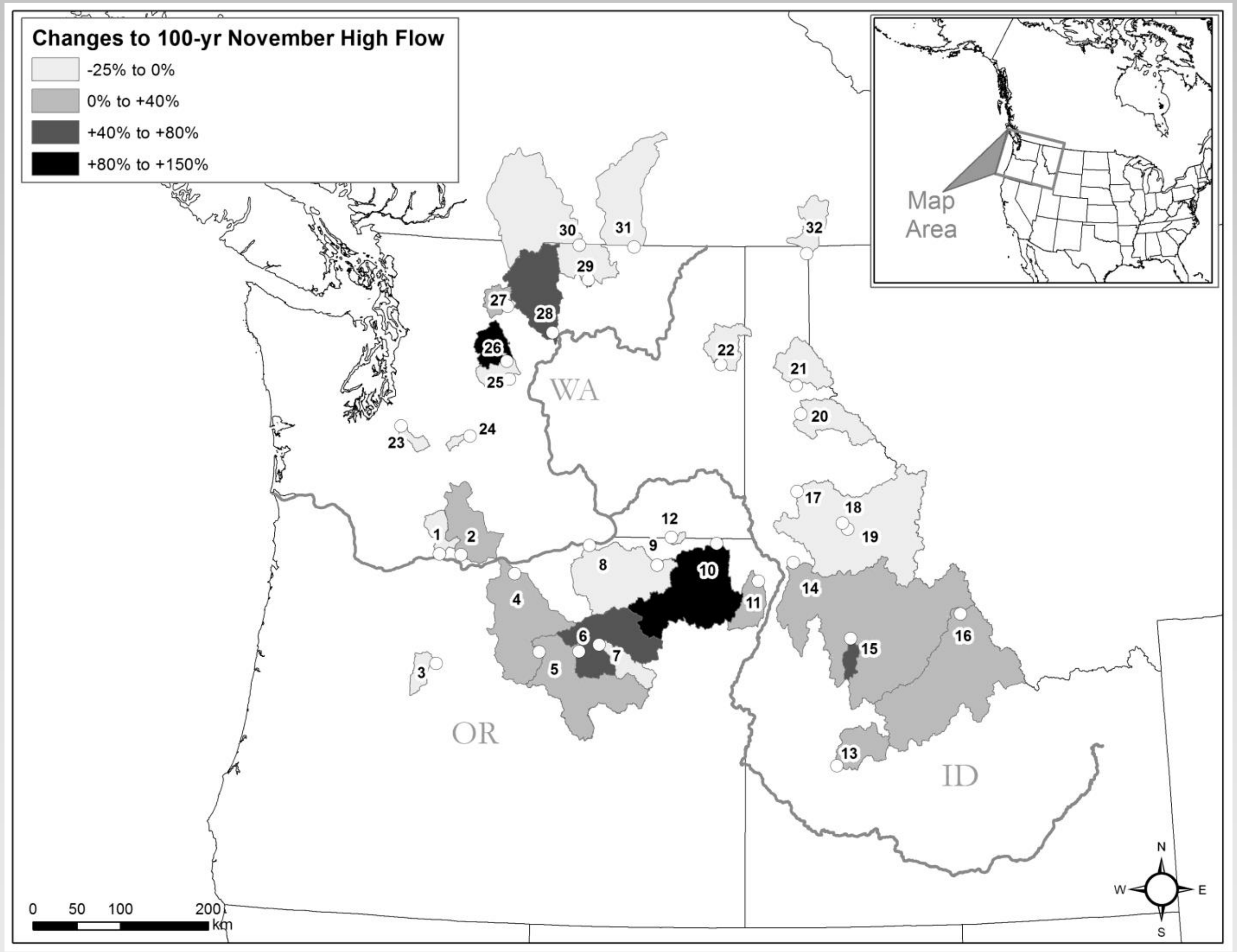
Source: Dittmer (2013)

High Flow events:
Late 20th century vs. Early century 100-year flow



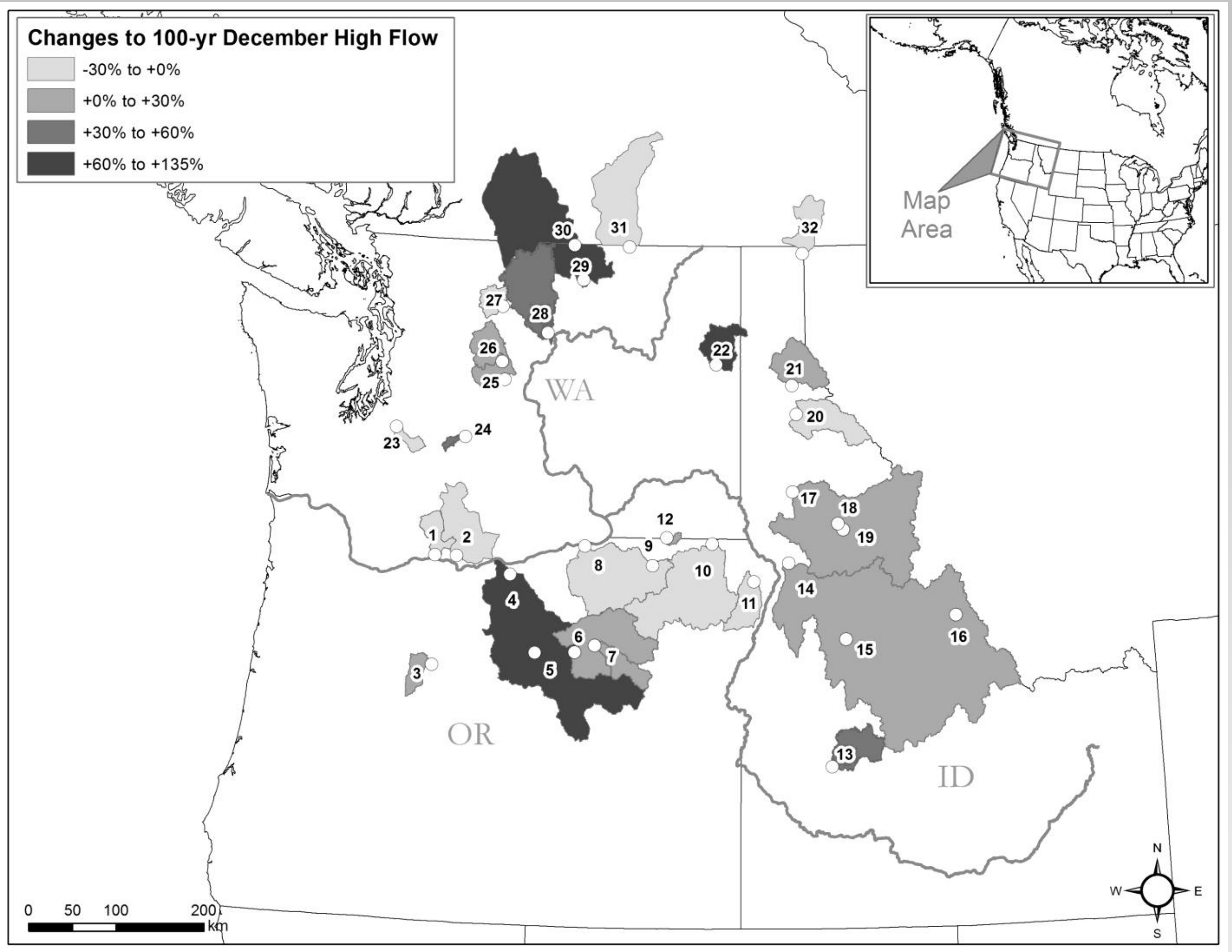
Source: Dittmer (2013)

High Flow events:
Late 20th century vs. Early century 100-year flow



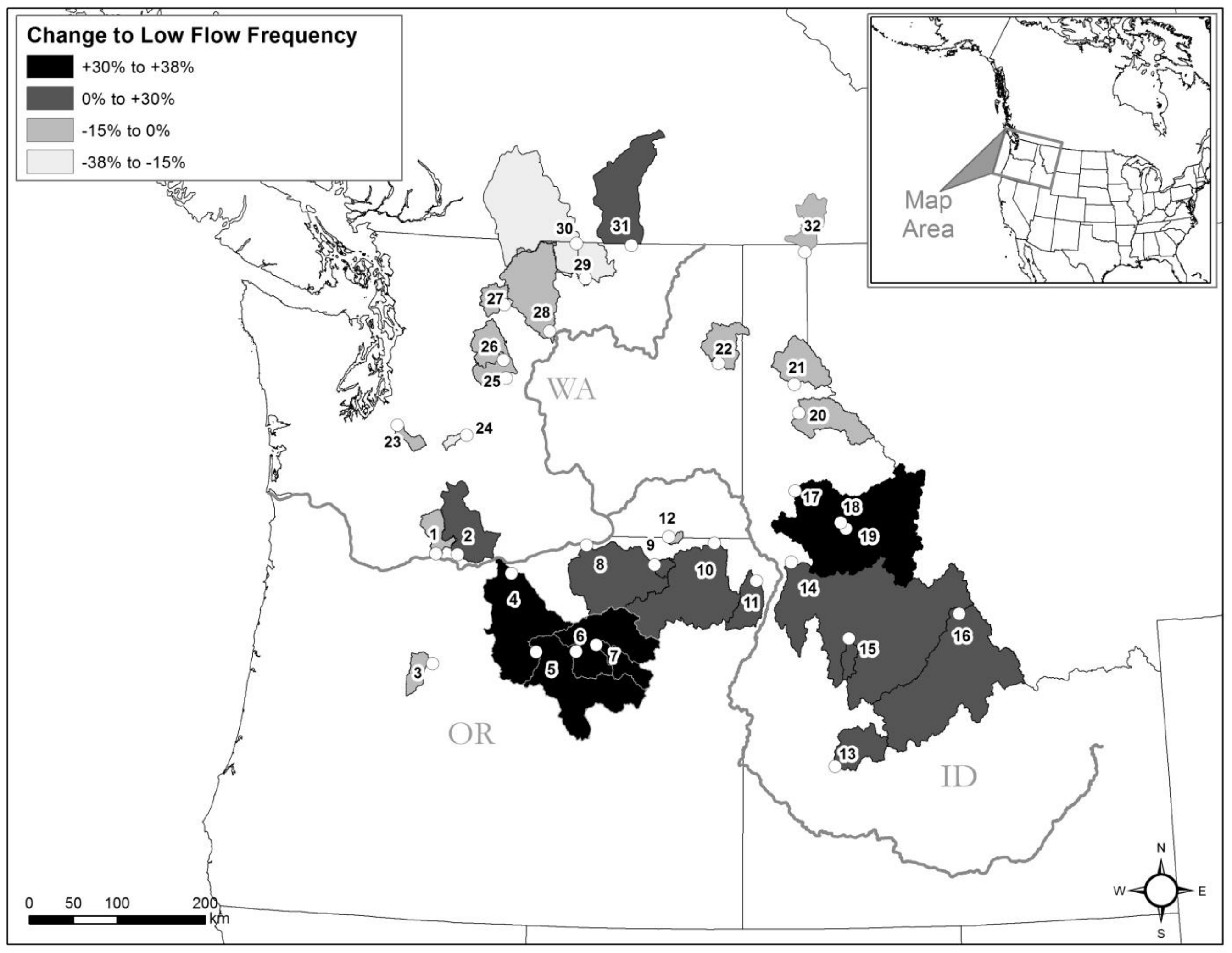
Source: Dittmer (2013)

High Flow events:
Late 20th century vs. Early century 100-year flow



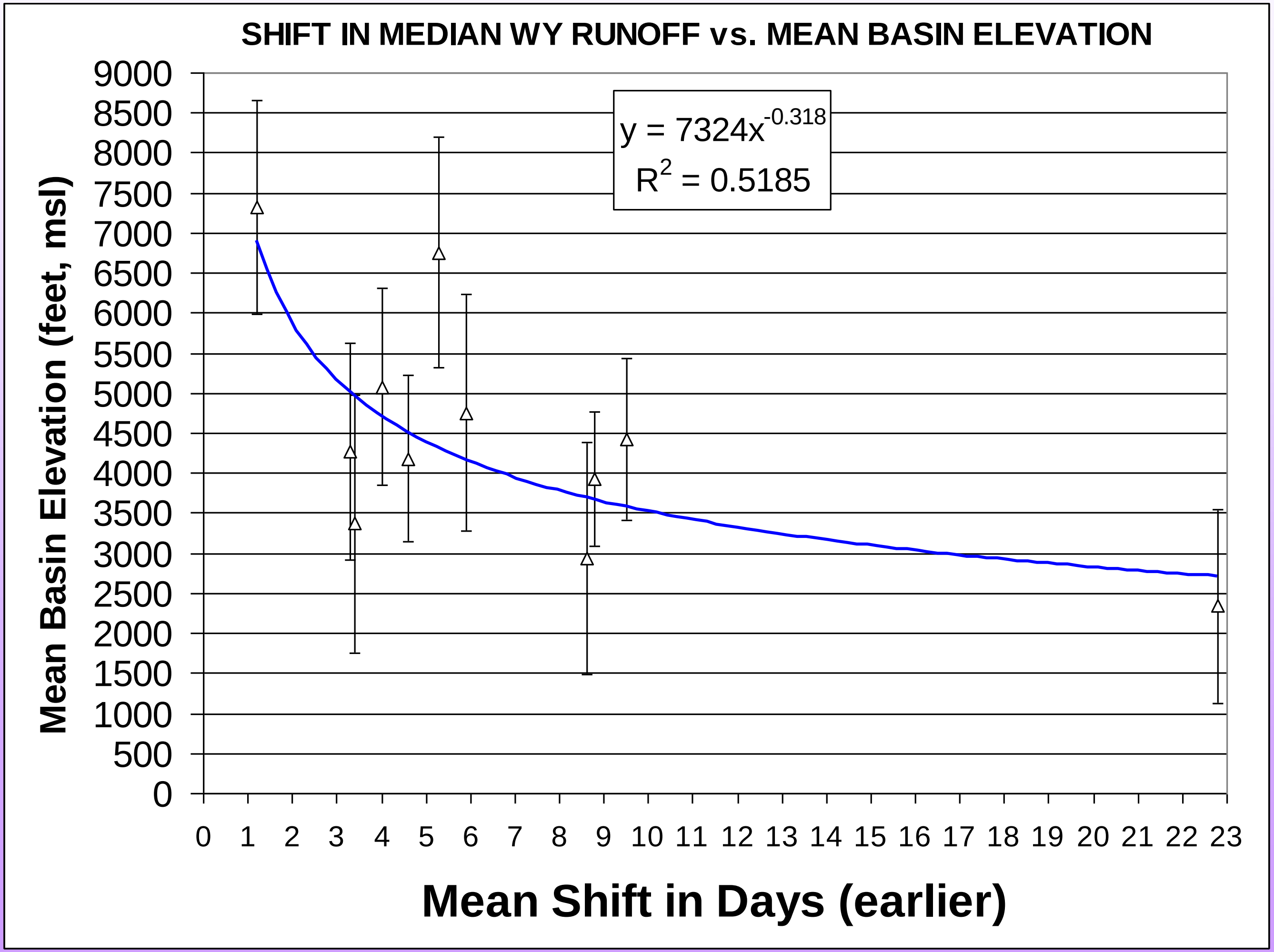
Source: Dittmer (2013)

Low Flow events:
Late 20th century vs Early century 7Q10-year flow



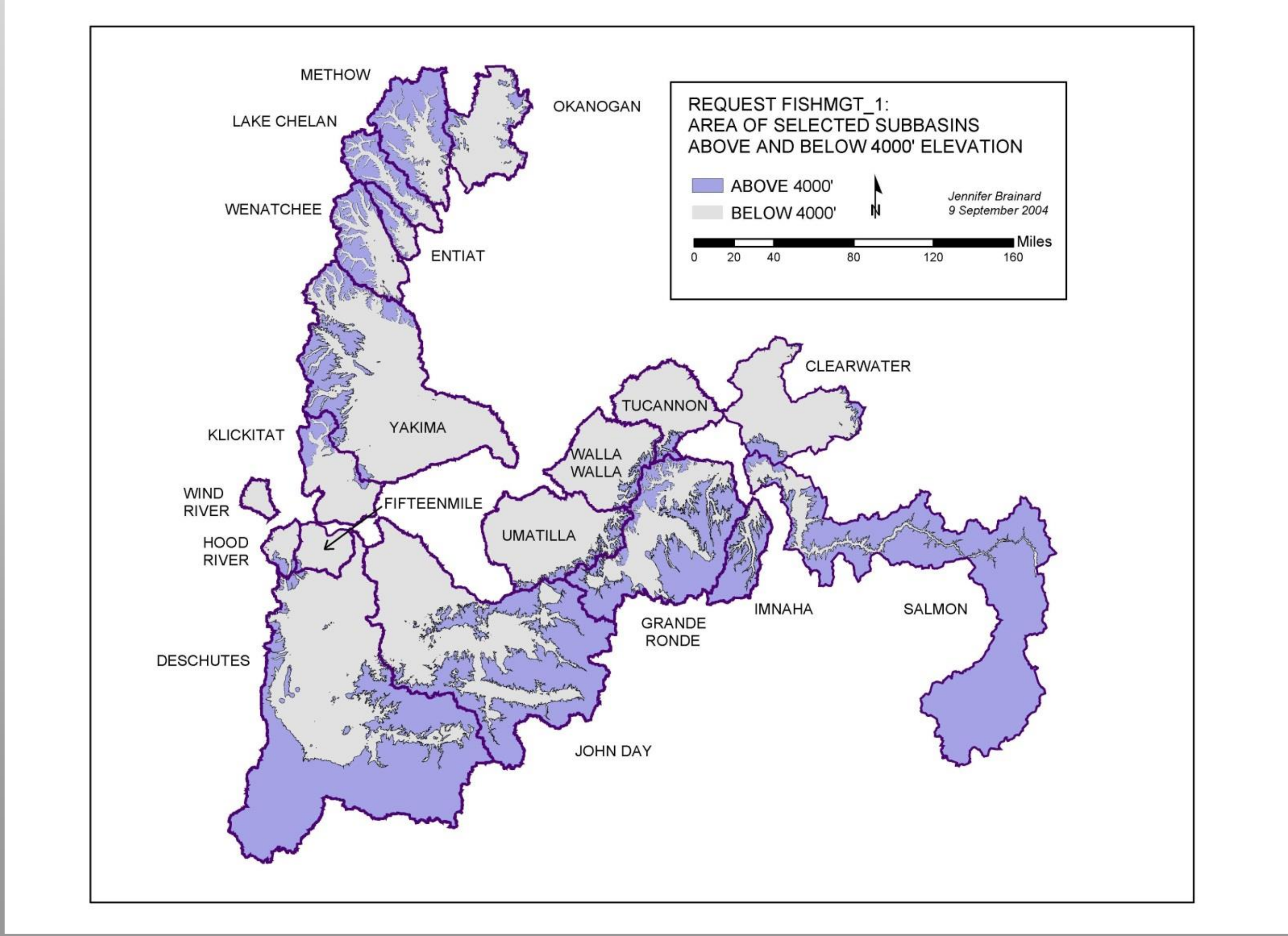
Source: Dittmer (2013)

Shift in Median Runoff Timing vs. Basin Elevation



Source: Dittmer (2013)

Climate Change Sensitivity: GIS assessment – tribal land



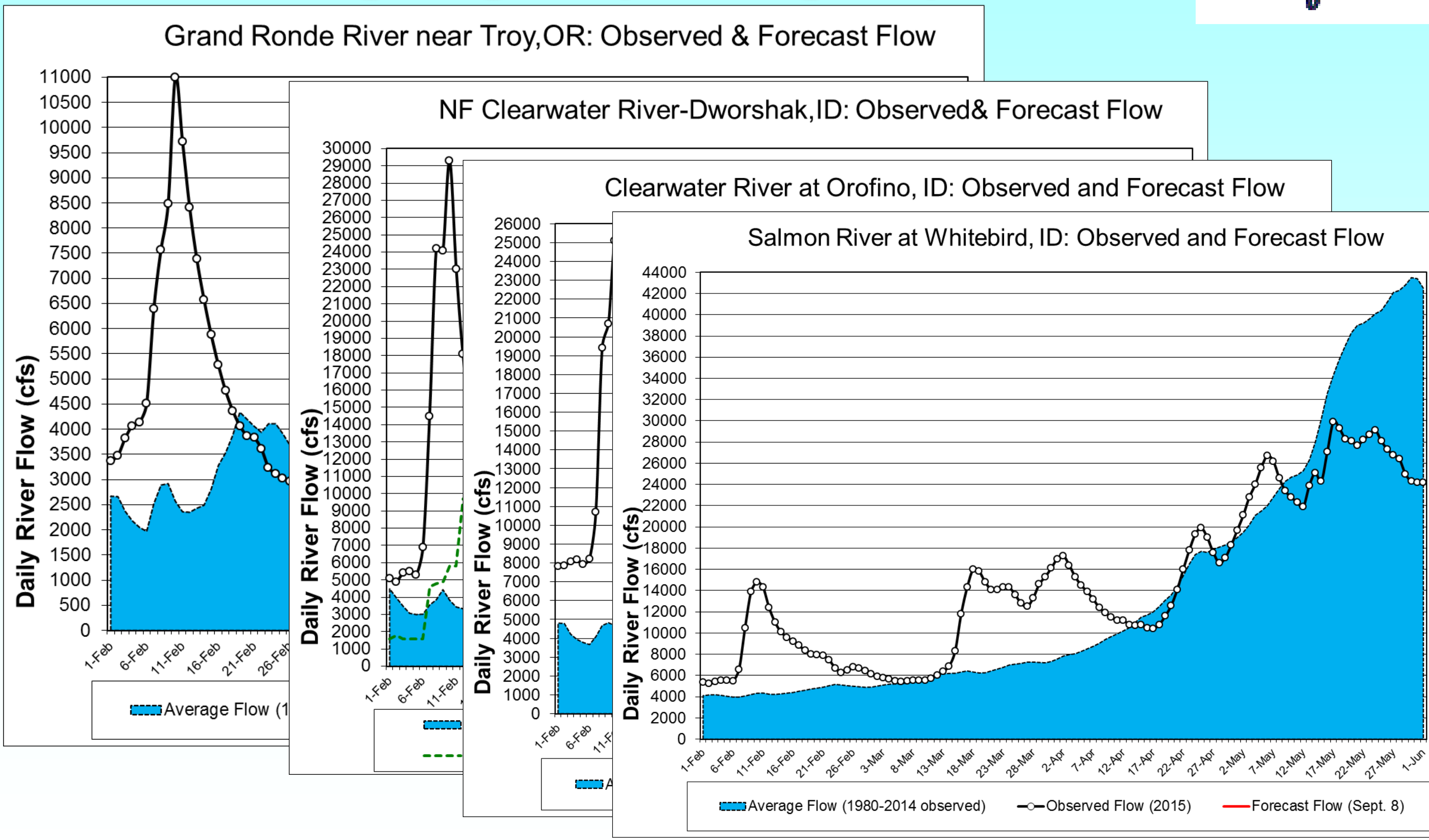
Source: David Graves, CRITFC (GIS data)

THE CLIMATE THAT IS…

Current Climate Change Issues

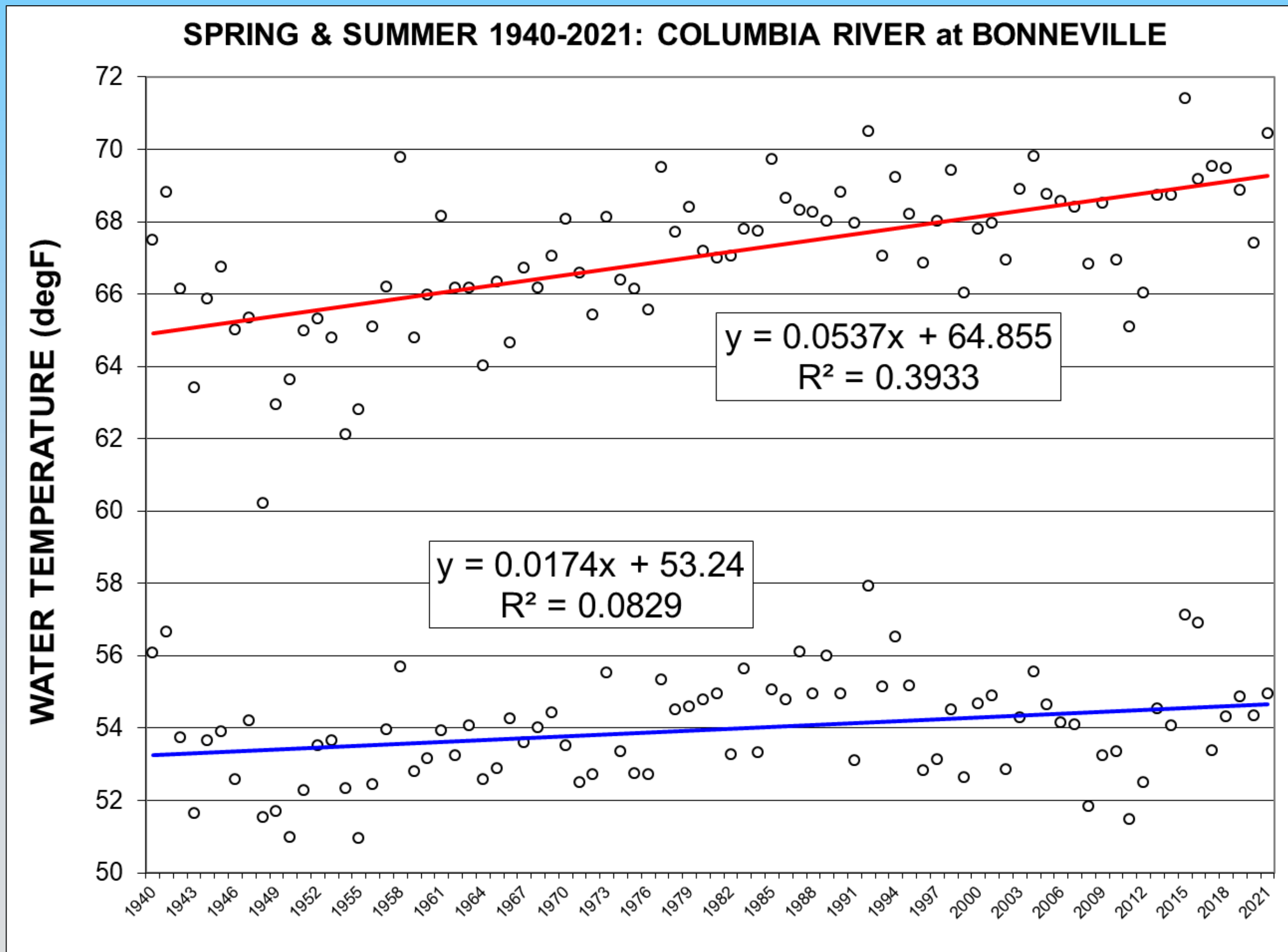
- **Warming** winters are *already* changing the tributary hydrographs!
- Weather patterns are becoming more extreme and variable. Examples: more severe hurricane days, new records set for temperature (day & night), severe weather (e.g., tornadoes) in the off-season, persistent (& more frequent) dry spells…drought, etc.
- Extreme weather variability will make water management in reservoirs more difficult and prone to **more operational errors**.
- The incubation of *redds* is sooner due to warmer winter water.
- The invasion of warm-water species is a growing problem.
- Hot summer Columbia R. water temperatures often exceed state standards for salmon. Adult salmon migration delays are more common at Bonneville Dam due to high temperatures (exceeds 68 degF). Fish may stray into cooler tributary streams to survive.

Changing Hydrographs



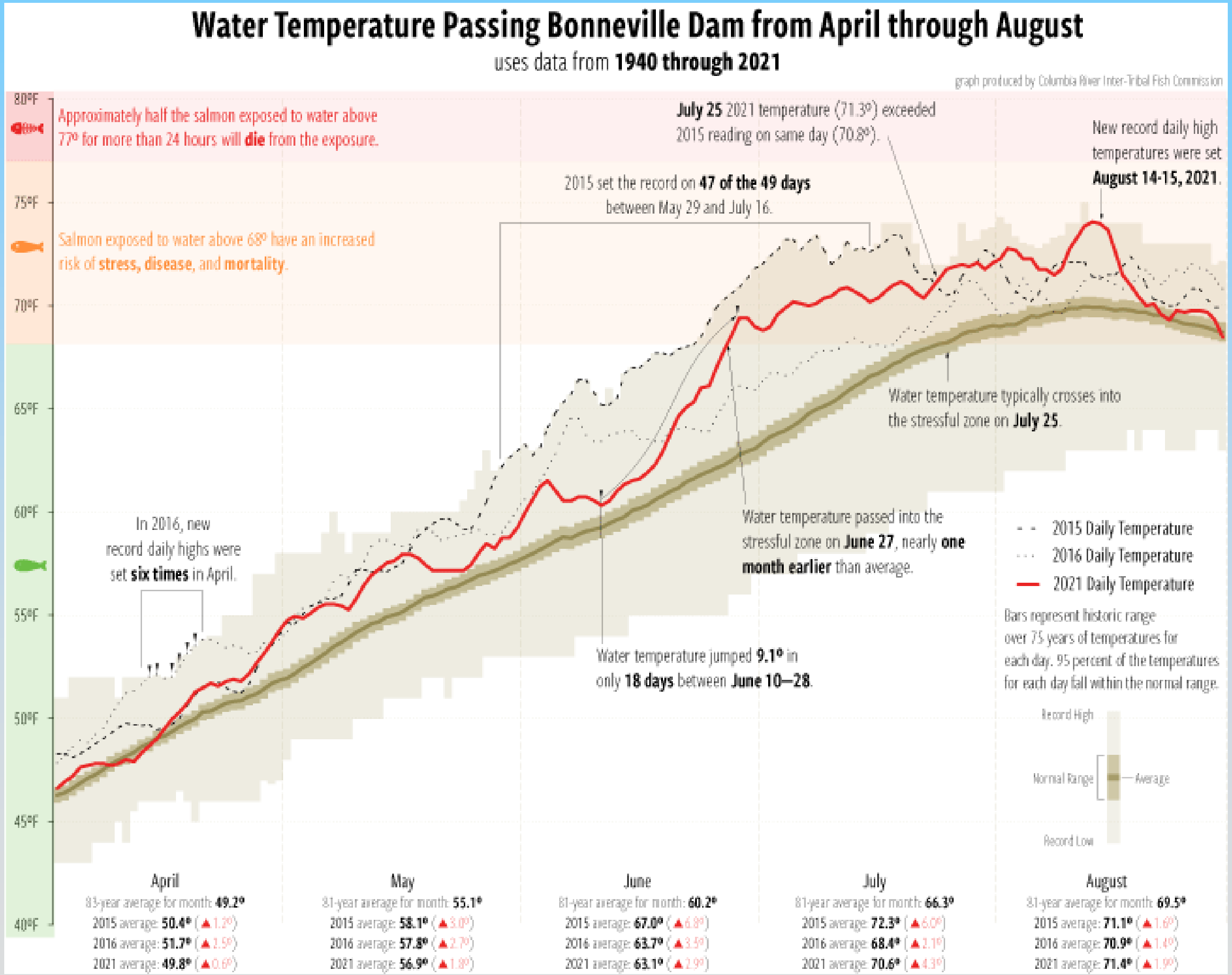
Source: NOAA-National Weather Service forecast data (2015)

Water Temperature: Columbia River Basin



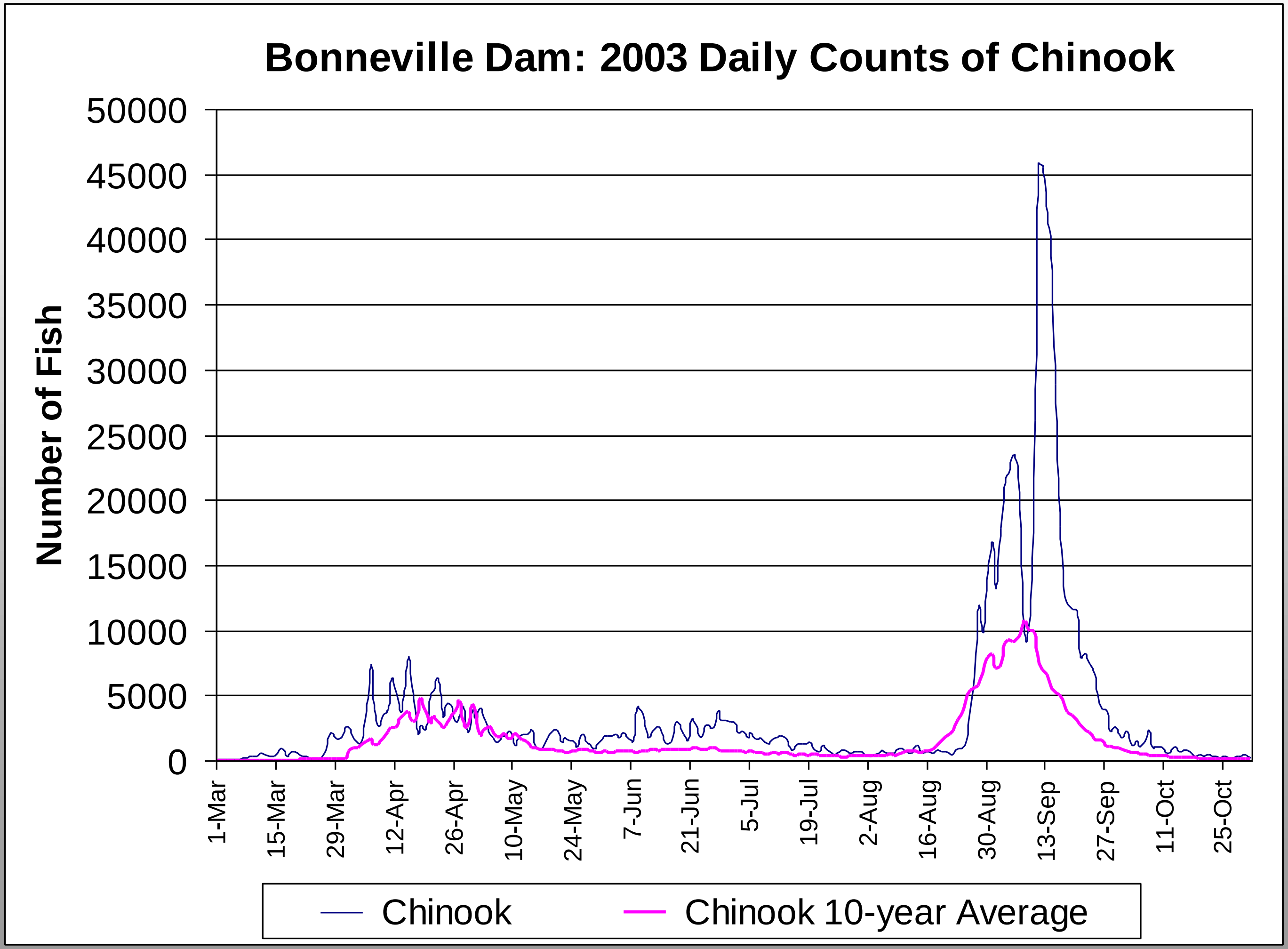
Data Source: US Army Corps of Engineers

Water Temperature: Columbia River Basin



Data Source: US Army Corps of Engineers; Graph by CRITFC

Water Temperature and Fish Passage



Note what happens when water temperatures cool down to 68 degF (next slide).

Water Temperature and Fish Passage

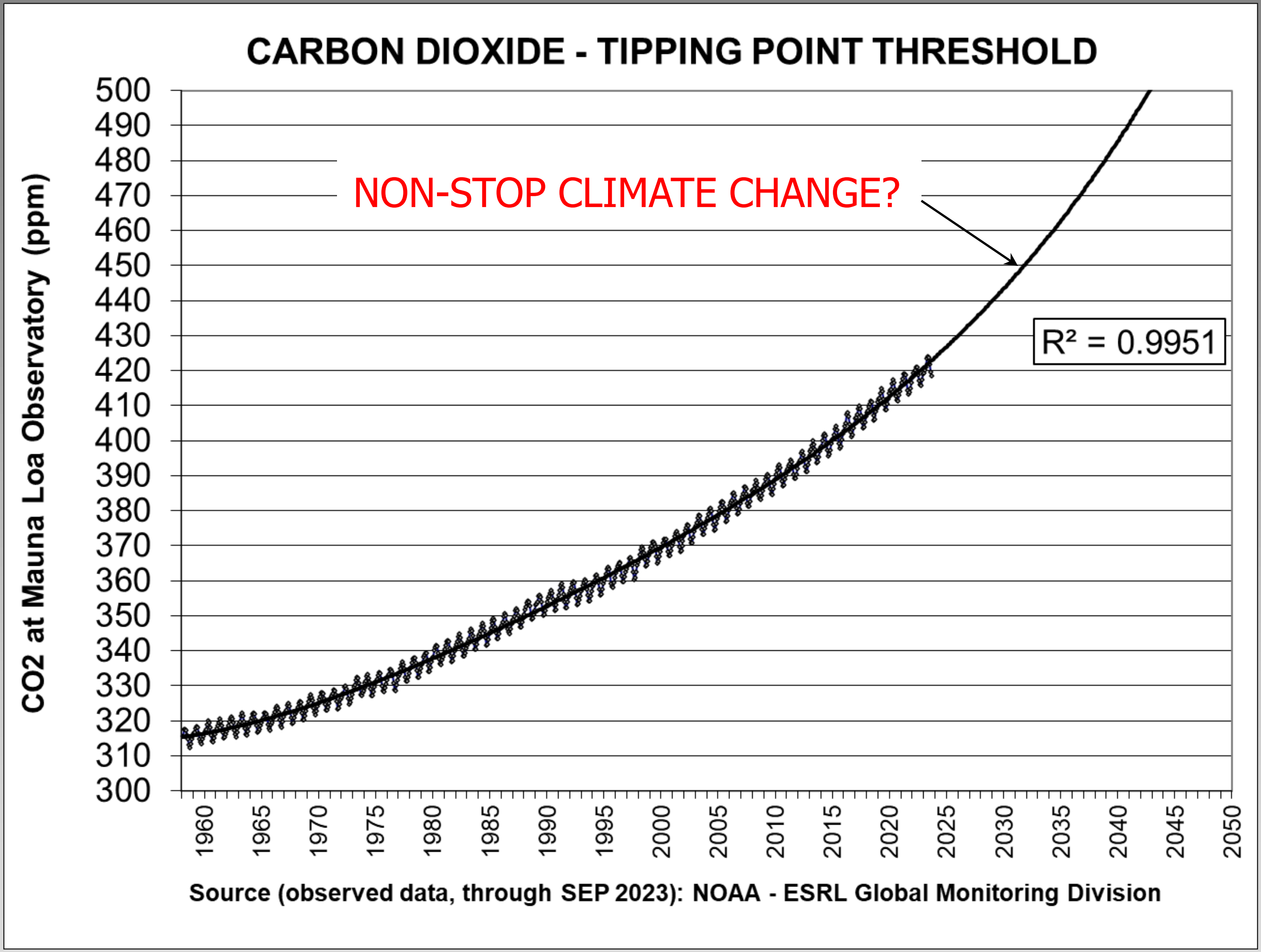
Traffic jam of salmon at the fish ladders of Bonneville Dam!!

THE CLIMATE THAT WILL BE…

Future PNW Impacts

- By 2070-2100: Temp.: +1 to +6 degC; Precipitation: -5% to +25%.
- *Fundamental shift* of hydro regime: Snow to Snow/Rain to Rain dominant.
- Loss of low level mountain snow (relative to 2000): April 1st: **-30%** by 2040.
- Increasingly highly variable (and harder to predict) spring and summer water supply. Water Quality is at *high risk*.
- Food security is at higher risk – species migration, shifts in weather, etc.
- Warming water temperatures will really stress the salmon. Will the Columbia River basin salmon retreat to cooler Canada BC and/or Alaska?
- Increased competition — salmon water vs. irrigation water vs. hydropower.
- Increase in Pacific Northwest coastal "Dead Zones." (http://www.latimes.com/news/nationworld/nation/la-na-deadzone2-2008may02,0,1285619.story)
- Extreme weather – major swings in hot/cold temperatures, rainfall, etc.
- Human health – more disease, air-borne pollutants, heat stroke.
- Could "climate refugees" move to the PNW and strain our land and water resources? Conflicts over PNW natural resources? Nexus of population growth and "climate refugees"? Great impacts to human health – the poor, elderly, and young children.

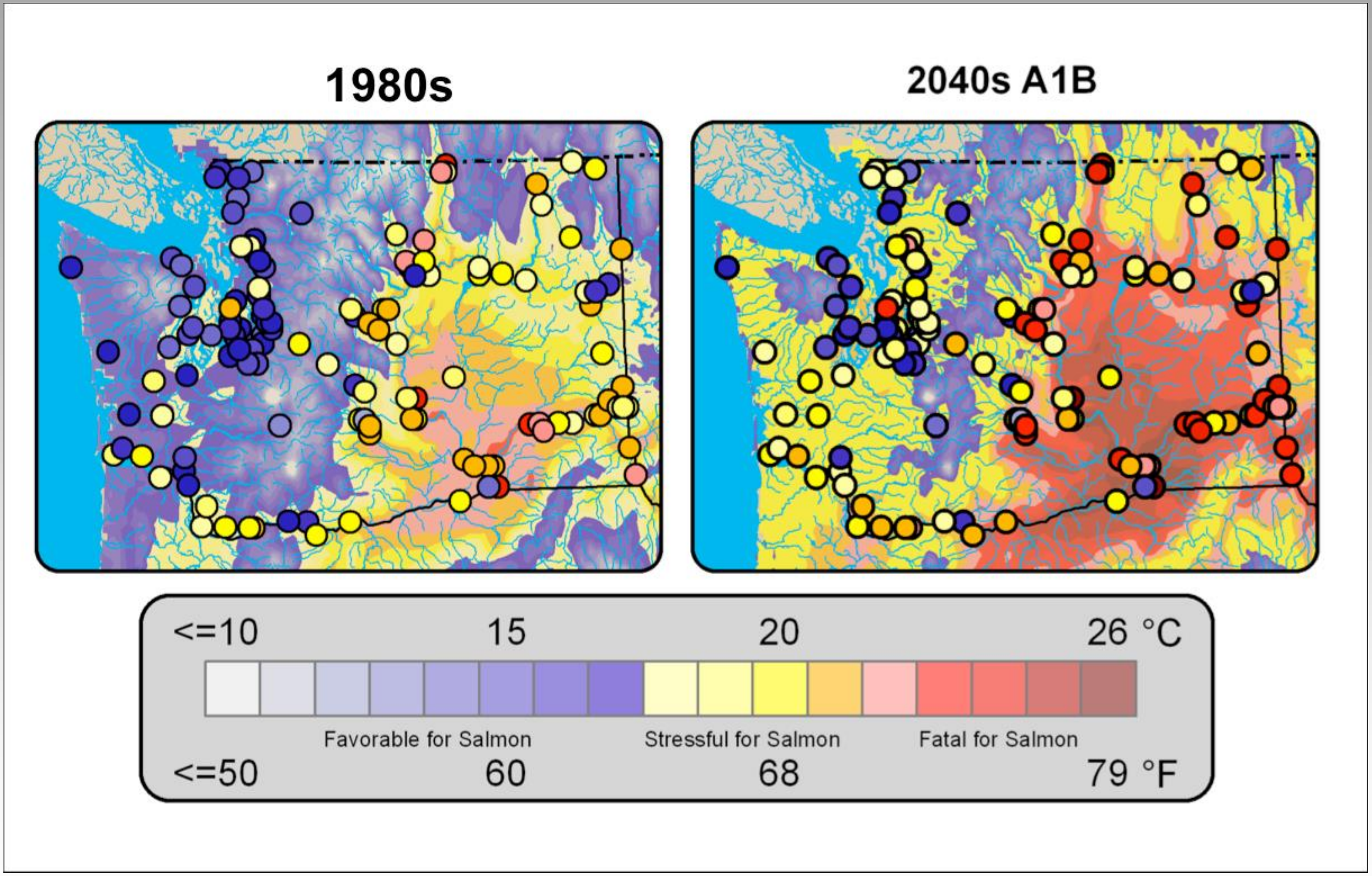
Countdown to CO2 Tipping Point?



Dr. James Hansen, NASA: https://pubs.giss.nasa.gov/abs/ha02210k.html

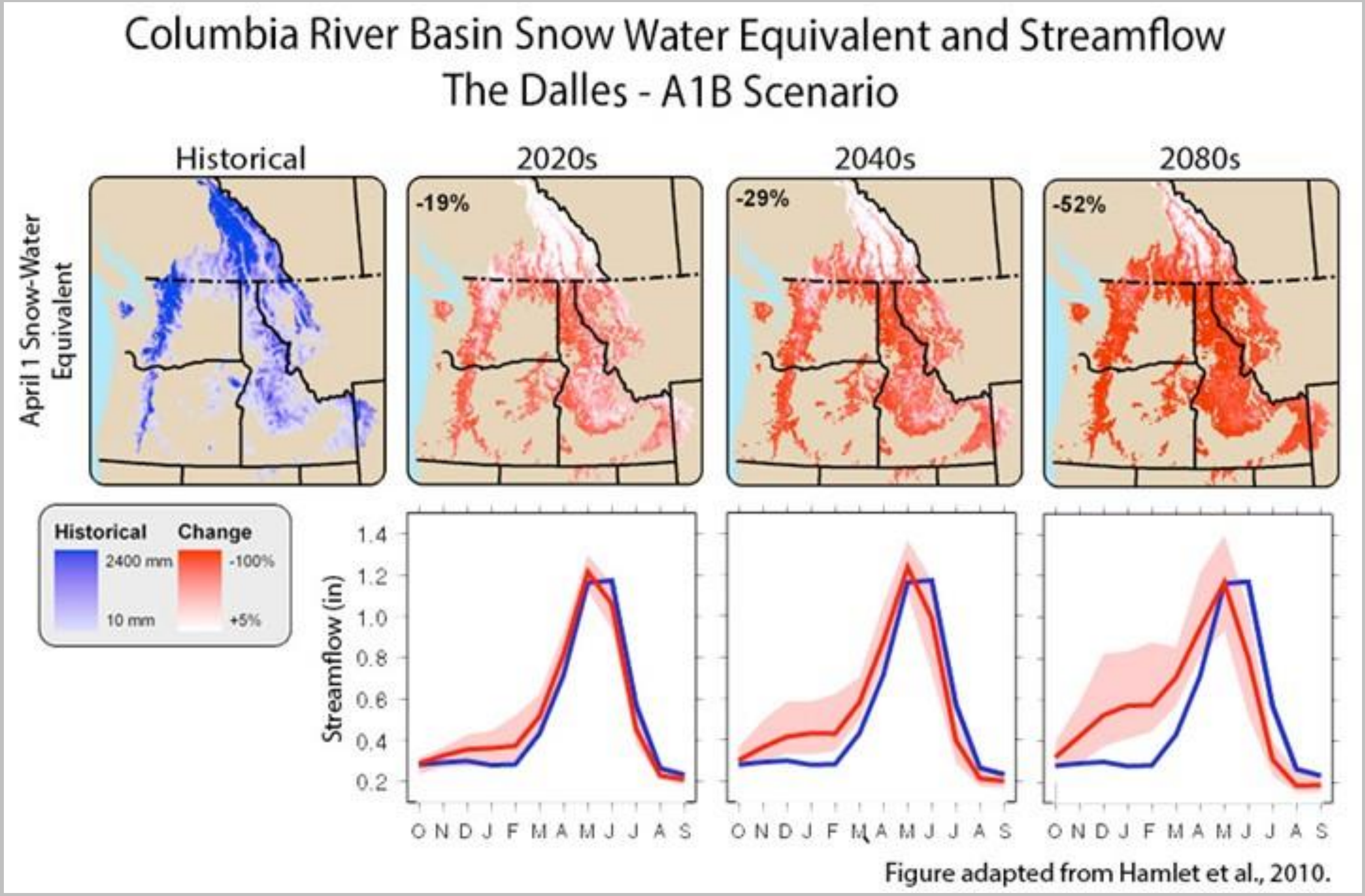
https://www.wired.com/2007/12/nasas-james-han/

Future PNW Climate



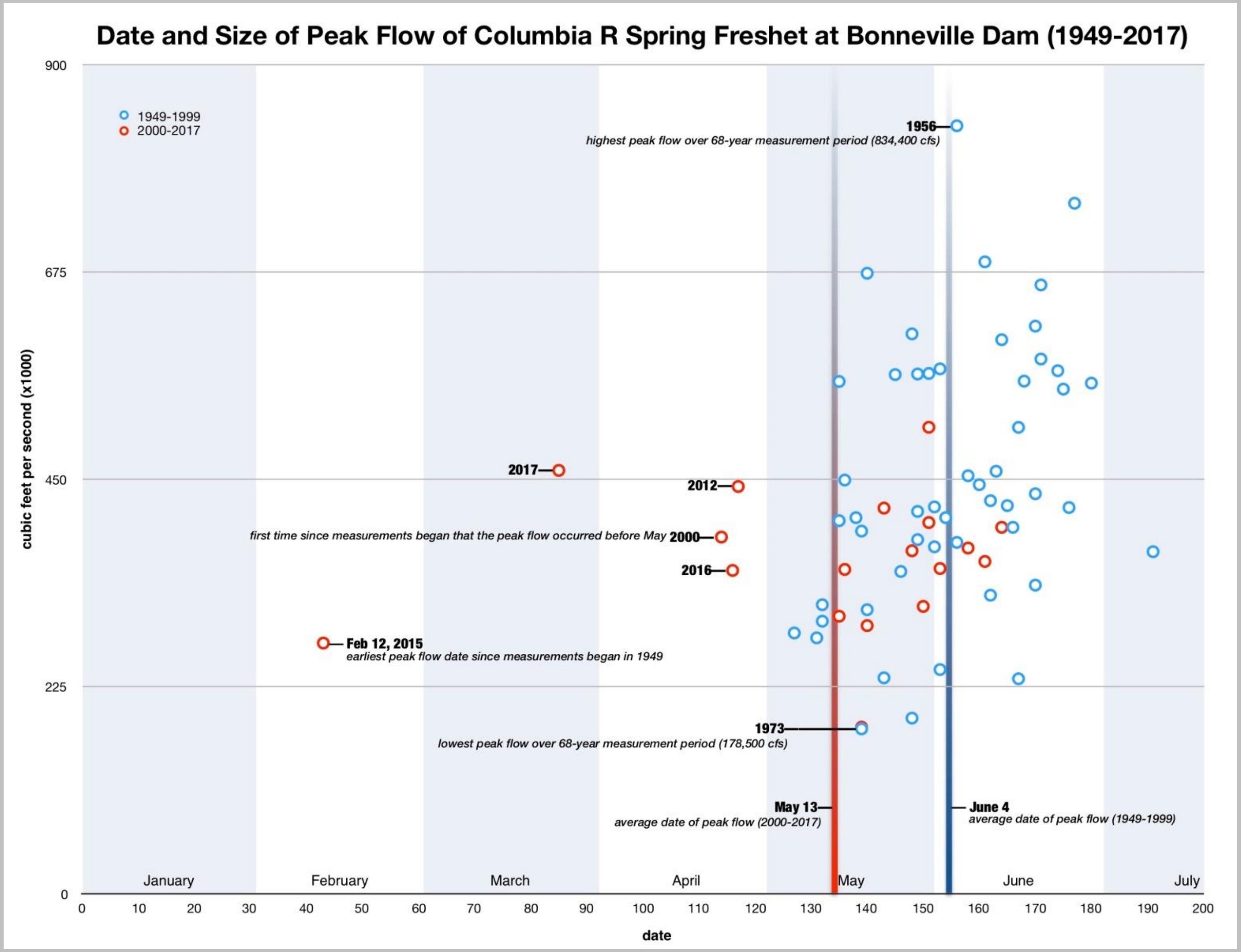
Source: Mantua et.al. (2010)
(http://cses.washington.edu/cig/res/ae/aekeyfindings.shtml)

Future PNW River Timing



Data source: 2014 UW- PNW Climate Science Conference (https://slideplayer.com/slide/5277540)

PNW River Timing - NOW

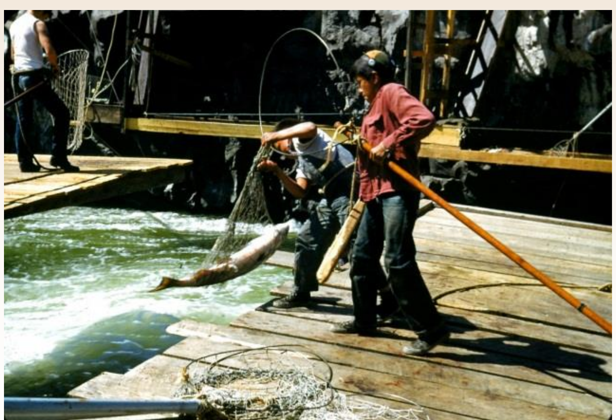


Data source: UW-DART (www.cbr.washington.edu/dart/query/river_graph_text), U.S. Army Corps of Engineers

WHY IT MATTERS…

Tribes…Salmon…Climate Change

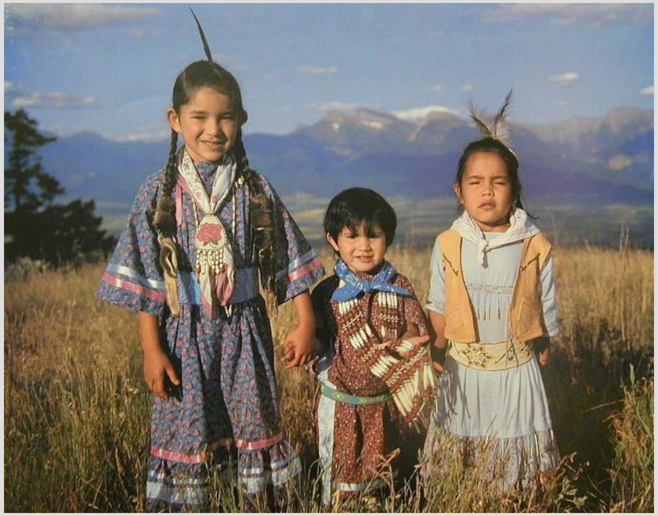
- Traditional tribal diets were *highly rich* in salmon. ☺
- PNW tribal populations were in sharp decline for over 100 years. Now they are rebounding – hence their need for more traditional foods...especially for their growing youth population.
- Shifting water resources will be difficult for many tribal communities, given their current water-use infrastructure.
- Salmon were/are a *major* part of PNW tribal religion and culture.



What Can be Done?

- More **Flexibility** and **Adaptability** built in our ecosystems <u>and</u> economies. Prepare society for increased weather variability and extremes.
- Reduce greenhouse gas emissions. Use more "green" energy (wind, solar) and less oil. **Absorb excess** greenhouse gas emissions from atmosphere.
- Promote natural water storage via Watershed, Riparian, Floodplain restoration. <u>Small</u> ponds absorb 20-50% more CO_2 than trees alone (www.agu.org/pubs/crossref/2008/2006GB002854.shtml)
- **Reforestation**…Economic incentive - carbon sequestration credits ("cap & trade"). (www.azcentral.com/arizonarepublic/local/articles/1207tribal-climate1207.html),(www.tribalclimate.org)
- "Carbon Sequestration" using Ultramafic (i.e., special volcanic) rocks (http://pubs.usgs.gov/ds/414) <u>and</u> Methane sequestration (*new idea*).
- Improve Columbia basin Water Forecasting to help Federal hydro operations: ENSO condition and flood control. Use alternative hydro operations - for earlier refill, enhance natural river flow.
- Maintain climate reporting stations ("coop" sites). <u>Restore</u> closed stations.
- Very bad climate change scenarios may <u>not</u> be inevitable. Don't panic!

Protect our Future…



What are your questions?

(Thank you very much for your time!)

Thank you to: David Graves, CRITFC's GIS Specialist, and Laura Gephart, Watershed Programs Coordinator. Research is partly supported by a 2009 EPA Indian Environmental General Assistance Program Grant and 2009 NOAA-PCSRP Watershed-Climate Change Grant.