Stream Temperature Science, WQ Temperature Standard & TMDLs, and Riparian Management in Forestlands

Informational Item: Environmental Quality Commission Meeting
June 19, 2014

Gene Foster & Josh Seeds: DEQ
Bruce McIntosh & Dave Jepsen: ODFW

Presentation Purpose

- Summary of the factors affecting stream temperatures in Oregon
- The importance of stream temperature for aquatic biota
- The rationale for minimizing anthropogenic warming and restoring and protecting natural thermal regime approach used in the temperature standard (including the Protecting Cold Water Criteria)
- Explain how TMDLs are used as a tool to protect aquatic species & restore natural thermal regimes
- Provide information on the connection between temperature standards & forest practices in Oregon & neighboring states.

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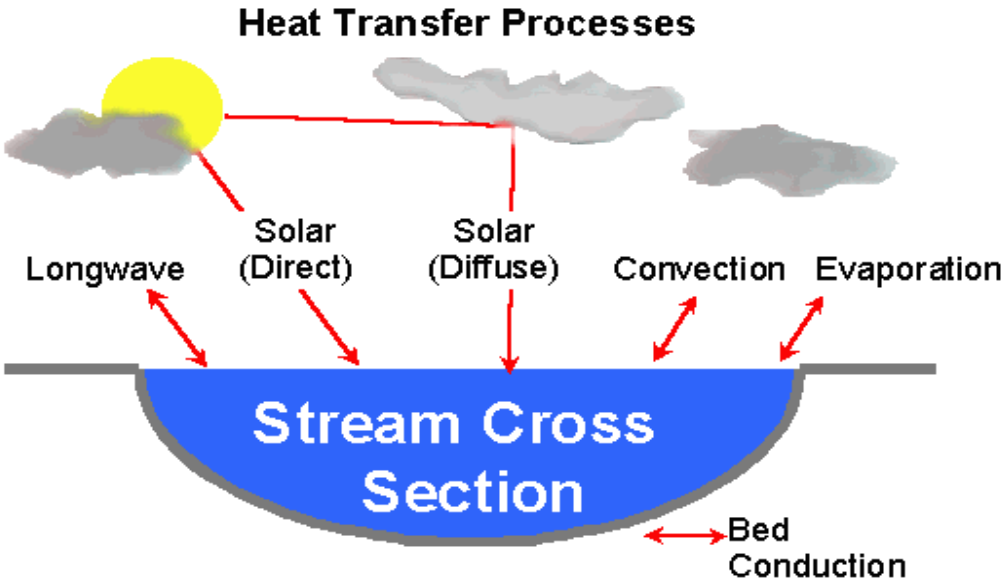
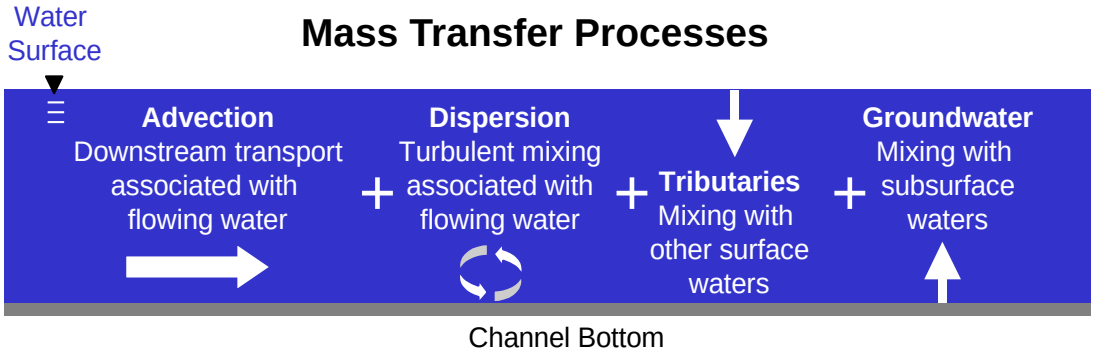
Basics of Stream Temperature

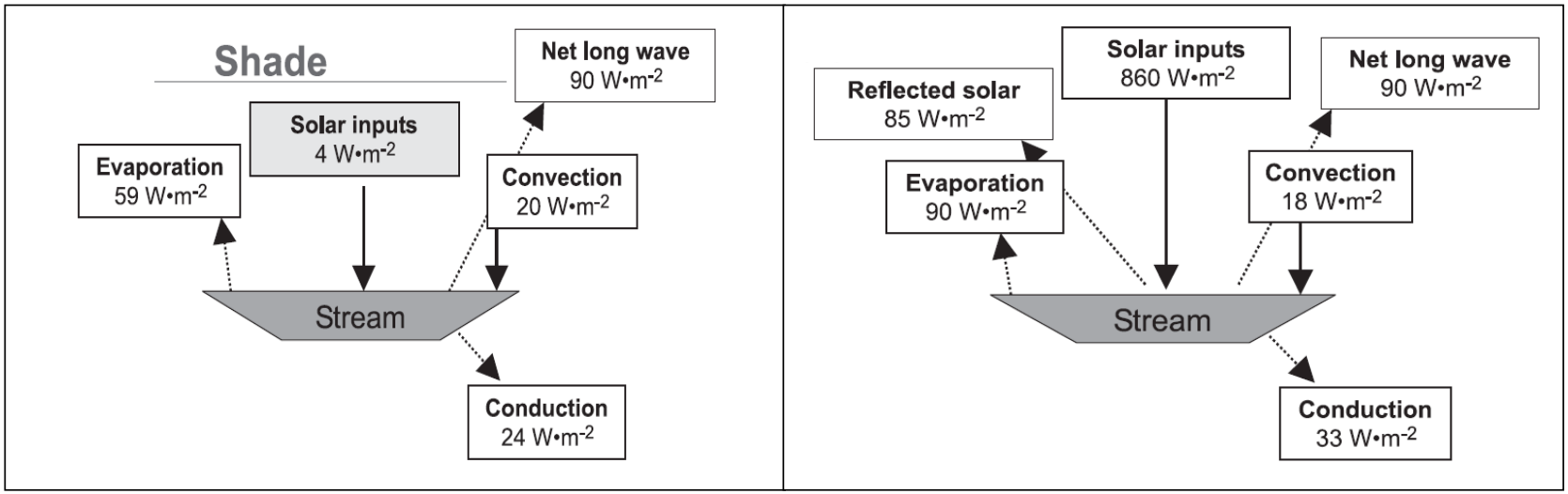
Stream temperatures within watersheds are affected by:

- Heat transfer
- Mass transfer





Basics of Stream Temperature



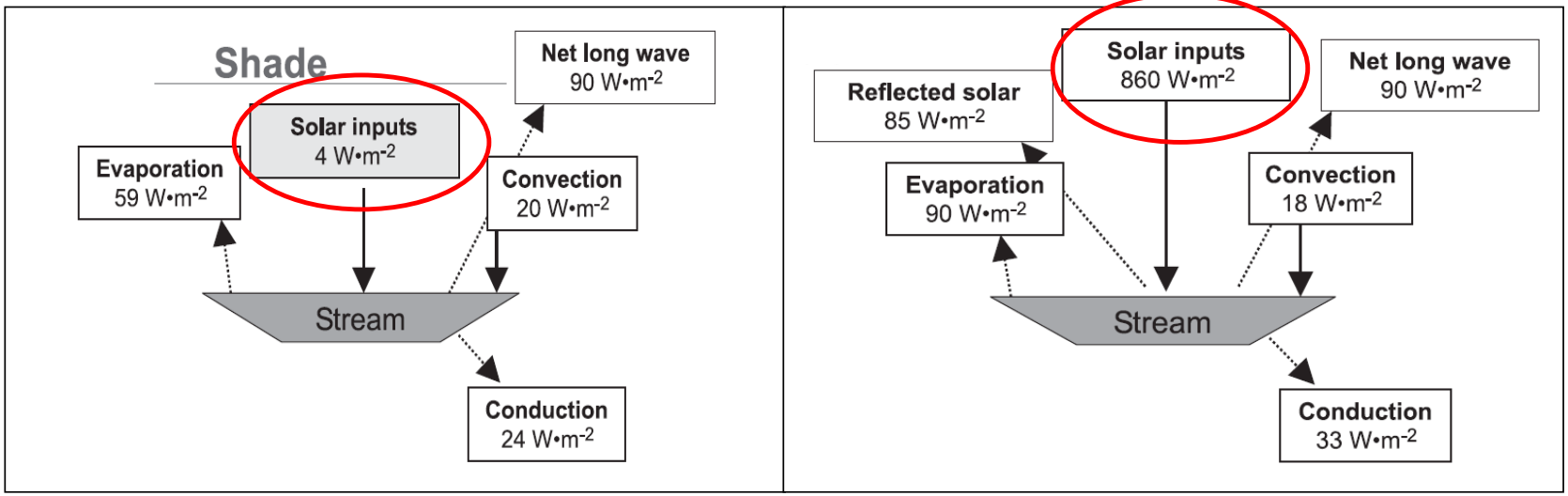
<u>Fully shaded:</u>
Thermal energy lost is -149 W*m^{-2}.

<u>Unshaded:</u>
Thermal energy gained is 580 W*m^{-2}.

- Solar energy drives temperature on smaller streams.
- Streams more easily absorb thermal energy from sunlight than lose it once absorbed.
- Dilution of thermal energy is not the same as dissipation.

Johnson 2004

Basics of Stream Temperature



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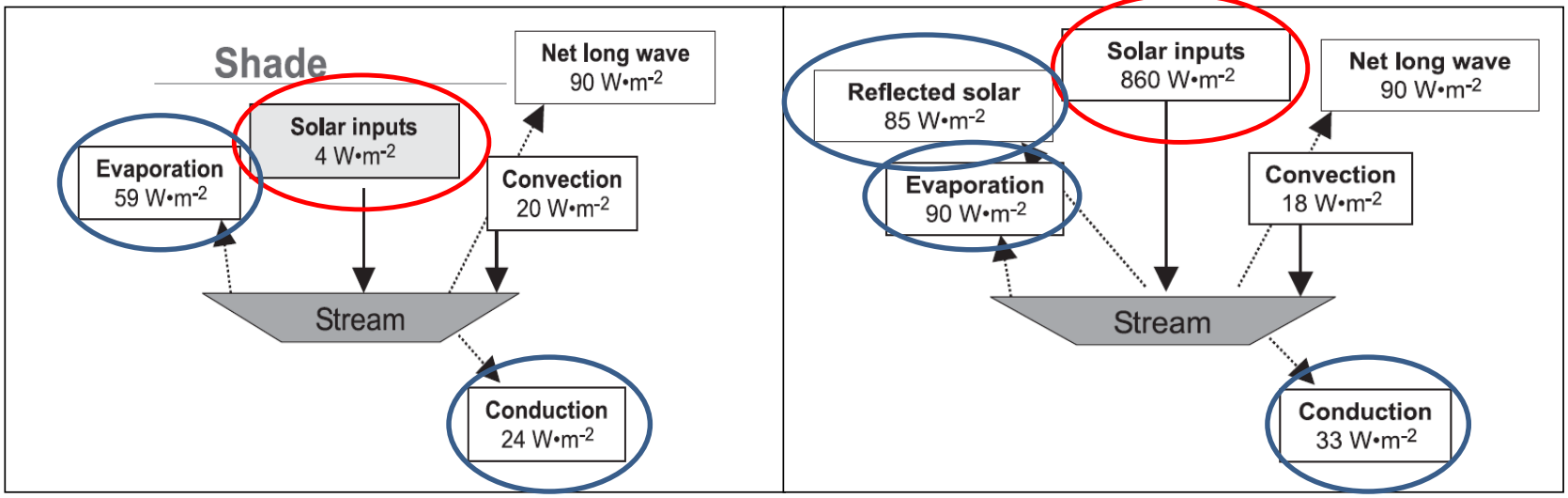

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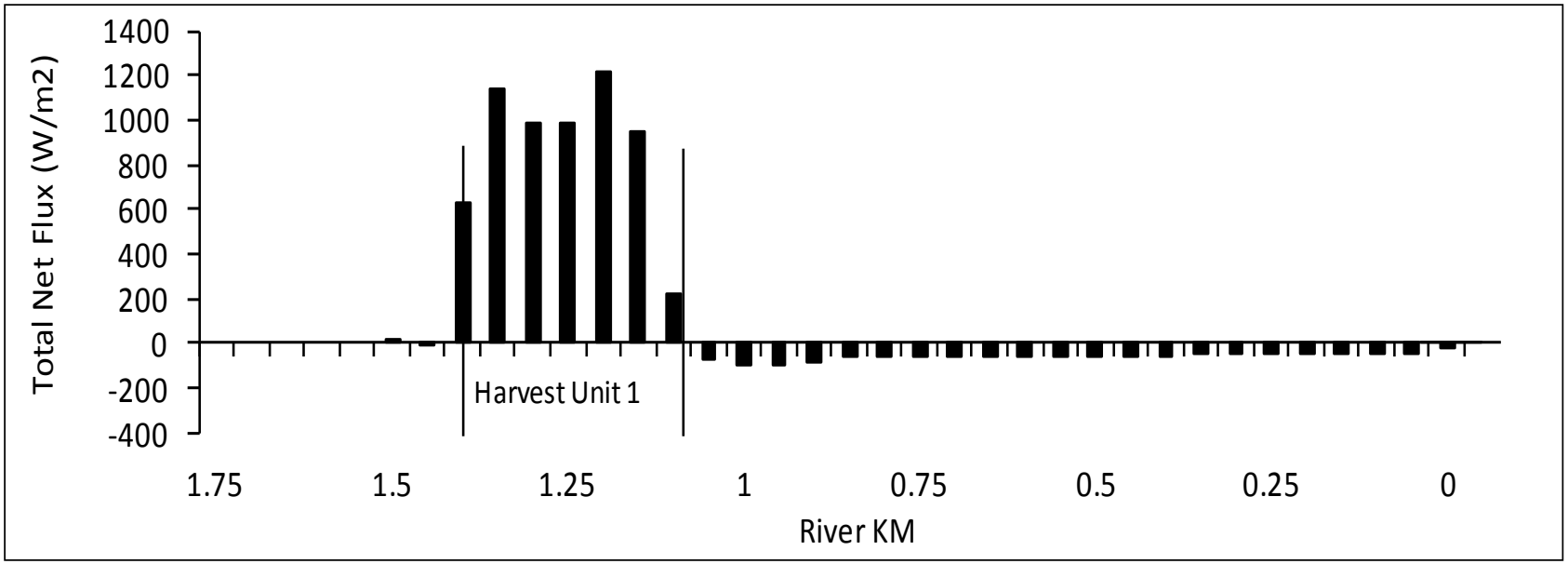
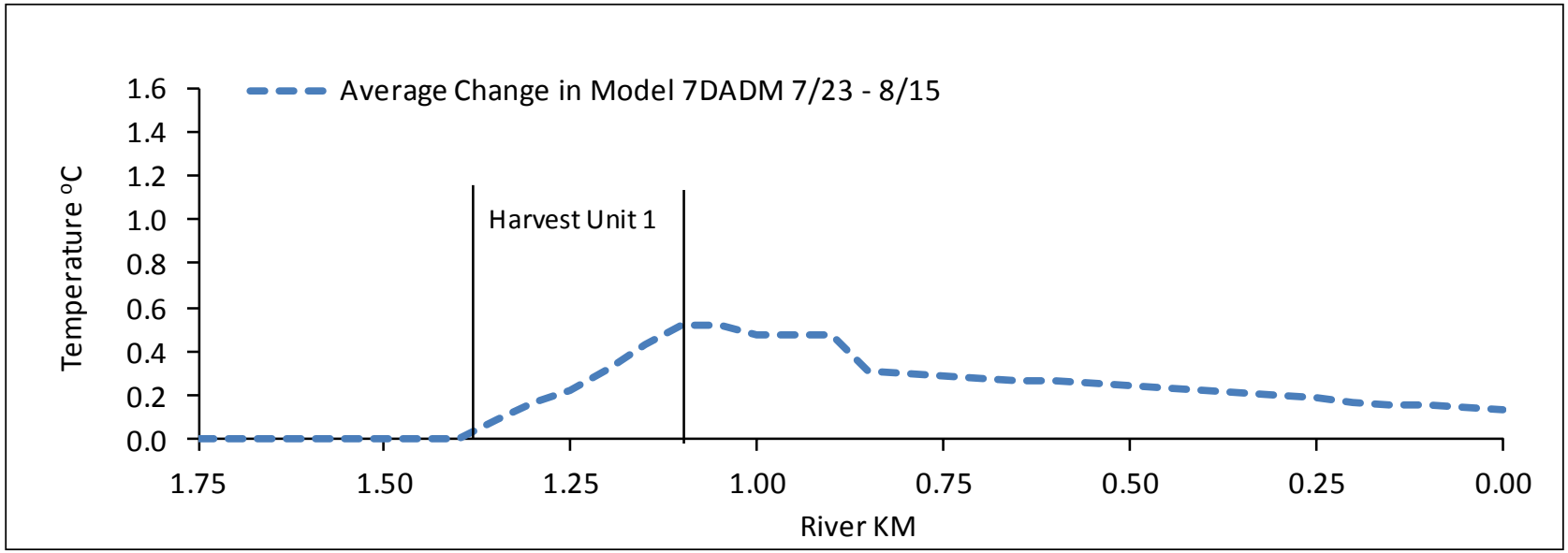
Johnson 2004

Harvest Effect on Net Energy Flux in Drift Creek Tributary



- Gain by solar radiation is greater than loss by other fluxes (evaporation, longwave radiation, etc).

Harvest Effect on Stream Temperature in Drift Creek Tributary



- Since gain is more efficient than loss, thermal energy can be transported downstream.

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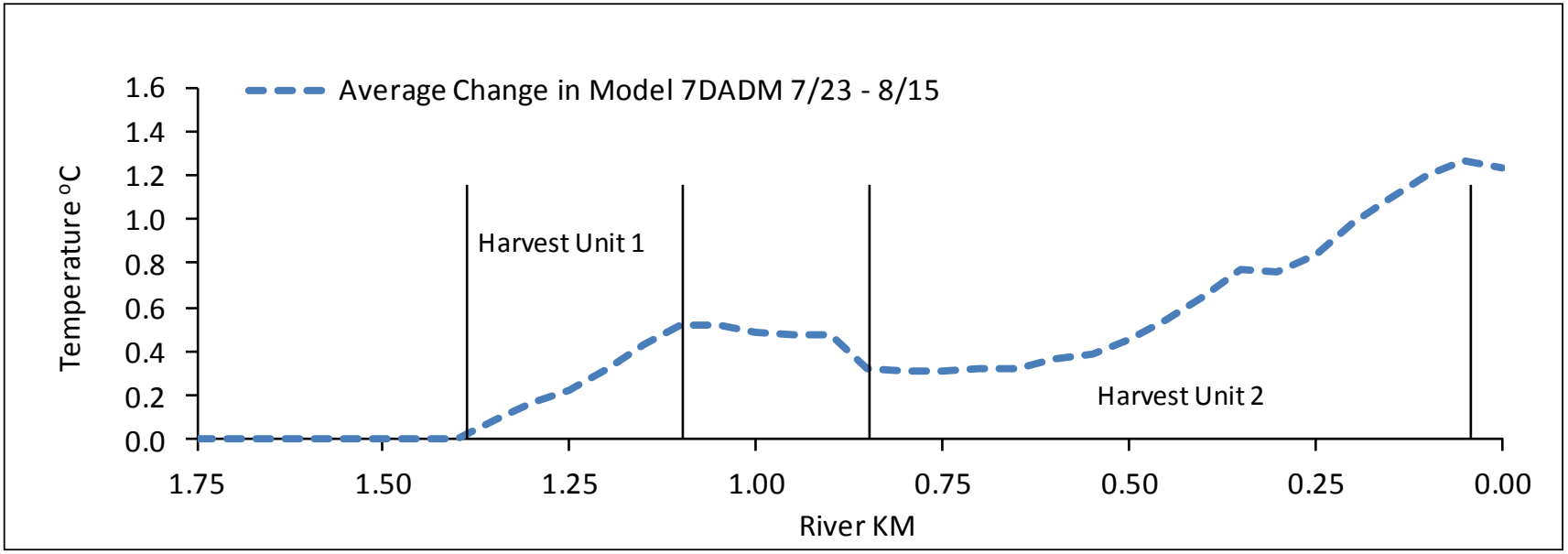
Multiple Harvest Effect on Cumulative Warming in Drift Creek Tributary



Disturbance on the Landscape

- Riparian disturbances reduce shade & increase stream temperature.
- About 10 years needed for thermal recovery after disturbance.
- Current disturbance regime is different than pre-settlement disturbance regime.
    - Harvest activities occur at a higher rate than natural disturbances.
    - Harvest rotations are substantially shorter than fire return intervals.
    - Important differences between natural disturbances & human disturbances.

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Landscape Disturbance Patterns

Middle Siletz River Watershed

- Chronic Disturbance
- Not Disturbed (since 1985)
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
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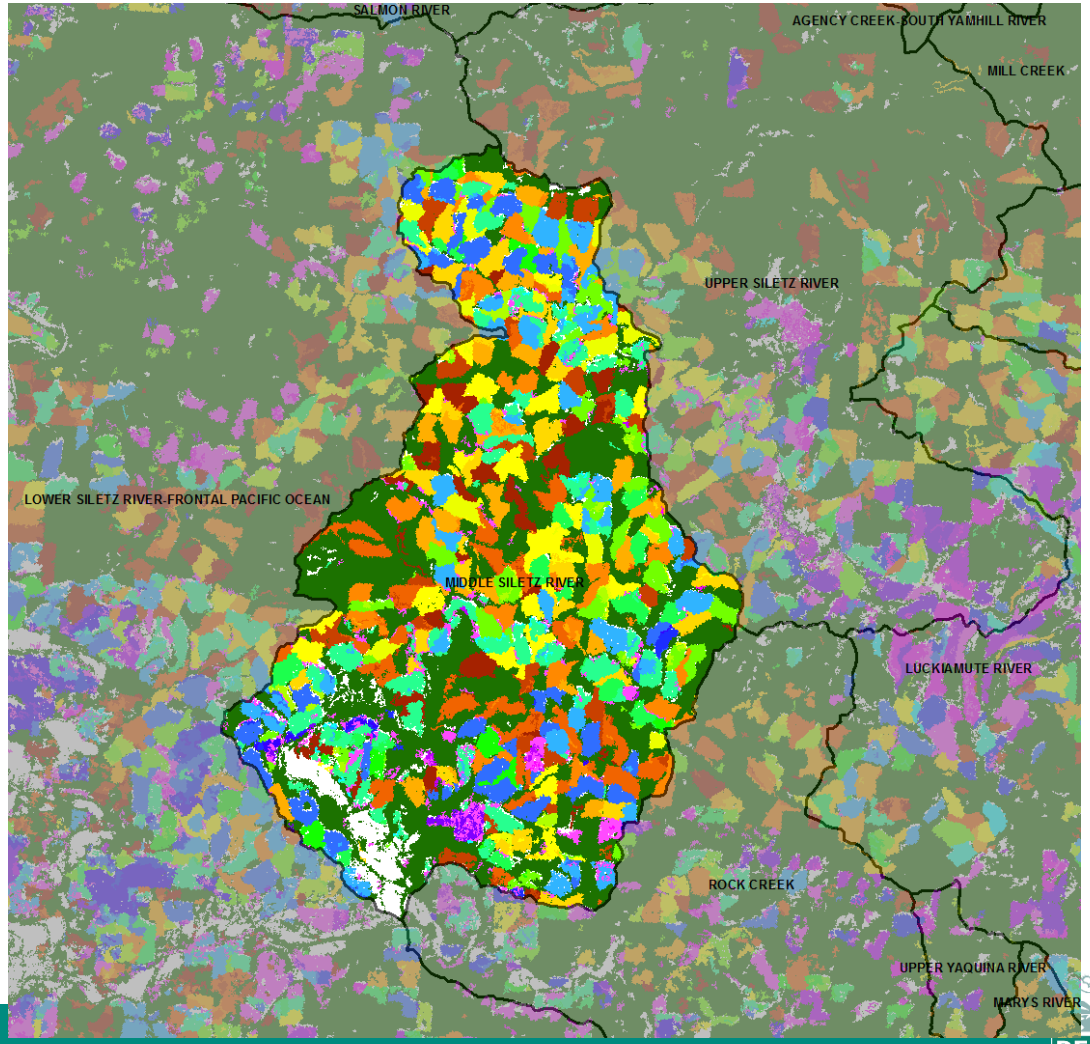
- 2007
- 2008
- 2009



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Landscape Disturbance Patterns

Drift Creek Watershed

- Chronic Disturbance
- Not Disturbed (since 1985)
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
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- 2006
- 2007
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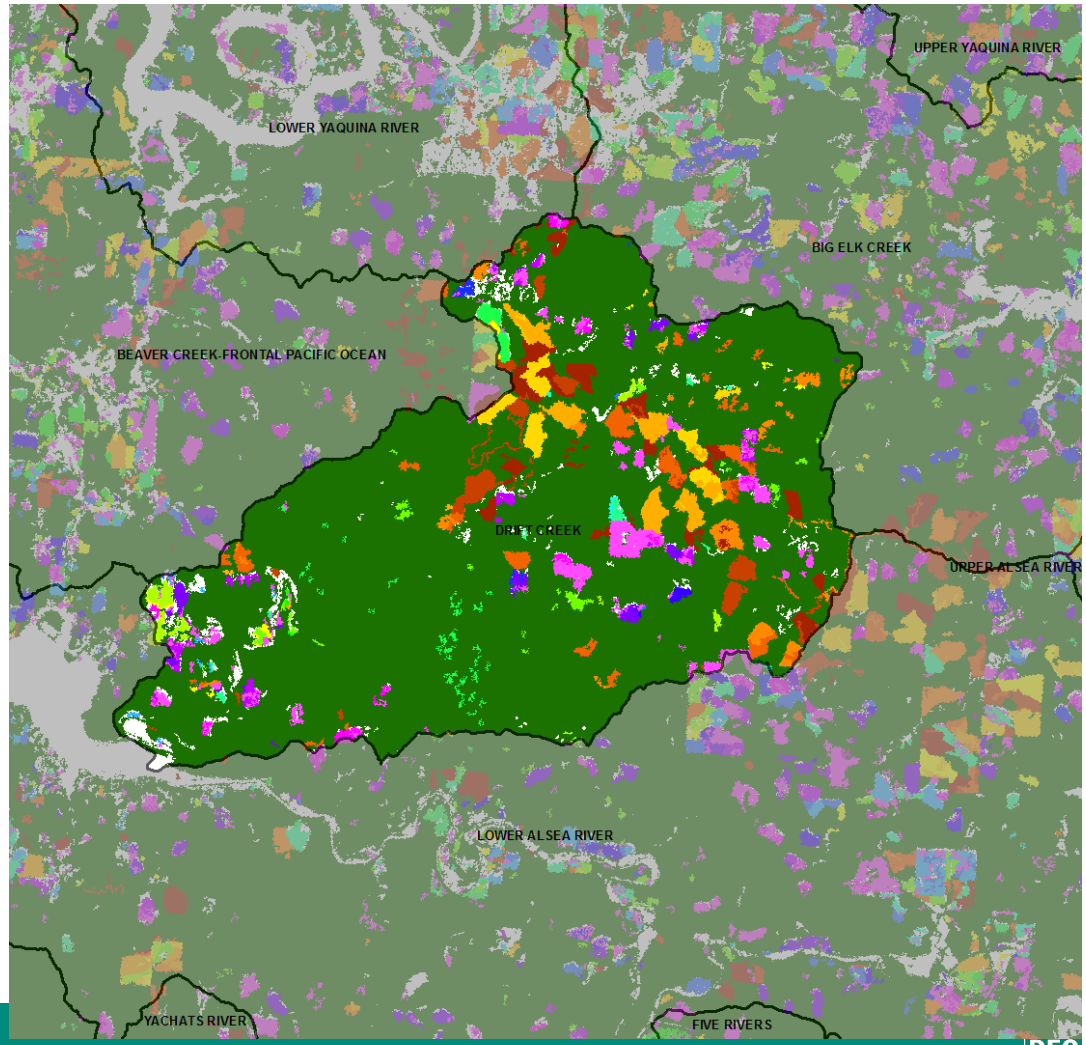
- 2009



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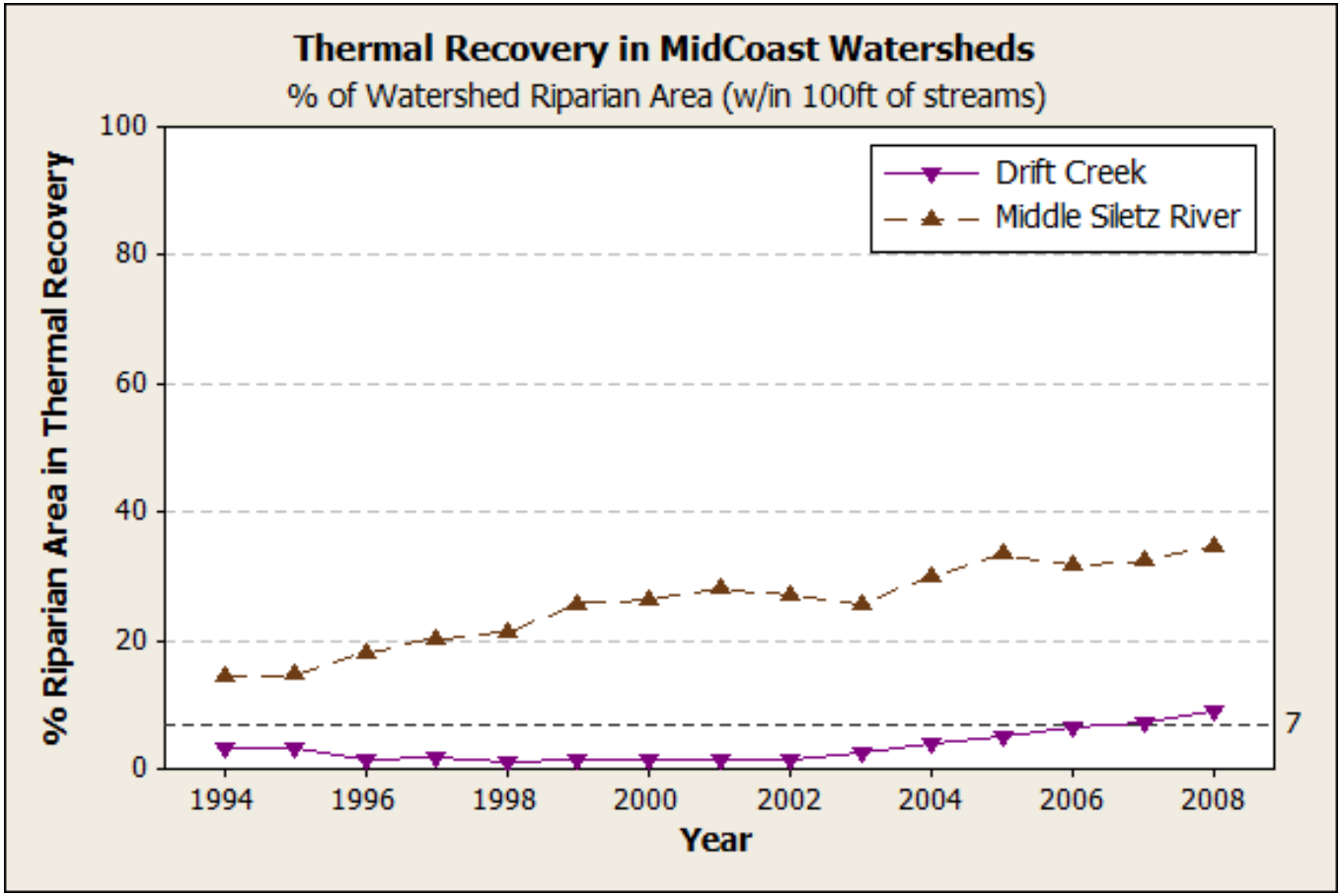
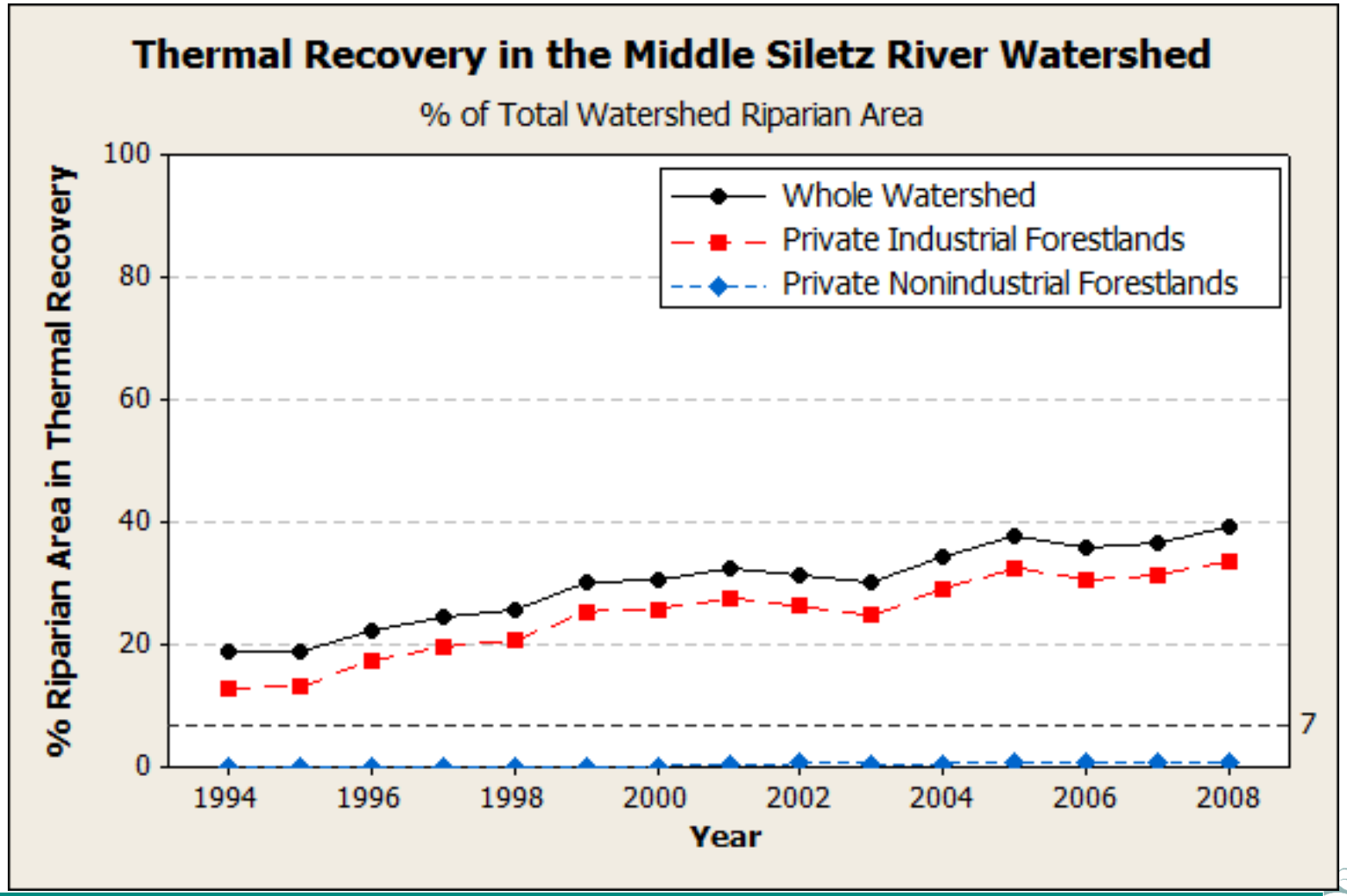
Riparian Area Disturbance

Middle Siletz River & Drift Creek

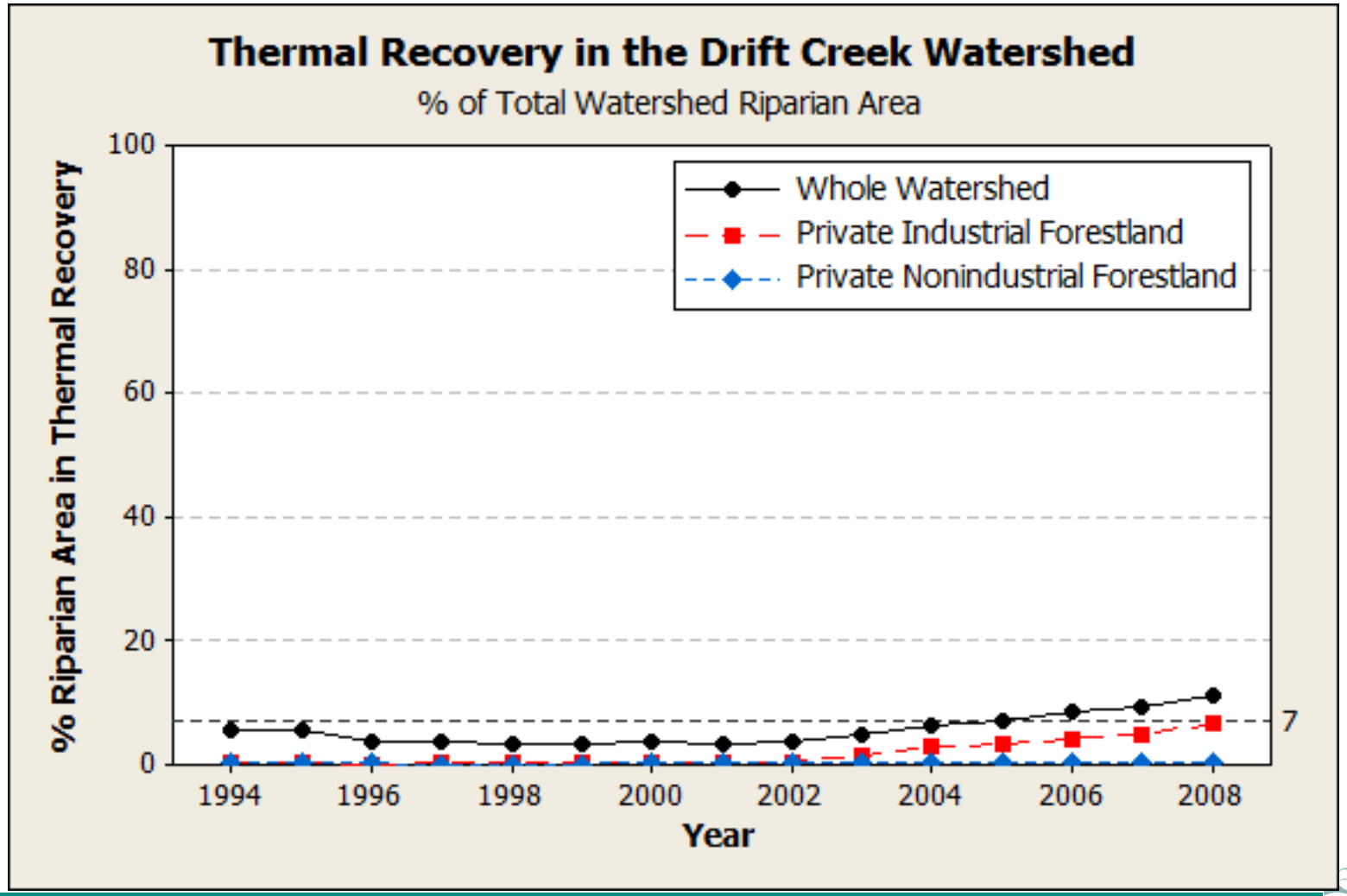


Riparian Area Disturbance by Land Use:

Middle Siletz River Watershed



Riparian Area Disturbance by Land Use:
Drift Creek Watershed



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Summary: Downstream Transport of Temperature & Watershed Disturbance Patterns

- Thermal loads can be transported downstream
- Riparian disturbances that reduce shade can increase thermal load to a waterbody
- Multiple riparian disturbances can cause a cumulative increase in temperature downstream
- There are multiple riparian disturbances in watersheds that can cause cumulative increases in temperature

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Stream Temperature & Aquatic Life

- Stream temperature influences the rate of ecological & physiological processes.
- Natural thermal regimes provide the best environmental conditions for native aquatic life.
- Temperature effects typically occur on a continuum, but are not linear. Increases above natural thermal potential:
  - Increase physiological risk to fish,
  - Increase extinction risk to salmonid populations, particularly when accrued across the landscape.
- Thermal diversity is necessary at multiple scales.

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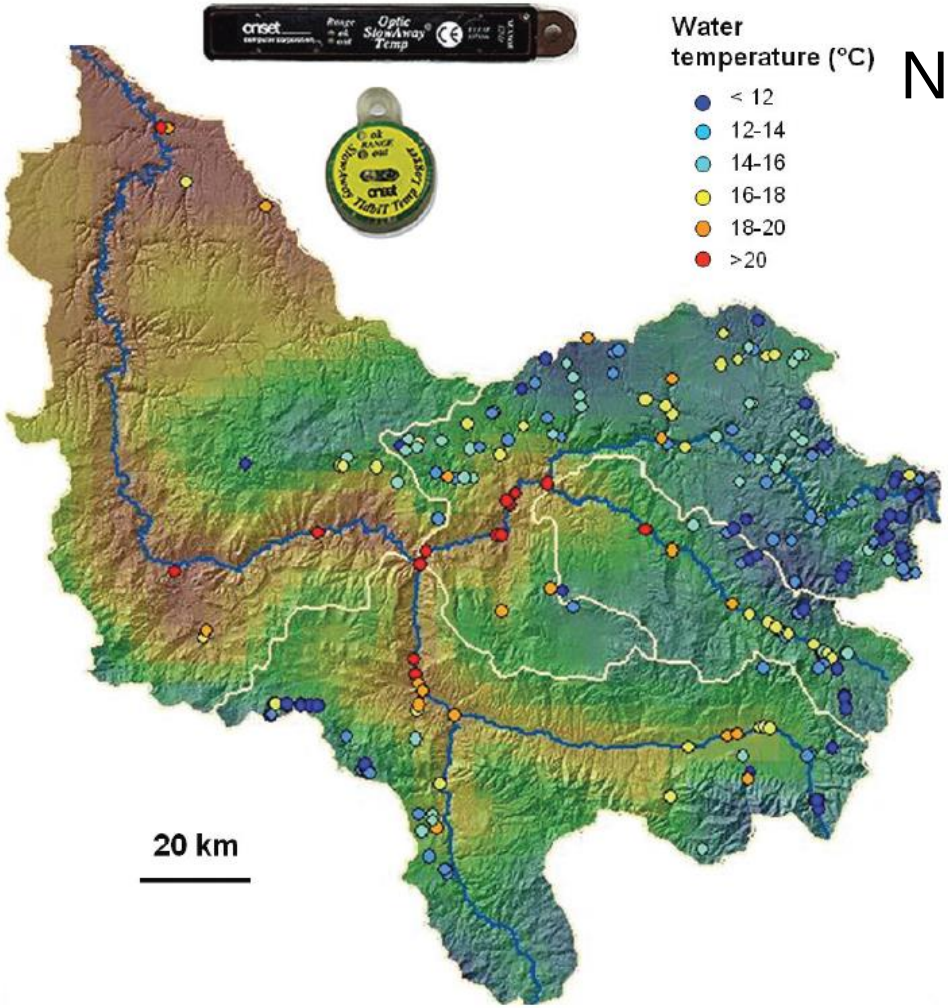
Natural Thermal Regimes



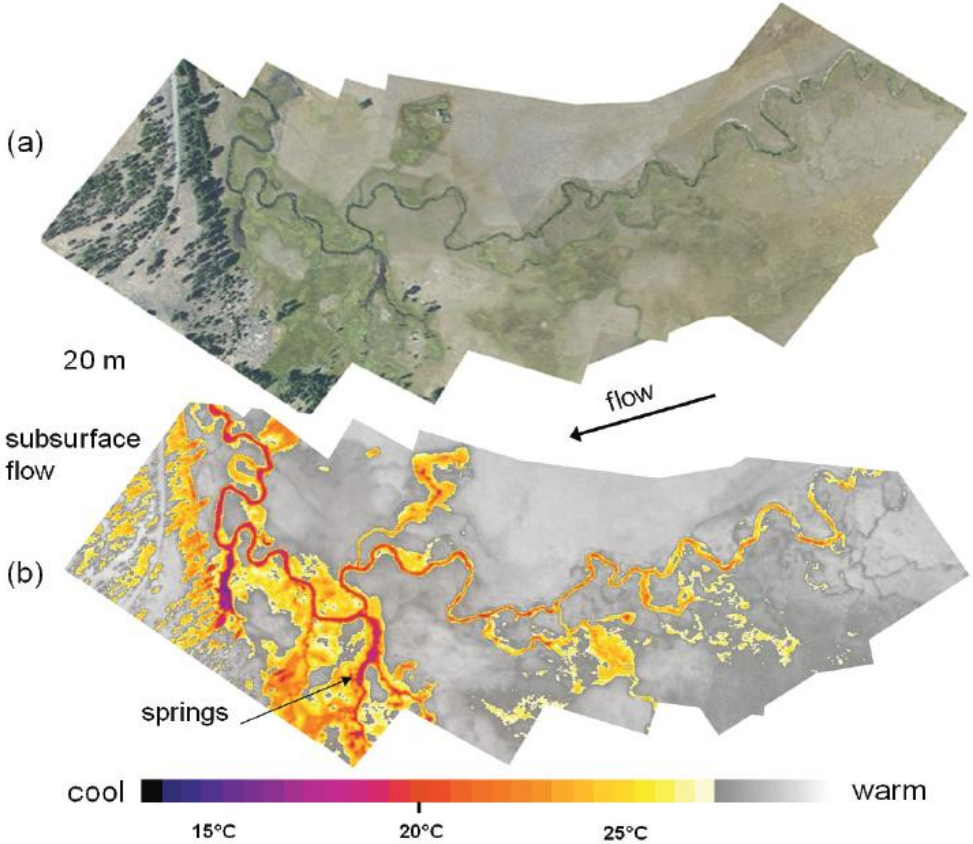
Natural thermal regimes are part of habitat complexity.

- Stream temperature is naturally variable.
- Landscape alteration changes the behavior of stream temperature.
- Fish life histories are linked to seasonal variability, promoting locally adapted populations.

Torgersen et al 2012

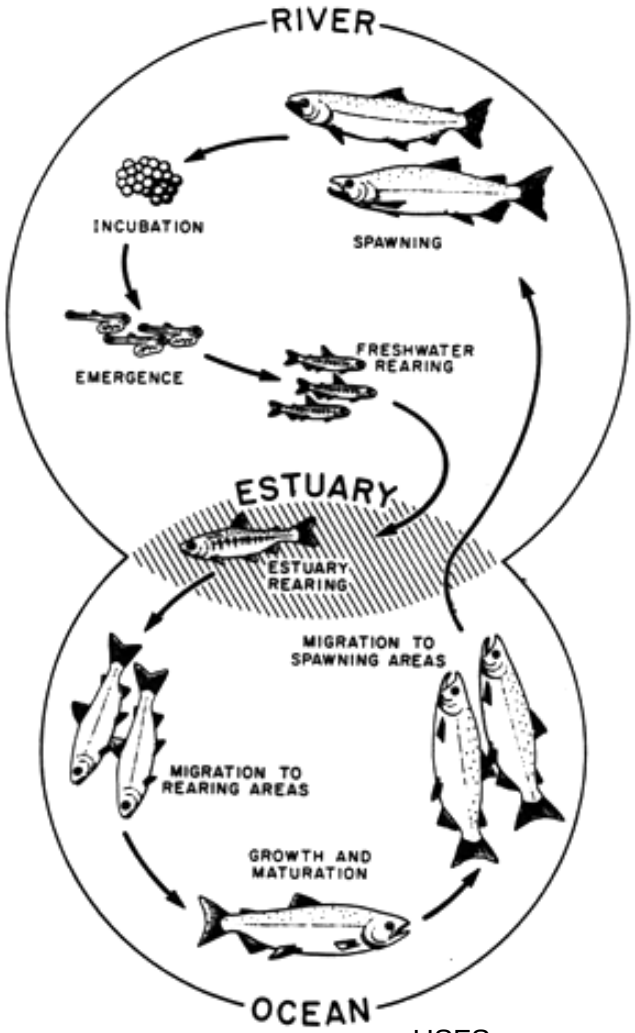
Loss of Stream Temperature Diversity
(including cold water)

- Reduces life history expression, local adaptation, & variation among populations.
- Reduces diversity in fish populations.
- Therefore, reduces population & meta-population resilience.



Torgersen et al 2012

Thermal Diversity & Biological Productivity



USFS

- Population productivity in freshwater is linked to temperature variability including colder waters.
  - Determines metabolic rates of fish & other aquatic ectotherms.
  - Fish exploit thermal variability to avoid heat stress & to meet metabolic & reproductive needs.
  - Coho exploiting thermal heterogeneity grow faster than individuals with other behaviors.

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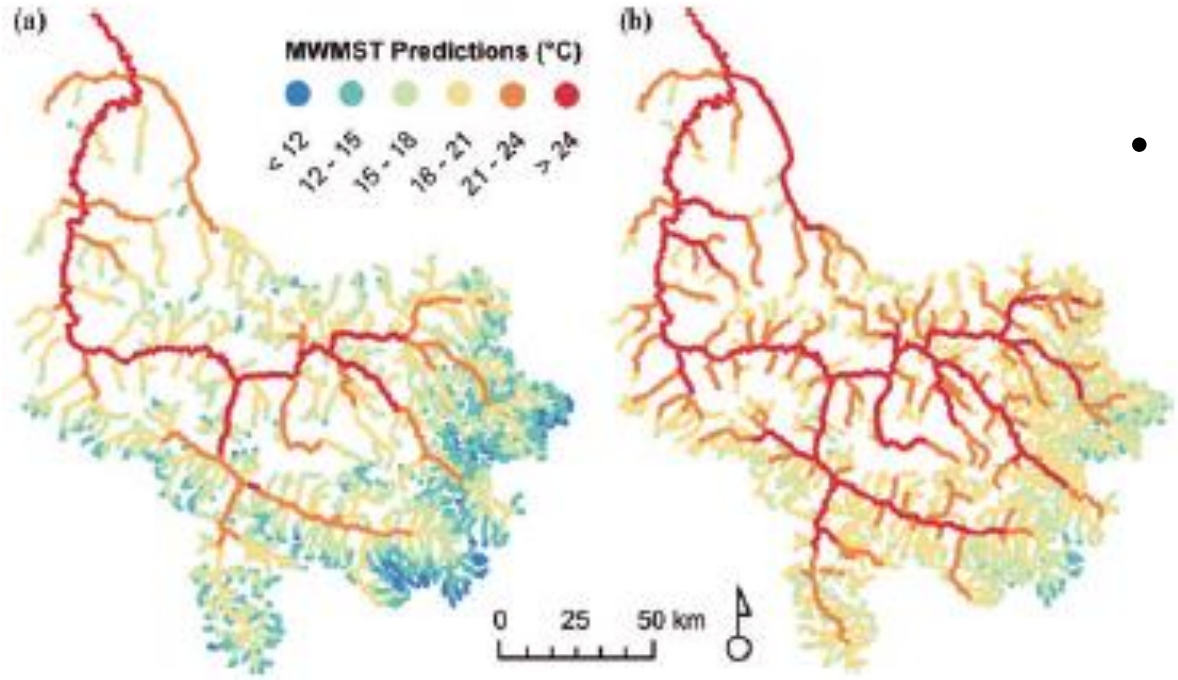
Temporal & Spatial Refuges

- A network of thermal refuges allows greater use of the overall stream network.
- Species with colder thermal requirements (e.g. bull trout) are confined to cold-water refuges.



- With climate change, current cold waters <u>will be</u> the future thermal refuges.

Ruesch et al 2012

Relevant Oregon Water Quality Standards for Managing Temperature

- Temperature Standard:

  Minimize anthropogenic warming;

  Maintain & restore natural thermal regimes across landscape for all aquatic species.

  - Biologically-Based Numeric Criteria
  - Protecting Cold Water criterion
  - Human Use Allowance
- Antidegradation Policy
- Designated Uses

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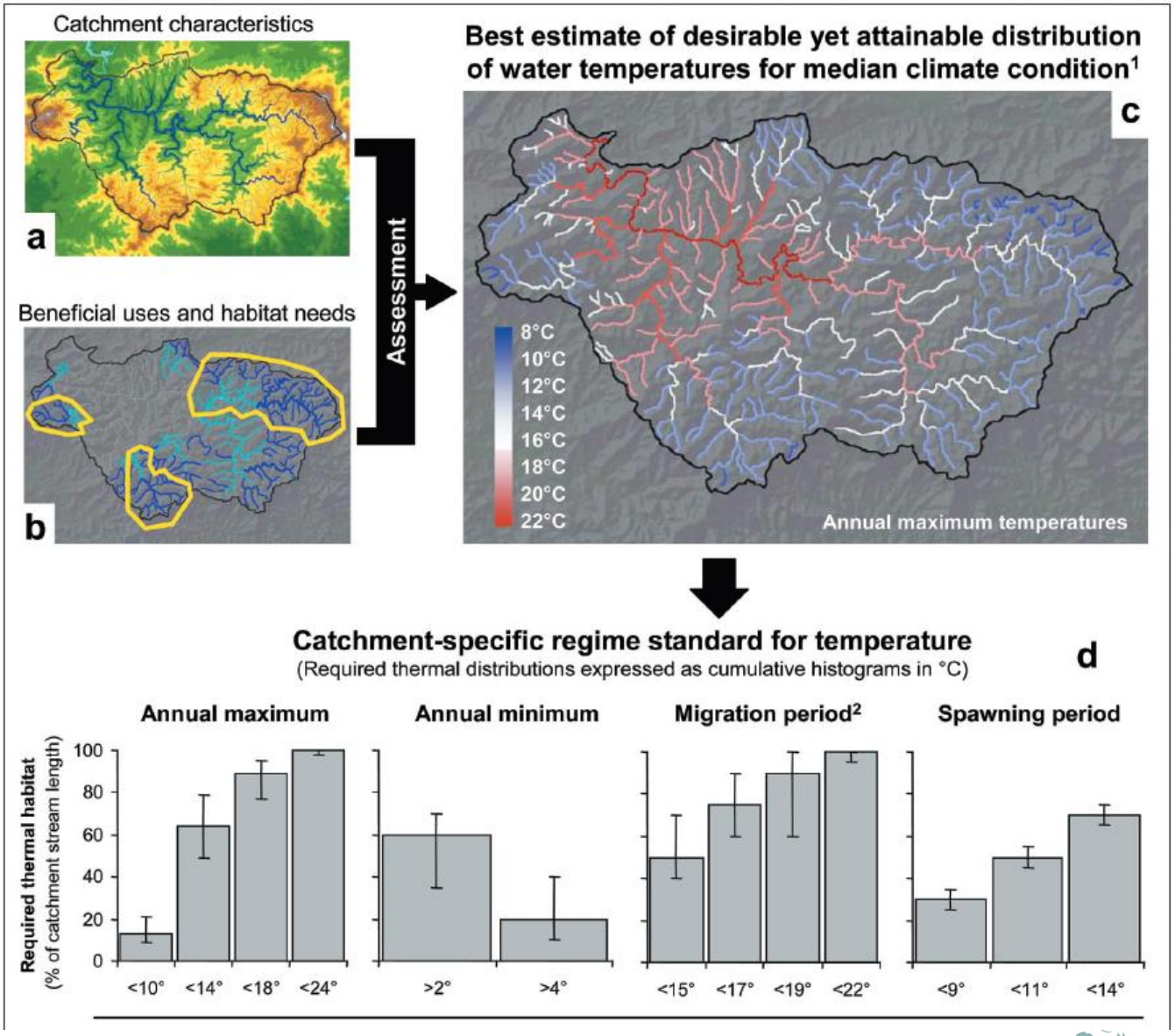
Protecting Cold Water Criterion

- Protects the natural thermal regime in waters colder than the numeric criteria.



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Temperature
Total Maximum Daily Loads

- TMDLs are a regulatory tool under the Clean Water Act to protect aquatic species & restore natural thermal regimes.
  - Human Use Allowance: 0.3°C for all human sources of thermal loading.
  - Human sources are given portions of the HUA as wasteload allocations (point sources) or load allocations (nonpoint sources).

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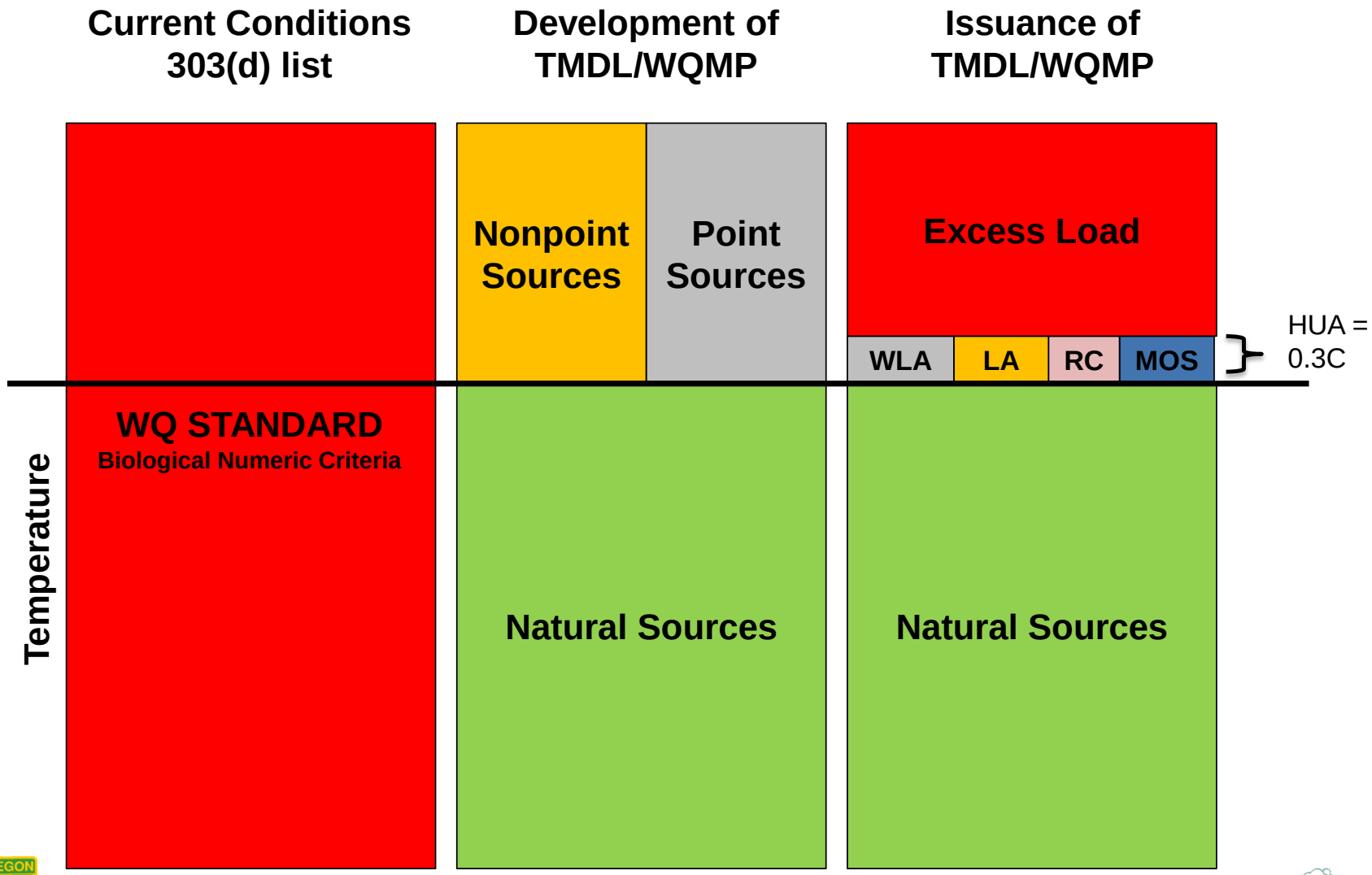
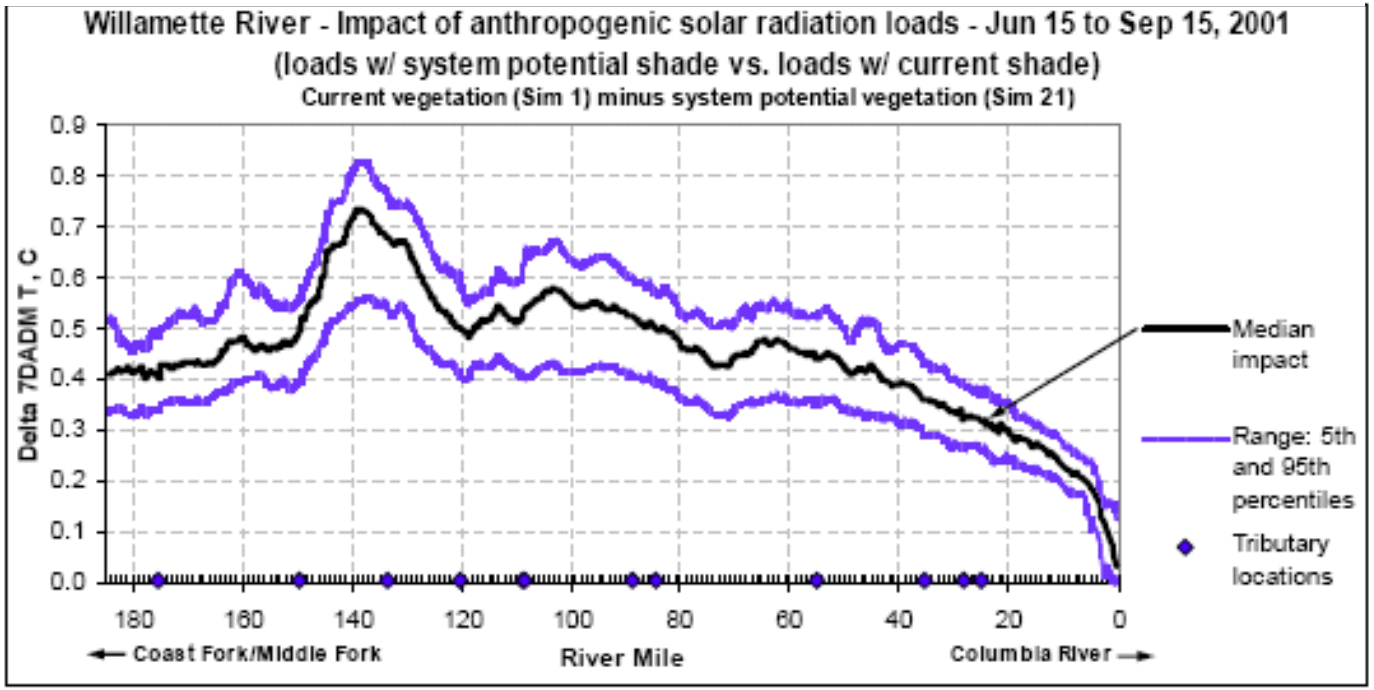
TMDL = WLA + LA + MOS + RC + NS



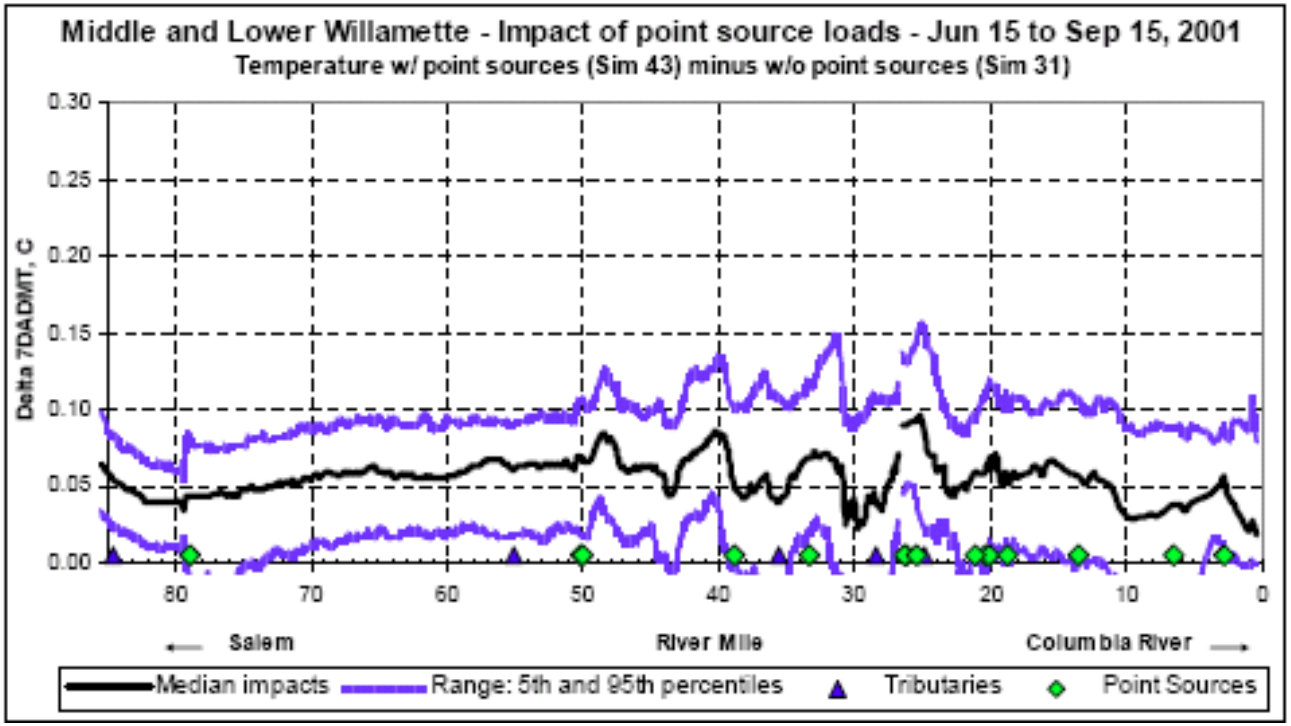
Willamette Temperature TMDL



•Nonpoint Source Impacts = Tenths of degrees

•Lack of shade is a larger source of heat than point sources for the mainstem Willamette

Willamette Temperature TMDL



•Point Source Impacts = Hundredths of degrees

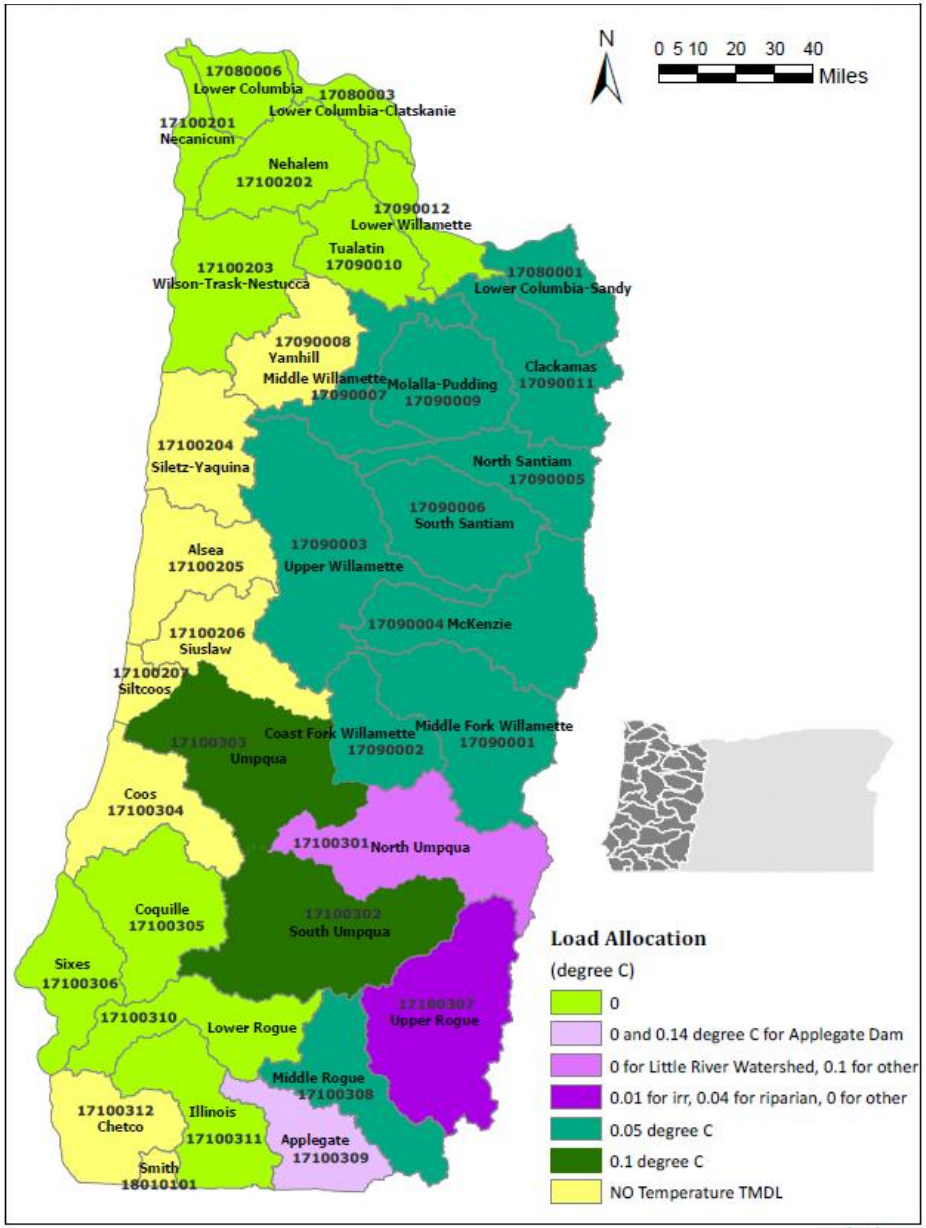
•Thermal effect from point sources are less than from nonpoint sources

•City of Wilsonville recently spent $300K on cooling towers to meet their WLA of 0.0029C

Load Allocations for Temperature in Western Oregon TMDLs

- Temperature load allocations range from 0°C to 0.14°C

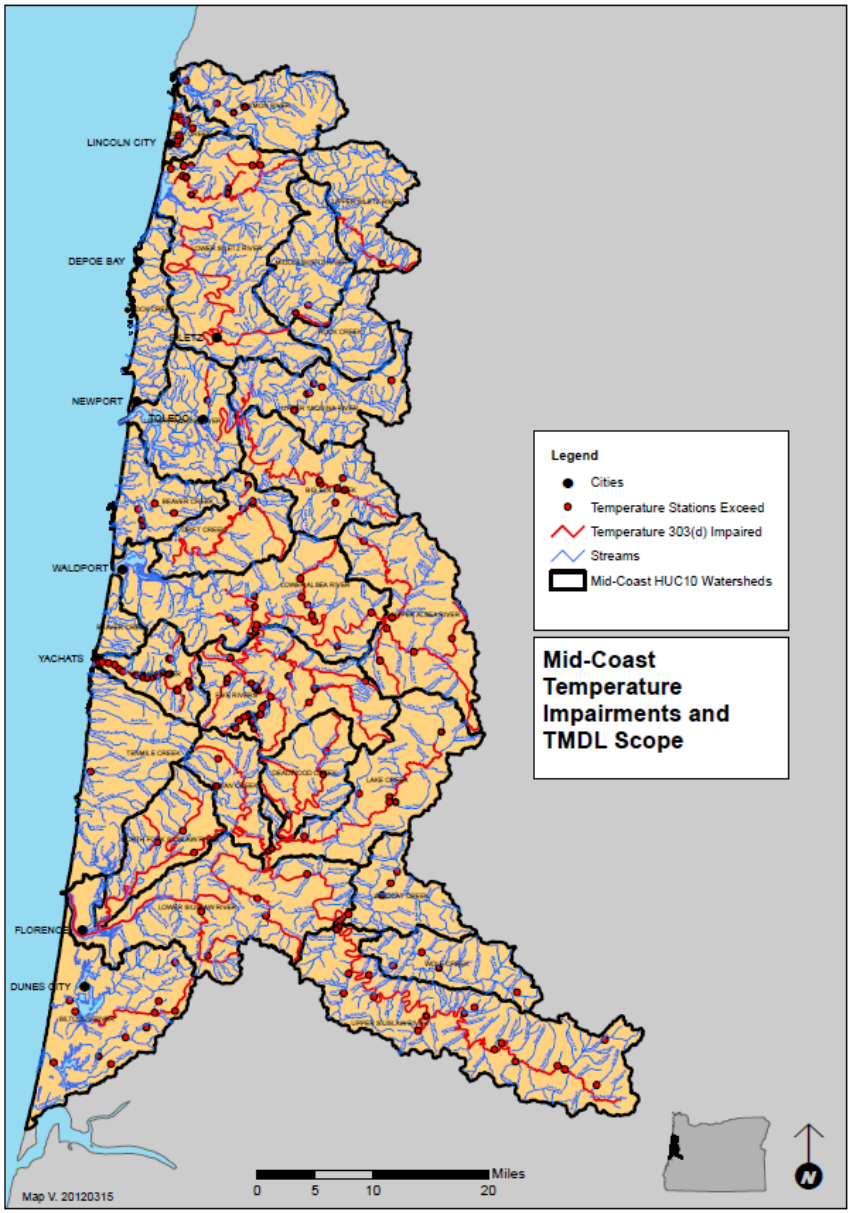
- DEQ expects that measures to meet TMDL load allocations would also meet the Protecting Cold Water Criterion



6/10/2014

TMDL Development for Temperature Impairments in the MidCoast

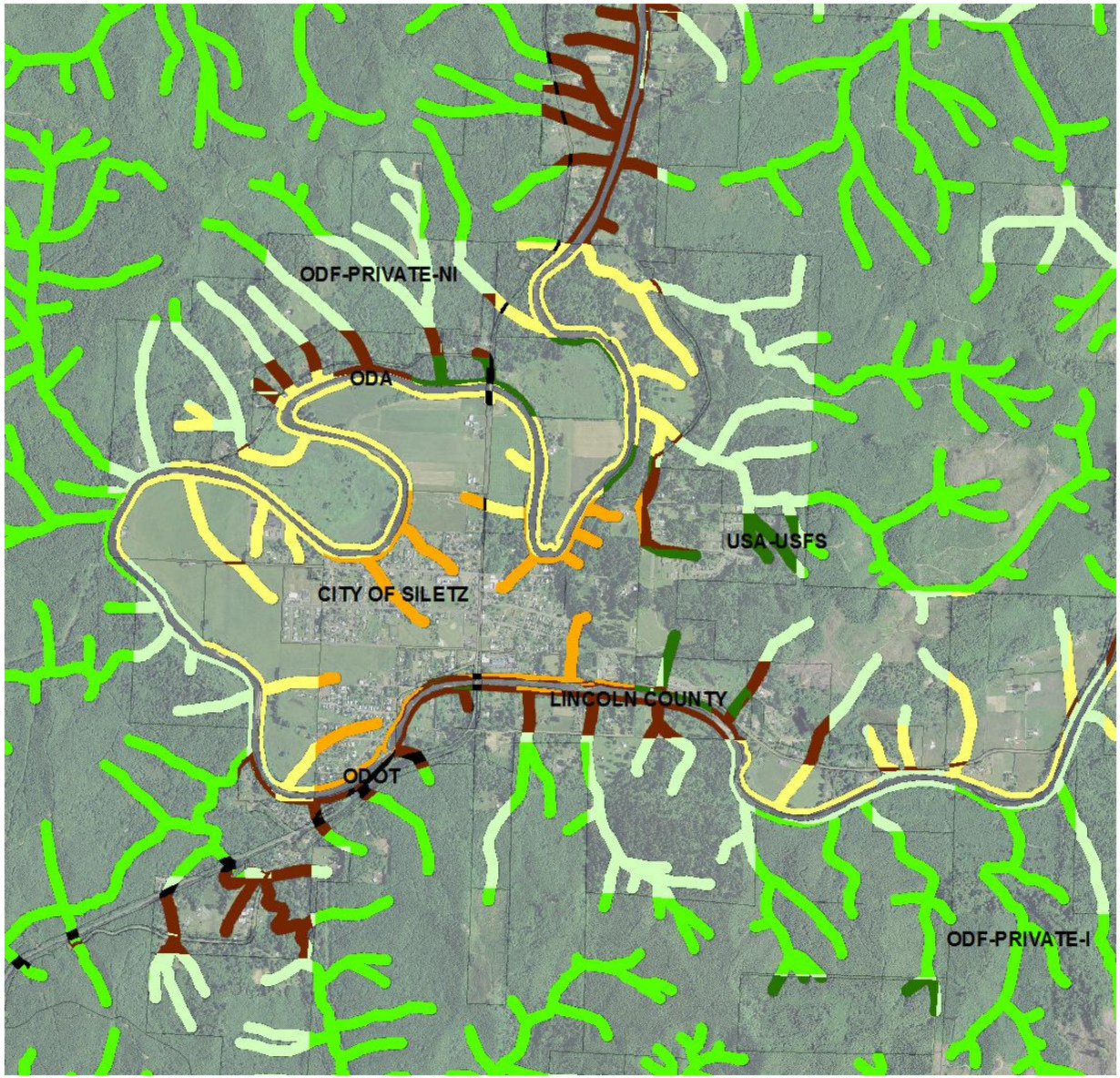
- 350+ data stations analyzed (1999 – 2011)
- 200+ stations exceed water quality standards
- 48+ streams identified as impaired - 303(d) list



Mapping Riparian Areas & DMAs

DMA

- City of Siletz
- Lincoln County
- ODA
- ODF-PRIVATE-I
- ODF-PRIVATE-NI
- ODOT
- USA-USFS



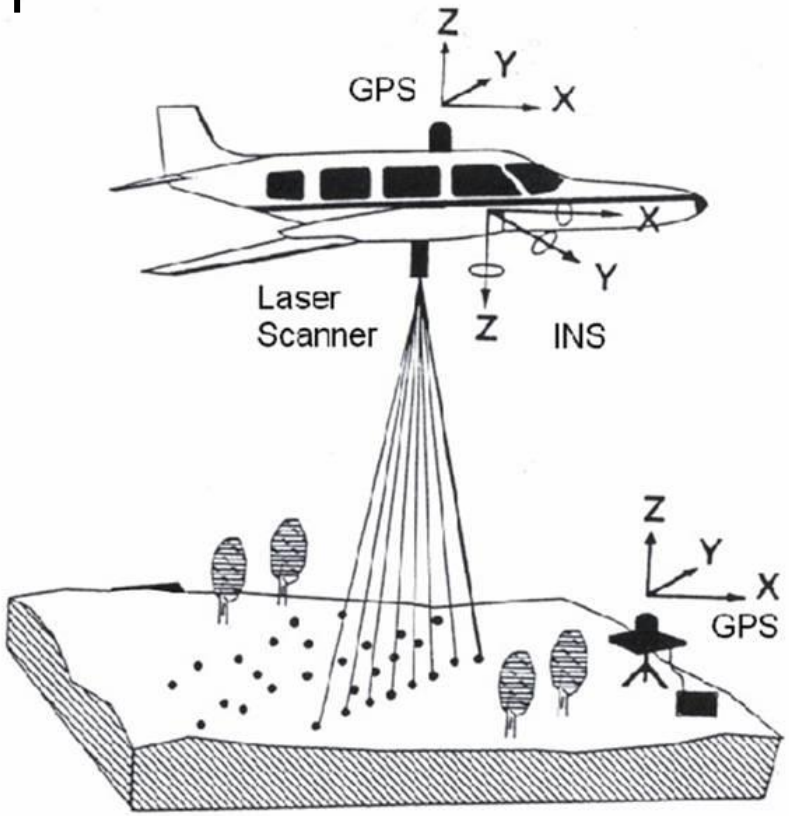
Quantifying Riparian Condition

Vegetation Inventory

- Quantify riparian vegetation condition
- Identify areas that are sources of thermal load

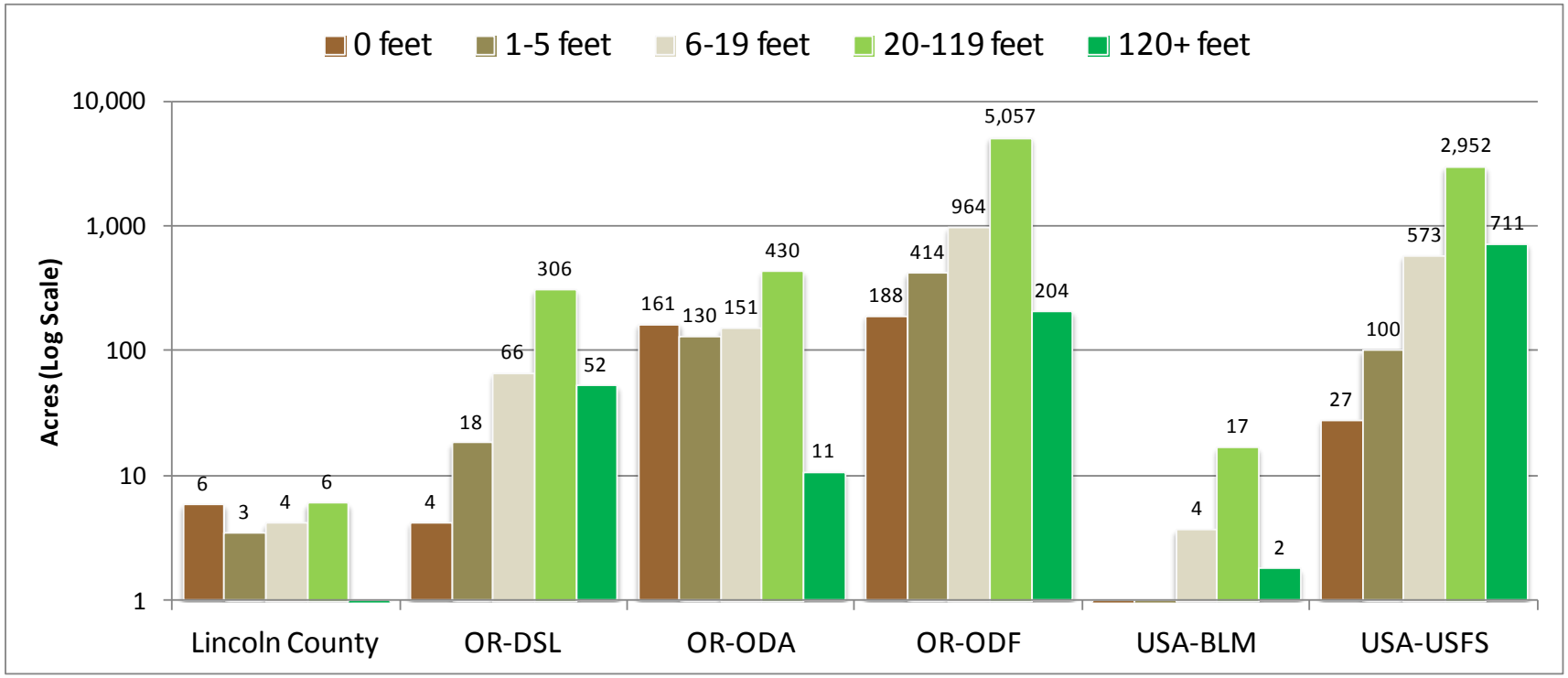
Identify DMA responsibility

- Prioritization of restoration



Quantified Riparian Condition

Big Elk Creek vegetation height by DMA



Riparian condition w/in 30m of Big Elk Creek quantified by using LiDAR

Protecting Cold Water in Adjacent States

Washington:

- No warming >2.8°C allowed for all nonpoint sources combined according to the temperature rule.
- Antidegradation policy & numeric criteria must be met.
  - >0.3°C increase in temperature is considered lowering water quality, requiring an antidegradation review.
- Forest practice sufficiency is measured against the >0.3°C increase threshold for all streams.
- Forest practice rules manage for habitat, require maintenance of shade & sediment filtration.

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Protecting Cold Water in Adjacent States

California (North Coast):

- Stream temperatures cannot be altered unless alteration does not adversely affect beneficial uses; *and*
- Stream temperature cannot be increased by more than 5°F (2.8°C) above natural temperature; *and*
- The North Coast Region Temperature Policy requires maintaining or achieving "site-specific potential effective shade" in riparian areas on private lands.
- Forest practice rules manage for shade, sediment retention, & habitat.

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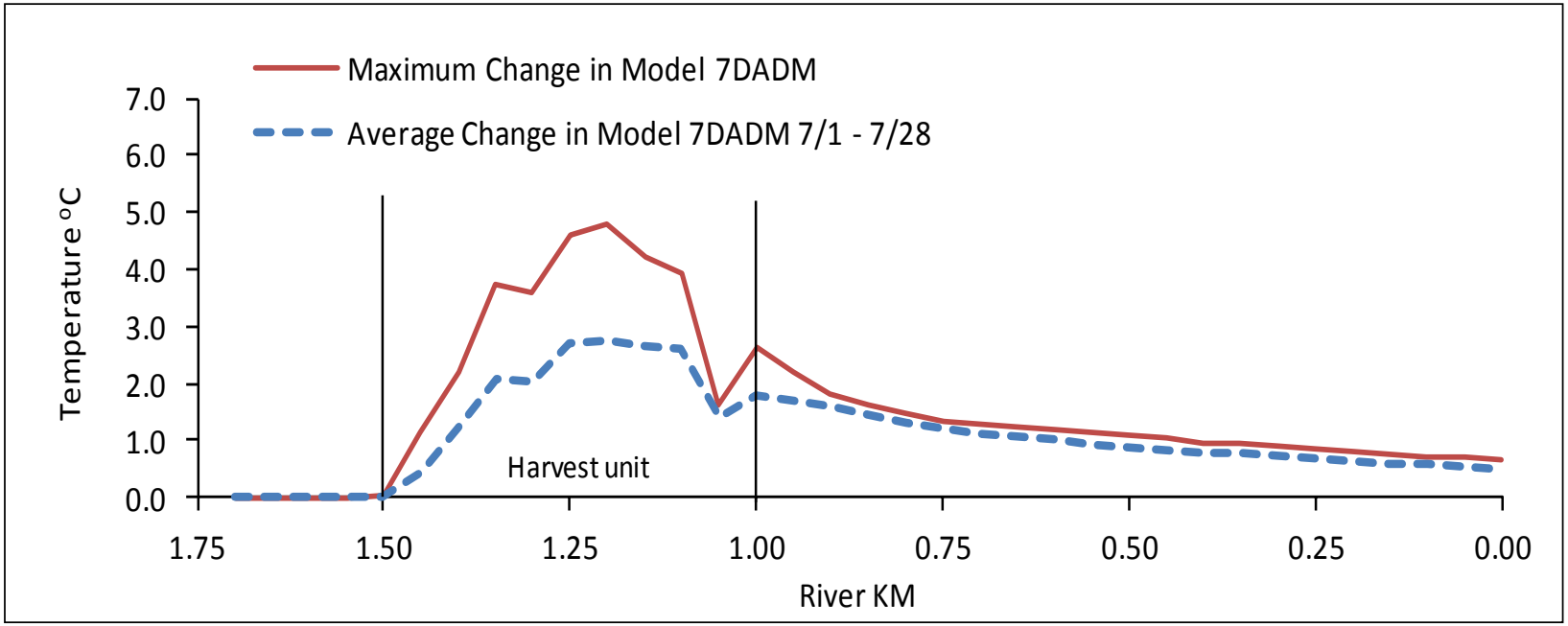
Questions?

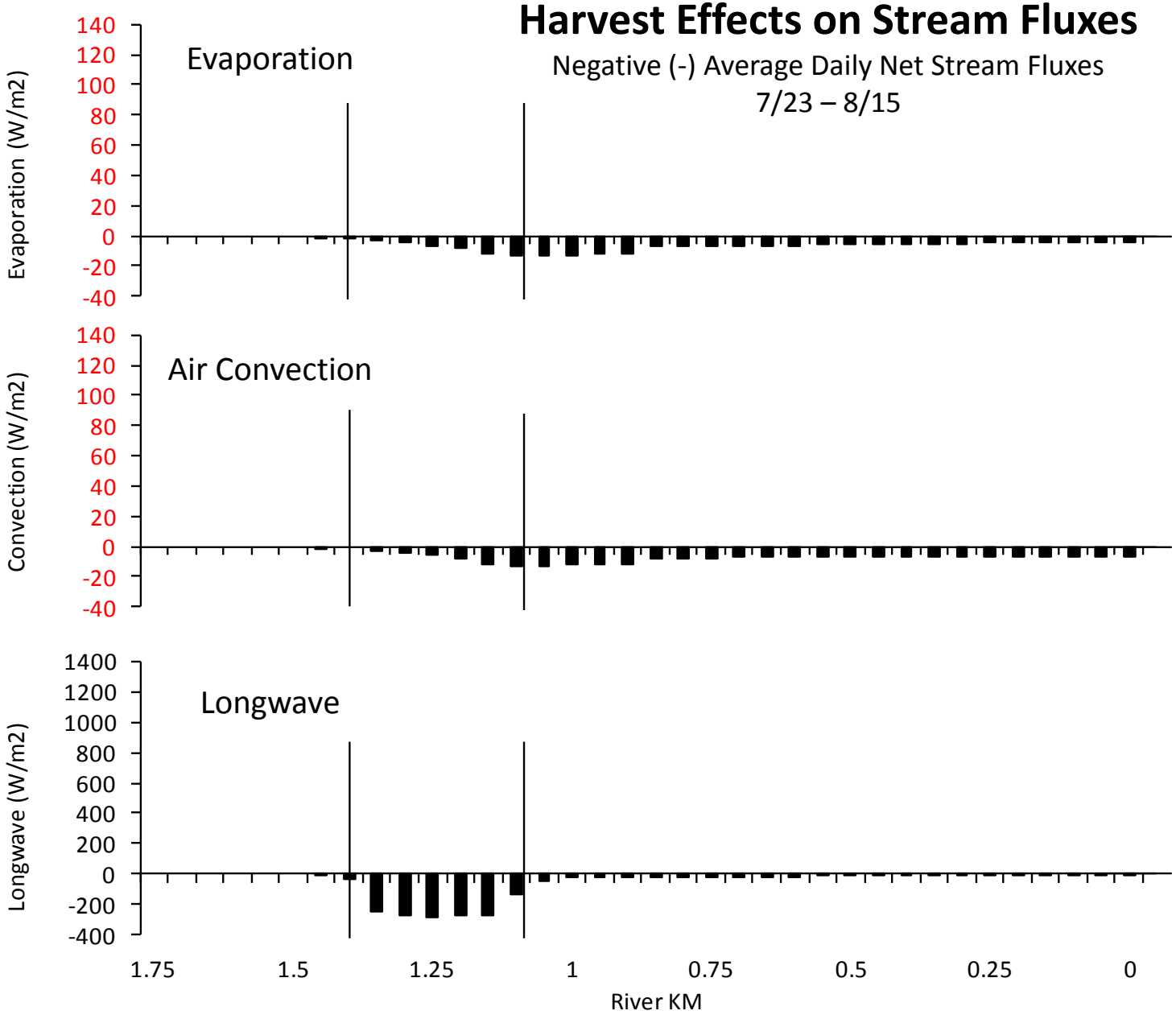
Heat Source Results for Argue Creek



Simulated change in longitudinal 7-day average daily maximum (7DADM) temperatures from harvest at RipStream site 7854, holding all factors constant except vegetation.

Harvest Effects on Stream Fluxes

Negative (-) Average Daily Net Stream Fluxes
7/23 – 8/15



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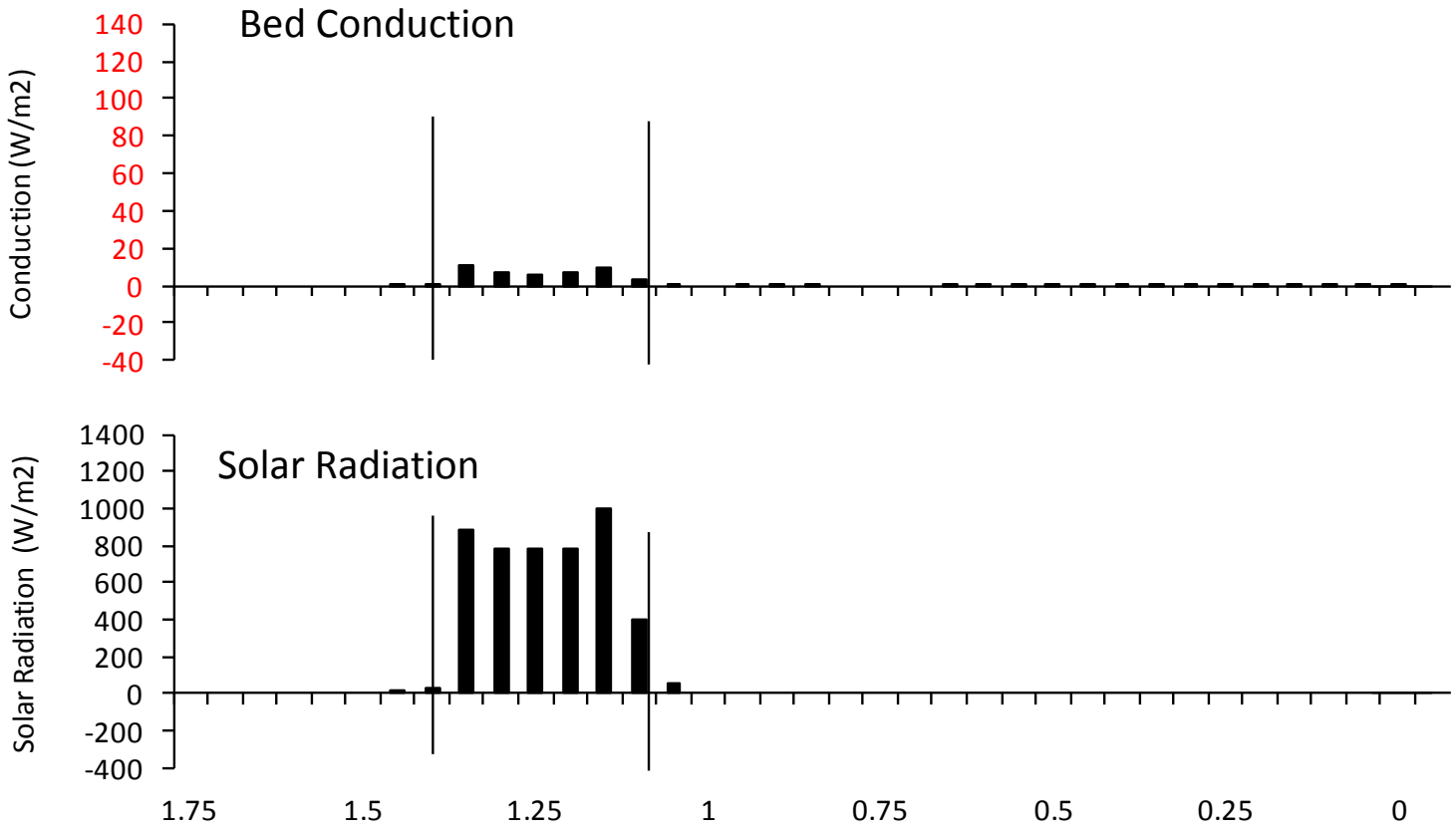

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Oregon Temperature WQS

(OAR 340-041-0028)(2)

Commission's Policy is:

- Protect aquatic ecosystems from adverse warming and cooling caused by anthropogenic activities;
- Minimize the risk to cold-water aquatic ecosystems from anthropogenic warming;
- Encourage the restoration and protection of critical aquatic habitat;
- Control extremes in temperature fluctuations due to anthropogenic activities;
- Minimize additional warming due to anthropogenic sources

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Protecting Cold Water Criterion (OAR 340-041-0028(11))

- PCW limits temperature increases to 0.3^{o}C in waterbodies colder than the numeric criteria, measured for all sources combined at the point of maximum impact where salmon, steelhead or bull trout are present [OAR …(11)(a)].
    - Natural thermal regime provides best conditions for fish.*
    - Value in diversity of temperatures, including colder than BBNC.*
    - Prevent accumulation of heat in fish-bearing reaches.*
    - Retain assimilative capacity for climate variation & climate change.

- Point sources must also limit warming in spawning reaches [OAR …(11)(b)].

- Some waterbodies may also be covered by a temperature TMDL. Meeting TMDL allocations should ensure PCW compliance.

*From Summary of 2003 TAC findings.

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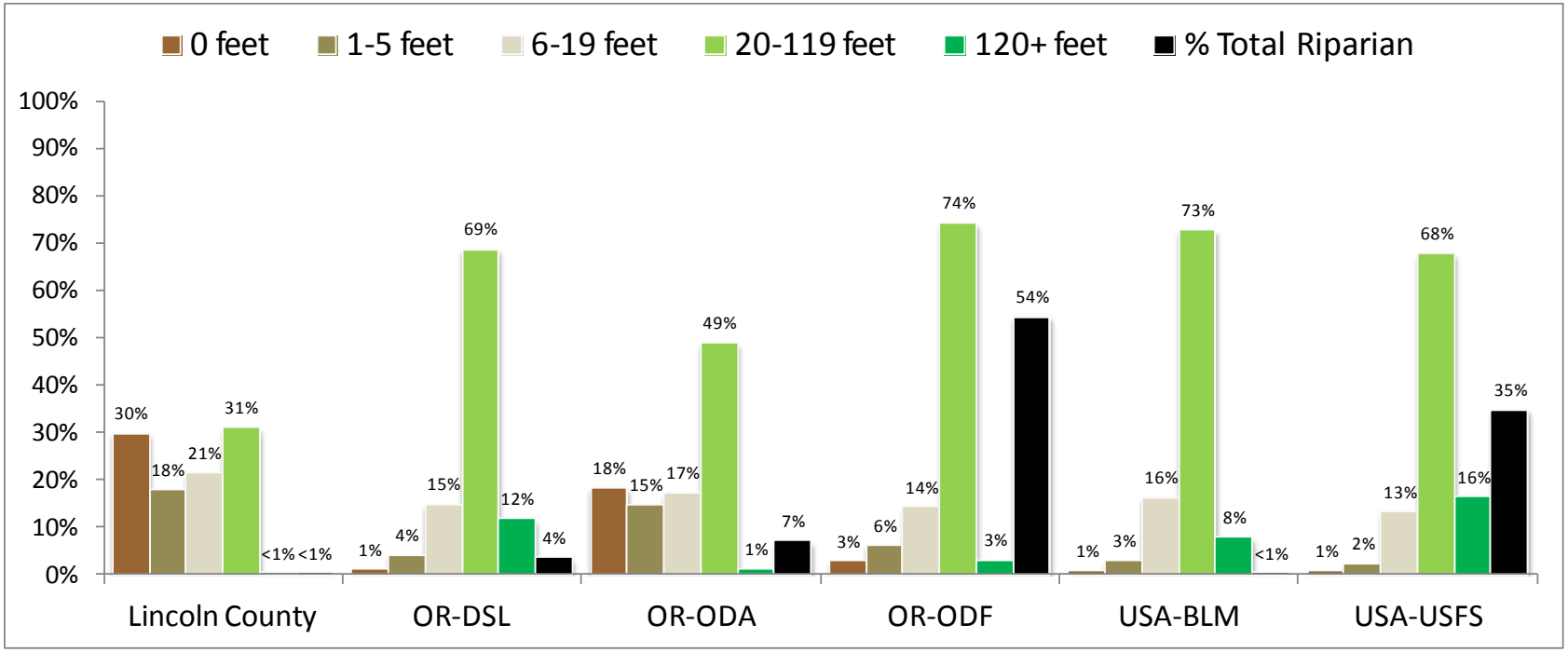
Percent area in each LiDAR vegetation height classification within 30 meters of the stream for each DMA in the Big Elk watershed