From:	Wu, Jennifer
To:	SEEDS Joshua; Henning, Alan; Leinenbach, Peter; jeffrey.lockwood@noaa.gov; Foster.Eugene@deq.state.or.us; Palmer, John; Labiosa, Rochelle
Subject:	FW: Draft presentation
Date:	Thursday, June 12, 2014 11:33:22 AM
Attachments:	DEQ ODFW Joint Presentation PCW & Fish EQC Meeting June 2014_draft.pptx

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Thanks for the draft presentation, Josh. We're ready to talk on the following points in the 5-6 minutes at the EQC meeting. Briefly, that's:

- Overall support for findings behind the need for a riparian rule
- Reiterating importance of cold water for fish as in the temperature guidance development
- Importance of PCW in EPA's approval of WQS and the numeric criteria

Jeff, we're going to adjust our talking points. John, FYI, on what DEQ and ODFW are covering. We can touch base when you have time.

From: SEEDS Joshua [mailto:SEEDS.Joshua@deq.state.or.us]
Sent: Wednesday, June 11, 2014 6:00 PM
To: Wu, Jennifer; Henning, Alan; Leinenbach, Peter; jeffrey.lockwood@noaa.gov
Cc: FOSTER Eugene P
Subject: Draft presentation

Here is the draft presentation as it is currently. The Mid Coast TMDL and comparison of states at the end needs doing and overall it needs to be shortened, but you get the idea. This should help with knowing what DEQ and ODFW are covering.

Thanks,

Josh

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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

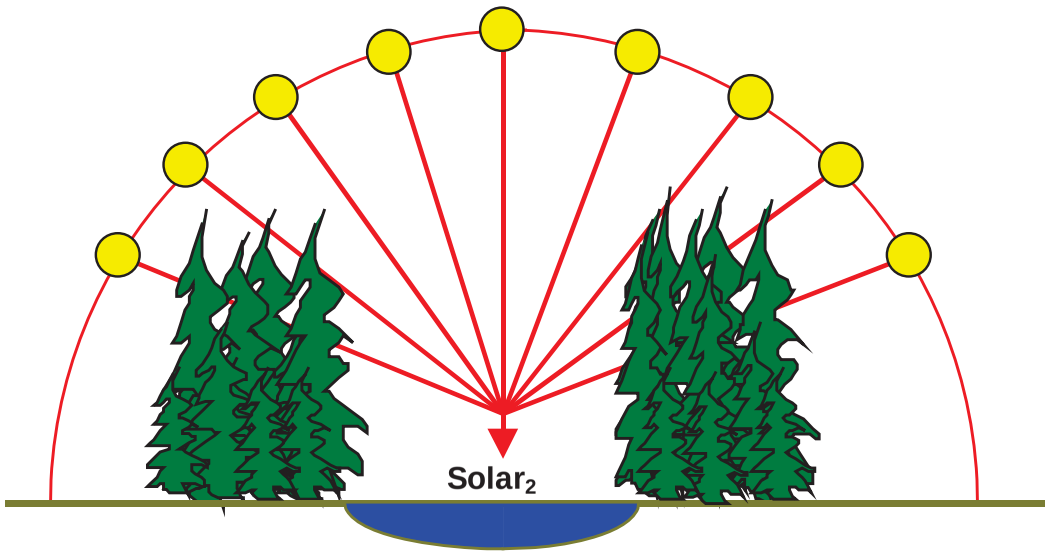
Presentation Purpose

- 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.

Basics of Stream Temperature

- Shade, flow, & channel complexity are important factors that affect stream temperatures within a watershed.
- Climate affects stream temperature.
- Effective shade is the percent of daily solar radiation blocked by vegetation & topography.

$Solar_1$ – Potential daily direct beam solar radiation load adjusted for julian day, solar altitude, solar azimuth and site elevation.



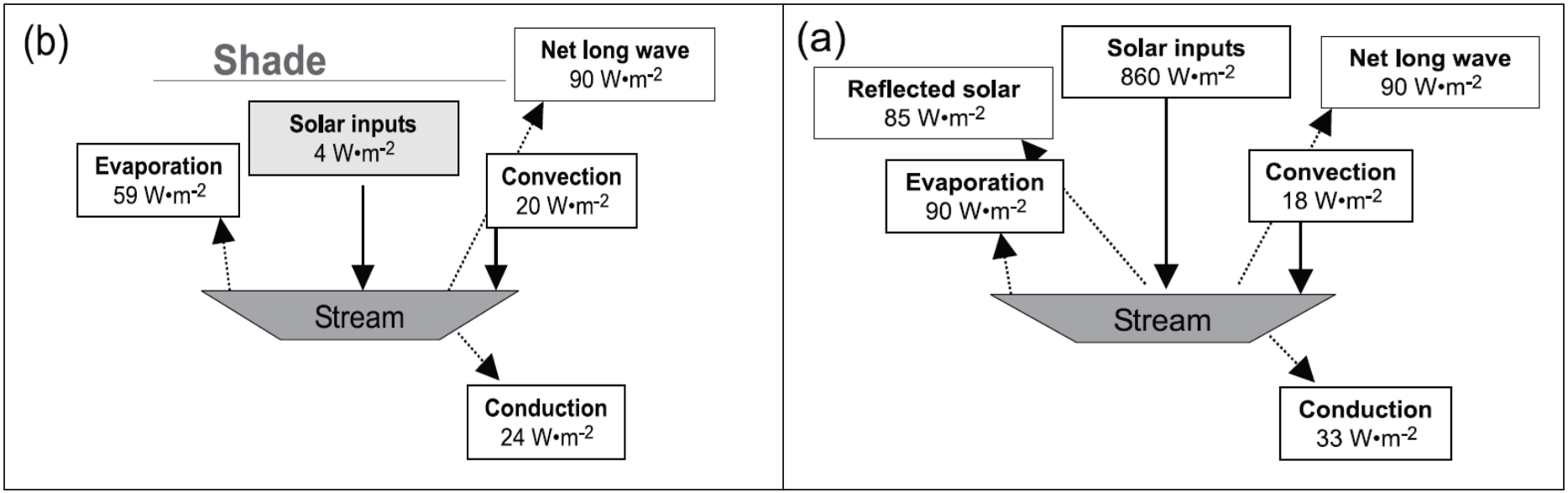
$$\text{Effective Shade} = \frac{(\text{Solar}_1 - \text{Solar}_2)}{\text{Solar}_1}$$

Where,

$Solar_1$: Potential Daily Direct Beam Solar Radiation Load

$Solar_2$: Daily Direct Beam Solar Radiation Load Received at the Stream Surface

Basics of Stream Temperature



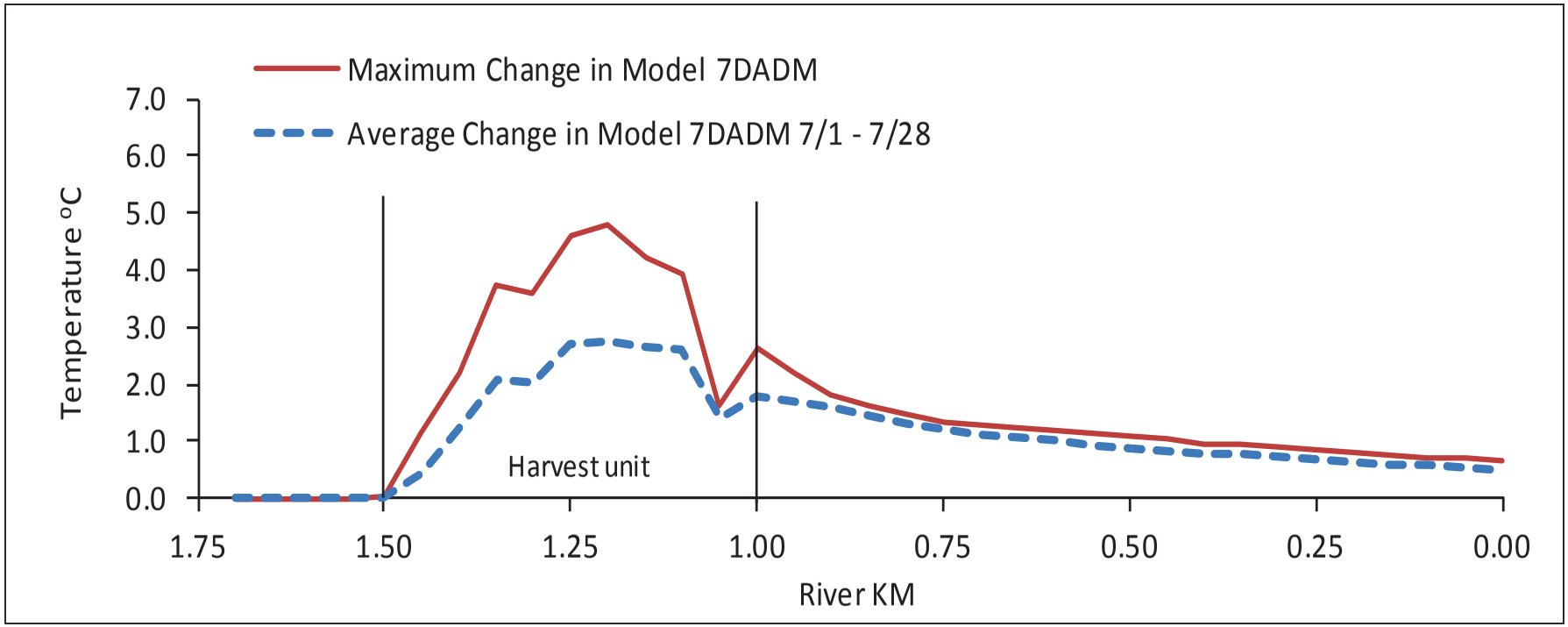
Heat energy fluxes at noon on July 20, 1997 on a **fully shaded** study stream in the H.J. Andrews Experimental Forest. **Heat energy lost is -149 W*m^{-2}.**

Heat energy fluxes at noon on July 20, 1997 on an **unshaded** study stream in the H.J. Andrews Experimental Forest. **Heat energy gained is 580 W*m^{-2}.**

Johnson 2004

- Solar energy drives temperature on smaller streams.
- Streams more easily absorb thermal energy from sunlight than lose it once absorbed.

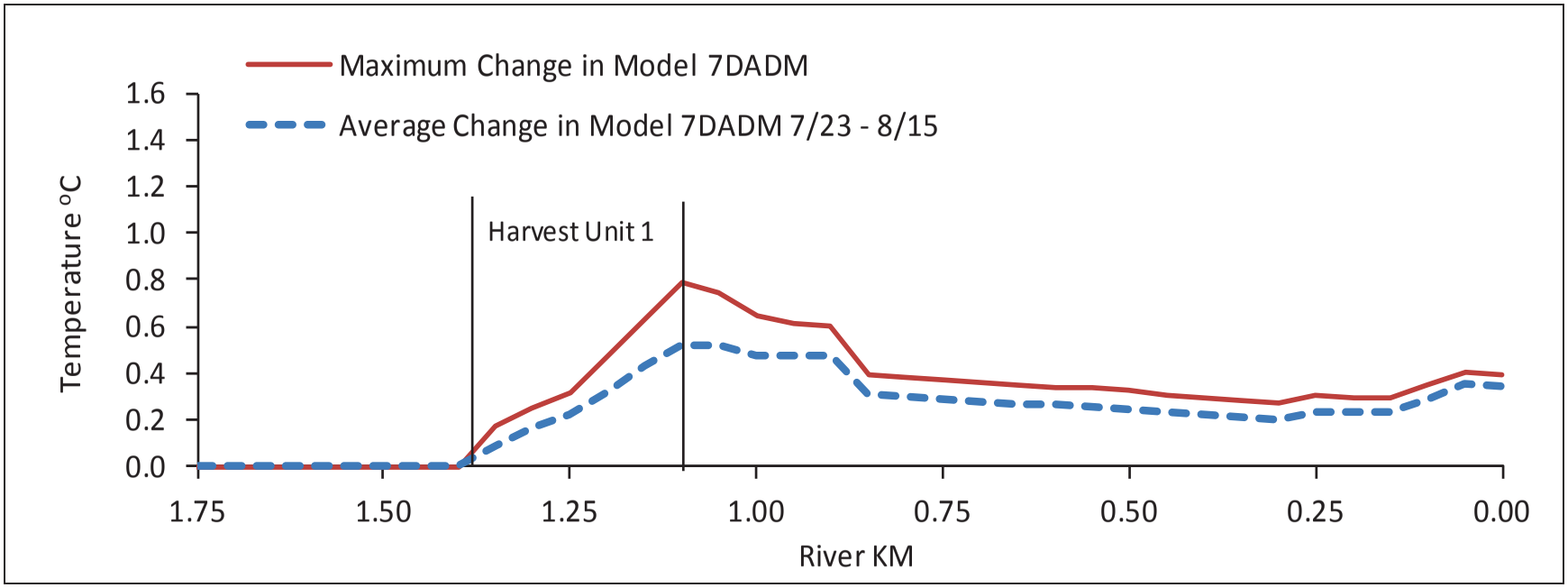
Heat Source Results for Argue Creek



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

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

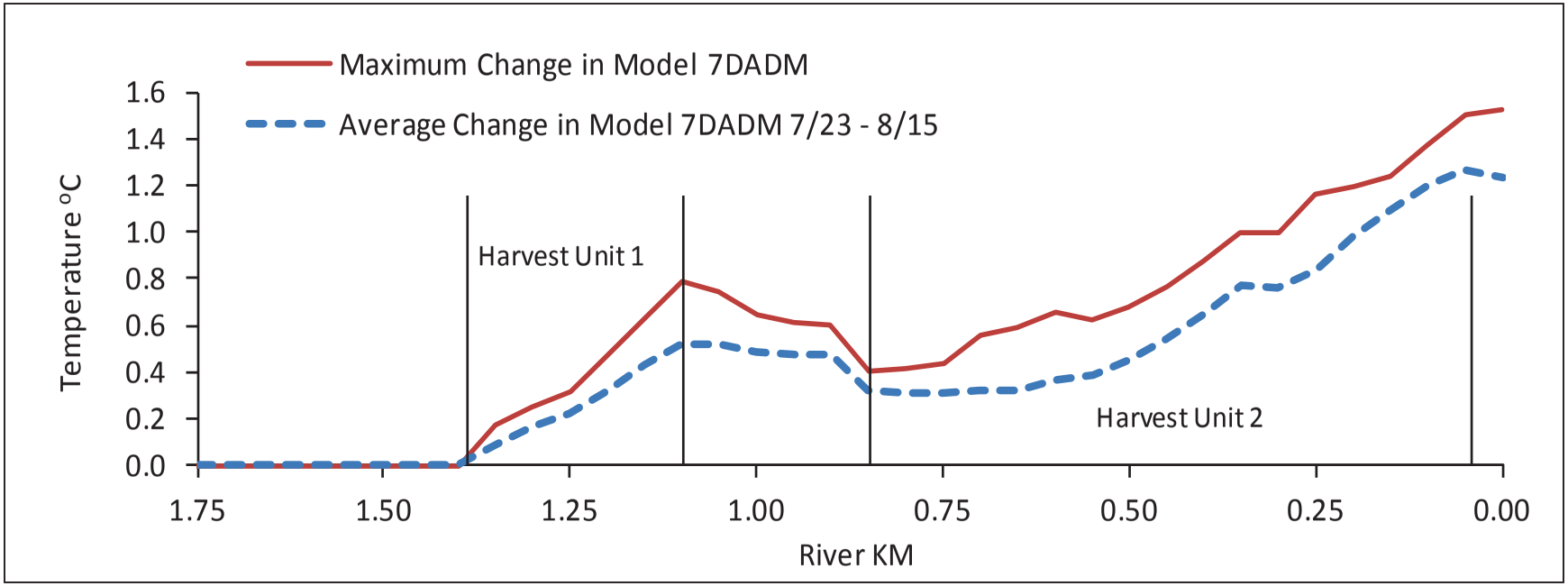
Heat Source Results for Drift Creek Trib



Simulated change in longitudinal 7-day average daily maximum (7DADM) temperatures from harvest at RipStream site 5556, holding all factors constant except vegetation.
Results only include effect of the Harvest Unit 1 in RipStream study area.

- Dilution of thermal energy is not the same as dissipation.

Heat Source Results for Drift Creek Trib



Simulated change in longitudinal 7-day average daily maximum (7DADM) temperatures from harvest at RipStream site 5556, holding all factors constant except vegetation.
Results include effects from the harvest unit in RipStream study area (Harvest Unit 1) and a second harvest unit downstream of the study area (Harvest Unit 2).

- Multiple disturbances & human activities can result in cumulative effects, even with undisturbed reaches present.

Stream Temperature & Aquatic Life

- Stream temperature determines the rate at which processes occur.
- Natural thermal regimes provide the best conditions for fish & other native aquatic life.
- Temperature effects typically occur on a continuum. Increases above natural thermal potential:
  - Increase risk to fish,
  - Can have negative effects on salmonid populations, particularly when occurring across the landscape (McCullough 1999, US EPA 2001).
- Thermal diversity is necessary at multiple scales.

Thermal heterogeneity *is* habitat complexity

- Natural Thermal Regimes (NTR) are dynamic and promote **biological diversity**
  - A NTR includes magnitude, frequency, duration, timing, and rate of change (Olden and Naiman 2010). It does not imply constancy.
  - Landscape conversion alters the mean *and* variance of stream temperatures (Steel et al. 2012).

NTRs & Biological Diversity

- Fish life history chronologies are mediated by predictable thermal variability (seasonality).
- Homing of salmonids promotes reproductive isolation, allowing natural selective forces like NTR to operate on heritable phenotypic traits, resulting in distinct, locally adapted populations (Hillborn et al. 2003).

NTRs & Biological Diversity

- Spatial variation in water temperature is linked to:
  - Population differentiation & differences in spawn timing in salmon
  - Ecologically important divergence in salmon at the within-stream scale
  - Salmonid subsidies (food pulses) that support within-network foraging movement & diversity of resident predators (Ruff et al. 2011).

NTRs & Biological Diversity

- Dampening the natural thermal variability & the temporal sequence of the natural thermal regime:
  - Reduces intraspecific diversity by reducing opportunities for local adaptation and genetic variation among populations or phenotypic variation within populations (Watters et al. 2003), and therefore, salmonid species diversity in Oregon.
  - Reduces population and meta-population (ESU) resilience, since diversity confers stability in fish population dynamics (production cycles).

Thermal heterogeneity *is* habitat complexity

- Thermal diversity in a stream network promotes aquatic **biological productivity**
  - Fish are less adapted to mean of water temperatures than to variability (diversity).
    - Fish can detect & exploit thermal heterogeneity to avoid heat stress, & meet metabolic and reproductive requirements (Hodgson and Quinn 1991, Torgersen et al. 2012).
    - Fish exploit thermal heterogeneity not only to survive, but thrive.

Thermal Diversity & Biological Productivity

- Under non-stressful temperatures, coho exploiting thermal heterogeneity grew at faster rates than individuals with other behaviors (Armstrong et al. 2013).
- Natural Thermal Regimes:
  - Directly influence metabolic rates, physiology, & life-history traits of aquatic ectotherms (Holtby et al.),
  - Help determine rates of important ecological processes such as nutrient cycling & productivity, and
  - Indirectly mediate biotic interactions (references in Olden and Naiman 2010).

Thermal Diversity & Biological Productivity

- Salmonid species with colder thermal requirements (ESA-listed bull trout) are confined to “cold-water refuges”.
  - If these refuges become warmer, bull trout habitat will shrink, due to competitive disadvantage with other salmonid species.
- Thermal refuges below the species-specific BBNC also buffer other cool/cold water adapted species from predation by invasive warm water predators

Thermal Diversity & Biological Productivity

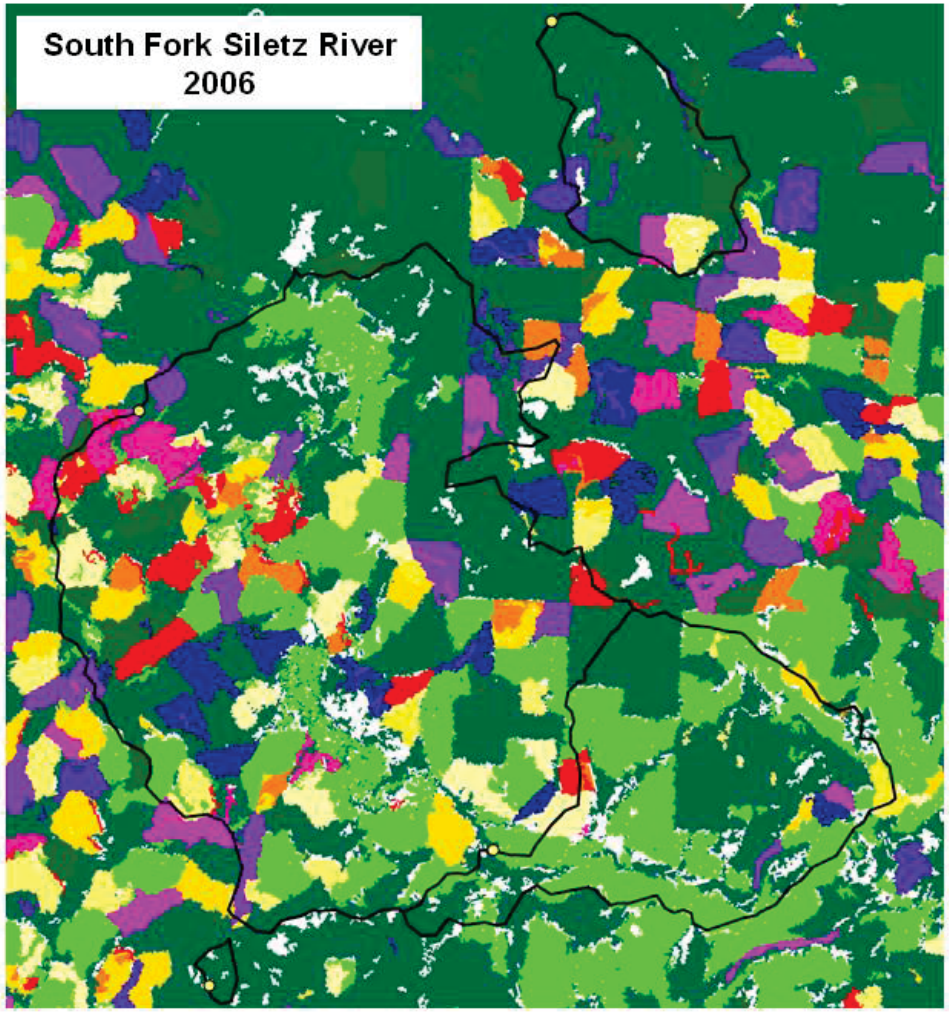
- With acute reach and segment scale temperatures, the only biological response is moving to habitat with sub-lethal temperatures.
  - A prerequisite for success of this stress-avoidance strategy is the presence of “stepping stone” reaches or patches that contain cooler water.
- In warm streams, thermal refuge patches provide opportunities for fish to thermoregulate (Ebersole et al. 2003)
  - A spatially distributed network of habitats with cooler temperatures allows a fish population to utilize a larger portion of a stream network, thereby reducing mortality.

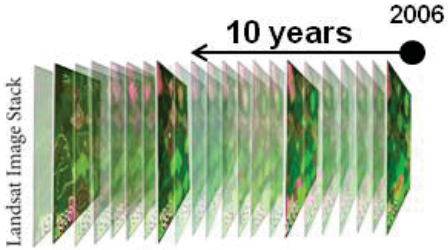
Disturbance on the Landscape

- Riparian areas in higher reaches burn as often as upland forest.
- Riparian areas in lower reaches burn less often than upland forest.
- Current disturbance regime is different than historic regime.
  - About 10 years for thermal recovery after disturbance.
  - Pre-settlement 2.4-6.7% of landscape in thermal recovery (Agee 1990, Wimberly 2002).
  - Fire return intervals in western Oregon range from 100-400yrs, 200yrs is typical (Morrison & Swanson 1990, Wimberly 2002).
  - With an even 40yr harvest rotation, 25% of landscape would be in thermal recovery at any time.

Disturbance on the Landscape

•Change detection analysis of LandSat data (1985-2009) in the Mid Coast Basin shows area in thermal recovery for 1994-2008.





Kennedy et al 2010.

Percent area disturbed in 2006 = 17%

Includes any harvest 10 years prior from 1996-2006.

Color = harvested 1996 - 2006

White = Non forested (Ag/Rural residential, meadow)

Dark Green = not harvested 1985 - 2006.

Light Green = harvested 1985-1996. (Not counted in total)

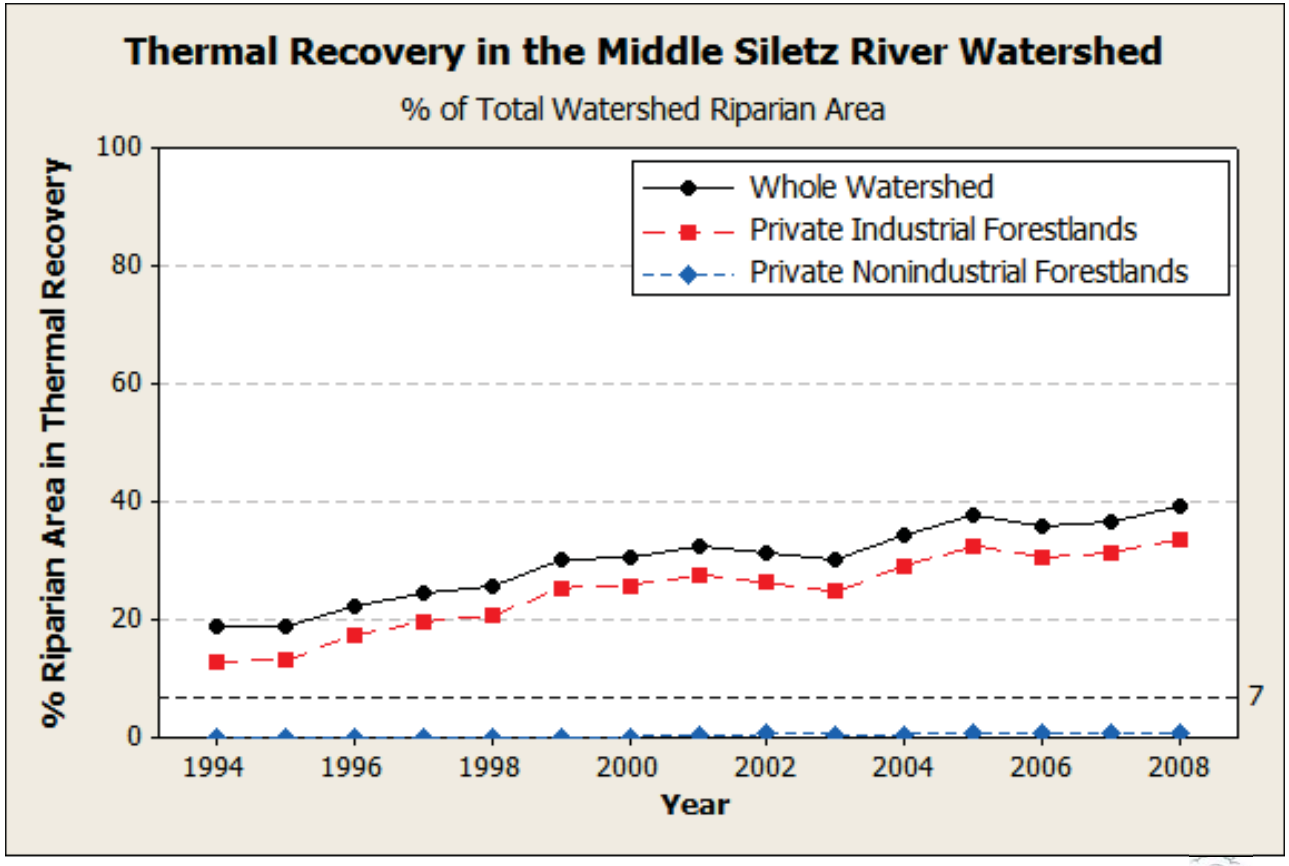
Disturbance on the Landscape

•Amount of riparian area (i.e. within 100ft of streams) disturbed between 1985-2009 varies in space & time.

•Middle Siletz River watershed private industrial forestland riparian area in thermal recovery:

•Maximum in 2008: 36.7%

•Minimum in 1994: 14.1%



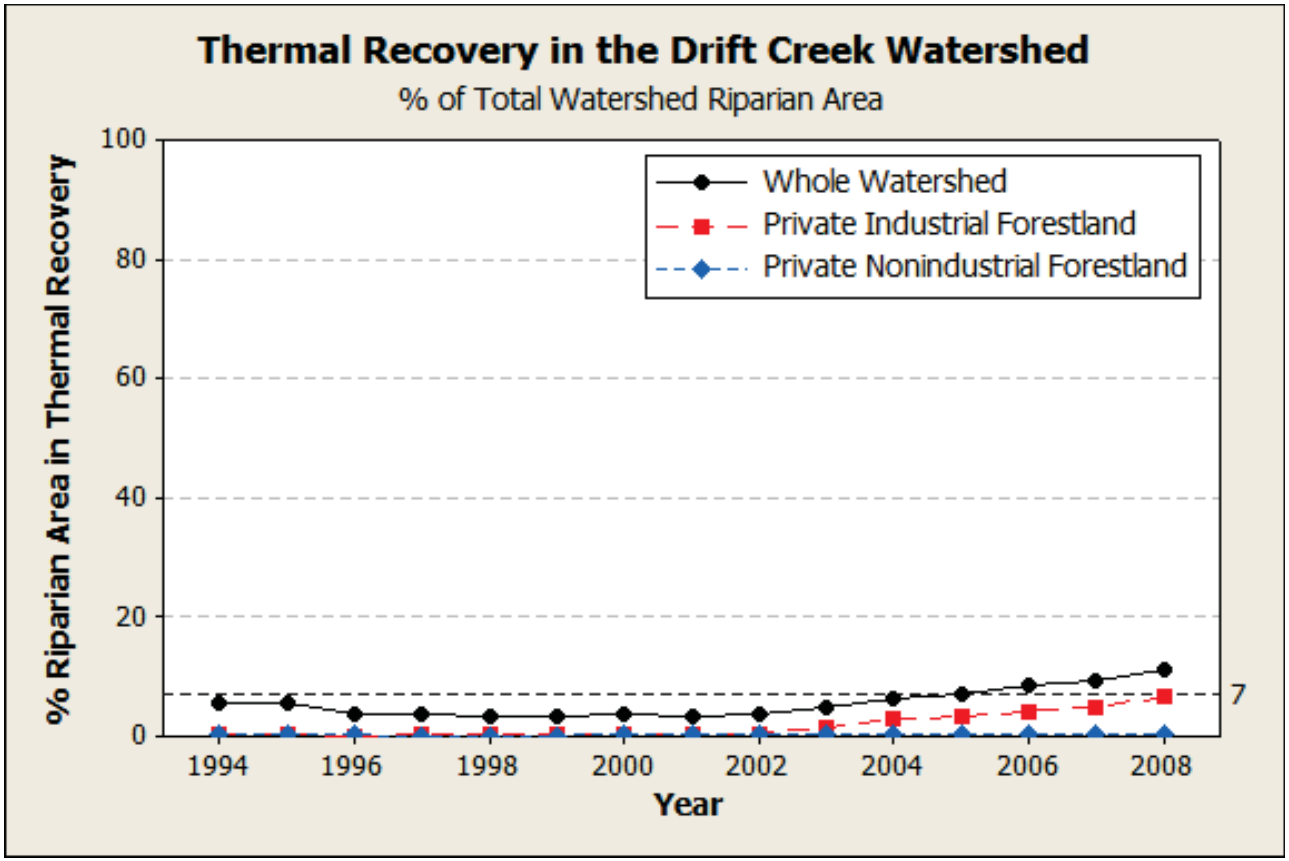
Disturbance on the Landscape

•Amount of riparian area (i.e. within 100ft of streams) disturbed between 1985-2009 varies in space & time.

•Drift Creek watershed private industrial forestland riparian area in thermal recovery:

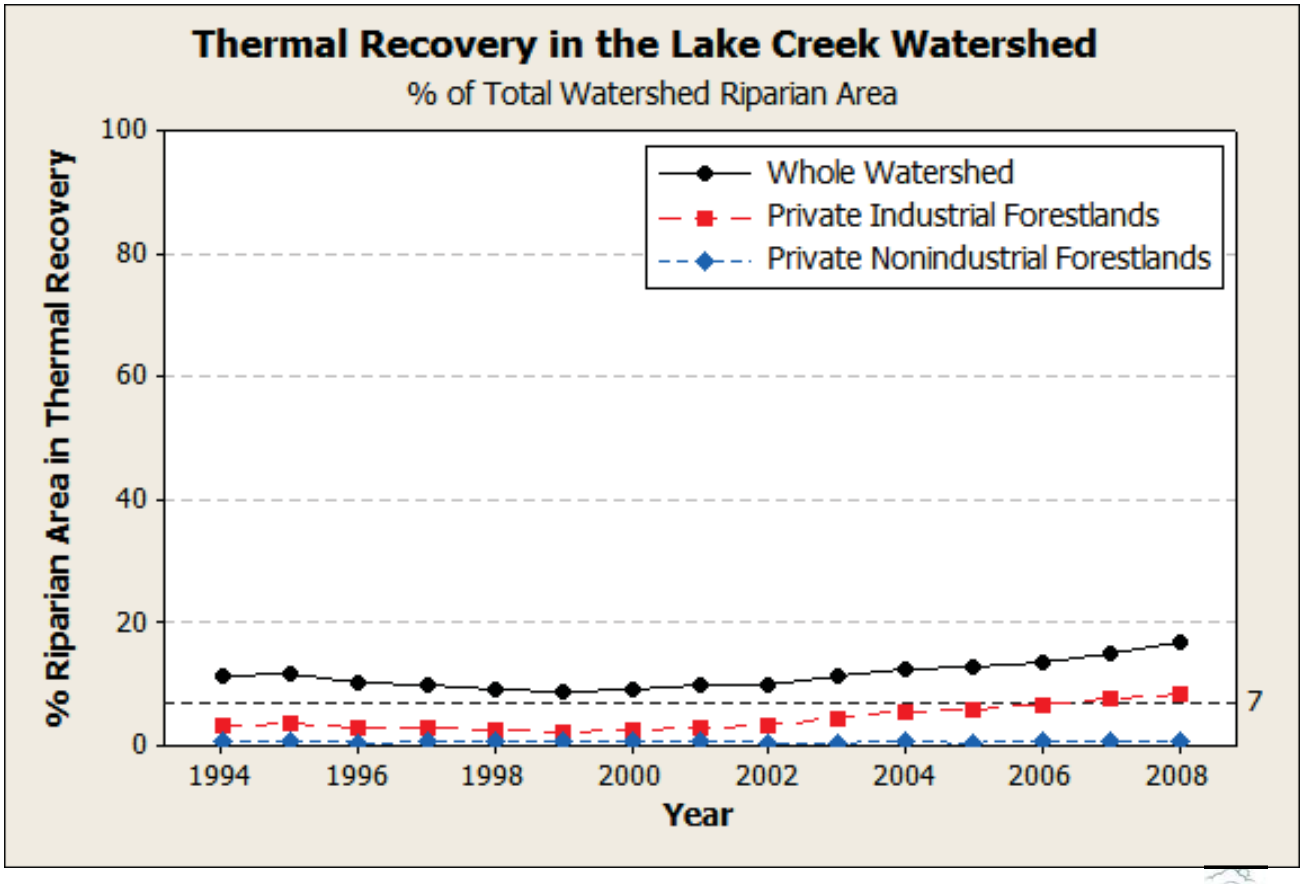
•Maximum in 2008: 25.8%

•Minimum in 1996: 0.2%



Disturbance on the Landscape

- Amount of riparian area (i.e. within 100ft of streams) disturbed between 1985-2009 varies in space & time.
- Lake Creek watershed private industrial forestland riparian area in thermal recovery:
  - Maximum in 2008: 34.5%
  - Minimum in 1999: 9.7%



Relevant Oregon Water Quality Standards

- Temperature Standard: Maintain & restore natural thermal regimes across landscape for all aquatic species
  - Biologically-Based Numeric Criteria (BBNC; OAR 340-041-0028(4))
  - Protecting Cold Water criterion (PCW; OAR 340-041-0028(11))
  - Human Use Allowance (HUA; OAR 340-041-0028(12)(b))
  - ~~Natural Conditions Criterion~~
- Antidegradation Policy
- Designated Uses

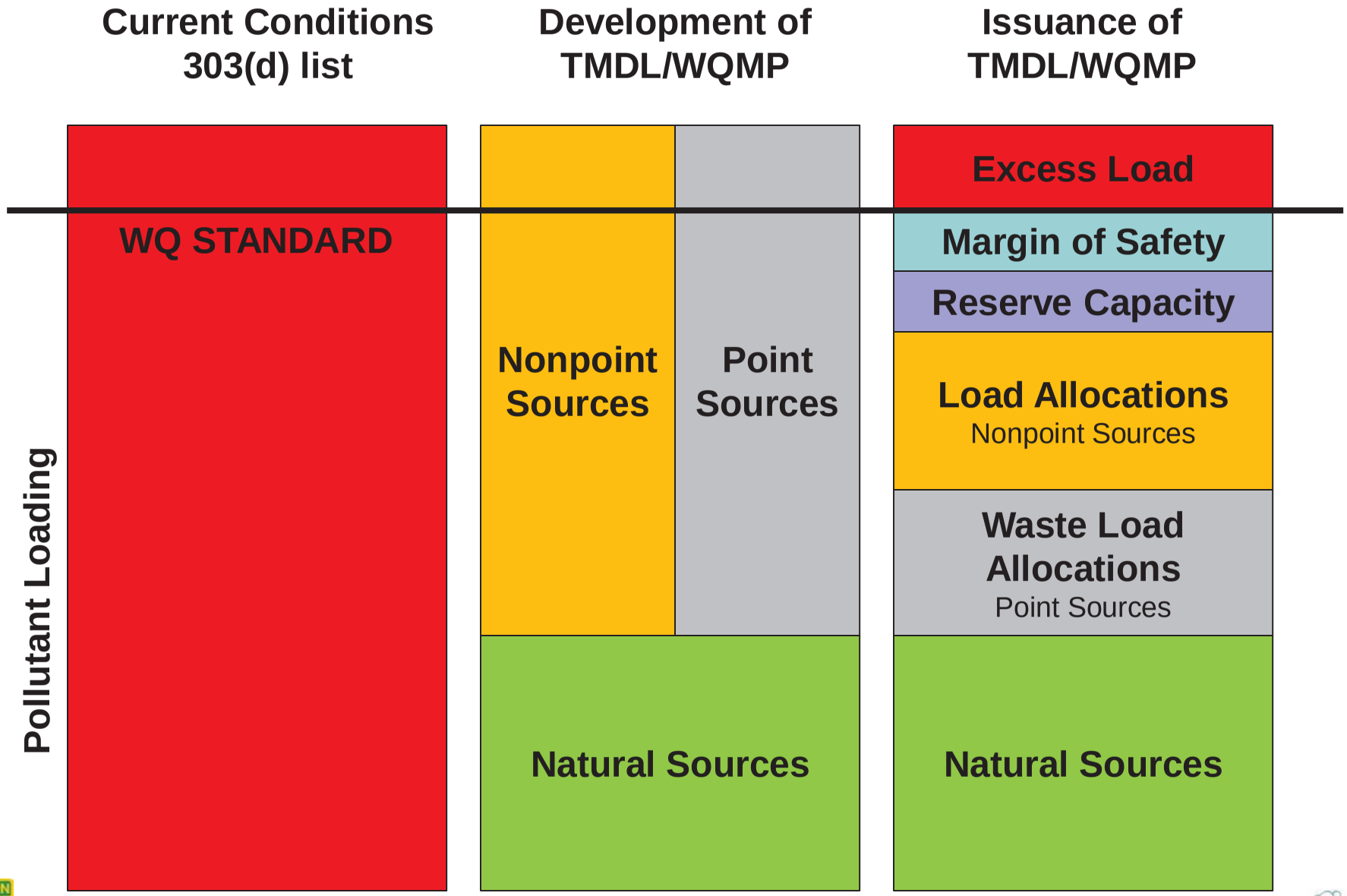
Protecting Cold Water Criterion

- PCW protects the natural thermal regime in waters colder than BBNC.
- Biologically-based numeric criteria are set at the upper end of the optimal range for salmonids.
- There is a need for water colder than the BBNC:
  - Small increases in stream temperature (>0.3°C) result in greater uncertainty about biological/ecological effects.
  - Heating of headwaters reduces the extent of downstream waters at optimal temperatures.
  - Fish often experience multiple stressors.
  - Need capacity to adapt to climate change & yearly variation.

Temperature
Total Maximum Daily Loads

- TMDLs are a tool 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 fractions of the HUA as wasteload allocations (point sources) or load allocations (nonpoint sources).

TMDL = WLA + LA + NS + MOS + RC



Temperature
Total Maximum Daily Loads

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

Temperature Total Maximum Daily Loads

- In the Willamette River TMDL, wasteload allocations are very small for point sources.
- The WLA for Wilsonville's sewage treatment is 0.0029°C (39 million kcal/day at summer 7Q10 flow)
  - Spending $?? On cooling tower to meet WLA

Map 4.4 303(d) Listings for Temperature and monitoring sites

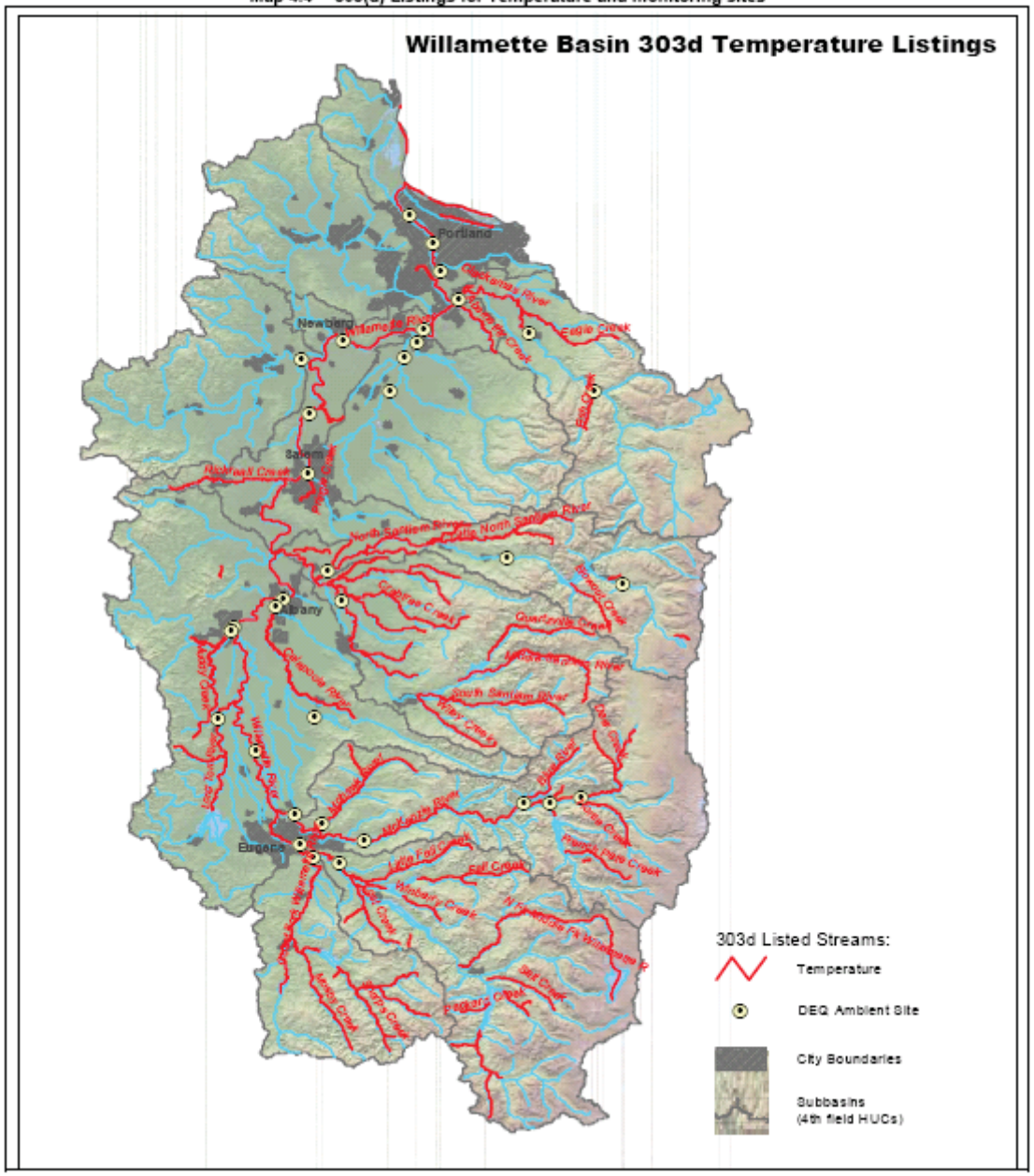
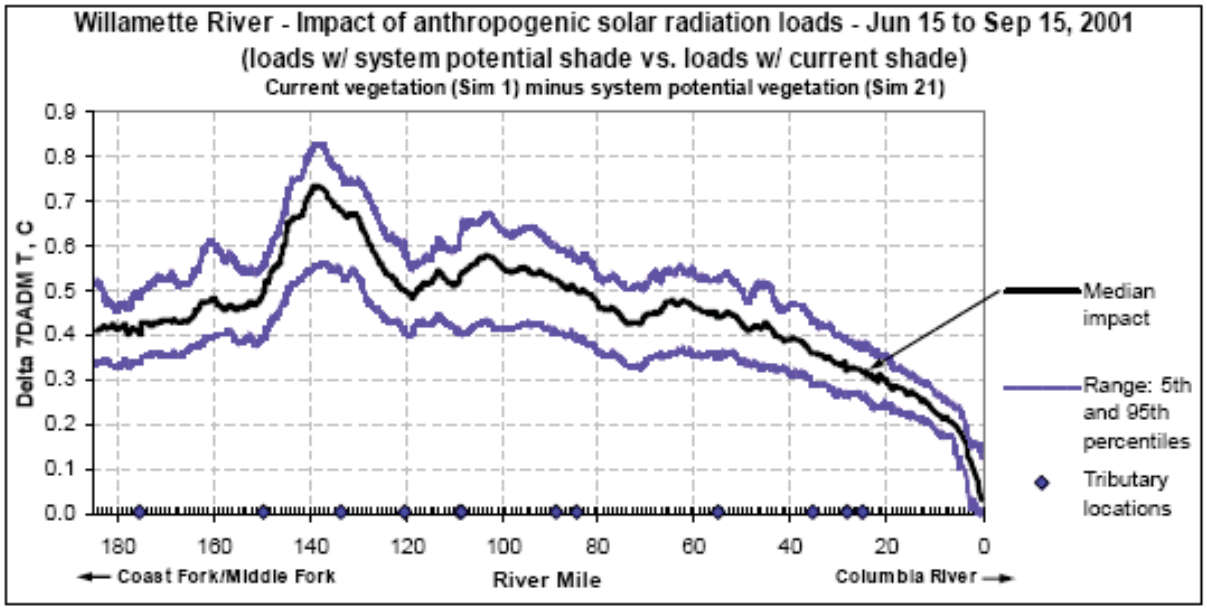


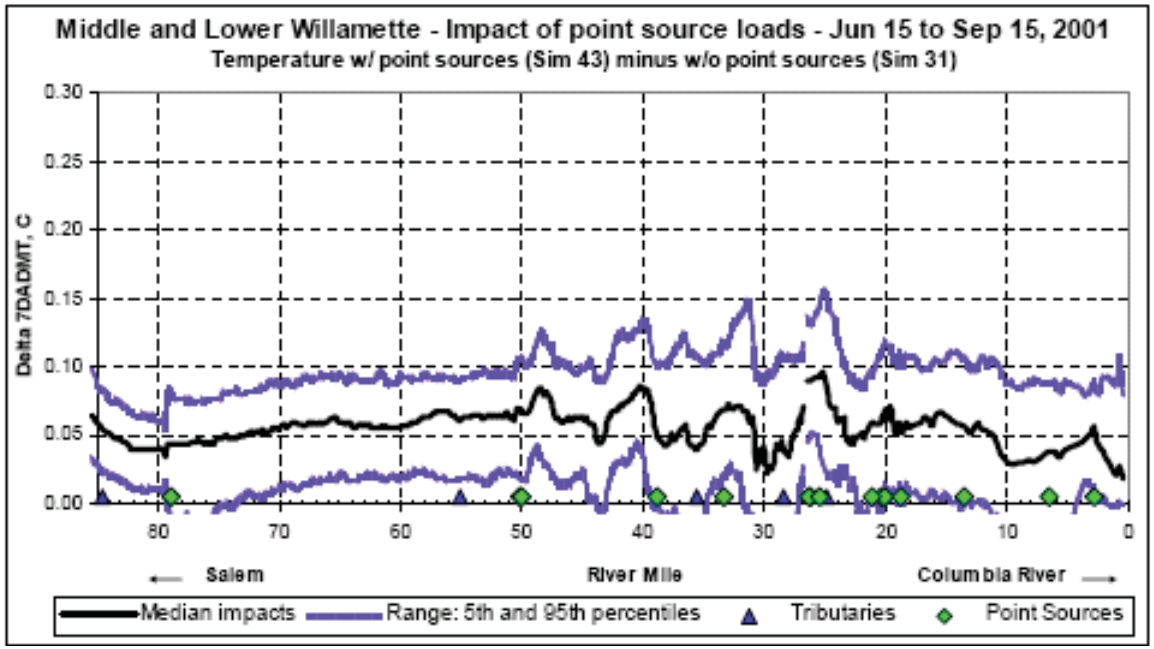
Figure 4.14 Maximum difference in seven day average of the daily maximum temperatures between 2001 calibrated model and 2001 calibrated model with system potential vegetation.



Nonpoint Source Impacts = Tenths of degrees

Point Source Impacts = Hundredths of degrees

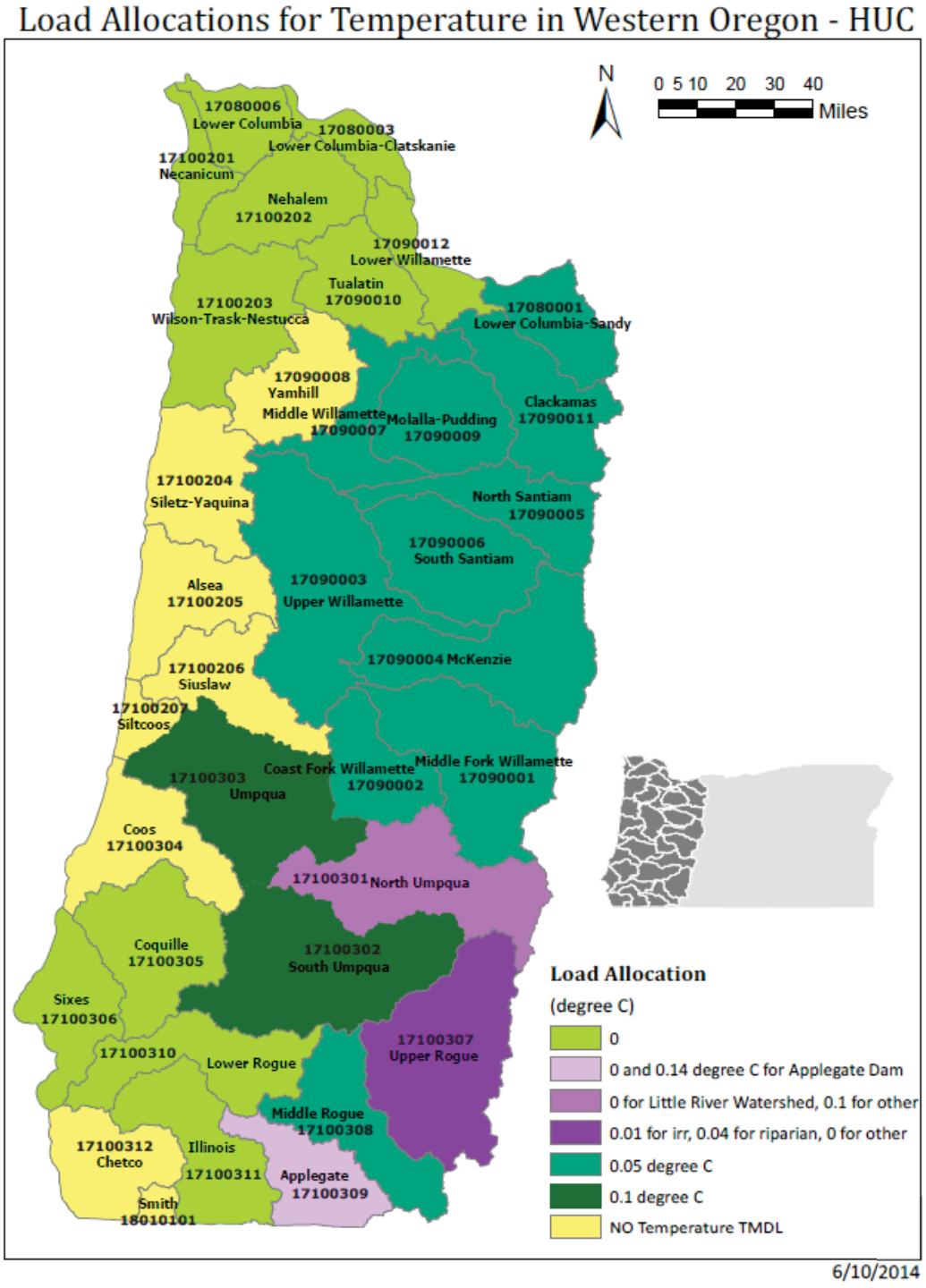
Figure 4.9 Current point source load effects on temperatures during late spring and summer 2001.



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

Temperature TMDLs in Western Oregon

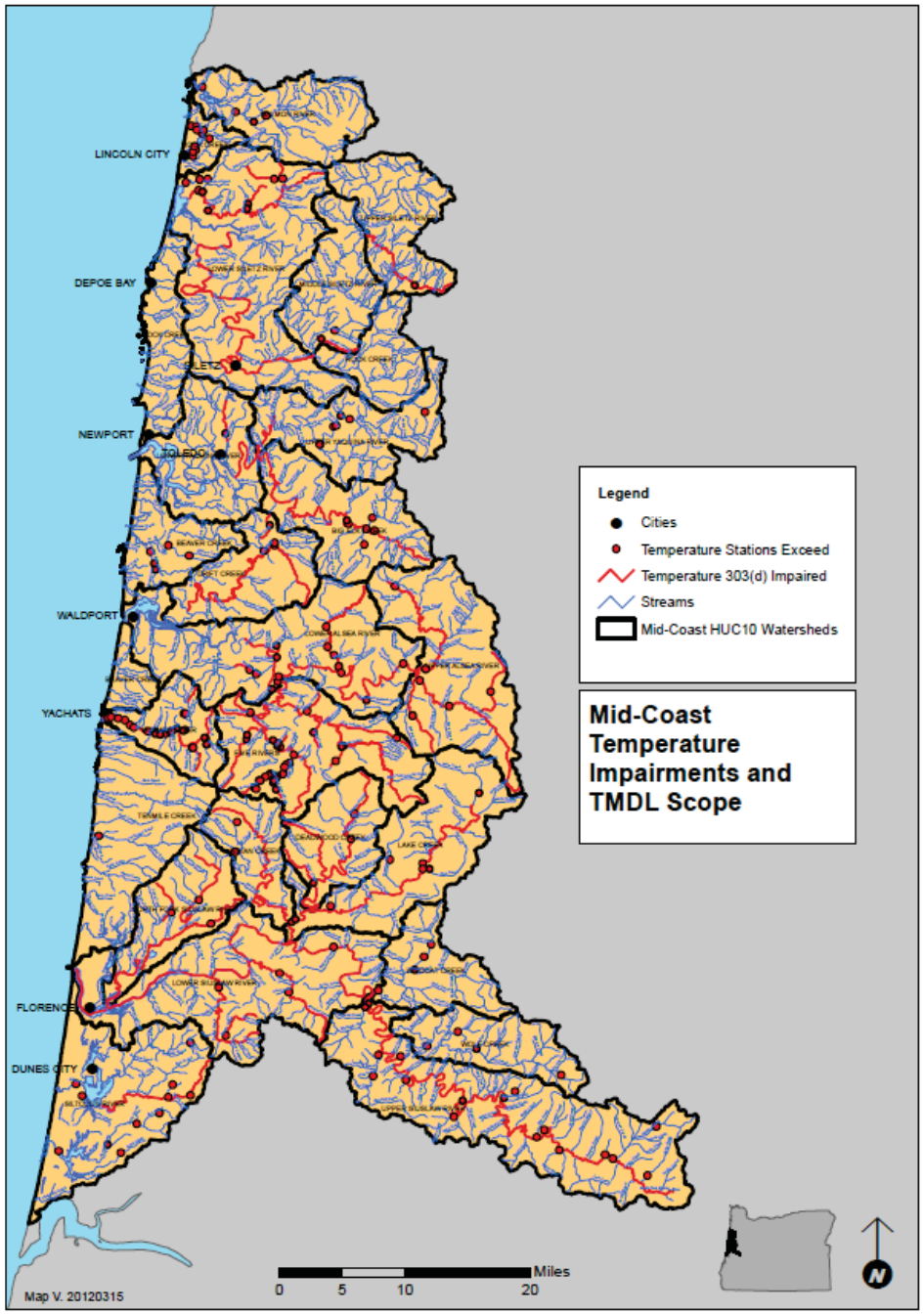
- Locations without Temperature TMDLs have 303(d) listings for temperature that require TMDL development.



Temperature TMDL development methods in the Mid Coast represent

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

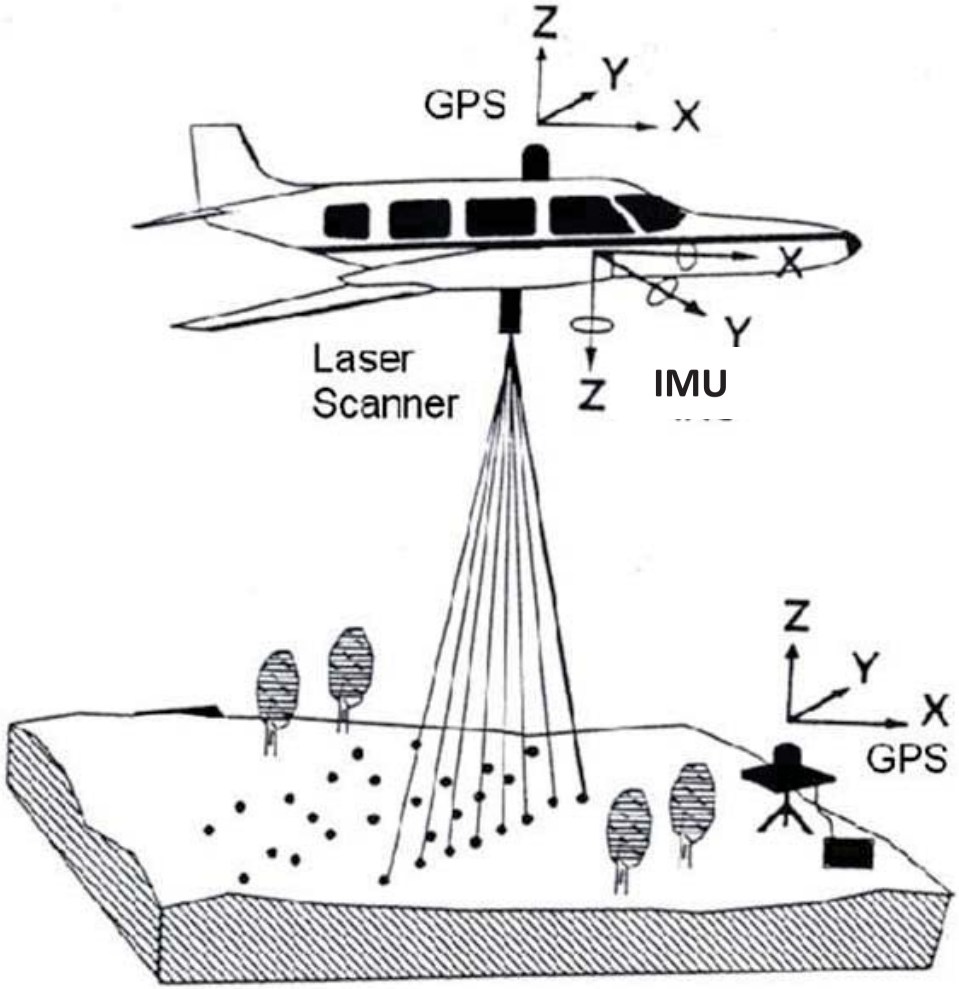


Temperature – Riparian Condition: Historic, Current, and Future Conditions

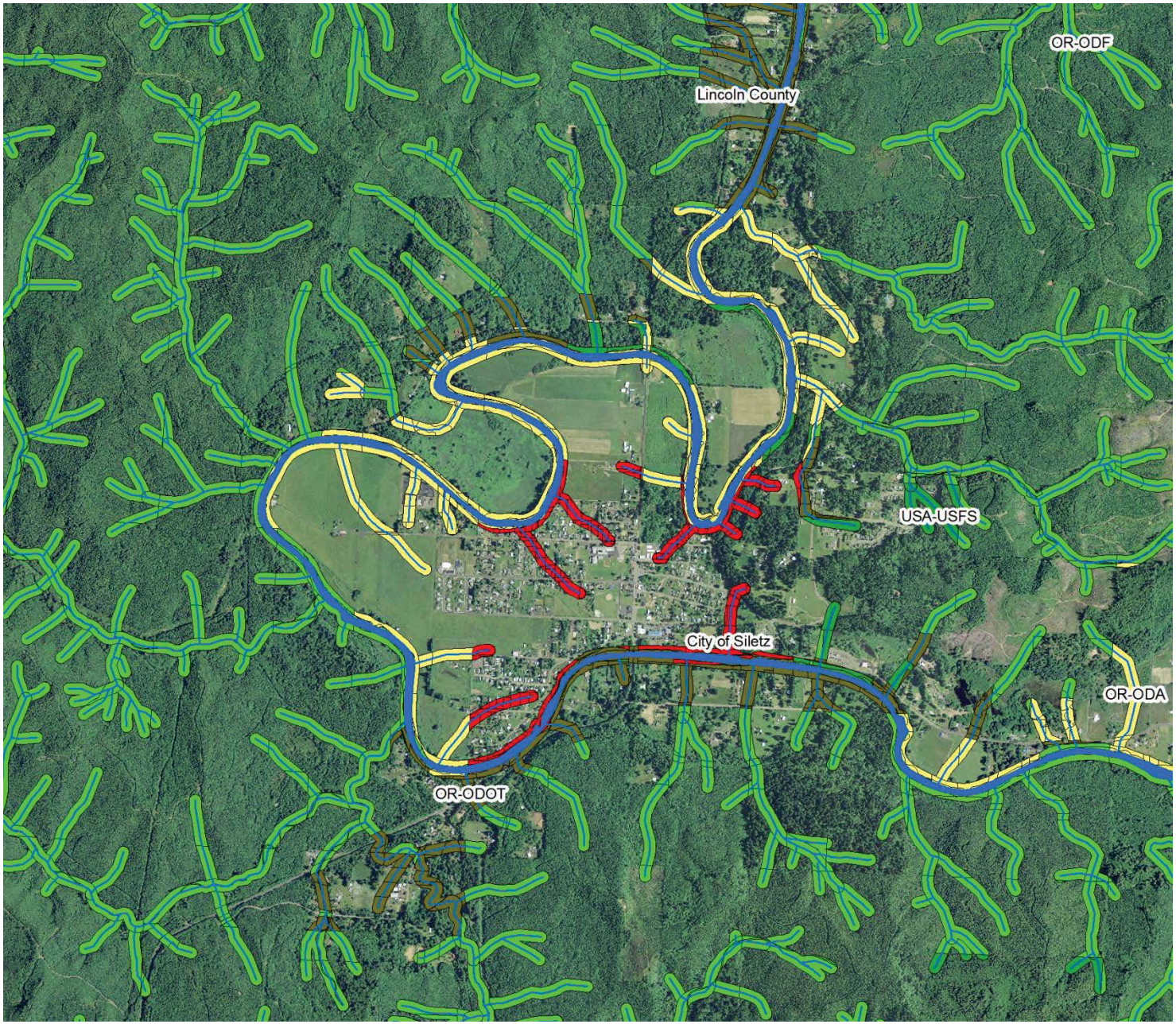
Vegetation Inventory

- Land Cover Classification
- Near Stream Area Delineation
- DMA / Responsible Person Mapping
- Example Results
- Example Prioritization

LiDAR (Light Detection and Ranging)

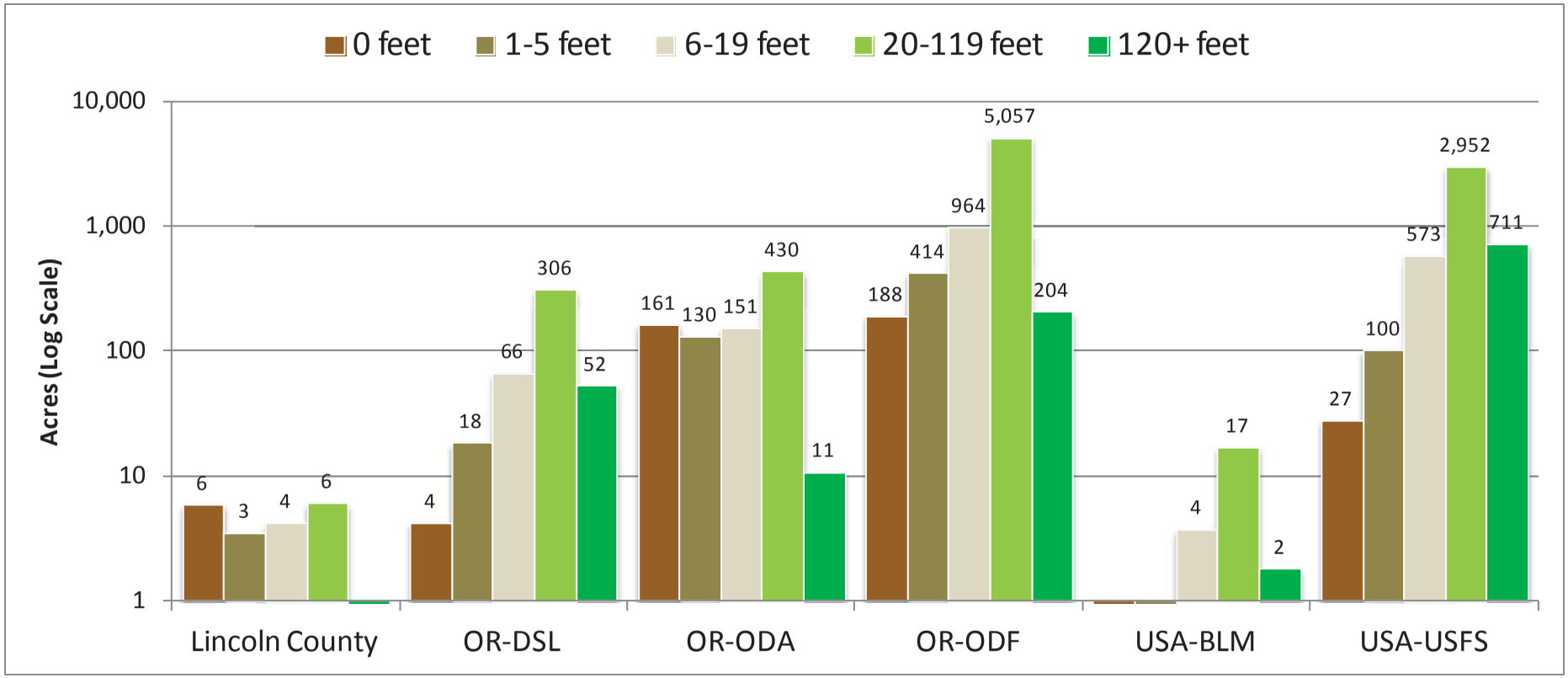


Near Stream Area DMA / Responsible Persons

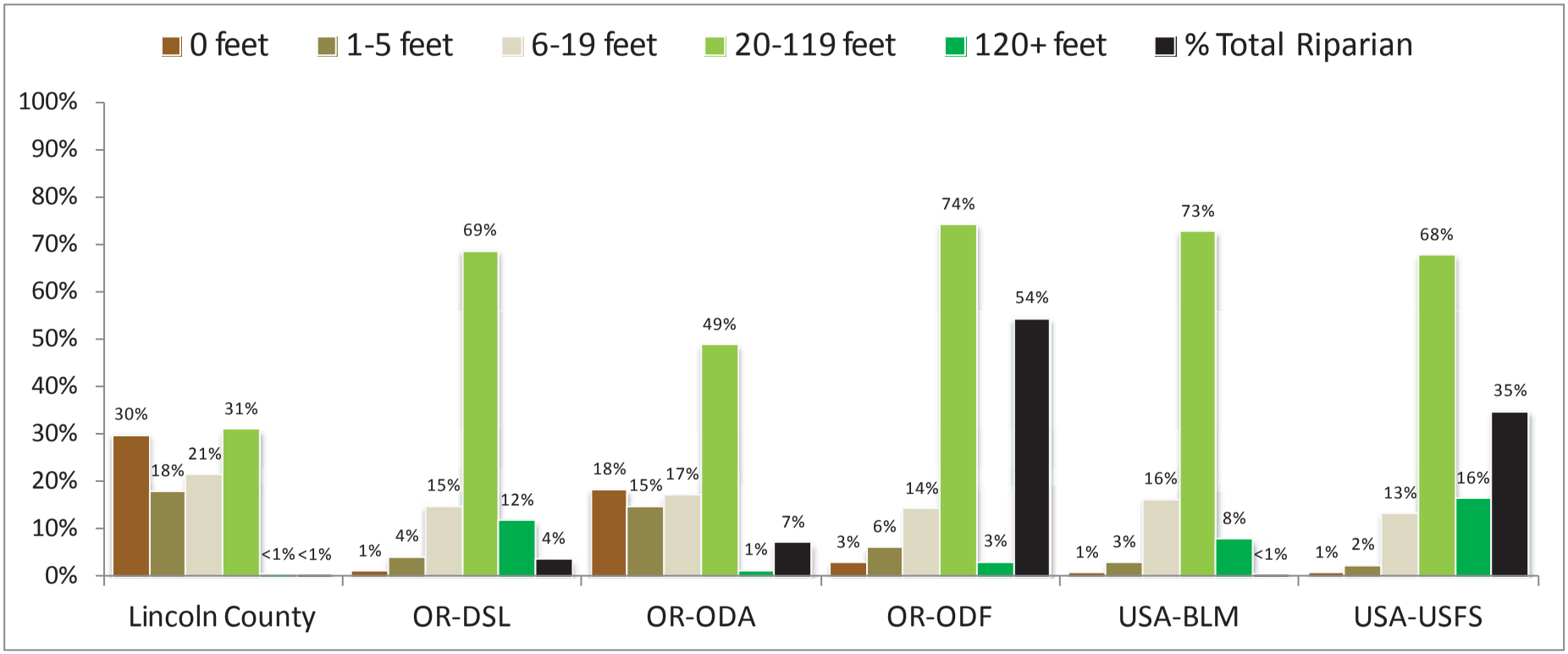


LiDAR Example: Big Elk Creek Watershed

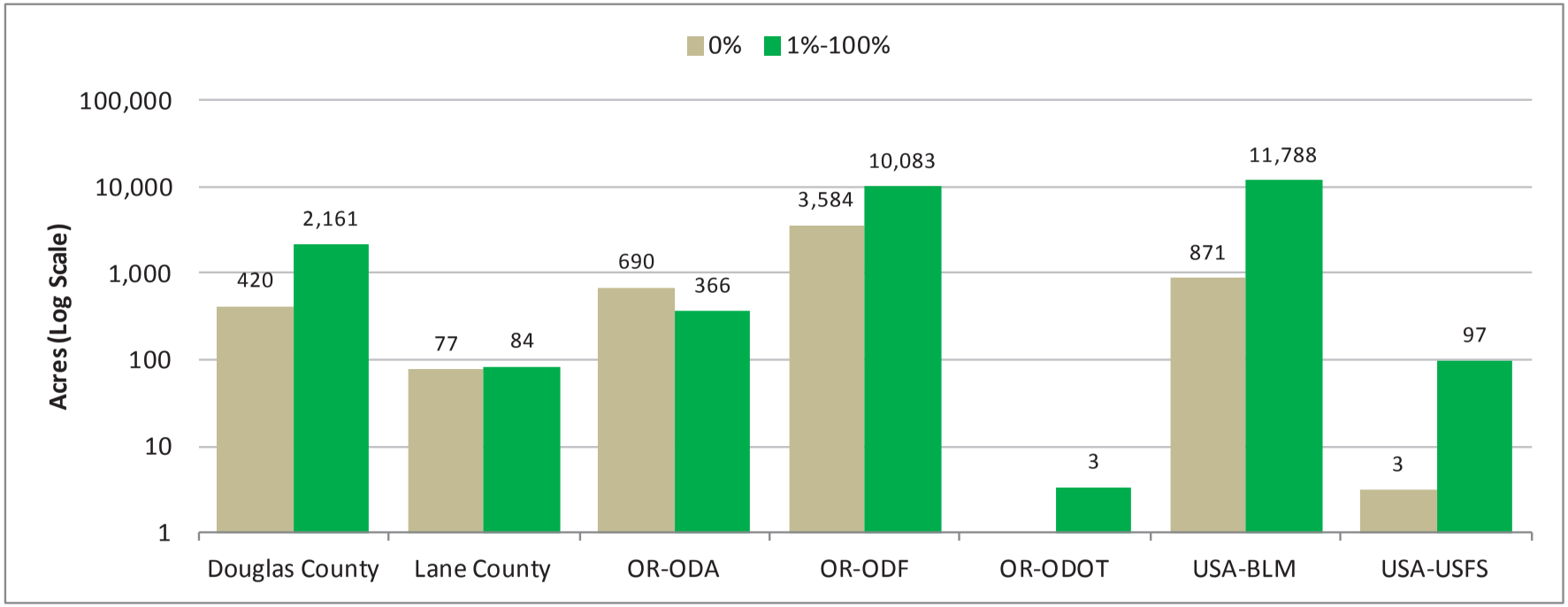
Acres in each LiDAR vegetation height classification within 30 meters of the stream in Big Elk Creek by DMA



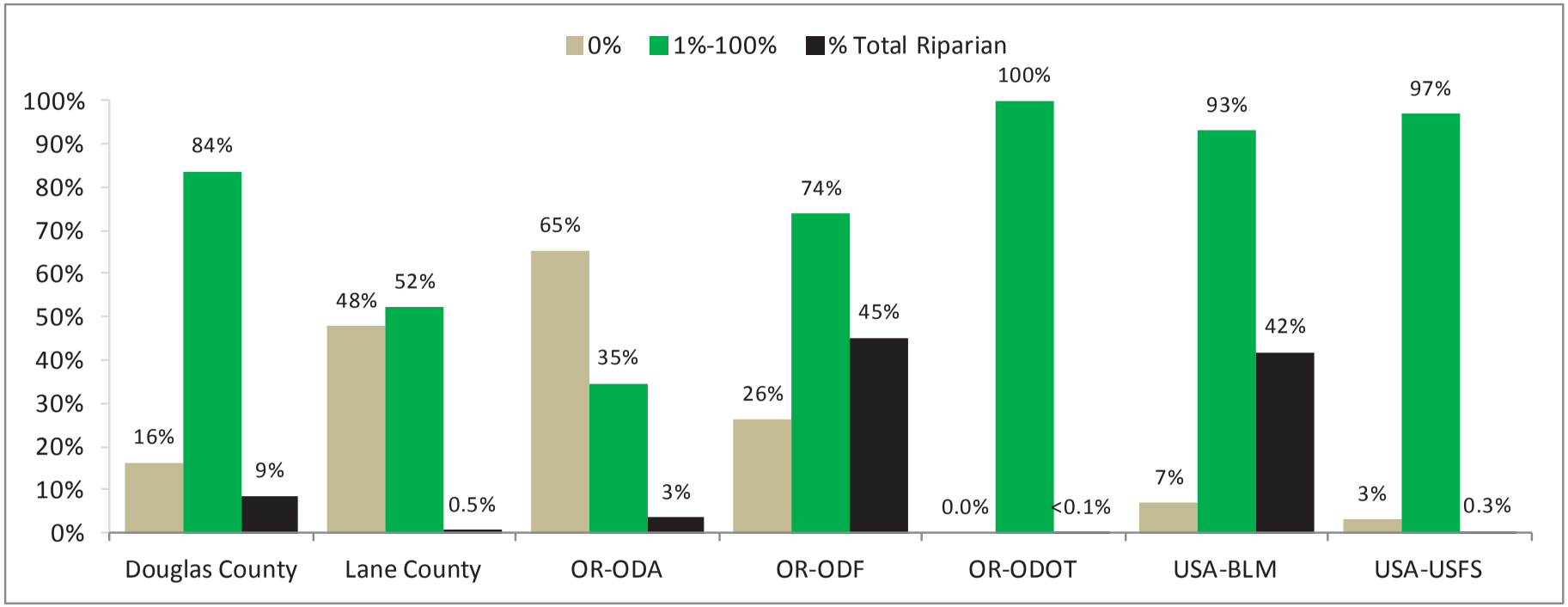
Percent area in each LiDAR vegetation height classification within 30 meters of the stream for each DMA in the Big Elk watershed

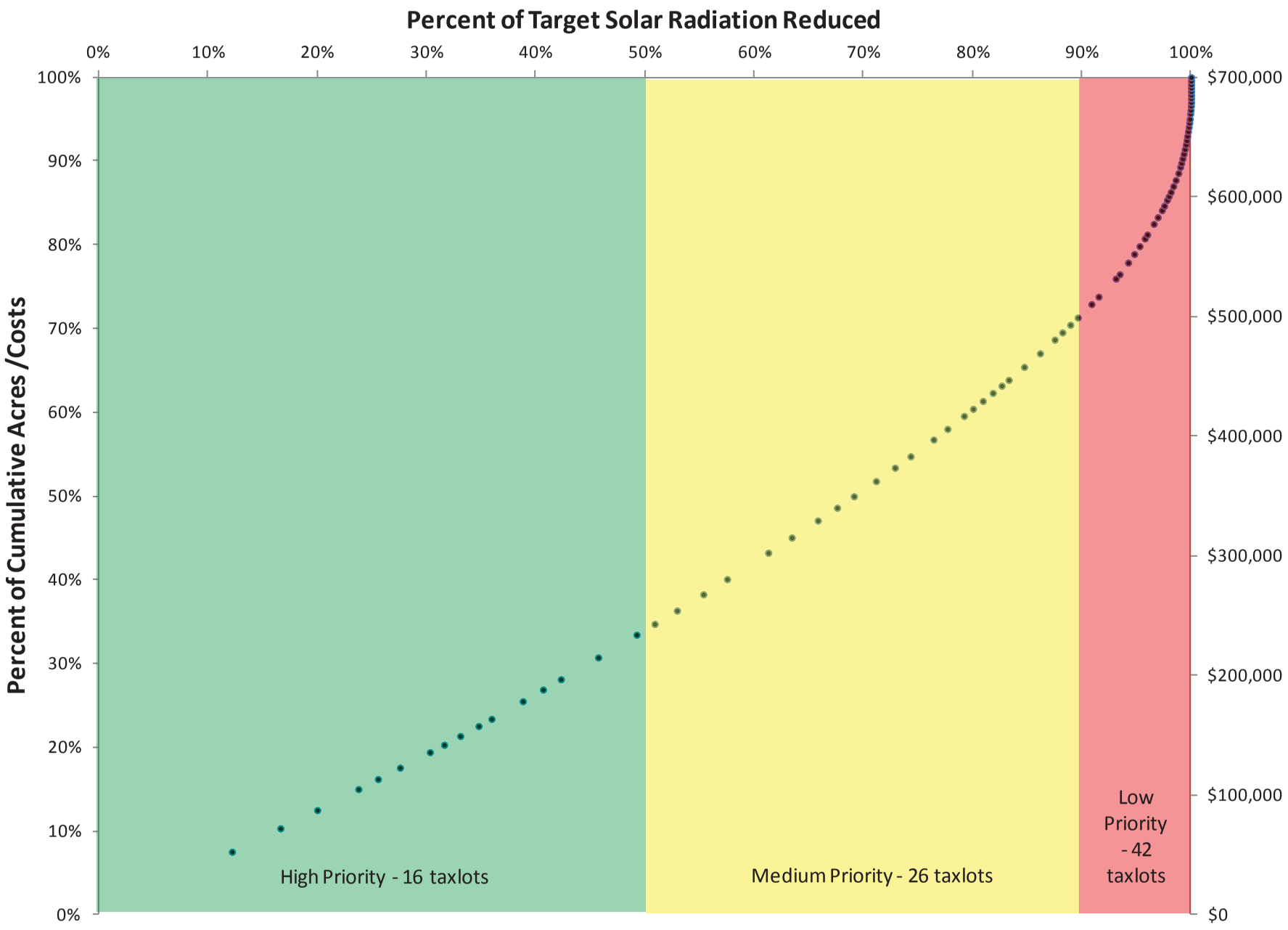


Acres in each NLCD vegetation canopy classification within 30 meters of the stream in the Upper Siuslaw River watershed by DMA



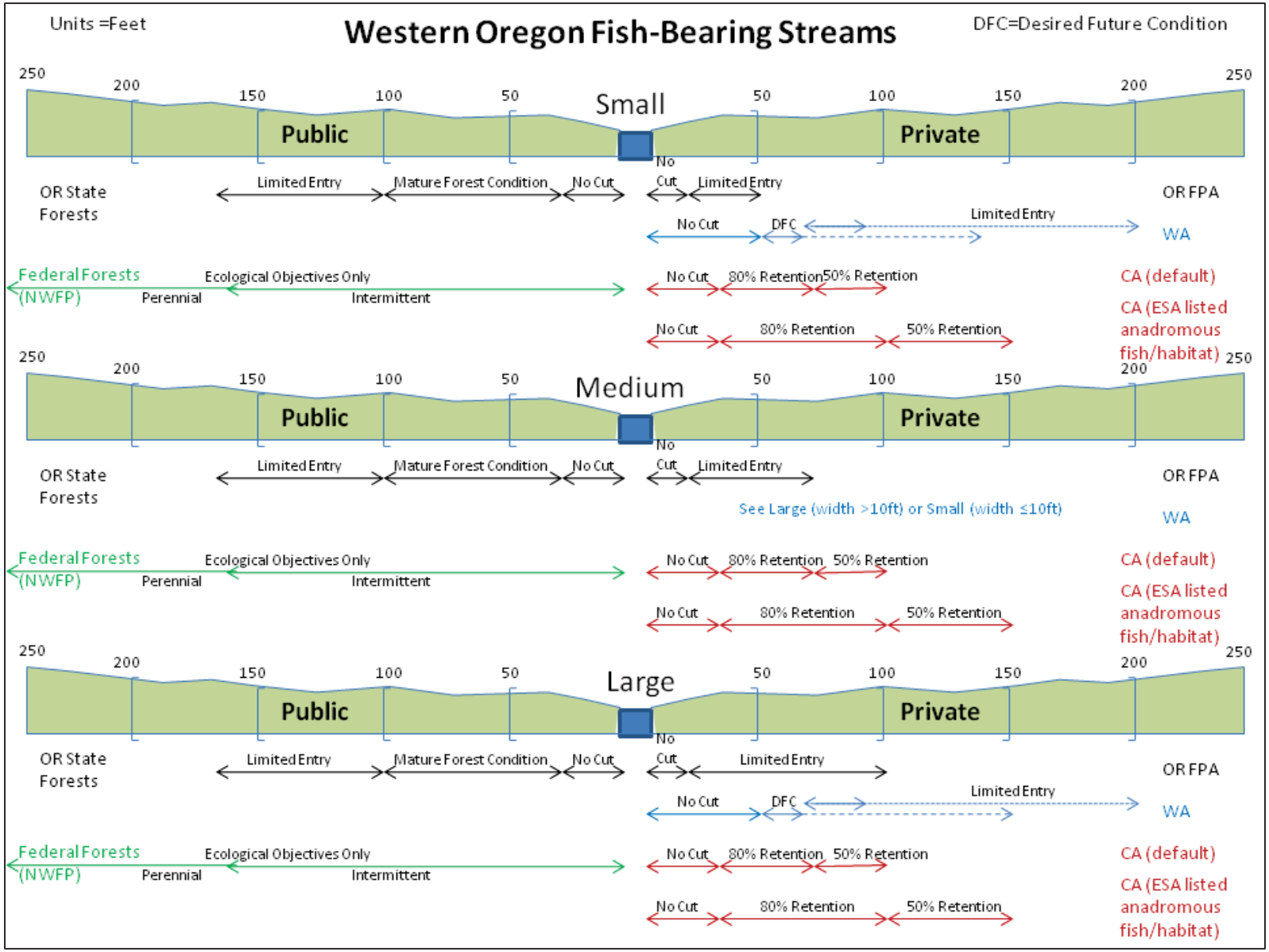
Percent area in each NLCD vegetation canopy classification within 30 meters of the stream for each DMA in the Upper Siuslaw River watershed




Percent of Target Solar Radiation Reduced
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Cumulative Acres /Costs
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
High Priority - 16 taxlots
Medium Priority - 26 taxlots
Low Priority - 42 taxlots

Protecting Cold Water Criterion

- WA temp standard
- CA temp/shade standard
- OR/WA/CA BMPs on Type-F or equivalent (figures)
- Note that this has been vetted with CA & WA


Units =Feet
Western Oregon Fish-Bearing Streams
DFC=Desired Future Condition
Small
Public
Private
250
200
150
100
50
No Cut
OR State Forests
Limited Entry
Mature Forest Condition
No Cut
Limited Entry
OR FPA
No Cut
DFC
Limited Entry
WA
Federal Forests (NWFP)
Ecological Objectives Only
Perennial
Intermittent
No Cut
80% Retention
50% Retention
CA (default)
CA (ESA listed anadromous fish/habitat)
Medium
See Large (width >10ft) or Small (width ≤10ft)
Large

Questions?

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

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.