Assessing the Status of Riparian Restoration, Protection, and Shading in the Southern Willamette Basin

TMDL Implementation Workshop
Salem, OR | April 3, 2019

Ryan Michie
Oregon Department of Environmental Quality

Source: Ryan Michie

Background

Project Questions and Objectives

Results

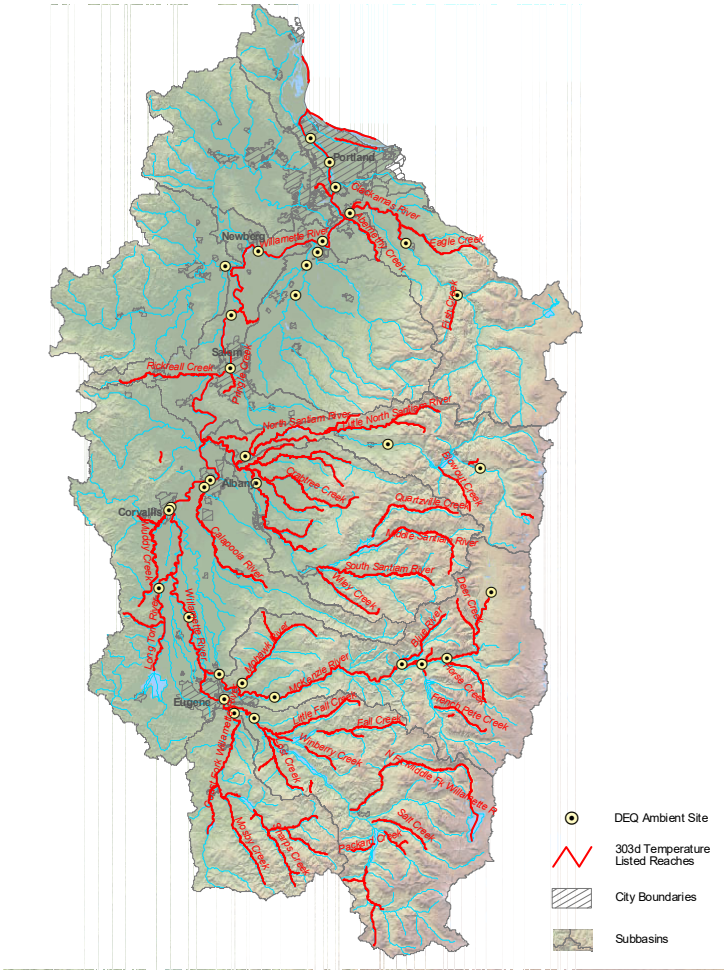
Willamette Basin Temperature TMDLs

~1300 known miles of streams impaired (DEQ 1998, 2002)

TMDL Approved by EPA in 2006

Major sources of warming

- Loss of streamside vegetation
- Dams / dam management
- Loss of channel complexity
- Water withdrawals
- Point source discharges



DEQ
State of Oregon Department of Environmental Quality

Willamette TMDL pollution reduction targets and other measures

Picture Source: Ryan Michie

Reduction in solar radiation load* = 14.53 teracalories/day

* along modeled streams

Restore and protect streamside vegetation

Achieve effective shade targets

Stream temperature targets for dams/reservoirs

Cold water refuge requirements

Point source effluent discharge limits

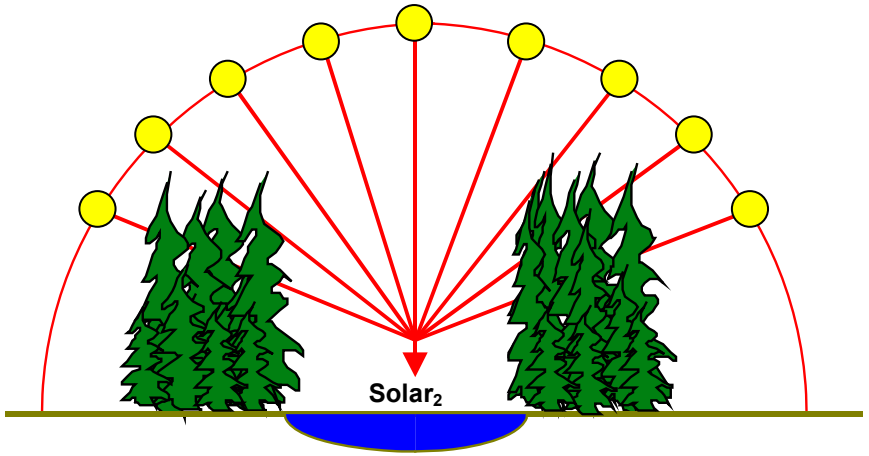
Effective Shade

Percent of the daily solar radiation flux blocked by vegetation and topography

Solar pathfinder

Picture Source: Ryan Michie

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

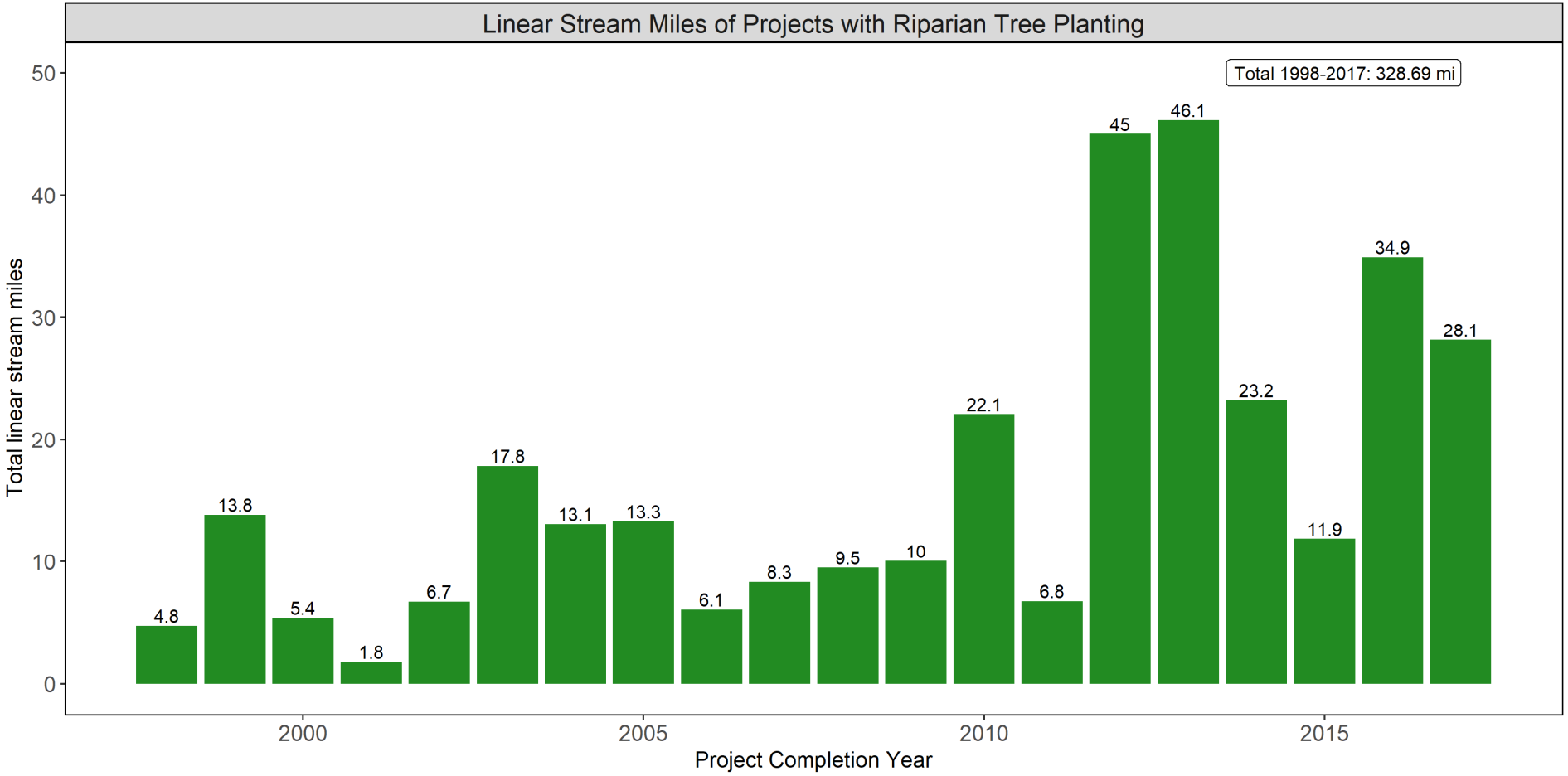
Study Questions

- **How much riparian tree planting and protection has been completed?**
  - Where are these projects located?
  - When were they implemented?
  - How much has been spent on these projects?
  - Who are the funders?
  - What is the expected solar radiation reduction?

- **What are current effective shade levels and status toward achieving the TMDL shade targets?**

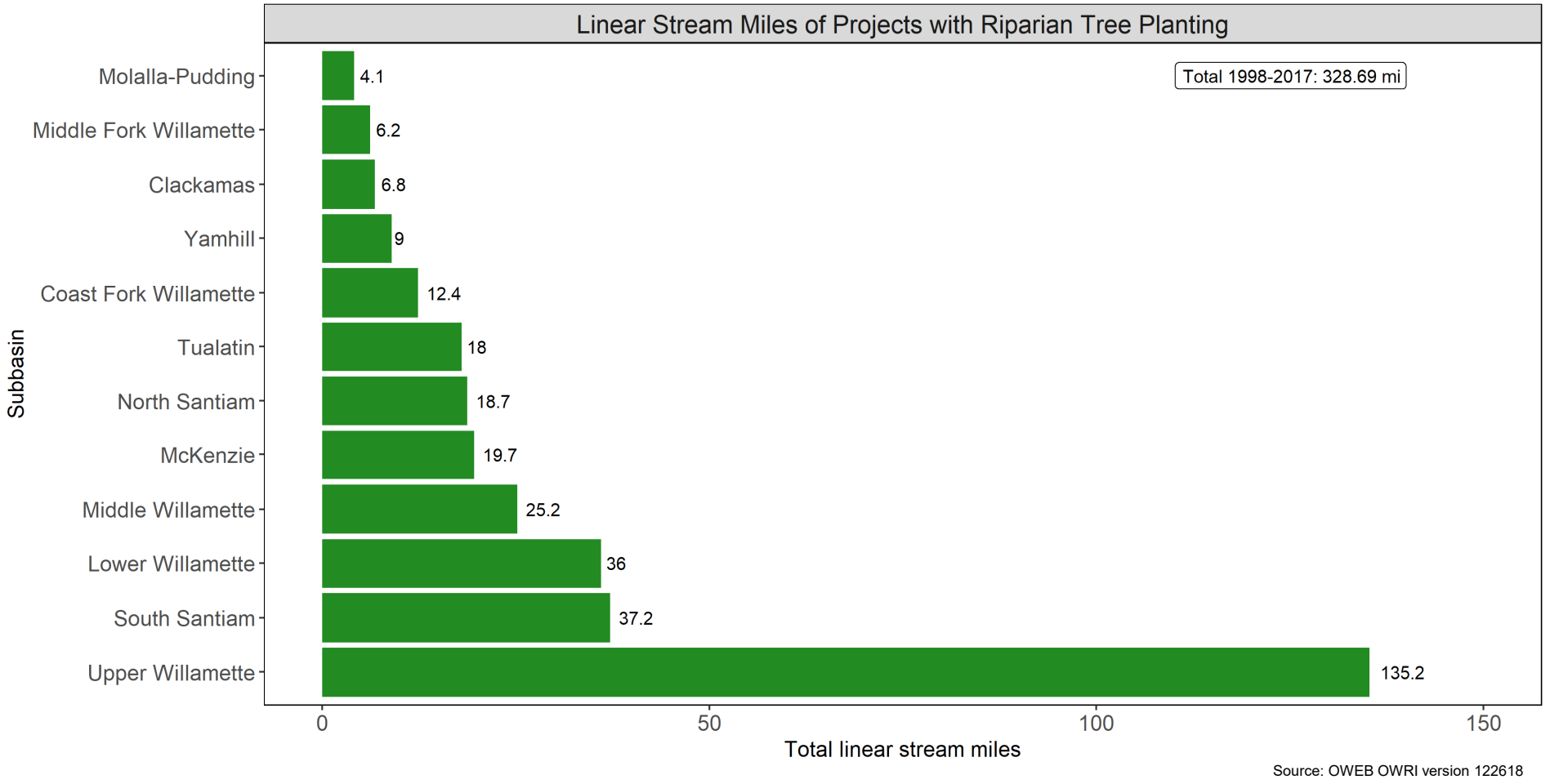
- **What are the stream temperature trends?**

How much riparian tree planting has been completed in the Willamette Basin?



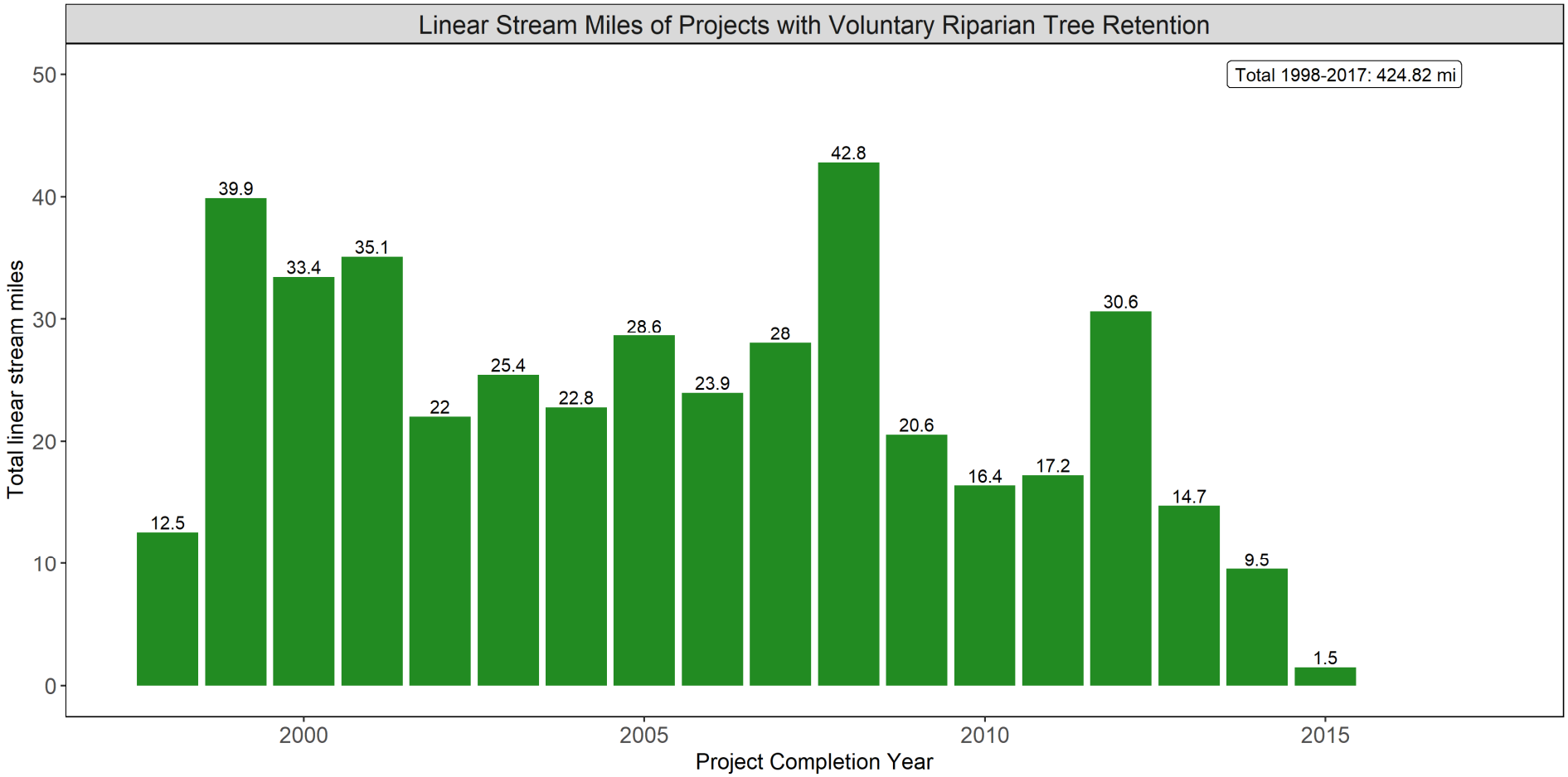
Source: OWEB OWRI version 122618

Riparian tree planting by Willamette Subbasins



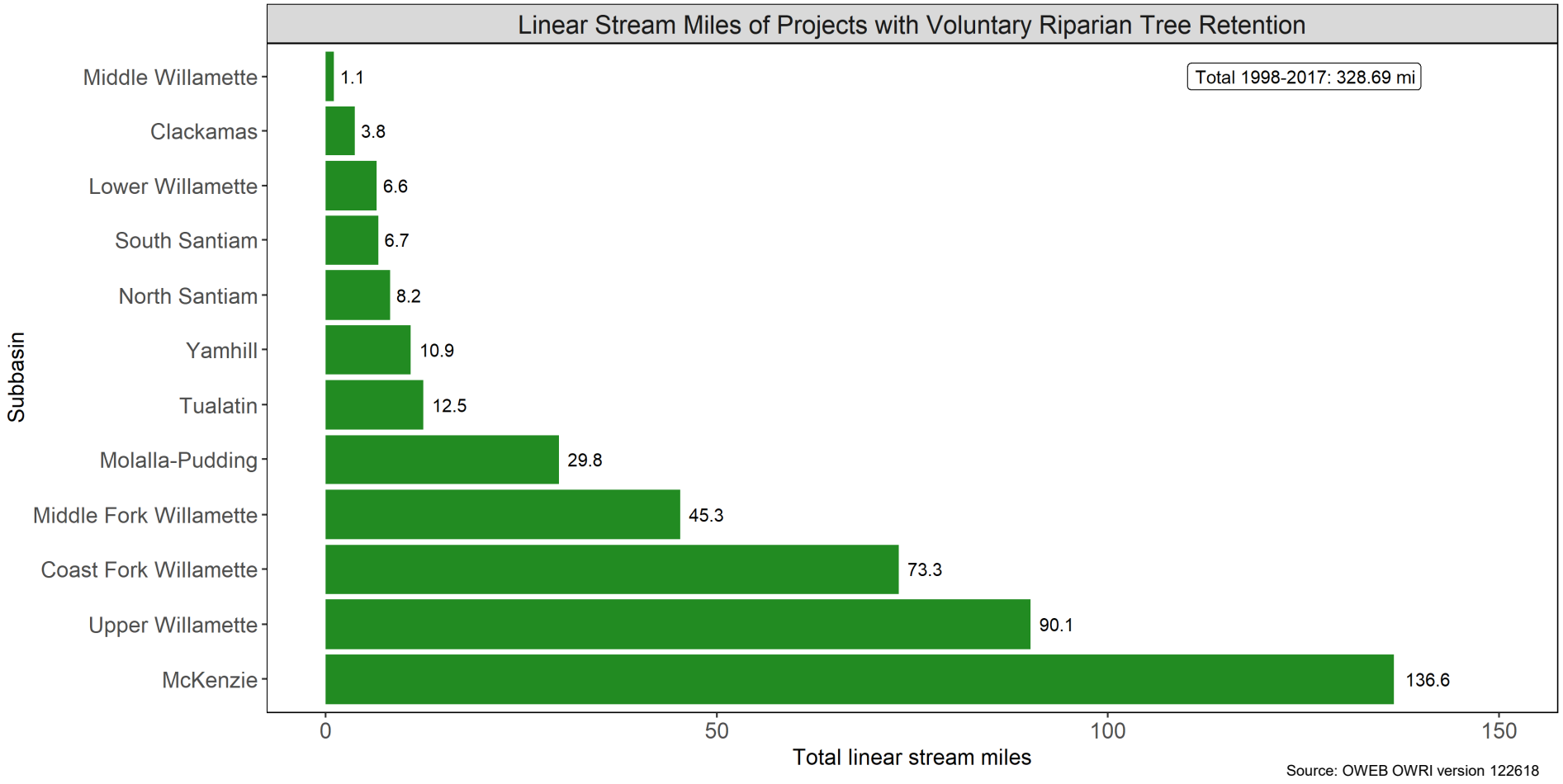
Source: OWEB OWRI version 122618

How much riparian tree protection has been completed in the Willamette Basin?



Source: OWEB OWRI version 122618

Riparian tree protection by Willamette Subbasins



Who are the Top Funders?

Projects with Riparian Tree Planting
1998 – 2017

Participant	Cash	Inkind	Total
City of Portland	$ 22,956,061	$3,008,739	$ 25,964,800
OWEB	$ 15,877,321	$ -	$ 15,877,321
ODFW	$ 1,176,565	$ 254,109	$ 1,430,674
Clackamas County	$ 710,731	$ 464,498	$ 1,175,229
Private Landowners	$ 374,875	$ 675,037	$ 1,049,912
ODOT	$ 934,800	$ 15,400	$ 950,200
BPA	$ 941,302	$ -	$ 941,302
USFS	$ 701,283	$ 190,154	$ 891,437
NRCS	$ 716,975	$ 47,844	$ 764,819
Clean Water Services	$ 563,418	$ 173,224	$ 736,642
City of Eugene	$ 667,000	$ 1,832	$ 668,832
USFWS	$ 277,681	$ 380,611	$ 658,292
Meyer Memorial Trust	$ 604,636	$ 6,000	$ 610,636
McKenzie River Trust	$ 111,955	$ 331,381	$ 443,336
Farm Service Agency	$ 389,130	$ 22,710	$ 411,840

Note: Totals by funder reflect total project contribution which may include additional activities beyond tree planting or tree retention.

Source: OWEB OWRI version 122618

Who are the Top Funders?

Projects with Voluntary Riparian Tree Retention 1998 – 2017

Participant	Cash	Inkind	Total
Longview Fibre Co.	$2,066,064	$ -	$ 2,066,064
Willamette Industries	$ 203,521	$1,090,983	$ 1,294,504
Longview Timberlands LLC	$ 157,630	$ 249,410	$ 407,040
Starker Forests	$ 194,954	$ 95,200	$ 290,154
Weyerhaeuser Company	$ 152,228	$ 43,752	$ 195,980
Port Blakely Tree Farms	$ -	$ 17,700	$ 17,700
Hampton Resources	$ 552	$ 12,500	$ 13,052
Giustina Land and Timber Co.	$ -	$ 8,500	$ 8,500
Roseburg Resources Company	$ 1,500	$ -	$ 1,500

Note: Totals by funder reflect total project contribution which may include additional activities beyond tree retention.

Source: OWEB OWRI version 122618

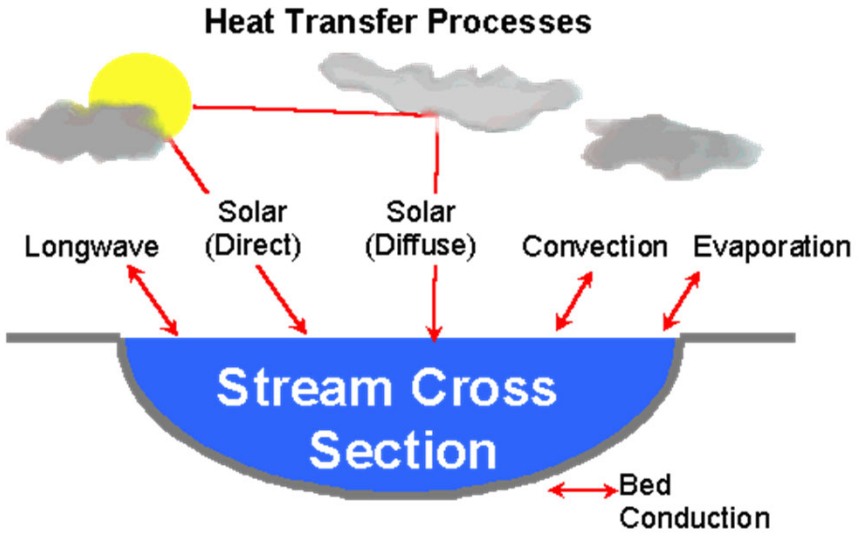
What are current effective shade levels and status toward achieving the TMDL shade targets?

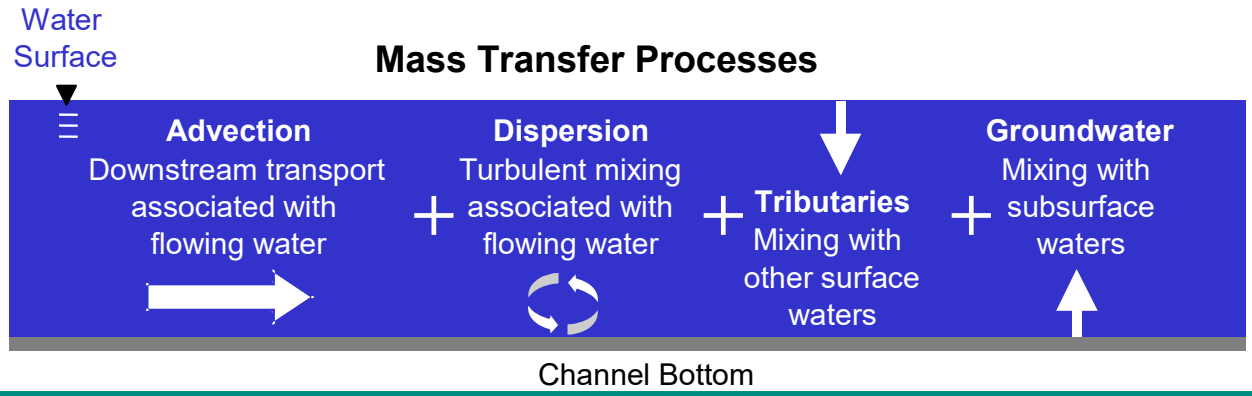
Solar pathfinder

Picture Source: Ryan Michie

- Mechanistic model
- Simulates 1D open channel hydraulics, heat flux, mass transfer, and stream temperature
- Developed in 1996 at Oregon State University
- Independently peer reviewed
- Applied in multiple published studies
- Open source: https://github.com/rmichie/heatsource-9

http://www.deq.state.or.us/wq/TMDLs/tools.htm


Heat Transfer Processes
Solar
(Direct)
Solar
(Diffuse)
Longwave
Convection
Evaporation
Stream Cross
Section
Bed
Conduction


Water
Surface
Mass Transfer Processes
Advection
Downstream transport
associated with
flowing water
Dispersion
Turbulent mixing
associated with
flowing water
Tributaries
Mixing with
other surface
waters
Groundwater
Mixing with
subsurface
waters
Channel Bottom

Model Inputs

Solar Modeling

Land Use/Land Cover
- Height / Elevation
- Canopy Closure / LAI
- Overhang
- Topographic Shade Angles

Stream Position
- Longitude
- Latitude

Channel Morphology
- Stream Elevation
- Gradient
- Bottom Width
- Channel Angle Z

Boundary Conditions & In/Out Flows
- Stream Temperature
- Stream Flow

Met Data
- Cloudiness
- Wind Speed
- Wind Coefficients “a” & “b”
- Relative Humidity
- Air Temperature

Substrate
- Deep Alluvium Temperature
- Sediment Thermal Conductivity
- Sediment Thermal Diffusivity
- Hyporheic zone thickness
- Percent Hyporheic exchange
- Porosity

Model Outputs

Temperature
- Stream Temperature
- Sediment Temperature

Flux
- Streambed Conduction
- Convection
- Evaporation
- Longwave

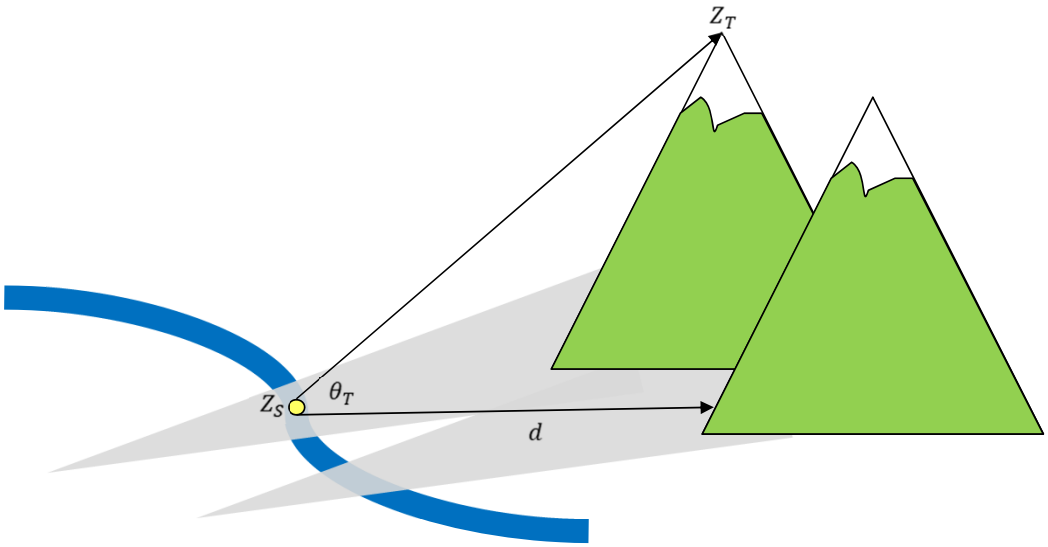
Solar Modeling
- Solar Radiation (Above Topography)
- Solar Radiation (Blocked by LULC)
- Solar Radiation (Above Stream Surface)
- Solar Radiation (Penetrating Stream)
- Effective Shade

- Thermal Radiation (Total)

Hydraulics
- Flow Rate
- Hyporheic Exchange (cms)
- Flow Velocity
- Top Wetted Width
- Average Wetted Depth
- Maximum Wetted Depth

Others
- Hydraulic Dispersion (square meters/second)
- Evaporation Rate (mm/hour)
- View To Sky

Topographic Shade Angles

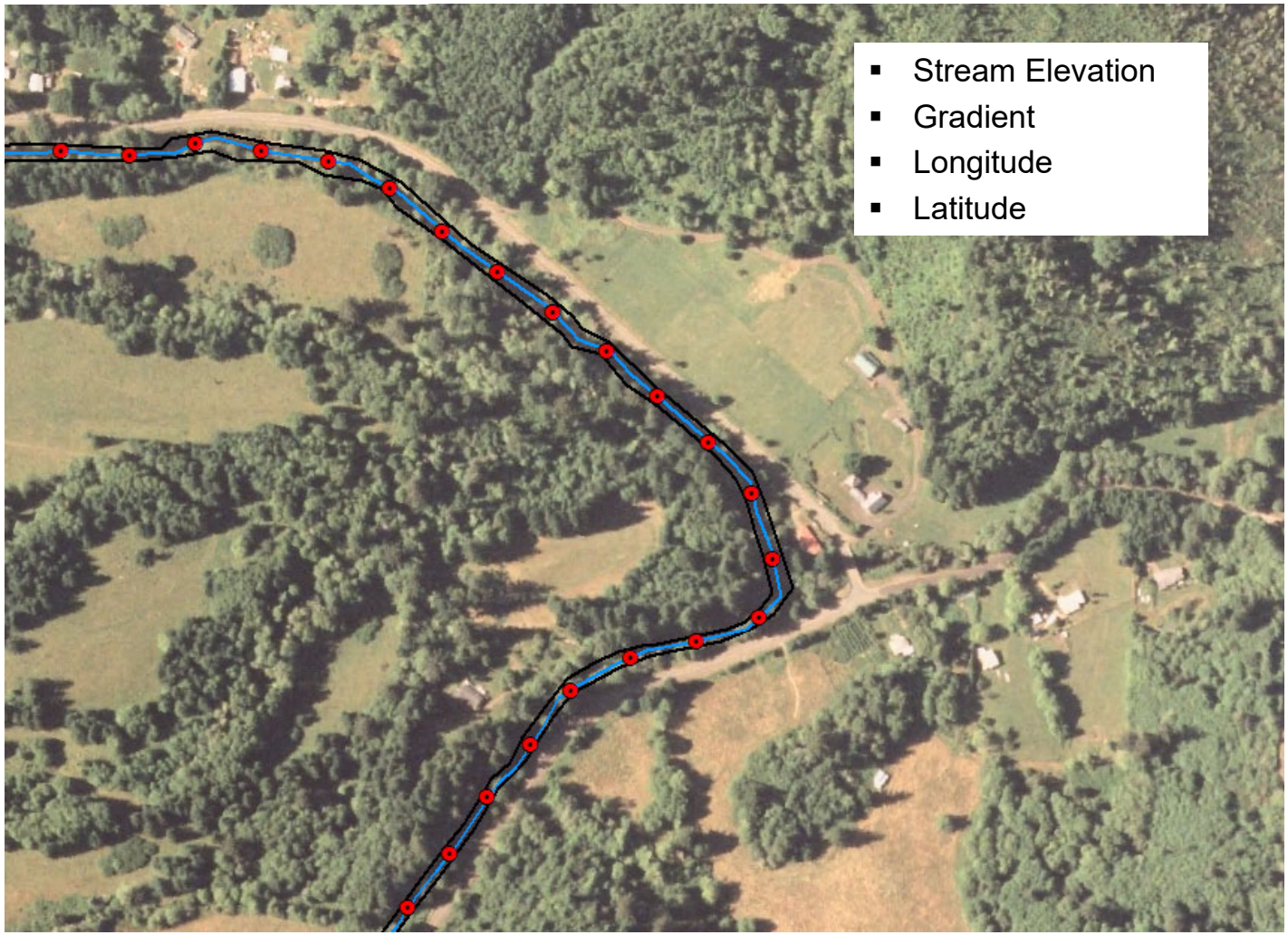


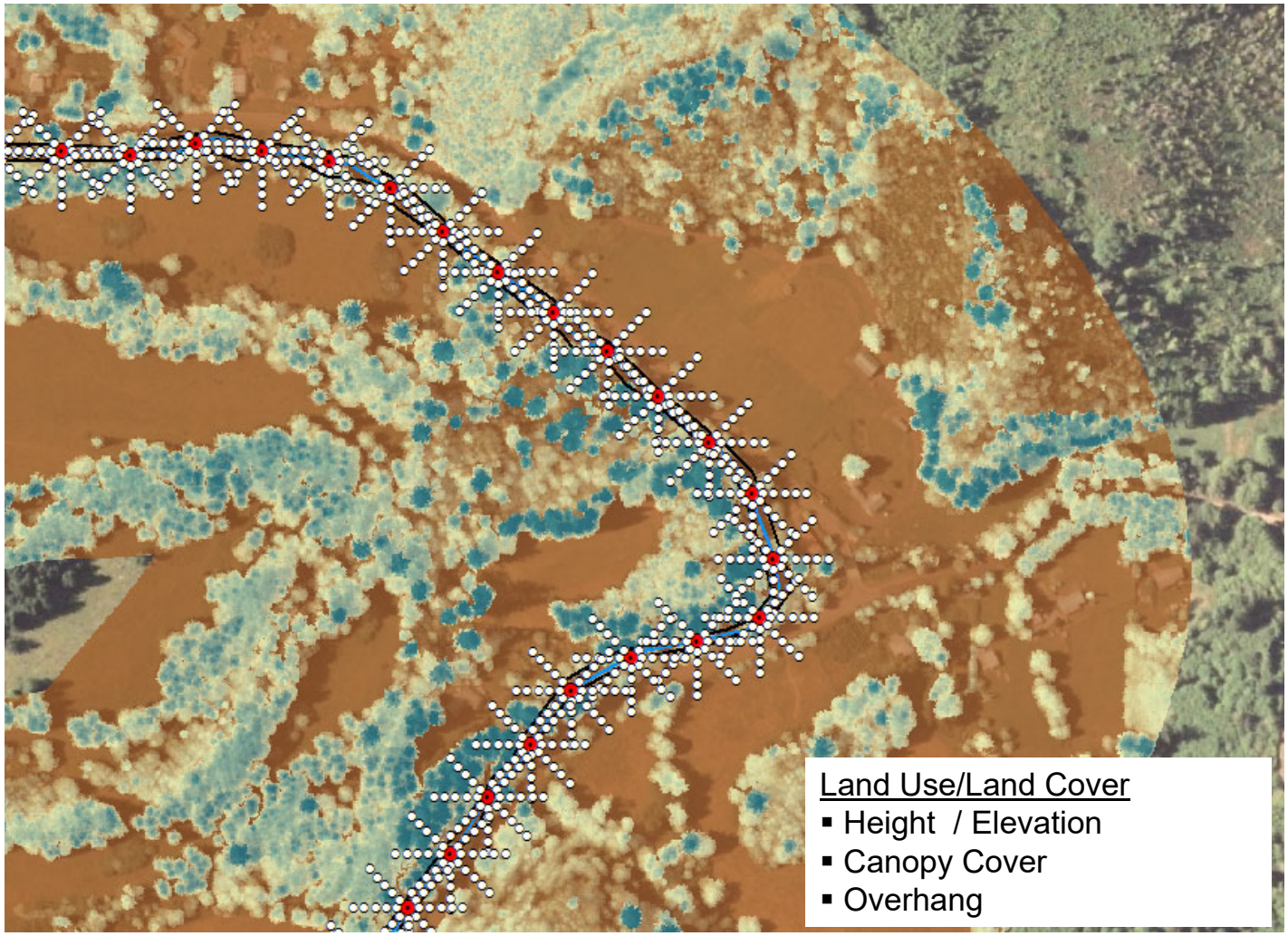
$$\theta_T = \tan^{-1}\left(\frac{Z_T - Z_S}{d}\right)$$ **Topographic Shade Angle**

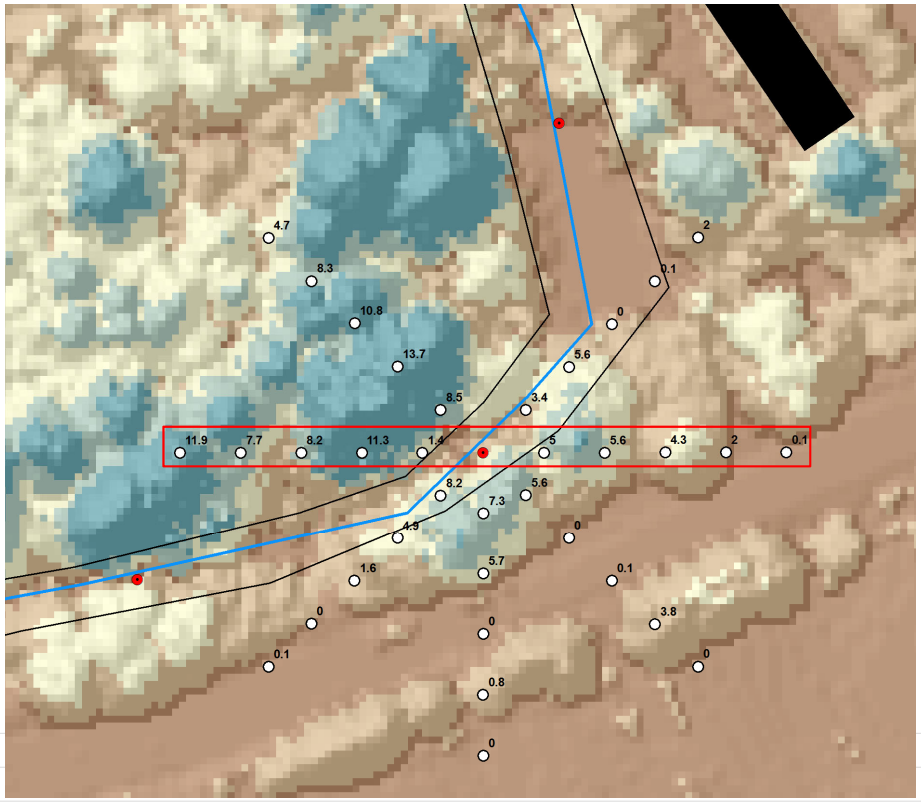
where,

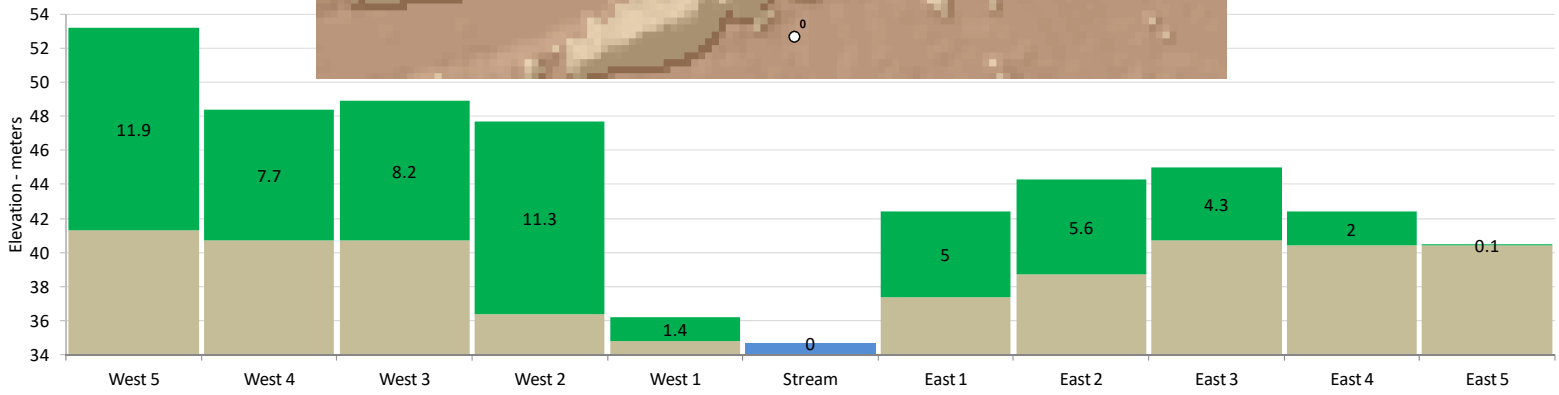
$\theta_T =$	The topographic shade angle (degrees)
$Z_T =$	The elevation (meters) at the topographic feature.
$Z_S =$	The elevation (meters) at the stream node.
$d =$	Horizontal distance (meters) from the stream node to the topographic feature.

Stream Position

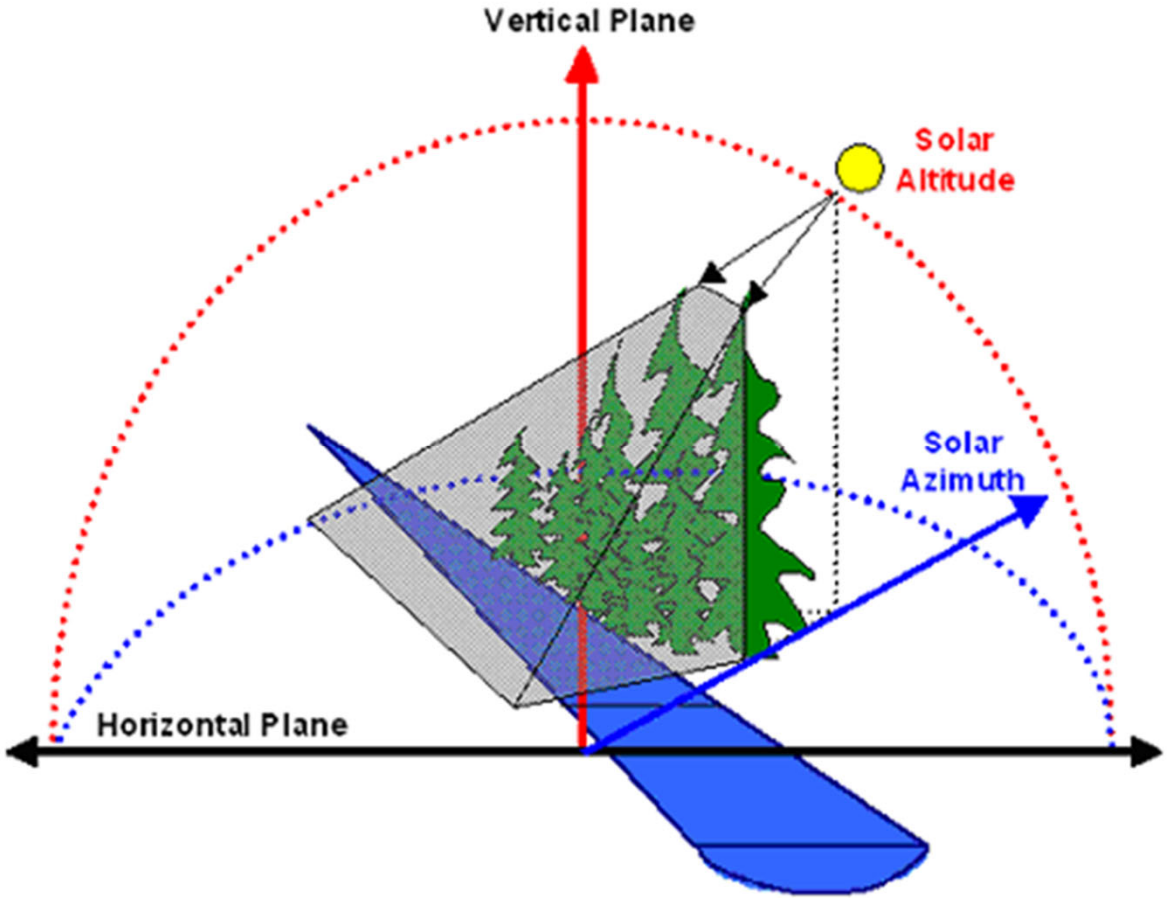



Land Use/Land Cover
▪ Height / Elevation
▪ Canopy Cover
▪ Overhang

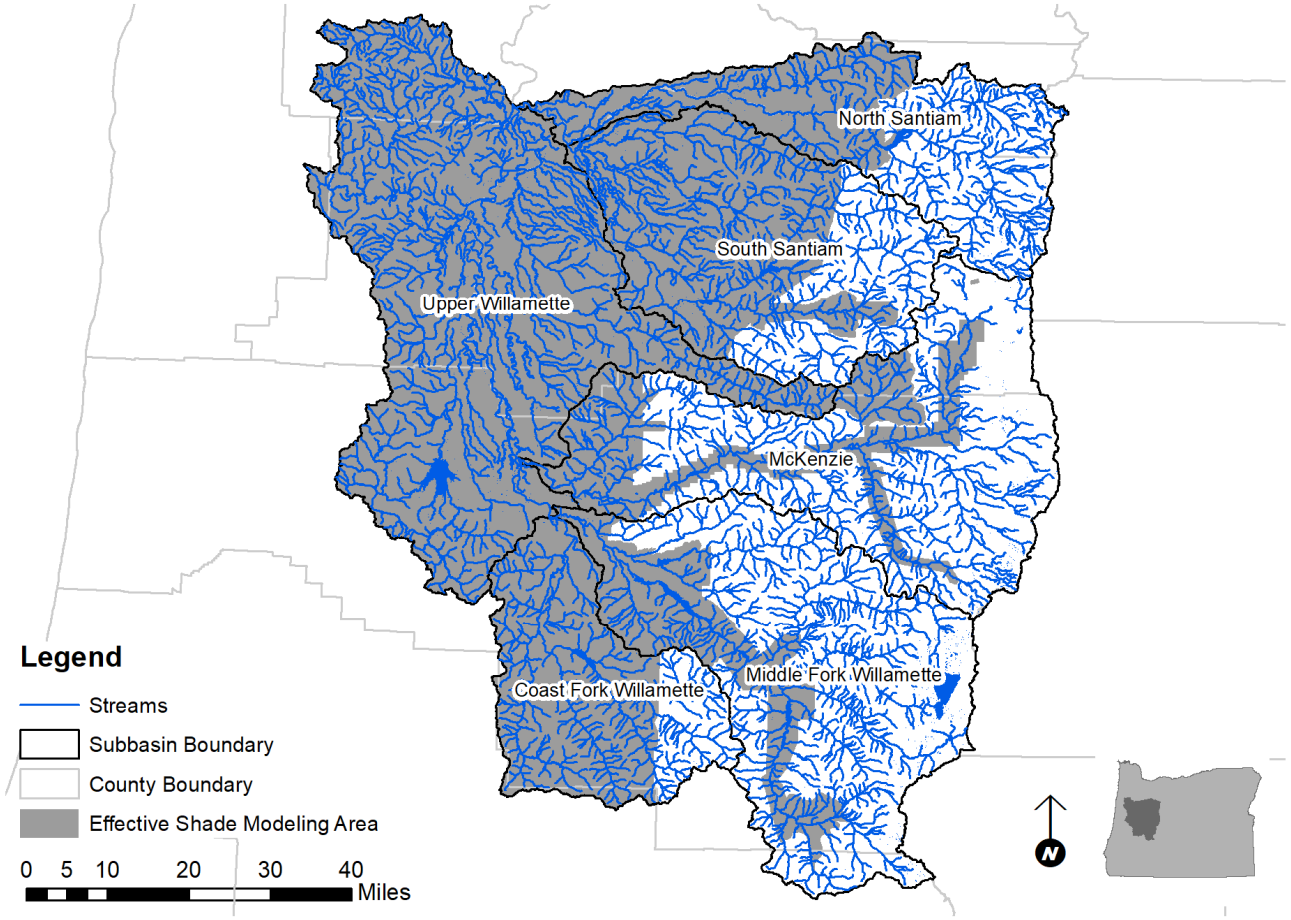

4.7
8.3
10.8
13.7
8.5
3.4
5.6
0
0.1
2
11.9
7.7
8.2
11.3
1.4
5
5.6
4.3
2
0.1
8.2
7.3
5.6
4.9
0
1.6
5.7
0.1
0
0
3.8
0.1
0
0.8
0


Elevation - meters
54
52
50
48
46
44
42
40
38
36
34
11.9
7.7
8.2
11.3
1.4
0
5
5.6
4.3
2
0.1
West 5
West 4
West 3
West 2
West 1
Stream
East 1
East 2
East 3
East 4
East 5

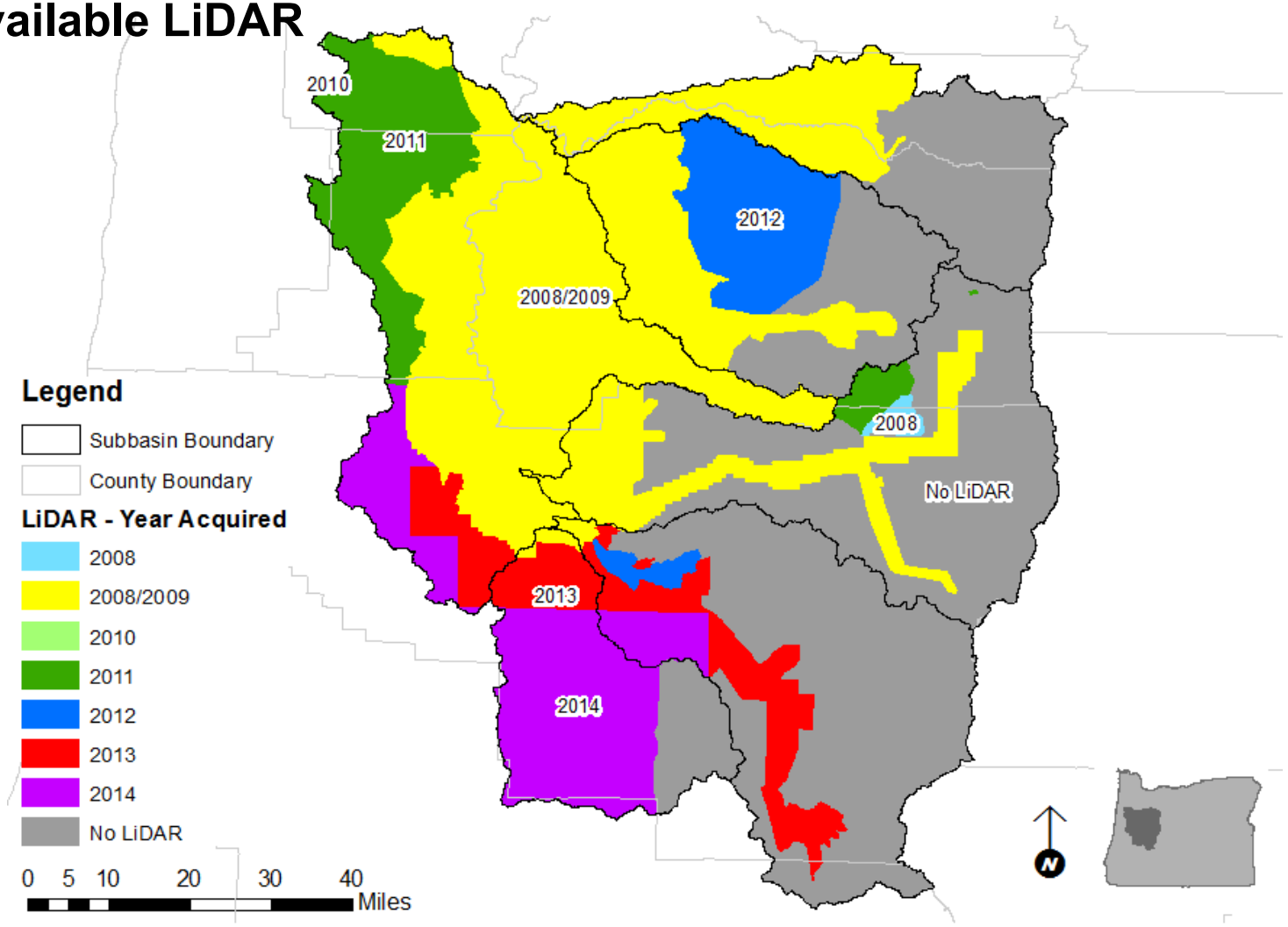
Solar Path and Flux Modeling



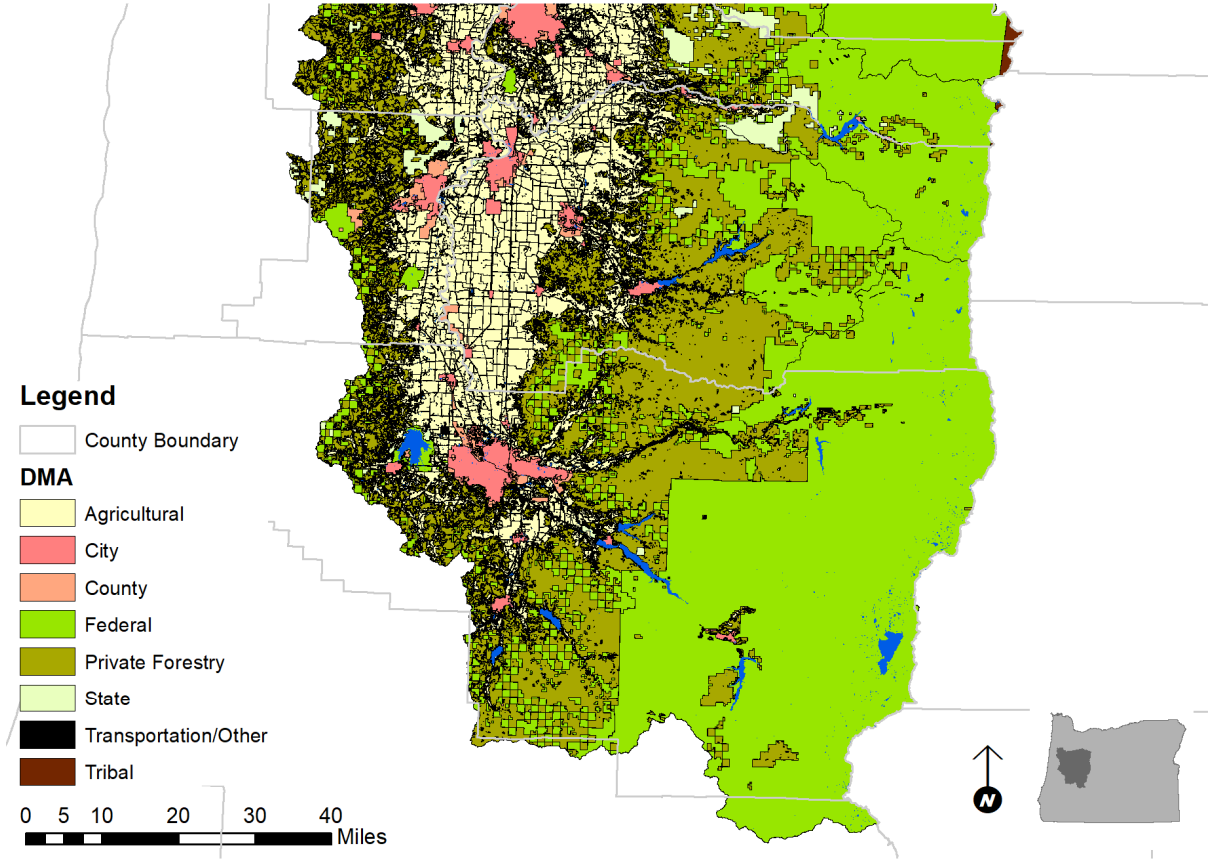
Modeling Study Area



Available LiDAR

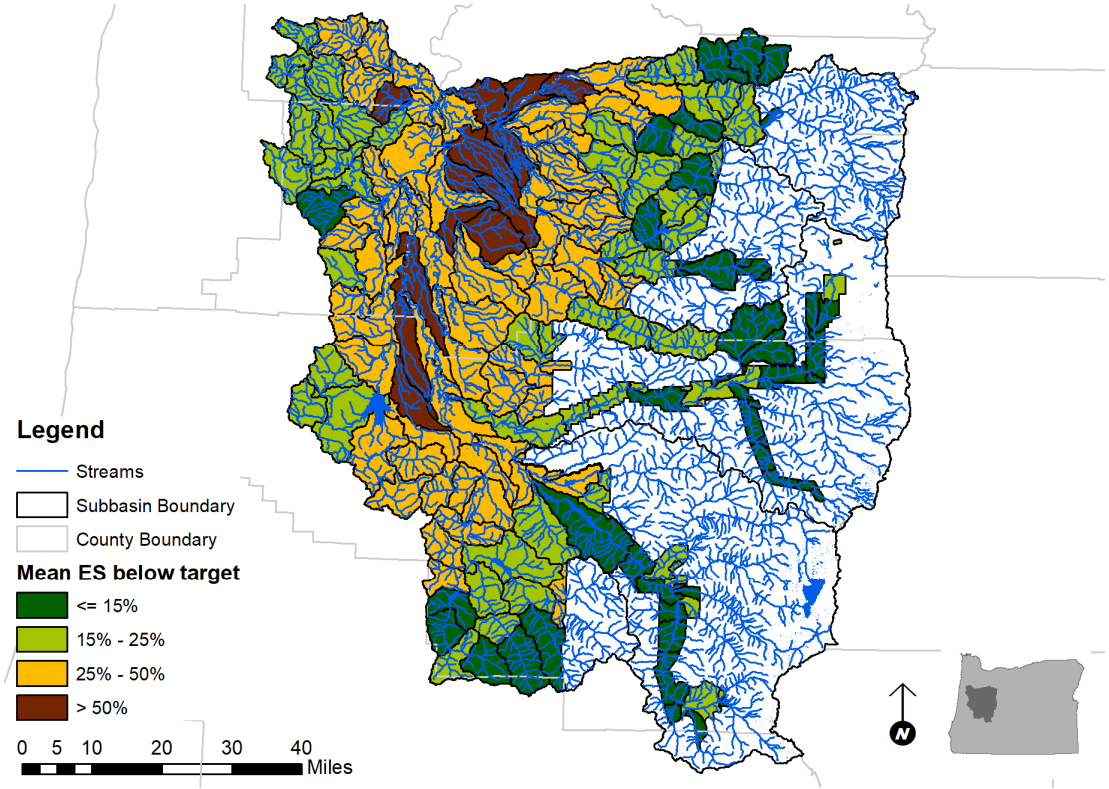


Mapped DMAs



DEQ
State of Oregon
Department of
Environmental
Quality

What is the status toward achieving the TMDL shade targets?



Mean Current Shade	Mean TMDL Target	Mean Shade Gap	Total Stream Miles Assessed	Stream Miles with 0%-15% Shade Gap	Stream Miles with 16%-25% Shade Gap	Stream Miles with 26%-50% Shade Gap	Stream Miles with 51%-100% Shade Gap
66%	92%	26%	13,625.6	7,540.7	994.1	1,587.5	3,503.3

What are the stream temperature trends in the Southern Willamette?

- Seasonal Kendall test for trend
- Evaluated data collected between January 01, 1998 to December 01, 2018
- Minimum of 8 years with results in the same month
- 25 stations had sufficient data for trend All USGS and some USFS.
- All significant ($p <= 0.20$) with a degrading trend (warmer temperatures)

DEQ
State of Oregon
Department of
Environmental
Quality