Coastal fog water relations at the watershed level

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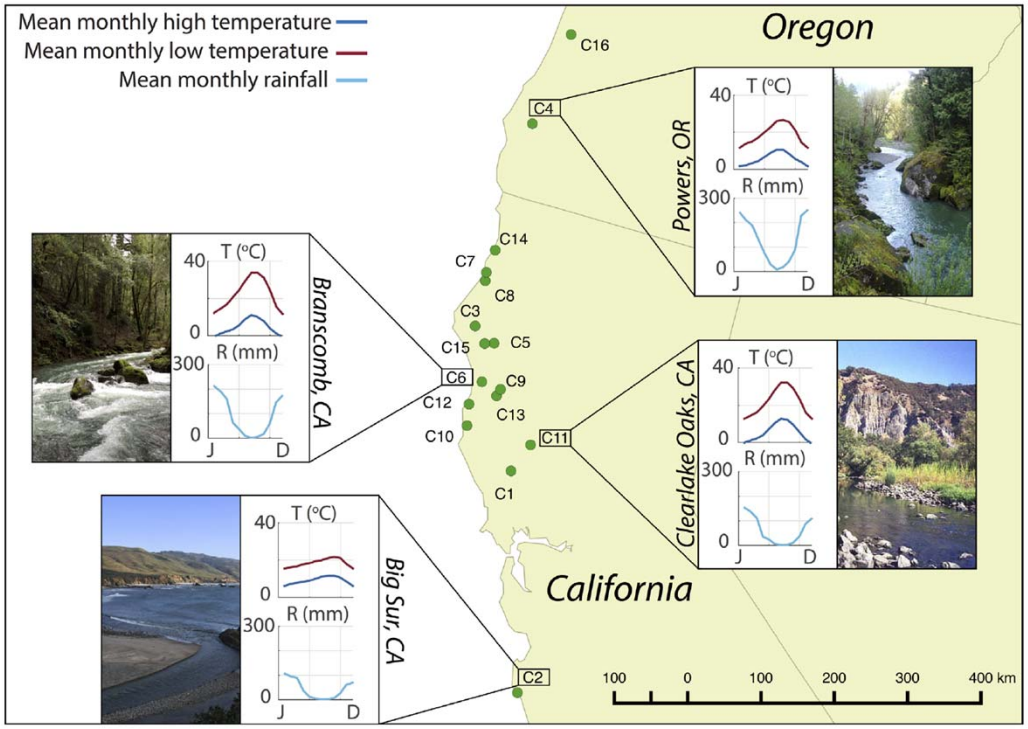
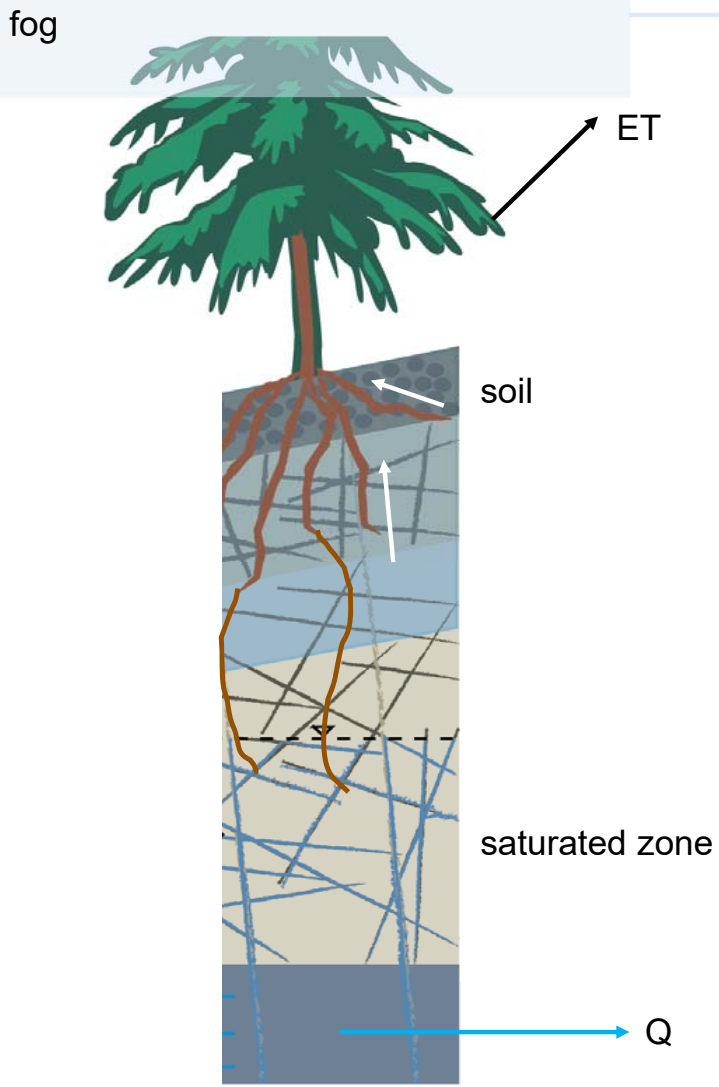
2017 Riparian Summit
October 18, 2017

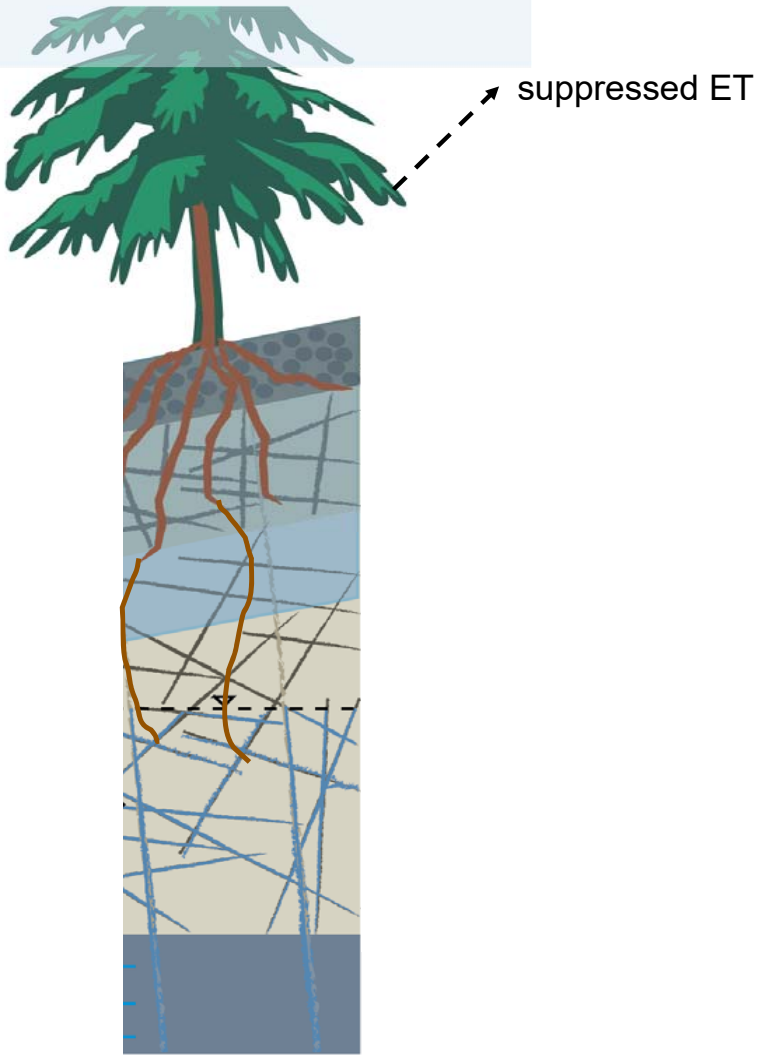


Dralle et al. 2015, *WRR*

In seasonally-dry climates, such as Northern California, fog water is often the only source of dry-season water input.

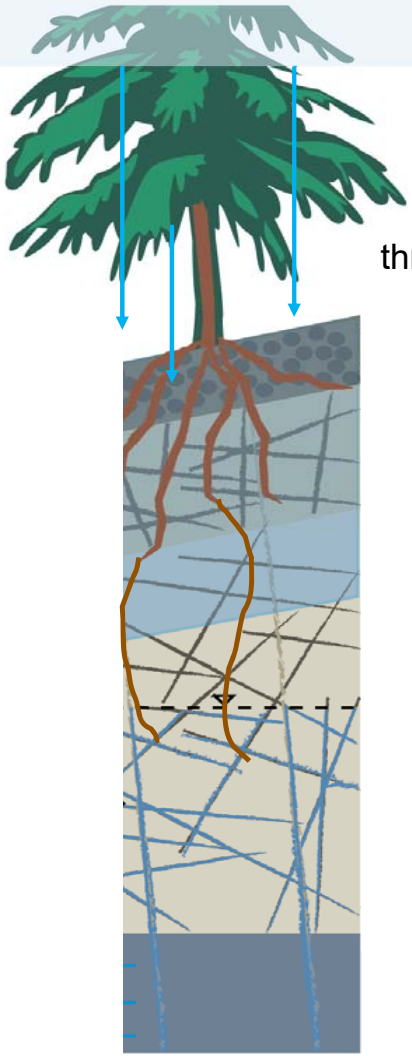

fog
ET
soil
saturated zone
Q

1 – Climatically



1 – Climatically

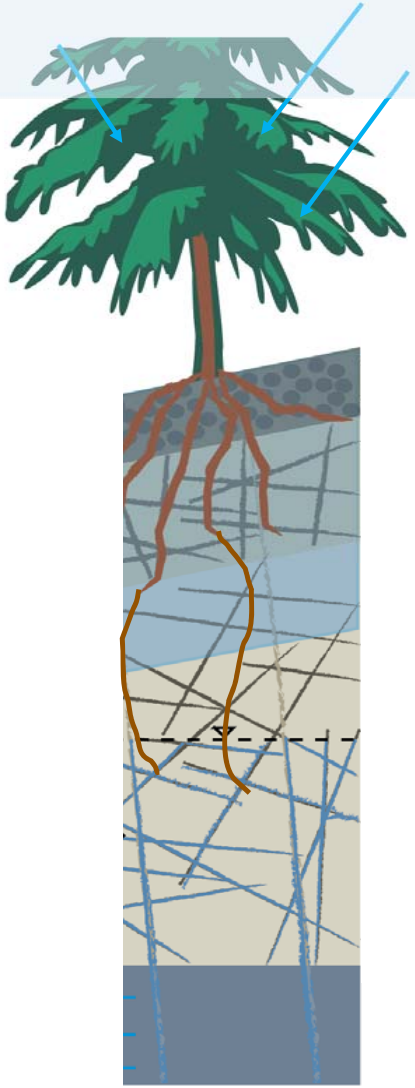
2 – Through direct water inputs



1 – Climatically

2 – Through direct water inputs

3 – Through foliar uptake



decreased transpirational loss
and water stress

Case study: Upper Pilarcitos Creek Watershed, CA

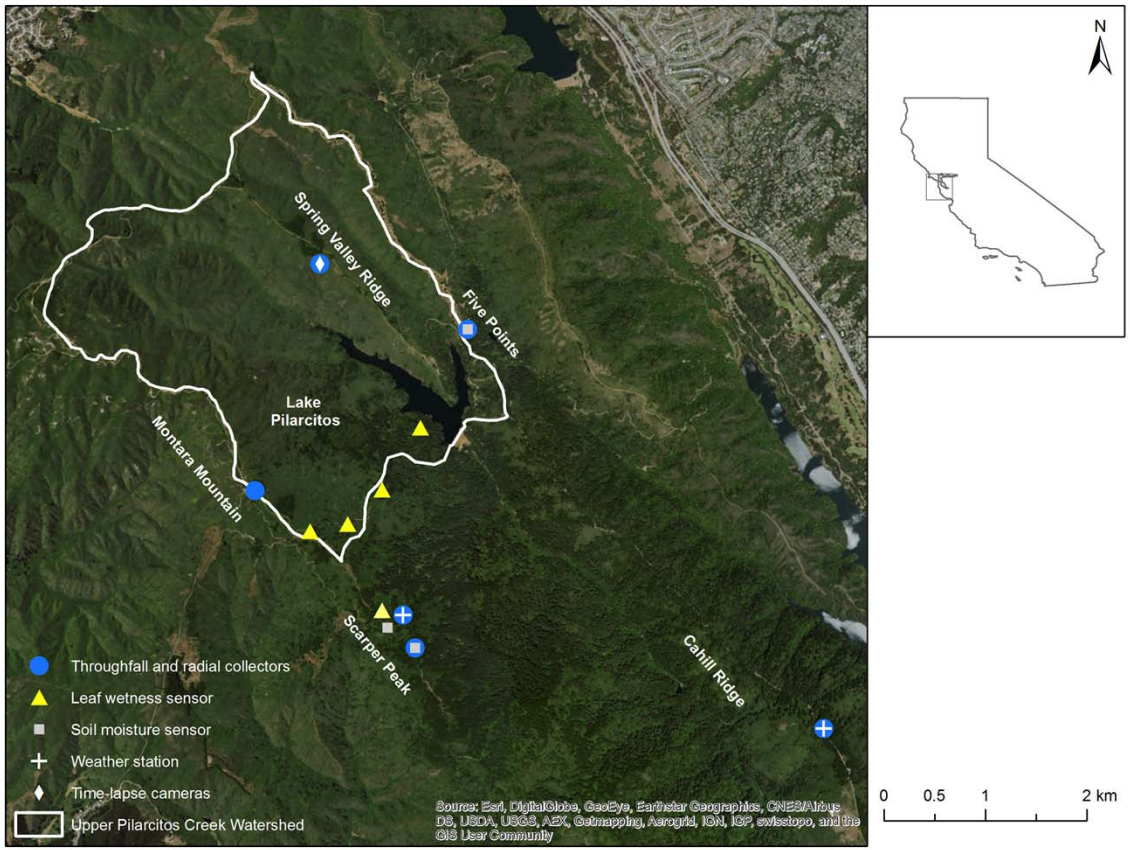
Objectives:

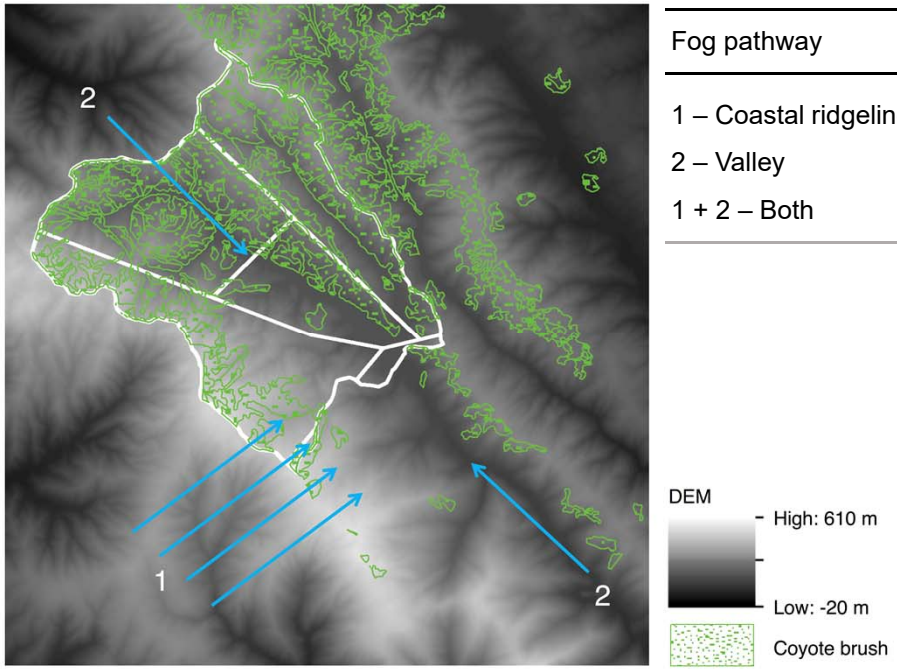
- to observe heterogeneities in fog events and deposition
- to identify the spatiotemporal controls of fog heterogeneity

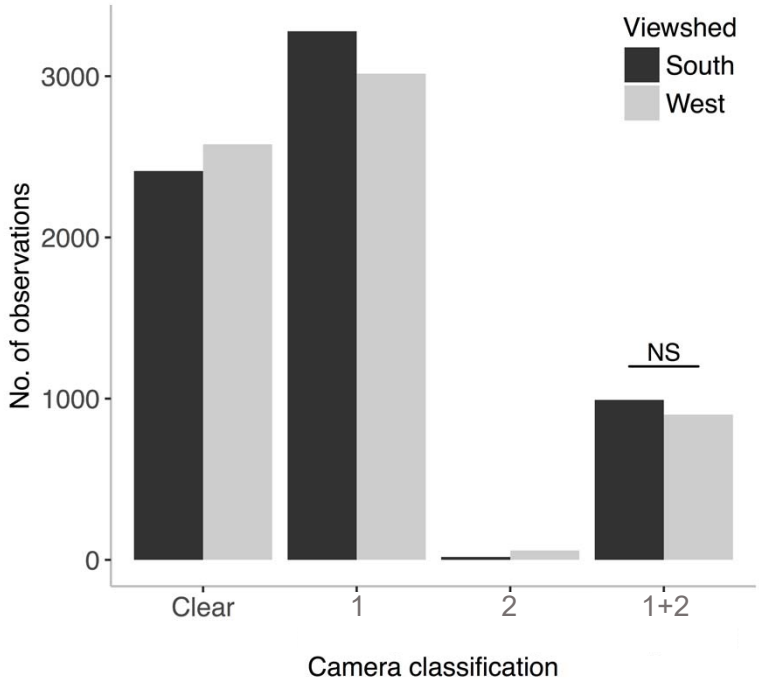
- to (create a new method to) estimate the watershed-level effects of fog when:
  - local observations are upscaled
  - these controls are considered

Case study: Upper Pilarcitos Creek Watershed, CA

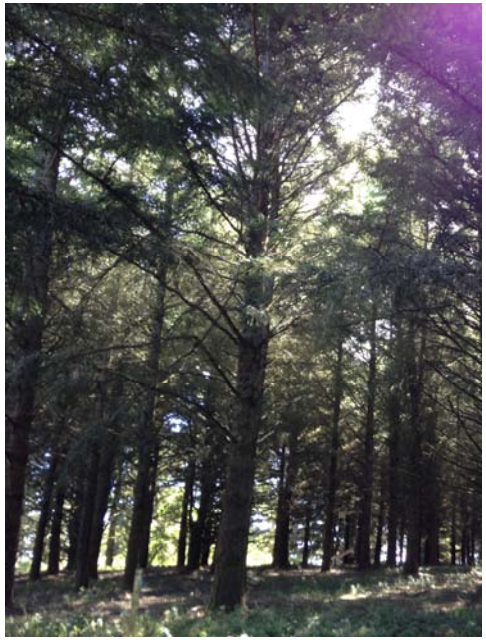
Google Maps, 2017


Spring Valley Ridge
Five Points
Lake
Pilarcitos
Montara Mountain
Scarper Peak
Cahill Ridge
Throughfall and radial collectors
Leaf wetness sensor
Soil moisture sensor
Weather station
Time-lapse cameras
Upper Pilarcitos Creek Watershed
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
N
0
0.5
1
2 km


2
1
2
Fog pathway
1 – Coastal ridgeline
2 – Valley
1 + 2 – Both
DEM
High: 610 m
Low: -20 m
Coyote brush

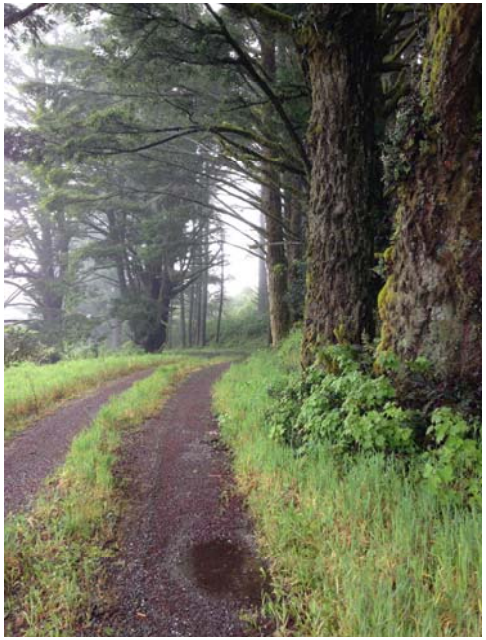

Viewshed
South
West
3000
2000
1000
0
No. of observations
NS
Clear
1
2
1+2
Camera classification

Clear



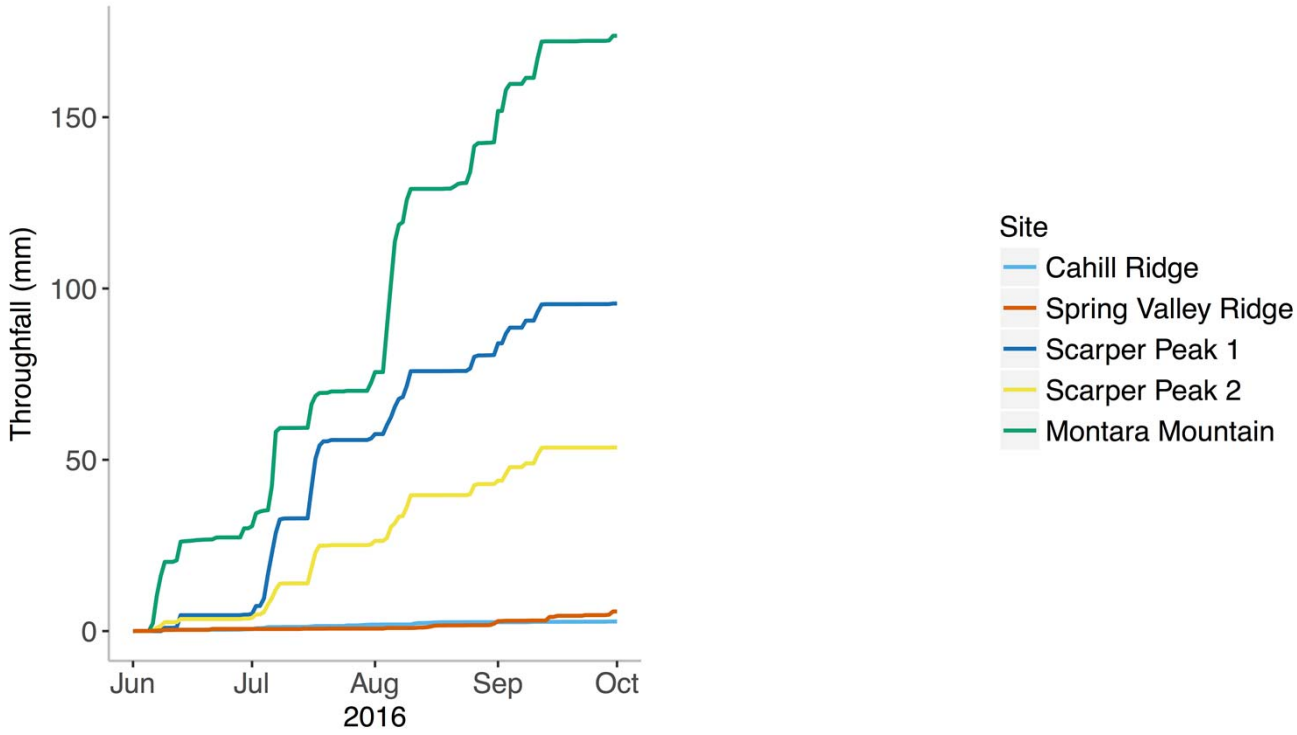
- low RH (~70%)
- higher air temp (~17ºC)
- 1ºC difference in temperature and 1% difference in VWC at 75mm and 300mm soil depth

Foggy

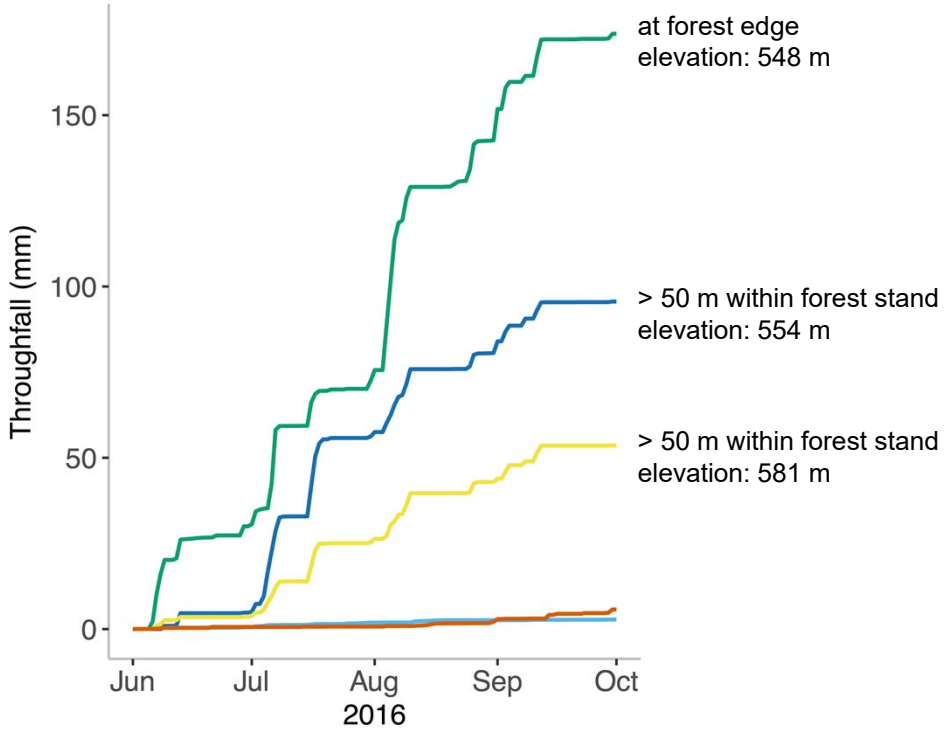


- max RH (~99%)
- cooler air temp (~11ºC)
- smaller difference in temperature and in VWC at 75mm and 300mm soil depth

Observed heterogeneities



Observed heterogeneities:
Distance to canopy edge



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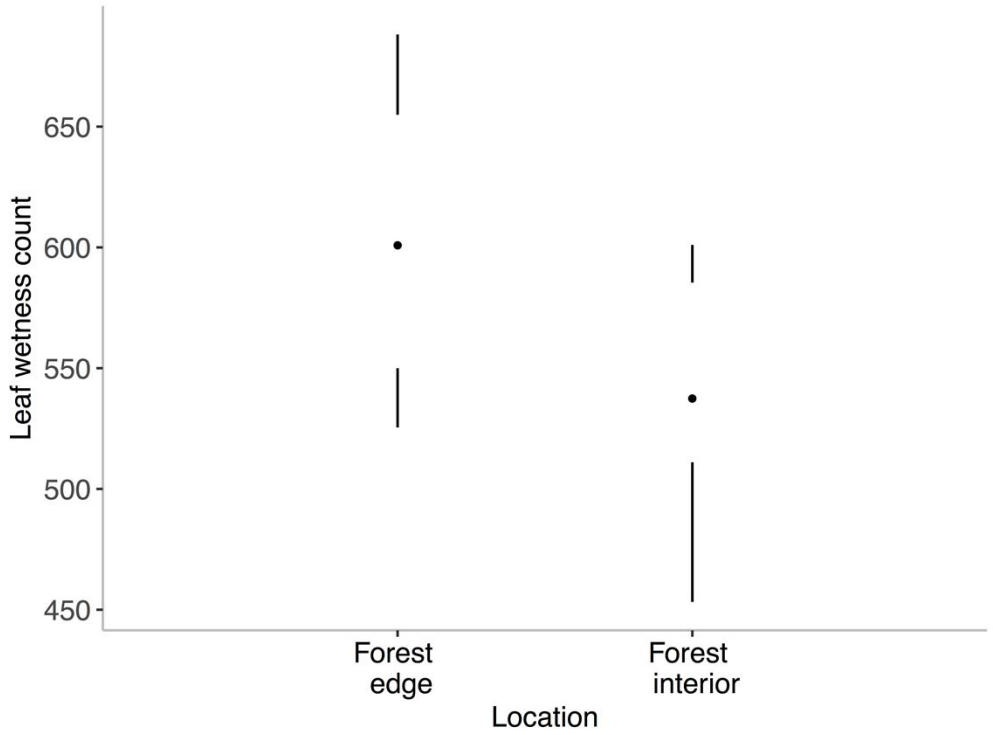
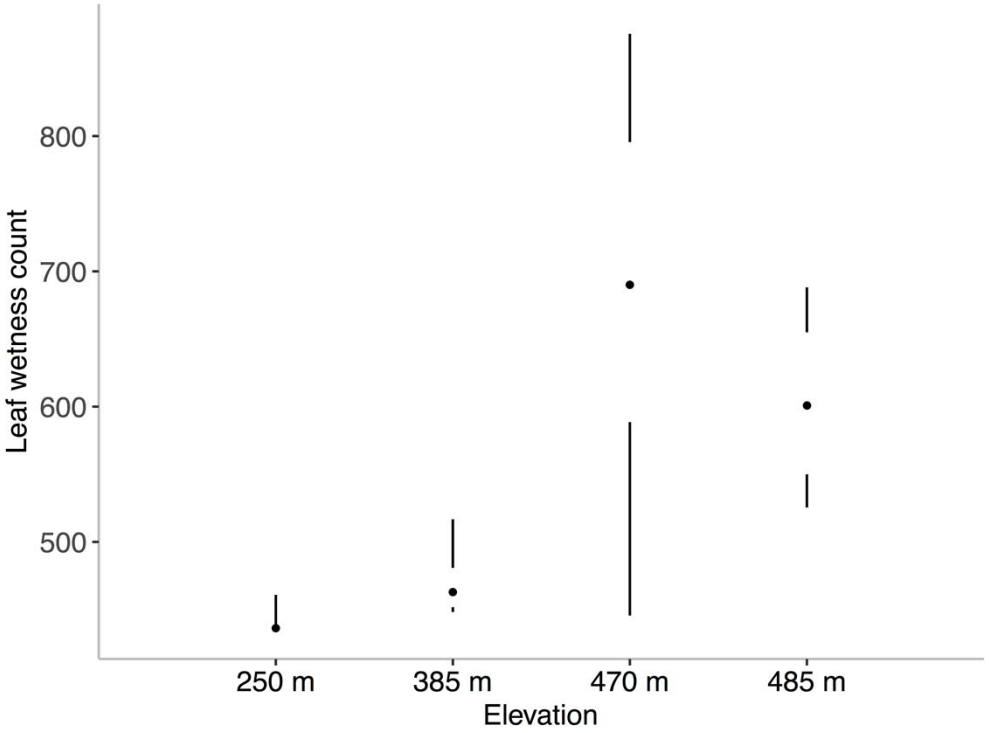
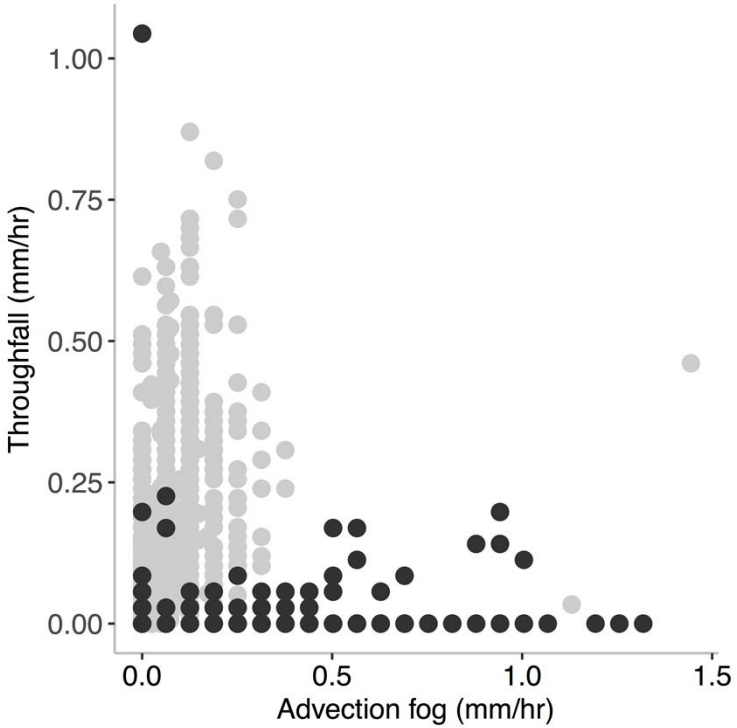


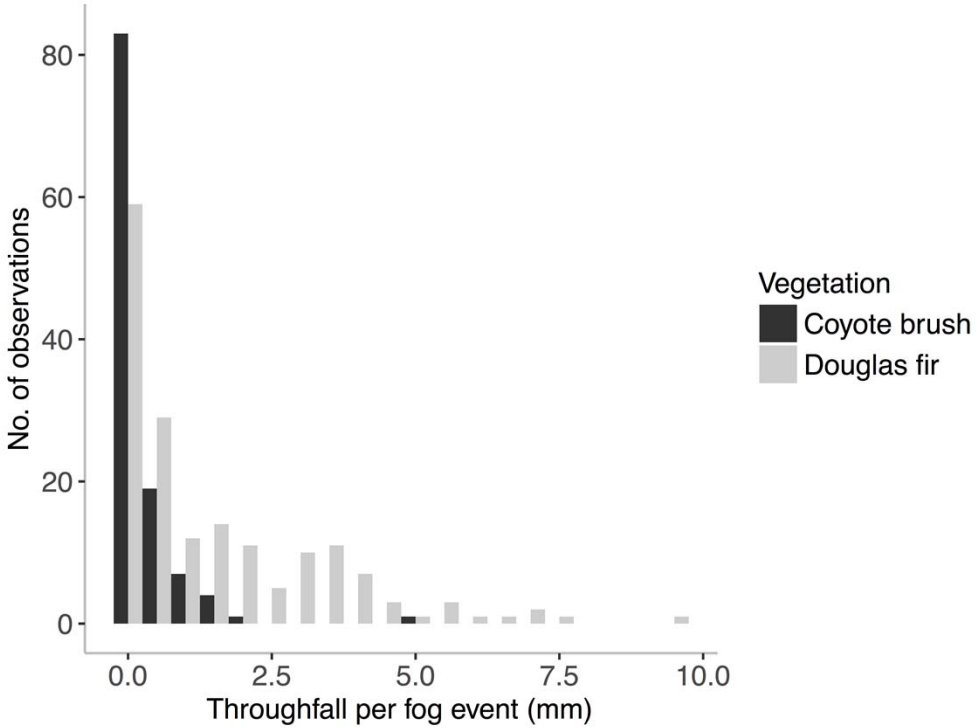
Observed heterogeneities:
Topography



		Percentage of time leaf wetness counts > 460	
Elevation	2014	2015	2016
250 m	19 %	13 %	2 %
385	36	32	27
470	54	63	43
485	--	66	59

Observed heterogeneities:
Vegetation canopy





The dominant **spatiotemporal controls of heterogeneity** in fog occurrence and flux in the Upper Pilarcitos Creek Watershed are:

- topography
- vegetation
- interannual variability

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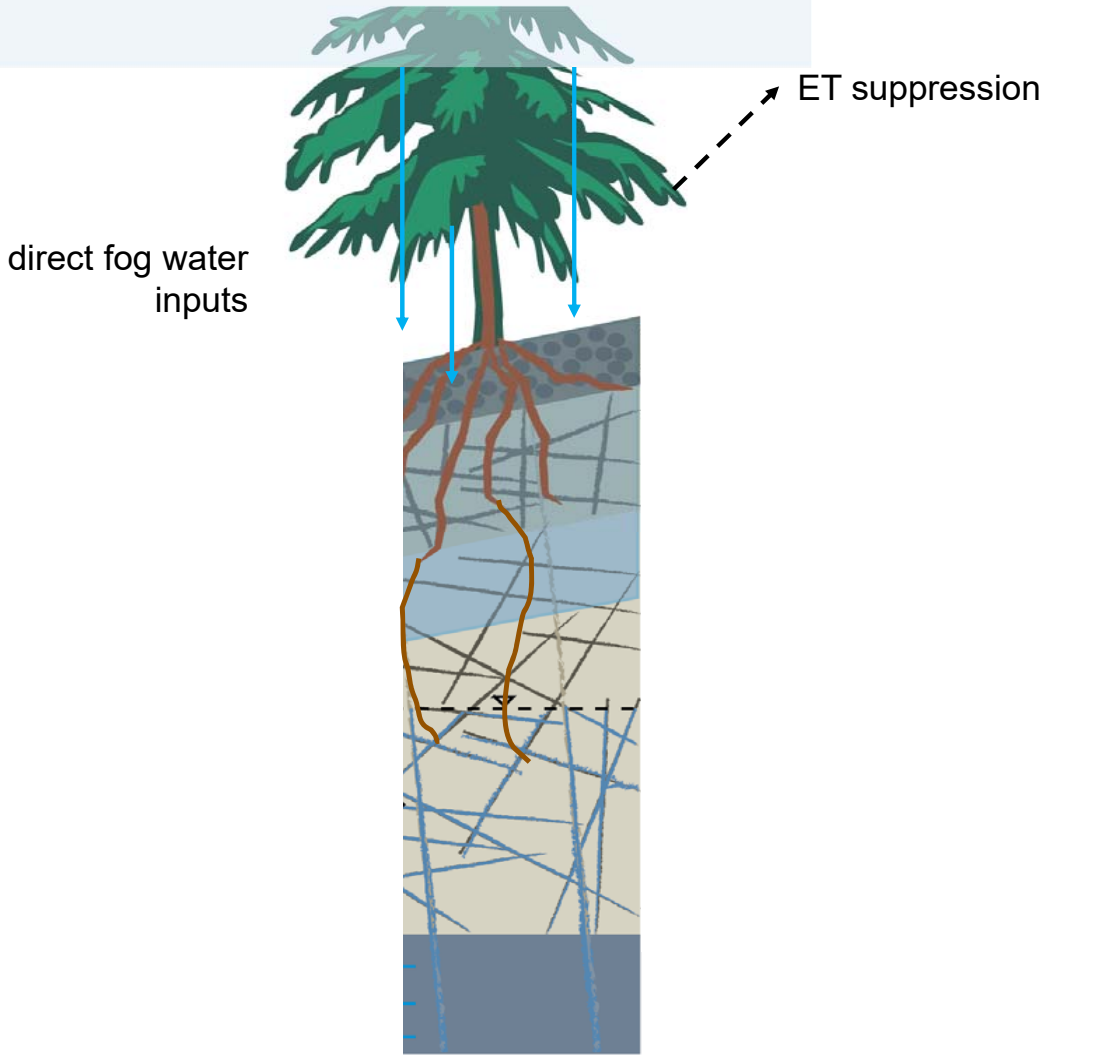
We need to consider:

- fog extent observations
- spatial changes in elevation and vegetation cover within areas of fog occurrence


ET suppression
direct fog water inputs

New upscaling method for fog water input estimate

Landsat
Aug. 5th, 2014

Thiessen polygon:

IDW:

Ordinary kriging:

Universal kriging:

Our scheme:

Throughfall (mm)

- 0 - 0.01
- 0.011 - 0.03
- 0.031 - 0.05
- 0.051 - 0.07
- 0.071 - 0.10
- 0.10+

At the watershed level:
Direct fog water inputs

	Average fog water flux
2014	6.7 mm
2015	2.6
2016	2.9

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→

+10-30 mm/season of fog-derived precipitation
1-3% of total annual water input

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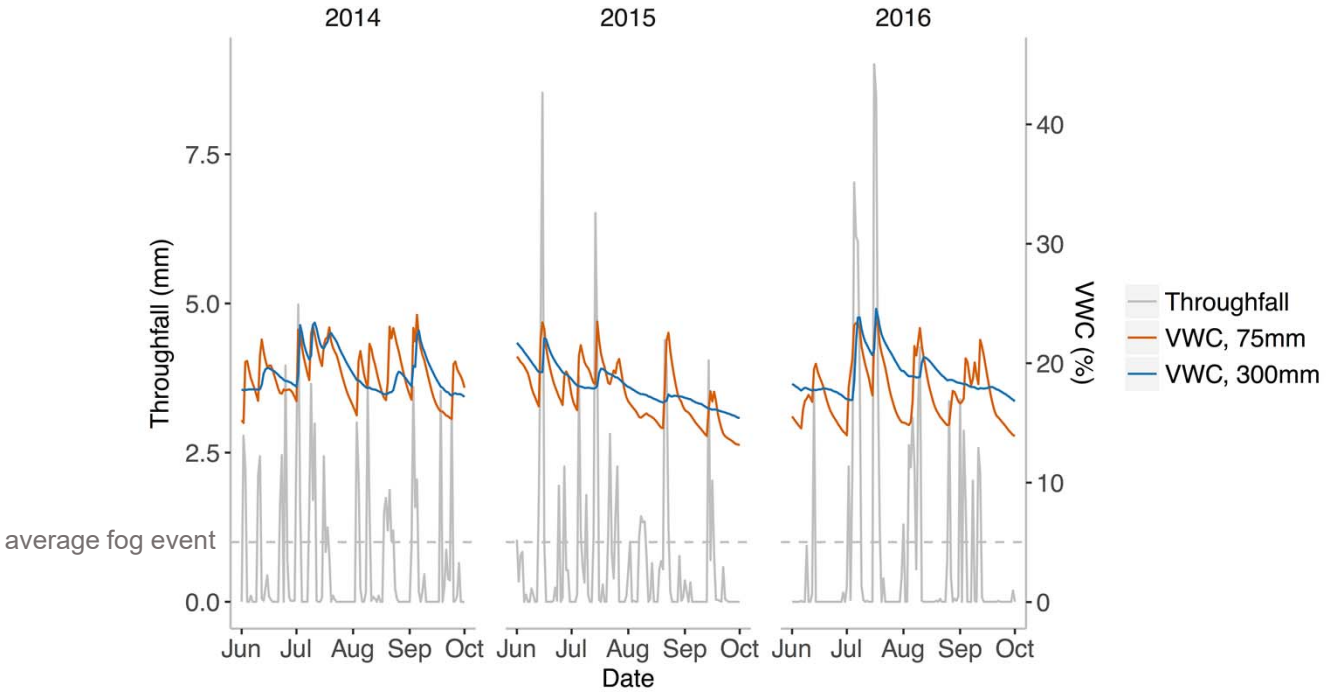
Direct fog water inputs



At the watershed level:
ET suppression

	Reductions per day
Open water evaporation	9.5%
Forest PET	41
Chaparral PET	17

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→ +125 mm/season of decreased transpiration demand

At the watershed level

-570 mm	dry season water deficit
+10-30 mm	direct fog water input
+125 mm	avoided transpiration loss

At the watershed level

-570 mm	dry season water deficit
+10-30 mm	fog-derived precipitation
+125 mm	avoided ET loss
-430 mm	dry season water deficit
-25%	

Conclusions

- Fog is critical in regions where high ecosystem demand for water coincides with the dry season
- Fog interacts with the water balance directly via fog water flux and climatically through reduced ET suppression
- Quantifying fog's hydrologic role during the dry season requires identifying the dominant controls on spatiotemporal heterogeneity of fog events
- In this watershed, avoided transpiration provides a more significant relief of summer watershed water deficit than fog water flux

Q&A

Thank you!

Instrumentation

Throughfall collector

Radial collector

Instrumentation

Soil moisture sensor

Leaf wetness sensor

Weather station