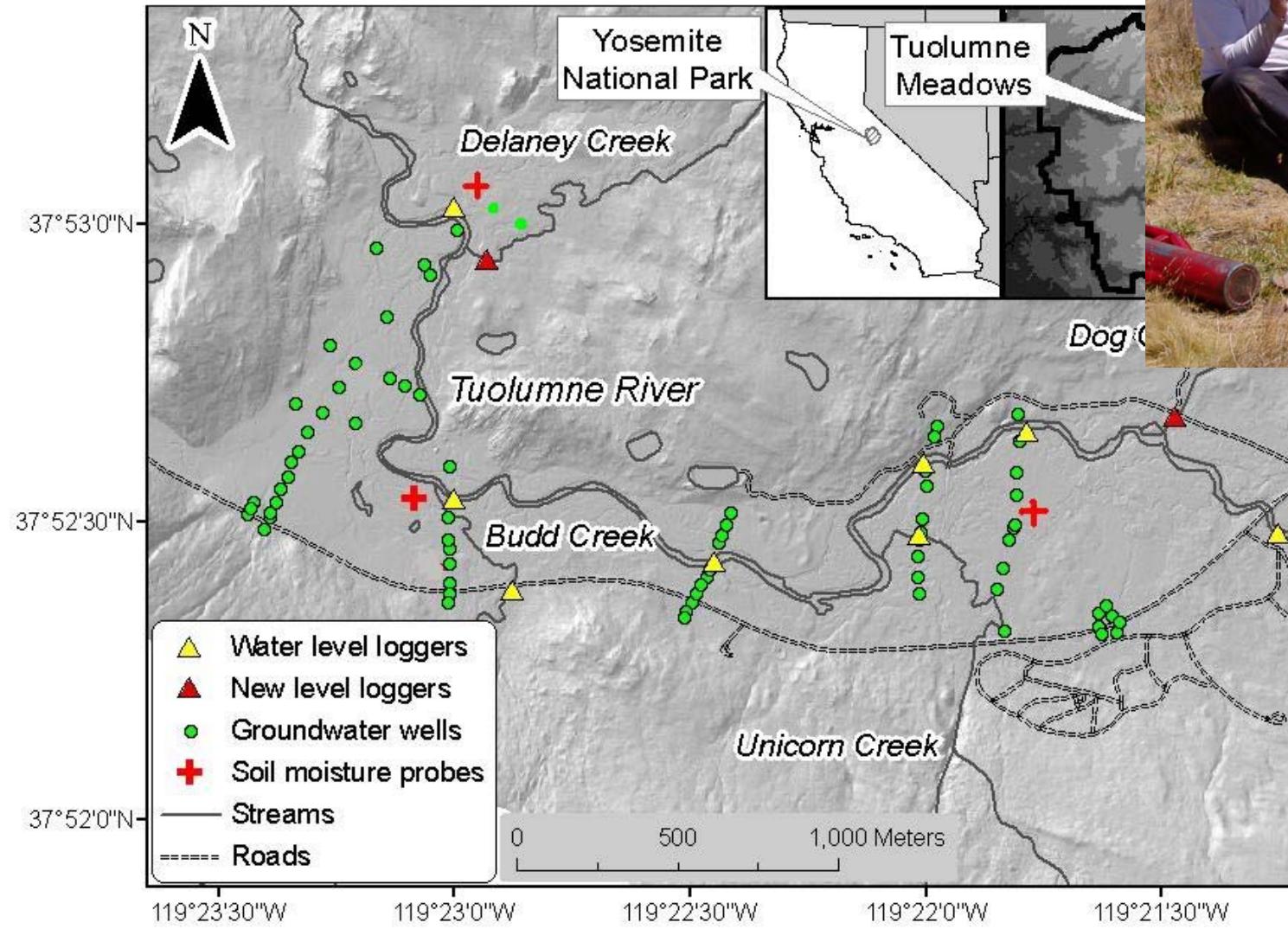


Tuolumne Meadows Hydroecology

Jessica Lundquist
University of Washington

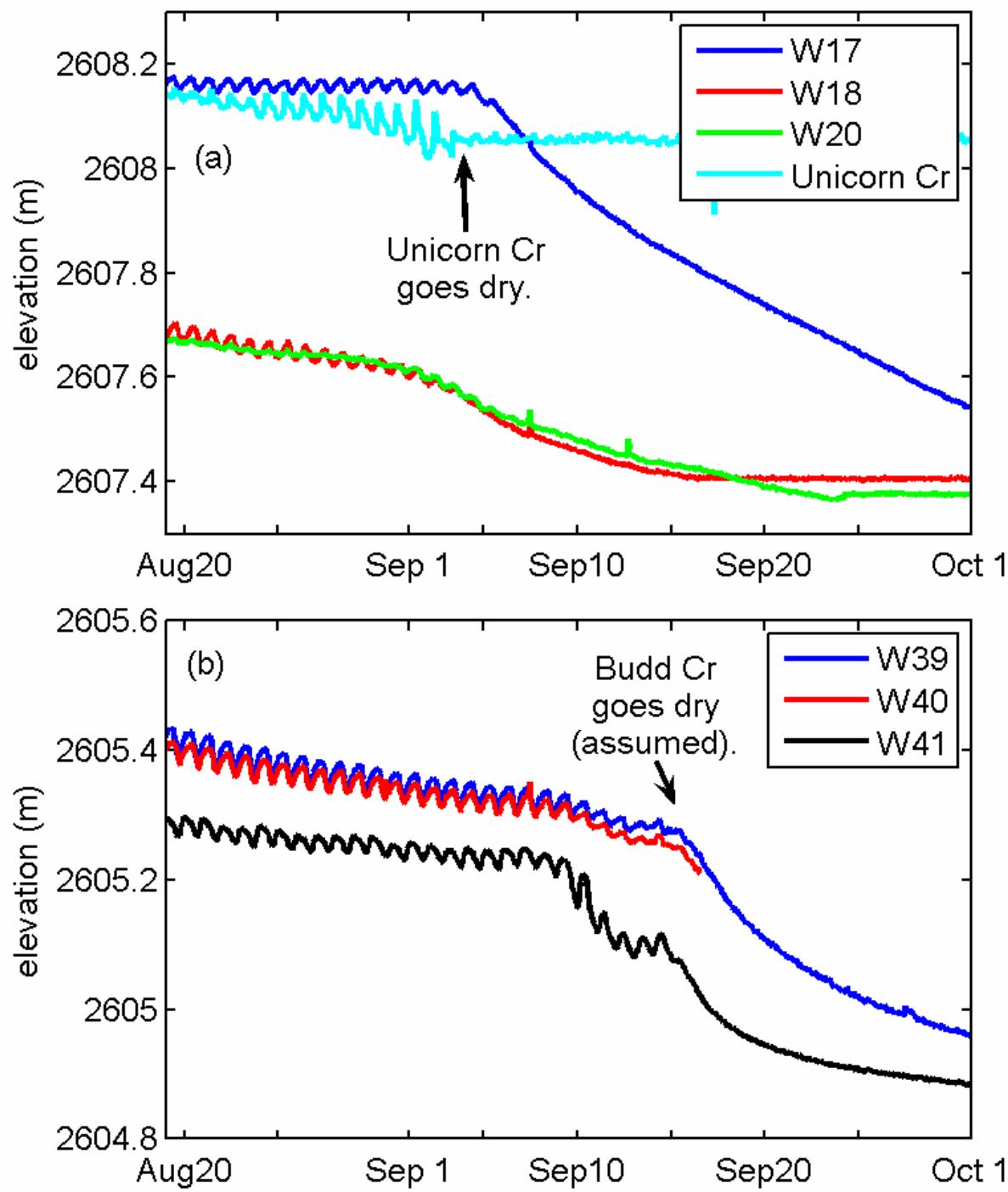
Steve Loheide
University of Wisconsin, Madison

What are we doing with all those wells?



Water beneath the surface is closely tied to water levels in the streams.

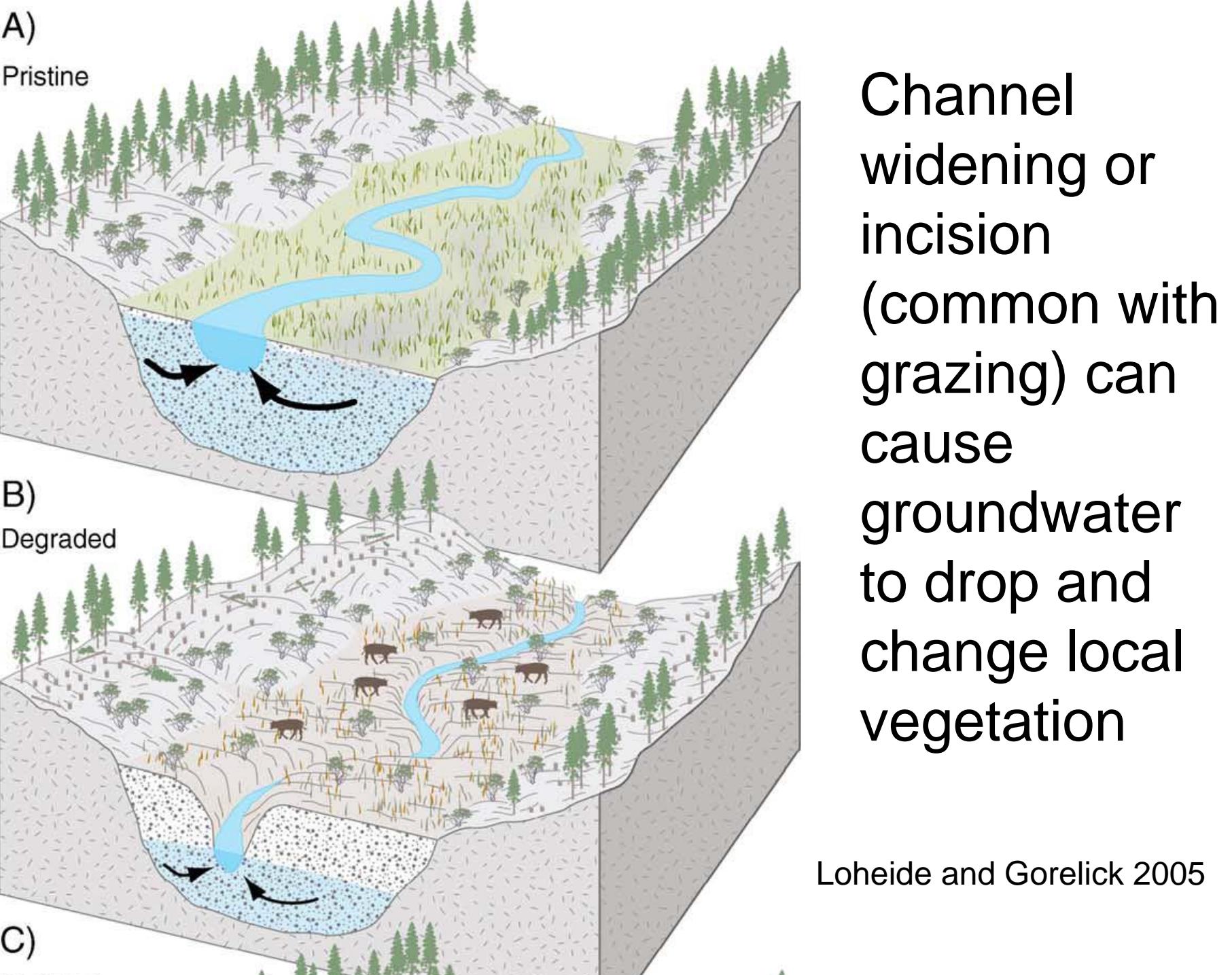
- Diurnal fluctuations each day in sites near streams
- When small streams go dry, water level drops quickly
- Height of water level in the stream controls height of water level in the meadow



Small changes in surface elevation = changes in depth to the water table = changes in vegetation communities



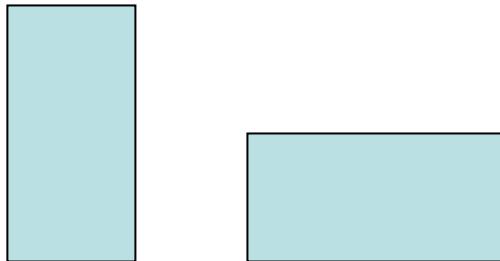
Terraces of different vegetation by Delaney Creek



Loheide and Gorelick 2005

Drop in groundwater table can change due to:

- Channel widening

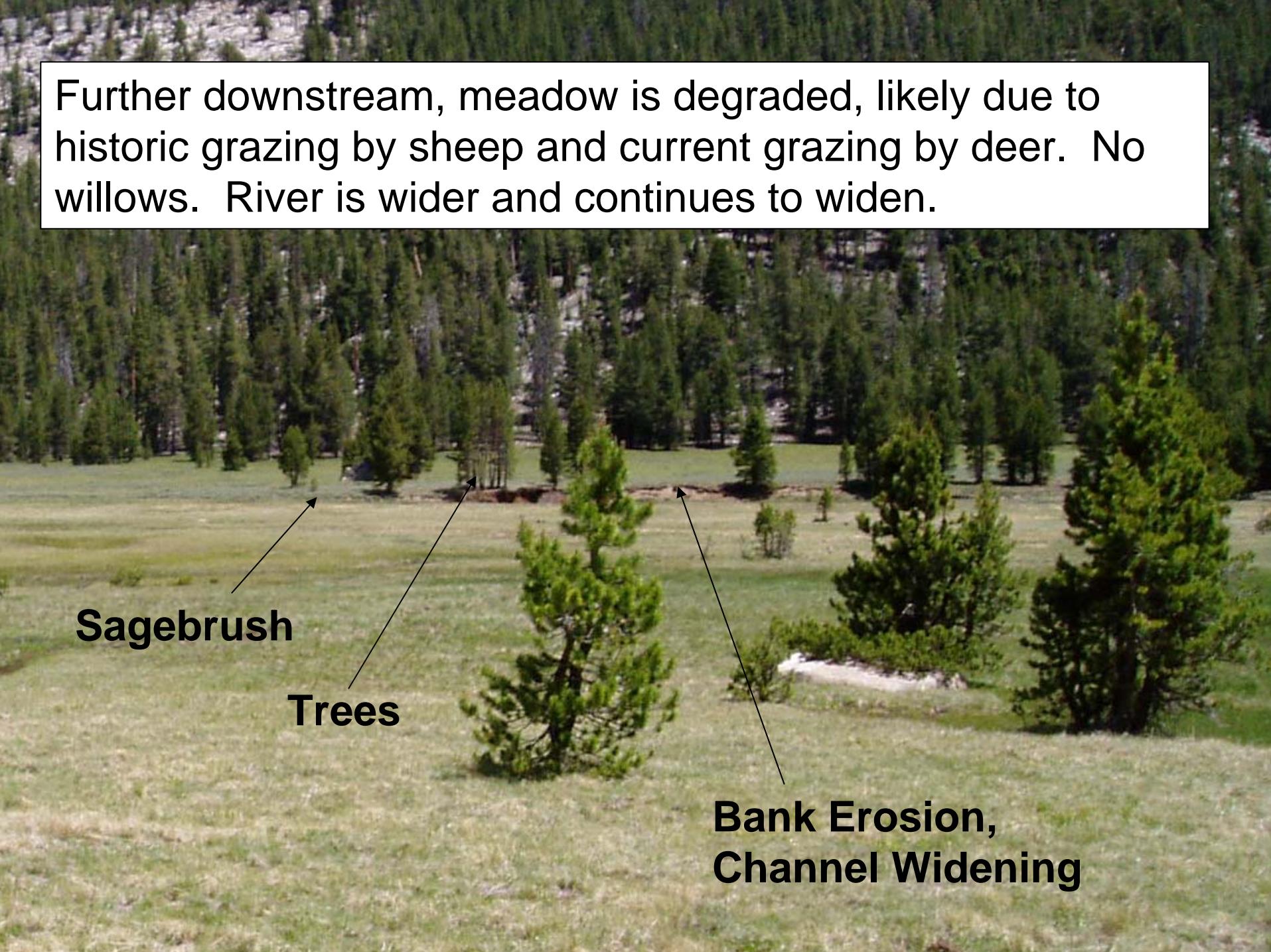


- Channel incision
- Loss of channel roughness (willows and logs)
 - $\text{Flow} = \text{Velocity} \times \text{Area}$
 - Faster velocity takes up less area for the same flow
- Decrease in annual streamflow (climate change)

Up Lyell Canyon, where willows line the river, it's narrow and deep. Meadows are healthy.



Further downstream, meadow is degraded, likely due to historic grazing by sheep and current grazing by deer. No willows. River is wider and continues to widen.



Sagebrush

Trees

**Bank Erosion,
Channel Widening**

River widening, incision, and bank erosion are evident throughout Tuolumne Meadows.



Headcuts, like this one along Unicorn Creek, are a unique form of widening and grow larger each year.



This occurs because culverts in old road are too small, and water is forced around, creating a little erosive waterfall.





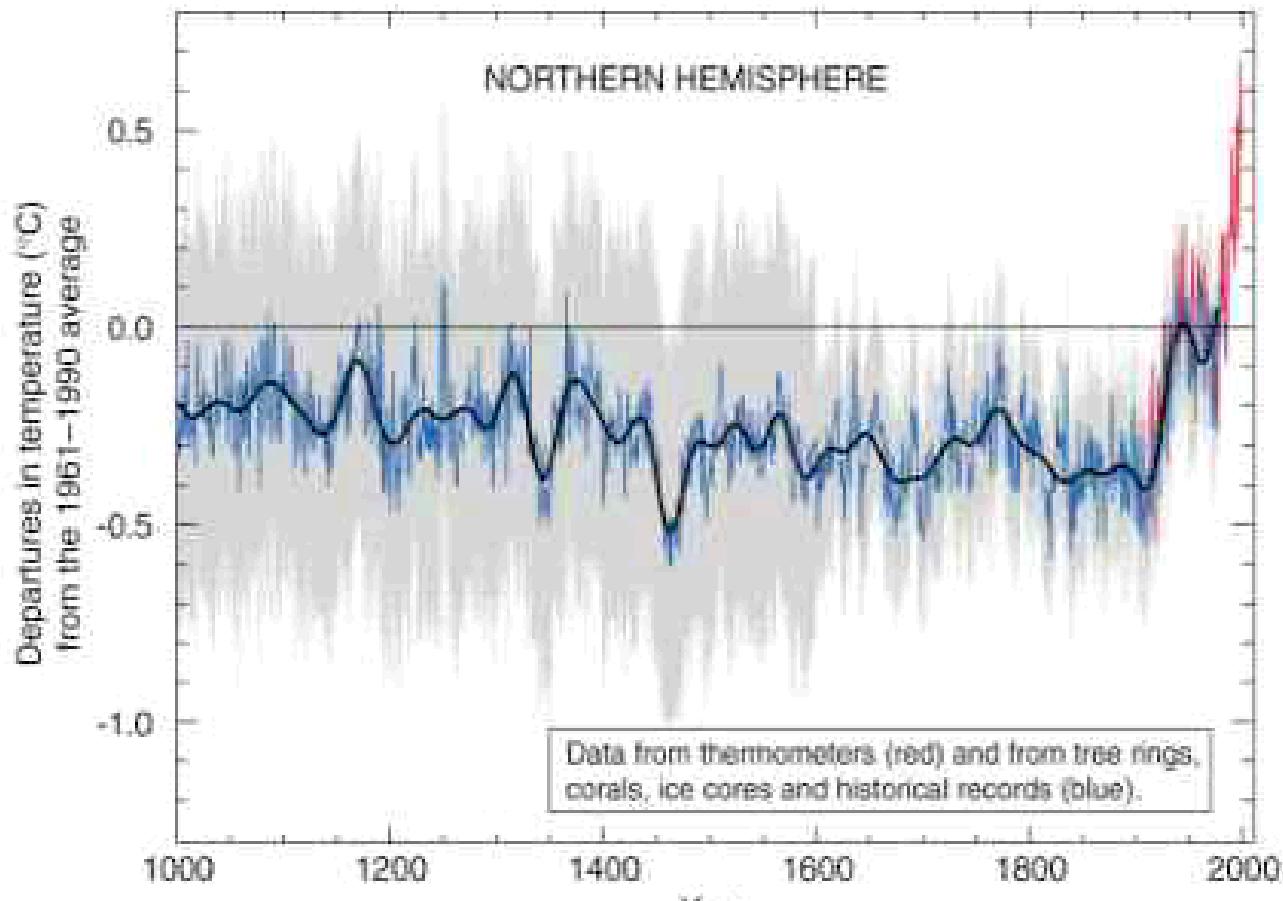
Incision below a culvert

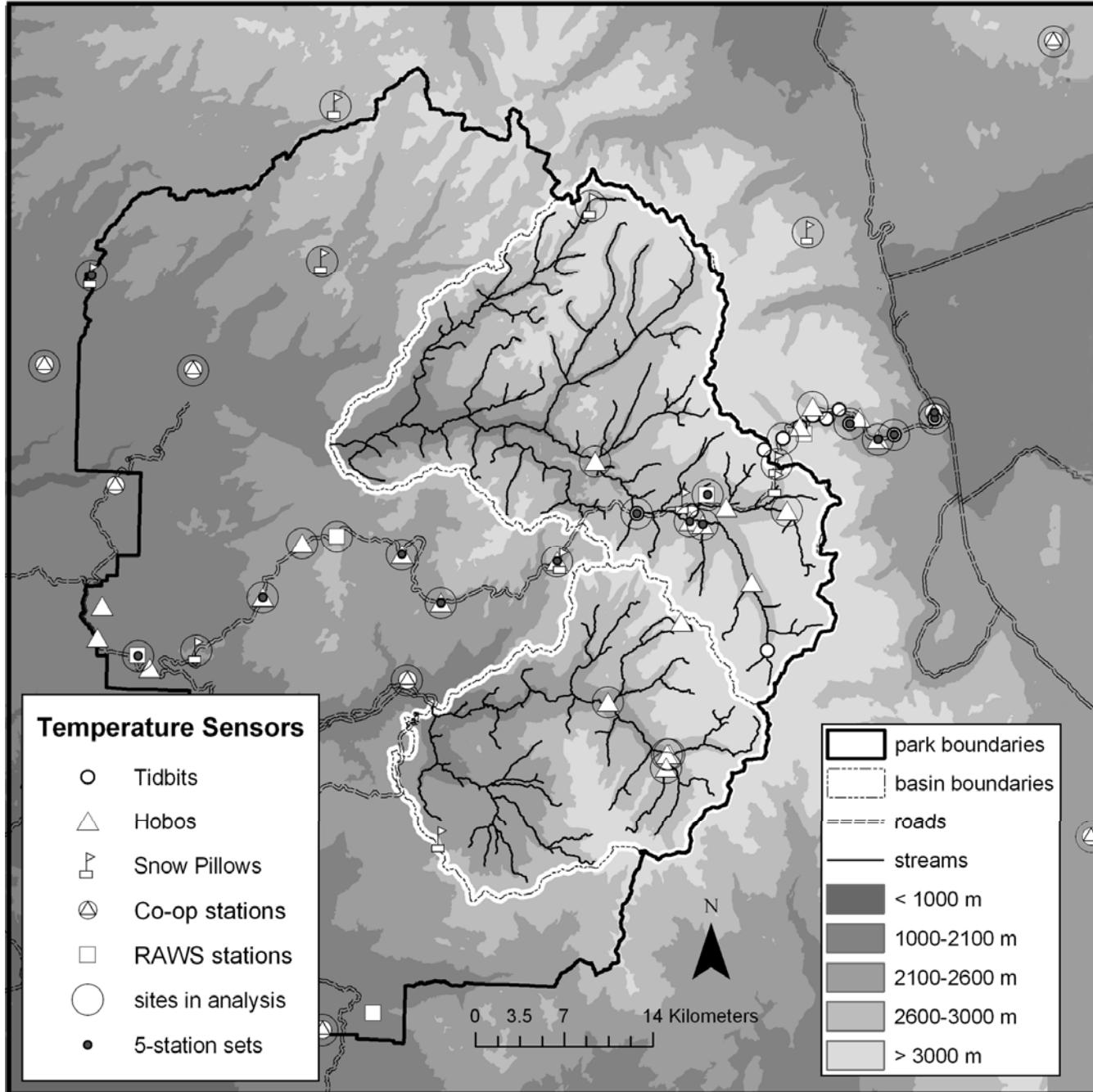
Tuolumne Cascades: Very low roughness = very shallow and fast flow.

Plants (e.g., willows, woody debris) increase roughness and result in deeper, slower streams



Shifts in climate and snow melt patterns affect streamflow and may have a large effect on meadow vegetation

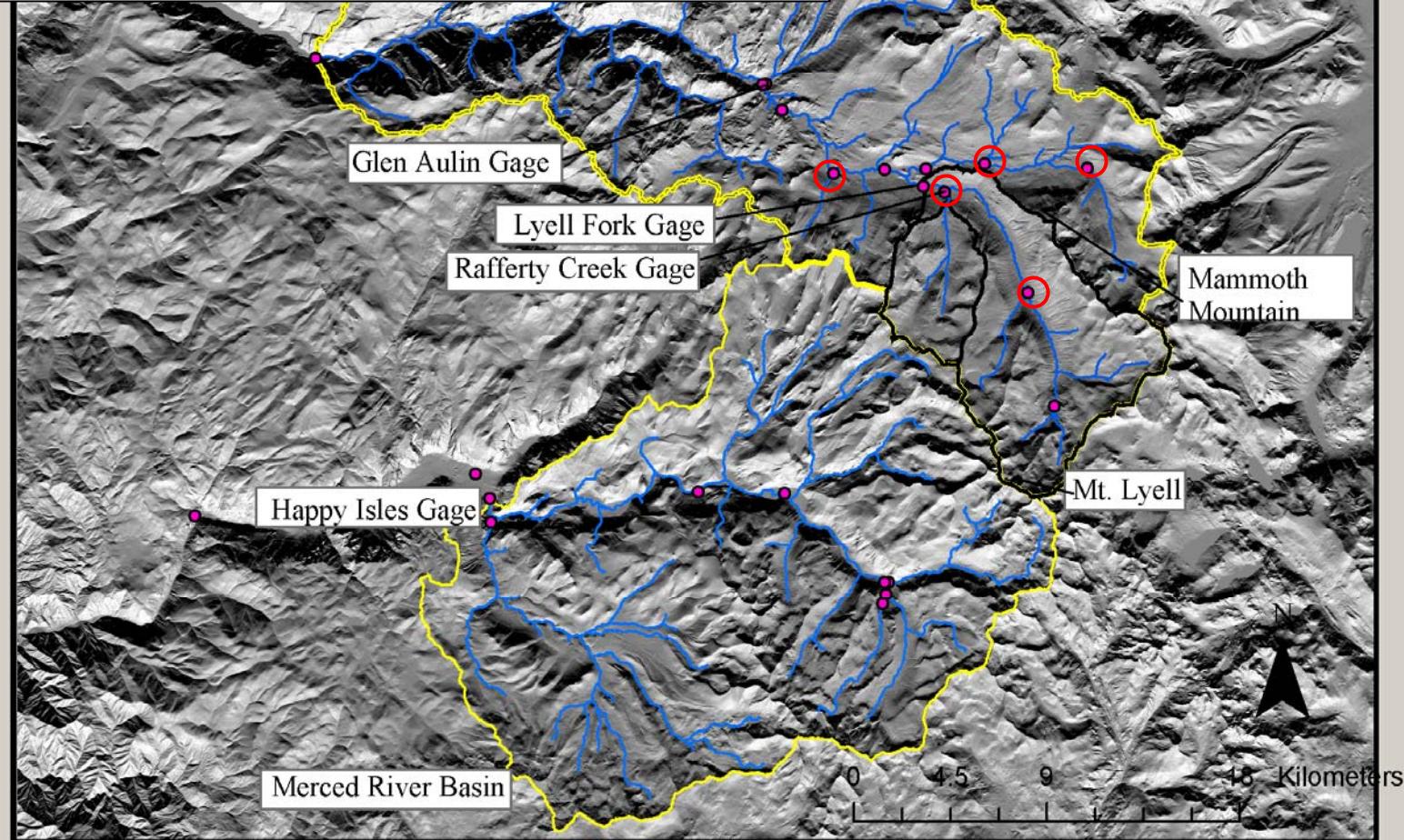




**Yosemite
Hydroclimate
Monitoring:
How climate
change
affects
different areas
of the park**

North-facing slopes hold snow longer than south-facing slopes, and this is even more pronounced in early melt years (the sun is lower in the sky earlier in the year).

- Stream sensors with Spring onset delayed in 2004



Conclusions

- Meadows initially degraded by sheep grazing (Muir's "hooved locusts")
- Likely a lot of factors affecting meadows now
- We're combining careful measurements with modeling to assess current meadow hydroecology and what restoration options might work best
- Trying to provide guidance for Tuolumne Management
 - Examples, could plant willows, fix culverts, but want to be sure of the science before we recommend anything specific