Vulnerability of Meadows in the Sierra Nevada

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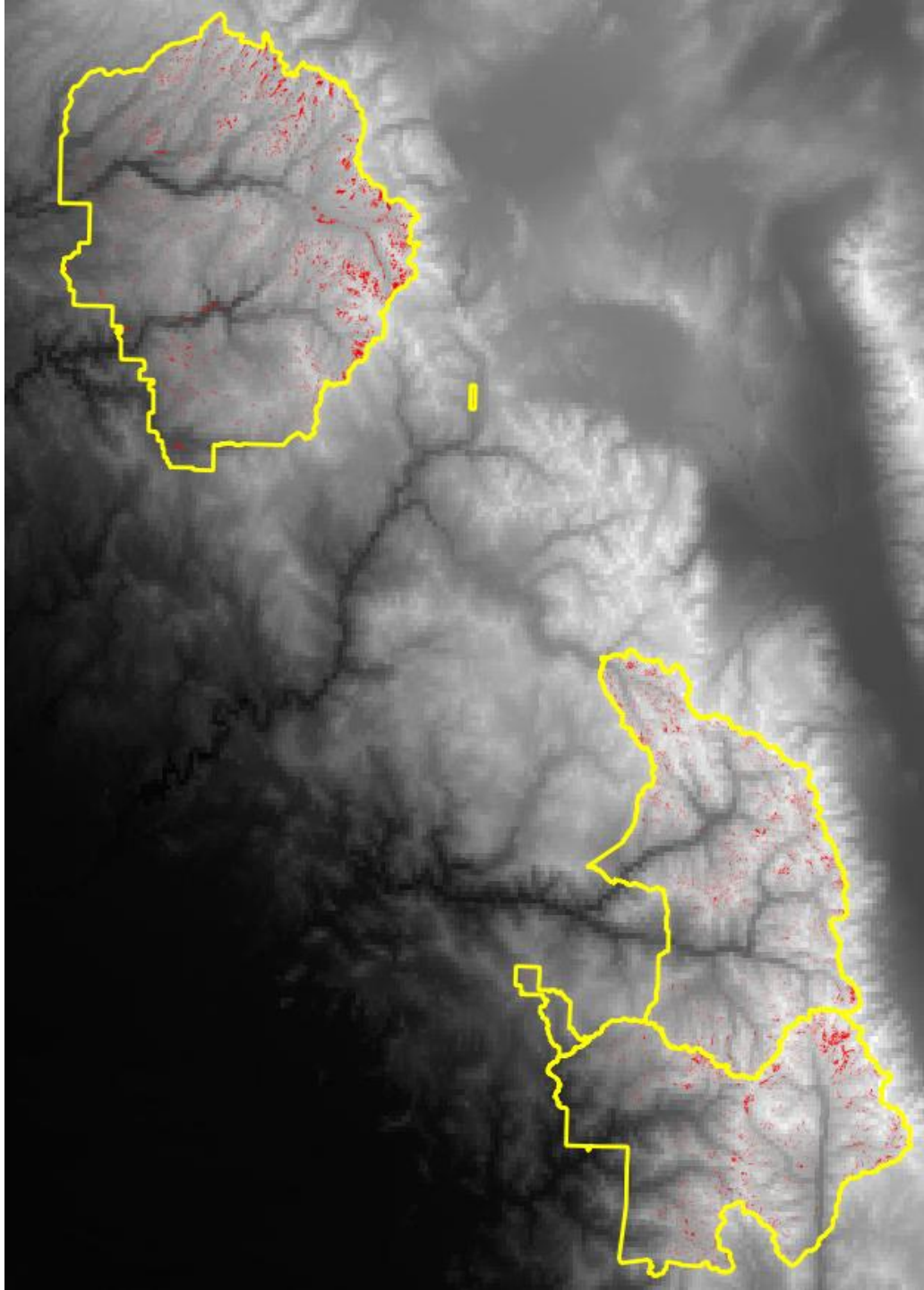
Presentation Outline

- Defining meadows
- Controls over meadow creation and persistence
- Vulnerability of meadows
  - Exposure to threats
  - Sensitivity to change
  - Adaptive capacity
- Attributing vulnerability to individual meadows

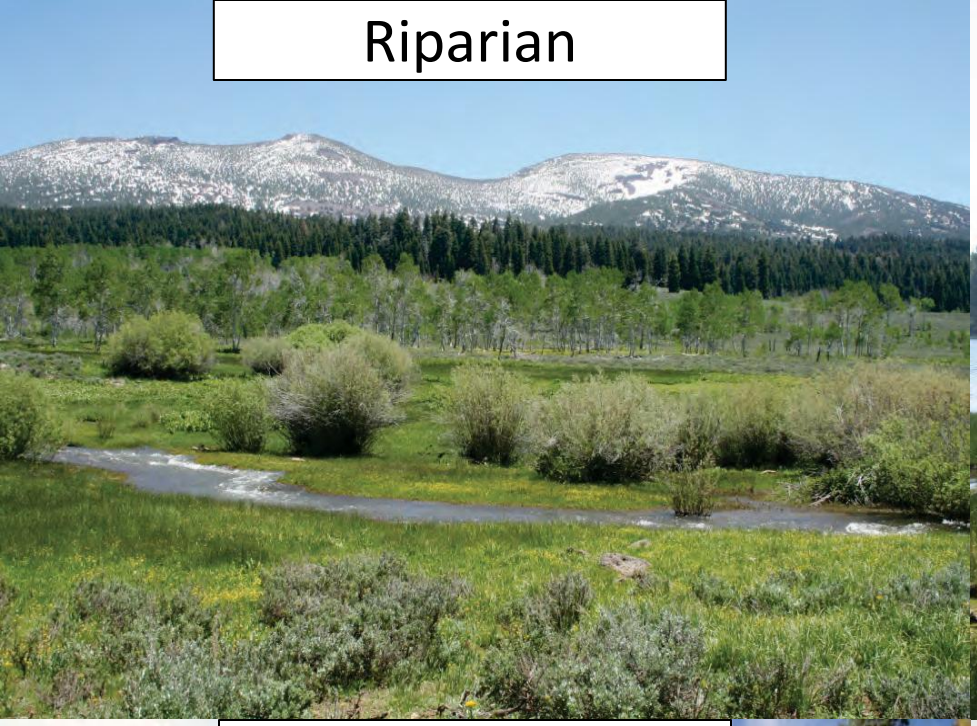
There are 8,246 meadows in the Sierra Nevada NPS parks alone (DEPO, SEKI, YOSE).

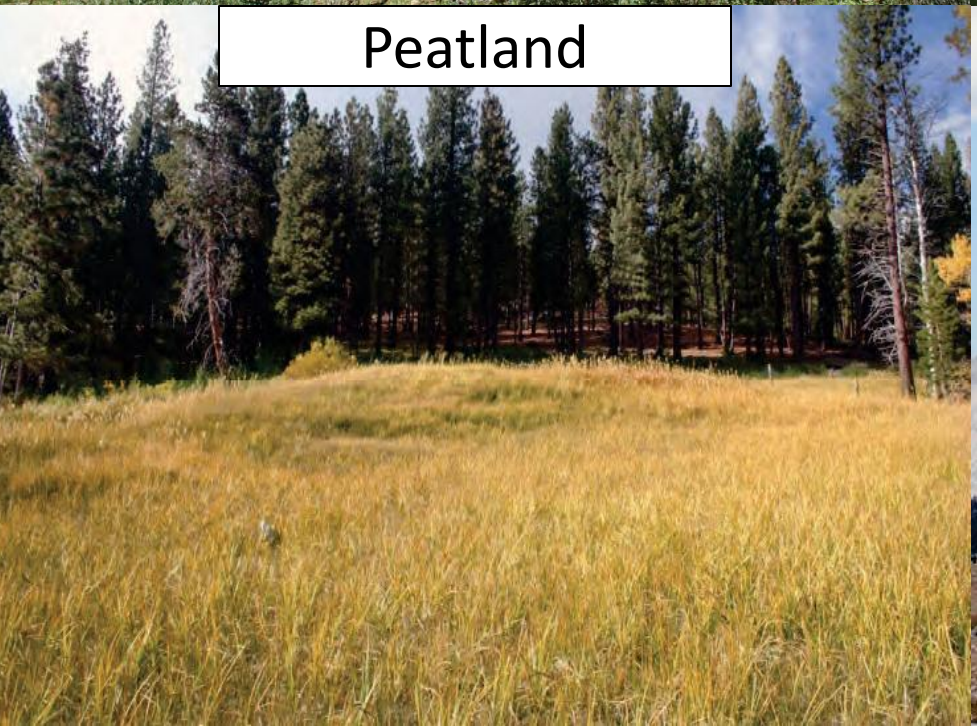
These meadows cover 3% of the landscape and are clustered at the upper reaches of watersheds.



Defining meadows

- Meadows are characterized by:
  - surface water and/or shallow groundwater
  - fine textured soils which sometimes contain significant amounts of organic matter
  - and herbaceous plant communities with woody species sometimes locally abundant.
- Meadows have been classified based on plant communities, soil types, elevational ranges, moistures gradients, and topography.
- The hydrogeomorphic classification of Weixelman et al. 2011 combines geomorphic and hydrologic characteristics and is especially informative to the process of evaluating meadow vulnerability.





photos from Weixelman et al. 2011

Meadows often contain multiple hydrogeomorphic types

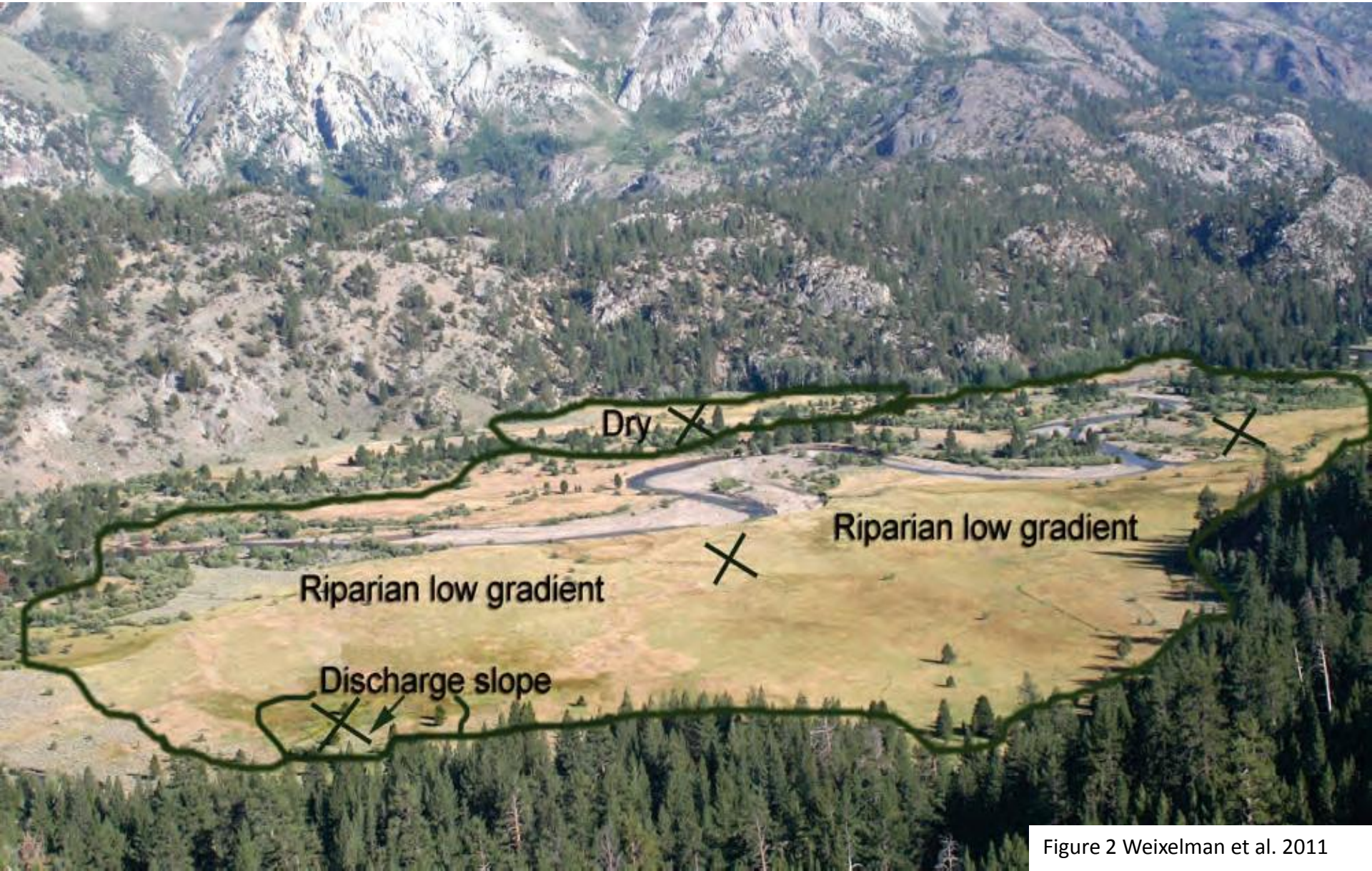


Figure 2 Weixelman et al. 2011

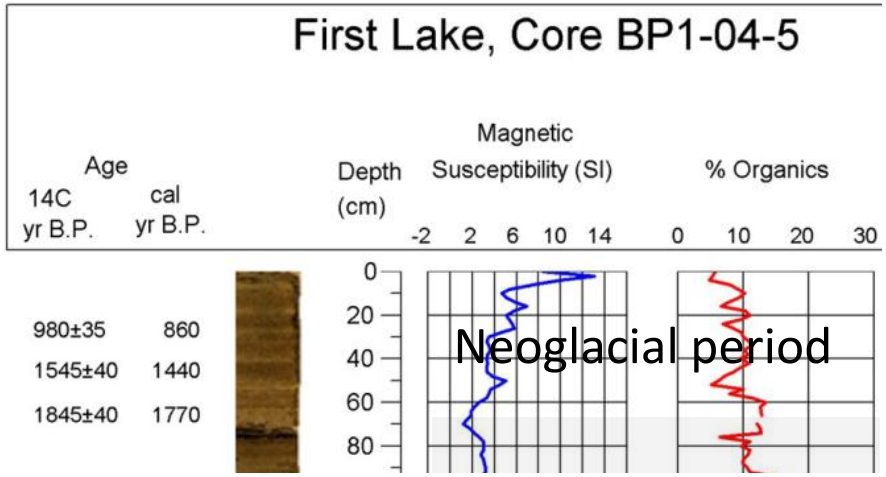
Controls over meadow creation and persistence

- Most current meadow sites were likely glaciated and scraped down to bedrock during the Pleistocene.
- Thus, soil formation and establishment of vegetation at current meadow sites began approximately 10,000 years ago at the dawn of the Holocene.

Controls over meadow creation and persistence

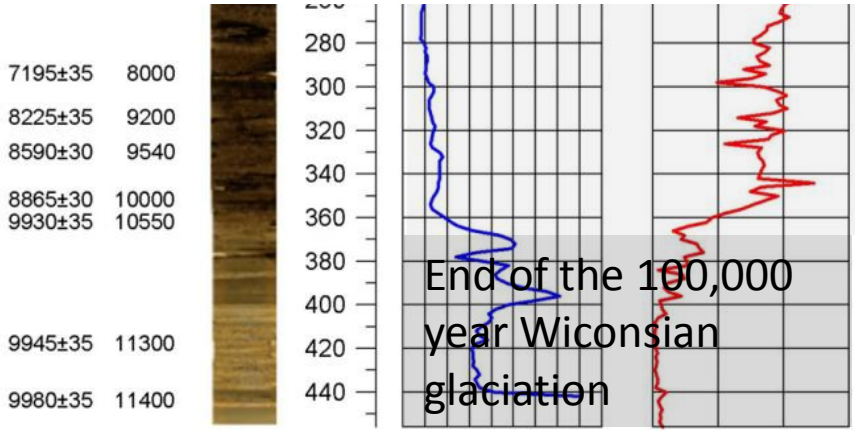
- Geomorphology affects soil formation and hydrologic potential
  - Very stable and changes slowly over geologic time (100s of thousands to millions of years or more).
- Climate affects the amount of surface and sub-surface water and the duration of seasonal saturation and inundation
  - Potentially unstable and can change rapidly over the course of decades to hundreds or thousands of years.

The palisade glacier activity record to the right indicates that glacial activity (magnetic susceptibility) was low and primary productivity (% organics) was high during most of the early and middle Holocene suggesting a relatively warm and dry climate.



Many (perhaps most?) of the meadows in the Sierra Nevada may be only a few thousand years old or less.

Buried tree stumps and alternating strata of organic and mineral soils suggest that many sites waxed and waned between meadows and forests during the neoglacial period.



modified from fig. 12, Boweman and Clark 2011

Vulnerability of meadows

- Exposure to threats
  - What factors threaten meadows?
- Sensitivity to change
  - What types of changes are we concerned about?
- Adaptive capacity
  - How resilient are meadows to change?

Vulnerability of meadows

Exposure to threats

- Climate change
  - Increasing minimum temperatures potentially affecting watershed hydrology (timing and amount of water present in meadows) and pine encroachment
- Contaminants
  - Increasing nitrogen and pesticide drift from the Central Valley potentially affecting plants, animals, and biogeochemical cycles
- Altered fire regimes
  - Changing vegetation characteristics of the surrounding forests potentially affecting watershed hydrology and pine encroachment
- Non-native invasives
  - Increasing competition for resources potentially affecting plant species and functional group composition
- Land use change
  - Livestock, pack stock, human recreation, and roads potentially affecting soil erosion and sedimentation rates and plant species and functional group composition

Vulnerability of meadows

Exposure to threats

- Land managers can potentially manage fire regimes, invasive plants, and land uses.
- Although they cannot directly manage climate change or contaminants originating from outside of their boundaries, they need to understand what their effects are and how they may interact with threats they can manage.

Vulnerability of meadows

Sensitivity to change

Changing from meadow to forest

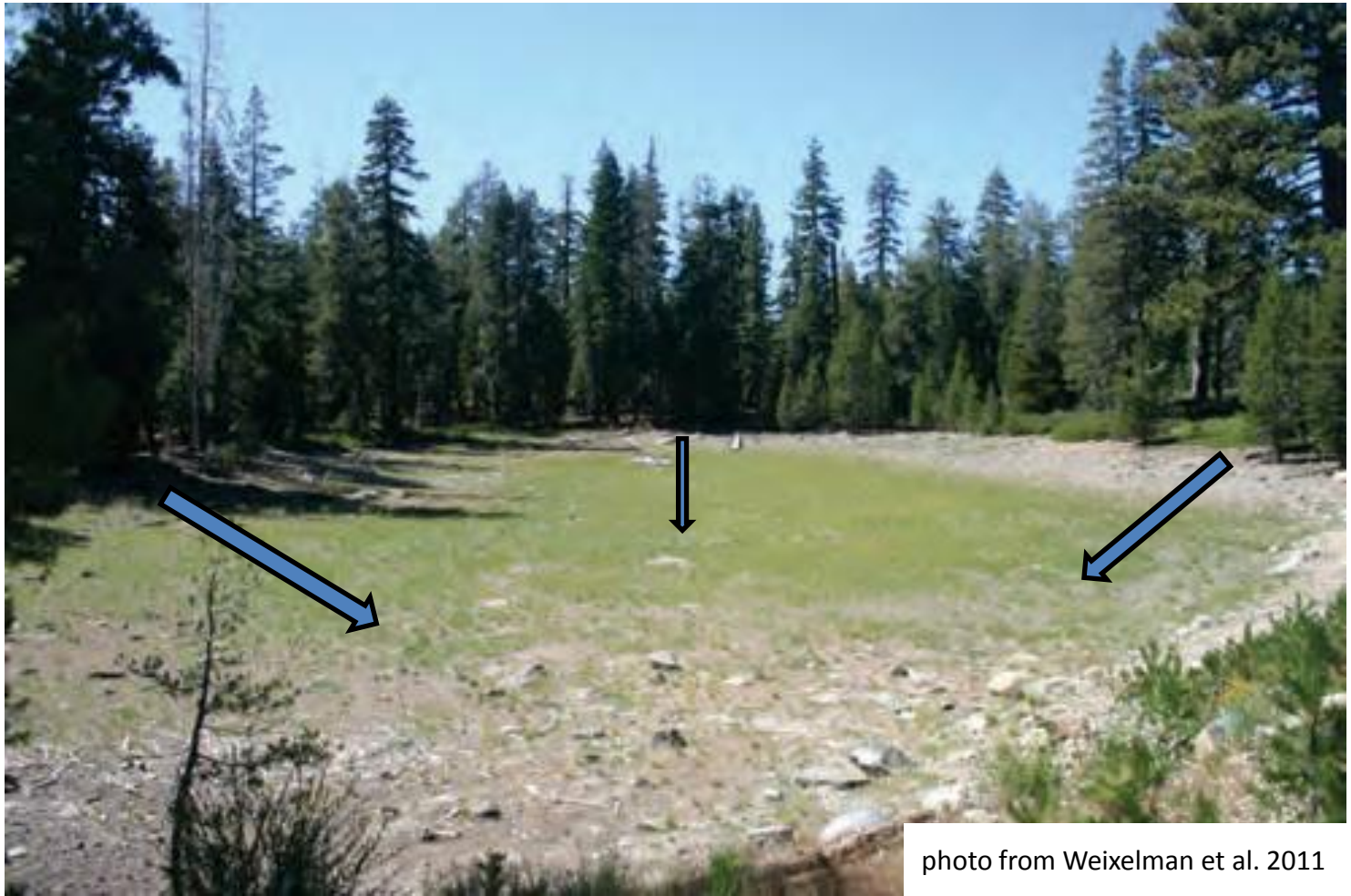


photo from Weixelman et al. 2011

Vulnerability of meadows

Sensitivity to change

Changing from one hydrogeomorphic meadow type to another, or from one set of dominant species to another.

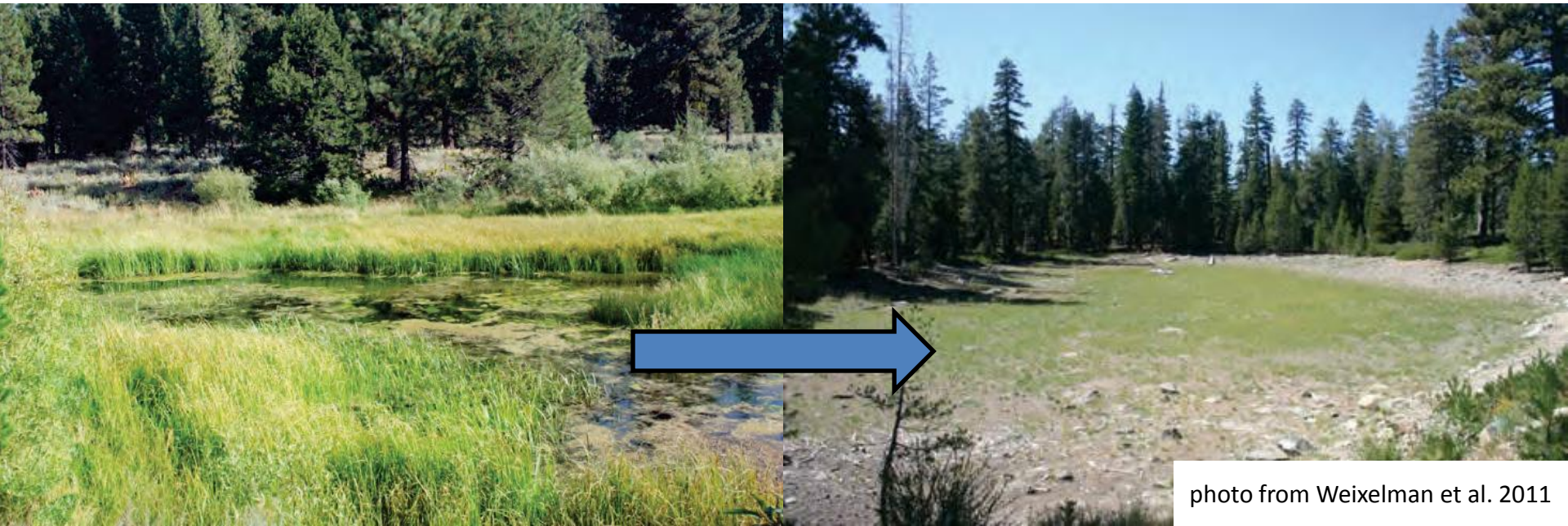


photo from Weixelman et al. 2011

Vulnerability of meadows

Sensitivity to change

Changing proportion of types within a meadow perimeter.

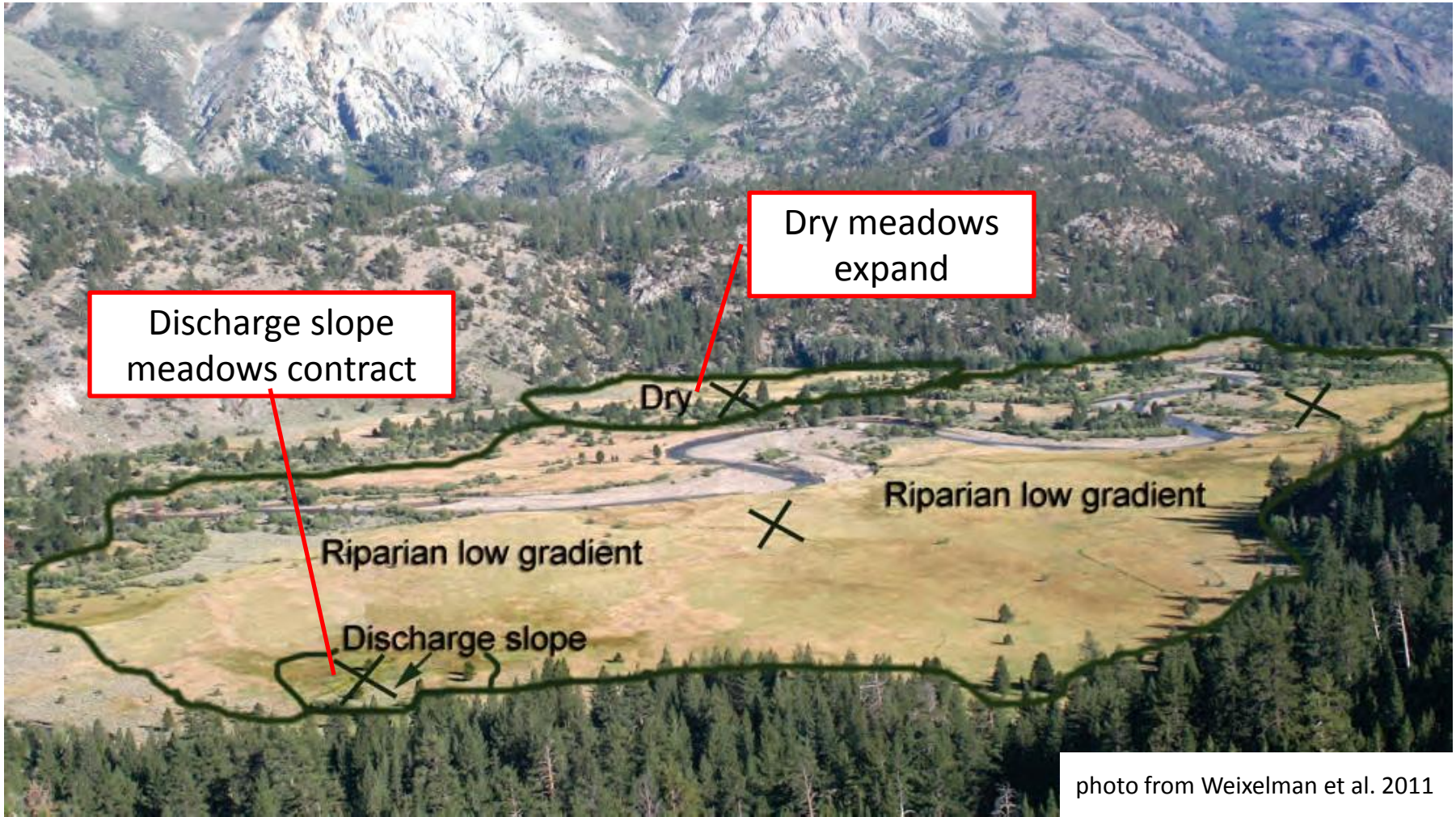


photo from Weixelman et al. 2011

Vulnerability of meadows

Adaptive capacity

- Stratigraphic evidence indicates that contemporary meadow sites have waxed and waned between meadow and forest vegetation during the recent past in response to climate shifts.
- This suggests a degree of site resilience allowing meadow vegetation to re-establish when climatic conditions allow.
- But meadows vary widely in their geomorphic characteristics, and potentially in their resilience.

Vulnerability of meadows

Adaptive capacity

- However, if the underlying geomorphology and hydrologic potential of meadows change due to stressors (e.g. land use or extreme weather events), then the resiliency of a site may be compromised.

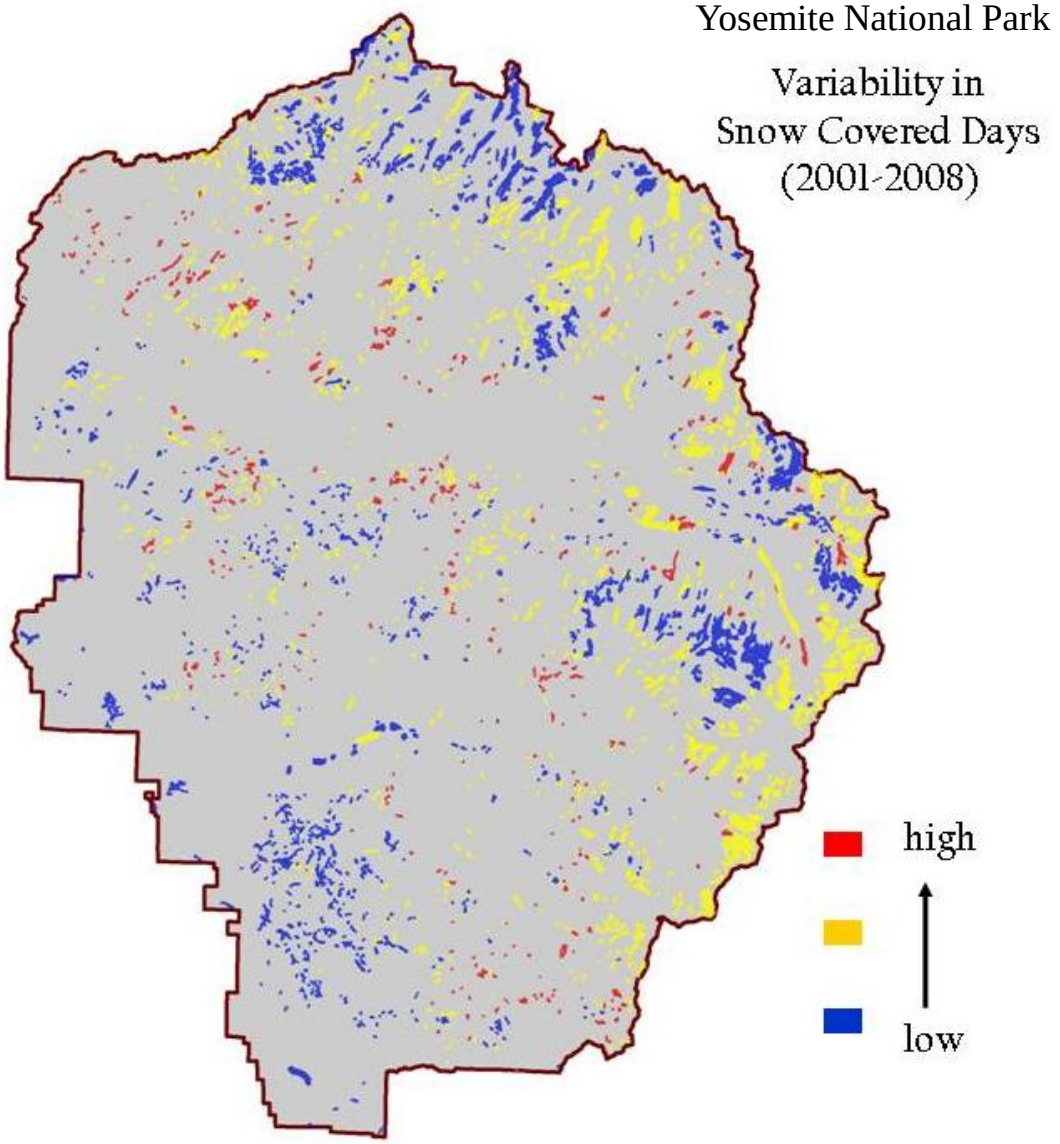
Stanislaus NF, photo by Tracy Weddle

Plumas NF, USFS photo

Attributing vulnerability to individual meadows

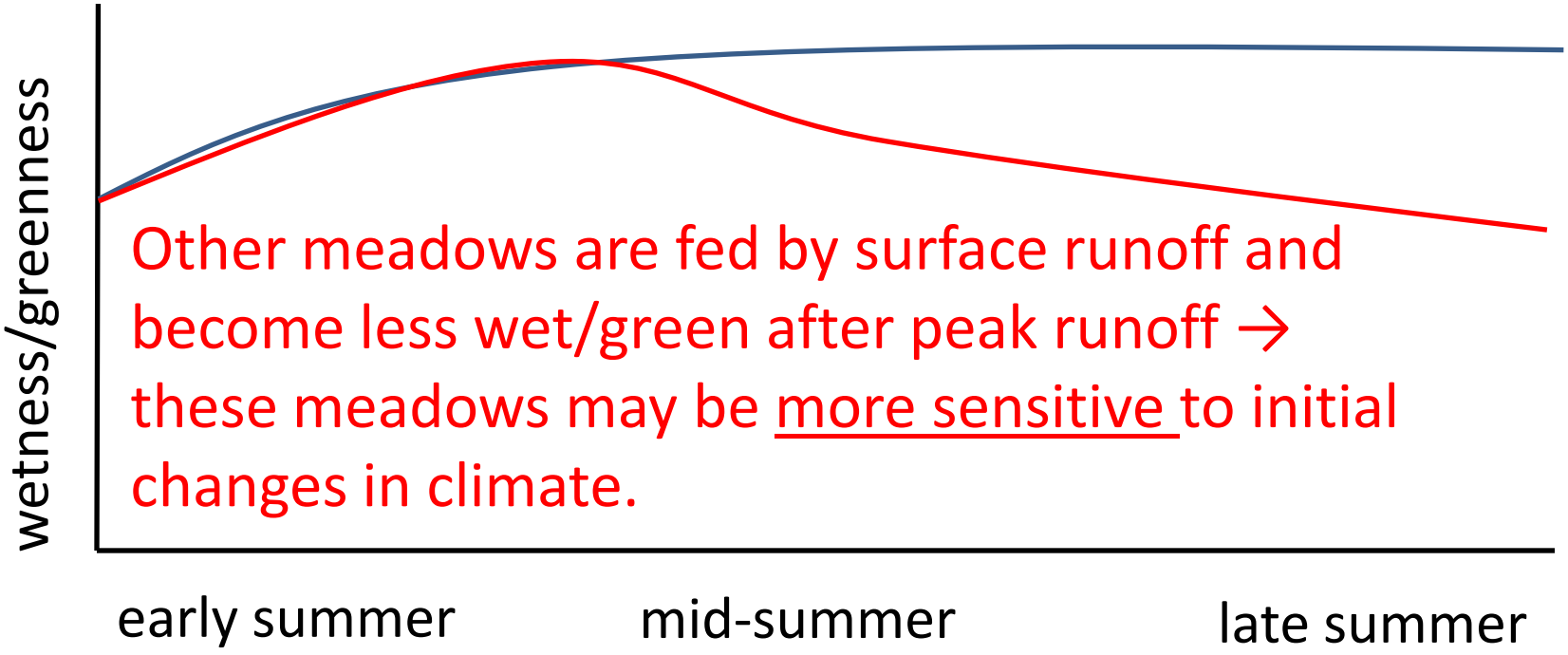
Meadows currently vary in the interannual variation of snow they receive.

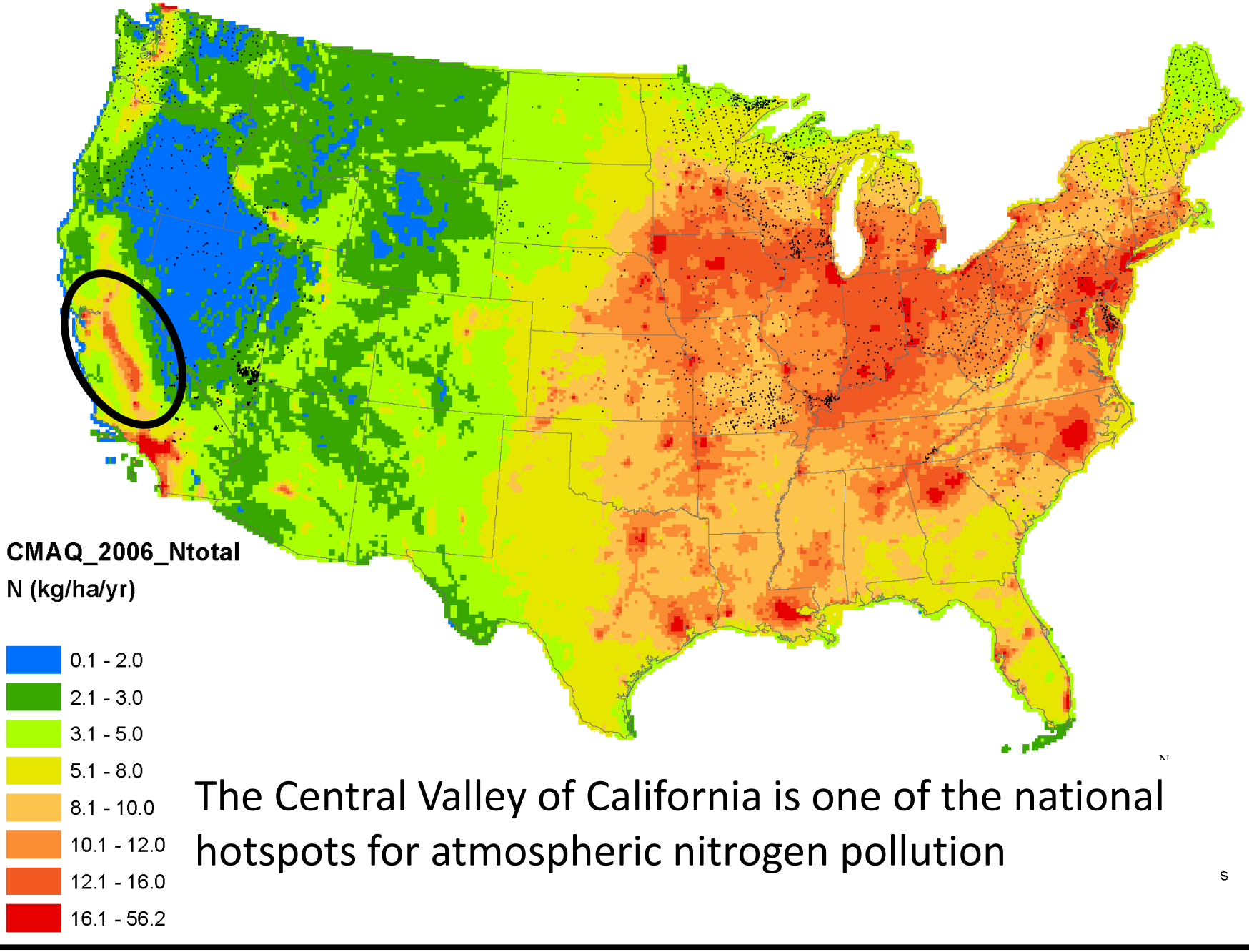
Meadows that currently experience low variability (high regularity) of snow may be more sensitive to a future of increased interannual climatic variability.



Attributing vulnerability to individual meadows

Some meadows are fed by ground water and remain wet/green throughout the summer → these meadows may be <u>less sensitive</u> to initial changes in climate.



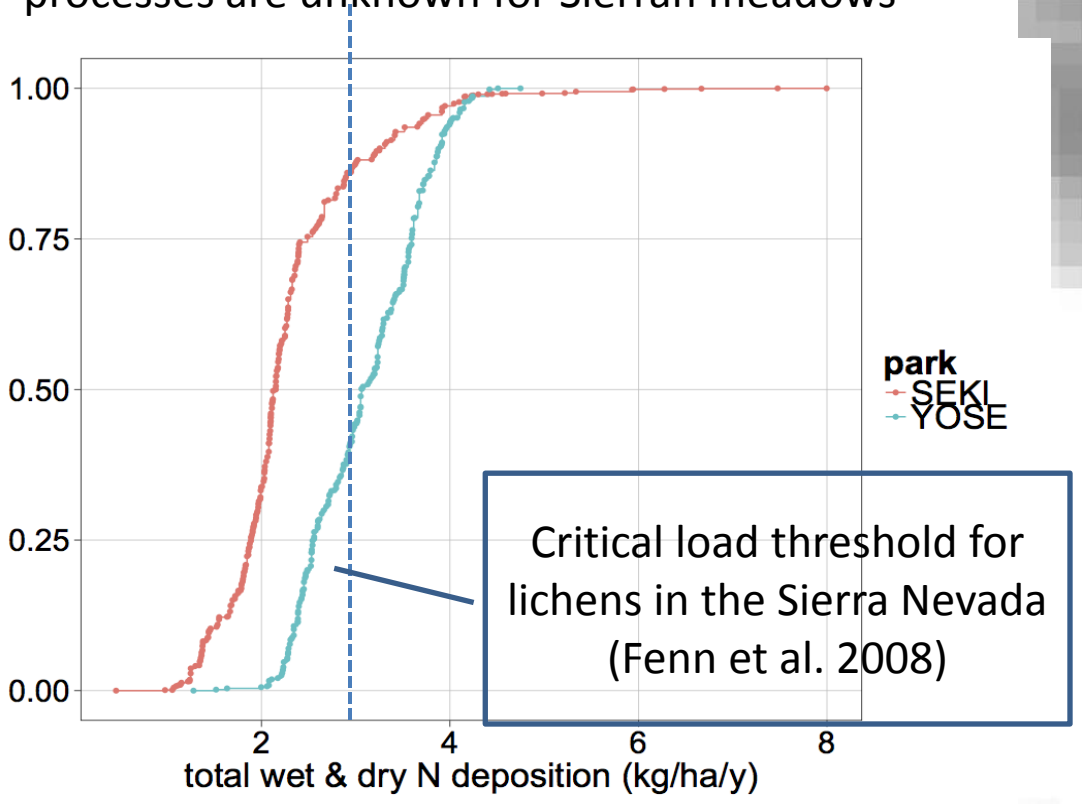


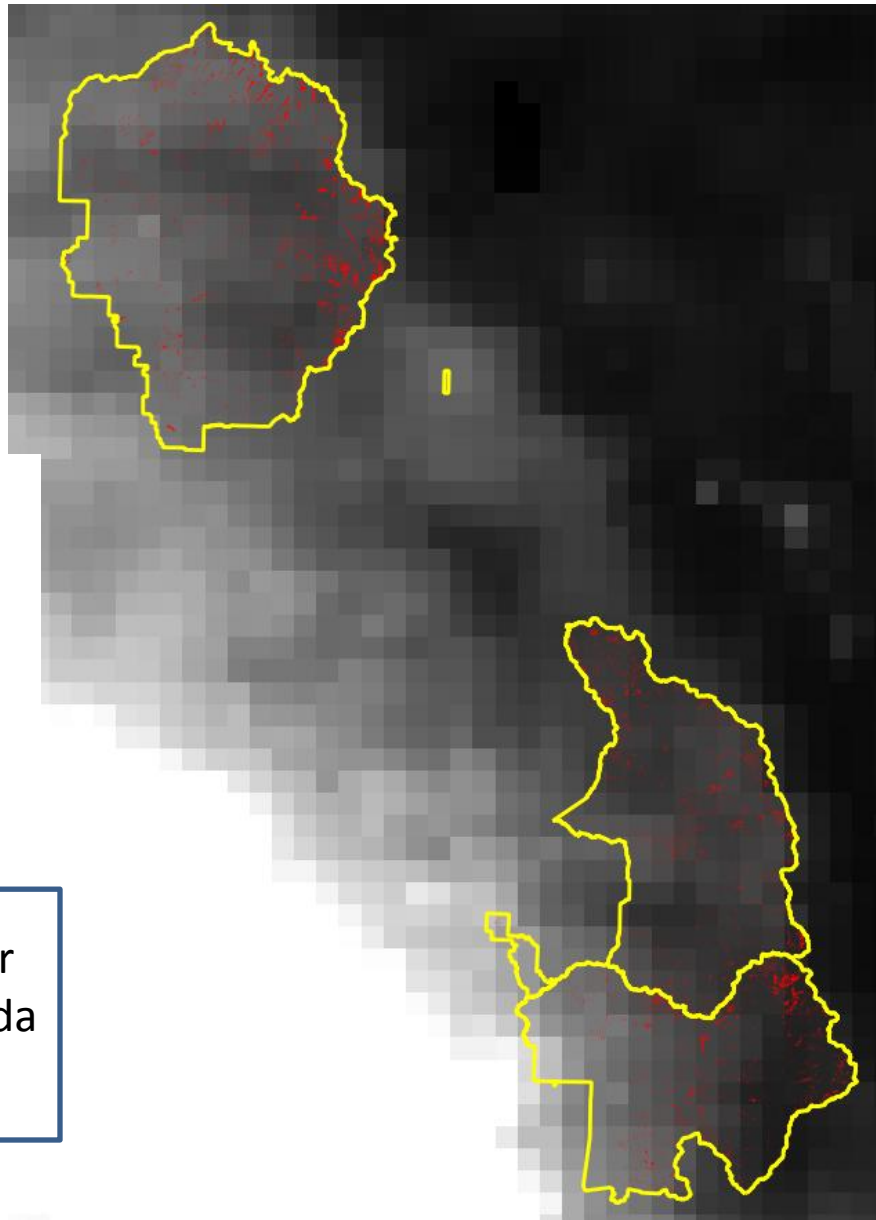
The Central Valley of California is one of the national hotspots for atmospheric nitrogen pollution

Attributing vulnerability to individual meadows

Approximately 55% of the meadows in YOSE and 15% of the meadows in SEKI have nitrogen deposition rates which may be in exceedance of critical loads for lichens.

Increased N can also accelerate decomposition of peat, promote plant invasions, and decrease plant species diversity, although critical loads for these processes are unknown for Sierran meadows





Need to better understand

- The aspects of meadow change which are most undesirable.
- Individual and interactive effects of stressor threats.
- Thresholds associated with meadow changes.
- Indicators of meadow resilience
  - to identify meadows that are robust to stressor effects and promote those resilience factors when possible through management actions.