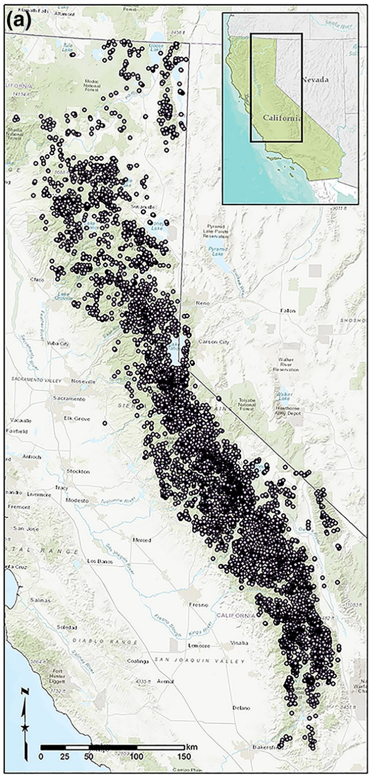
Prioritizing and monitoring meadow conservation and restoration actions based on climate vulnerability



Project Overview

- We analyzed meadow vegetation response to contemporary variation in climate and characterized how these responses varied in accordance with hydrogeomorphic contexts (e.g., geology, elevation) at an ecoregional scale;
- We developed a meadow monitoring tool that allows stakeholders to visualize near real-time vegetation conditions using climate and satellite image archives through Google Earth Engine cloud computing and visualization technology
- We developed a spatially-explicit vulnerability assessment of meadows in the Sierra Nevada, Southern Cascades, Modoc Plateau, Northwestern Basin and Range, and Mono and Sierra Nevada foothills; and
- We developed a decision framework that provides guidance on where to focus restoration and conservation actions based on meadow climate vulnerability assessment results.

Figure Above: Study region with each meadow identified as a point.

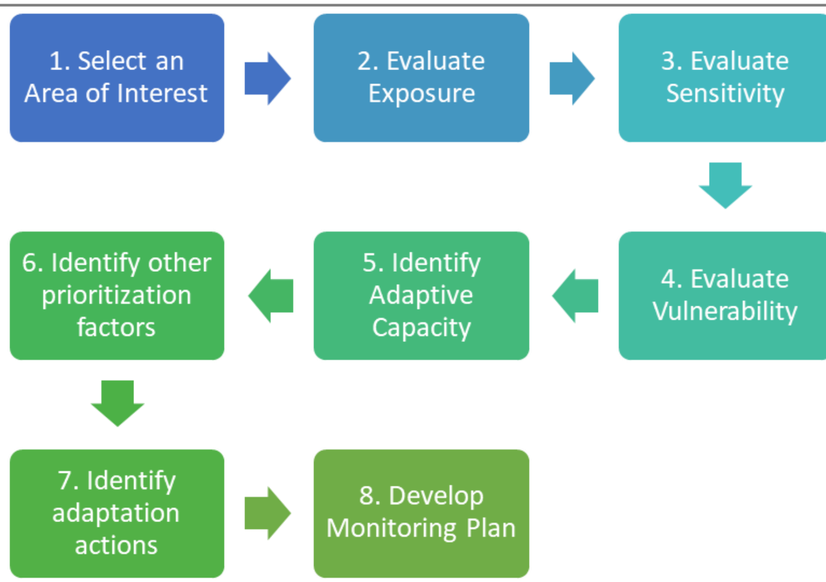


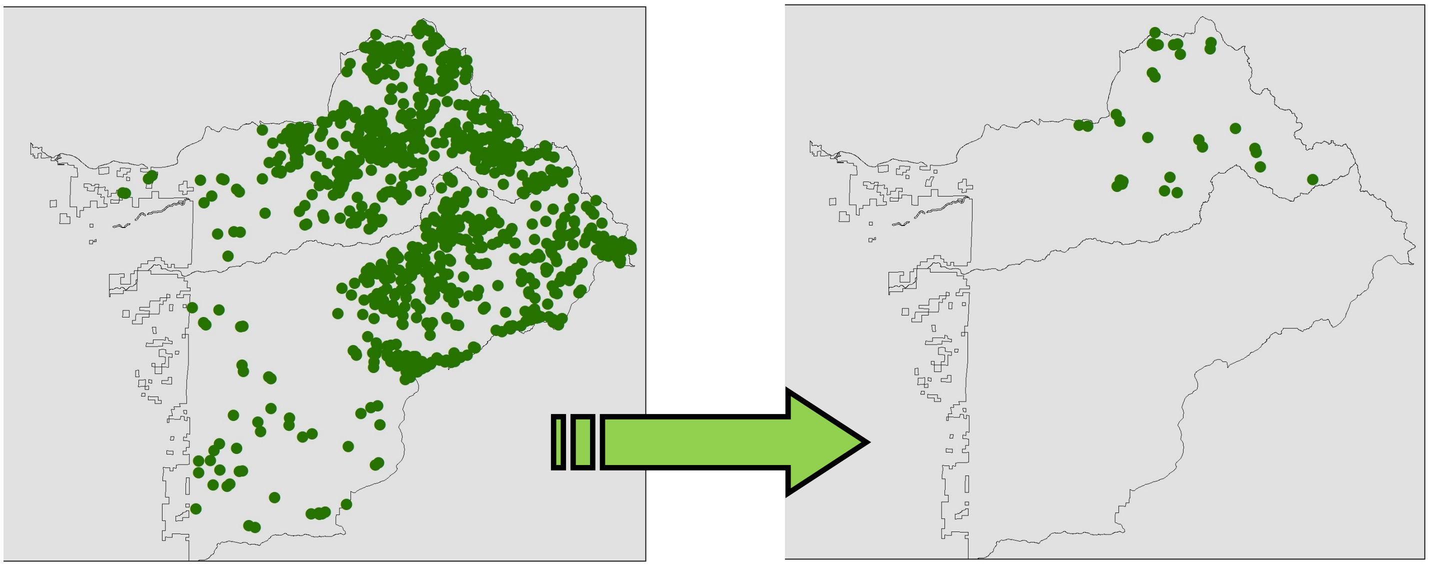
Figure Right: Eight steps in the decision framework, each consisting of a series of questions that are answered based on management objectives.

Results

- *The climate metric meadows are most sensitive to is April 1 snowpack.*
- *Meadow sensitivities to snowpack varied with long-term average meadow climate, indicators of watershed subsurface water storage capacity, and indicators of meadow vegetation composition.*
- *Alpine and subalpine meadows with high average annual precipitation but limited catchment subsurface storage exhibited the highest sensitivities.*
- *Meadows with higher adaptive capacity include large meadows, with more extrusive igneous or metamorphic rock relative to intrusive igneous rock, meadows with higher storage capacity, and with greater than 25% cover in the watershed, and meadows found in areas that were historically drier.*

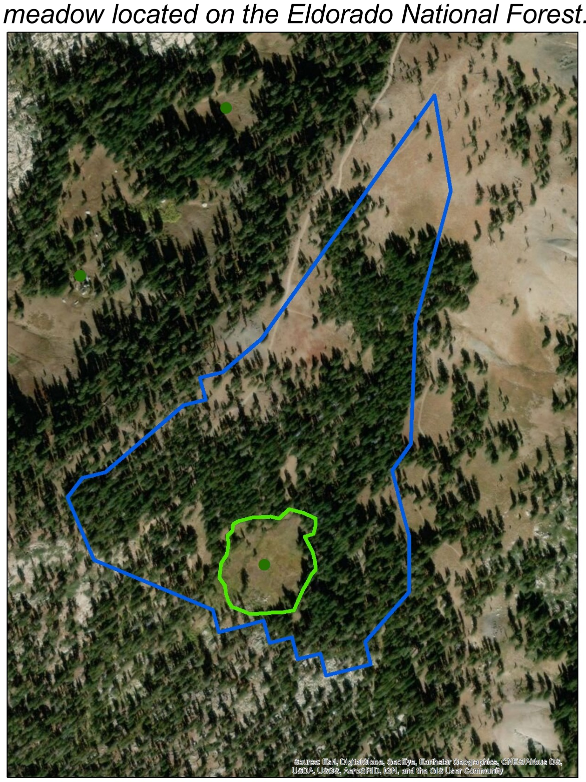
Spatially Explicit Meadow Vulnerability Assessment And Decision Framework

The decision framework can be used to prioritize restoration at multiple meadows or to evaluate meadow restoration actions for a single meadow.



Example Above: In this example meadows were evaluated through the decision framework with a goal of increasing climate resilience for key aquatic species in the Collaborative Forest Landscape Restoration Cornerstone project footprint on the Eldorado and Stanislaus National Forests. Thirty meadows were identified from 911 meadows to focus restoration and conservation actions.

Example Below: The decision framework provides a tool for managers to evaluate a single meadow for climate vulnerability and to develop climate-meadow specific adaptation actions associated with this analysis. The meadow identified below is Upper Onion meadow located on the Eldorado National Forest.



Exposure	Moderate
Sensitivity	Low to moderate
Adaptive Capacity	Low

Management Implications

- *Good candidate to implement management actions to improve climate resilience (increase adaptive capacity and reduce sensitivity.)*
- *May experience some change relative to historic conditions, but is not expected to completely change and therefore restoration actions may be more predictable.*

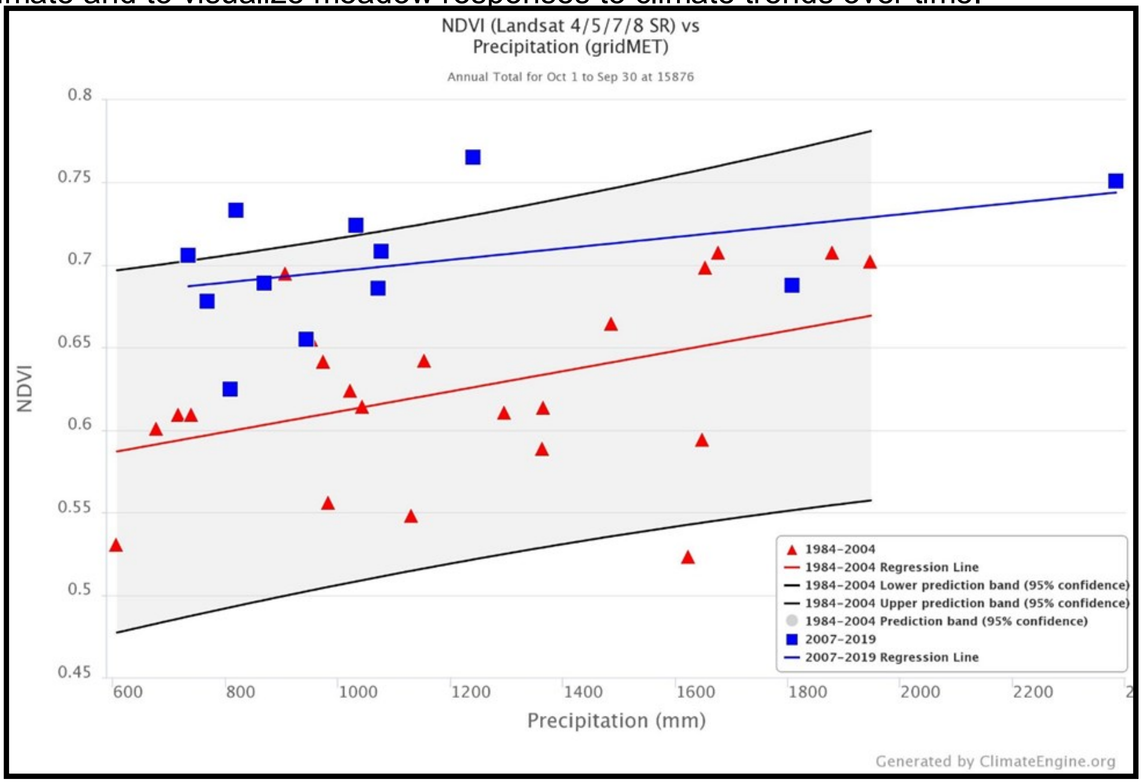
Adaptation Actions

- *Increase snowpack retention and maintain forest cover in the watershed.*
- *Make sure there are not continuing anthropogenic impacts. Trails, roads, and grazing should be considered if present.*
- *Reduce upland species invasion such as conifer encroachment.*

Meadow Monitoring Tool

Climate Engine can be used to assess and monitor meadow conditions and responses to climate and management activities in real time.

- The Climate Engine app includes a feature to evaluate specific meadows based on their UC Davis meadow ID.
- A protocol for meadow monitoring using Climate Engine is included in the decision framework. The method allow the user to visually compare pre vs. post restoration vegetation vigor irrespective of climate and to visualize meadow responses to climate trends over time.



Climate Engine Figure: Cookhouse Meadow (Lake Tahoe Basin Management Unit) pre-restoration (1984-2004) NDVI (measure of greenness/biomass) compared to post-restoration (2007-2019) NDVI. Some of the post-restoration data falls outside of the 95% area of confidence for pre-restoration, suggesting restoration was successful at increasing meadow greenness. In addition the regression line for post-restoration is higher than for pre-restoration regardless of climate (recent extreme drought is captured in post-rest data).

Citations:

Albano, C.M., M.L. McClure, S.E. Gross, W. Kitlasten, C.E. Soulard, C. Morton, and J. Huntington. 2019. *Spatial patterns of meadow sensitivities to interannual climate variability in the Sierra Nevada*. Ecohydrology: e2128. https://onlinelibrary.wiley.com/doi/full/10.1002/eco.2128

Gross, S., M. McClure, C. Albano, and B. Estes. 2019. *A spatially explicit meadow vulnerability decision framework to prioritize meadows for restoration and conservation in the context of climate change*. Version 1. vulnerability data: https://databasin.org/datasets/1a28fdee63c14f83ad4d2169a33c9e00 ; project gallery: https://databasin.org/galleries/542e640d4a2d46b7b27811b1f01c7919

Meadow monitoring tool—Climate engine: https://clim-engine.appspot.com/sierrameadows ;

UC Davis Meadow Dataset: https://meadows.ucdavis.edu/

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