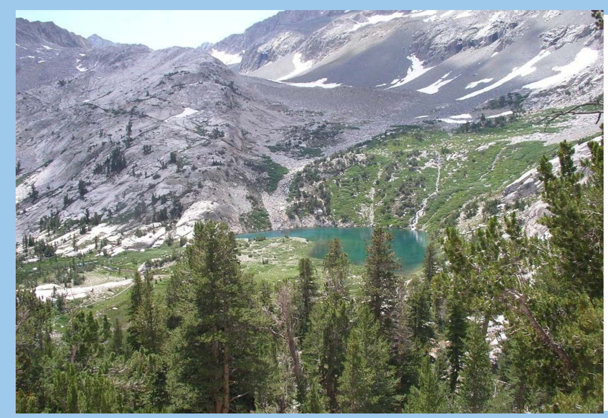

Using sensitive montane species as indicators of hydroclimatic change in meadow ecosystems of the Sierra Nevada, California

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GC11A-0972
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1. CONSERVATION MANAGEMENT WITH CLIMATE CHANGE

Montane amphibian species selected for modeling:
- Sierra yellow-legged frog (***Rana sierrae***)
- Mountain yellow-legged frog (***Rana muscosa***)
- Yosemite toad (***Anaxyrus canorus***)
- Southern Long-toed salamander (***Ambystoma macrodactylum sigillatum***)

- Few conservation strategies utilize management plans based on ecological responses to hydroclimatic data.
- For many sensitive species, sparse empirical observation data and the inability to apply various climate models to functional spatial scales often prevents use of species distribution models in applied management
- Amphibians have been used as key indicators of climate change in a variety of habitat models, but few incorporate **hydrologic** variables with Generalized Circulation Models (GCM) to effectively integrate watershed scale impacts and identify variables or habitats which may provide specific opportunities for effective watershed or species management

AMPHIBIAN SPECIES OF THE SIERRA NEVADA

- Have adapted life histories to montane meadow ecosystems, including timing the initiation of breeding around hydroclimatic signals associated with runoff from spring snowmelt, making them highly vulnerable to climate change
- Are important management species, both ecologically and as species of special concern or threatened/endangered species.

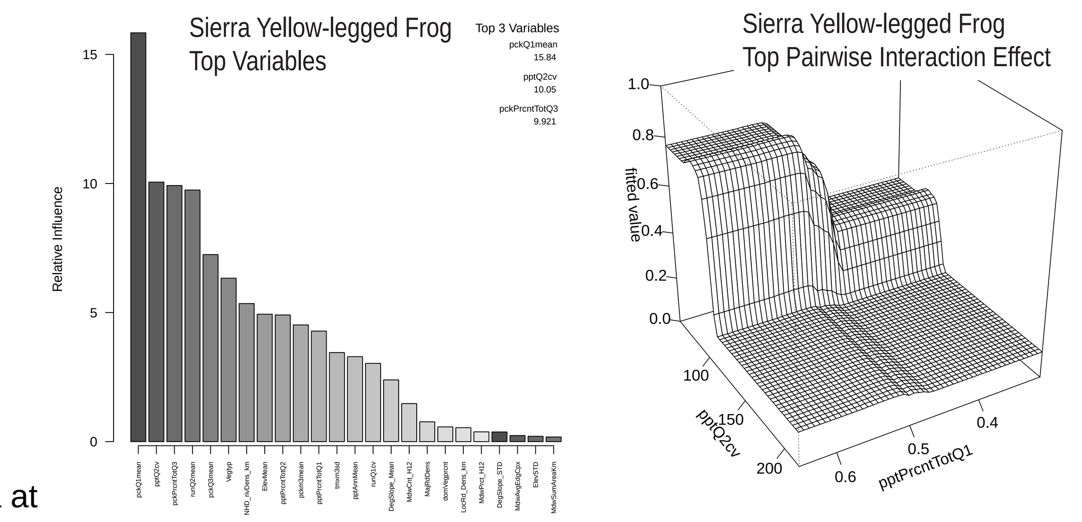
Objectives

- **Integrate recent machine learning methods utilized in species distribution modeling (SDM) with downscaled hydroclimatic data for the Sierra Nevada of California**
- **Apply boosted regression tree (BRT) ensemble methods to identify key environmental and hydroclimatic variables for sensitive montane amphibians**
- **Demonstrate quantifiable model outcomes which can be more effectively utilized by conservation managers to understand climate change impacts at a species scale**

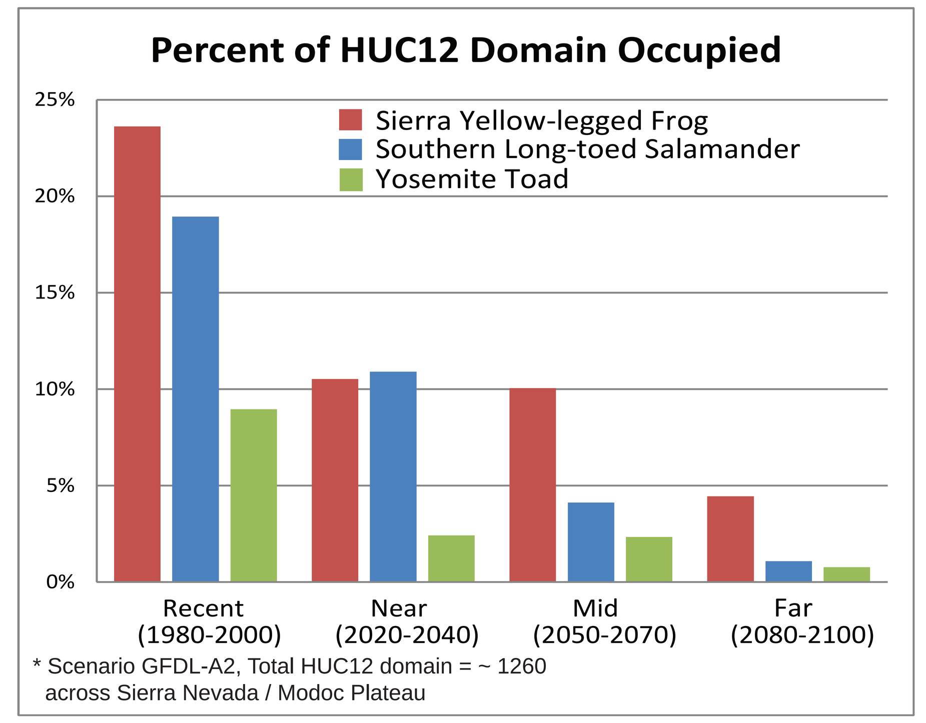
2. BOOSTED REGRESSION TREE (BRT) MODELING

BRTs
- Can handle sharp discontinuities common in sparsely sampled species or large study areas
- Functional with multiple variable types and missing data
- Fit complex non-linear relationships
- Useful to determine most influential variables and identify interaction effects

Model Inputs
- Used downscaled hydroclimatic BCM data at HUC12 resolution with PCM and GFDL-A2
- Models were trained using current species ranges and validated/tested with obs. data

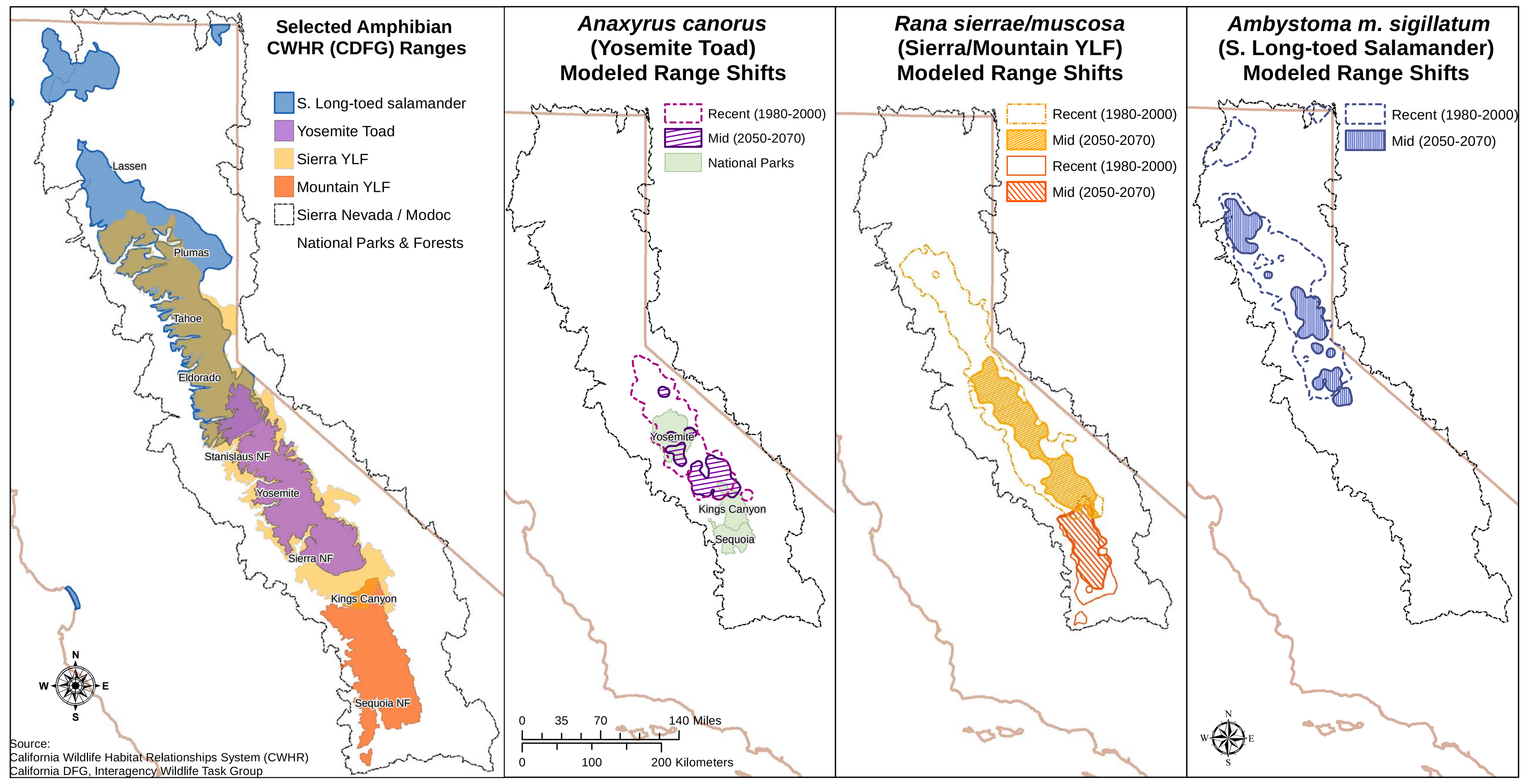


Over 80 variables were ultimately used in each species model, however, influential variables were primarily hydroclimatic. However, R. sierrae and A. canorus were strongly influenced by Numb. of Meadows within Hydrologic Units (HUC12).



* Scenario GFDL-A2, Total HUC12 domain = ~ 1260 across Sierra Nevada / Modoc Plateau

3. MONTANE AMPHIBIANS AND DISTRIBUTION SHIFTS

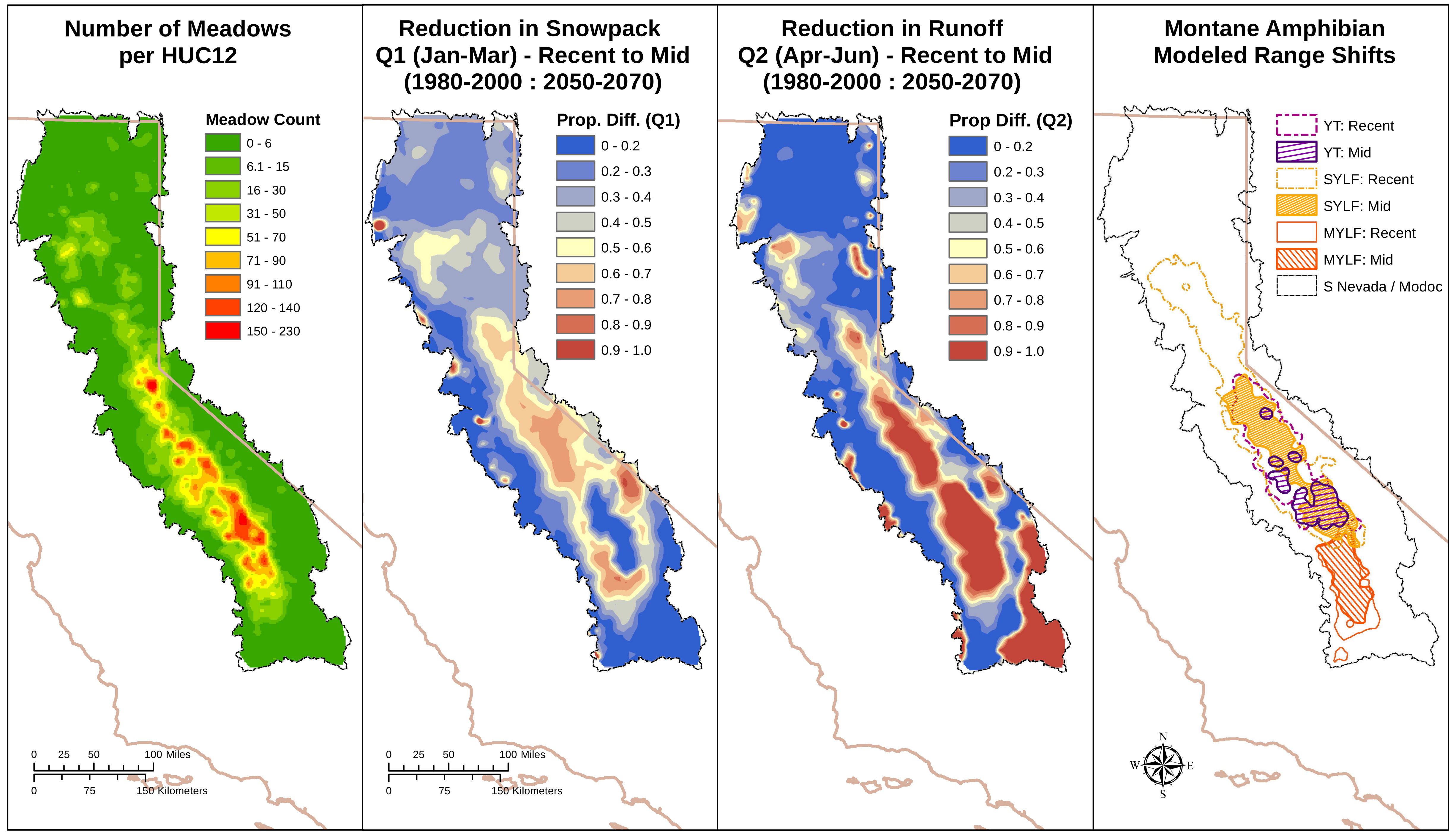


- Models show all species appear highly vulnerable to hydroclimatic change
- Extreme reductions in modeled range were observed as early as mid-century (2050-2070).

Modeled Probability of Occupancy	S. Long-toed Salamander	Yosemite Toad	SYL Frog	MYL Frog
% Decline: 2000 to 2070	78%	88%	57%	27%

Important modeled variables included: snowpack, runoff, precipitation, veg type, and meadow count

4. HYDROCLIMATIC CHANGE AND MONTANE SPECIES



Climate Warming Impacts On Amphibians

-- In the Sierra Nevada, one of the greatest climatic concerns is the predicted reduction in mountain snowpack and associated snowmelt.

-- Reductions in snowpack affect the timing and variability of critical snowmelt runoff periods—important seasonal signals that amphibian species in montane ecosystems have evolved life history strategies around.

- **Integration of hydroclimatic change and species distribution models can identify areas with the greatest resilience (lowest probability of signficant climatic changes)**
- **These areas provide the greatest potential for restoration / species persistence with limited time and funding**

5. IMPLICATIONS FOR CONSERVATION MANAGEMENT

Spp. persistence may depend on habitat resilience:

- **Climate change *will* cause sensitive species ranges to contract…"adaptive management" difficult to apply**
- **Best approach should identify important regions that will be *most resilient* to climate change and focus resources in areas where there is a greater chance for species persistence**
- **Meadows are critical habitat metrics for ecologic and hydroclimatic stability**

- **BRTs can be broadly applied with changing climate and revised scenarios to:**

- Determine specific effects on a habitat for an indicator species
- Identify potential triggers and interaction effects which should be considered in restoration and conservation efforts
- Identify specific regions which may be more resilient to climate change to focus resources for habitat / species conservation

ACKNOWLEDGEMENTS / REFERENCES

Funding for this project provided by National Fish & Wildlife Foundation, Resource Legacy Fund, and the Center for Watershed Sciences, UC Davis.

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