Forecasting the Response of Terrestrial Habitats to Climate Change in the Northern Sierra

Louis **Provencher**[#], Greg **Low**[&†], Dick **Cameron**[&], Kirk **Klausmeyer**[&], Jason **Mackenzie**[&]

[#]TNC NEVADA, [†]APPLIED CONSERVATION INC., [&]TNC CALIFORNIA

The Nature Conservancy

Protecting nature. Preserving life.™

Acknowledgments #1

Funding:

A. Seelenfreund

Resources Legacy Fund

Technical Support:

Kori Blankenship, TNC's LANDFIRE

Liz Rank, The Nature Conservancy's Fire Learning Network

Acknowledgments #2 Expertise

- Franco Biondi, UNR
- Dave Conklin, Conservation Biology Institute
- David Edelson, TNC CA
- Jim Gaither, Jr., TNC CA
- Kyle Merriam, USFS Plumas National Forest
- Jason Moghaddas, Feather River Land Trust
- Rich Niswonger, U.S. Geological Survey, NV
- Robert Nowak, UNR
- Davis Prudic, retired, U.S. Geological Survey, NV
- **Hugh Safford**, USFS Pacific Southwest Region
- Rebecca Shaw, TNC CA
- Jason Sibold, Colorado State University
- **Jim Thorne**, UC-Davis

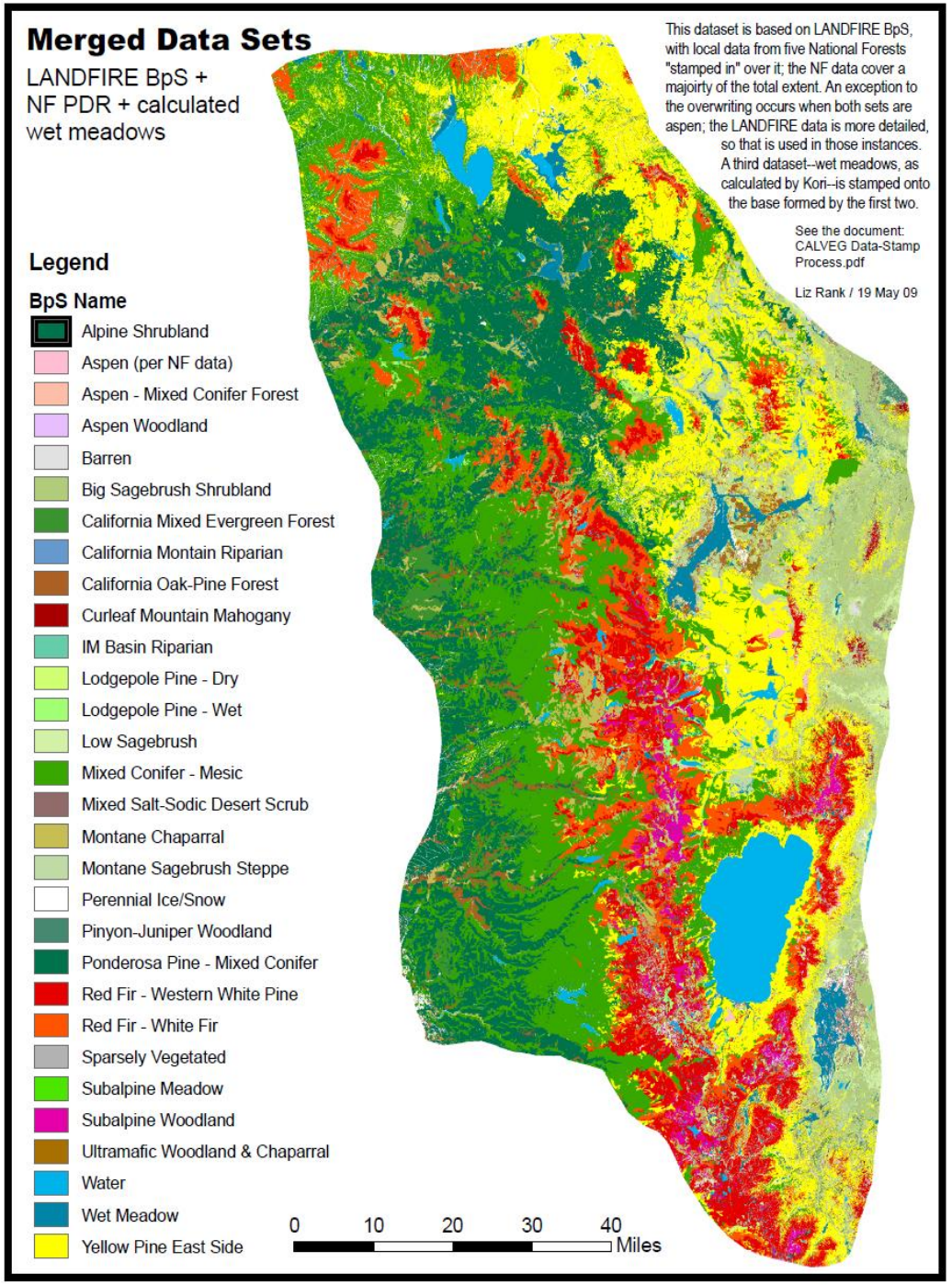
Goals

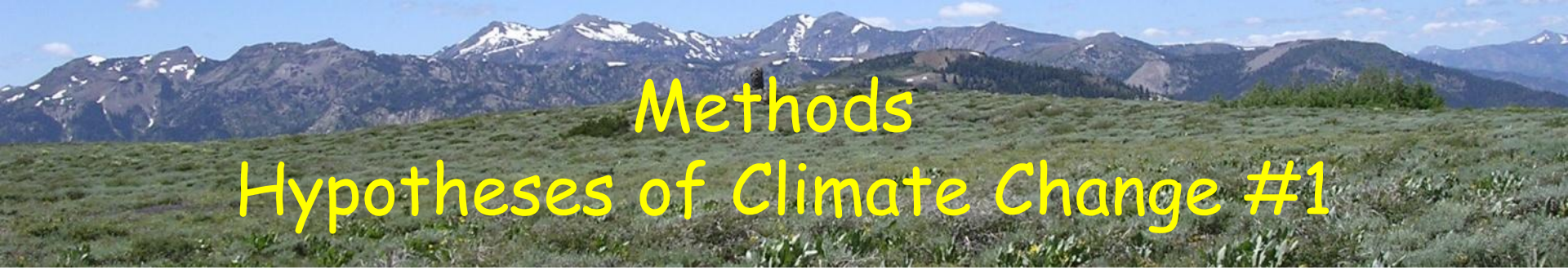
Northern Sierra Partnership (NSP) climate change report:

- Integrates climate projections, forecasts of the response of major habitat types, and management simulations to determine:
  - Northern Sierra's habitats at greatest risk from projected future climate changes;
  - **Coarse conservation strategies that might be most cost-effective for reducing or adapting to climate risks for selected at-risk ecosystems.**

Mapping

- About 5 million acres
- Base layer: LANDFIRE
  - ✓ Ecological systems = biophysical Settings (BpS)
  - ✓ Subsumed small BpSs
  - ✓ Vegetation classes within BpS
- Additional geodata:
  - ✓ National Wetland Inventory
  - ✓ USFS National Forest "stamped" over LF geodata
  - ✓ Applied crosswalk rules for vegetation classes in new BpS

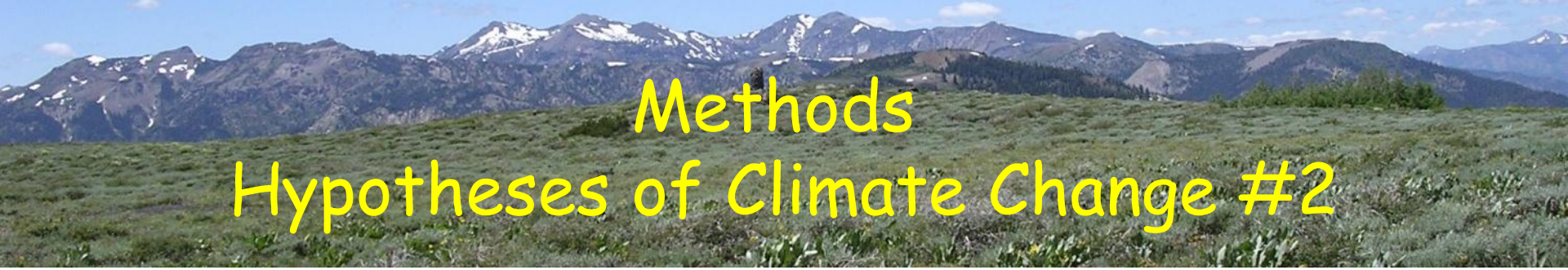




Methods
Hypotheses of Climate Change #1

- Based on temperature, precipitation, and CO_2

- **Directly supported hypotheses:**
  - ✓ More frequent, larger fires
  - ✓ Higher tree mortality during longer growing season droughts
  - ✓ Longer period of low flows
  - ✓ Longer period of groundwater recharge during colder months (more effective recharge)
  - ✓ Increased dispersal of non-native species



Methods
Hypotheses of Climate Change #2

Inferred hypotheses:

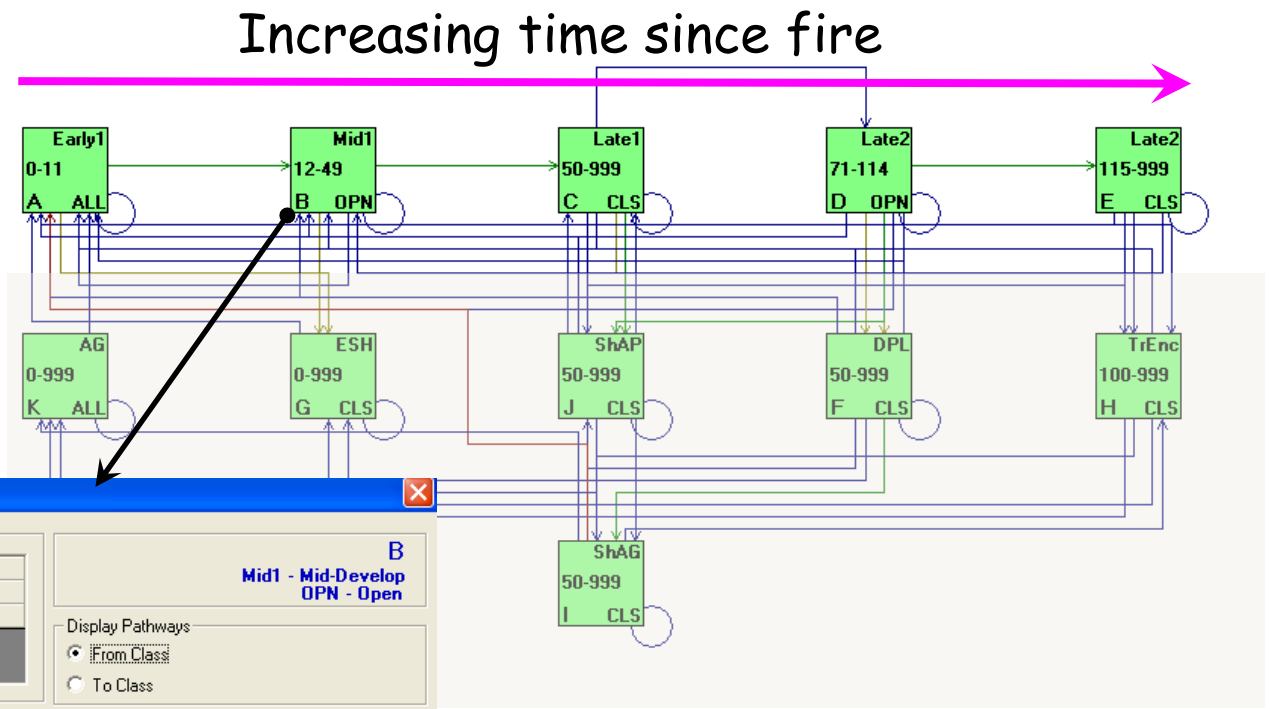
- ✓ Greater conifer and deciduous tree species recruitment and growth in meadows/wetlands/riparian due to drought and CO_2 fertilization
- ✓ Impaired recruitment of willow and cottonwood due to modified hydrology
- ✓ Faster growth of fast-growing native tree species
- ✓ Increased recruitment of high-elevation trees
- ✓ Increased dispersal of pinyon and juniper in shrublands

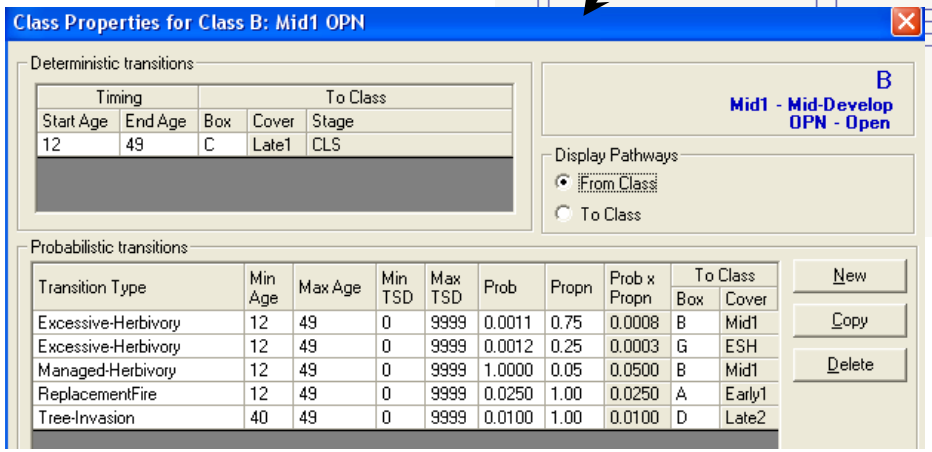
Methods
Vegetation Forecasting 101

- ✓ Updated or created 25 state-and-transition models (STM) in VDDT software

Reference classes

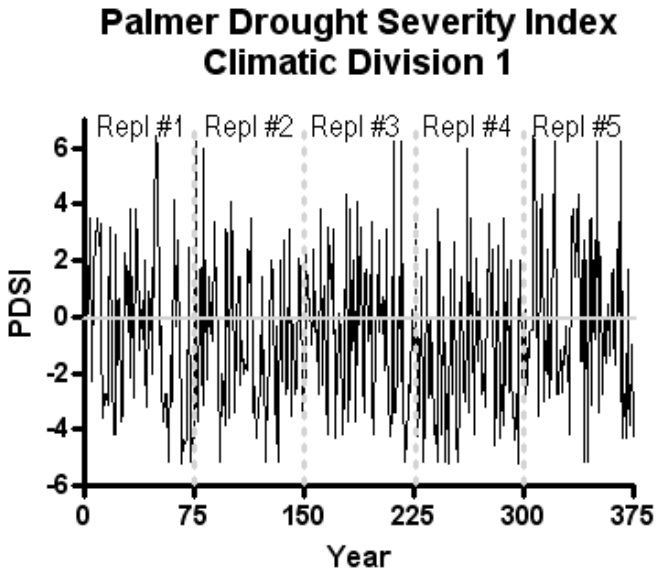
Uncharacteristic classes



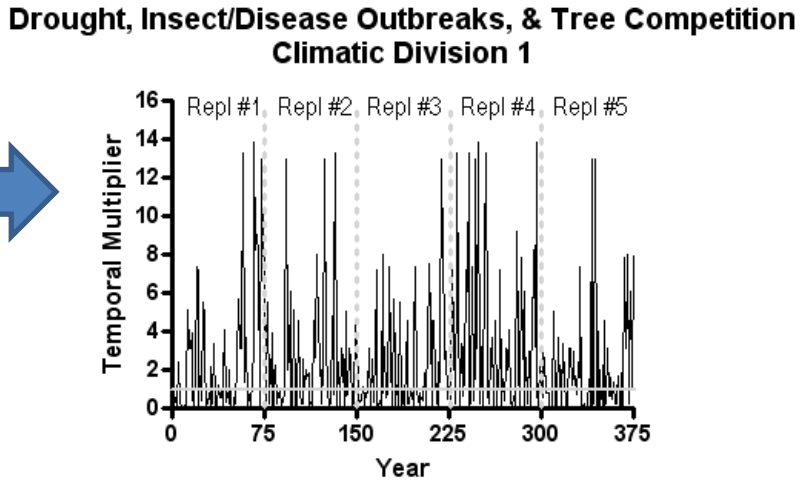


Methods
Temporal Multipliers

- ✓ Created time series of parameter variability dependent on climate projections
  - Extended recent past climate 50 years into future
  - Modified current climate using CA PCM A1Fi climate projections



$0.6 * e^{-0.6 * PDSI}$



Methods
NRV & Metrics

- Reference condition is Natural Range of Variability (NRV)
  - % OF EACH VEGETATION CLASS WITHIN EACH BPS UNDER NATURAL DISTURBANCE REGIME
- Ecological Departure (ED) is the dissimilarity between NRV and current % of vegetation classes per BpS
- High Risk Vegetation (HRV) is the total % of "bad" classes: 1) expensive to fix, 2) exotics, 3) pathways to 1) or 2).
- % loss of acres from one BpS to others.

Ecological Departure

Which vegetation classes are "out of whack" per BpS

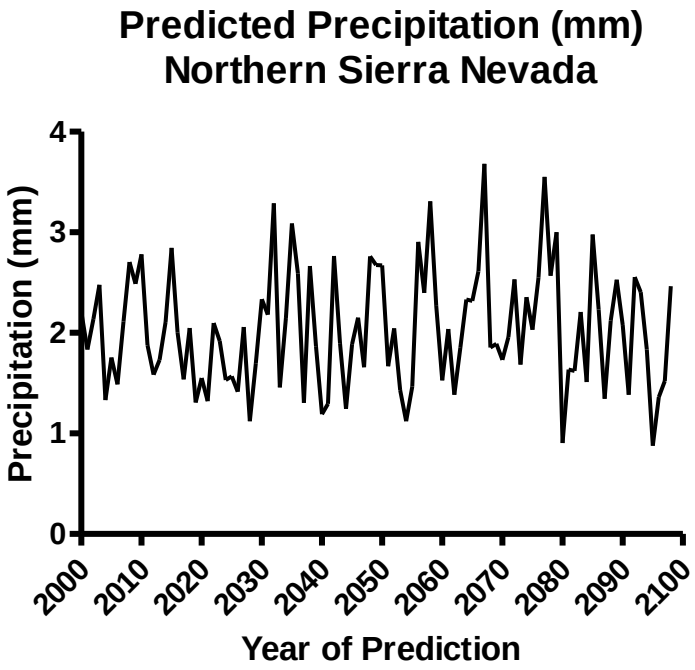
Expected % = Natural Range of Variability (NRV) achieved under post-settlement climate

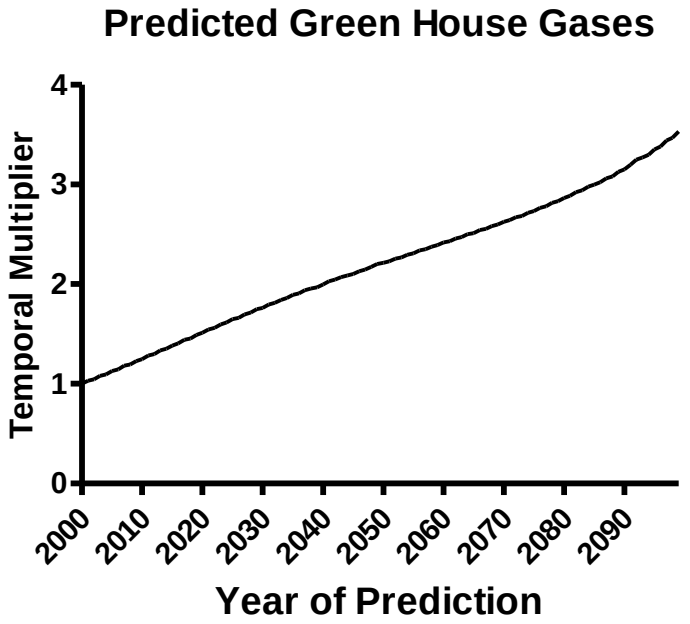
Vegetation Classes	Actual % in Class	Expected % in Class
Class A – Early Development, Open Herbaceous vegetation is dominant; shrub cover is 0 to 10%.	**<1%**	**20%**
Class B – Mid Development, Open Mountain big sagebrush cover up to 30%; herbaceous cover typically >50%.	**6%**	**50%**
Class C – Mid Development, Closed Shrubs are dominant with canopy cover of 31-50%. Herbaceous cover is typically <50%. Conifer sapling cover is <10%.	49%	15%
Class D – Late Development, Open Conifers are the upper lifeform; conifer cover is 10- 30%, herbaceous cover 10 - 30%, shrub cover 5 - 30%	6%	10%
Class E – Late Development, Closed Conifers are dominant; conifer cover is 31 – 80%, herbaceous cover >10%, shrub cover >5%	**<1%**	**5%**
Class U – Uncharacteristic	**38%**	-

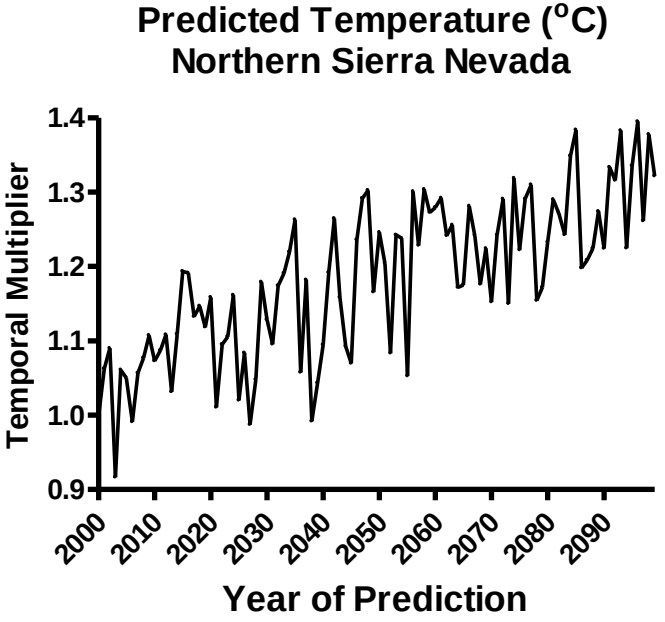
Too Little

Too Much

Methods
Temporal Multipliers & CC





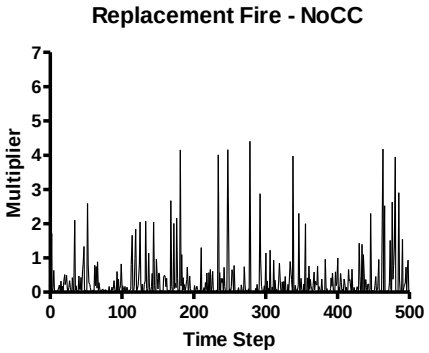


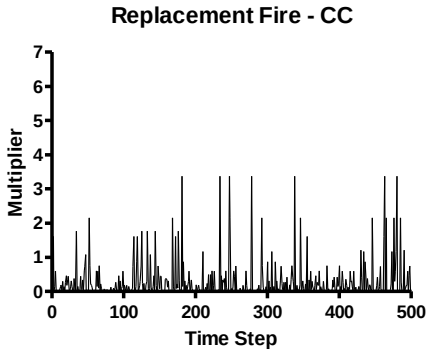
i) Precipitation & temperature from PCM simulations for Northern Sierra Nevada (based on Dettinger et al. 2004) under the "business-as-usual" (A1Fi) climate change scenario.

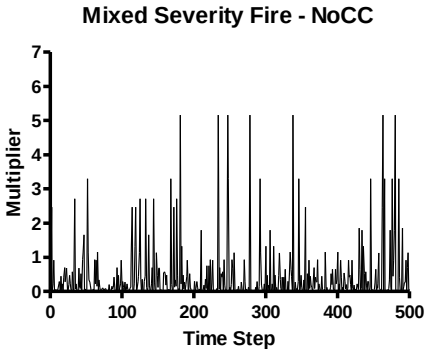
ii) GHG from IPCC (2007) report

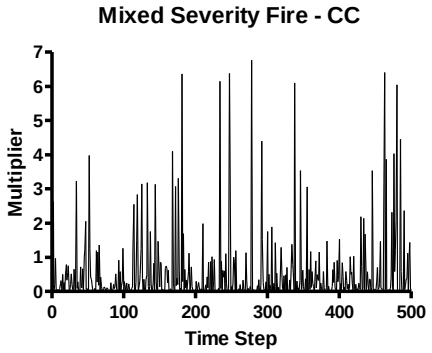
Methods
Temporal Multipliers
No CC *vs.* +CC

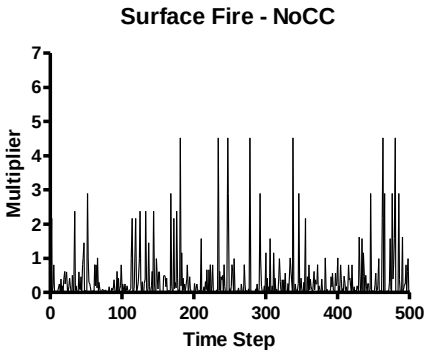
- Expressed our hypotheses of climate change by modifying trends and variability of model parameter(s) using temporal multipliers.
- No guidance on how to implement CC algorithms – used common sense and heuristic transformations.

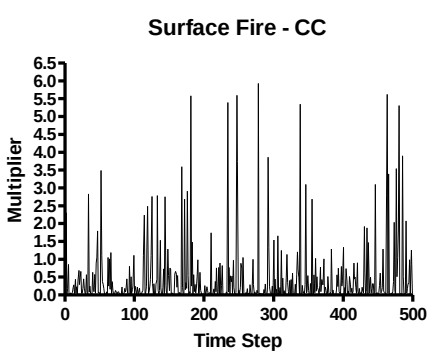






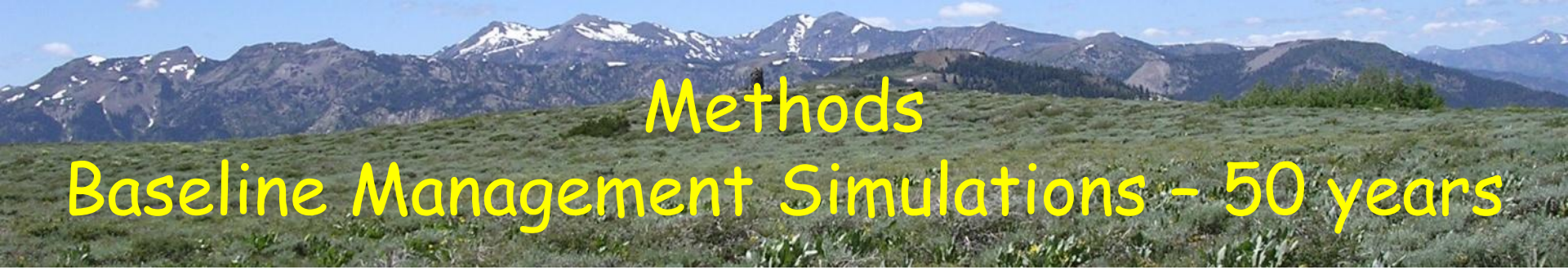






Methods
Range Shifts

- ✓ Estimated range shifts among BpSs caused by CC and based on historic vegetation changes (Wislander data) and **Maxent** projections.
  - Used Thorne's (UC Davis) conversion matrices of Wislander and new surveys to estimate vegetation conversion pathways & rates over 80 years after eliminating management-caused shifts (e.g., fire exclusion favoring mixed conifers over ponderosa pine)
  - Used TNC CA's Maxent bio-climatic estimates of major species "stress" (i.e., current habitat unsuitable in future) to estimate maximum rates of conversion: %BpS lost/80-year projection
- ✓ Assumed that range shifts occur <u>after stand replacing events</u> (e.g., chaparral replaces CA red fir after fire)



Methods
Baseline Management Simulations – 50 years

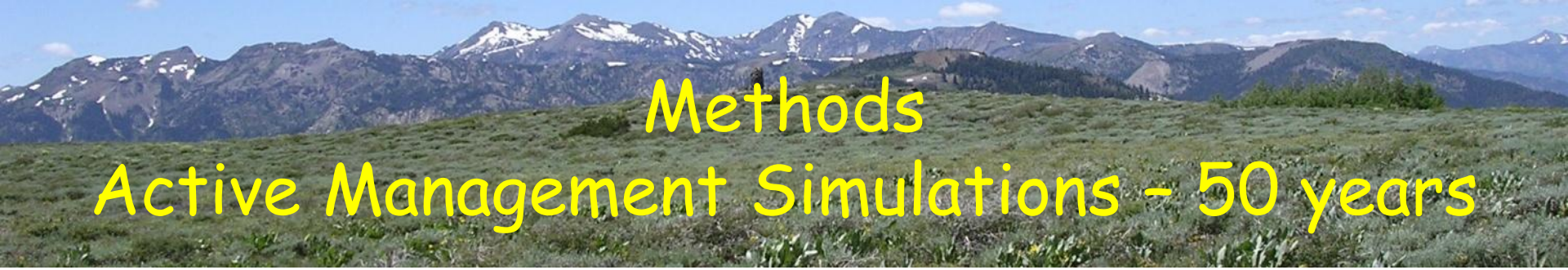
- First performed MINIMUM MANAGEMENT scenario using 5 replicates
  - Livestock grazing + fire suppression + no active management
  - Without CC
  - With CC
  - Compared ED, HRV, % range shifts

Results
Baseline Management Simulations – 50 years

- Identified 5 out of 25 BpSs needing future management because of **added** effects of CC:

BpS	Acres	Ecological Departure	High-Risk Vegetation	Range Shifts
Lodgepole Pine – Dry	8,900			
Aspen-Mixed Conifer	12,100			
Aspen Woodland	6,400			
California Montane Riparian	58,100			
Wet Meadow	108,400			

- 3 BpSs "improved" with CC
  - red fir-white pine; red fir-white fir; serpentine woodland & chaparral



Methods
Active Management Simulations – 50 years

- All active management scenarios included CC
- MAXIMUM and STREAMLINED MANAGEMENT scenarios using 5 replicates
  - Livestock grazing + fire suppression + active management
  - Compared ED, HRV, % range shifts
- MAXIMUM MANAGEMENT scenario = "get rid of the problem at all costs"
- STREAMLINED MANAGEMENT scenario = Achieve the best ecological solution for the least cost (i.e., highest Return on Investment)

Goal
Active Management Simulations – 50 years

- Desired future condition is not a trivial issue
  - If managers want to preserve BpSs **as they are today**, then aggressively manage for the next 30 years
  - If managers are willing to let CC cause range shifts, then manage whenever as ecological condition degrades

- We chose the first option: "hold the fort" as much as possible

Results
Baseline Management Simulations – 50 years

	Minimum Management			Streamlined Management			
BpS	ED	HRV	Range Shifts	ED	HRV	Range Shifts	Cost $/year
Lodgepole Pine – Dry	68	0	7	31	0	2	40,000
Aspen-Mixed Conifer	86	0	30	42	0	26	153,000
Aspen Woodland	48	0	19	23	0	6	150,000
California Montane Riparian	74	73	0	29	26	0	263,000
Wet Meadow	89	85	4	52	46	5	1,944,000

Streamlined Management Actions

BpS	Acres	Rx Fire	Thinning	Exotic Weed Inventory	Exotic Weed Control	Floodplain Restoration	Restoration of Unpalatable Vegetation
Lodgepole Pine – Dry	8,900	800; 0					
Aspen-Mixed Conifer	12,100	125; 0	125; 200				
Aspen Woodland	6,400		10; 0				
California Montane Riparian	58,100			500; 1,600	250; 1,200		
Wet Meadow	108,400			200; 2,000	100; 1,000	2,000; 0	800; 0

A; B = 1st 20 years; Next 30 years

Conclusions #1

- Climate change degraded 5 out of 25 BpSs
  - ✓ Well-known restoration methods need to be implemented in the next 30 years to increase BpS resilience
  - ✓ Cost is high: wet meadow restoration costs $100 million over 50 years
- 8 BpSs will experience increased HRV with or without CC due to:
  - ✓ + cheatgrass in upland forests and shrublands
  - ✓ + exotic forbs in montane riparian systems and wet meadows
- Climate change "improved" 3 BpSs by returning fire regimes to more natural state:
  - CA red fir-western white pine & -white fir
  - Ultramafic (serpentine) woodland & chaparral

Conclusions #2

- Riparian systems and wet meadows often on private lands
  - NRCS and State agencies will likely be major sources of funding
  - Potential for more rapid actions
- All systems of concerns found on public lands (USFS & BLM)
  - Major policy and funding challenges due to
    - ✓ Scale of actions
    - ✓ Litigious public land management in California and Tahoe Basin
    - ✓ Very restrictive management in Tahoe Basin
- The restoration need is actually larger than presented here
  - We only addressed added effects of CC
  - Many other BpSs require management

Questions

Is Portfolio Robust?

- 1st part of project mostly done by CA staff
- Not this presentation
- Generated future climate with ensemble approach
- Robust, but two areas more resistant to climate change:
  - ✓ Upper East Fork Carson River
  - ✓ Yuba River watershed