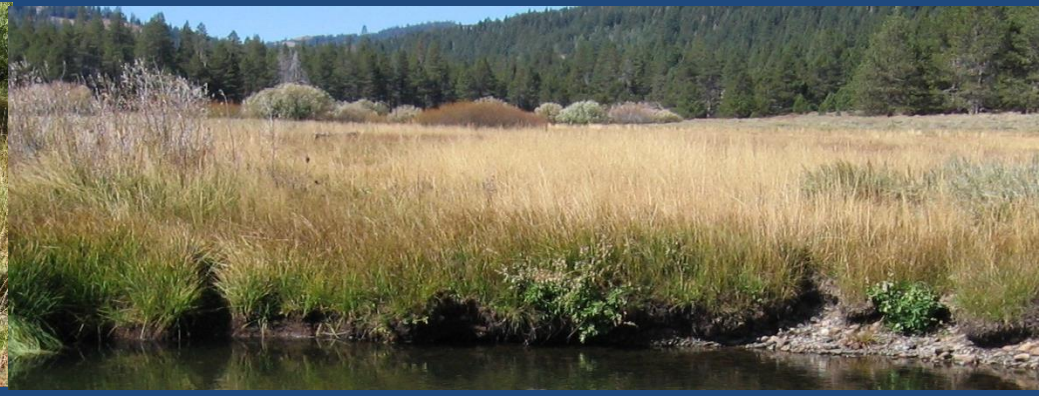
Restoration Effects on Meadow Carbon: The Sierra Meadows Restoration Research Partnership Project



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Stillwater Sciences
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Sierra Foothill Conservancy
Truckee River Watershed Council
South Yuba River Citizen's League
American Rivers
US Forest Service

Stillwater Sciences

What is a meadow?

- Dominated by herbaceous plant communities (woody species can occur but not dominate)
- Rooting zone saturated for at least 2-3 weeks of growing season
- Water sources can include surface water flooding, groundwater, subsurface flows, and snowmelt

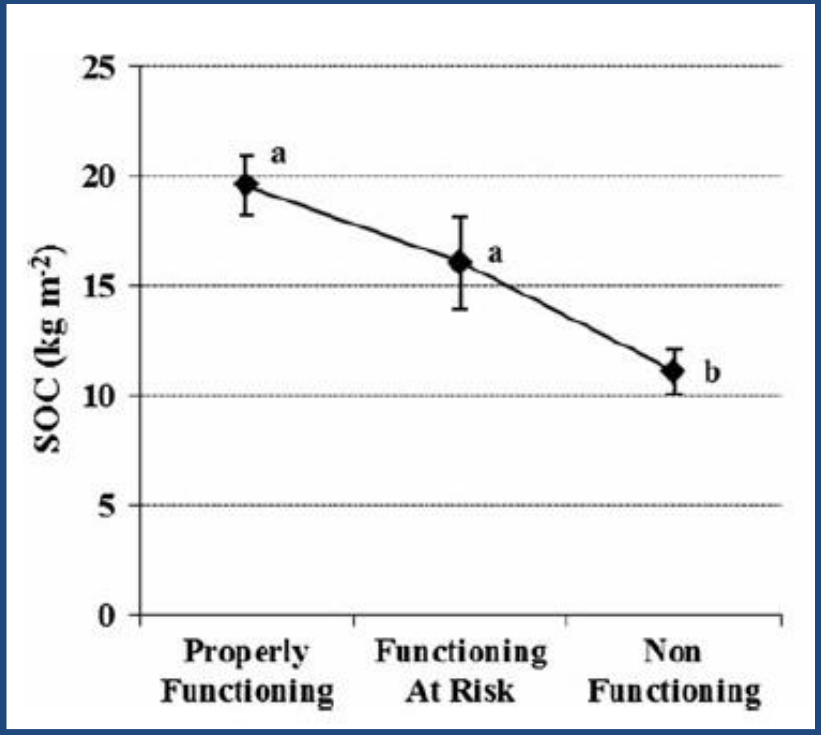
Weixelman et al. 2011

Meadows in the Sierra Nevada and S. Cascade

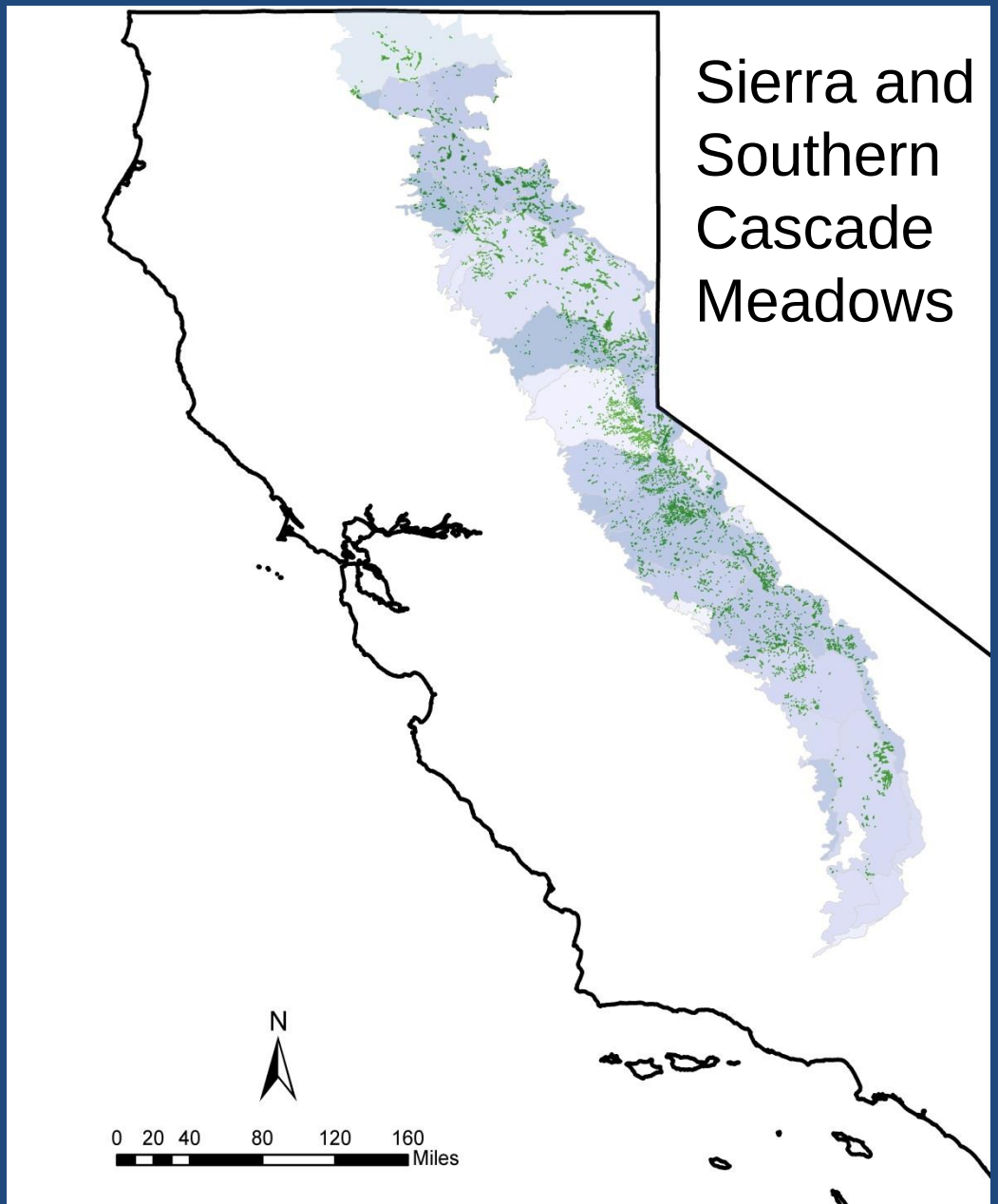
Total Number: >18,000 meadows

Total Acreage: >275,000 acres

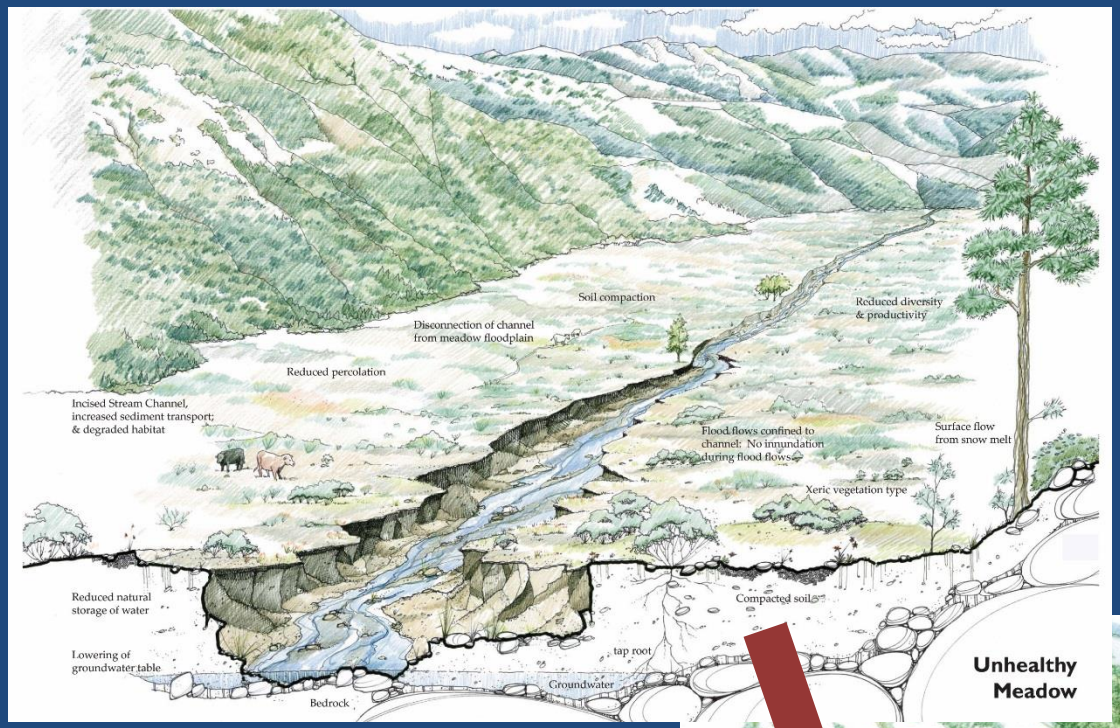
(Meadows Layer V2, USFS on Meadows Clearing House)

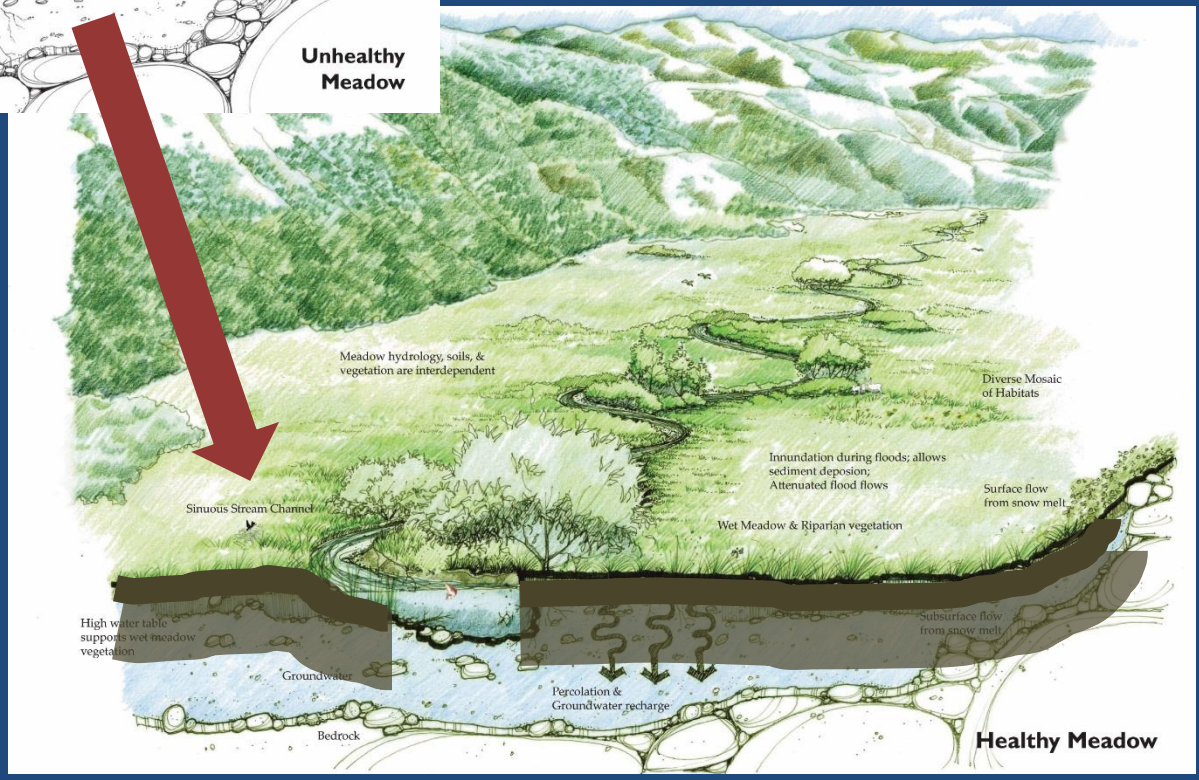


Norton et al. 2011



Many things change with meadow restoration





The Biggest Carbon Reservoir is the Soil

Overarching Question:

Does hydrologic restoration of meadows result in a net increase in carbon sequestration?

- How much for how long?
- What are measureable co-variates?

Hypotheses

Compared to degraded conditions, hydrologic restoration results in:

1. Increase in net C input to soil via plant production.

2. Decrease in net C oxidation loss from soil via aerobic decomposition.

3. The net increase in N_2O and CH4 fluxes to atmosphere is small in comparison to the increase in C input.

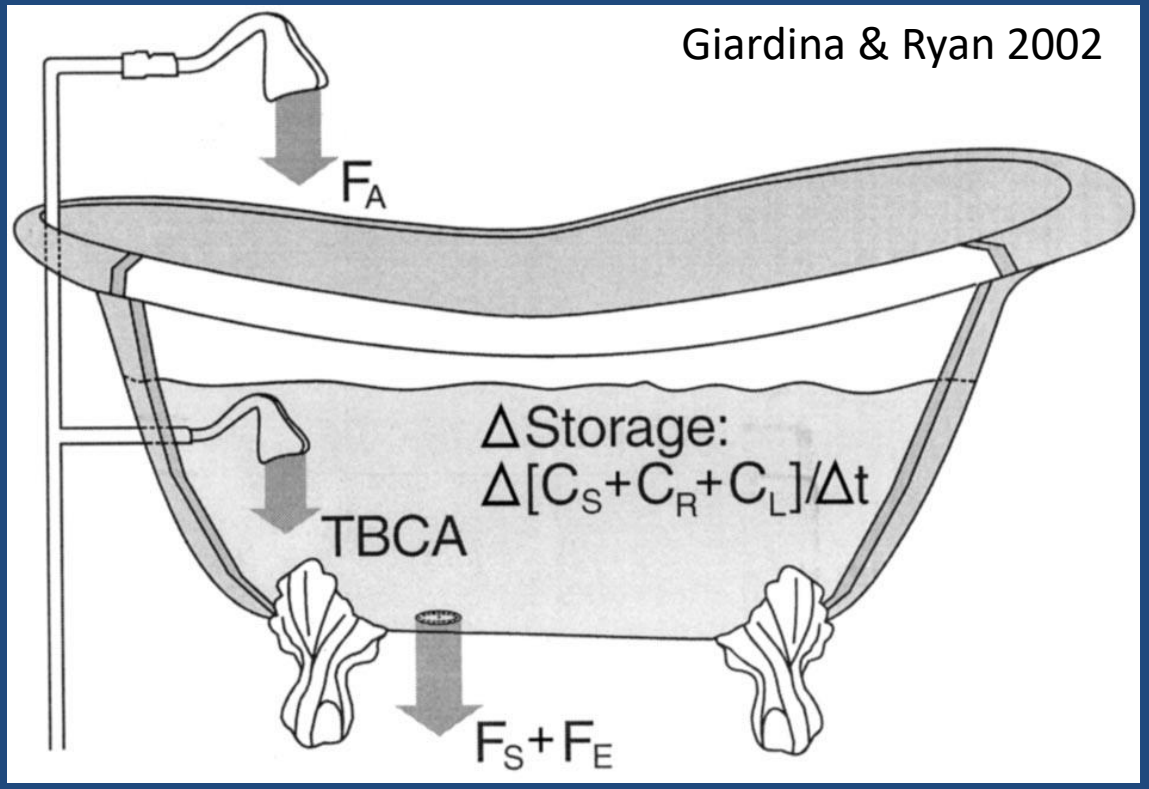
Estimation of Net Ecosystem C storage

Conservation of Mass Approach

Additions to Soil
Litter fall (senescent biomass) F_A
Belowground Allocation (TBCA)

Losses from Soil
Soil respiration (F_s)
CH4, Erosion, Leaching loss (F_E)

Change in Pools
Soil C (C_s)
Root C (C_R)
Litter layer C (C_L)



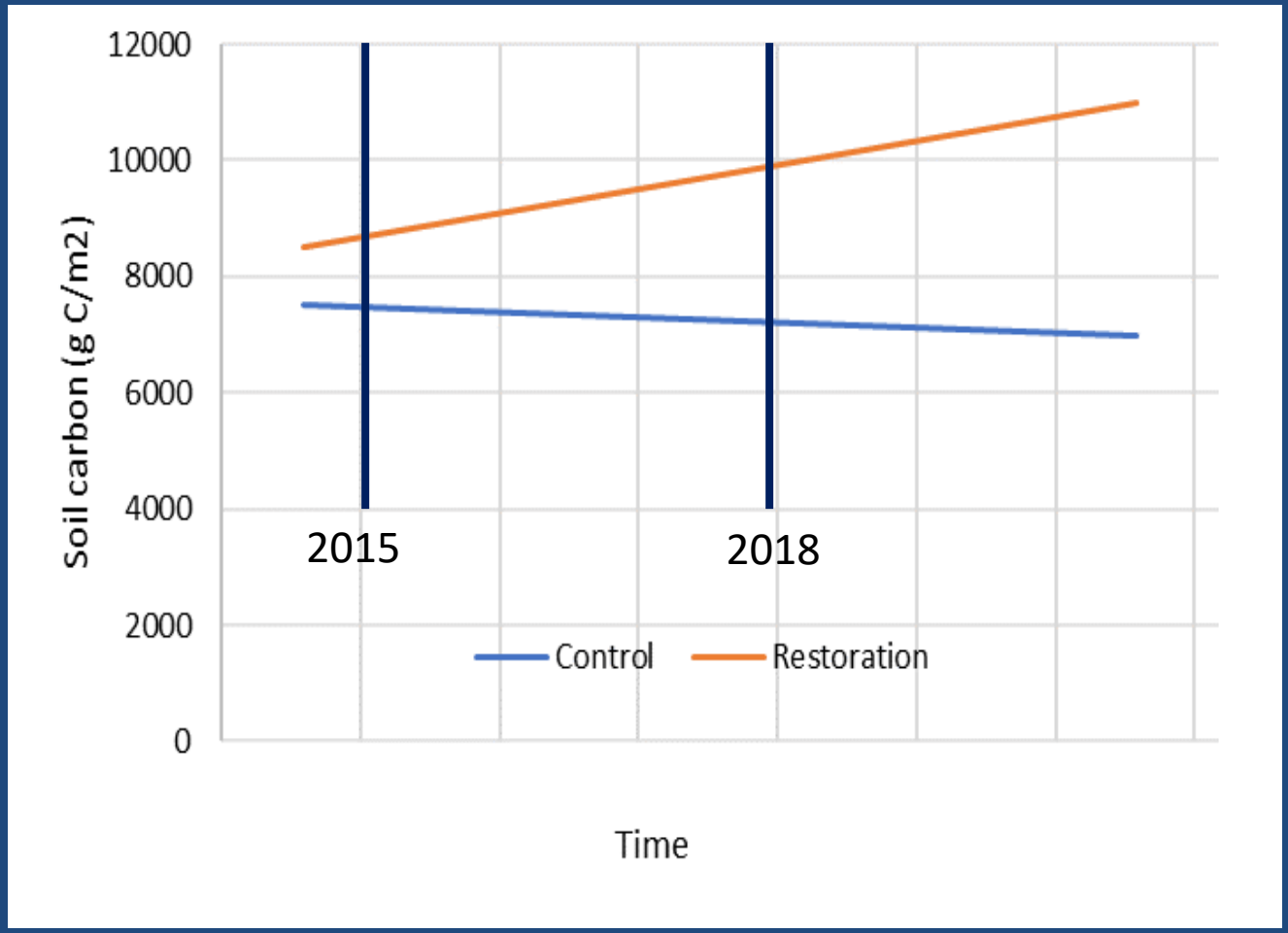
Additions, less change in storage, must equal Losses

$$F_A + TBCA - \Delta[C_s + C_R + C_L]/\Delta t = F_s + F_E$$

TBCA (unknown addition) is all the losses plus change in storage less the other additions

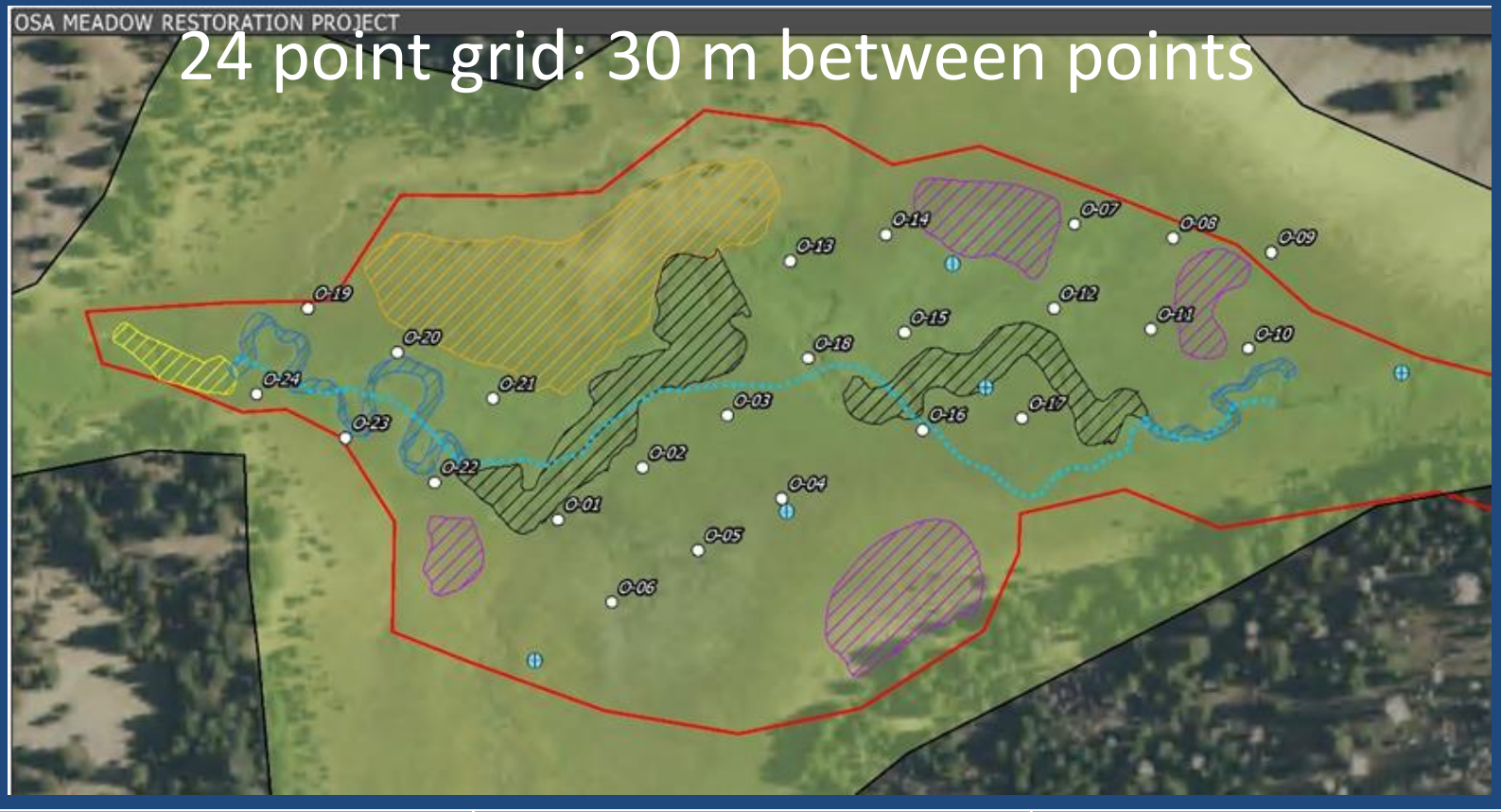
$$TBCA = F_s + F_E + \Delta[C_s + C_R + C_L]/\Delta t - F_A$$

BACI = Before-After Control-Impact



Green, R.H. 1979. Sampling design and statistical methods for environmental biologists. Wiley Interscience. Chichester, U.K.

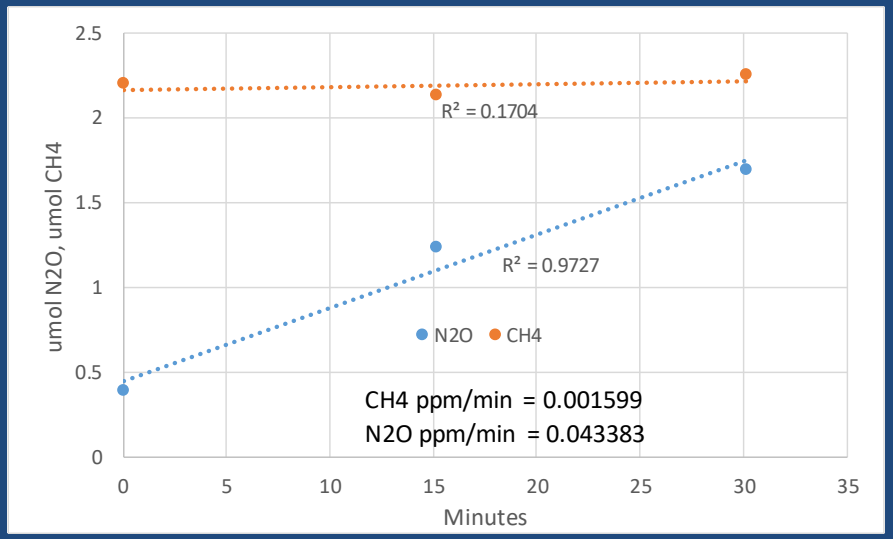
Sampling Design

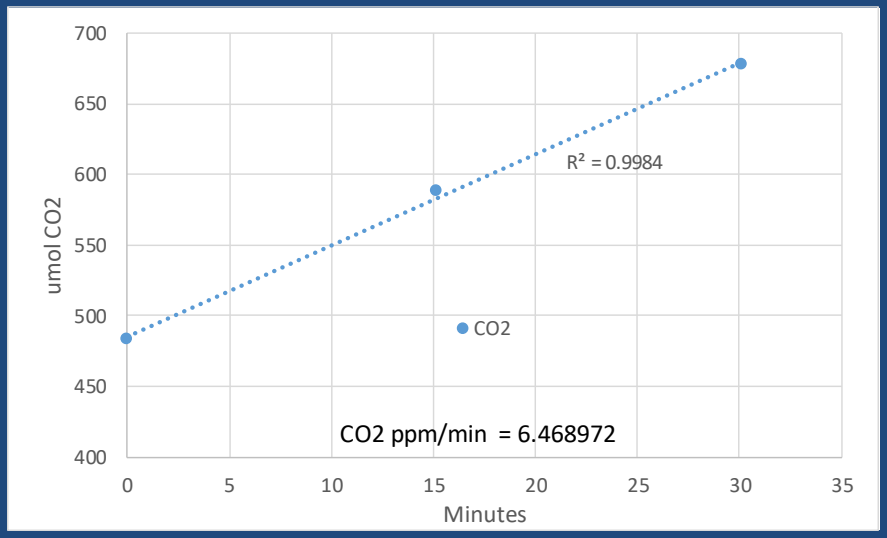


Core carbon measurements	Potential proximal controls	Potential distal controls
GHG fluxes	Soil temperature	Depth to groundwater
Soil carbon content to 1 m	Air temperature	Soil and plant C:N ratio
Belowground root carbon to 1 m	Soil moisture	Plant community composition
Senescent aboveground carbon	Local precipitation data	Peak biomass

How do we measure gas flux?

In Situ Incubation in Static Chambers with 3 time points





Before - After Control - Impact (BACI) Design

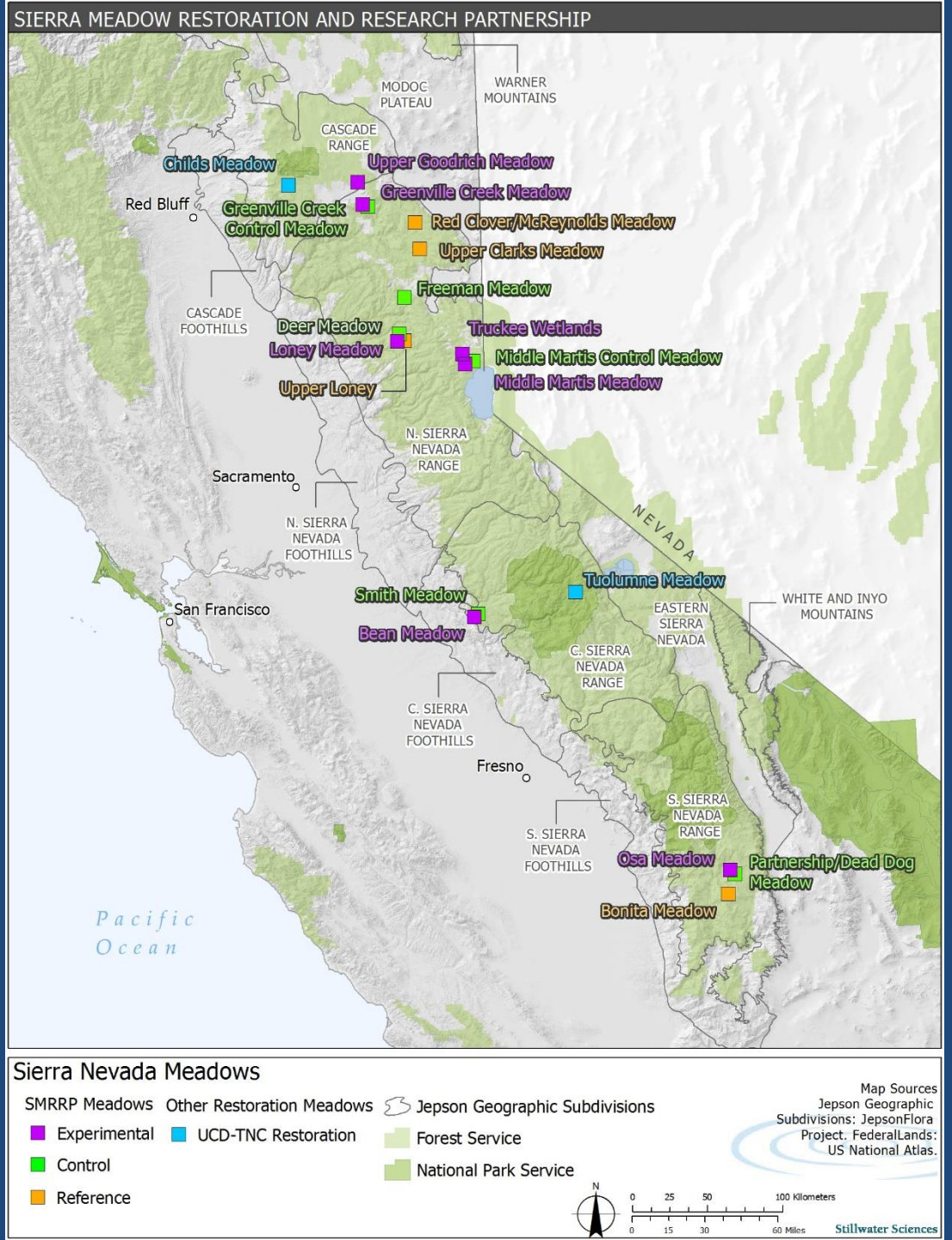
7 Impact (restoration meadows)
7 Control
2 Reference
2 Previously restored
18 Total

Primary response variables

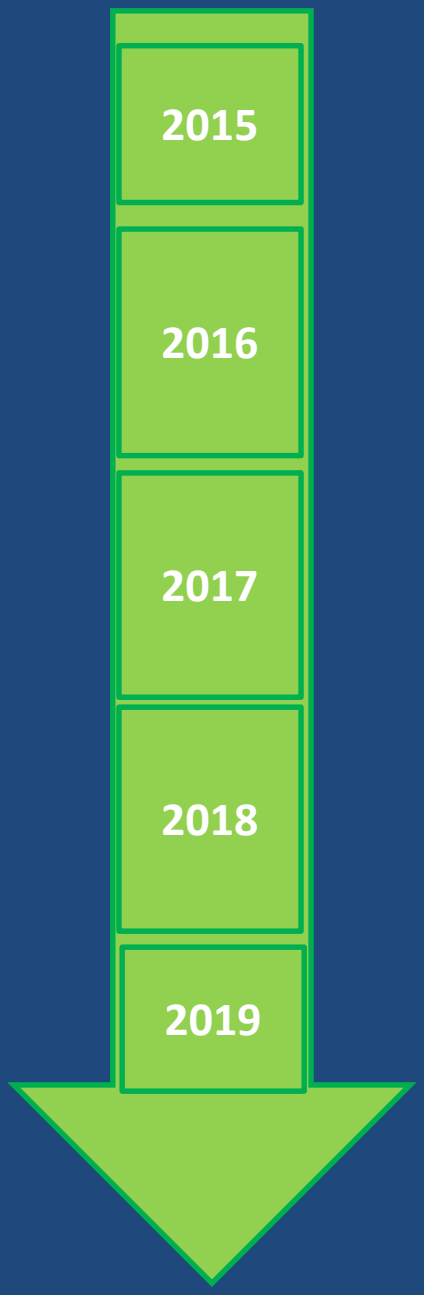
- CO_2, N_2O, CH_4 flux
- Net ecosystem carbon storage

Hypothesized Co-variates

- Soil temperature
- Soil water content
- Air temperature
- Vegetation biomass
- Plant species composition
- Vegetation wetland status
- Soil texture
- Groundwater level



Original Project Timeline



Summer 2015 to Summer 2016

Pre-implementation

- Select & Layout sites
- Finalize methods, train
- Pre-restoration field measurements

Summer 2016 to Summer 2017

Implementation

- Implement
- (Measure year of ‘consolidation’)

Summer 2017 to Summer 2018

Y1 Post implementation

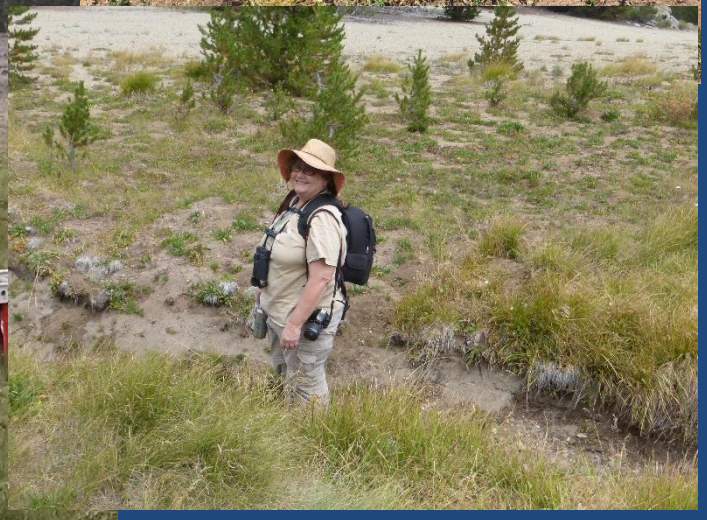
- Post-restoration field measurements
- Calculate and compare baseline and restored C sequestration values

Summer 2018 to Spring 2019

Crunch and Model

- Develop quantitative model for meadow C sequestration
- Develop carbon accounting protocol for meadows

We are MANY!!



Thanks and Acknowledgements

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NFWF
CDFW