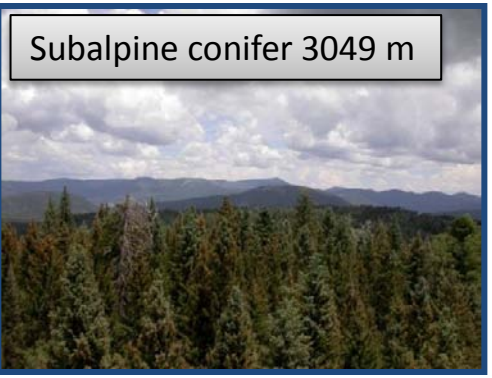
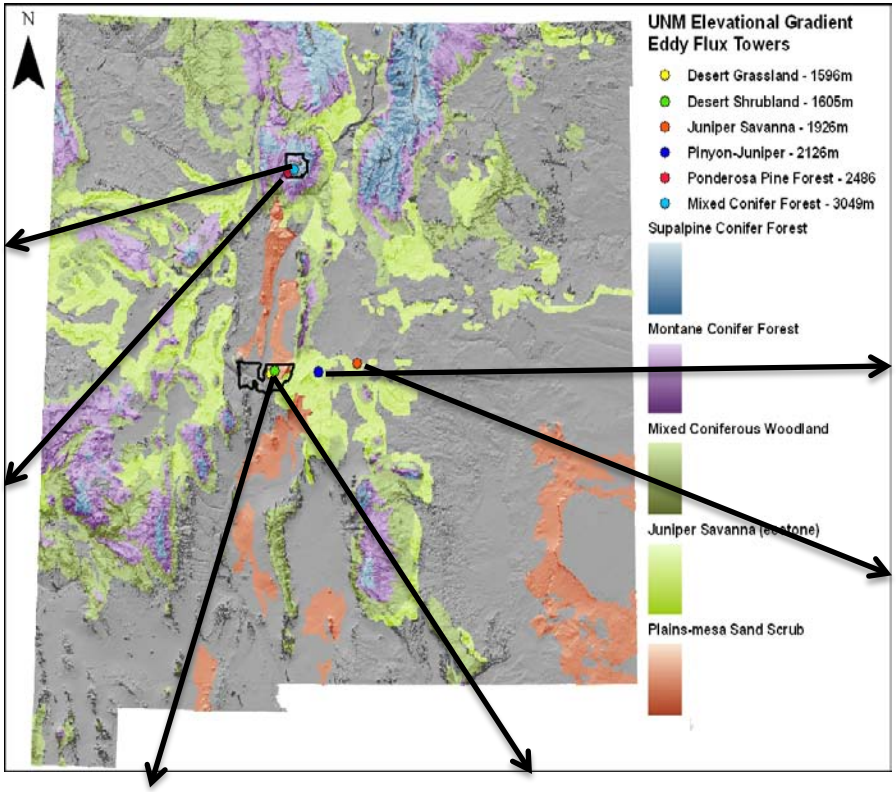
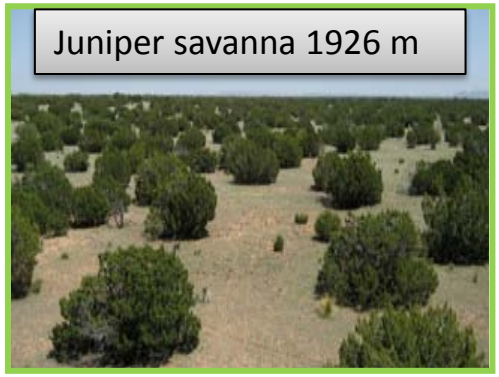
Use of a tower network to reduce uncertainties about how carbon balance in the southwest will respond to climate change

Marcy Litvak
University of New Mexico, Albuquerque, NM
Sevilleta LTER

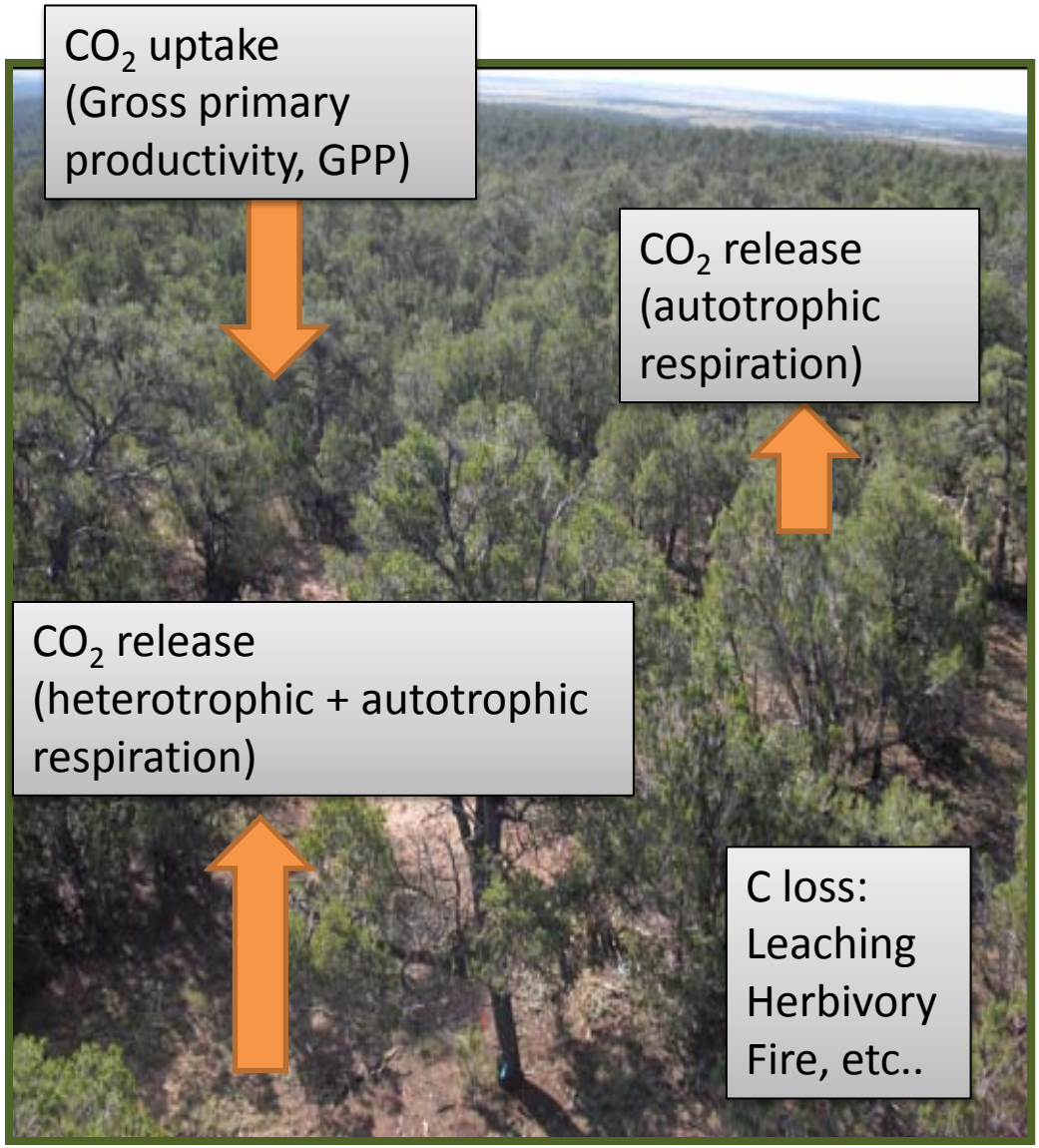
New Mexico Elevation Gradient







Eddy covariance – ecosystem carbon fluxes



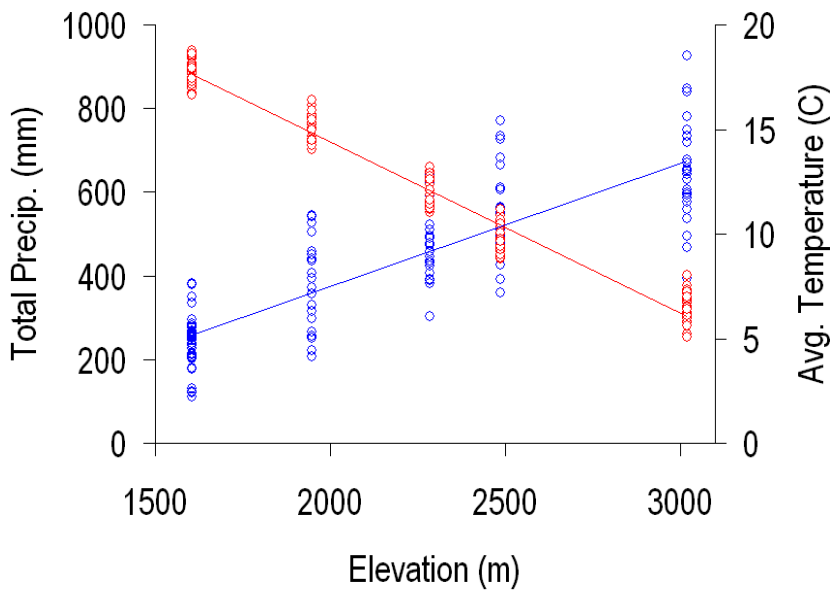
Net ecosystem exchange (NEE) = Net CO_2 uptake

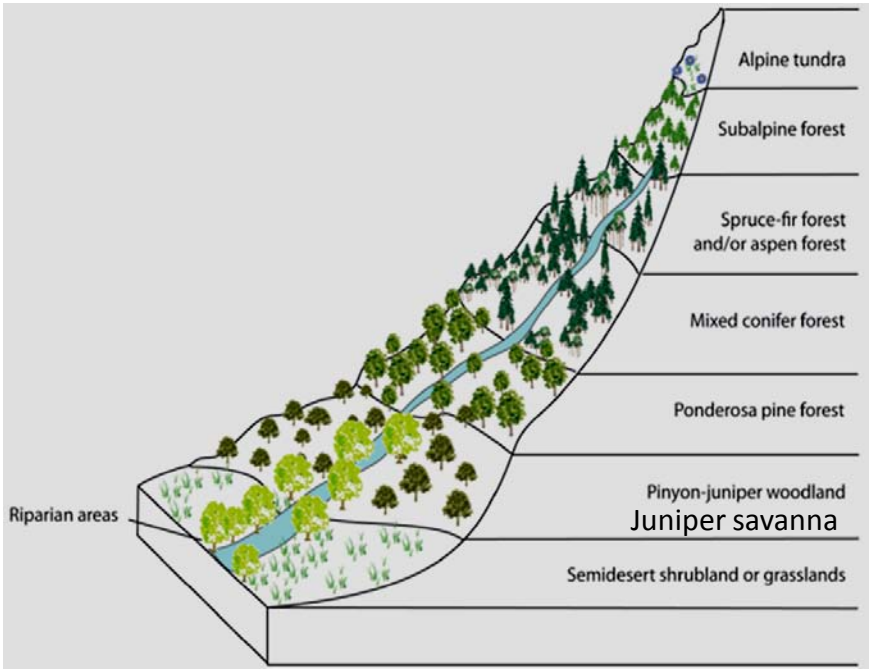
$$NEE = C\ in\ (GPP) - C\ out\ (R_e)$$

GPP = gross primary productivity
R_e = Ecosystem respiration

$g\ C\ m^{-2}\ time^{-1}$ (day, month, yr)

Spatial heterogeneity in SW

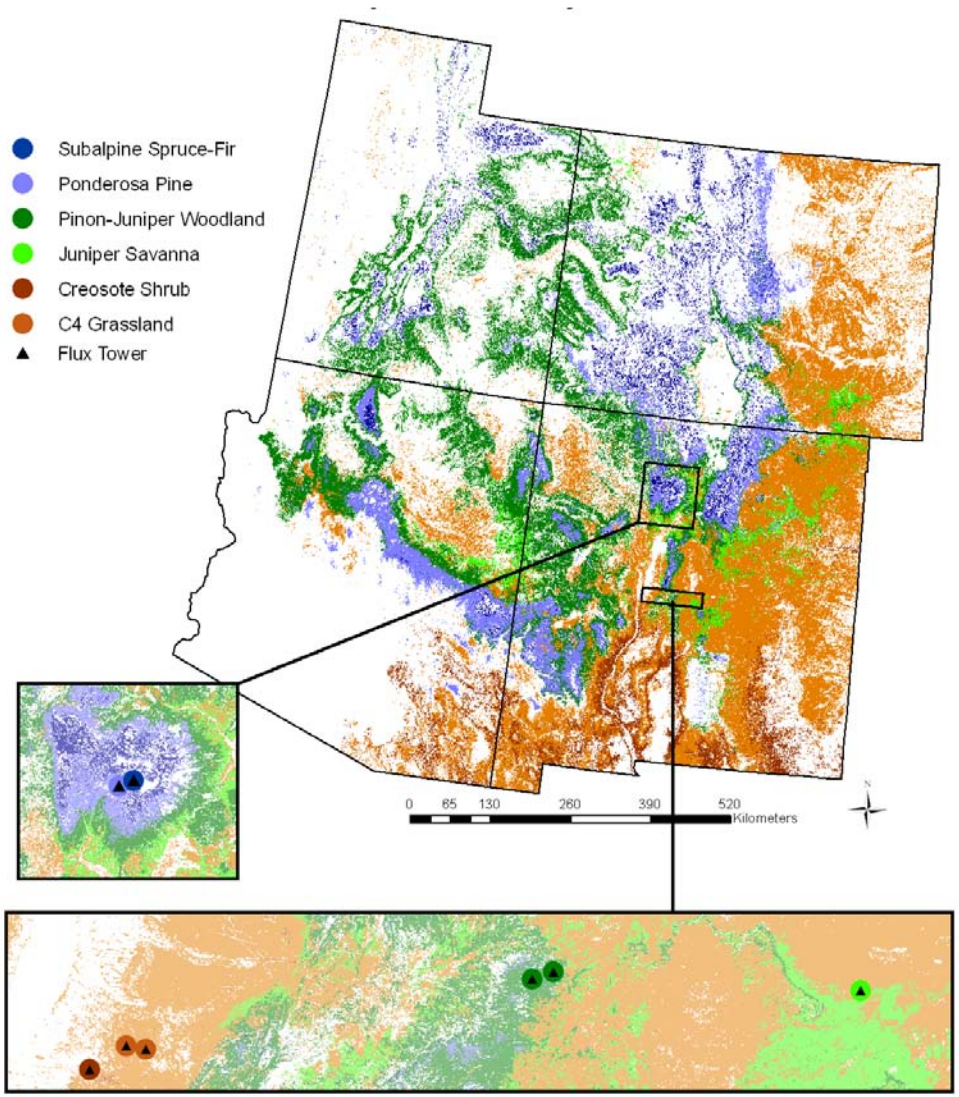






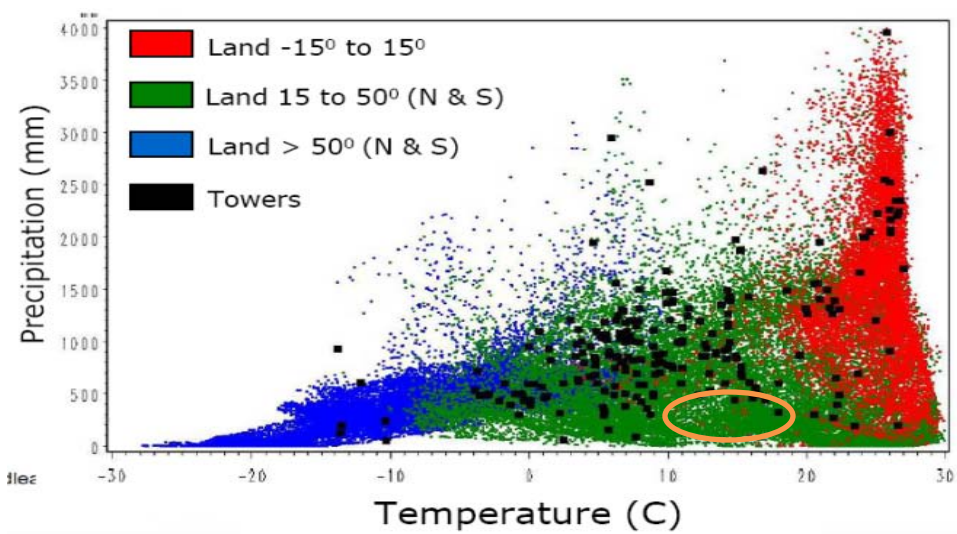



Biomes represented by the NMEG



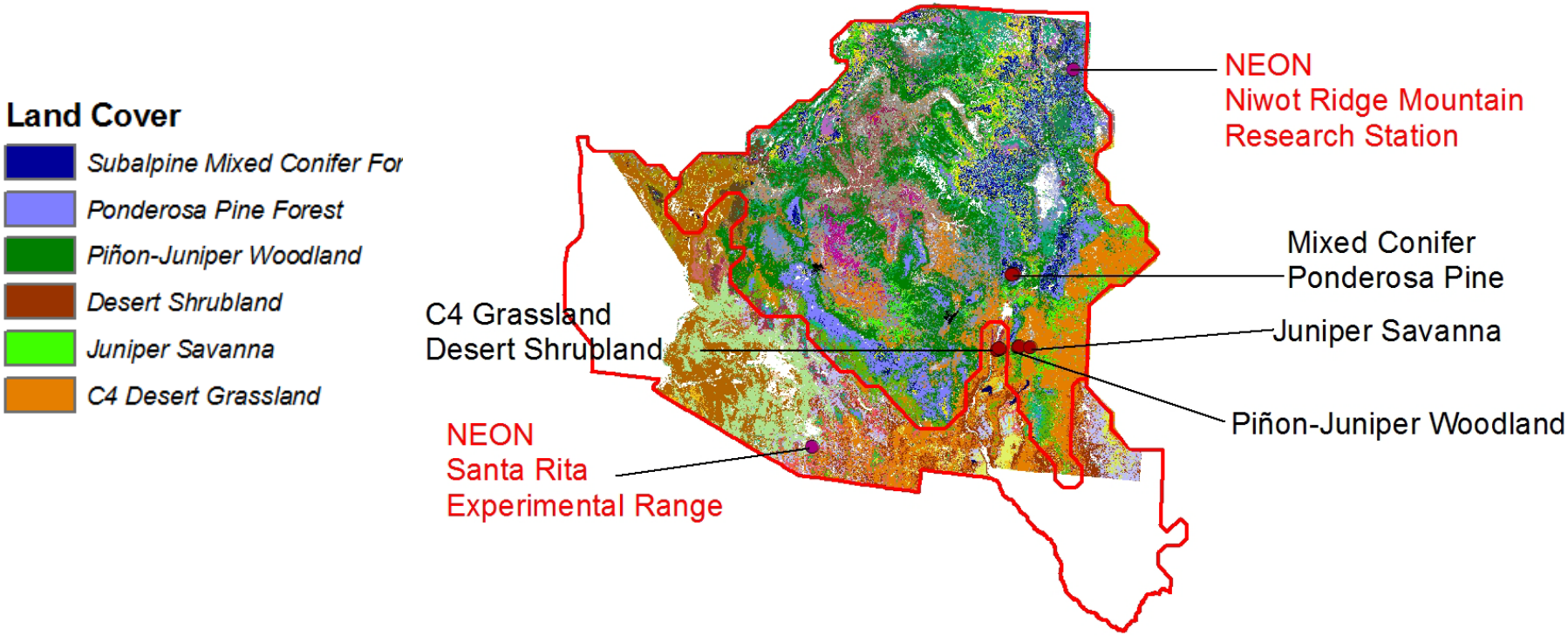
landcover data from the Southwest Regional Gap Analysis Project (SWReGAP)(http://earth.gis.usu.edu/swgap).

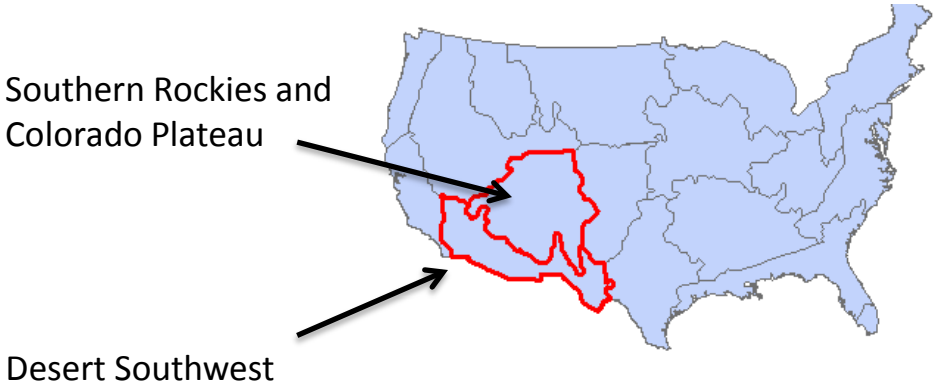
Contributions to Ameriflux, FLUXNET

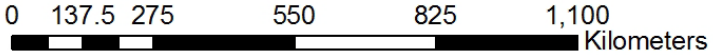


FLUXNET synthesis 2007

Contributions to NEON

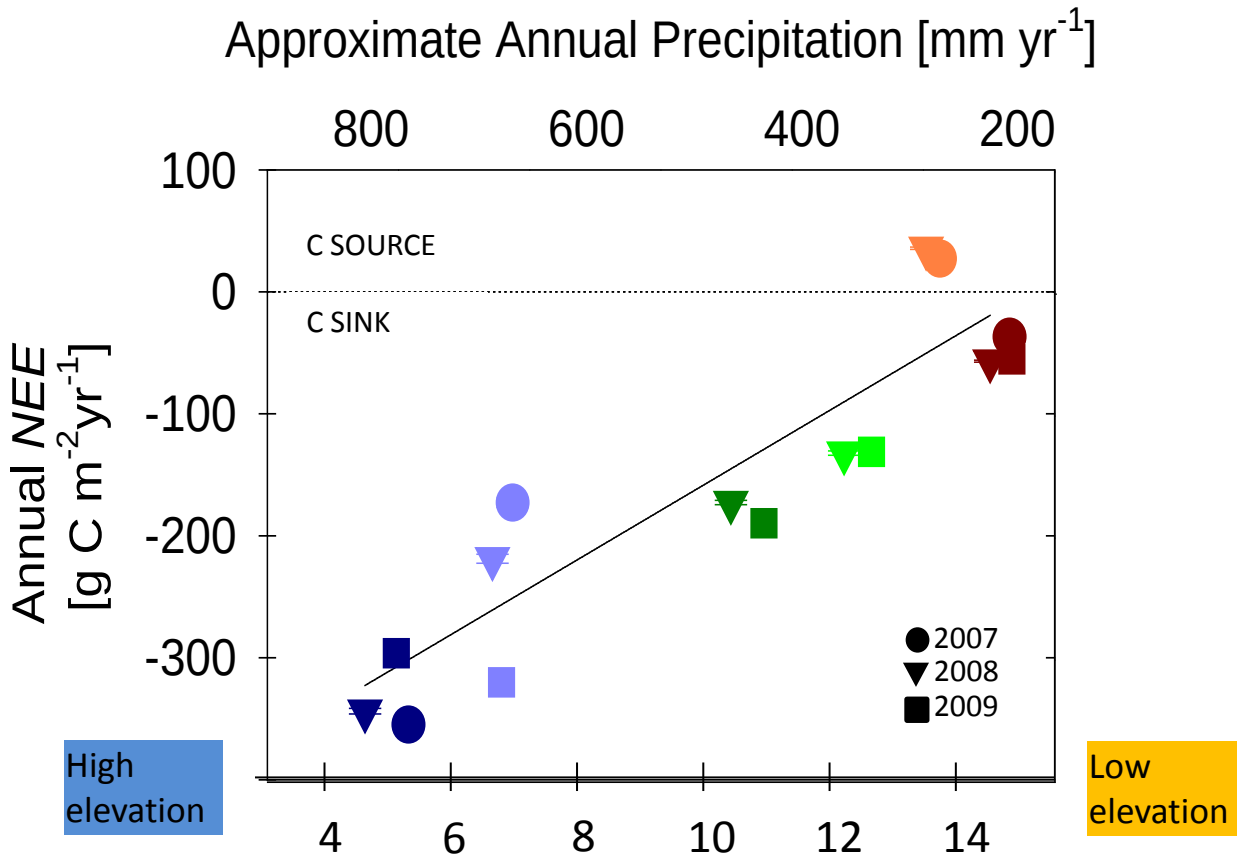






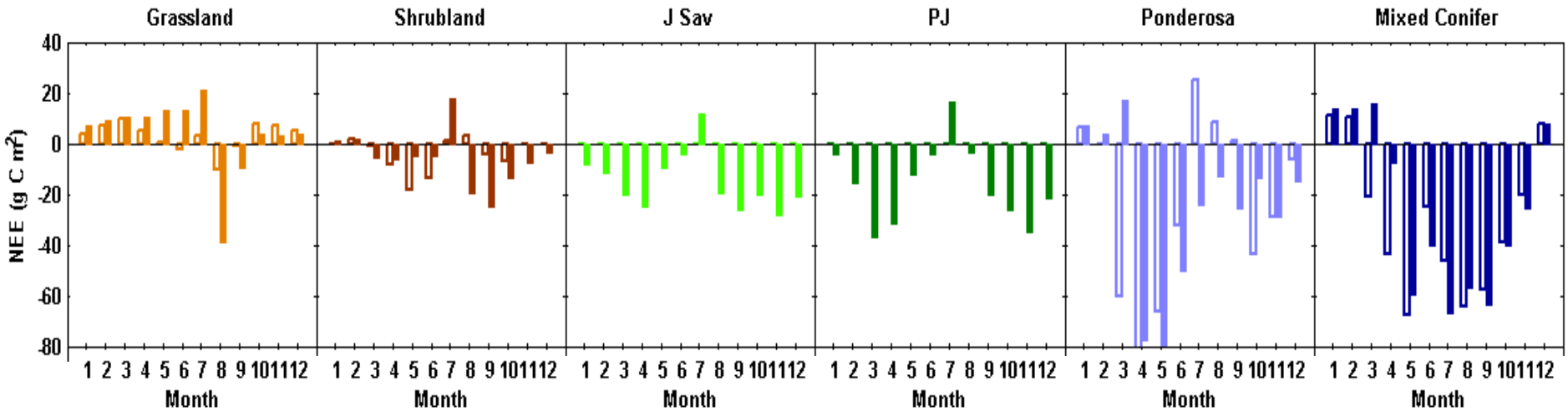
Climate dependence of carbon fluxes and storage

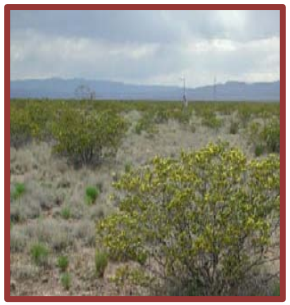
Anderson-Teixera et al. GCB, 2011



Seasonal Patterns – Carbon uptake

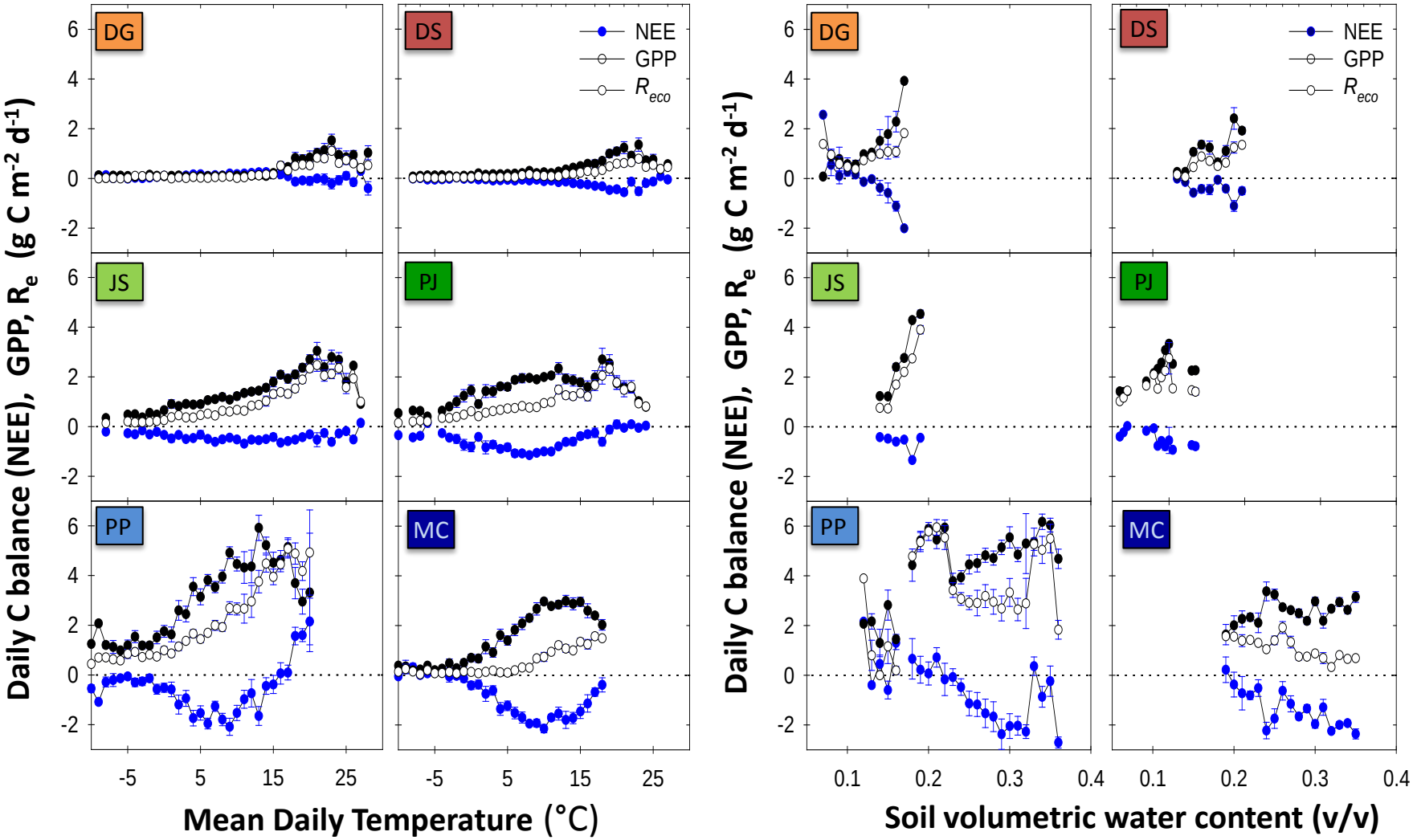
Open bars = 2007 Closed = 2008



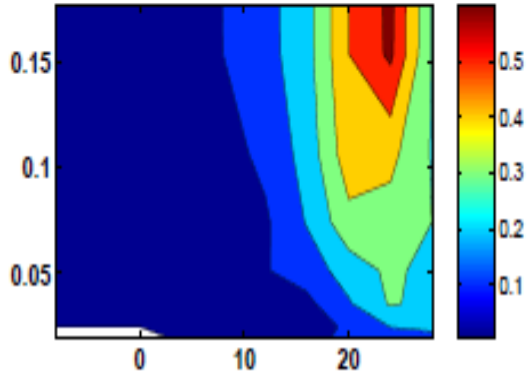


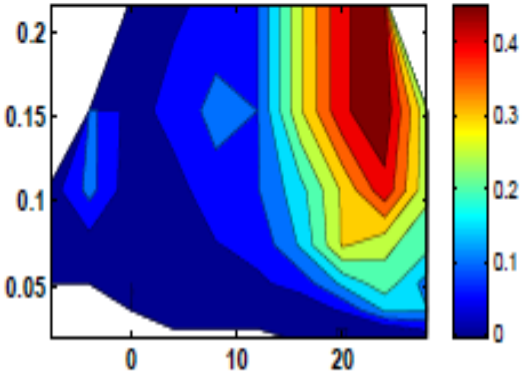
Response curves to temperature, soil water content

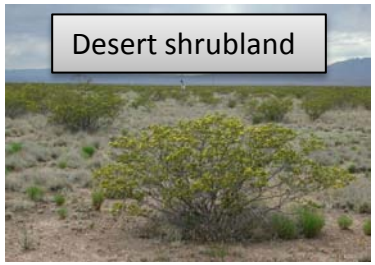


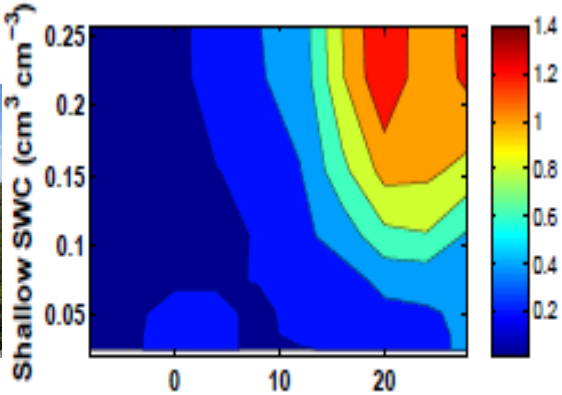
Anderson-Teixeira et al. (*GCB; 2011*)

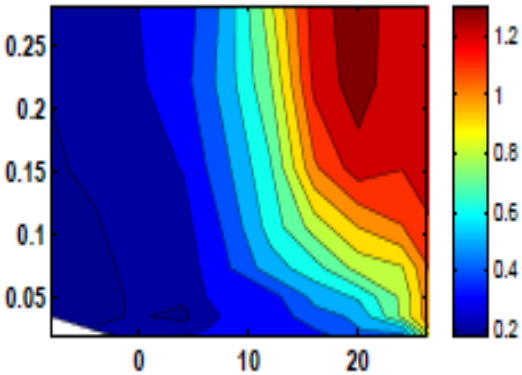
Total nighttime ecosystem respiration rates (g C m^{-2} $night^{-1}$)

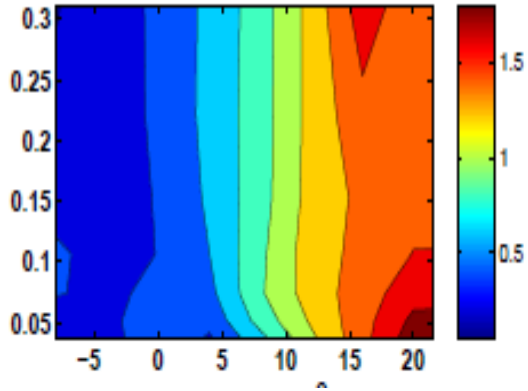


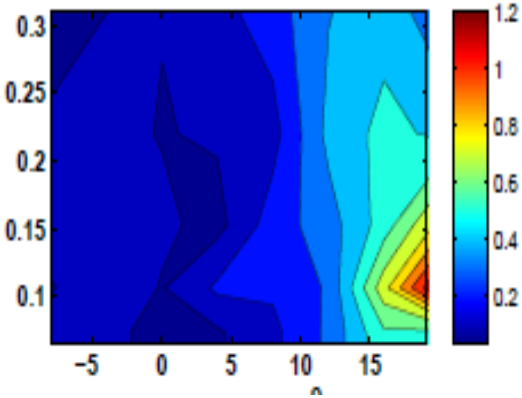








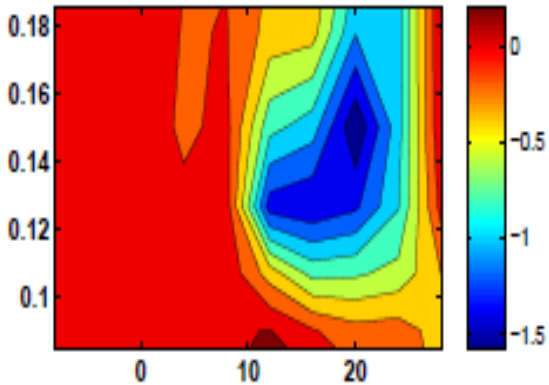


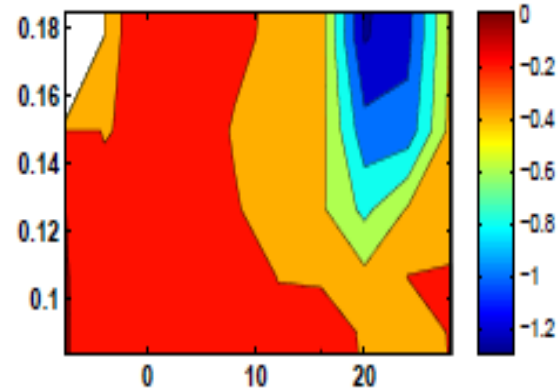


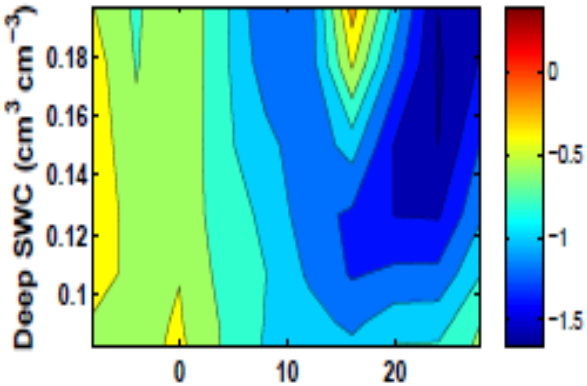
Mean night air temp (°C)

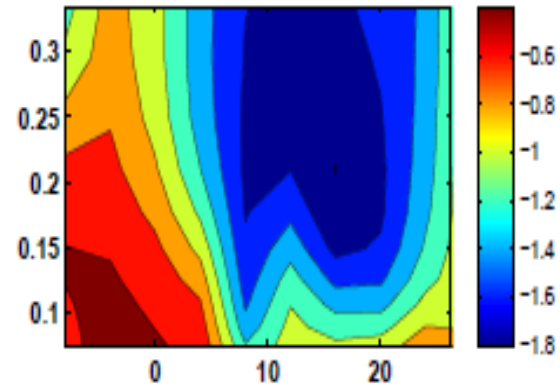
Mean night air temp (°C)

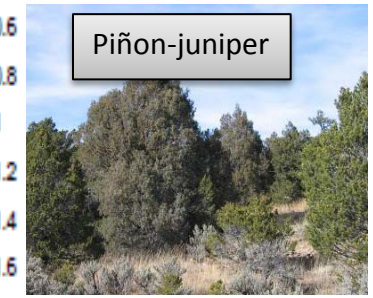
Total daily C uptake (g C m^{-2} day^{-1})

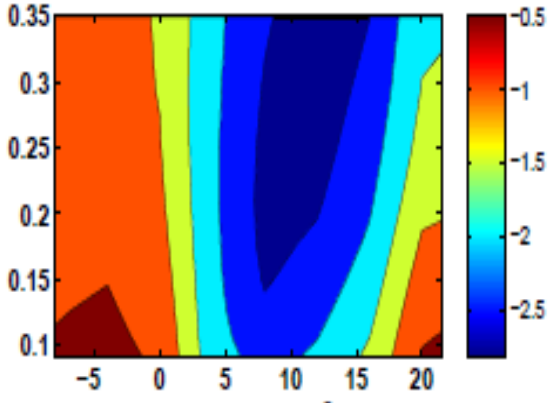


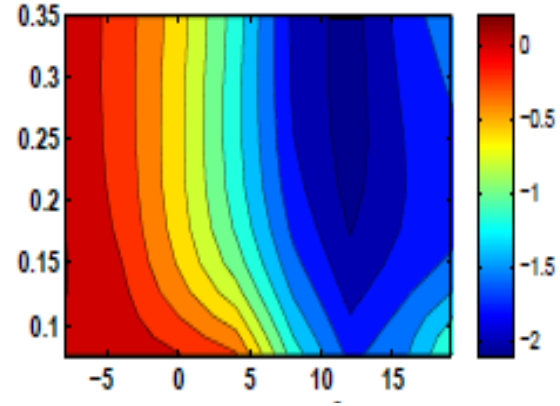










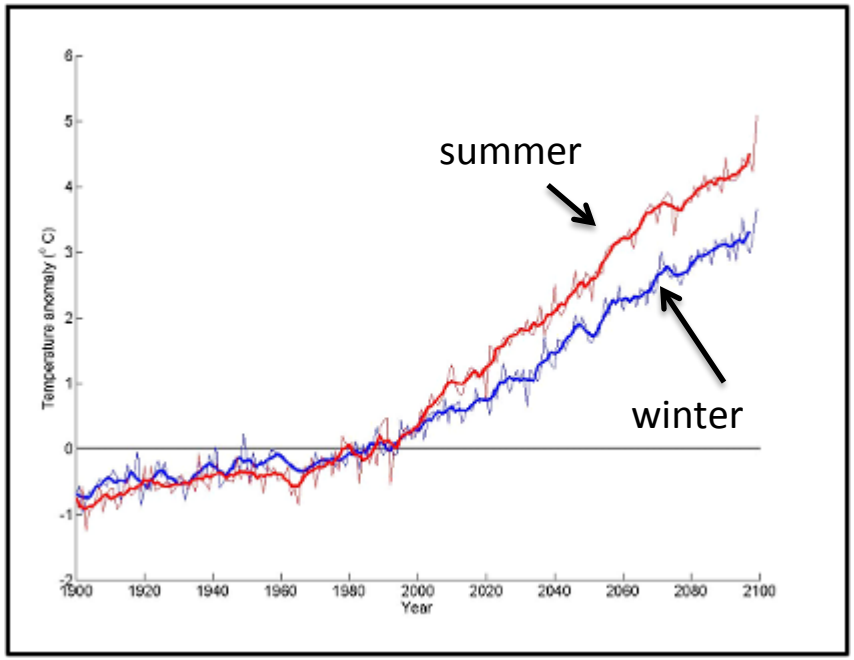


Mean day air temp (°C)

Mean day air temp (°C)

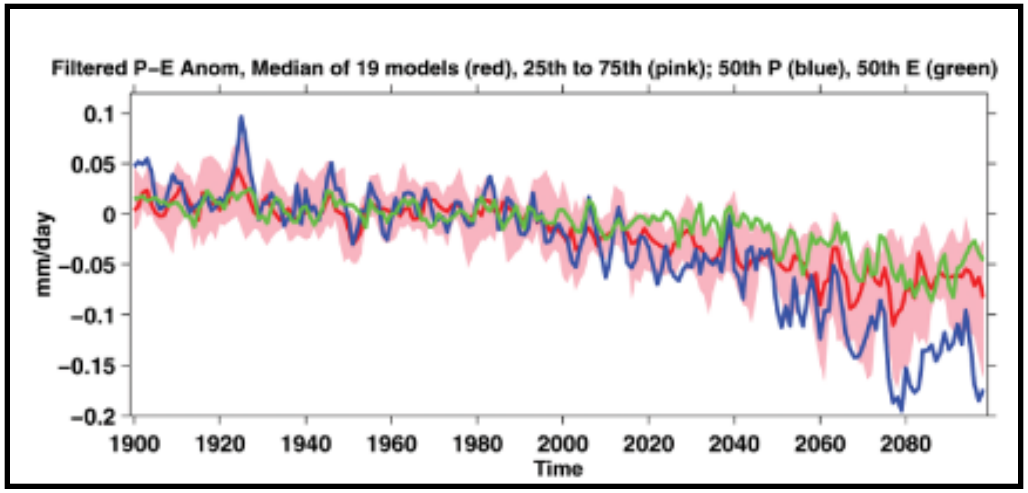
Climate change in the SW

Temperature



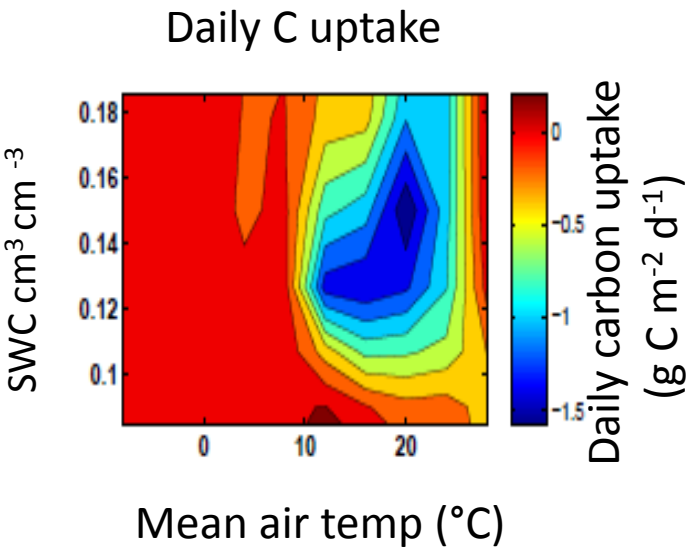
Predicted temperature increase of 3 - 4 C
18 models used A1B emissions storyline
Gutzler 2007

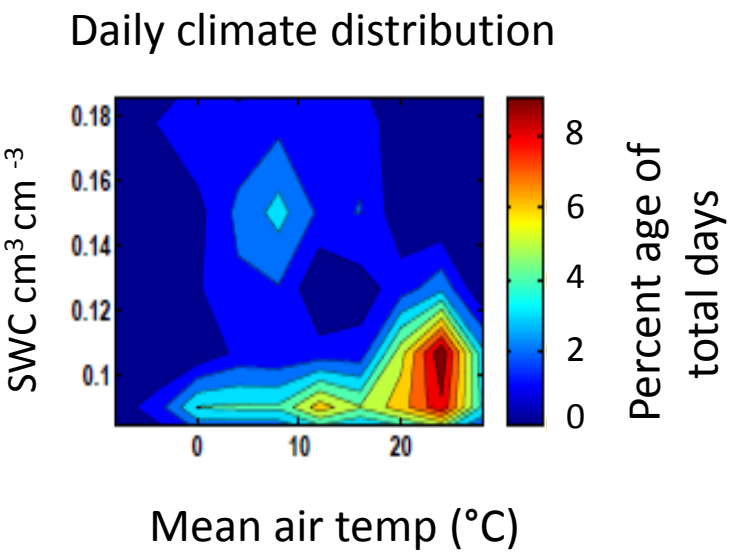
Precipitation



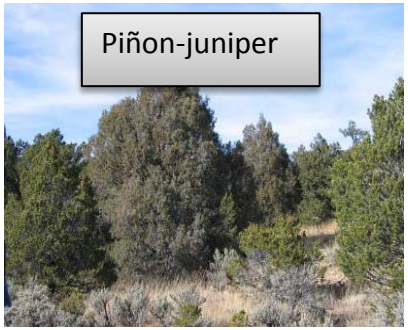
19 models used A1B emissions storyline
Seager et al., 2007

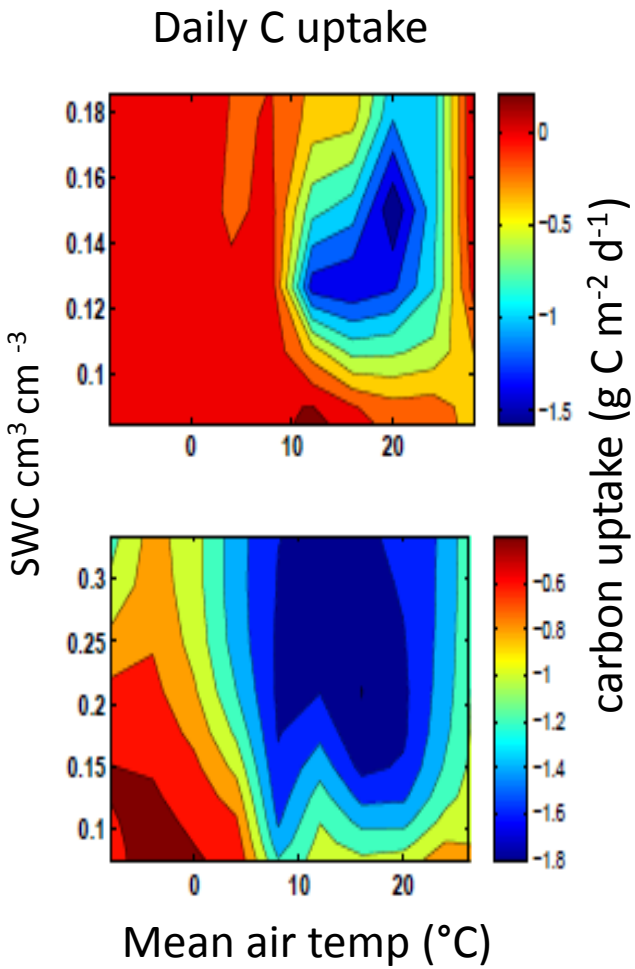

Desert grassland

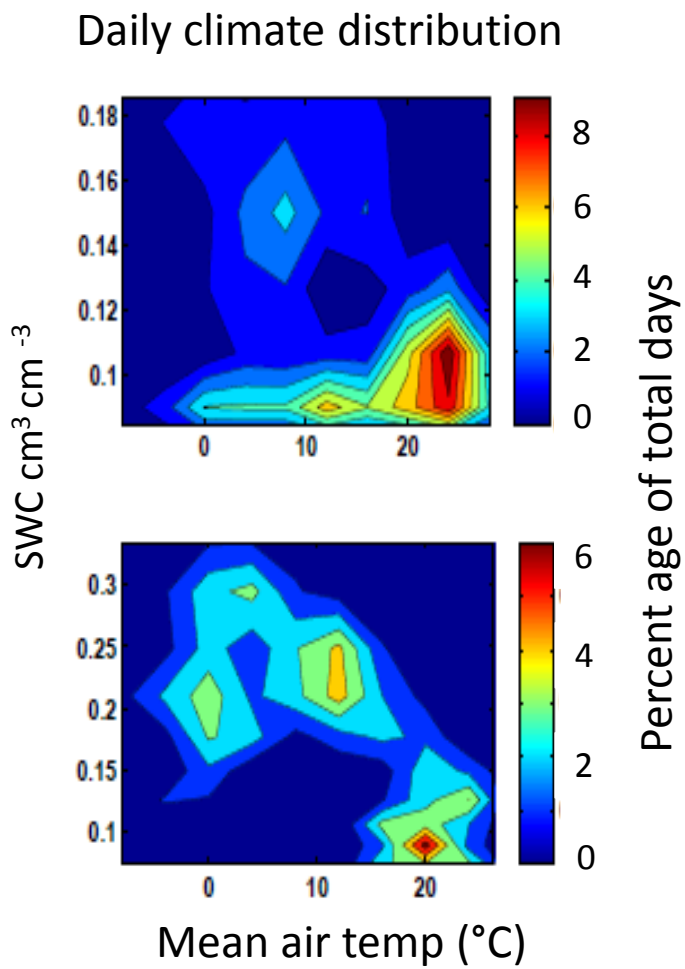

Daily C uptake
SWC cm3 cm -3
0.18
0.16
0.14
0.12
0.1
0
10
20
0
-0.5
-1
-1.5
Daily carbon uptake
(g C m-2 d-1)
Mean air temp (°C)

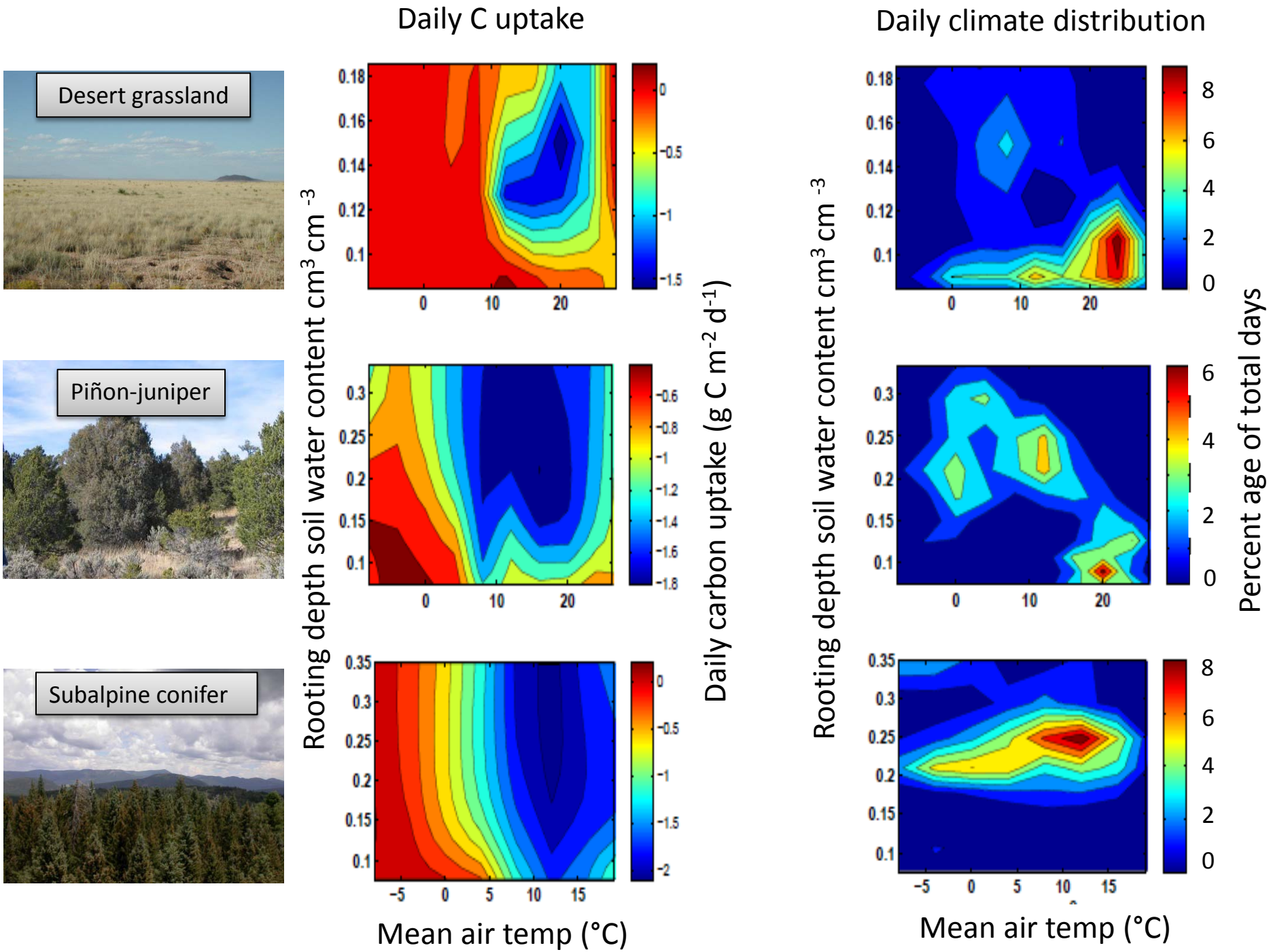

Daily climate distribution
SWC cm3 cm -3
0.18
0.16
0.14
0.12
0.1
0
10
20
8
6
4
2
0
Percent age of
total days
Mean air temp (°C)

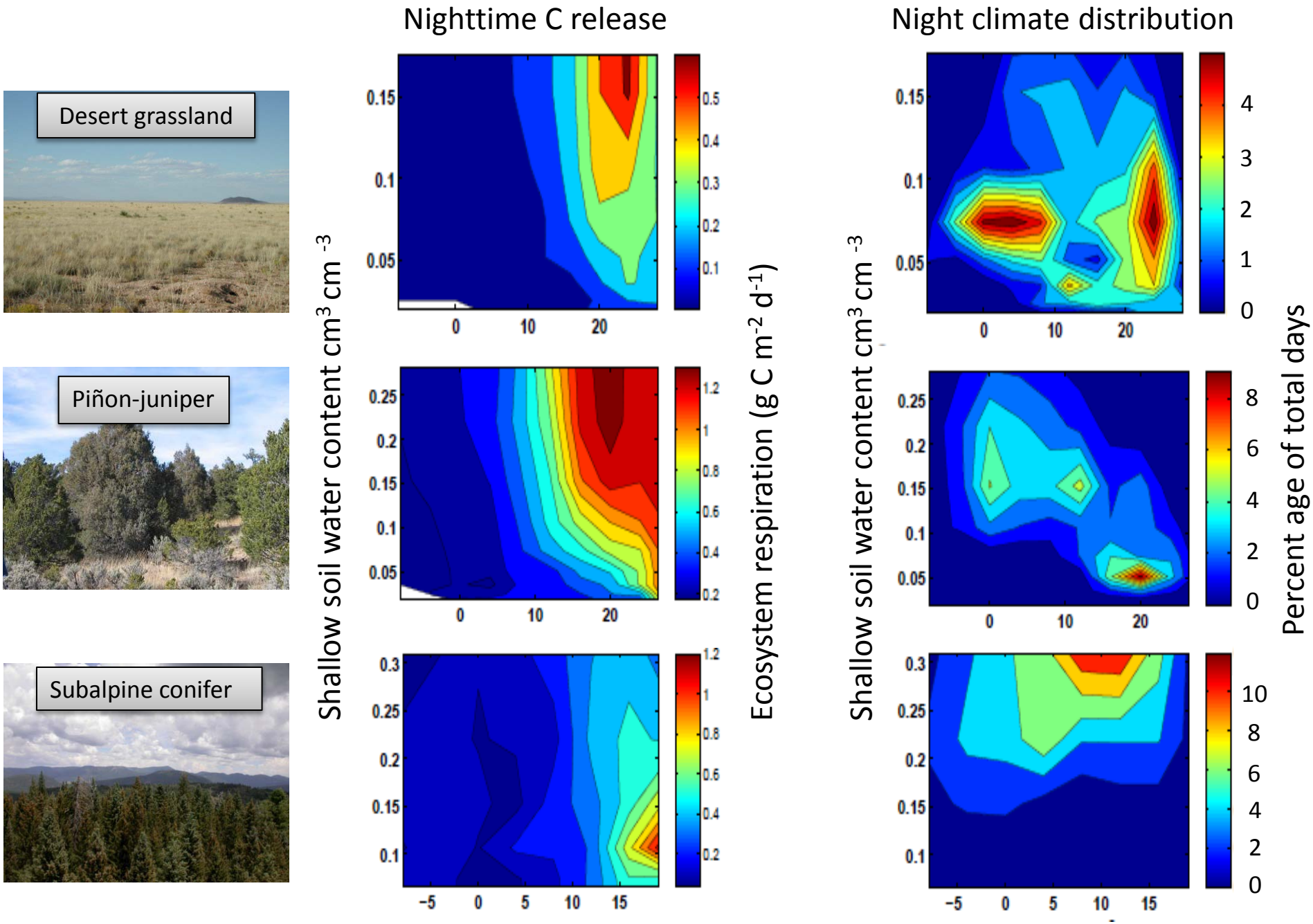

Desert grassland


Piñon-juniper

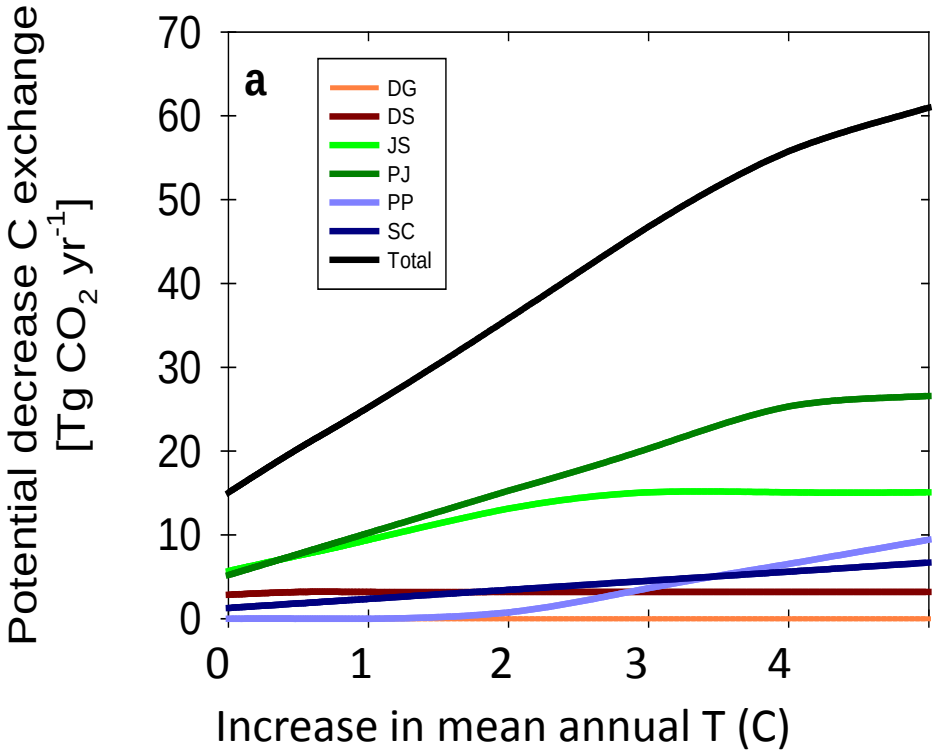

Daily C uptake
SWC cm3 cm -3
carbon uptake (g C m-2 d-1)
Mean air temp (°C)

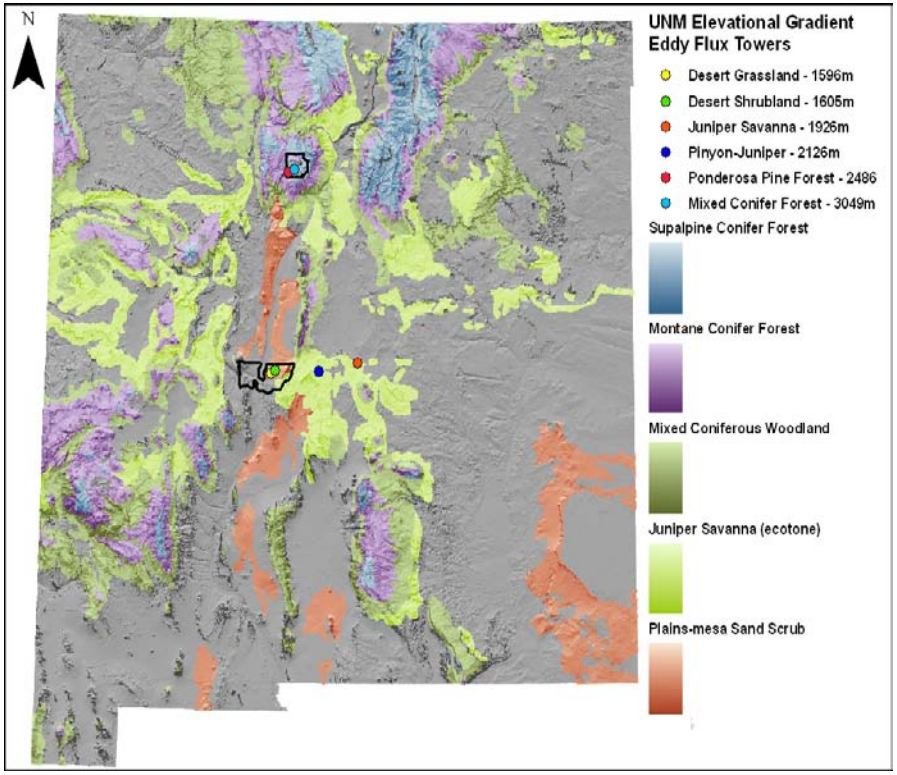

Daily climate distribution
SWC cm3 cm -3
Percent age of total days
Mean air temp (°C)


Daily C uptake
Daily climate distribution
Desert grassland
Piñon-juniper
Subalpine conifer
Rooting depth soil water content cm3 cm -3
Daily carbon uptake (g C m-2 d-1)
Percent age of total days
Mean air temp (°C)
Mean air temp (°C)


Nighttime C release
Night climate distribution
Desert grassland
Piñon-juniper
Subalpine conifer
Shallow soil water content cm3 cm -3
Ecosystem respiration (g C m-2 d-1)
Percent age of total days

Predicted change to NM terrestrial ecosystem carbon balance as mean annual temperature (MAT) increases





A 4°C increase in MAT could reduce annual C sequestration by ~56 Tg CO_2 y^{-1}

- 16% annual US residential emissions
- 8% annual US industrial emissions
- 3% of US transportation emissions

Anderson-Teixeira et al. (*GCB; 2011*)

Importance of long term research

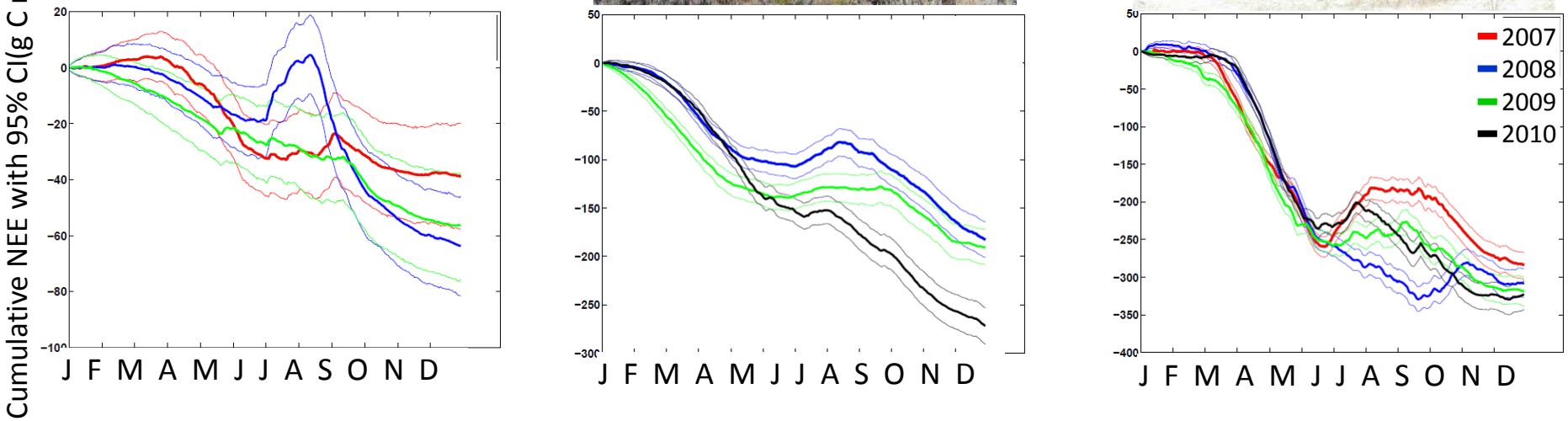
Long term continuous measurements of NEE will:

- ❑ Represent the full range of climate variability
- ❑ Measure the effects of disturbance on ecosystem function

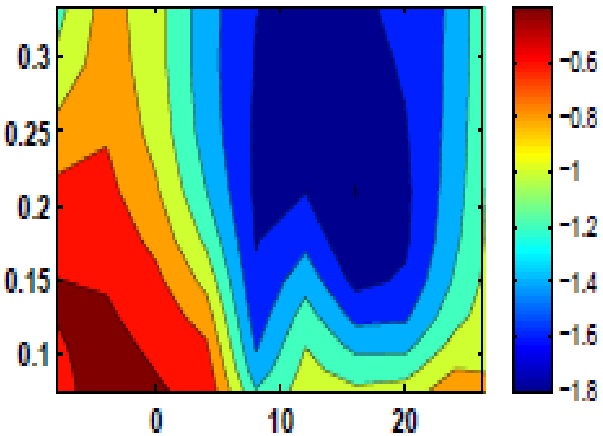
Desert shrubland

Piñon-juniper

Ponderosa pine



Response surfaces should change with climate and disturbance



?

Change in:

- Temperature
- precipitation regime
- cloud cover
- etc.....

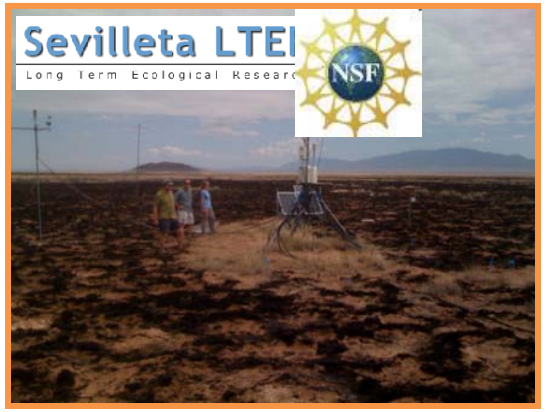
?

Extensive piñon mortality in N. NM in 2002
Photo credit: Dr. Craig Allen, USFS

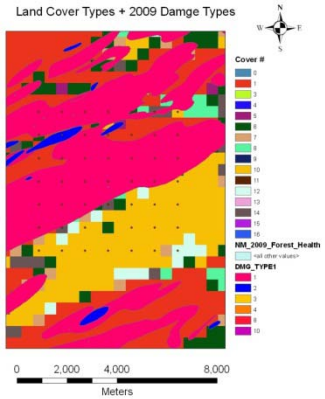
Disturbance and long term research

Fire

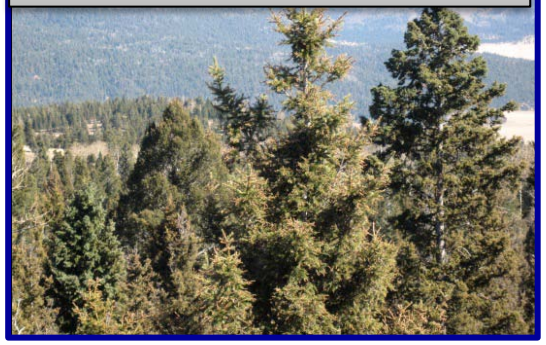
Desert grassland 1596 m



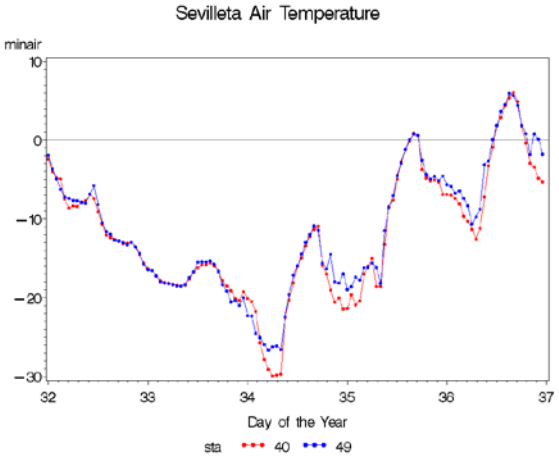
Spruce budworm



Subalpine conifer 3049 m



Extreme cold



Desert shrubland 1605 m

Overall Conclusions

1. NMEG valuable network for examining C dynamics in semi-arid ecosystems in the SW US

2. Spatial heterogeneity in SW should not be ignored. Semi-arid biomes vary distinctly in C sink strength and sensitivity to temperature and precipitation

3. We are likely to see a decrease in C sequestration throughout the region if temperature increases and precipitation decreases.

4. Long-term monitoring of these sites crucial to accurately predict how C dynamics will respond to changes in climate and/or disturbance

5. More complex ecosystem models required (currently using SIPNET, CLM)






Acknowledgements

- **People**

  Litvak Lab

  Andy Fox, Krista Anderson-Teixera, Leo Stoscheck, Dan Krofcheck, John DeLong, Daniel Brese, Andy Hawk, Sarah Hicks, Alek Chakroff, Shaila Cockar, Alexandra Reinwald (REU), Dena Smith, Emma Elliot Smith, Cecilia Payan, Scott Rossol, Tallie Segel

  UNM

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  SAHRA, CZO, U of Arizona, Valles Caldera sites

  Paul Brooks, Scott Gilmore, John Petti, Jon Chorover, Peter Troch

  Sevilleta Bigfoot sites

  Shirley Kurc and Eric Small

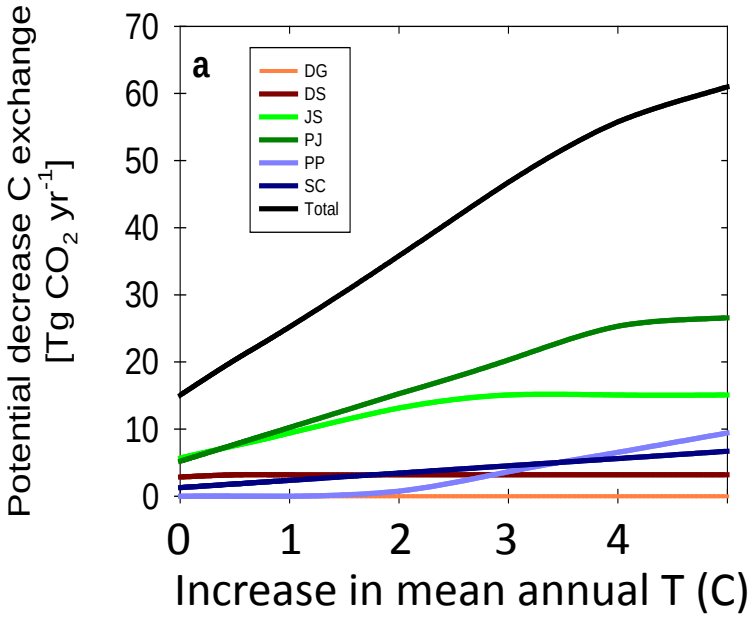
  Land owners/managers

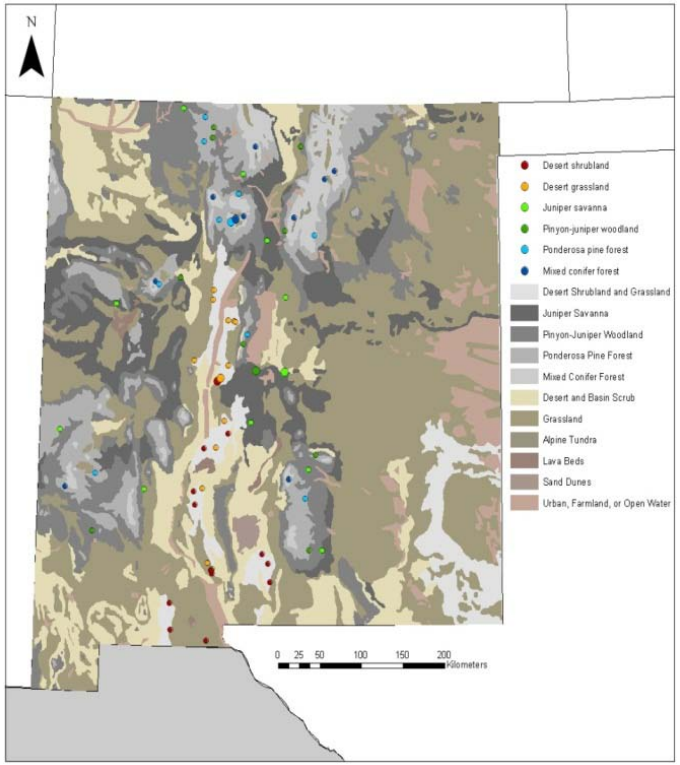
  Seven Up Seven Down Ranch, Heritage Land Institute, Sevilleta LTER, Valles Caldera (Bob Parmenter)

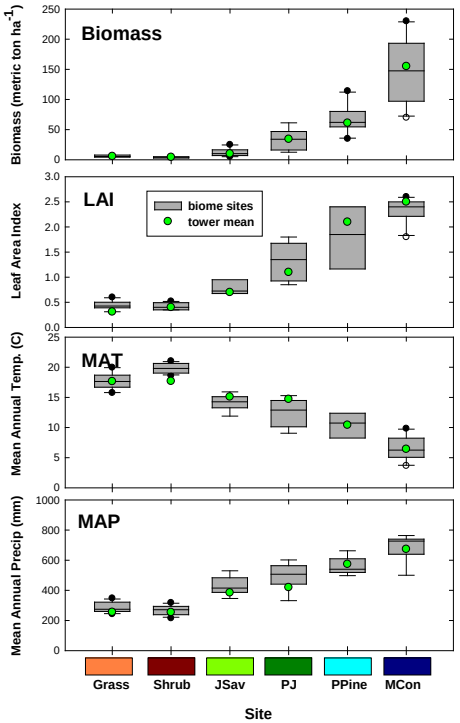
- **Funding sources**

Predicted change to NM terrestrial ecosystem carbon balance as mean annual temperature (MAT) increases

Biomes account for 57% of area in NM







A 4°C increase in MAT would reduce C sequestration by ~56 Tg CO_2 y^{-1}

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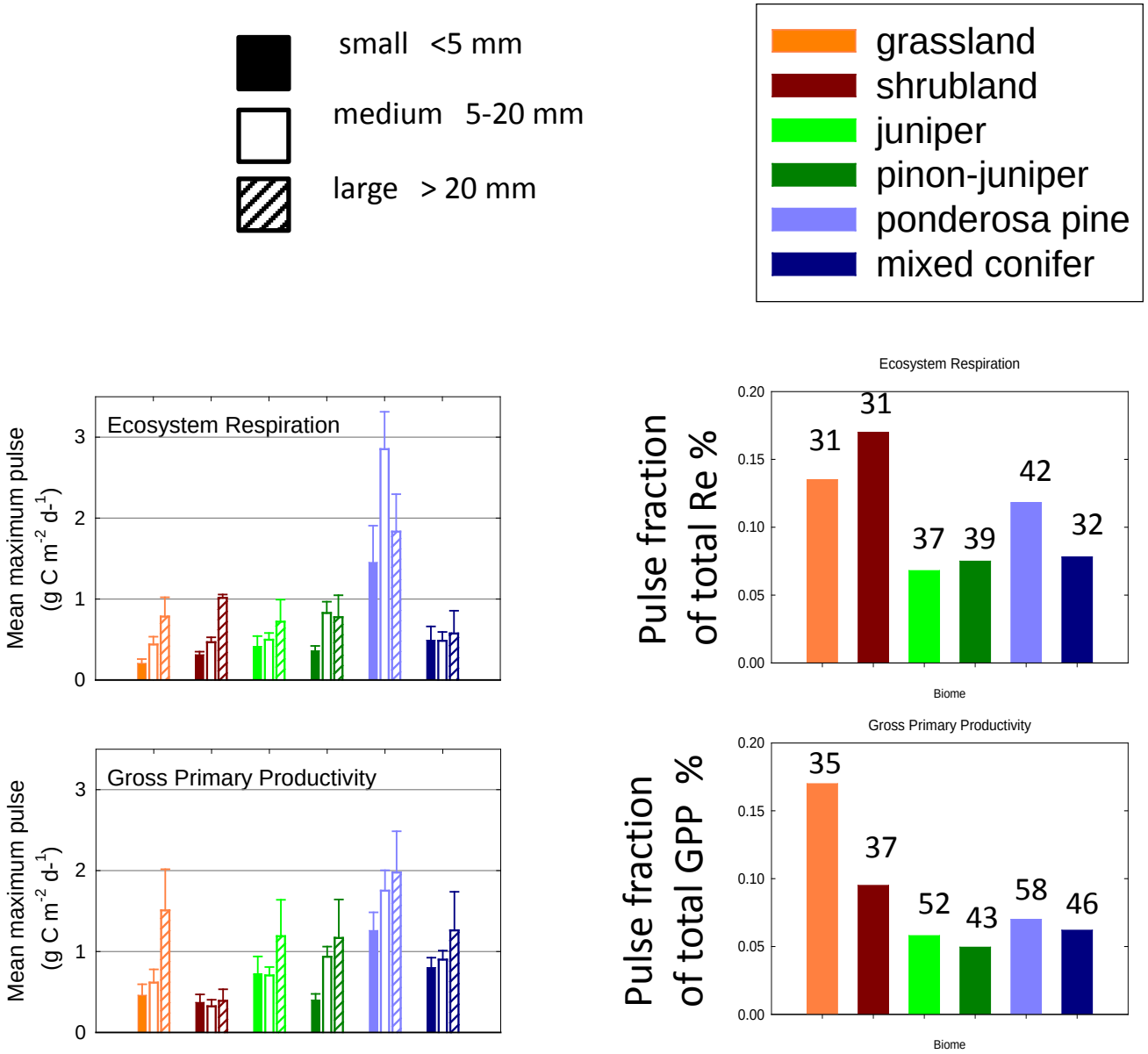
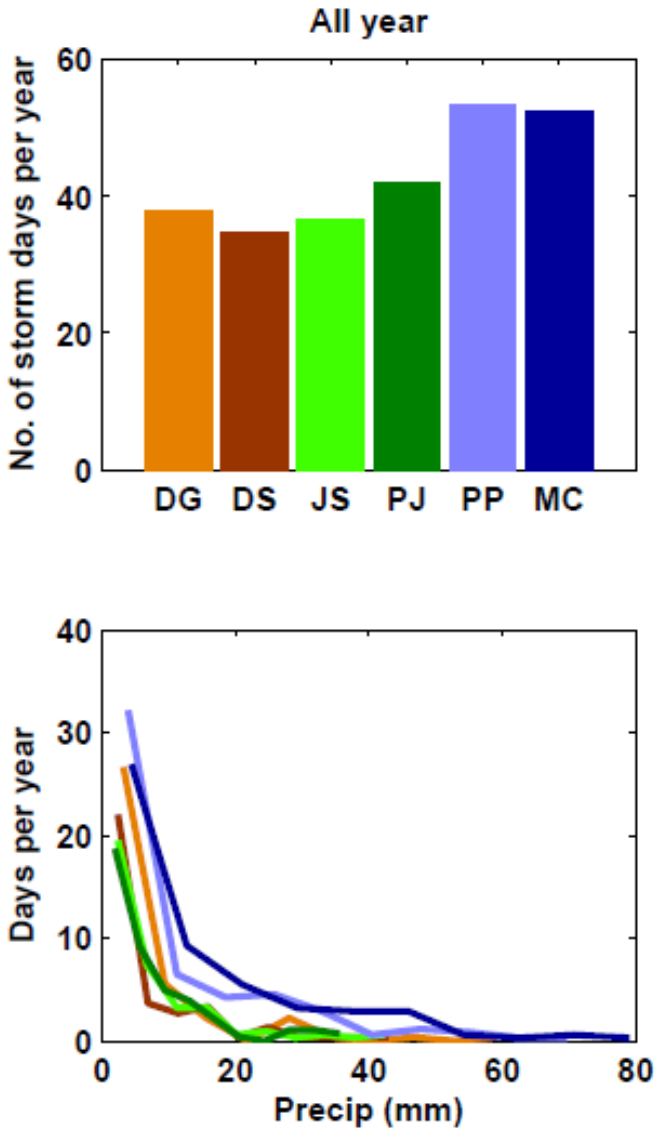
Anderson-Teixeira et al. (*GCB; 2011*)


small <5 mm
medium 5-20 mm
large > 20 mm
grassland
shrubland
juniper
pinon-juniper
ponderosa pine
mixed conifer
Ecosystem Respiration
Mean maximum pulse
(g C m-2 d-1)
0
1
2
3
Gross Primary Productivity
Mean maximum pulse
(g C m-2 d-1)
0
1
2
3
Ecosystem Respiration
Pulse fraction
of total Re %
0.00
0.05
0.10
0.15
0.20
31
31
37
39
42
32
Biome
Gross Primary Productivity
Pulse fraction
of total GPP %
0.00
0.05
0.10
0.15
0.20
35
37
52
43
58
46
Biome


All year
No. of storm days per year
60
40
20
0
DG
DS
JS
PJ
PP
MC
Days per year
40
30
20
10
0
0
20
40
60
80
Precip (mm)


grassland
shrubland
juniper
pinon-juniper
ponderosa pine
mixed conifer