Carbon dioxide uptake by arid ecosystems: what we know about today's situation and how global change may affect this

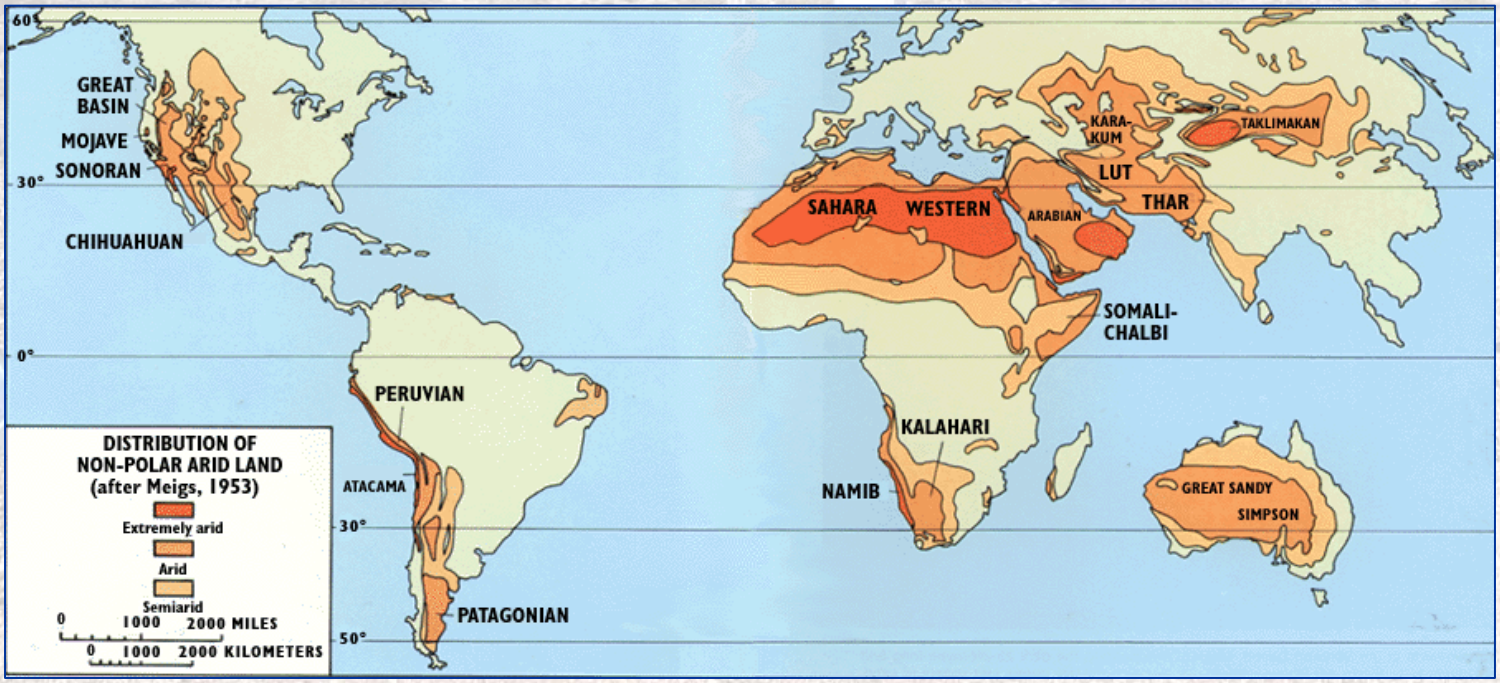
John A. Arnone III[1], Richard L. Jasoni[1], Jessica D. Larsen[1], Lynn F. Fenstermaker[1], Georg Wohlfahrt[2]

[1]Desert Research Institute, [2]University of Innsbruck

September 25, 2008

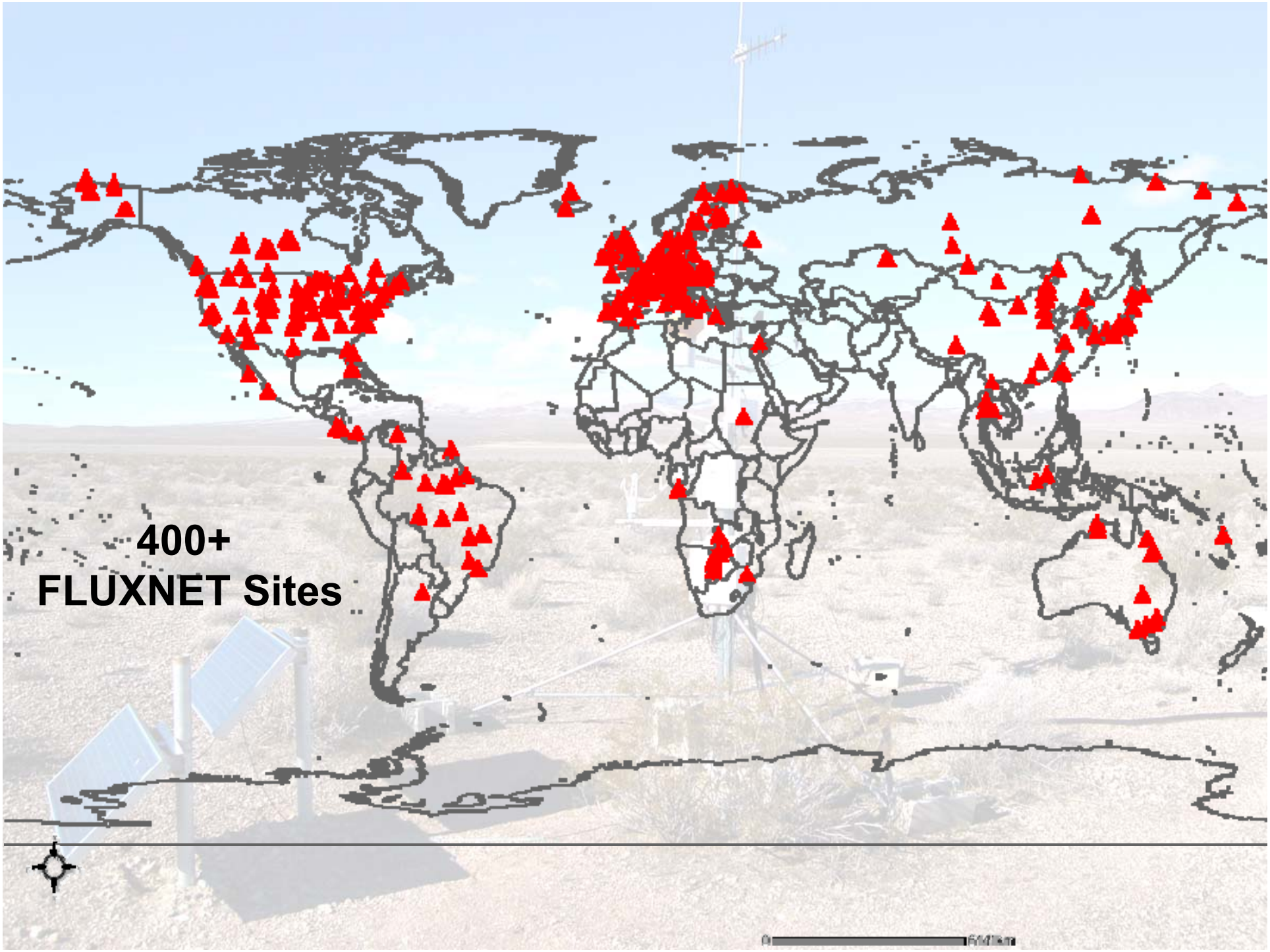
Why should we care about deserts?

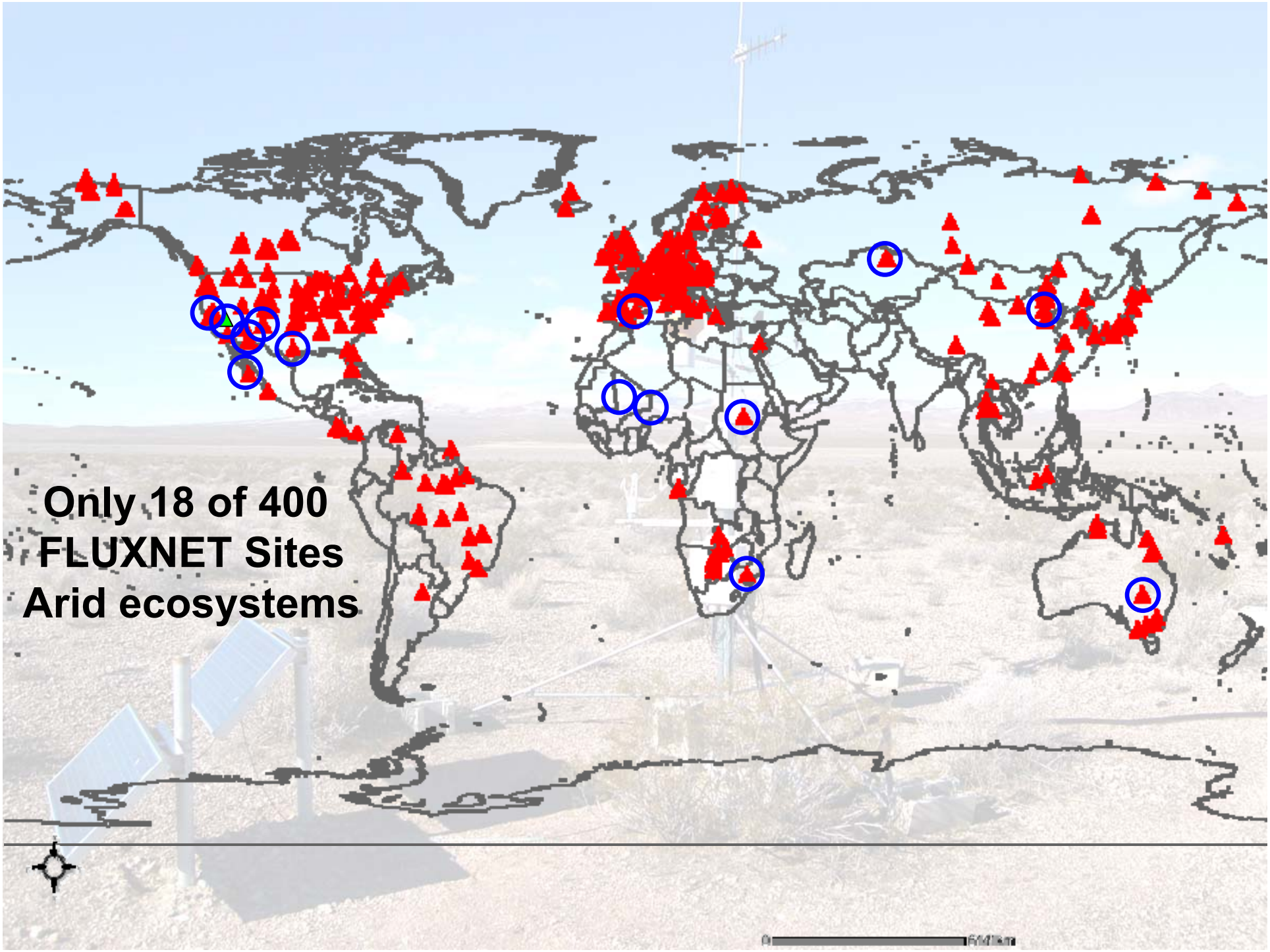
- Cover >35% of Earth's land surface; expanding because of desertification
- But existing deserts and semi-arid ecosystems may become more "woody"

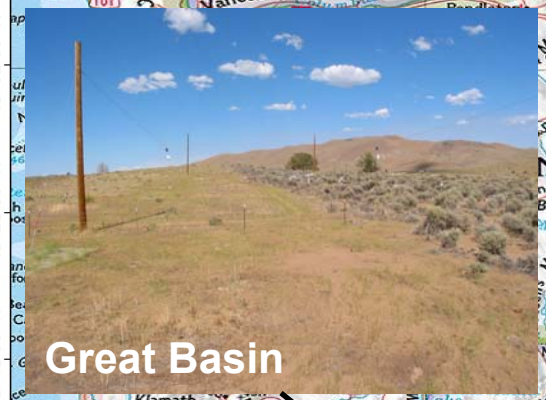


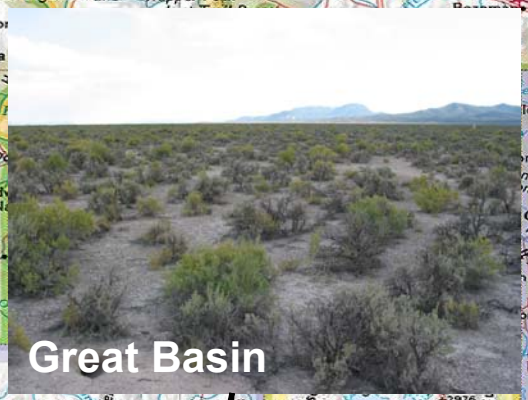
Why should we care about deserts?

- Responsive to global change
- New data suggests net CO_2 uptake may be higher than expected
- 37% of the world's population lives near deserts
- Contains 8% of the world's C stores – biomass = 8 Gt, soils = 191 Gt


400+
FLUXNET Sites


Only 18 of 400
FLUXNET Sites
Arid ecosystems





Nevada study sites

123°09'00" W 121°10'00" W 119°10'00" W 117°10'00" W 115°10'00" W 113°10'00" W 111°11'00" W 109°11'00" W 107°11'00" W WGS84 103°24'00" W

45°02'00" N 43°25'00" N 41°48'00" N 40°11'00" N 38°34'00" N 36°57'00" N 35°20'00" N 33°43'00" N 31°19'00" N

TN 13½° MN

0 100 200 300 miles

0 100 200 300 400 km

Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Desert Annual Net Ecosystem Productivity (NEP)

Desert	Location	Year	NEP ($g\ C\ m^{-2}\ yr^{-1}$)	Notes	Reference
Mojave Desert	S. Nevada	2004	-127	FACE Amb CO_2 - dome	Jasoni et al. 2005
			-90	FACE Elev CO_2 - dome	
		2005	-180	FACE Amb CO_2 - dome	
			-93	FACE Elev CO_2 - dome	
		2005	-102	MGCF- EC	Wohlfahrt et al. 2008
		2006	-110	MGCF- EC	
		2007	-81	MGCF- EC	
Great Basin	E. Nevada	2006	-18	SPVET01 - EC	Unpublished
			-59	SPVET02 - EC	(Arnone/Jasoni)
			-56	WRVET01 - EC	
		2007	-53	SV5 - EC	
			-59	SV6 - EC	
			-7	SV7 - EC	
	N. Nevada	2001	-33	Post-fire - dome	Obrist et al. 2003
			20	Shrub - dome	
		2004	49	Post-fire - dome	Unpublished
			56	Shrub - dome	(Jasoni/Arnone)
Sonoran	Baja California Mexico	2002	-39	EC	Hastings et al. 2005
		2003	-52	EC	

How much might deserts contribute to global NEP?

- Average NEP of these sites = -21 g C m^{-2} yr^{-1}

  = -21,000,000 g C km^{-2} yr^{-1}

- Arid shrublands = 20% of Earth's land surface

  20% of 148,939,100 km^2

= 29,787,280 km^2 x -21,000,000 g C km^{-2} yr^{-1}

= 0.63 Gt C yr^{-1}

= 8.75% of anthropogenic CO_2 emissions

How much might deserts contribute to global NEP?

- Average NEP of these sites = -50 g C m^{-2} yr^{-1}

  = -50,000,000 g C km^{-2} yr^{-1}

- Arid & semi-arid ecosystems ca. 30% of Earth's land surface

  30% of 148,939,100 km^2

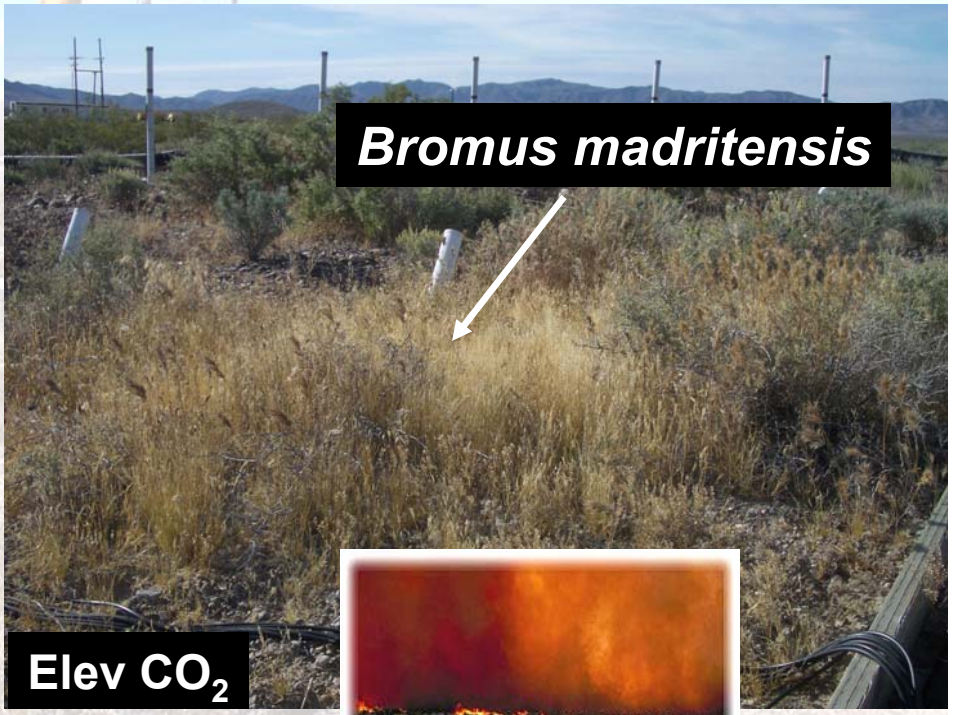
= 44,681,730 km^2 x -50,000,000 g C km^{-2} yr^{-1}

= 2.23 Gt C yr^{-1}

= 31% of anthropogenic CO_2 emissions

Ecological feedbacks to desert C balance

Growth of invasive grass stimulated in wetter year



Large C losses ←

Smith *et al*. (2000), *Nature*

Take-home points

1. Deserts may be playing a much larger role in modulating global atmospheric CO_2

2. However, need a lot more multi-year data sets from the world's deserts

3. Rising anthropogenic atmospheric CO_2 may:
   - suppress desert ecosystem CO_2 uptake by stimulating soil microbial respiration that may be offset if rainfall increases
   - increase growth of invasive grasses increasing wildfire risk and large losses of carbon

4. Must still determine where the NEP carbon is going in the ecosystem (NPP – vascular plants, autotrophic cryptobiotic crusts)