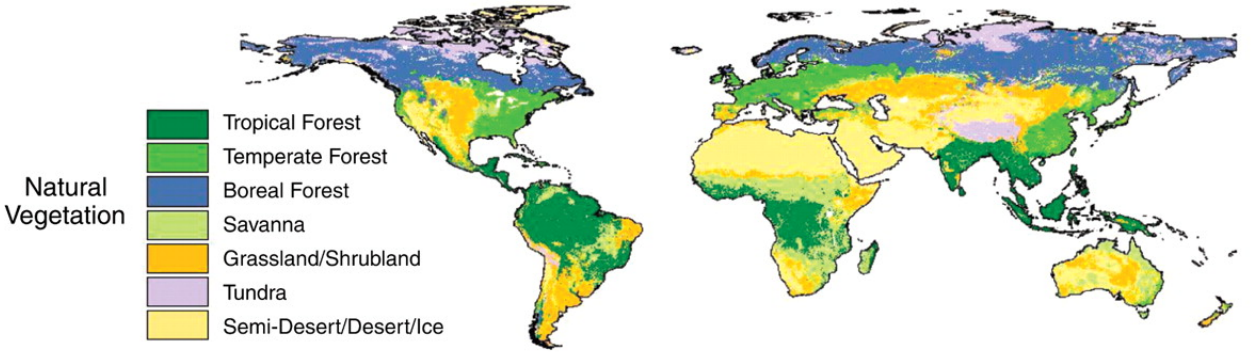
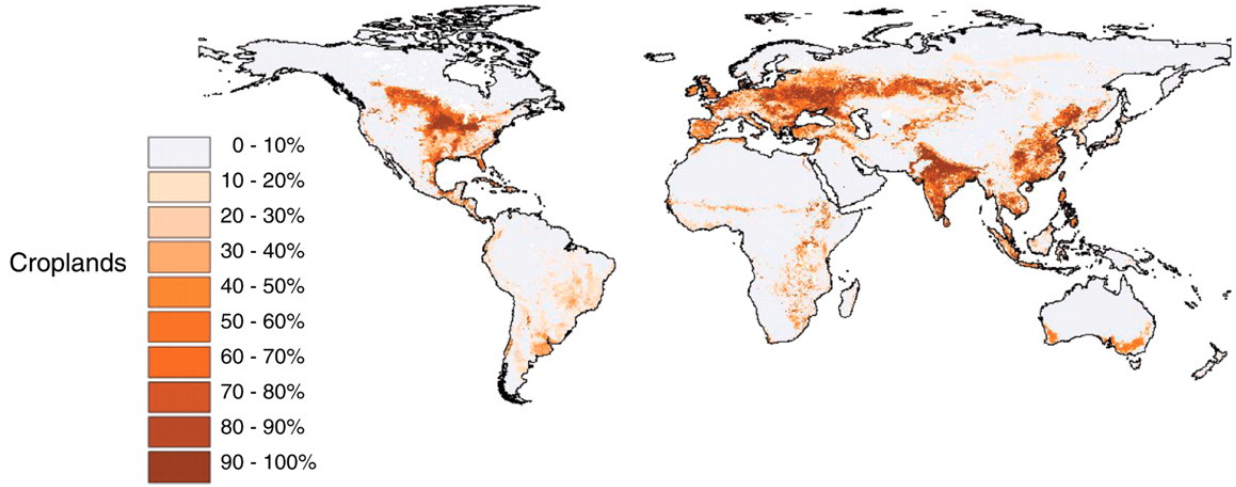
How do land management practices affect net ecosystem CO_2 exchange of an invasive species infestation?

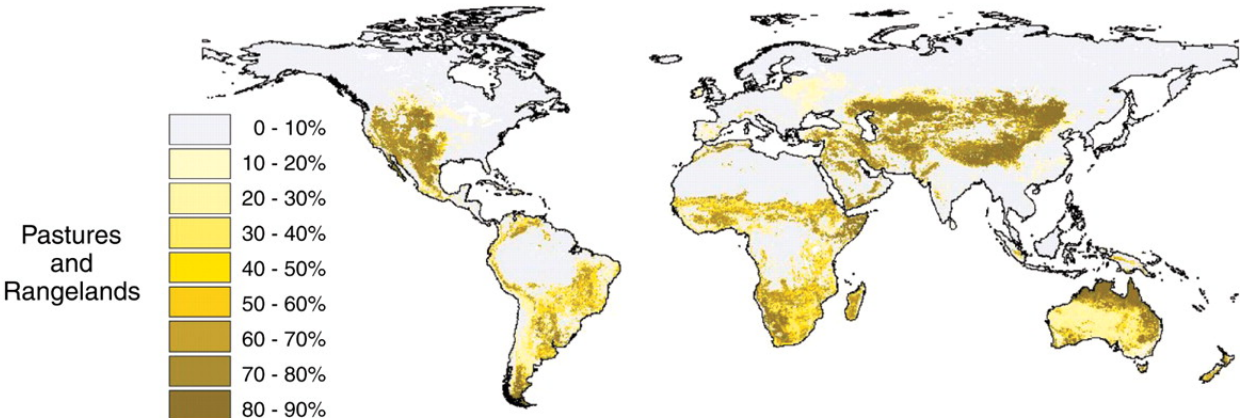
GeoLunch seminar

by

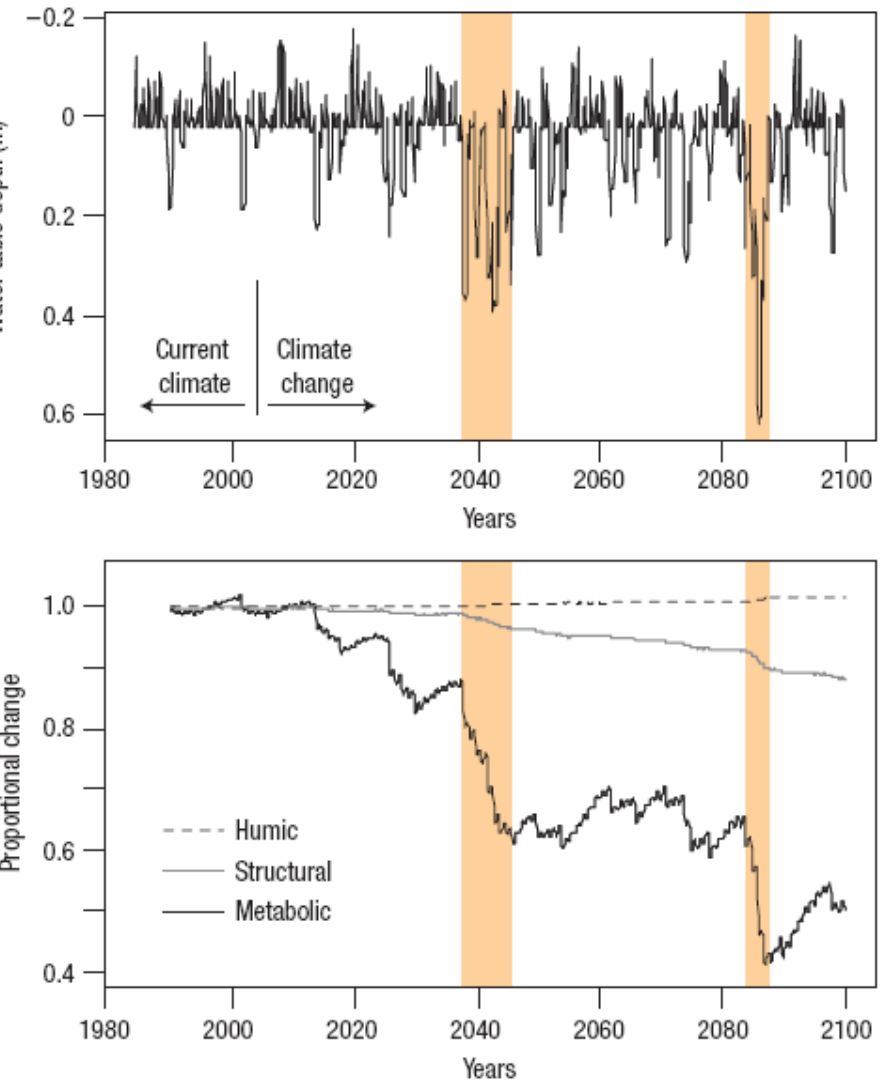
Oliver Sonnentag, PhD


Natural Vegetation
Tropical Forest
Temperate Forest
Boreal Forest
Savanna
Grassland/Shrubland
Tundra
Semi-Desert/Desert/Ice

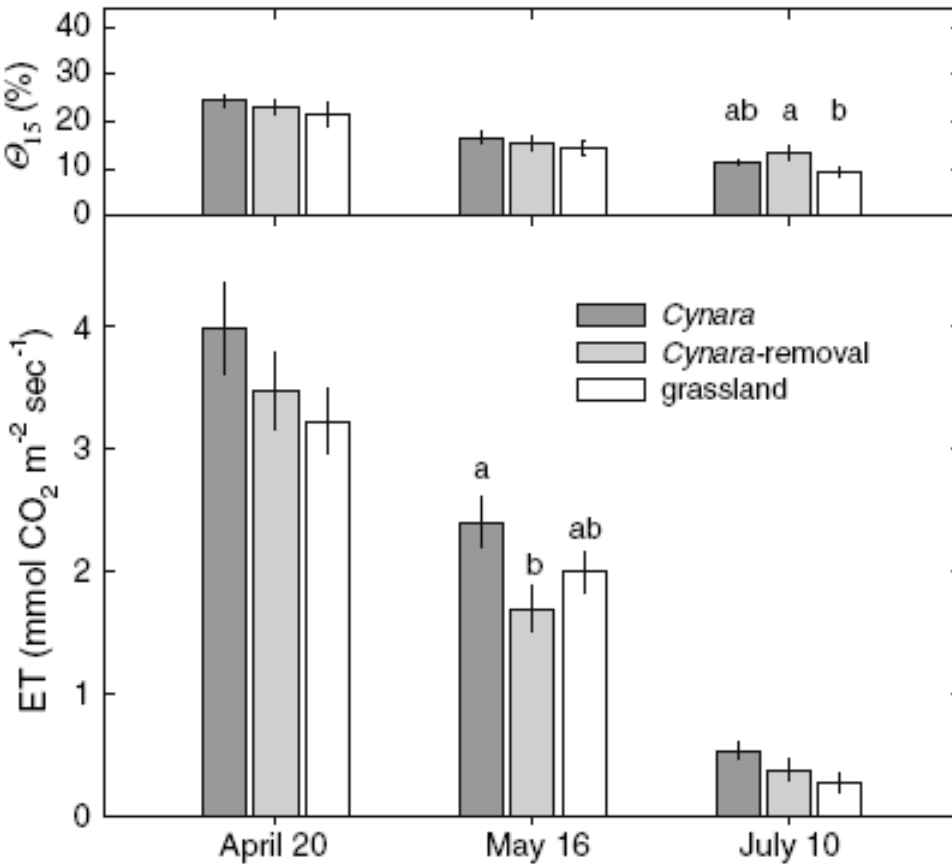

Croplands
0 - 10%
10 - 20%
20 - 30%
30 - 40%
40 - 50%
50 - 60%
60 - 70%
70 - 80%
80 - 90%
90 - 100%


Pastures and Rangelands
0 - 10%
10 - 20%
20 - 30%
30 - 40%
40 - 50%
50 - 60%
60 - 70%
70 - 80%
80 - 90%

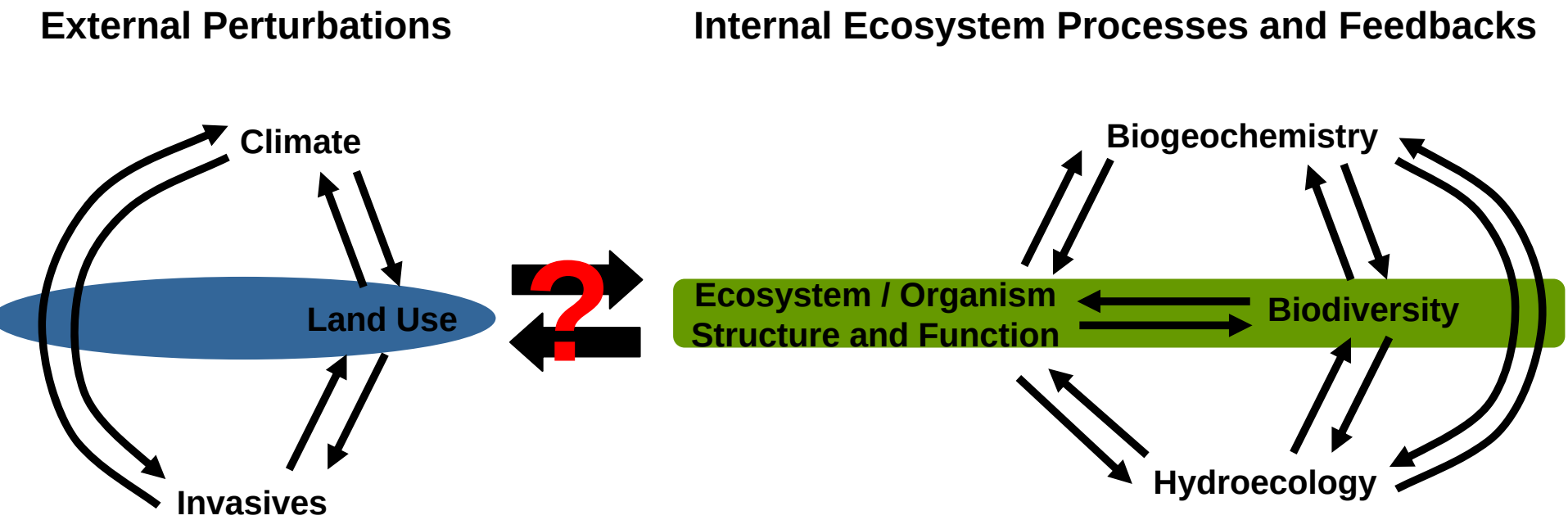
Research Context



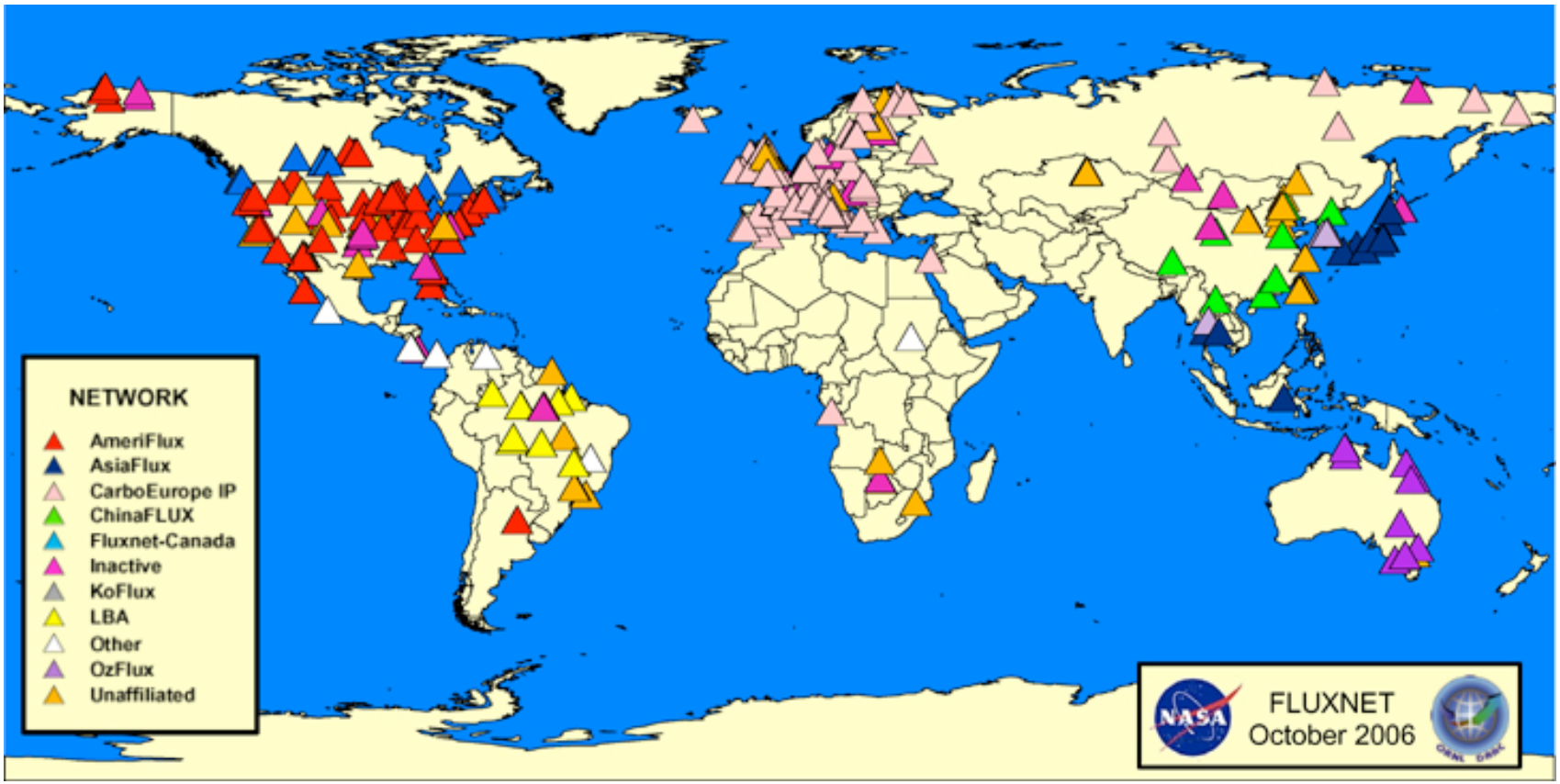
(Ise et al., 2008, NG, 1:763-768.)



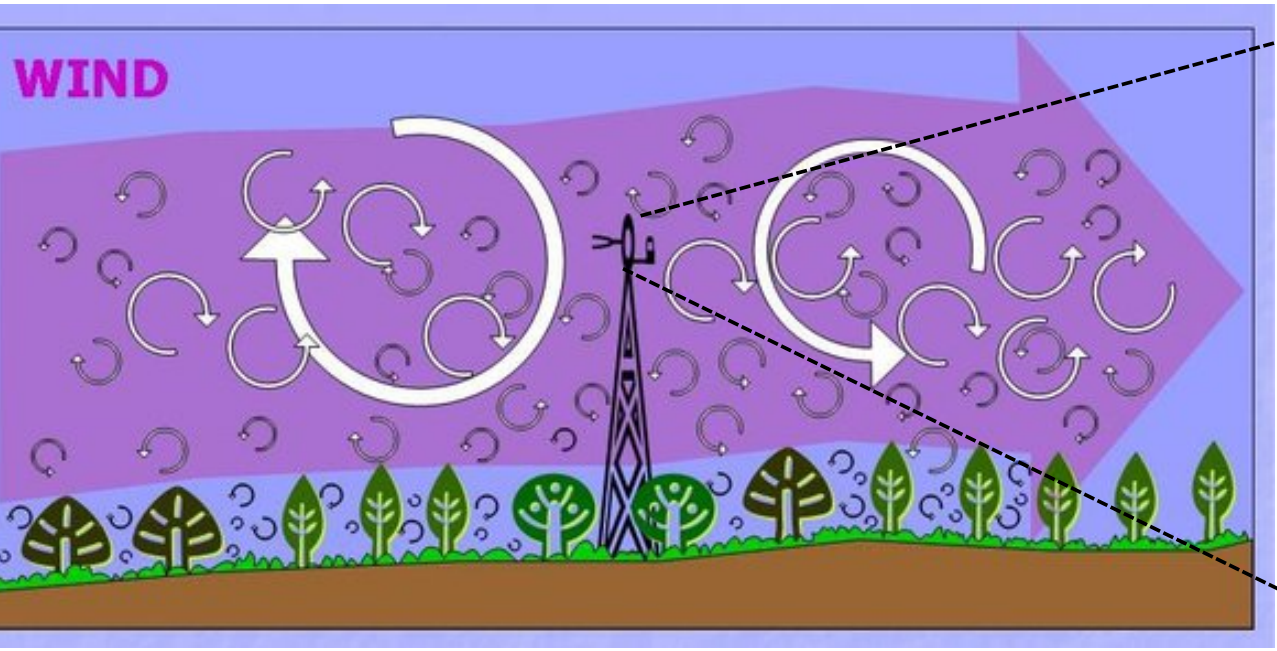
(Potts et al., 2008, BI, 10:1073-1084.)

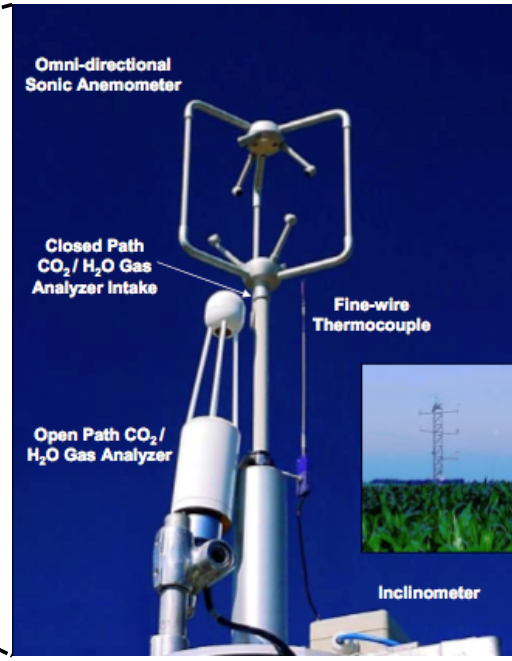


How are gas and energy exchanges of infested ecosystems affected by different land management practices?
How do these effects vary in time and space as a function of changing environmental conditions?


NETWORK
AmeriFlux
AsiaFlux
CarboEurope IP
ChinaFLUX
Fluxnet-Canada
Inactive
KoFlux
LBA
Other
OzFlux
Unaffiliated
NASA
FLUXNET
October 2006

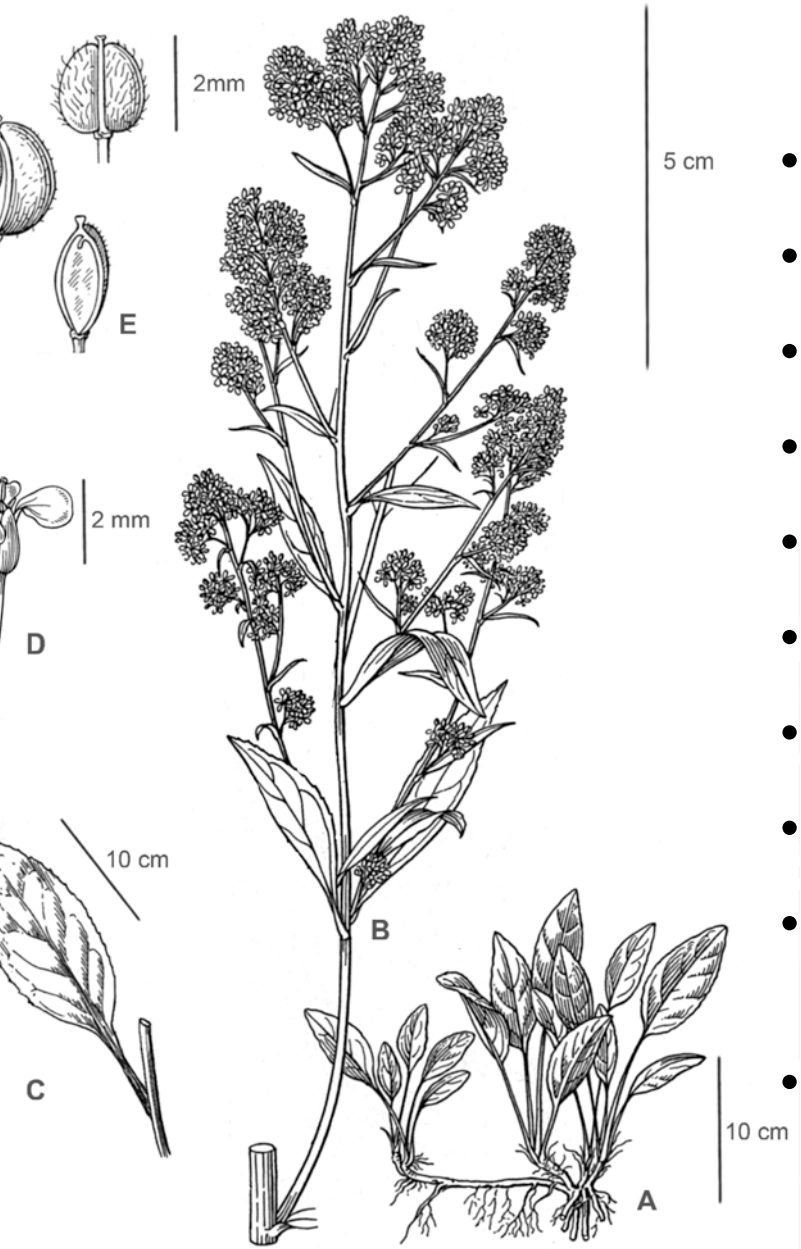
ddy covariance





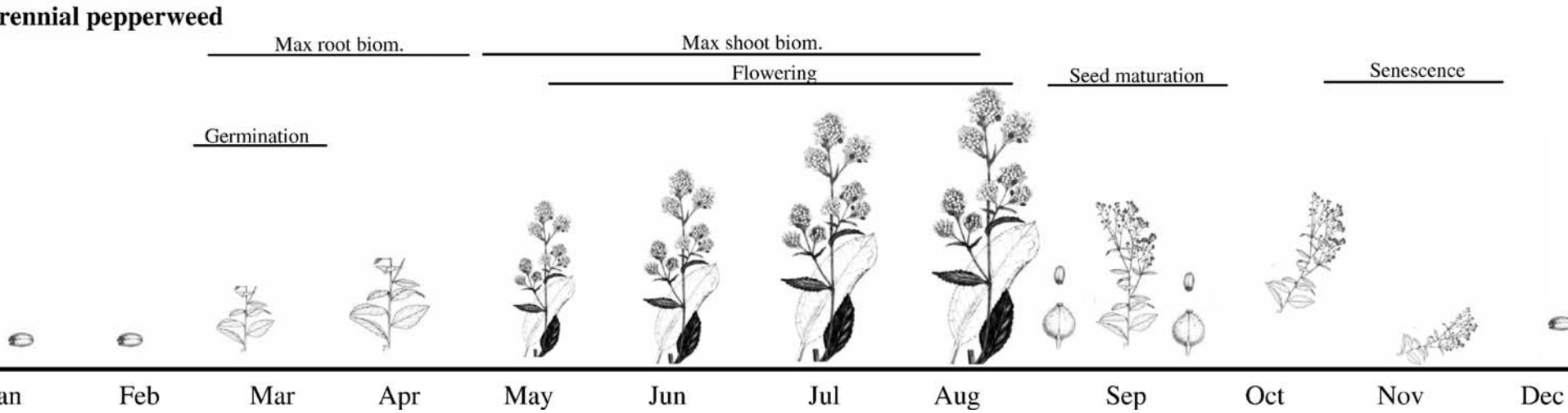
- EC: micrometeorological technique that measures vertical flux transported by edd
- Flux: how much of XYZ moves through a unit area per unit time
- Vertical flux: covariance of vertical velocity and concentration of the entity of inter
- Net ecosystem exchange (NEE):
  ecosystem respiration (R_{eco}) – gross ecosystem productivity (GEP)

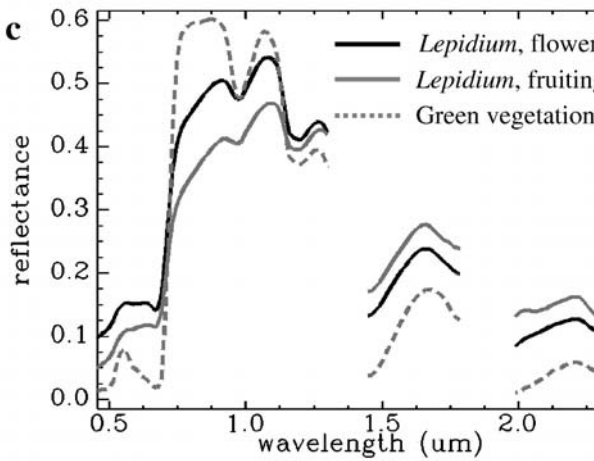
epidium latifolium



- Perennial pepperweed
- Immigrated to NA from SE Europe/ W Asia (193
- USA: established and invasive in all W states
- Very tolerant (saline – alkaline soils)
- Dense patches as monocultures
- Max. canopy height: 2 m
- Ideal climate: Mediterranean
- Pastures & hay meadows: reduced forage quali
- Control measures:
  burning, flooding, grazing, mowing, herbici
- Pastures: grazing + mowing

epidium latifolium



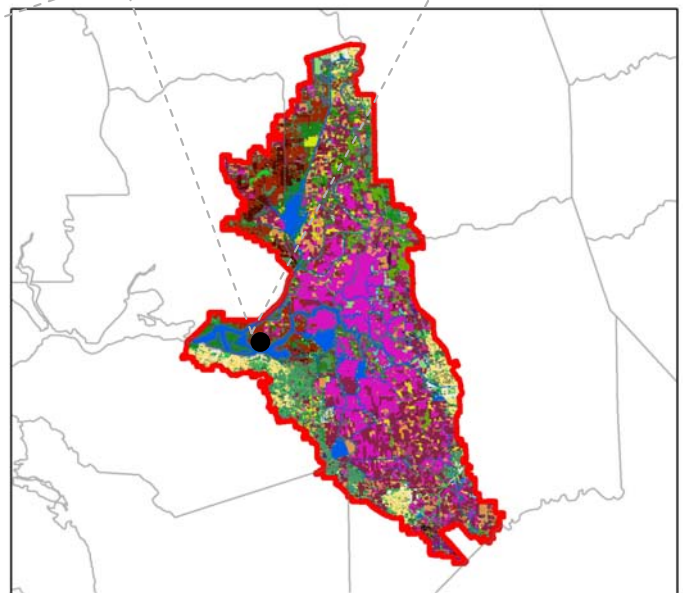


A study sites: Ameriflux

Sherman Island

IGBP: grassland

California Delta



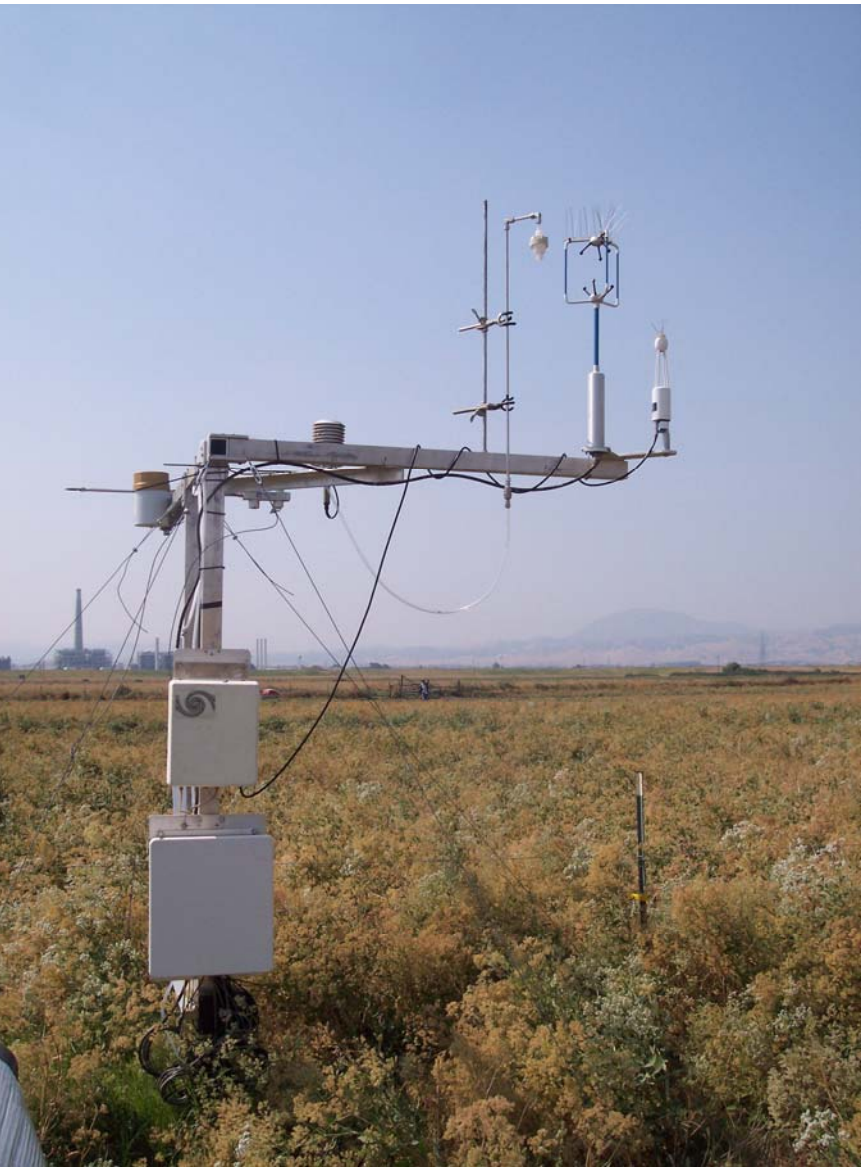
Vaira Ranch

IGBP: grassland

How do land management practices affect net ecosystem CO_2 exchange of an invasive species infestation?

- How does year-round grazing affect pepperweed canopy development?
- Is it possible to identify phenologial key events such as flowering from the limited spectral information of digital camera imagery?
- How does pepperweed flowering affect GEP and R_{eco}?
- How does the 2008 mowing event affect NEE compared to 2007 and 2009?
- Does the mowing event affect NEE through GEP and R_{eco} or through both component fluxes?
- Can the combined effects of pepperweed flowering and mowing on NEE potentially be tracked using remote sensing techniques of lower spectral resolution such as MODIS?
- If yes, what are the relevant spectral regions? Are these spectral regions similar for uninfested grasslands?

ddy covariance



• <u>Eddy covariance</u>:

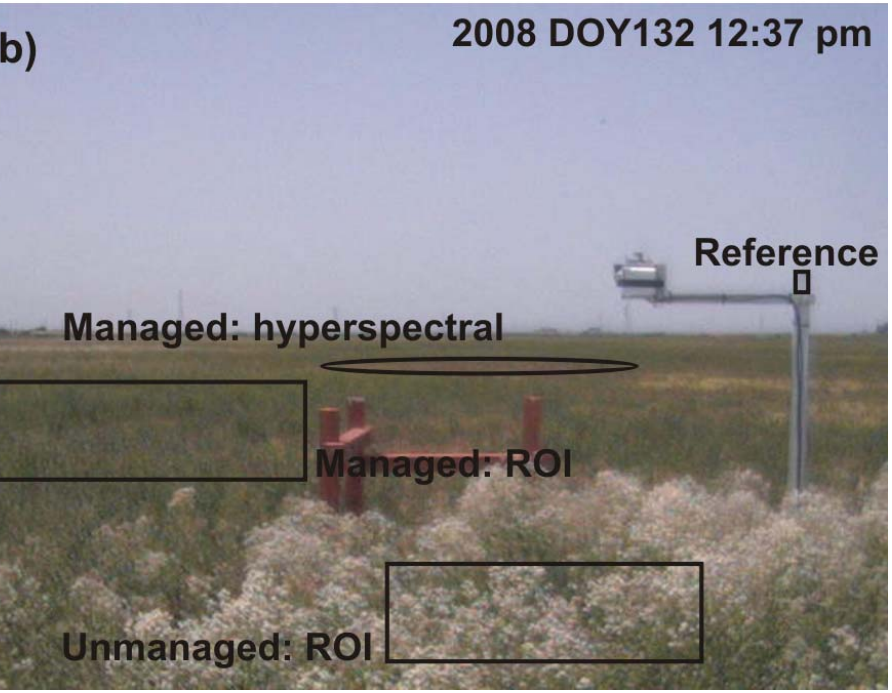
sonic anemometer (u, v, w, v_{sound}, T_{sonic})

IRGA (ρ_{CO2}, ρ_{H2O})

• <u>Environmental measurements</u>:

frequency domain reflectometer probes (VLSMC), tipping bucket rain gauge (PP pressure transducer (WTD), thermistor (and capitance (RH) sensor, copper-constantan thermocouples (T_{soil}), four component net radiometer (R_{net}), quantu sensors (PAR_{in}, PAR_{out}), heat flux plates

ear-surface remote sensing



- <u>Hyperspectral canopy reflectance</u>:

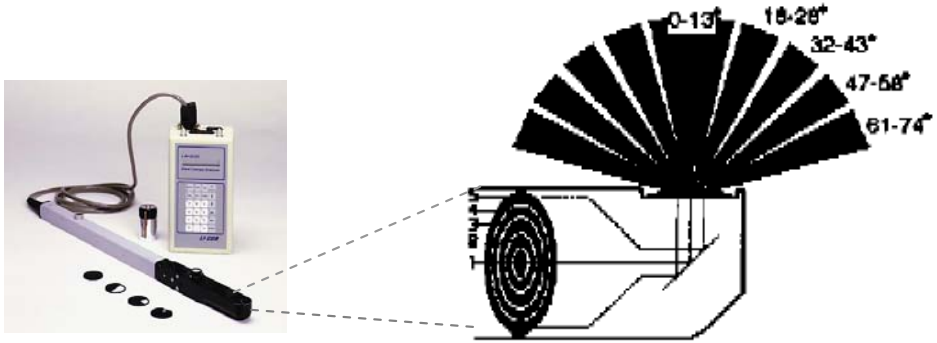
  OO (USB2000+) hand-held spectrometer (350-1100 nm) at weekly-biweekly intervals

- <u>Networked digital camera</u>:

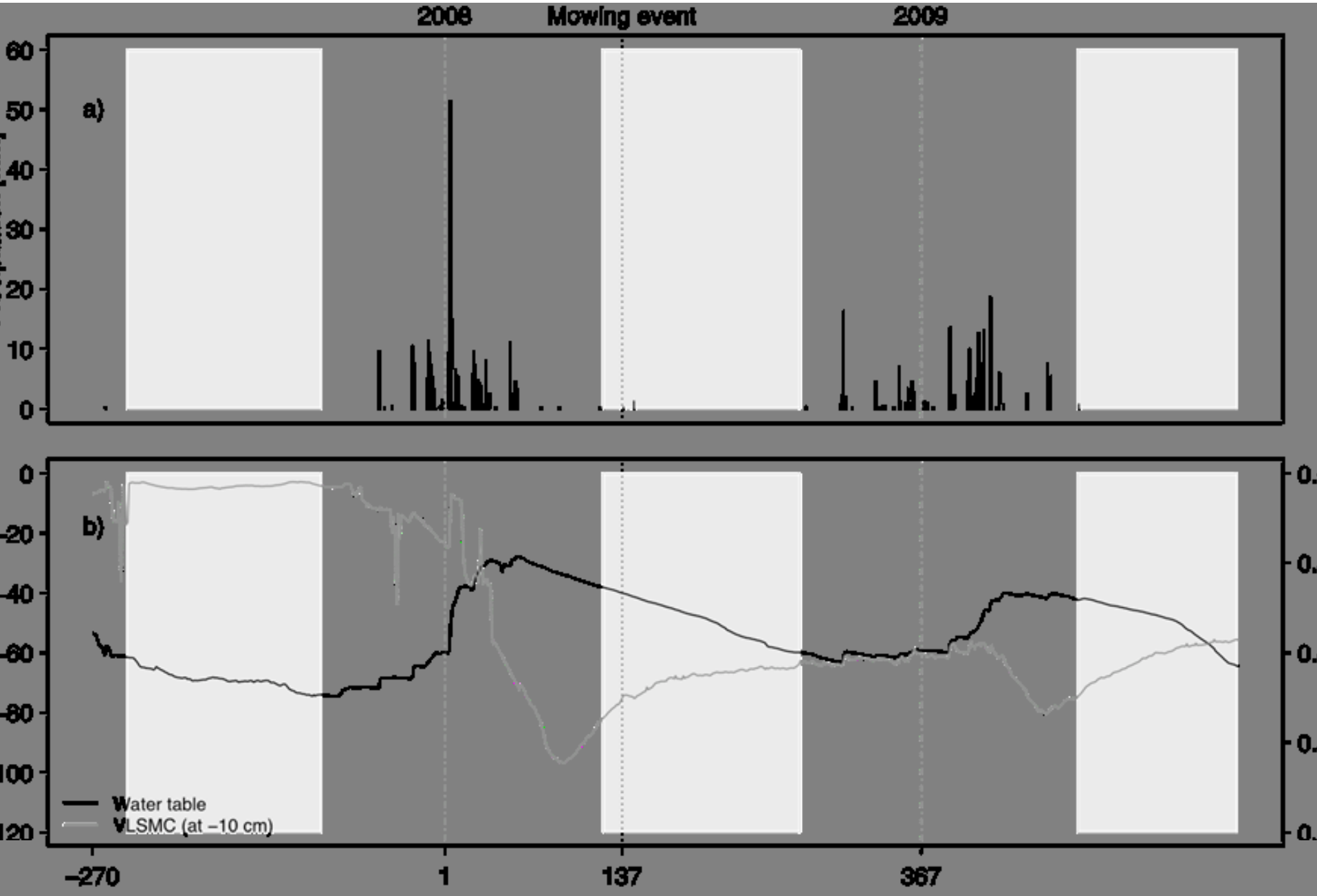
  Off-the-shelf, low-cost digital camera (~USD 100) at 30min intervals (well, theoretically…)

- <u>Leaf area index:</u>

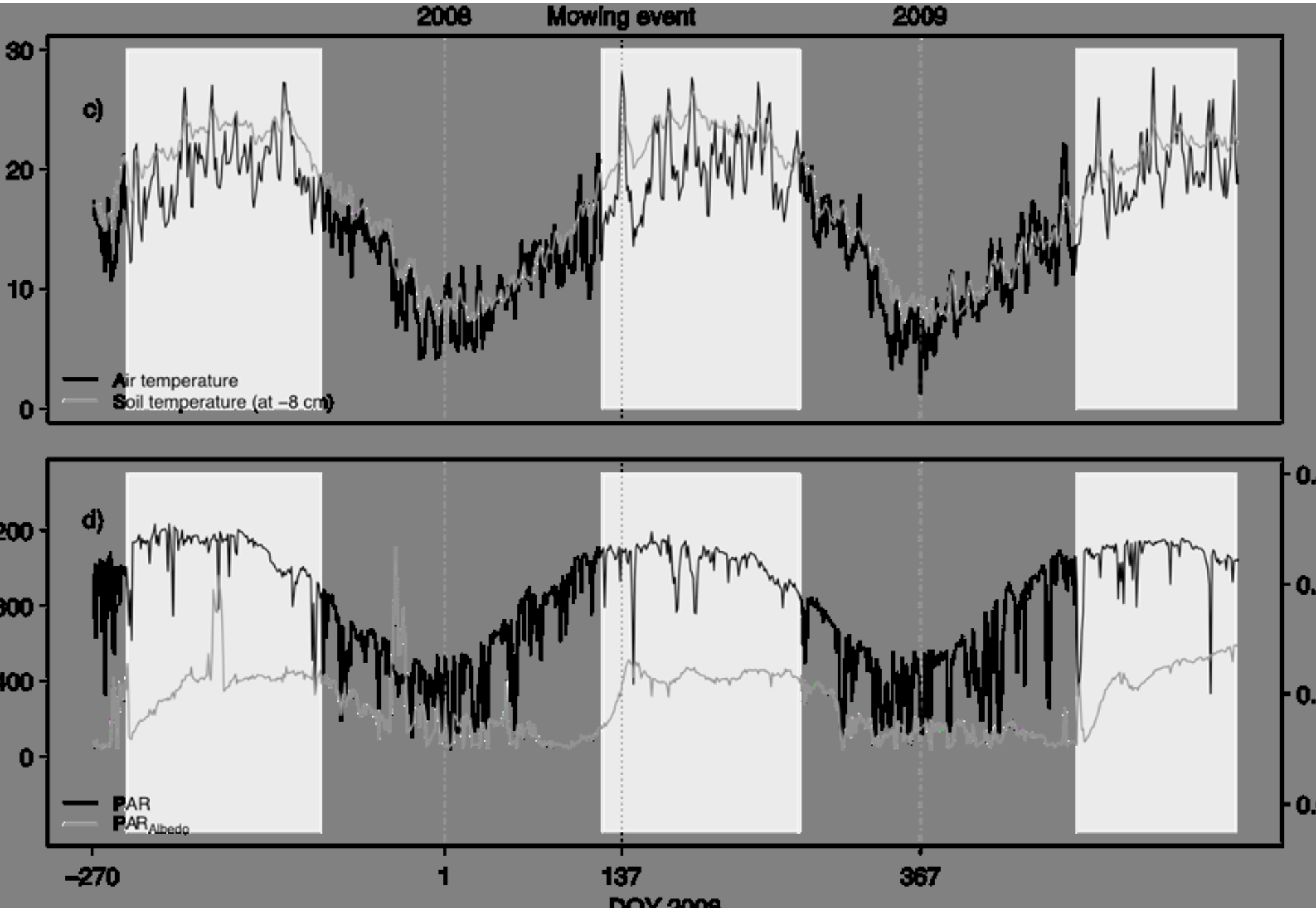
  LAI-2000 Plant Canopy Analyzer weekly-biweekly intervals



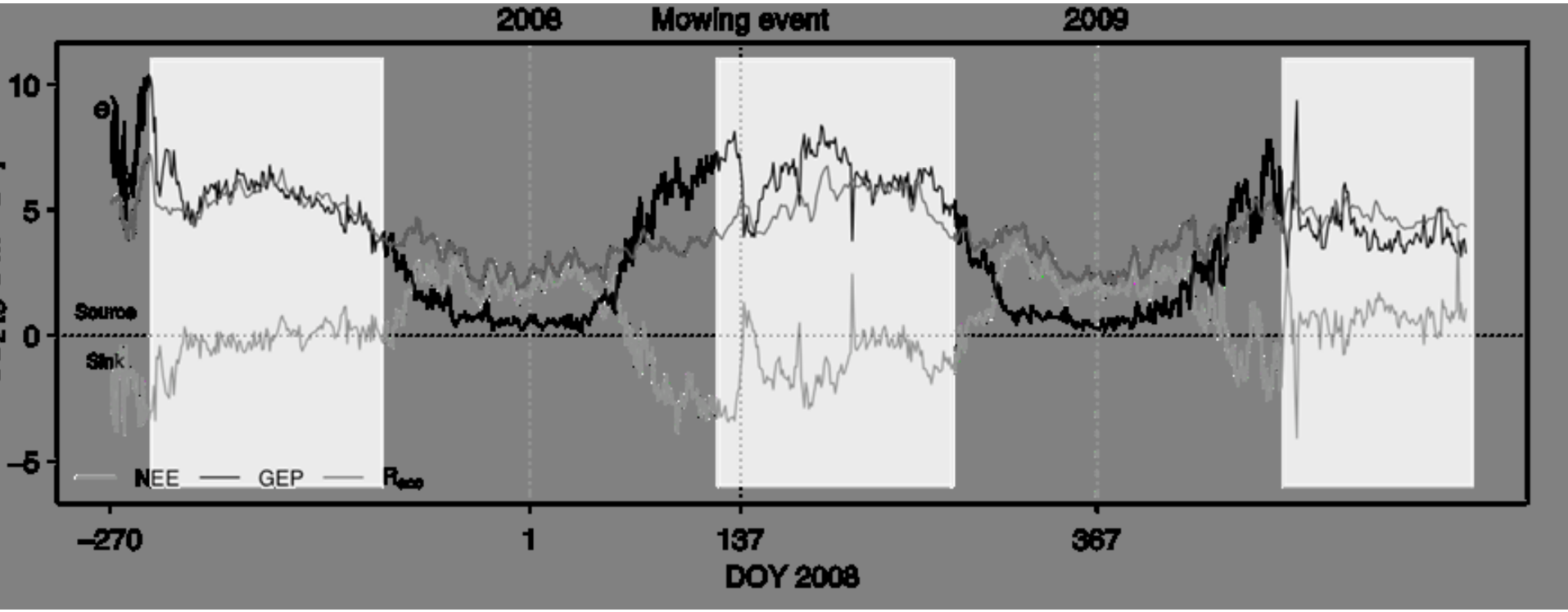
Meteorological conditions



Meteorological conditions

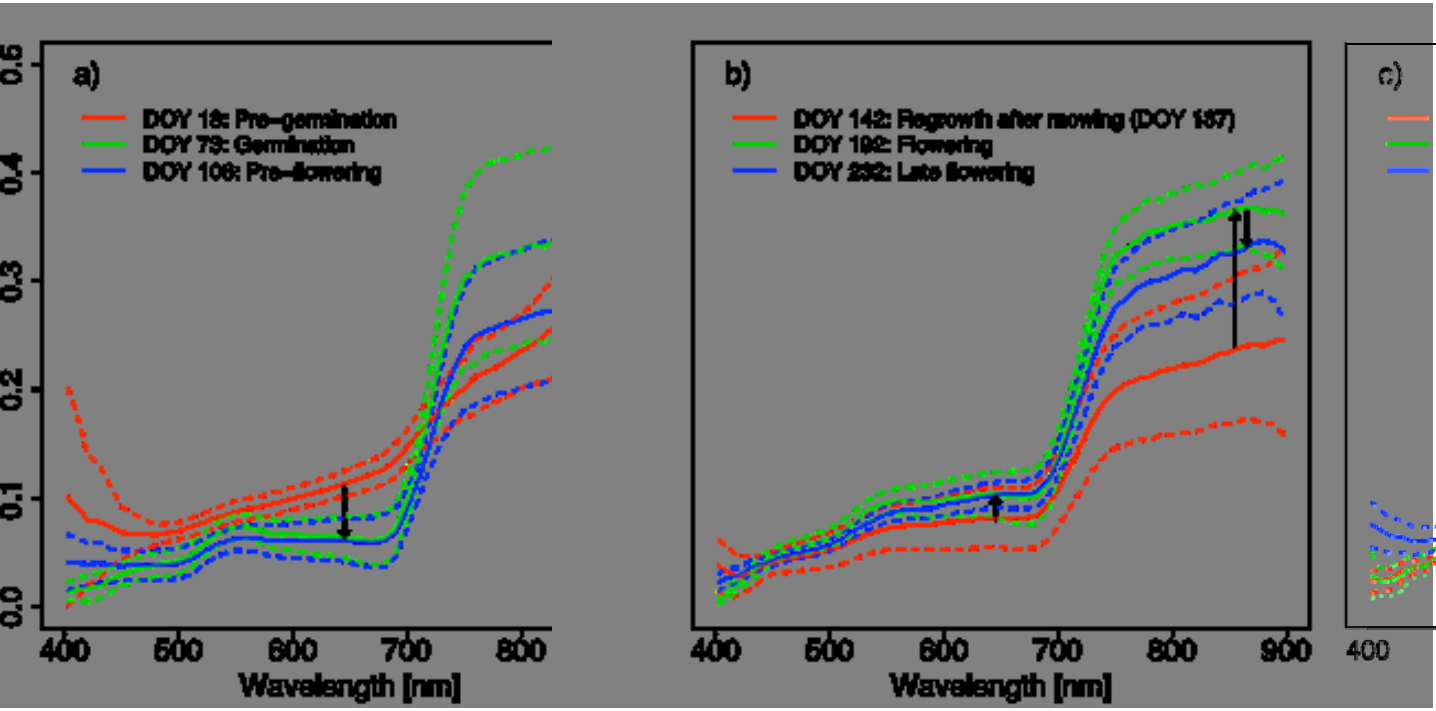


et CO_2 ecosystem exchange



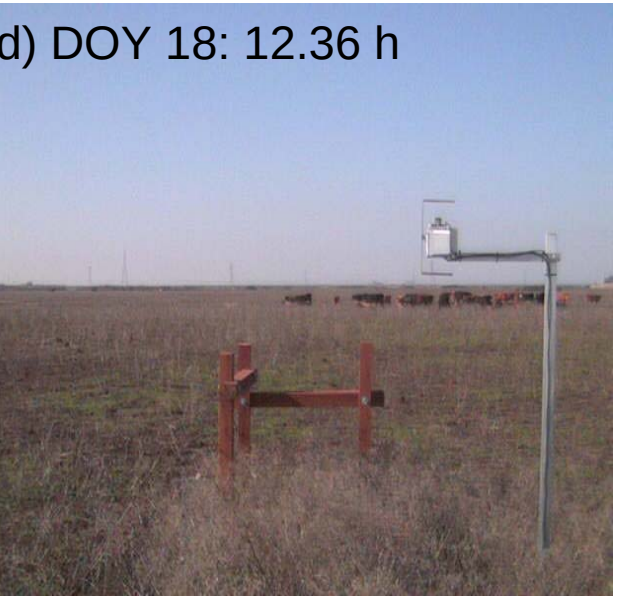
CO_2 sink-source-strength between years seems to be largely controlled by land management practices (mowing).

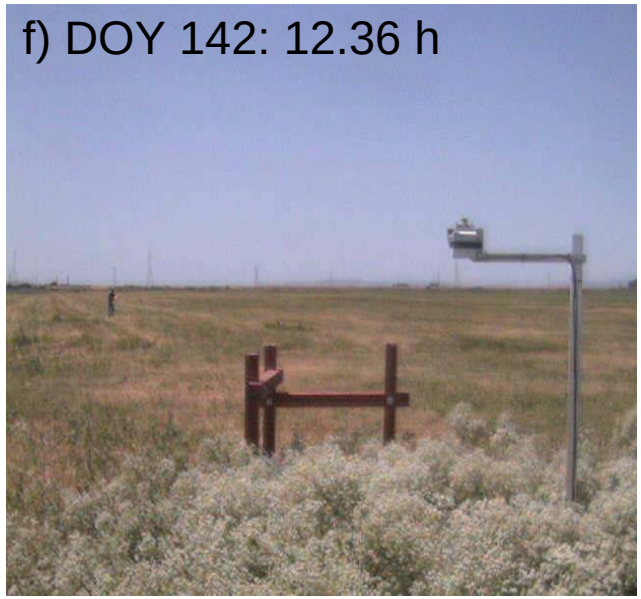
yperspectral canopy reflectance

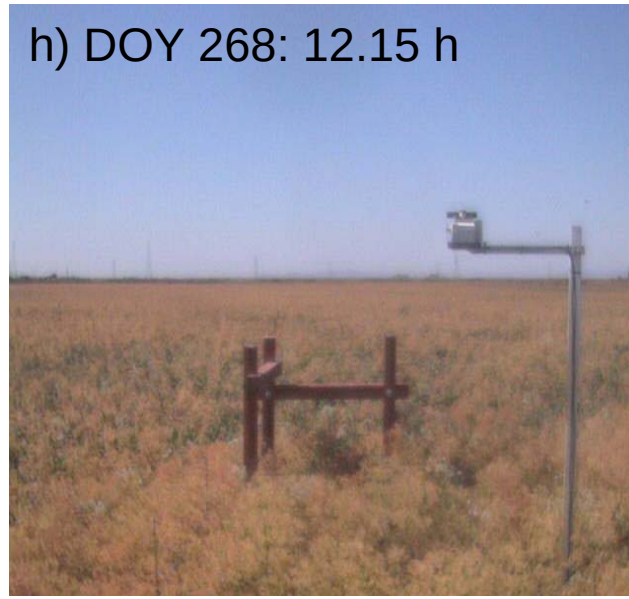


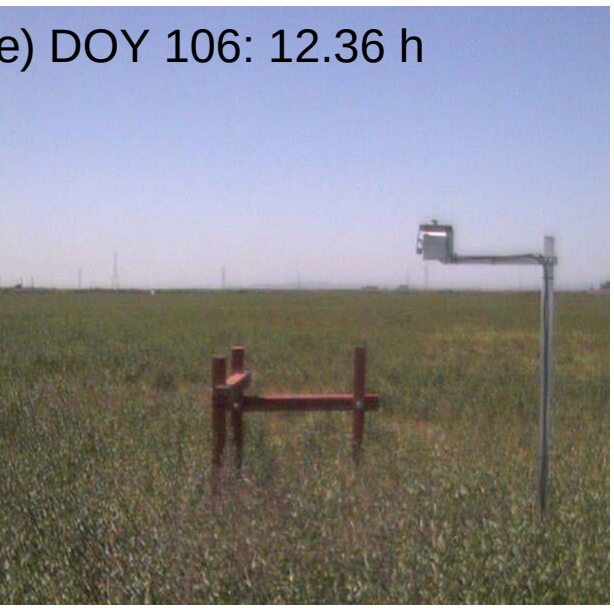
Spectral characteristics of a pepperweed canopy under year-round grazing are complex, even more so when subject to mowing!

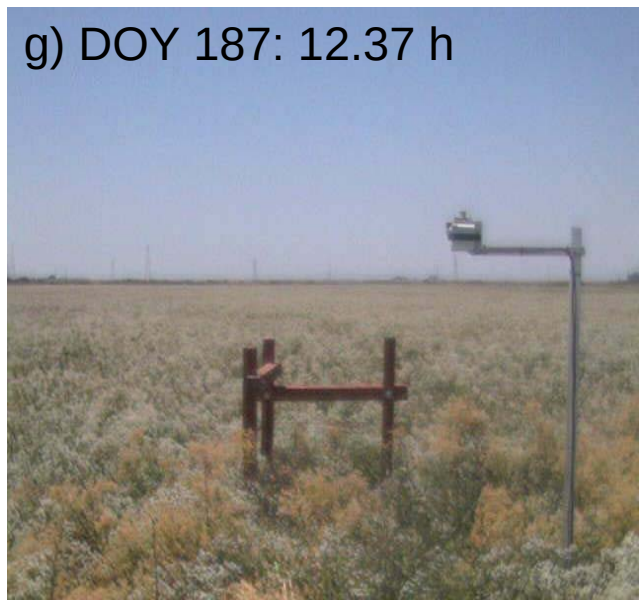
etworked digital camera





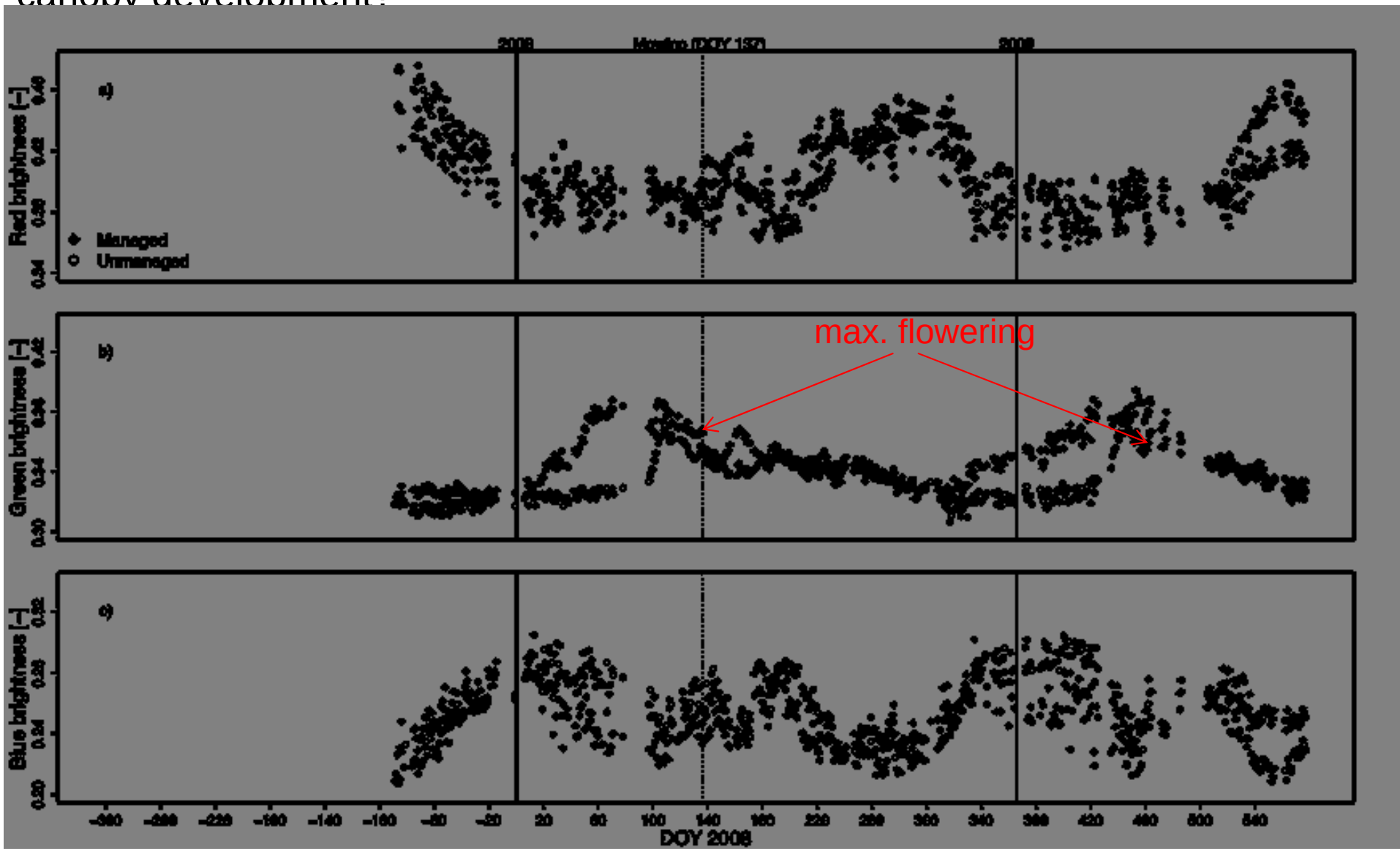






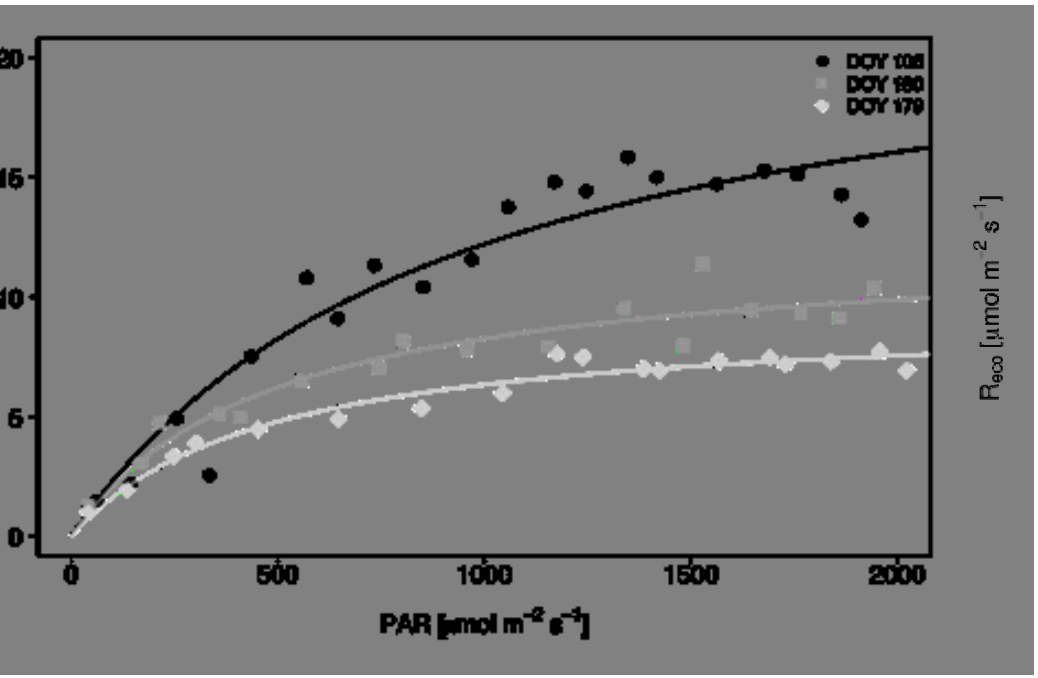
epperweed canopy development

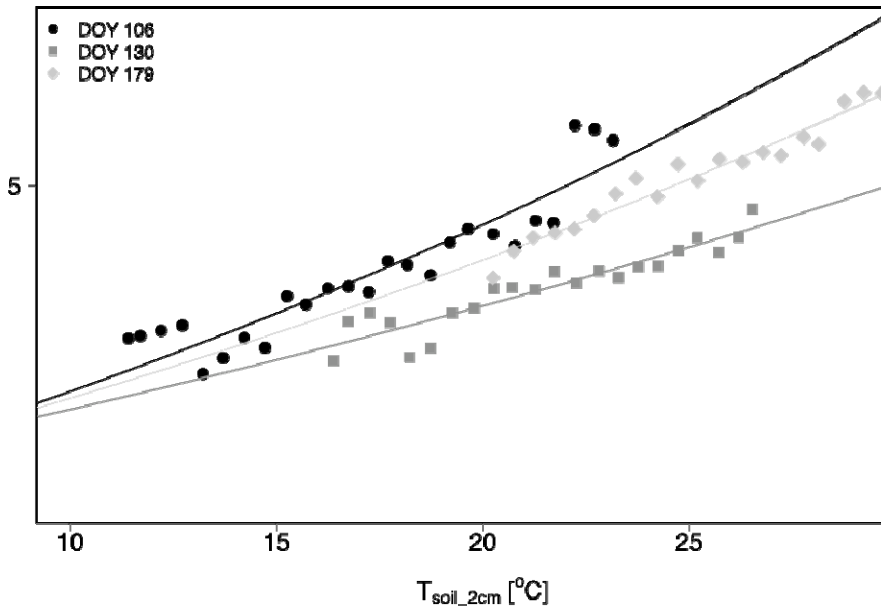
How does year-round grazing and mowing affect pepperweed canopy development?



epperweed flowering

How does pepperweed flowering affect *gross ecosystem productivity* (GEP) and *ecosystem respiration* (R_{eco})?

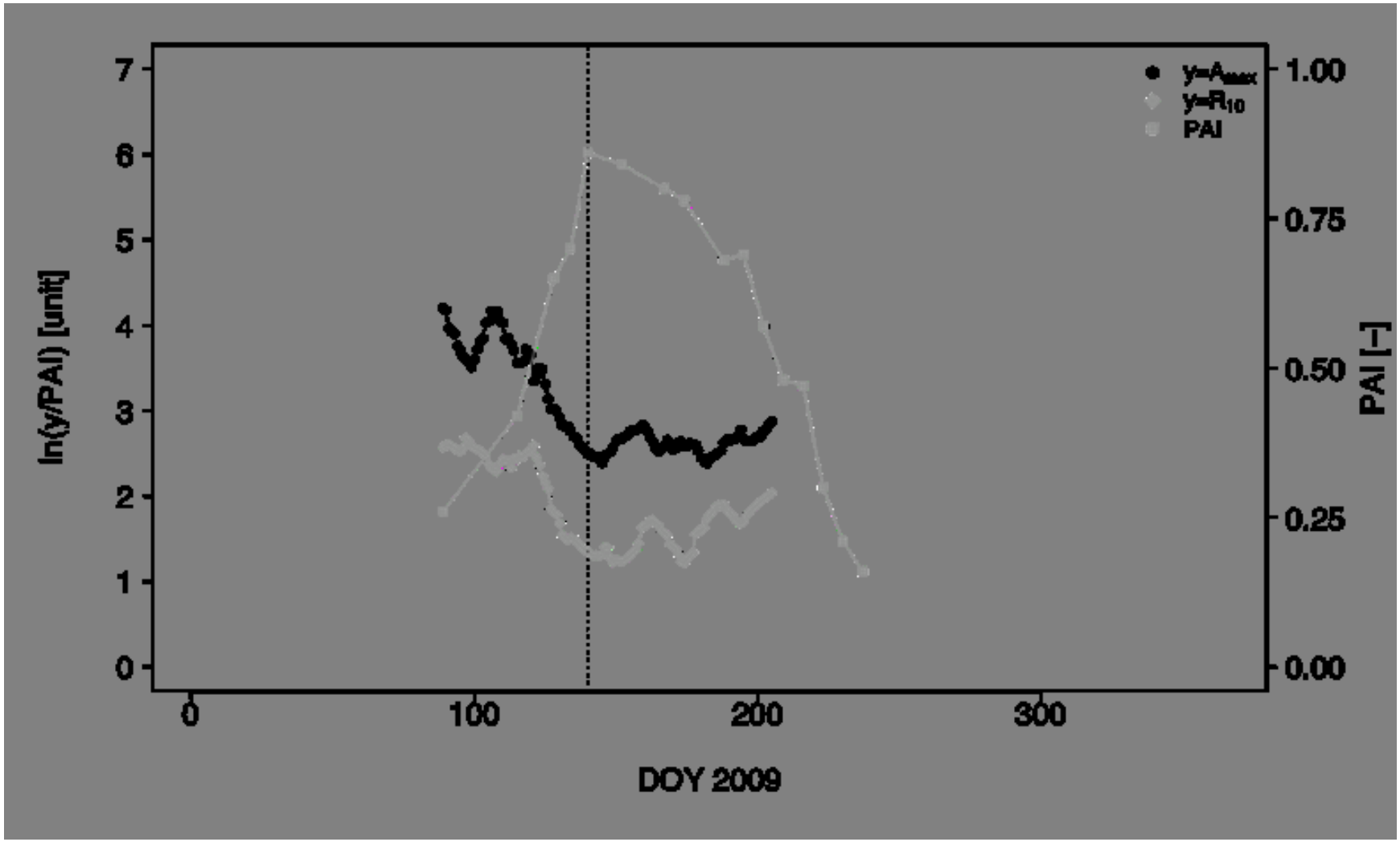




$$GEP = \frac{\alpha * PAR * A_{\max}}{\alpha * PAR + A_{\max}}$$

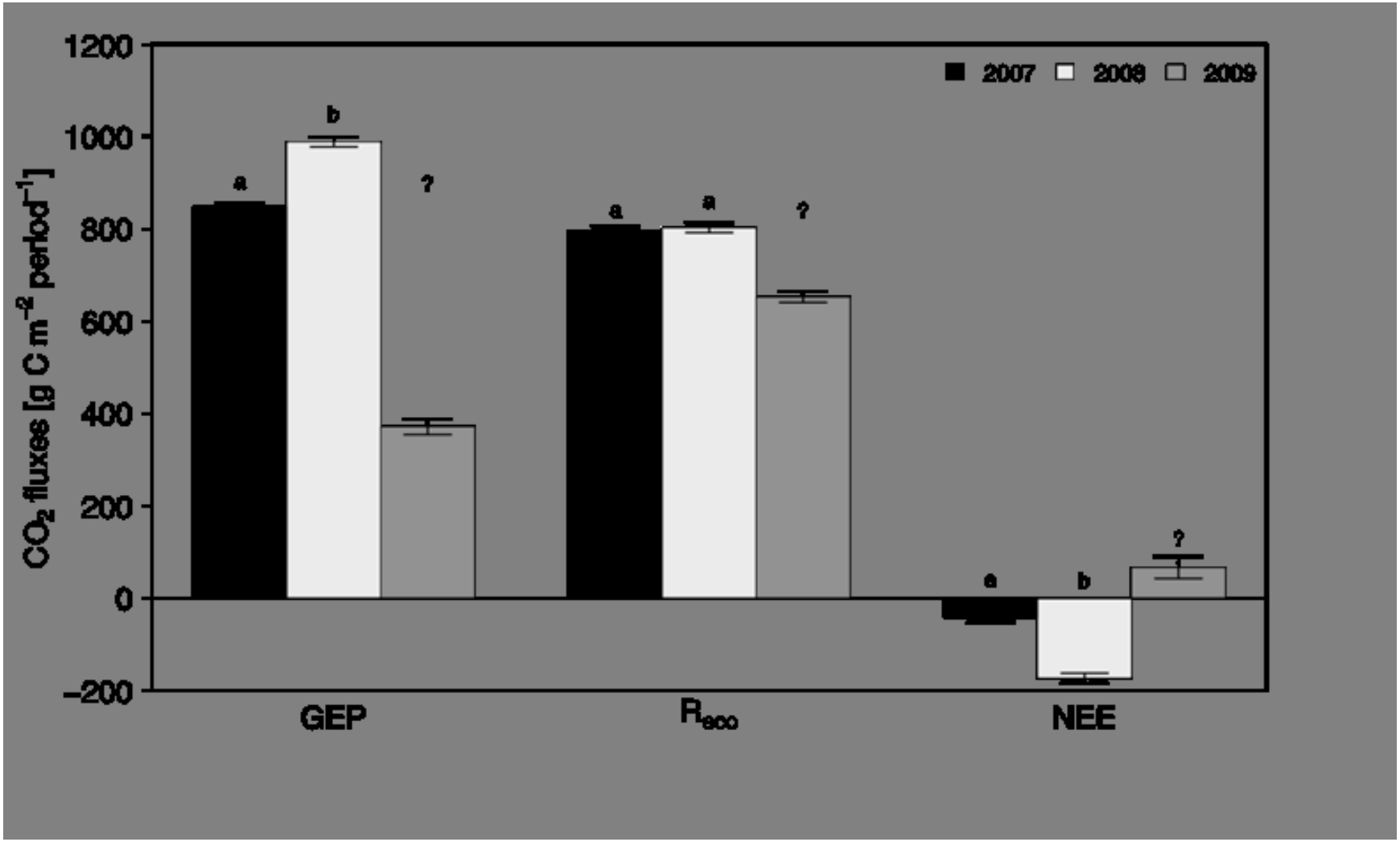
$$R_{eco} = R_{10} * Q_{10}^{(T_{soil\_2cm} - T_{10})/10}$$

epperweed flowering

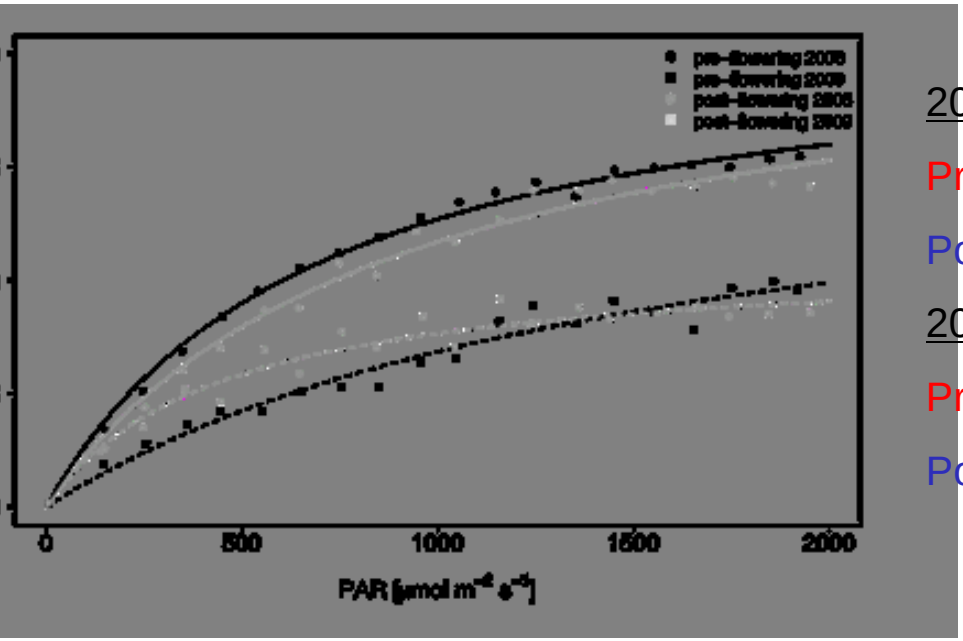


Both GEP and R_{eco} appear to decrease with the onset of flowering as indicated by decreasing PAI-normalized A_{max} and R_{10}, respectively.

How does the 2008 mowing event affect *net ecosystem exchange* (NEE) compared to 2007 and 2009?



Does the mowing event affect NEE through GEP and R_{eco} or through both component fluxes?



2008

Pre-A_{max} (95% CI) = 21.61 (20.63, 22.71) μ mol m^{-2} s^{-1}

Post-A_{max} (95% CI) = 17.84 (14.42, 23.79) μ mol m^{-2} s^{-1}

2009

Pre-A_{max} (95% CI) = 22.05 (20.14, 24.42) μ mol m^{-2} s^{-1}

Post-A_{max} (95% CI) = 11.08 (10.03, 12.42) μ mol m^{-2} s^{-1}

2008

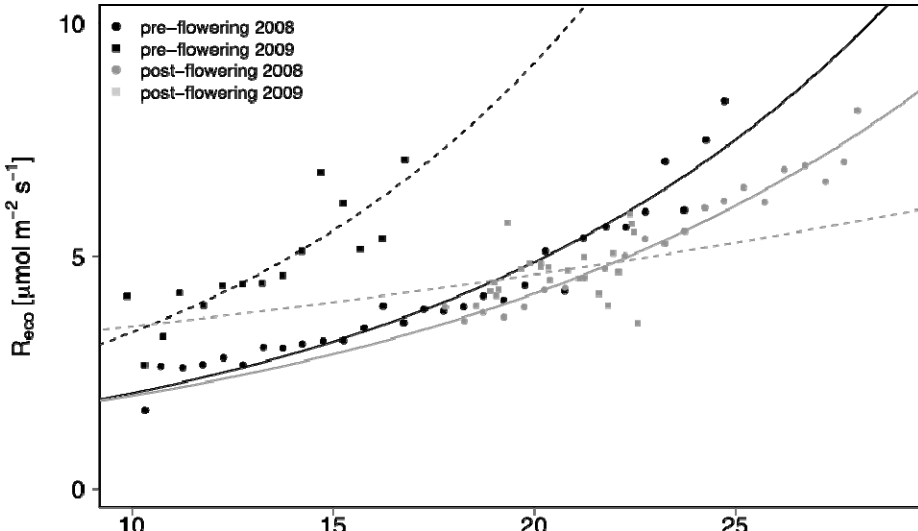
Pre-Q_{10} (95% CI) = 2.37 (2.15, 2.61)

Post-Q_{10} (95% CI) = 2.10 (1.95, 2.27)

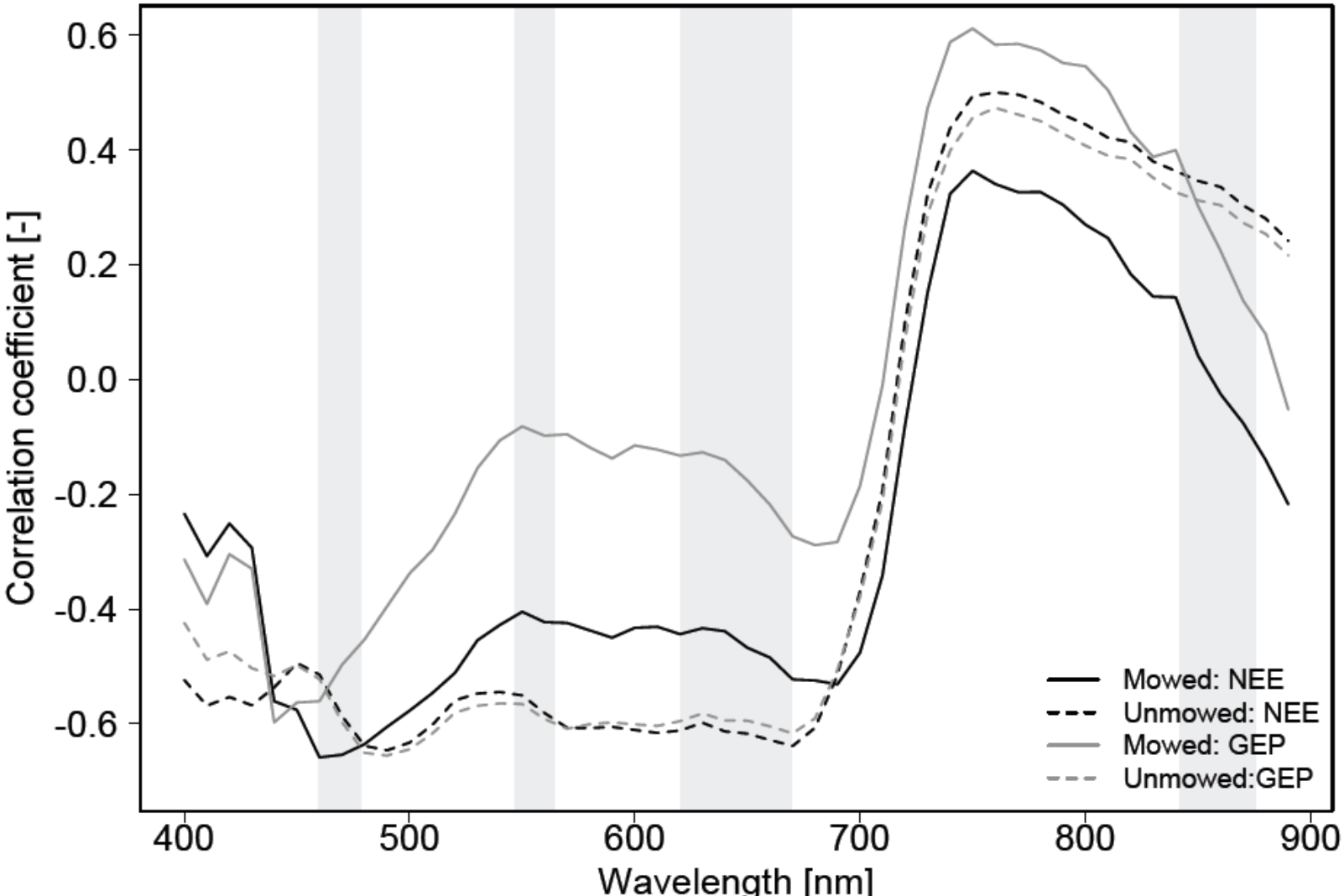
2009

Pre-Q_{10} (95% CI) = 3.36 (1.98, 3.78)

Post-Q_{10} (95% CI) = 1.32 (0.87, 2.00)

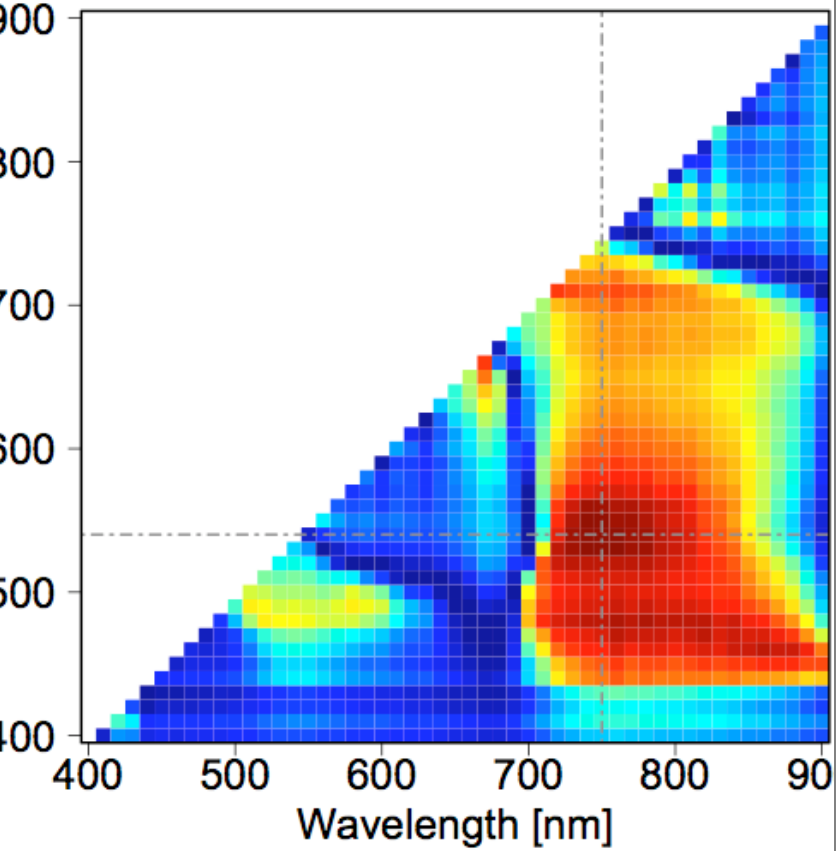


Can the combined effects of pepperweed flowering and mowing on NEE potentially be tracked using remote sensing techniques of lower spectral resolution?

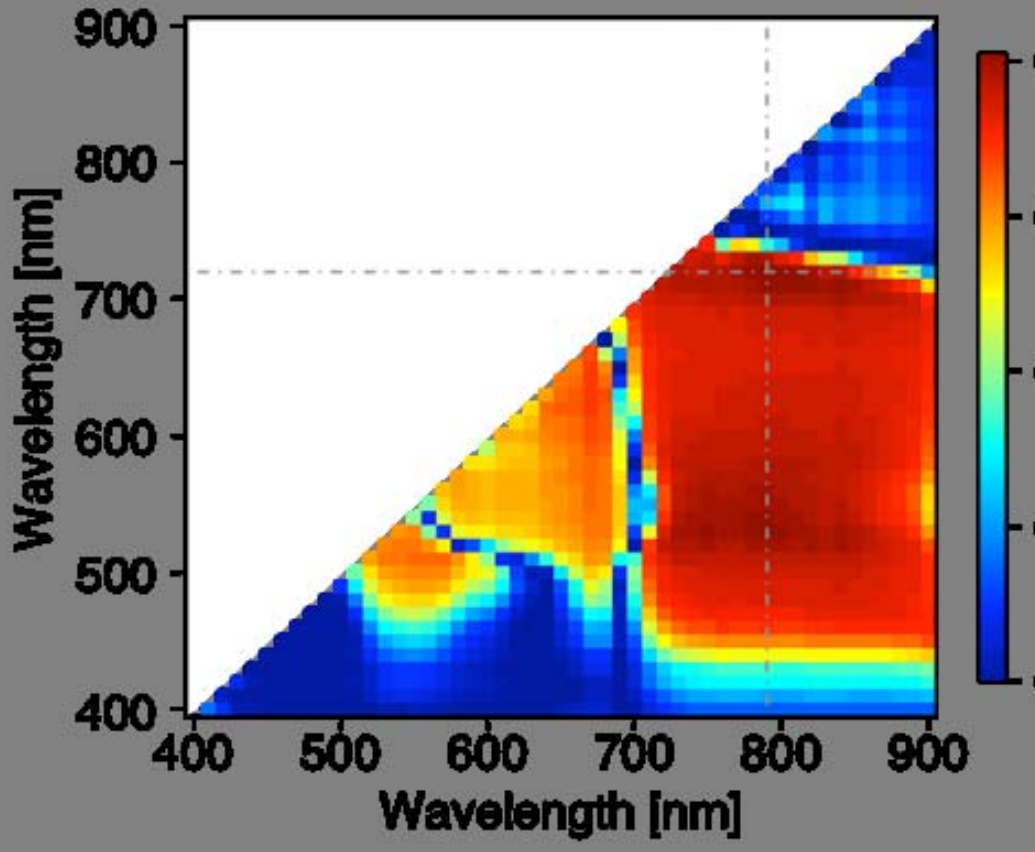


What are the relevant spectral regions? Are these spectral regions similar for uninfested grasslands such as Va

Sherman Island: GEP



Vaira: GEP



$$NDSI = \frac{x \quad y}{\lambda_x + \lambda_y}$$

- Year-round grazing appears to allow for earlier pepperweed germination by preventing the the accumulation of litter and dead stalks.
- Due to the timely-bounded spectral uniqueness of pepperweed during flowering, key phenological events can be identified from the limited information of digital camera imagery.
- Pepperweed flowering appears to decrease photosynthetic CO_2 uptake, mostly likely because of light limitation due to shading.
- Pepperweed flowering appears do decrease R_{eco} perhaps due to the reduced contribution of autotrophic respiration? Various R_{eco} components are difficult to quantify due the site's complex land use/ drainage history.
- Mowing appears to increase the site's CO_2 sink strength mostly due to increased photosynthetic CO_2 uptake but also by counterbalancing the effect of flowering on R_{eco}.
- The combined effects of pepperweed flowering and management on net productivity can most likely be tracked by coarse spectral resolution imagery combing NIR and blue information.

My collaborators at UC Berkeley

Dennis Baldocchi (ESPM)

Maggi Kelly (ESPM)

Matteo Detto (ESPM)

Ben Runkle (CEE)

Youngryel Ryu (ESPM)

Jaclyn Hatala (ESPM)