

Carbon cycling in dry grasslands: Regulation of biotic and abiotic litter decomposition



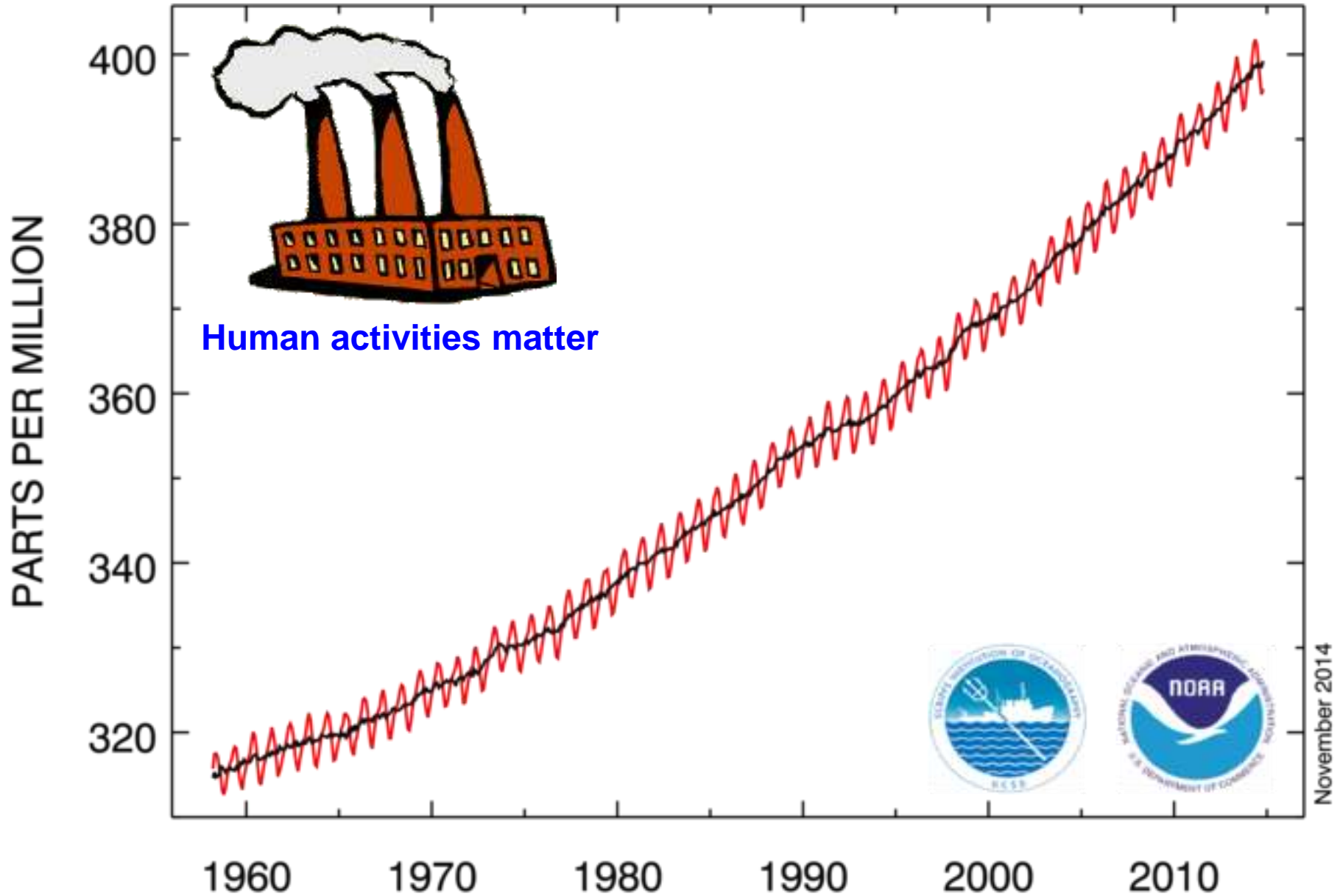
Heather Throop
heather.throop@asu.edu



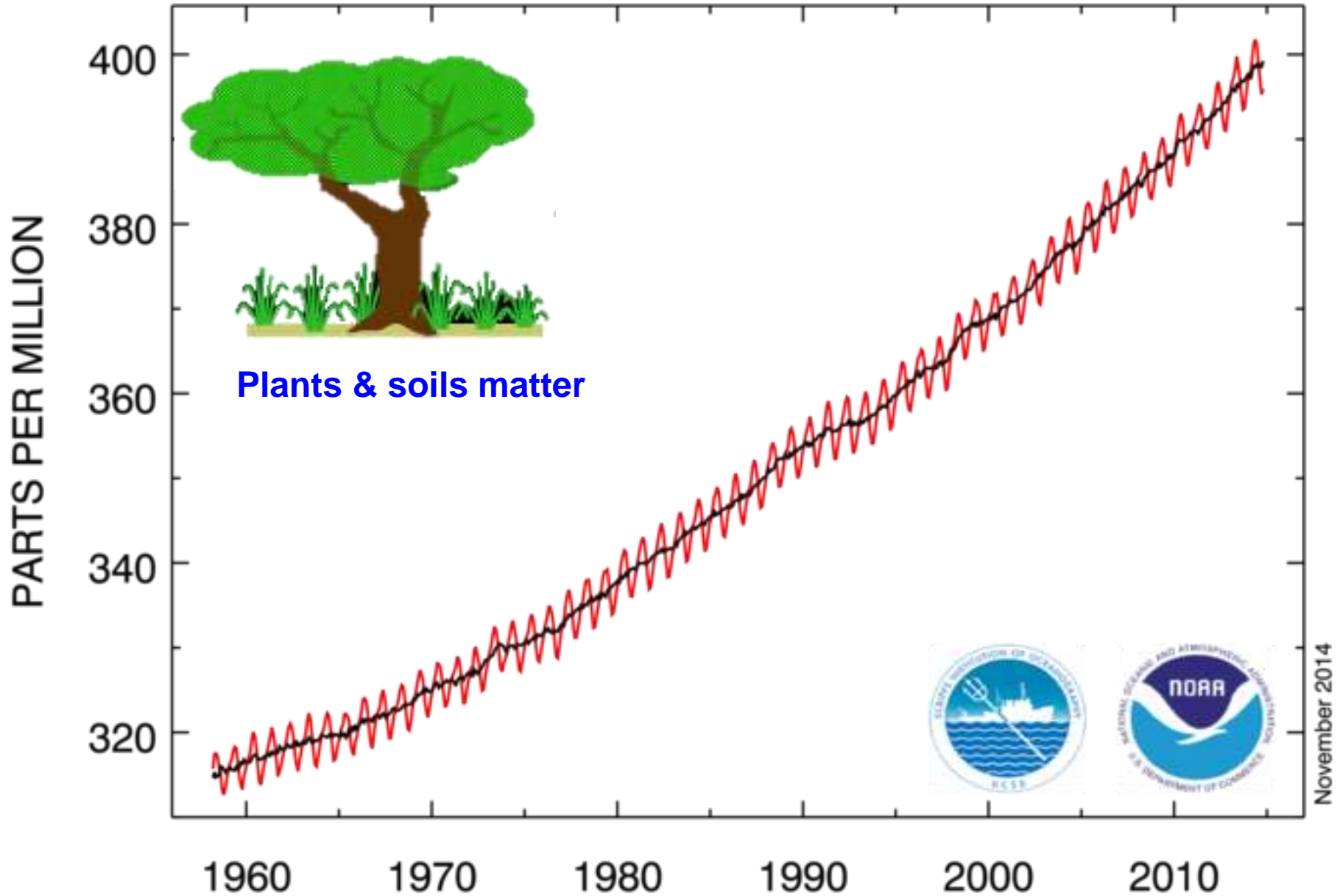
With thanks to: Steve Archer, Paul Barnes, Rebecca McCulley, Hanna Lee, Daniel Hewins, Kelsey Kurupas, Maria Bravo-Garza

Funding: US National Science Foundation

Atmospheric CO₂ Concentration



Atmospheric CO₂ Concentration



November 2014

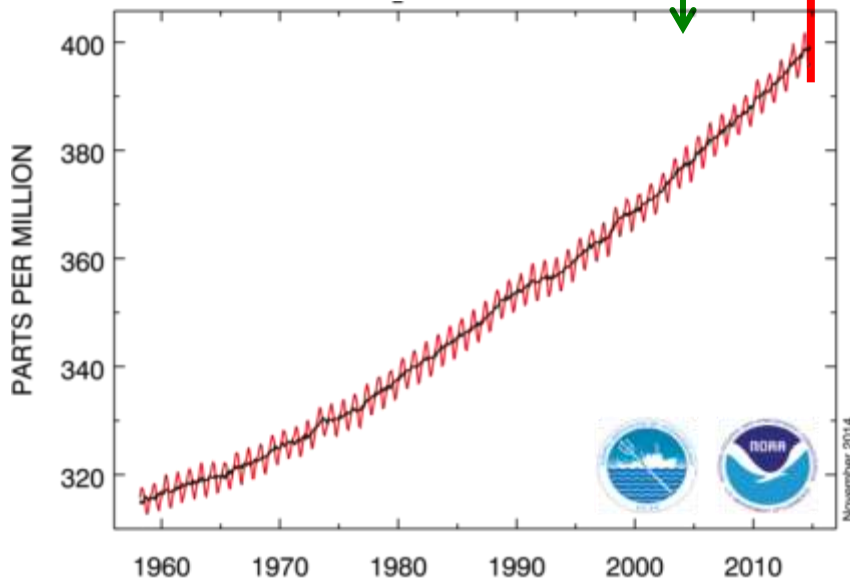
We're lucky.

~530 ppm
Where we could be

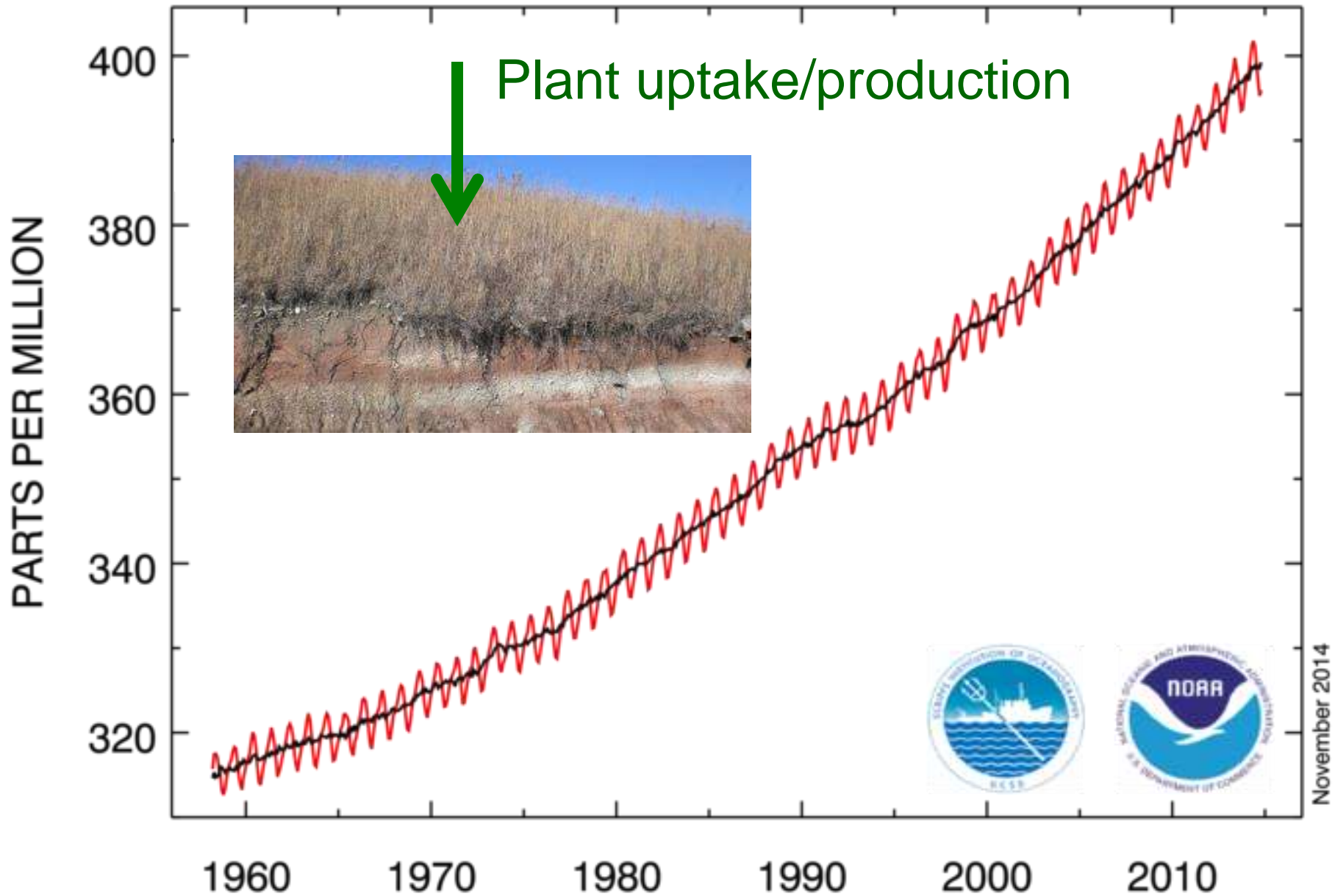
~465 ppm
With ocean sink
→ ocean acidification

2015: ~400 ppm
With ocean & terrestrial sinks
→ plant biomass & soils
(bush encroachment?)

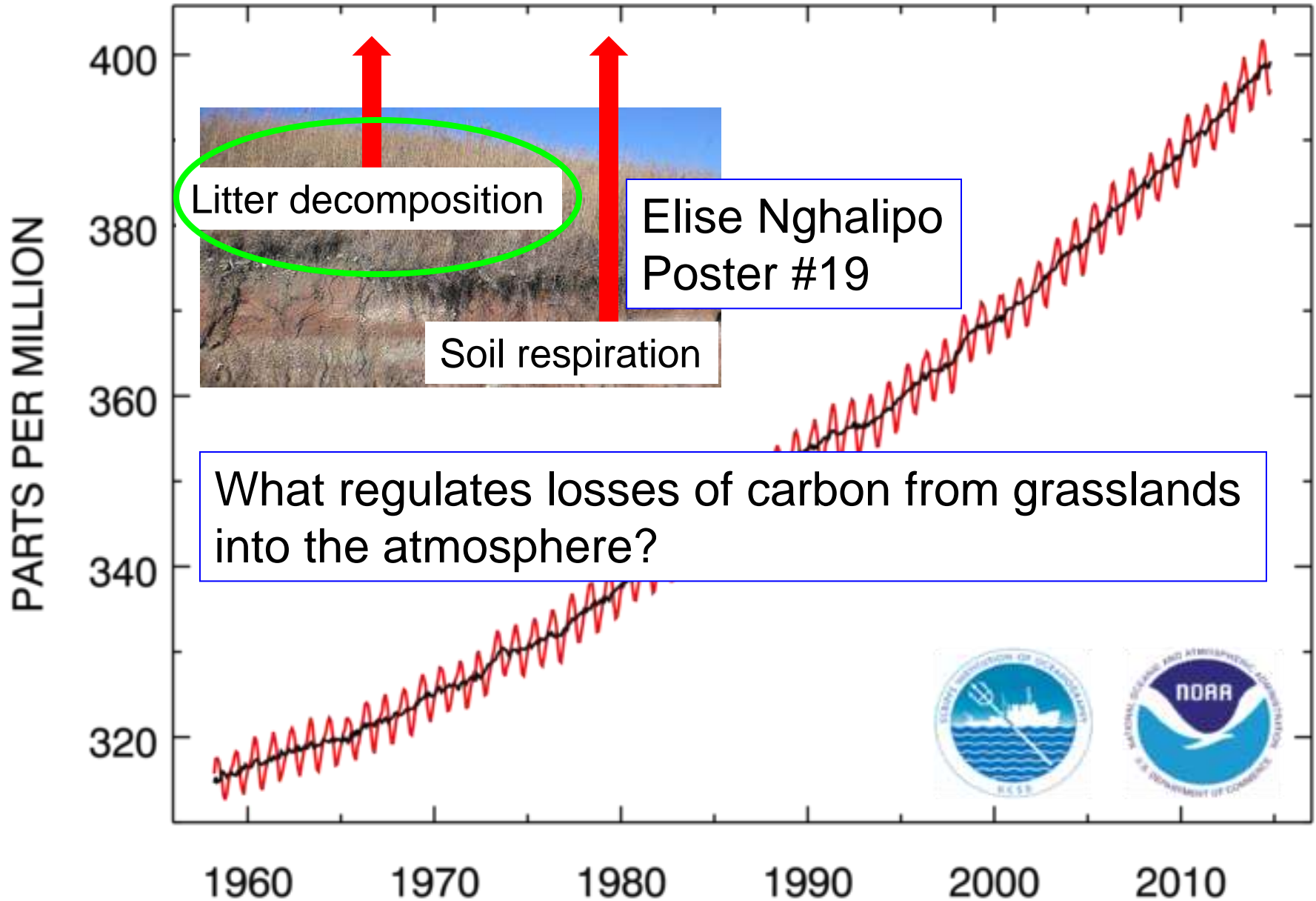
Pre-industrial: 270 ppm



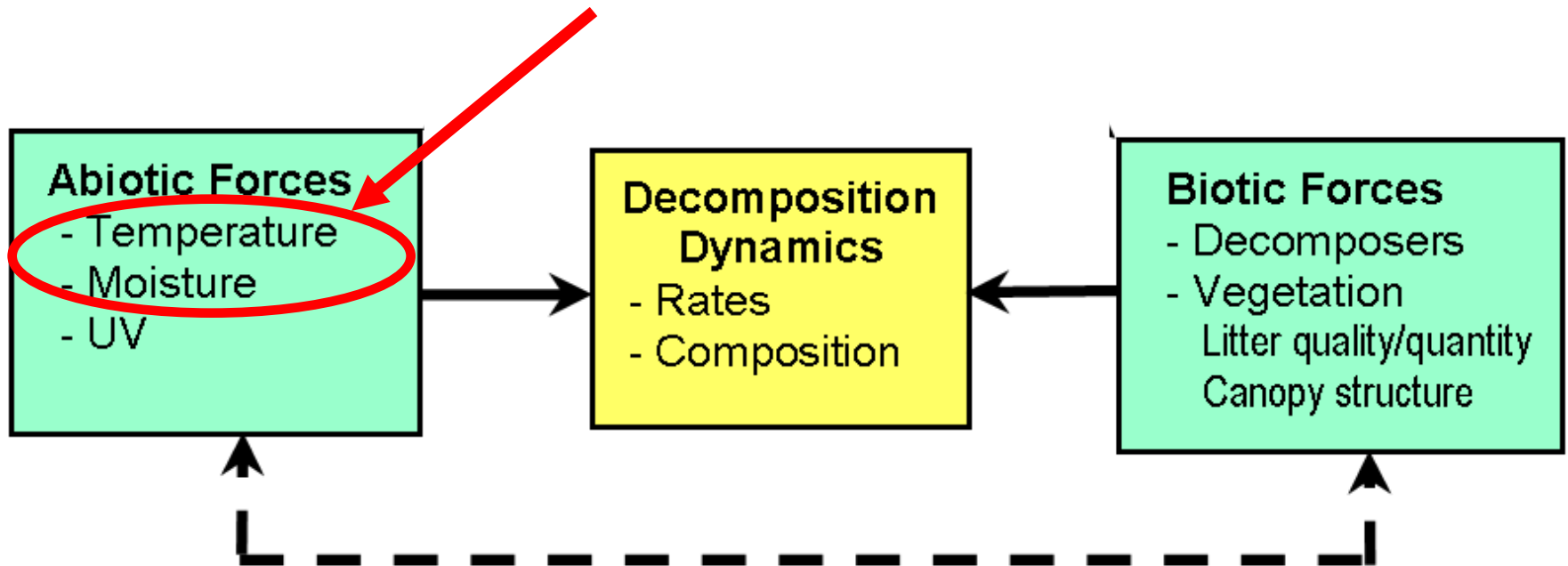
Atmospheric CO₂ Concentration



Atmospheric CO₂ Concentration

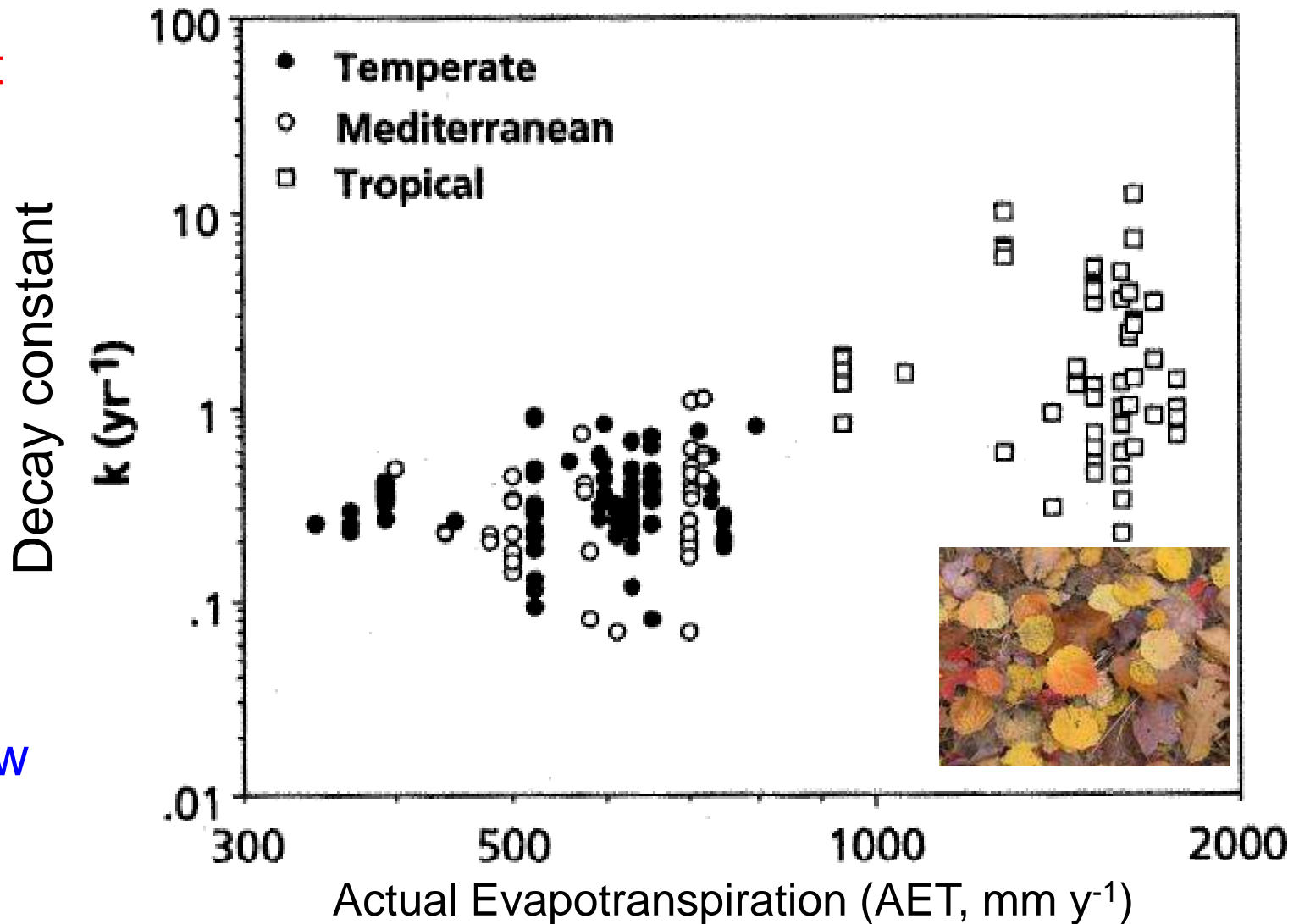


Broad scale drivers



Models based on climate usually predict decomposition successfully

Fast



Slow

Aerts 1997 *Oikos*

Models underestimate decomposition in dry grasslands

Ecology, 62(1), 1981, pp. 275–277

© 1981 by the Ecological Society of America

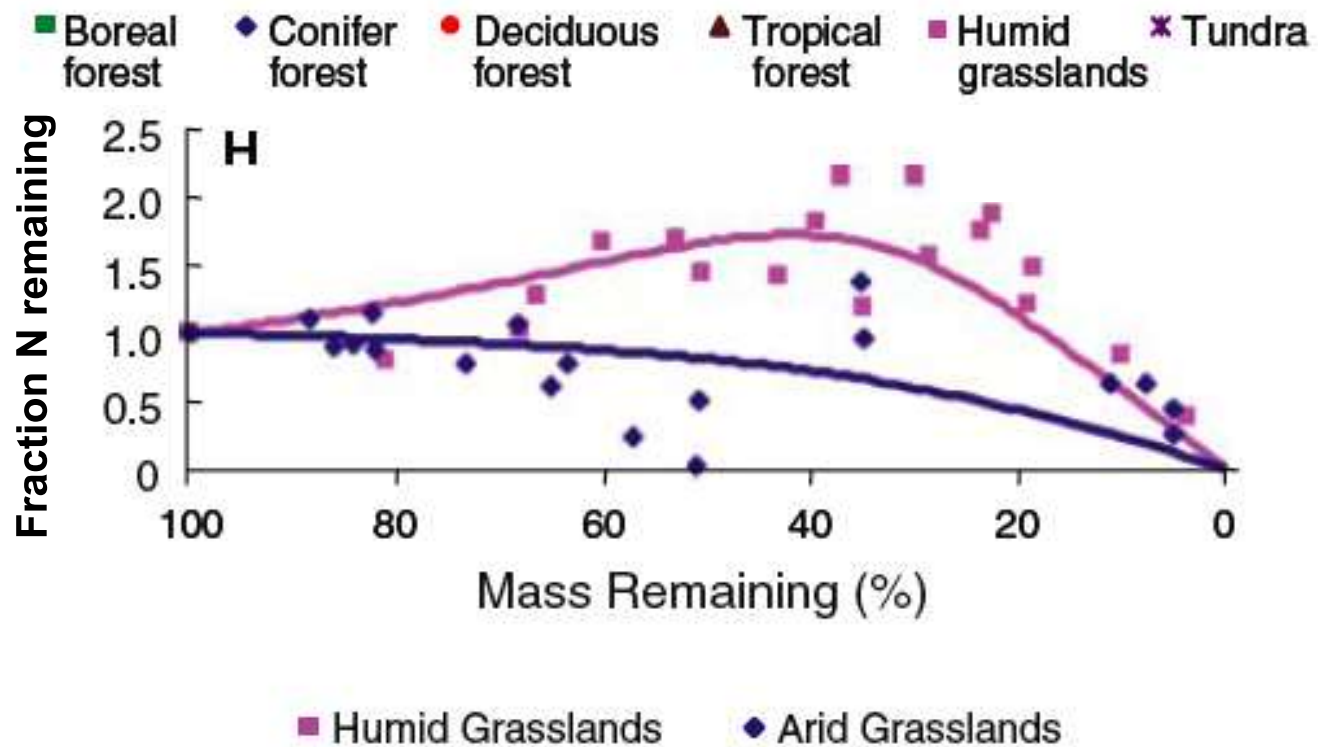
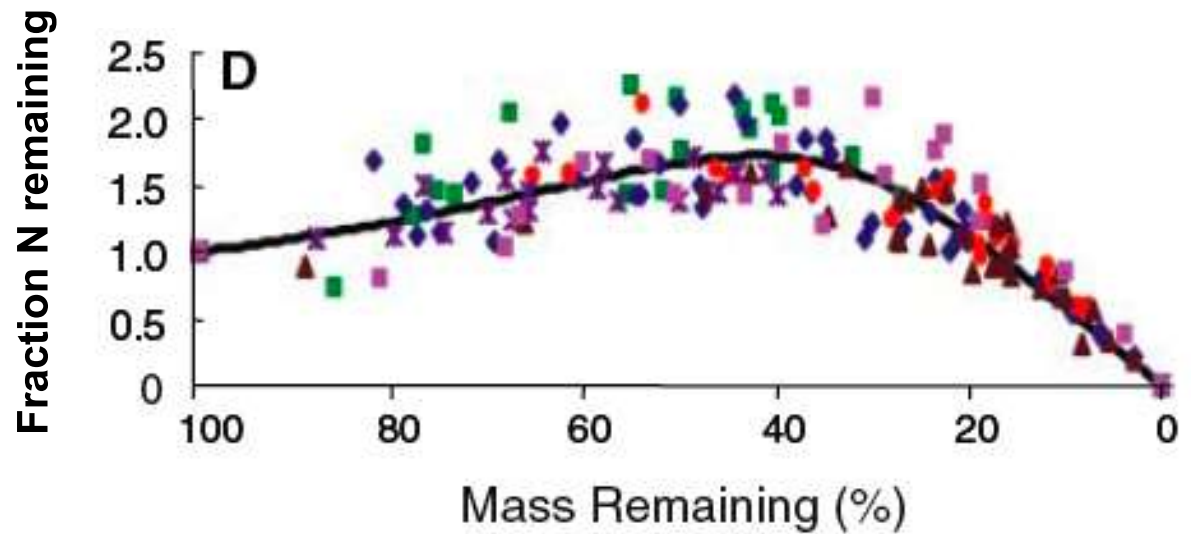
EXCEPTIONS TO THE AET MODEL: DESERTS AND CLEAR-CUT FOREST¹

W. G. Whitford², V. Meentemeyer³, T. R. Seastedt⁴, K. Cromack, Jr.⁵, D. A. Crossley, Jr.⁴, P. Santos^{2,7}, R. L. Todd⁴, and J. B. Waide⁶

Dry
grasslands
are a
consistent
outlier

WHY??

Parton *et al.* 2007
Science



Dry grasslands characterized by spatial heterogeneity in vegetation structure



Bush encroachment increases spatial heterogeneity



Rob Wu, Santa Rita Experimental Range
Sonoran Desert, Arizona

How does vegetation structure affect biotic & abiotic decomposition?

Bare ground



Grass



Intact shrub



mesh litterbags



“Old” stump
1935



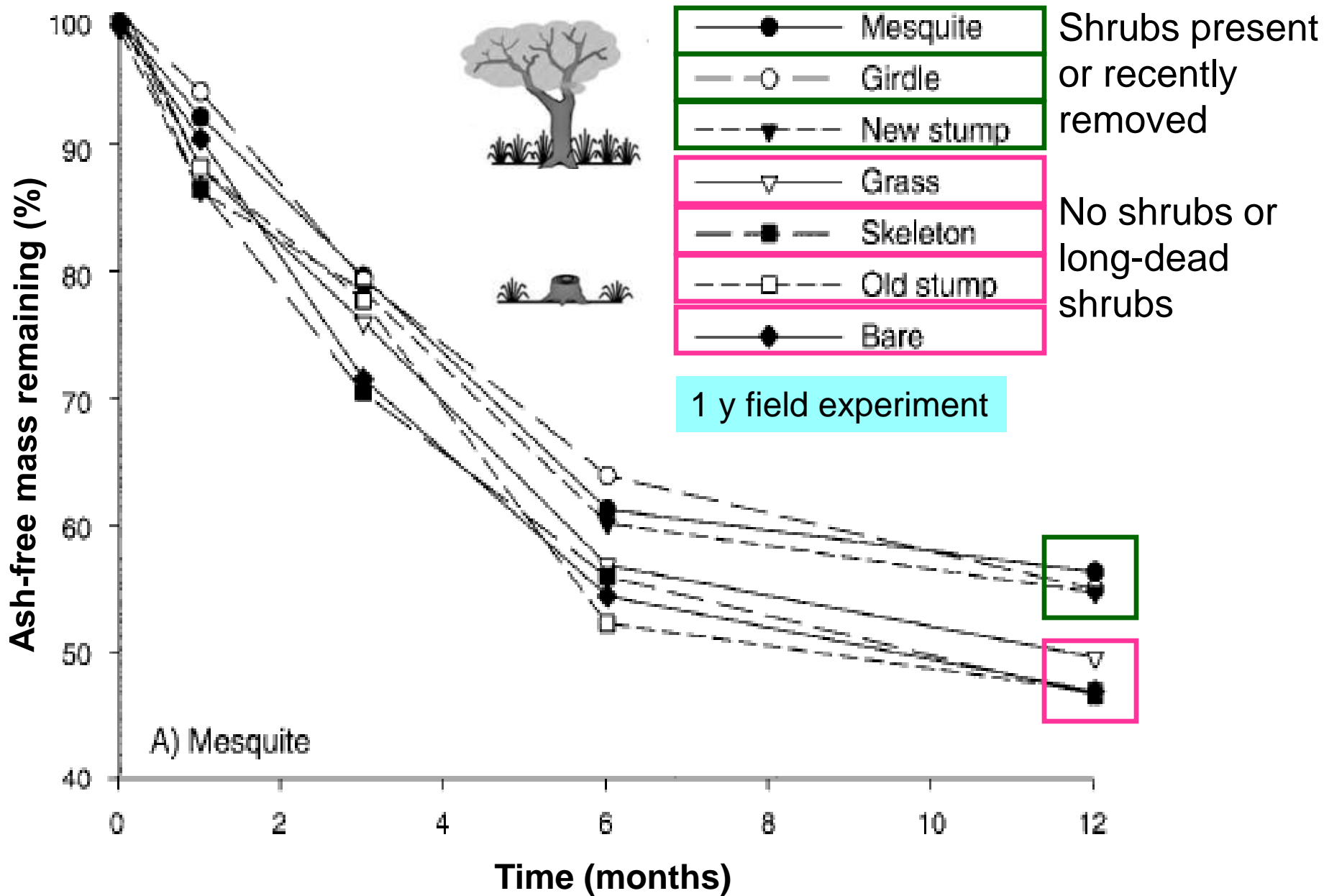
Skeleton
1960



Girdled
2004

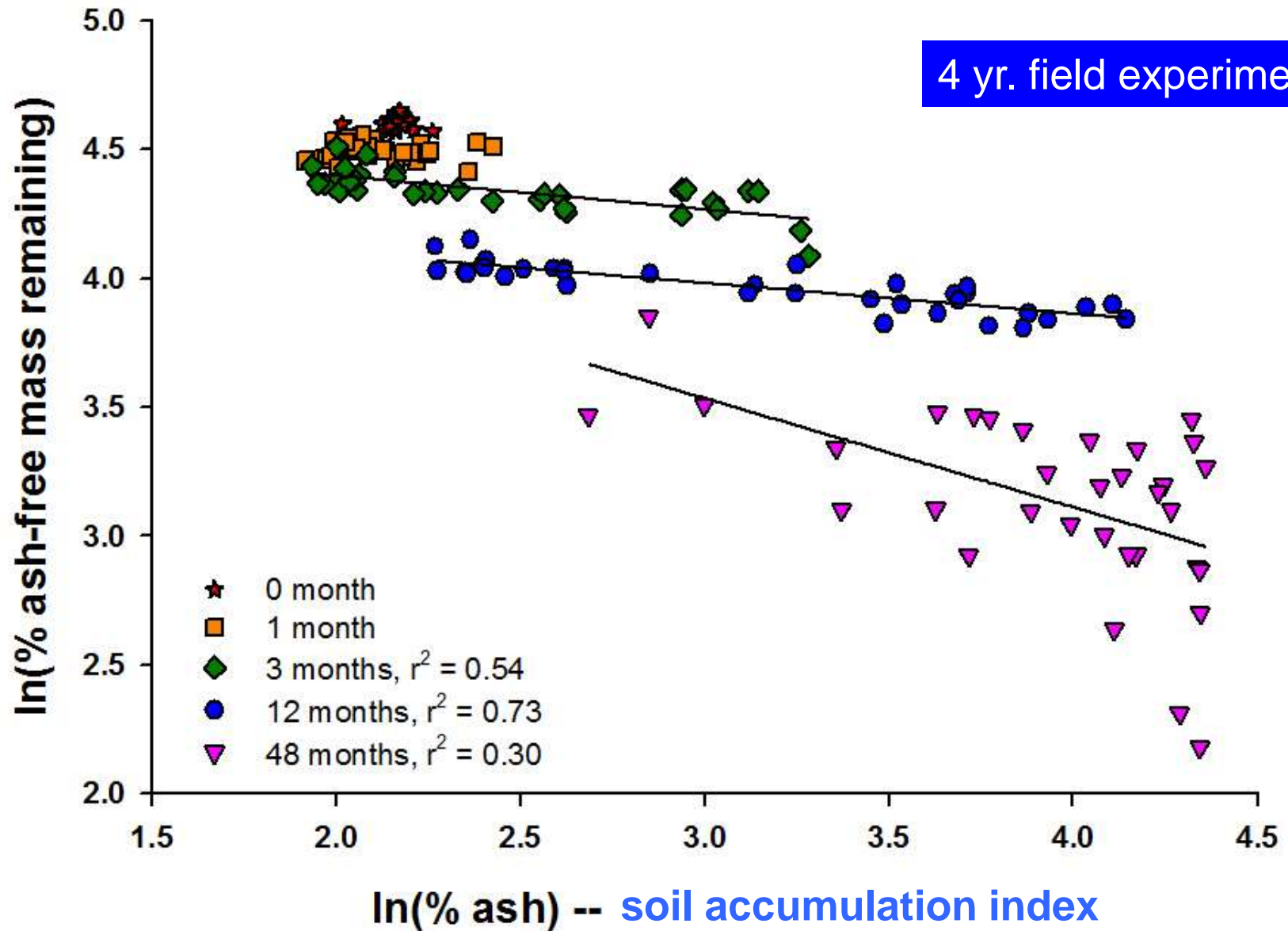


“New” stump
2004

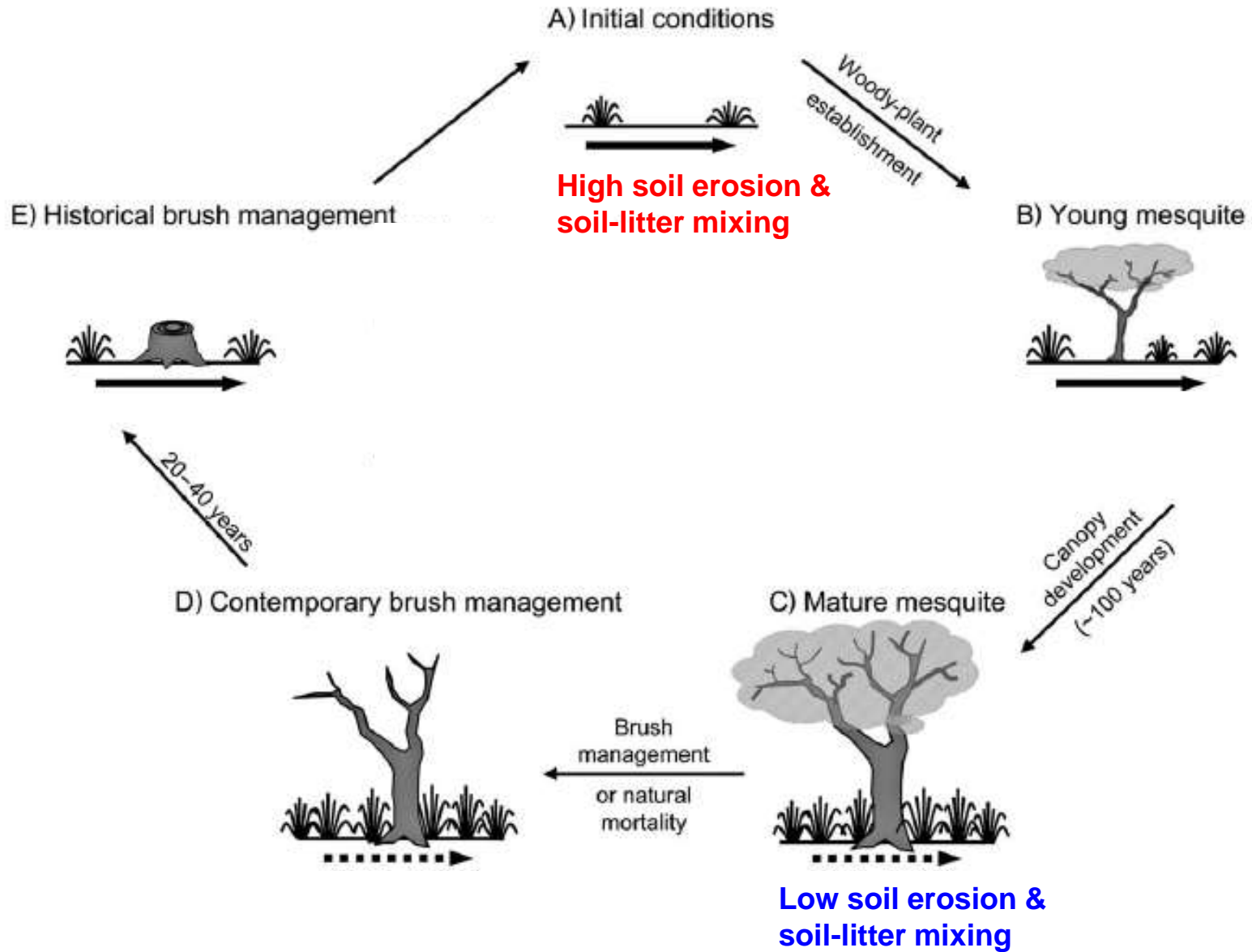


Decomposition strongly related to soil-litter mixing

4 yr. field experiment



Vegetation structure mediates decomposition via soil erosion



Why does soil-litter mixing enhance decomposition?

➤ microbial colonization?

✓ PLFA, lab incubations

➤ microclimate buffering?

✓✓✓ PLFA, lab incubations + field experiments

➤ abrasion?

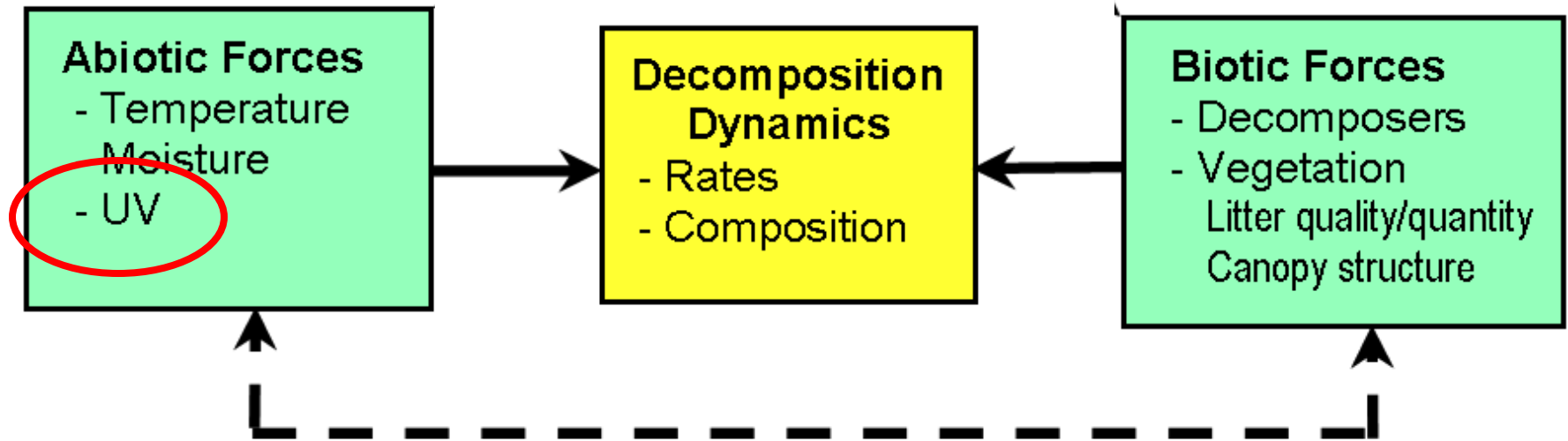
✓ lab incubations – *transient influence*



Lee *et al.* 2014, Hewins *et al.* 2013, Bravo-Garza *et al.* in prep, Kurupas & Throop in prep



UV Photodegradation can be Important for Decomposition



Vol 442|3 August 2006|doi:10.1038/nature05038

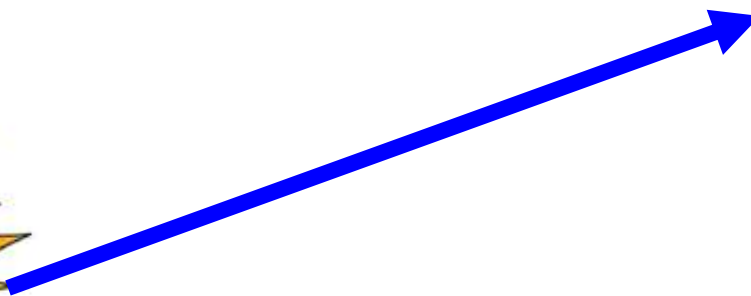
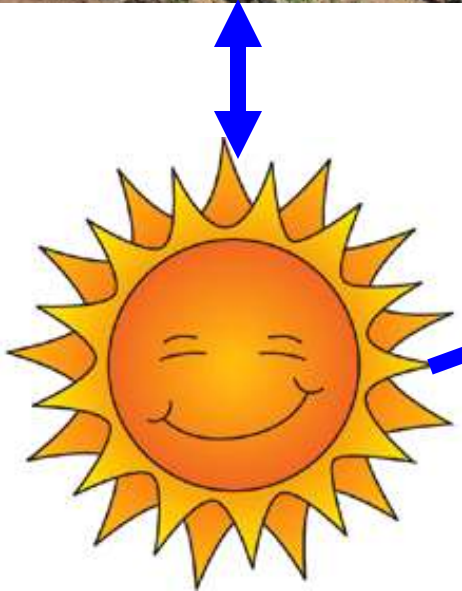
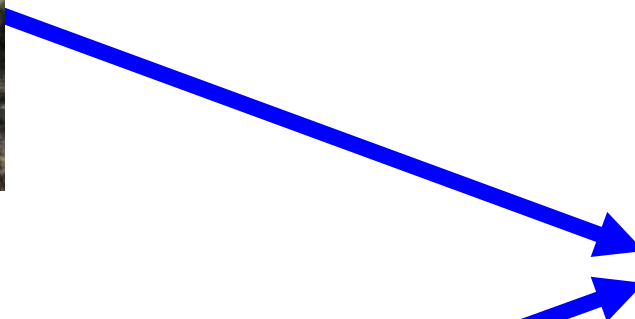
nature

LETTERS

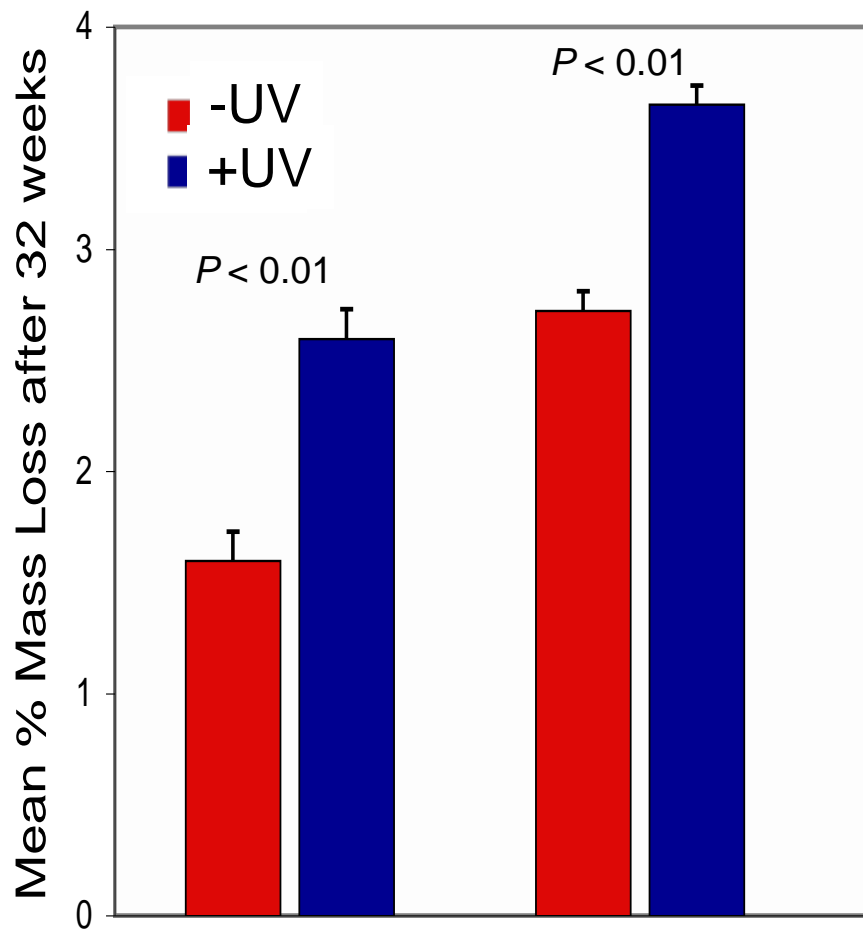
Plant litter decomposition in a semi-arid ecosystem controlled by photodegradation

Amy T. Austin¹ & Lucia Vivanco¹

How do soil movement and UV interact to affect decomposition?



Controlled environment study:
UV exposure enhances mass loss



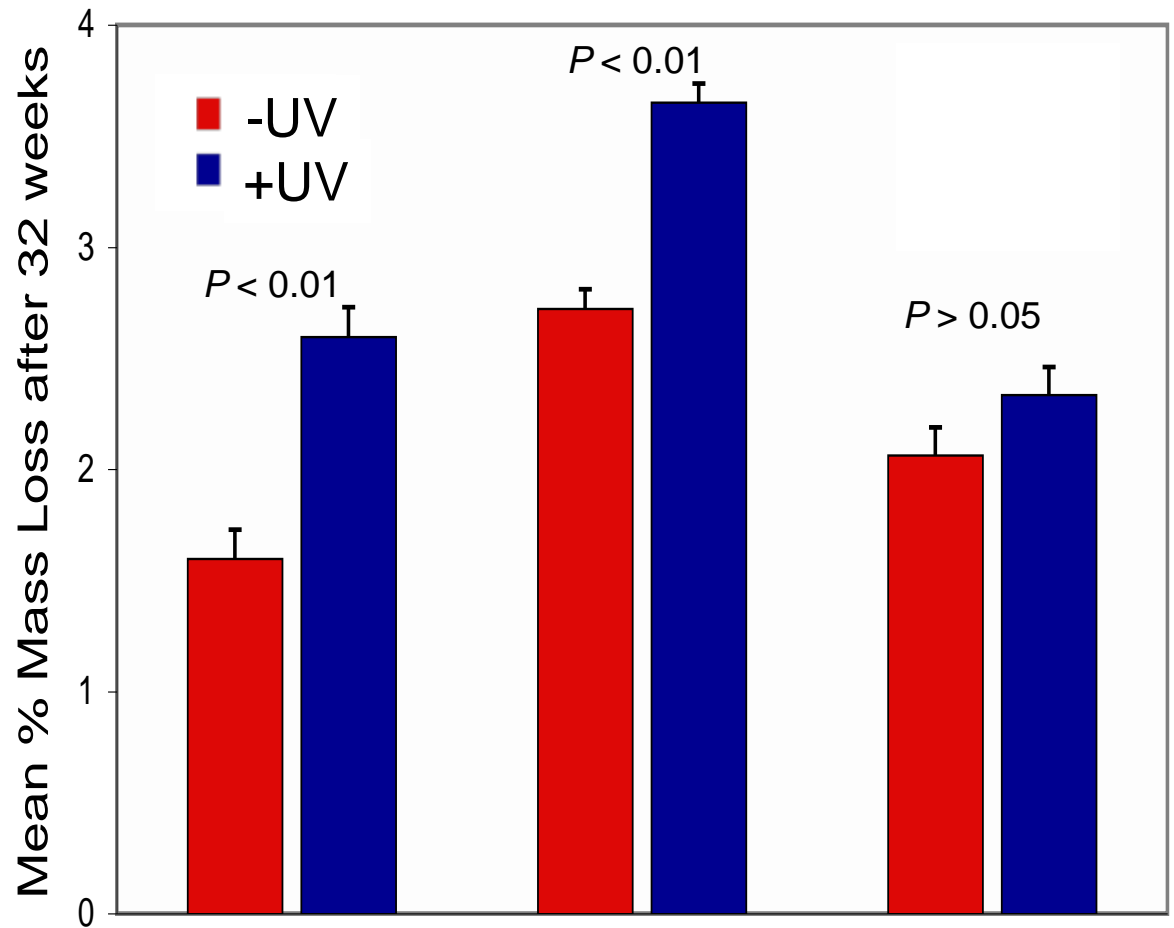
No Soil

Moderate Soil



Barnes *et al.* 2012 *Ecosystems*

Heavy soil cover
mediates UV effect



No Soil

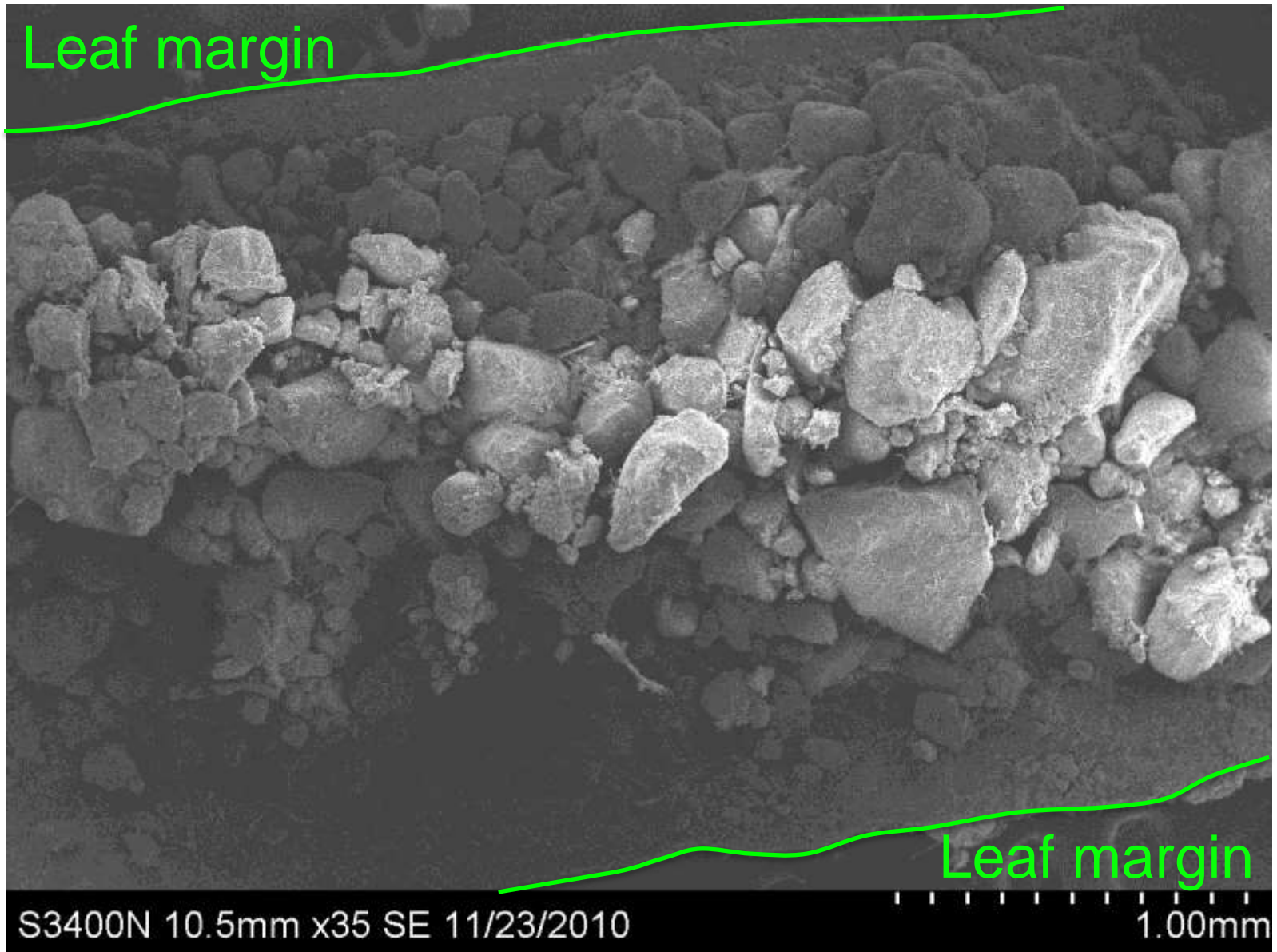
Moderate Soil

Heavy Soil



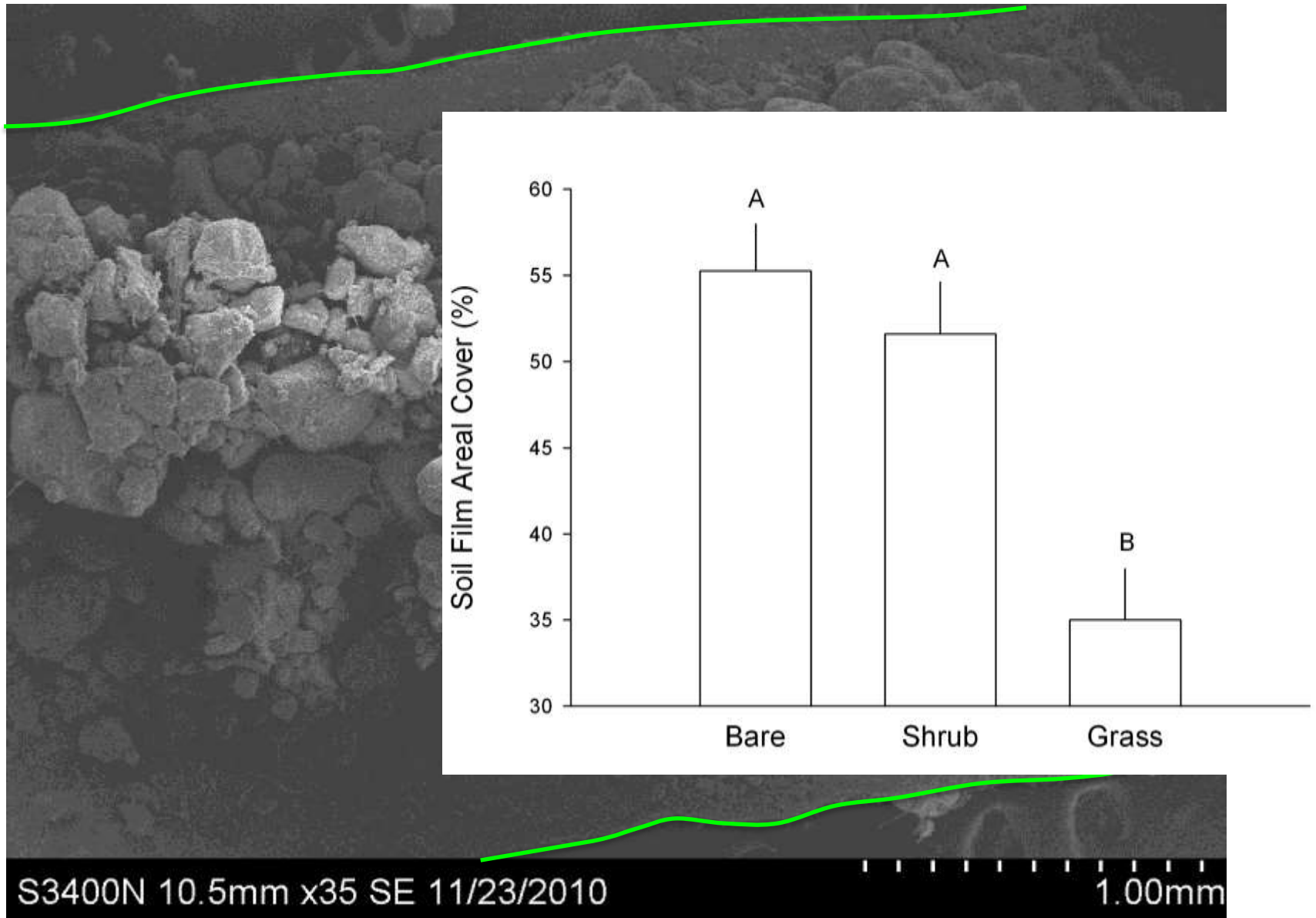
Barnes *et al.* 2012
Ecosystems

Tightly adhering soil-microbial films develop on decomposing litter



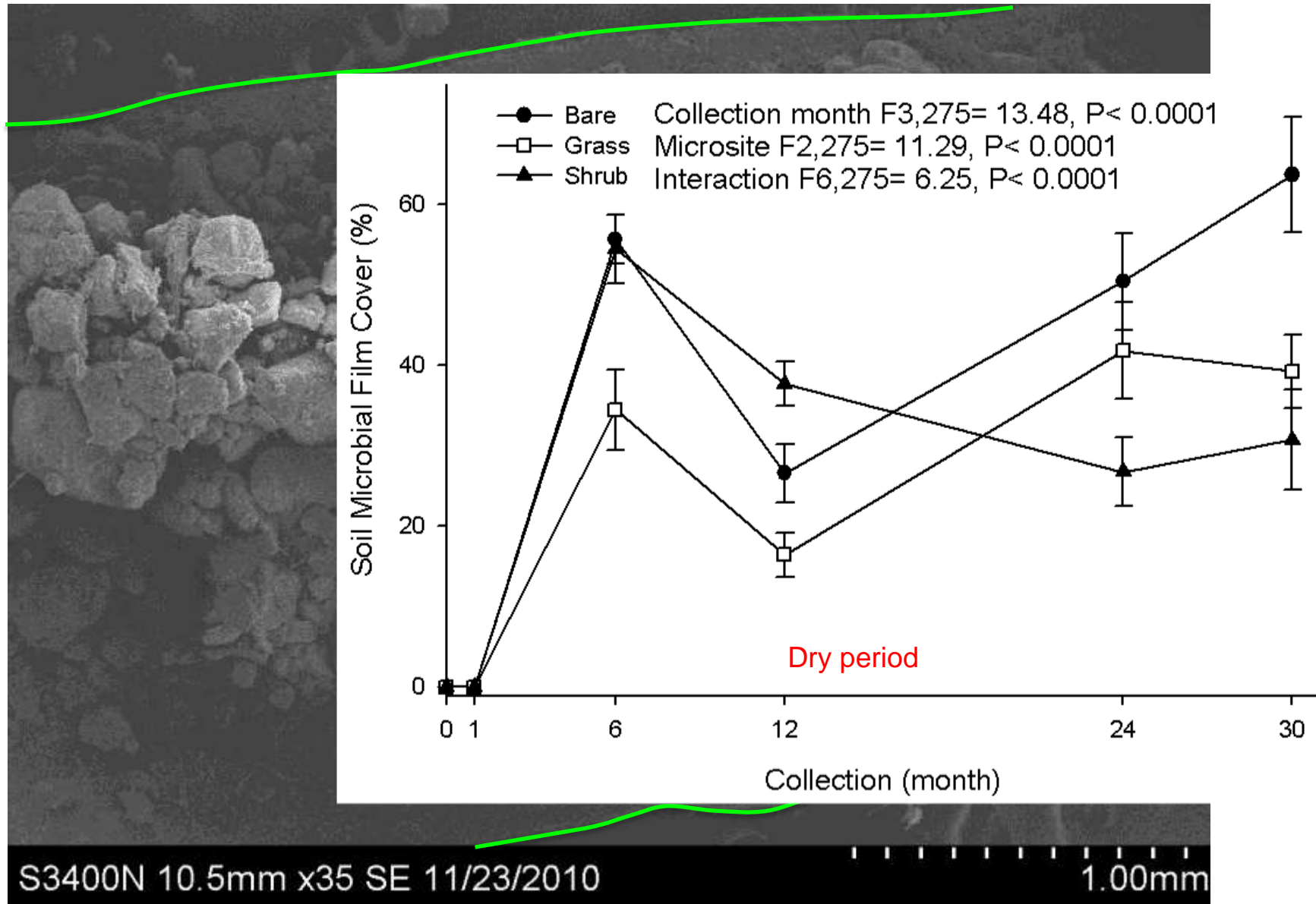
Barnes *et al.* 2012 *Ecosystems*

Soil film cover reflects vegetation & erosional environment

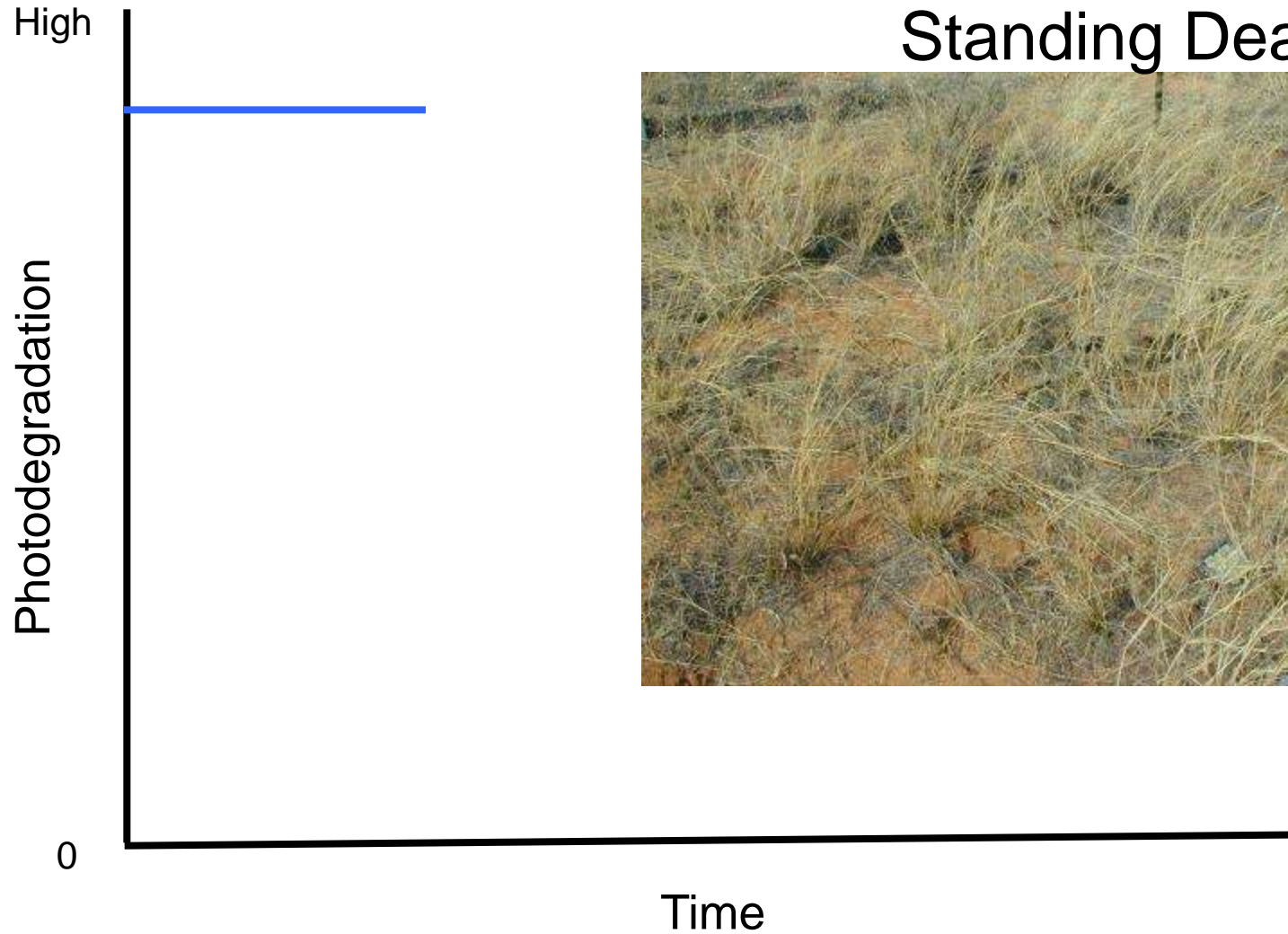


Barnes *et al.* 2012 *Ecosystems*

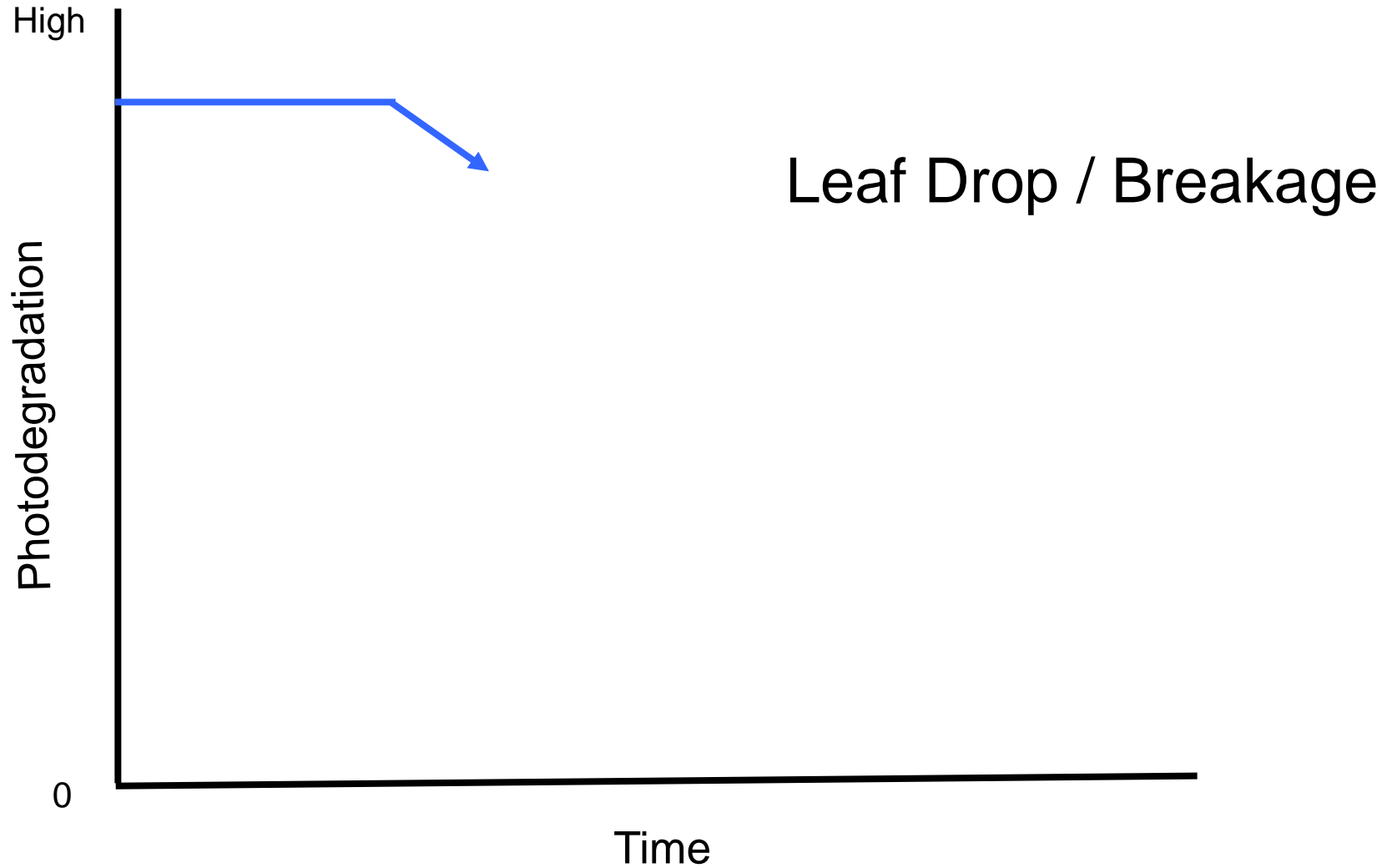
Soil microbial films are temporally dynamic



Photodegradation Dynamics Conceptual Model

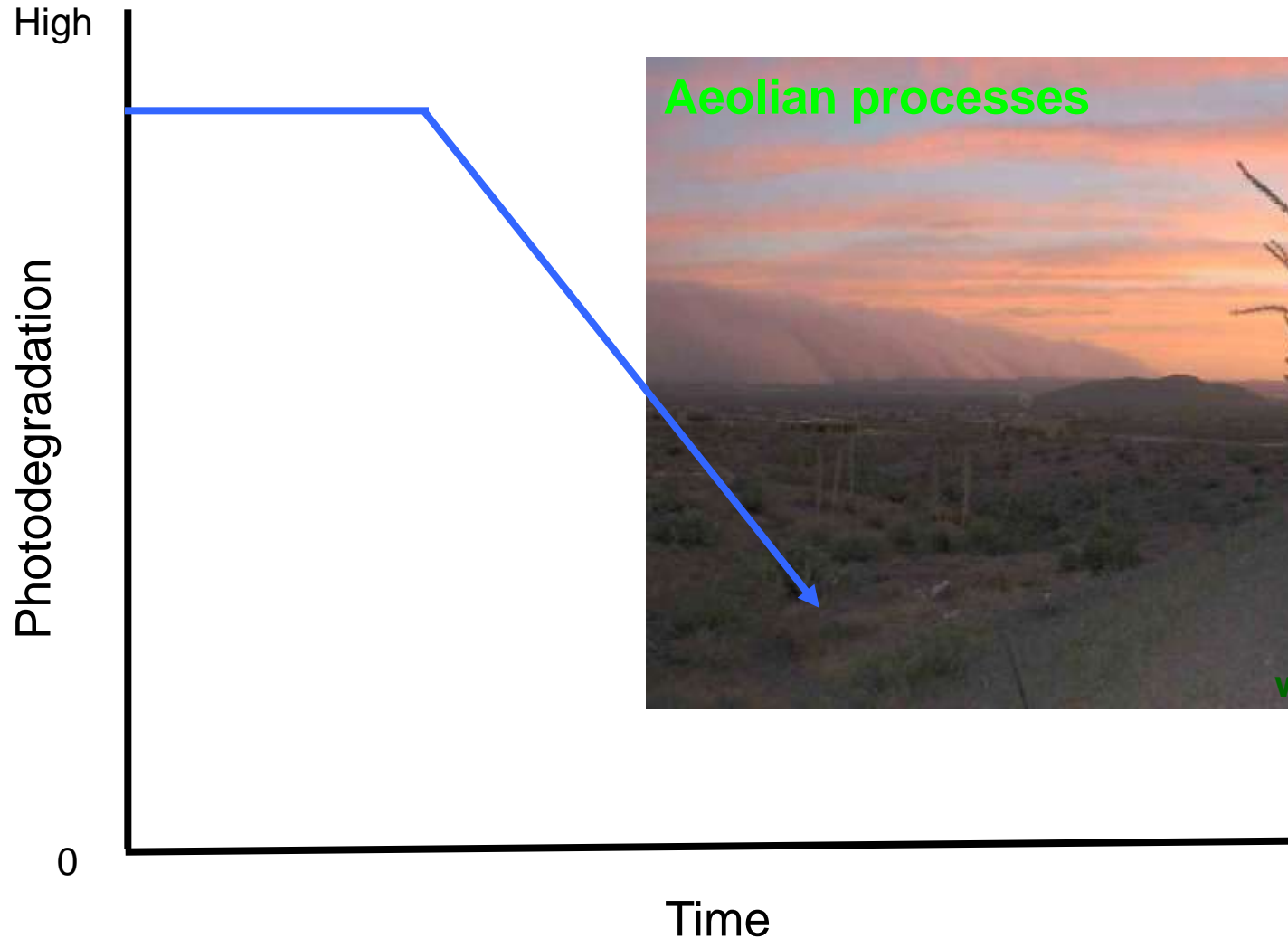


Photodegradation Dynamics Conceptual Model

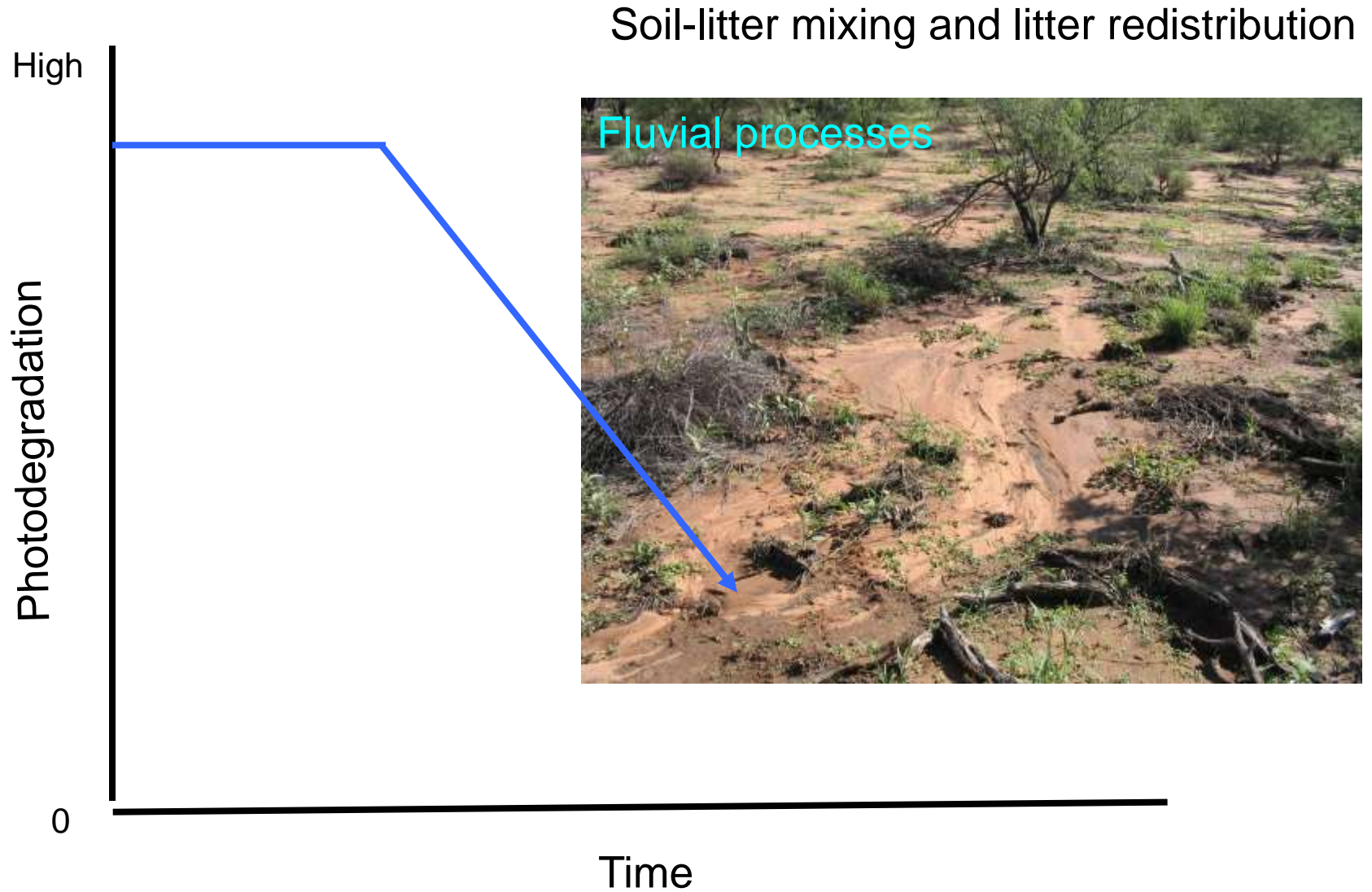


Photodegradation Dynamics Conceptual Model

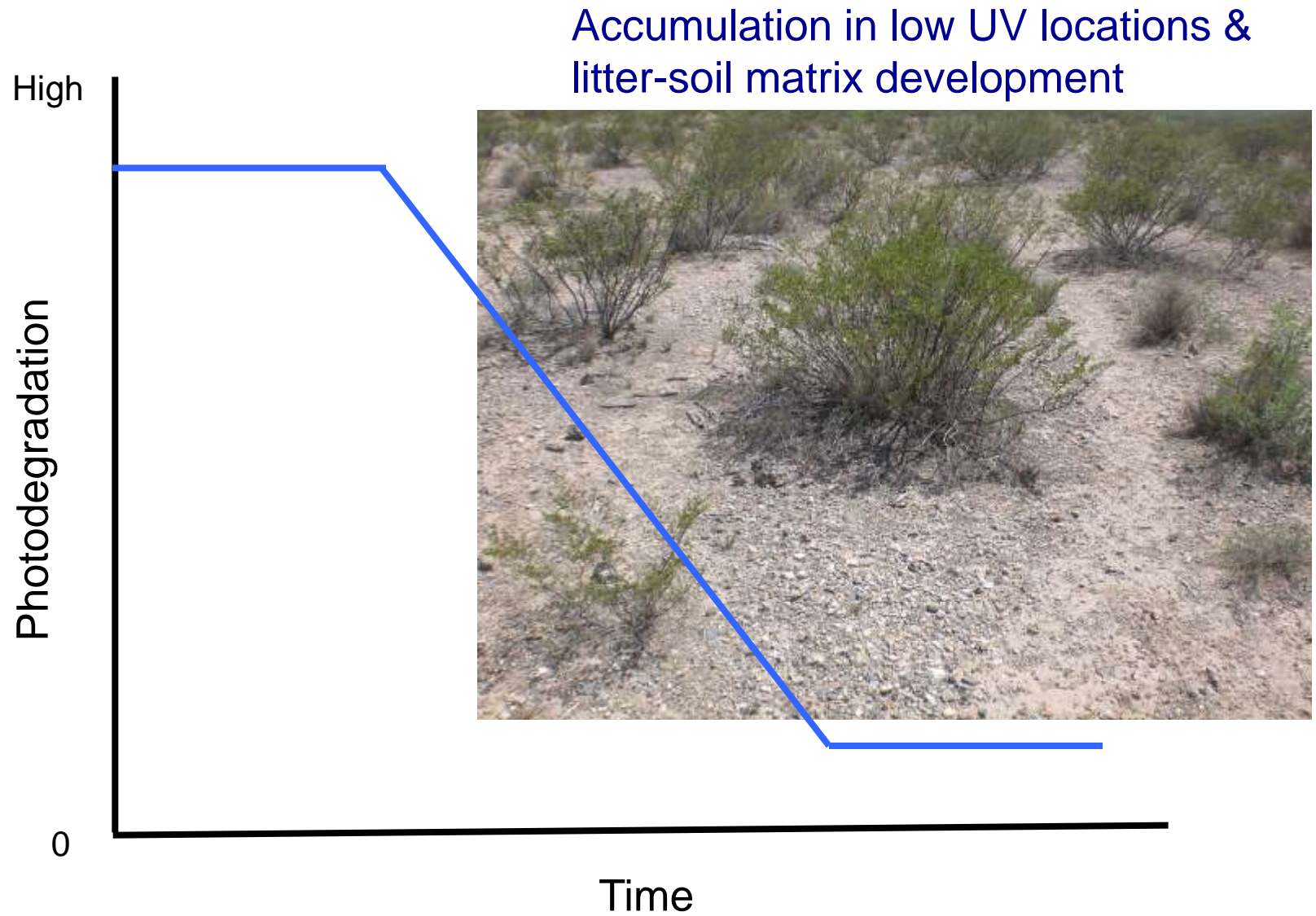
Soil-litter mixing and litter redistribution



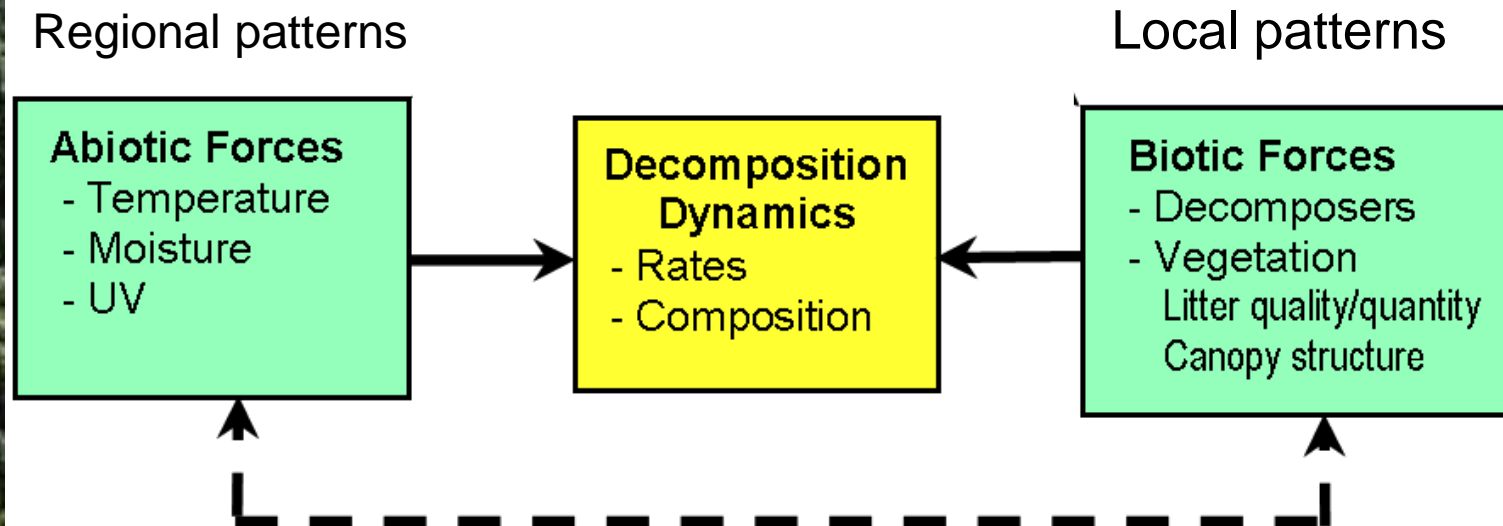
Photodegradation Dynamics Conceptual Model



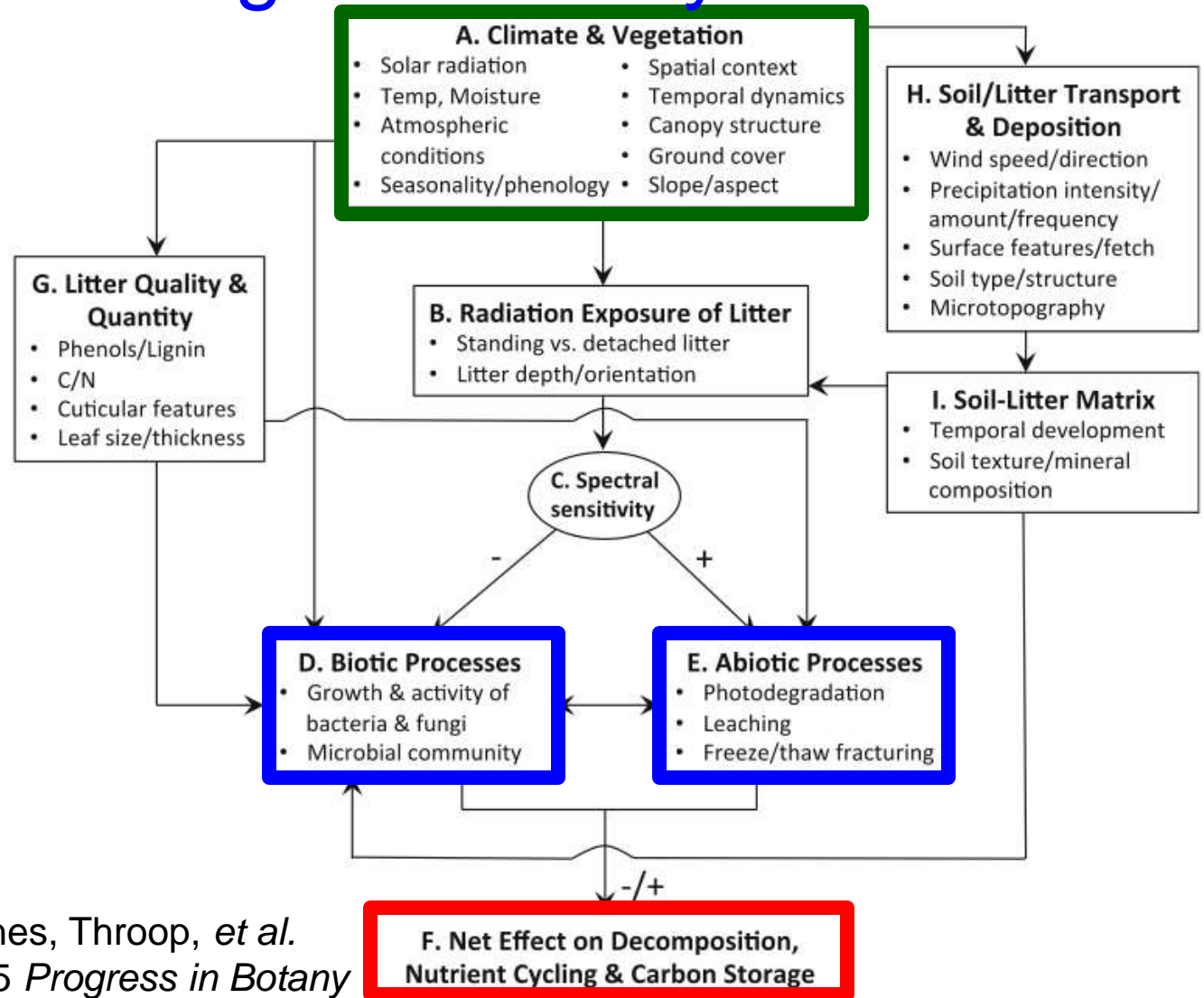
Photodegradation Dynamics Conceptual Model



Simple Models from Mesic Systems...



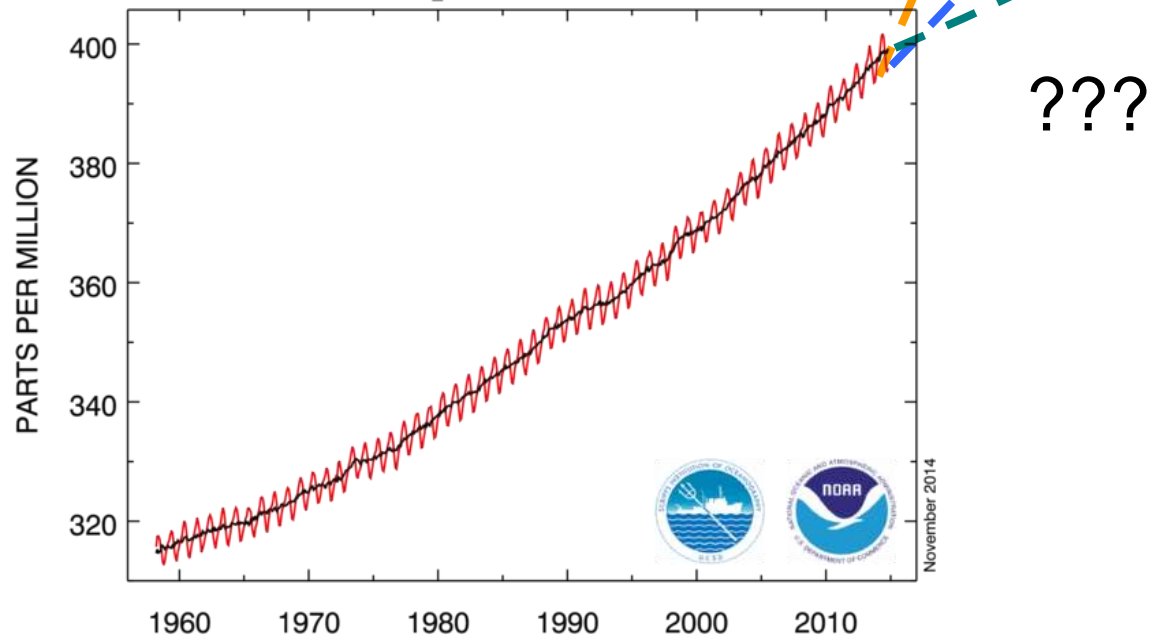
... Need Modification for Heterogeneous Dry Grasslands.



Barnes, Throop, *et al.*
2015 *Progress in Botany*

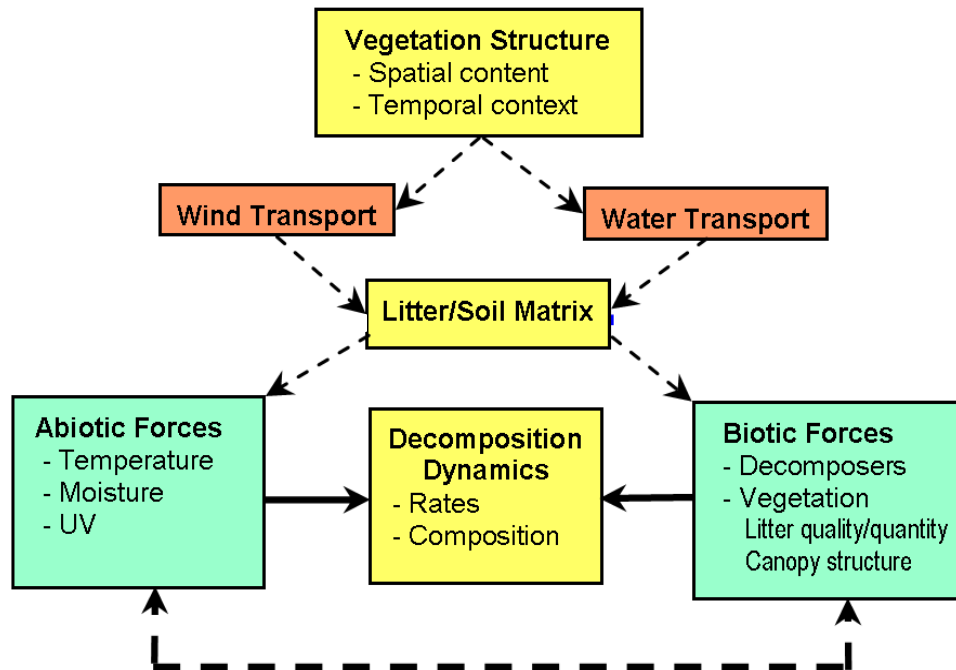
Projecting C Cycling in Dry Grasslands

- Patterns of carbon uptake and release critical for understanding carbon cycling → future atmospheric CO₂
- Soil-litter mixing and soil microbial films
 - accelerate decomposition
 - mediate UV photodegradation
- Simple climate-based models require revision for dry grasslands



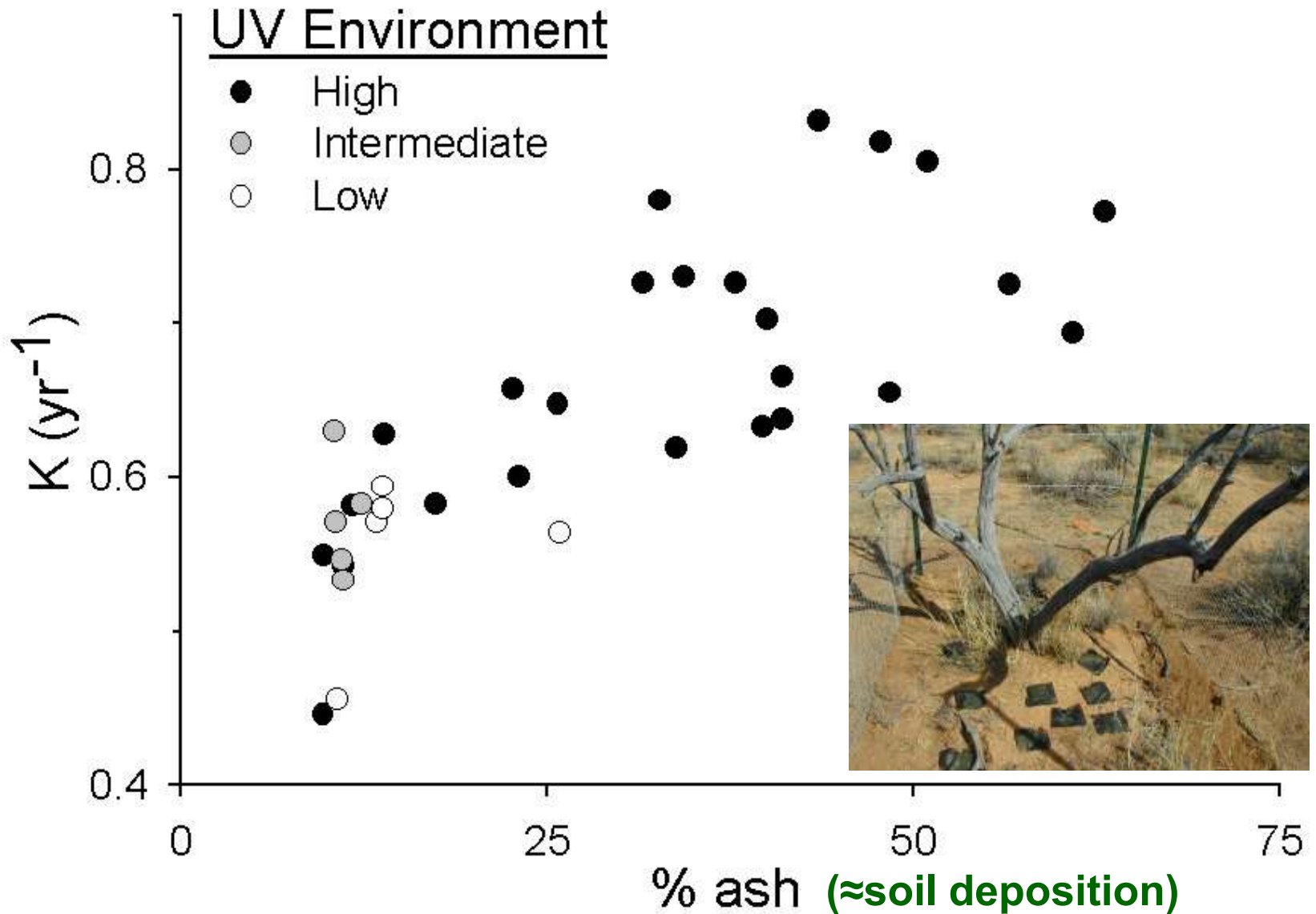
Decomposition in Dry Grasslands

- Does not follow expected patterns based on simple climate models
- Soil-litter mixing and soil microbial films
 - accelerate decomposition
 - mediate UV photodegradation
- Simple models for mesic systems... require modification for heterogeneous dry grasslands.



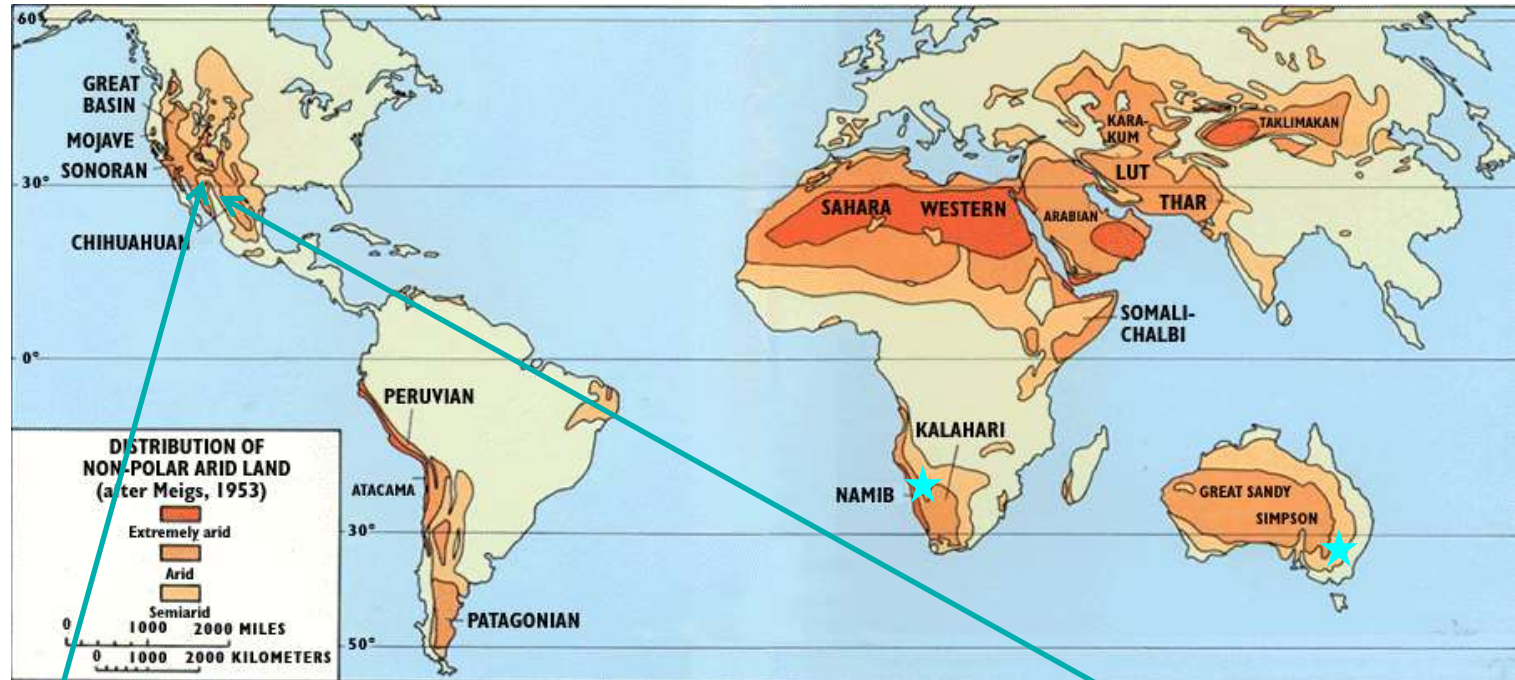
Throop & Archer,
Progress in Botany,
2009 & 2015

Santa Rita Experimental Range



Throop & Archer 2009 *Progress in Botany*

Dry grasslands



Atmospheric CO₂ Concentration

