

Playing in the DIRT:
Soil and litter experiments exploring carbon through space and time

Drylands account for:

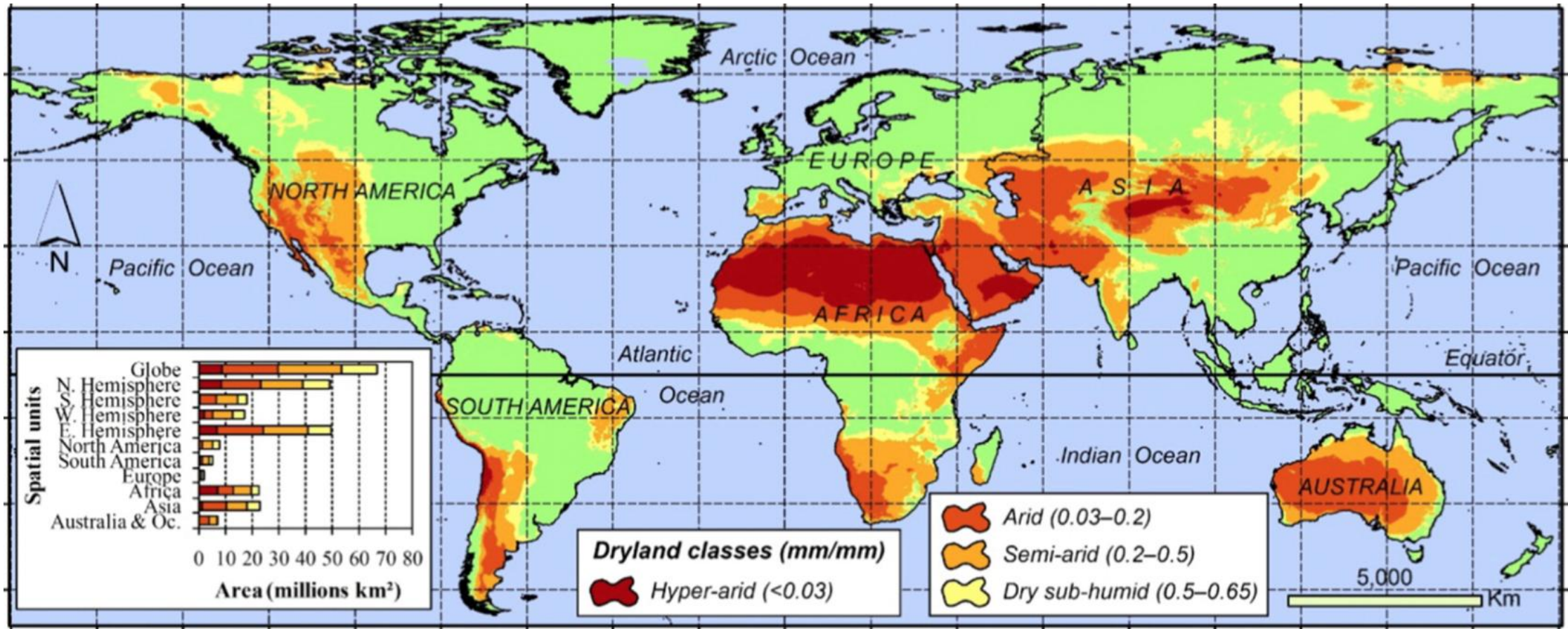
~45% of the Earth's terrestrial surface

35% terrestrial primary production

20% soil carbon (C)

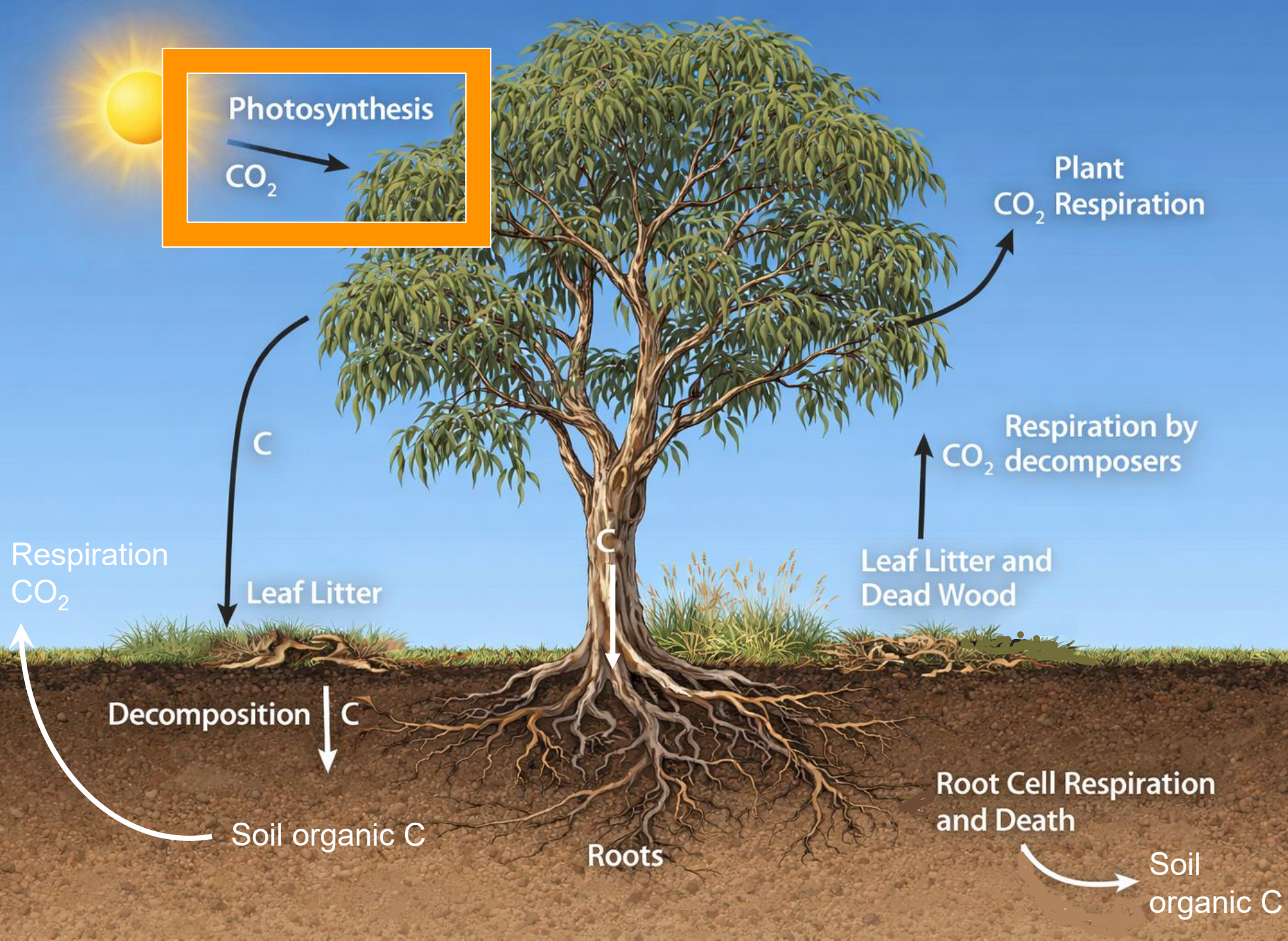
important controls over global C cycling

Controls over biogeochemical processes poorly understood → limited predictive capacity



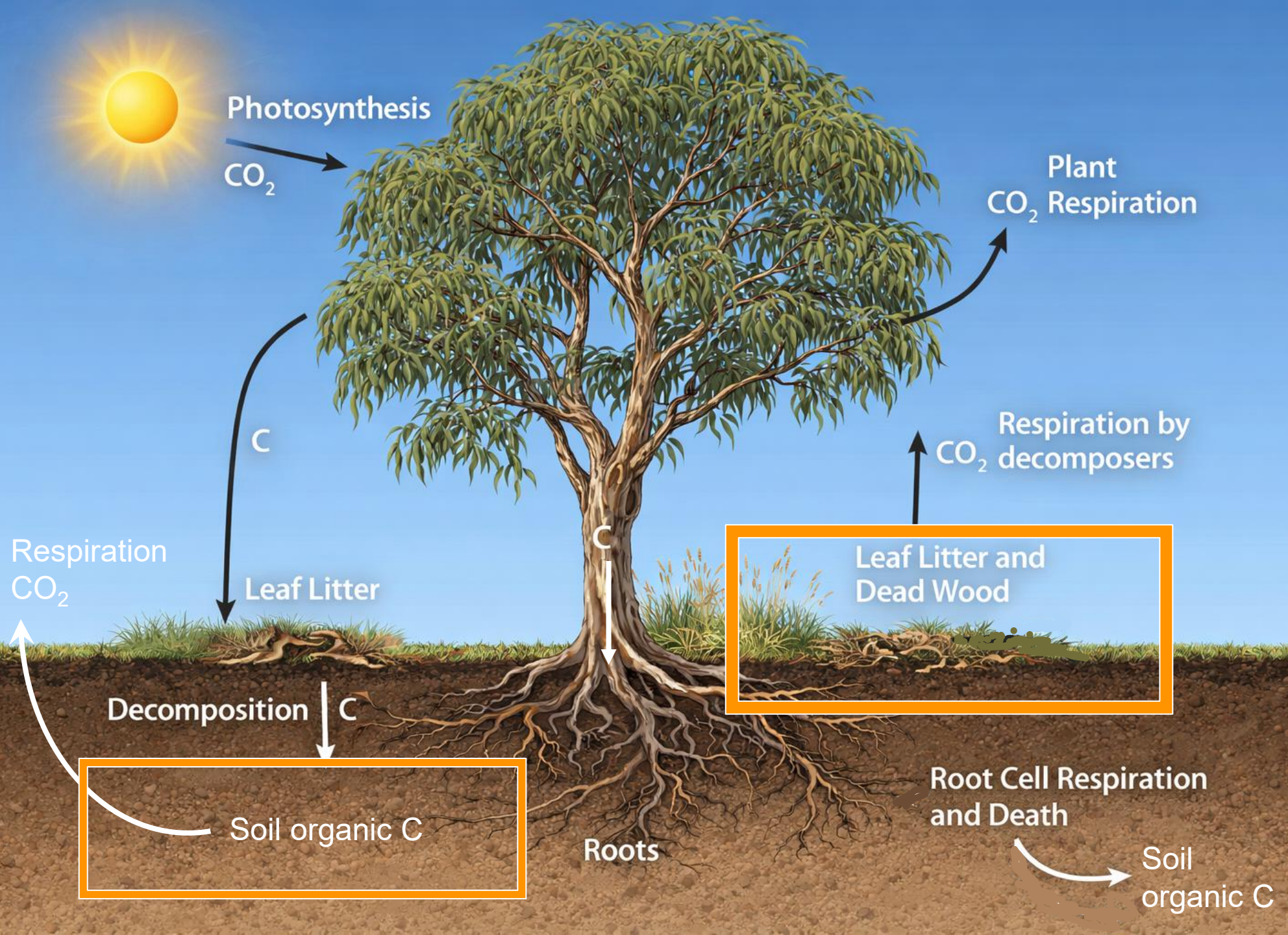
Dryland Carbon Cycle:

**C inputs well
constrained**



Dryland Carbon Cycle:

**Controls over
soil C and
heterotrophic
respiration
poorly
constrained**



1902 Woody Encroachment @ SRER: Playground for C Cycle Mechanisms



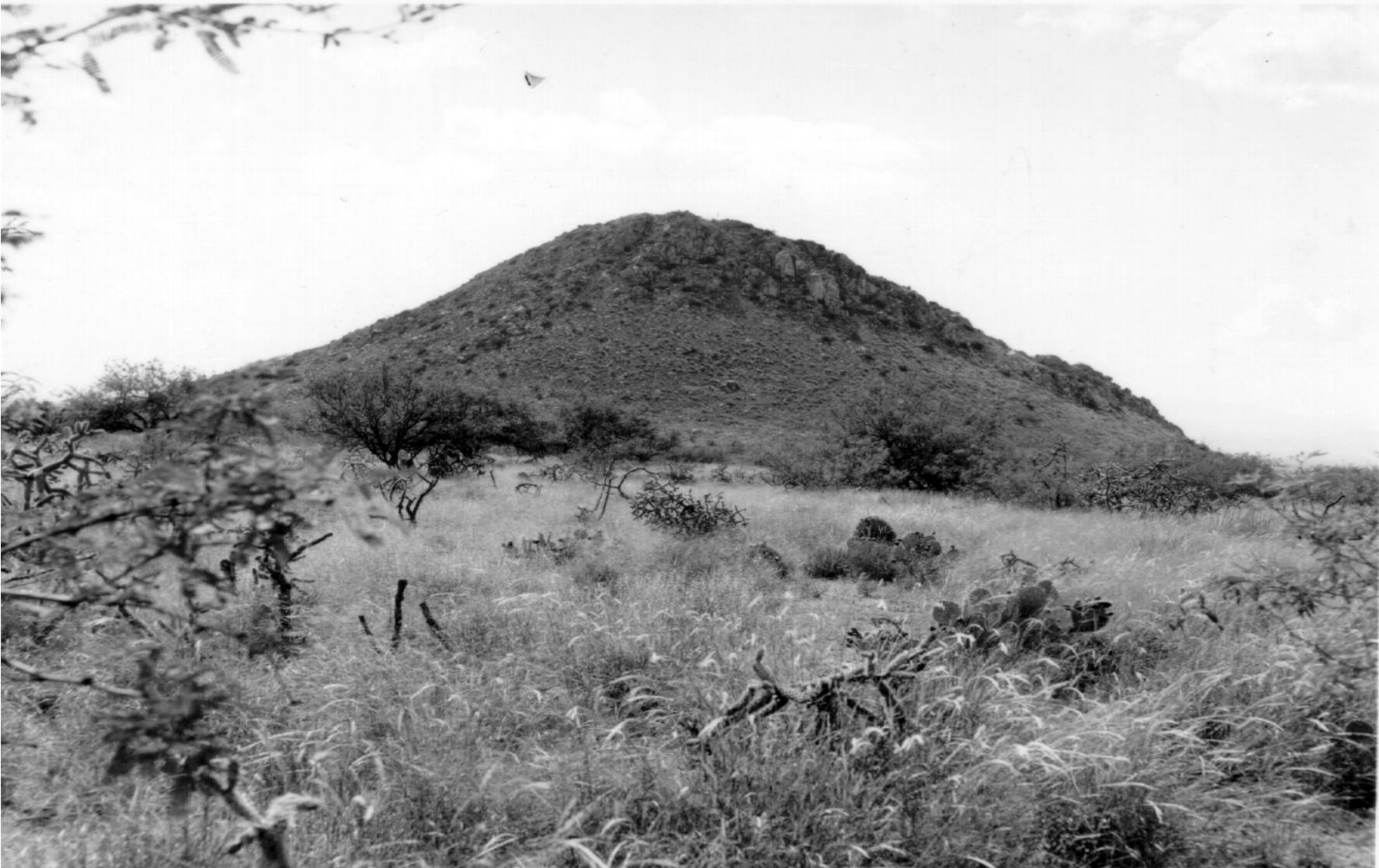
Huerfano Butte, Santa Rita Experimental Range, Arizona

1938



Huerfano Butte, Santa Rita Experimental Range, Arizona

1971



Huerfano Butte, Santa Rita Experimental Range, Arizona

2003

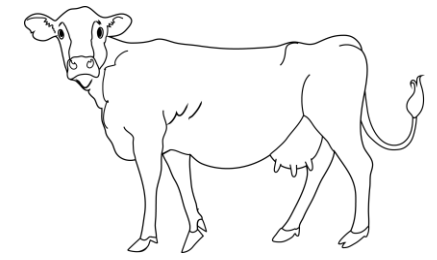
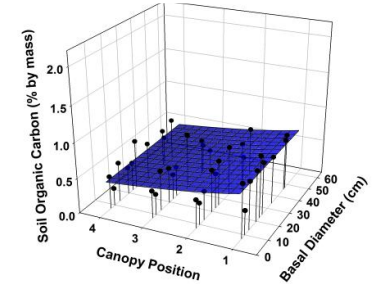
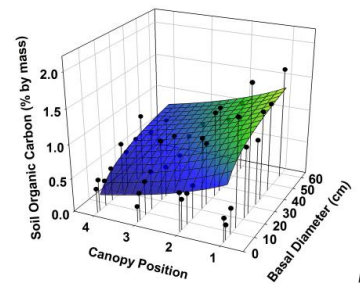


Huerfano Butte, Santa Rita Experimental Range, Arizona



Woody encroachment → substantial changes in spatial patterns of soil C pools

- Predictable when space, time, land management accounted for



- Primarily shrub material
 - lignin-derived phenols, stable isotopes
- Primarily leaf inputs
 - substituted fatty acids
- Most C persists <50 y; spatial patterns degrade
 - lab incubations, density fractions, stable isotopes, spatial models

Long-term C projects at SRER

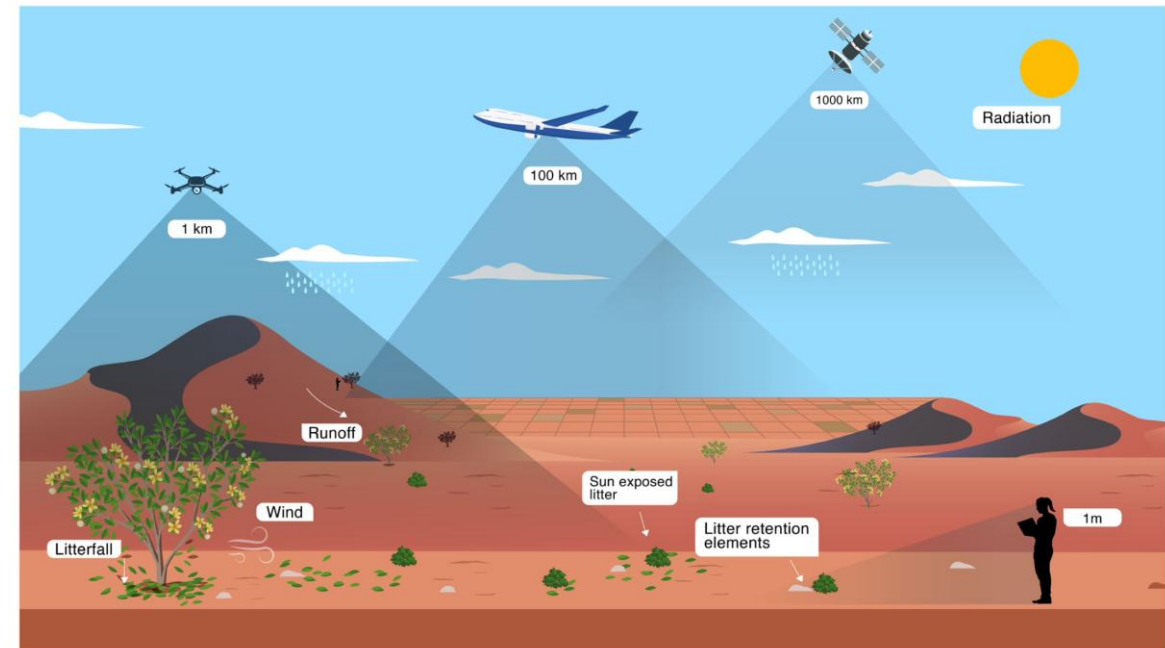
D-DIRT

Dryland Detrital Input and Removal Treatments



DeAD

Decomposition Across Drylands



Long-term C projects at SRER

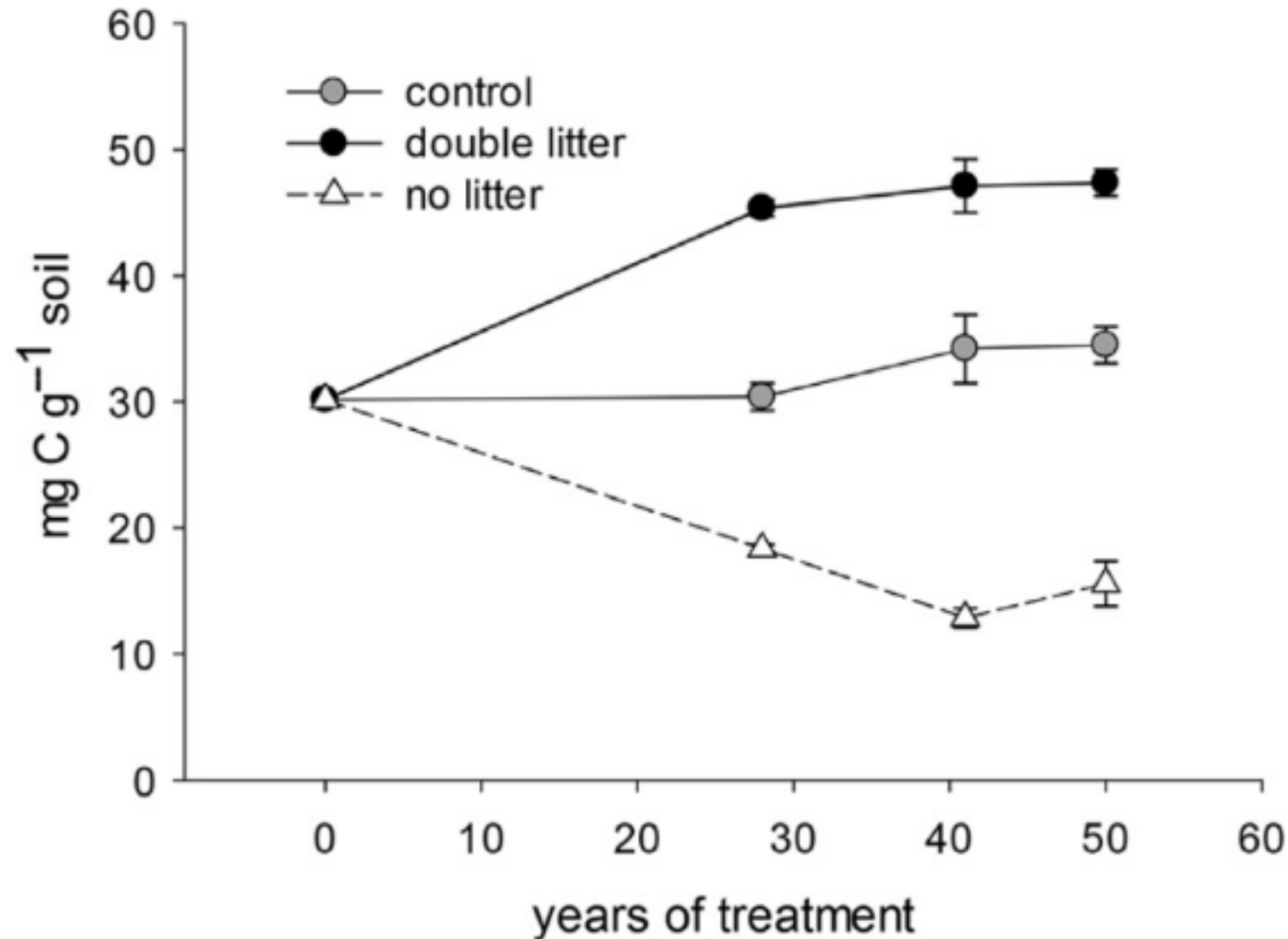
D-DIRT

Dryland Detrital Input and Removal Treatments



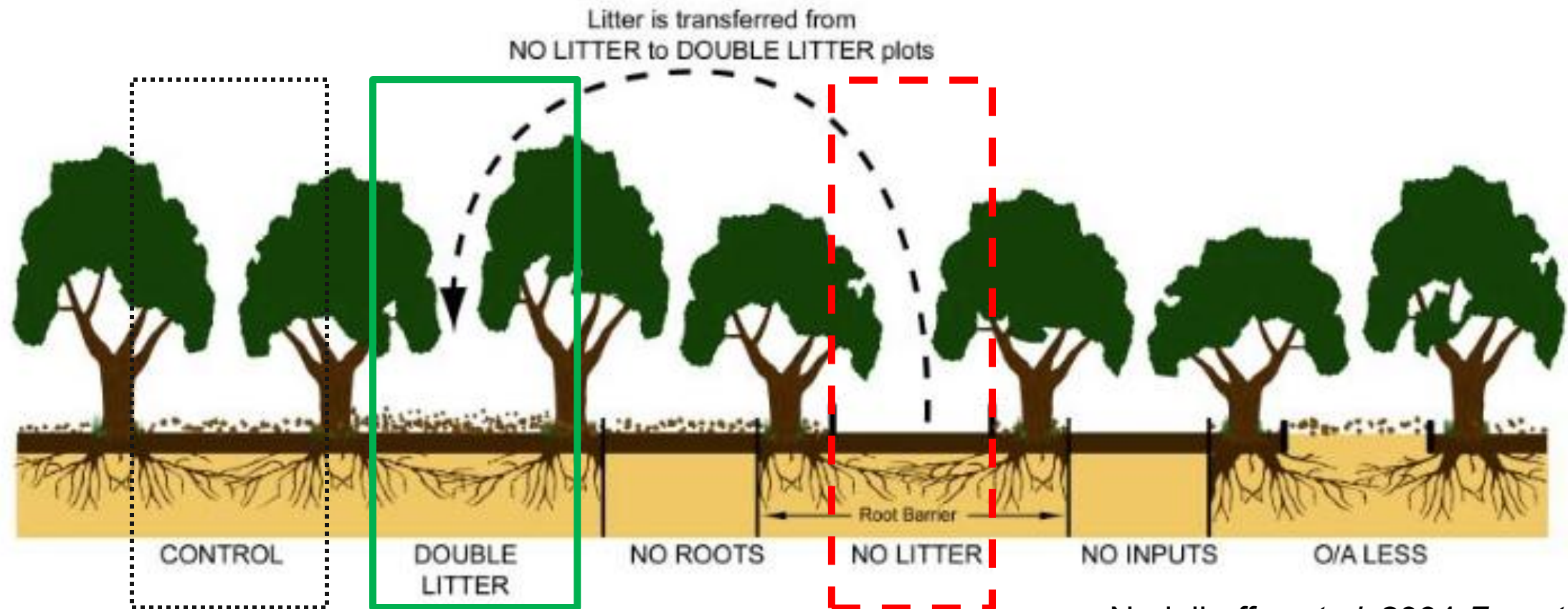
*What controls the size
& stability of soil
organic carbon pools?*

Wisconsin Plots – Francis Hole (est. 1956)

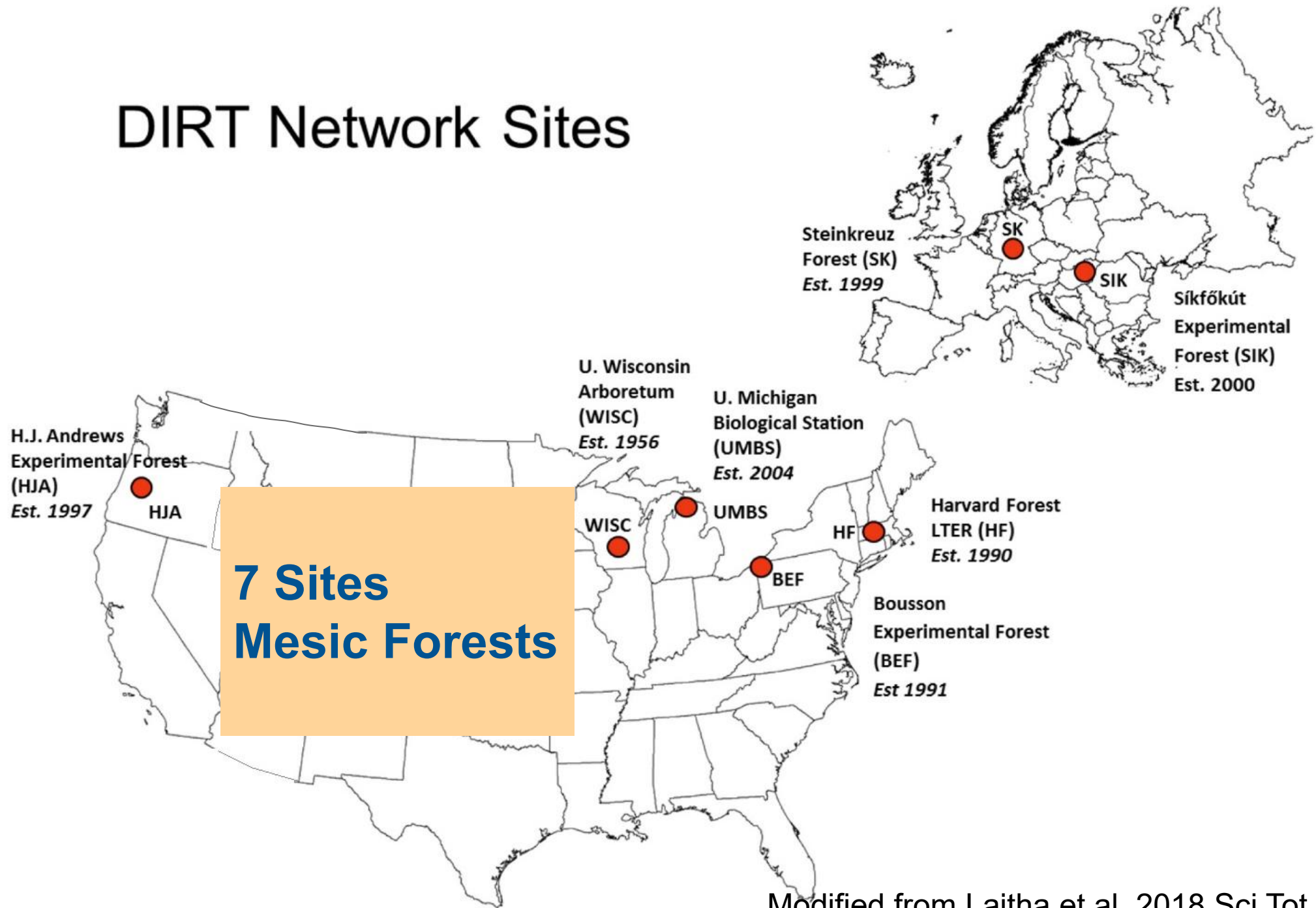


Soil C changes in
~30 y and stabilizes

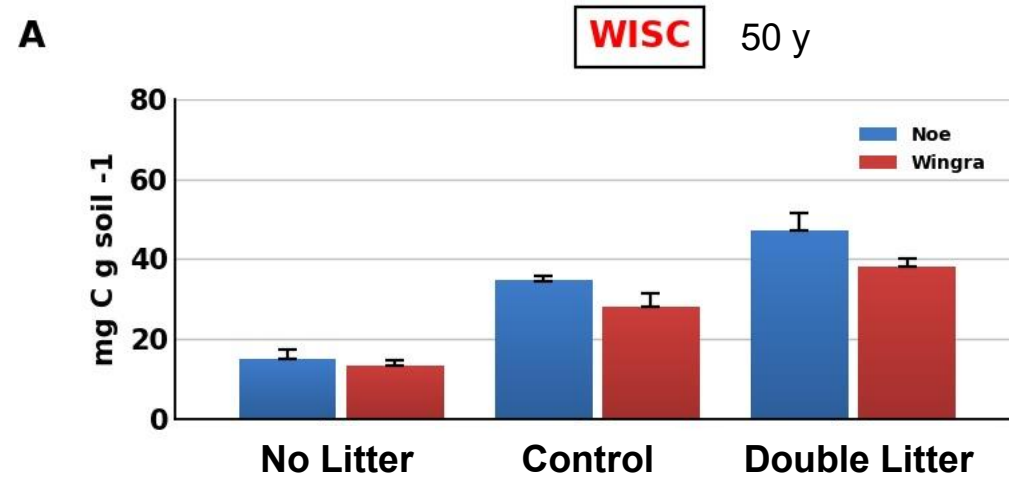
Detrital Input and Removal Treatments (DIRT)



DIRT Network Sites

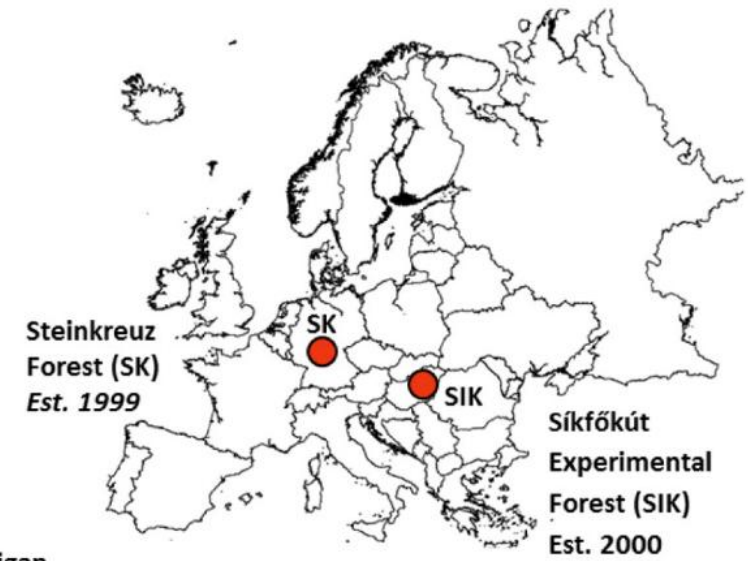
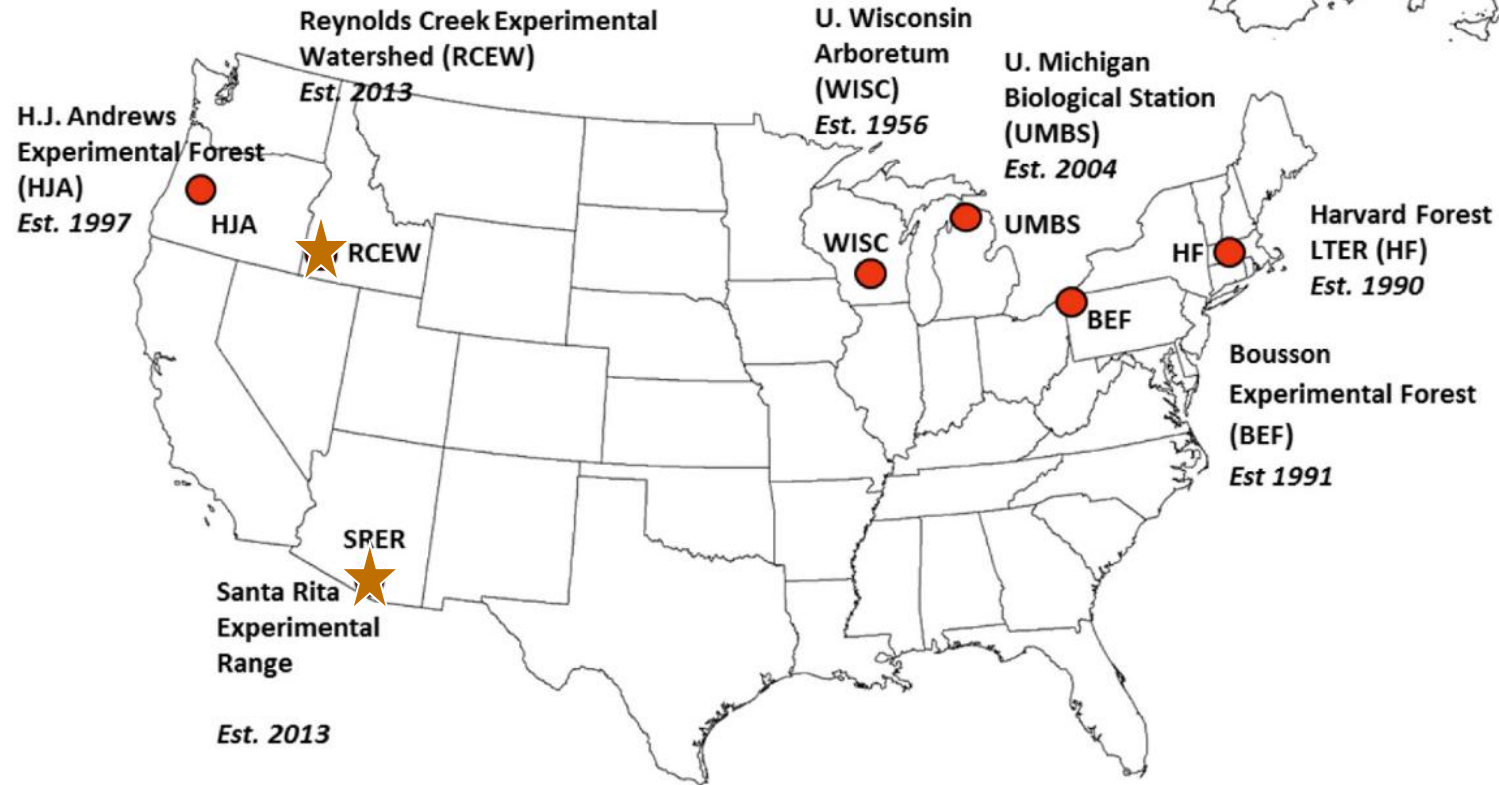


DIRT sites suggest more complex soil C responses.



How do soil C dynamics differ in dryland sites?

Dryland DIRT (D-DIRT)

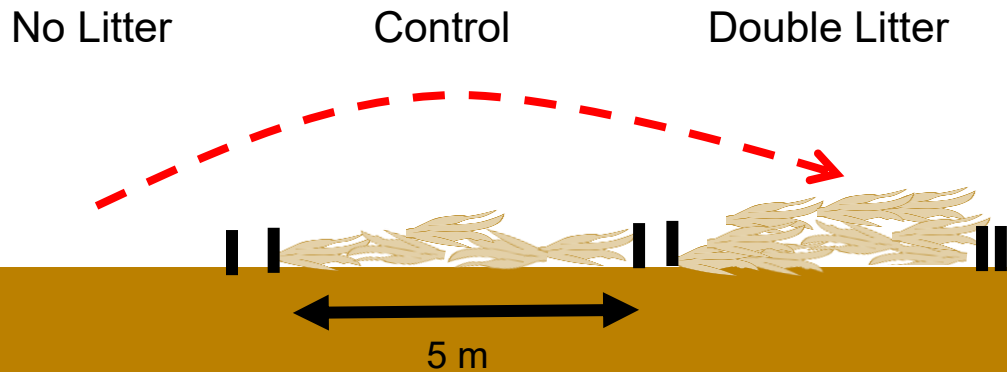


★ Mu Us Sandy Land Yanchi, China Est. 2018

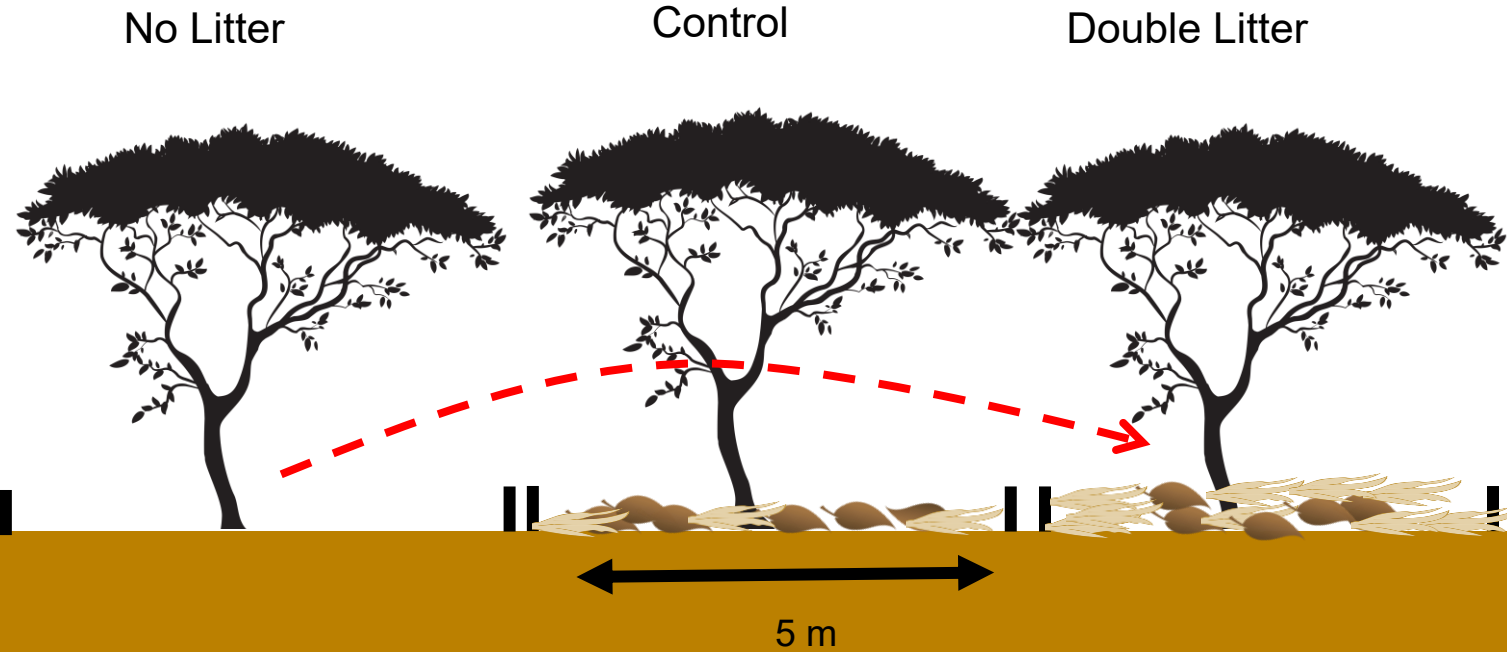
Dryland DIRT (D-DIRT)

Aboveground litter manipulations
Grass versus shrub inputs

Grass Plots

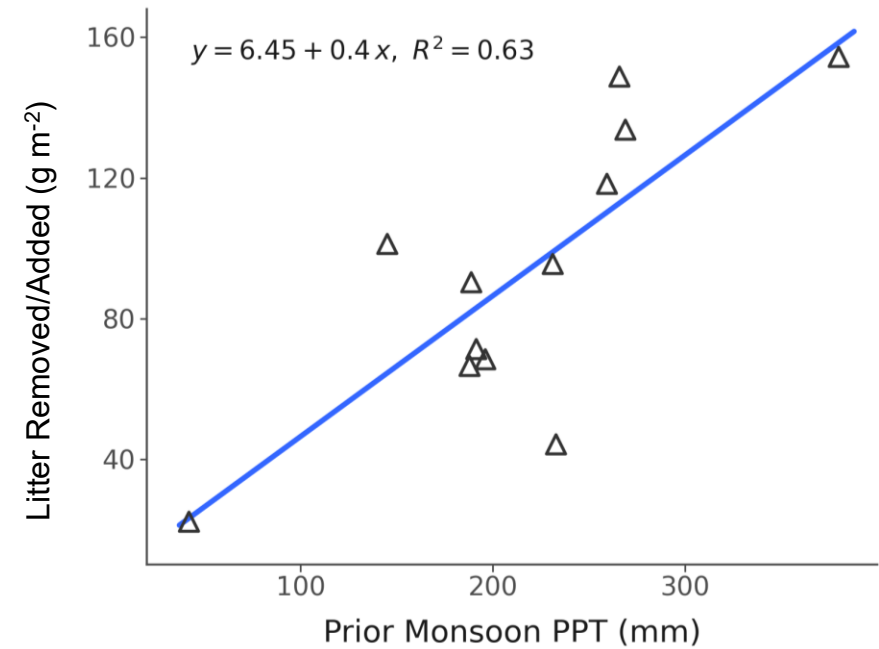
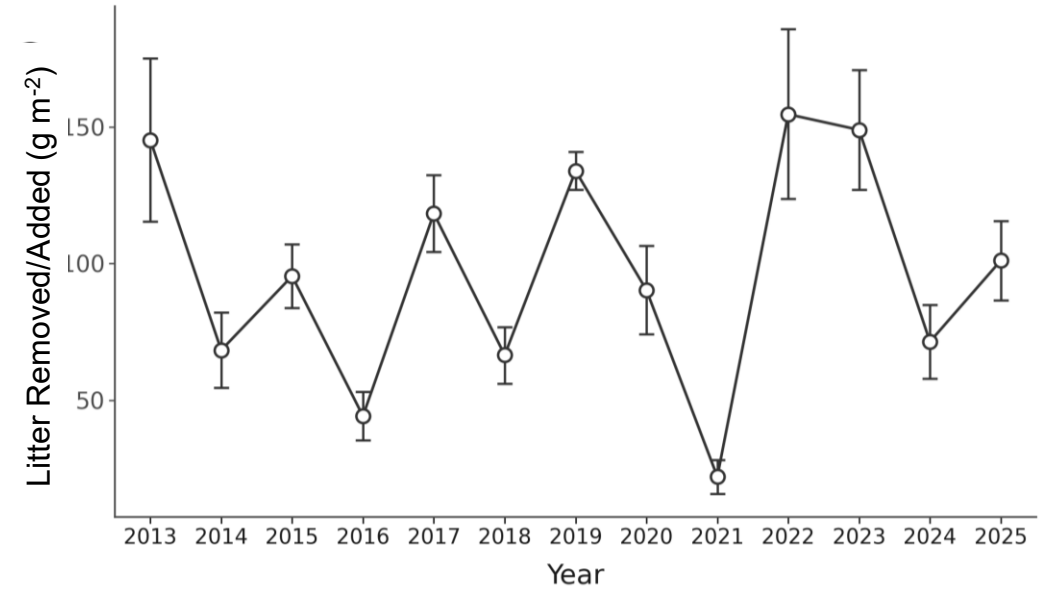


Shrub Plots



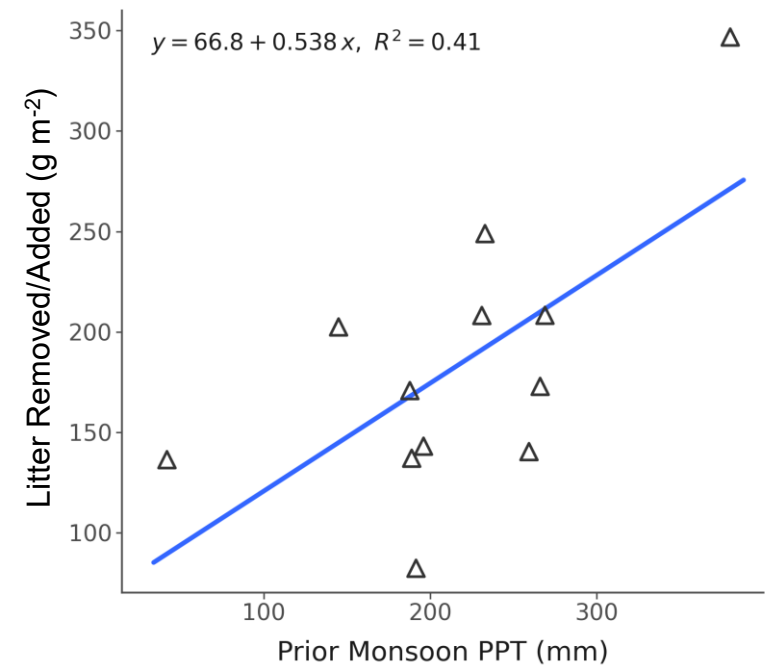
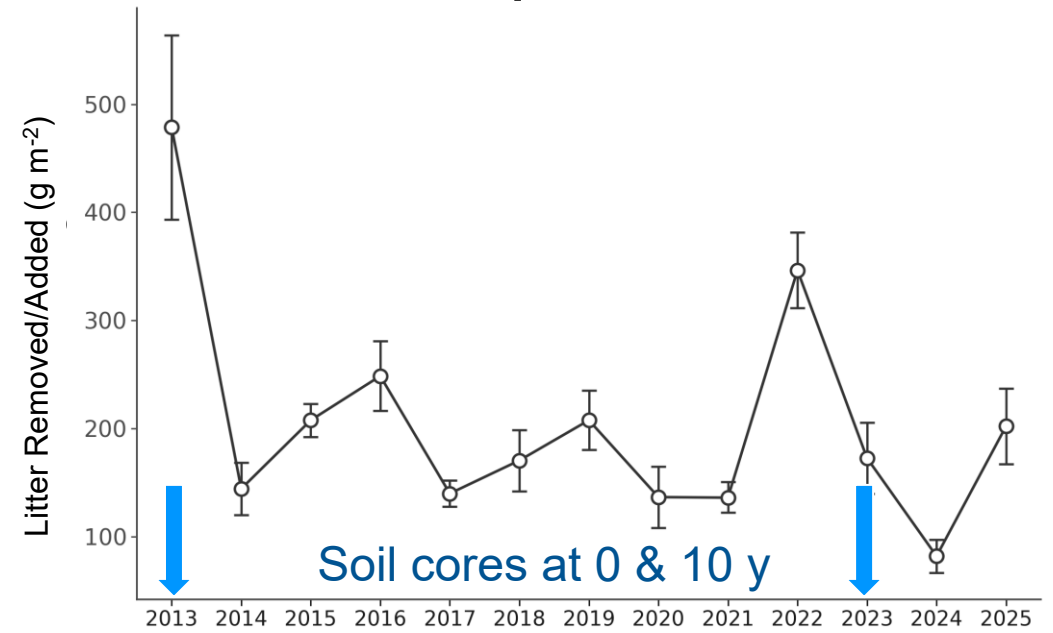


Grass Manipulations





Shrub Manipulations



SRER D-DIRT

How have long-term additions/removals changed soil carbon?

Please visit Allelua Niyokwizera's poster during lunch!



Spoiler: SRER is not Wisconsin!

SRER D-DIRT

What are the other impacts of all this litter manipulation?

Work in progress:

Soil carbon chemistry & stability

Wood and leaf litter decomposition

Surface mineral stabilization

Your ideas?

Come play in the D-DIRT with us!



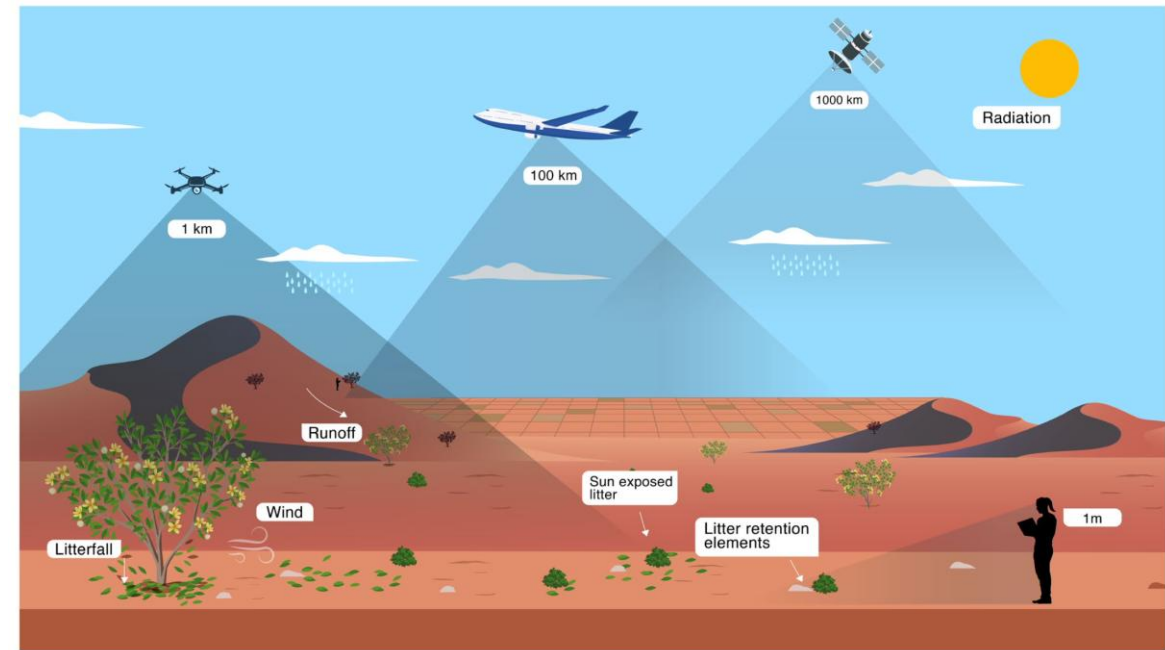
Thanks to the D-DIRT Team: Allelua Niyokwizera, Kate Lajtha, Marie-Anne de Graaff

Long-term C projects at SRER

DeAD

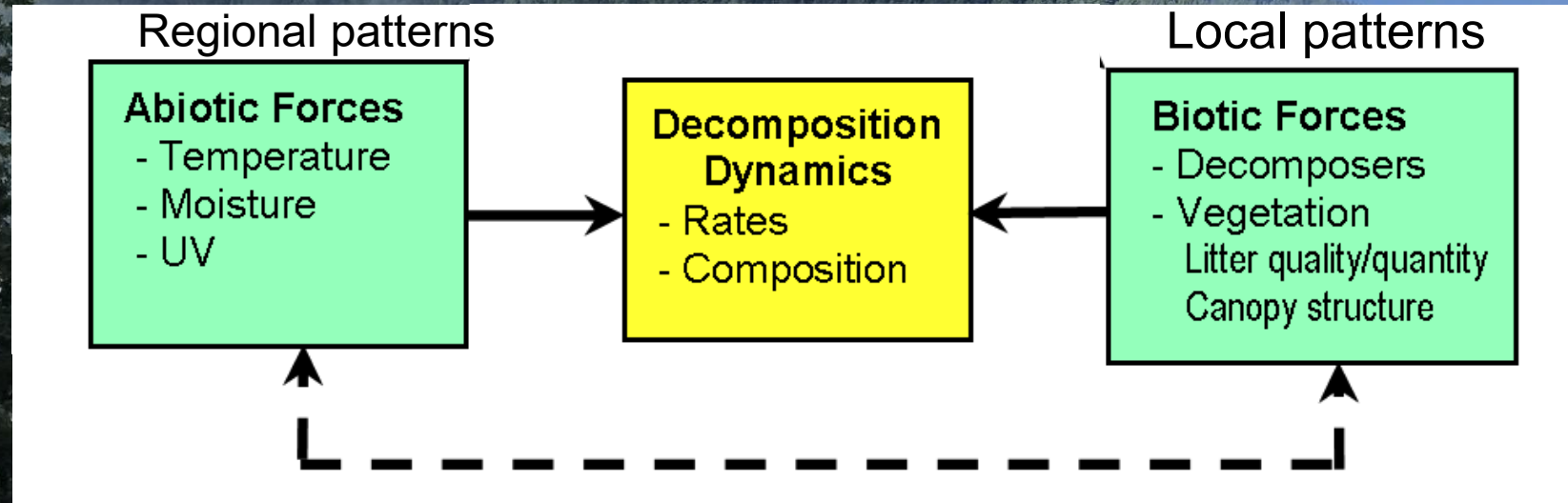
Decomposition Across Drylands

How is litter distributed across drylands and how does this affect C dynamics?



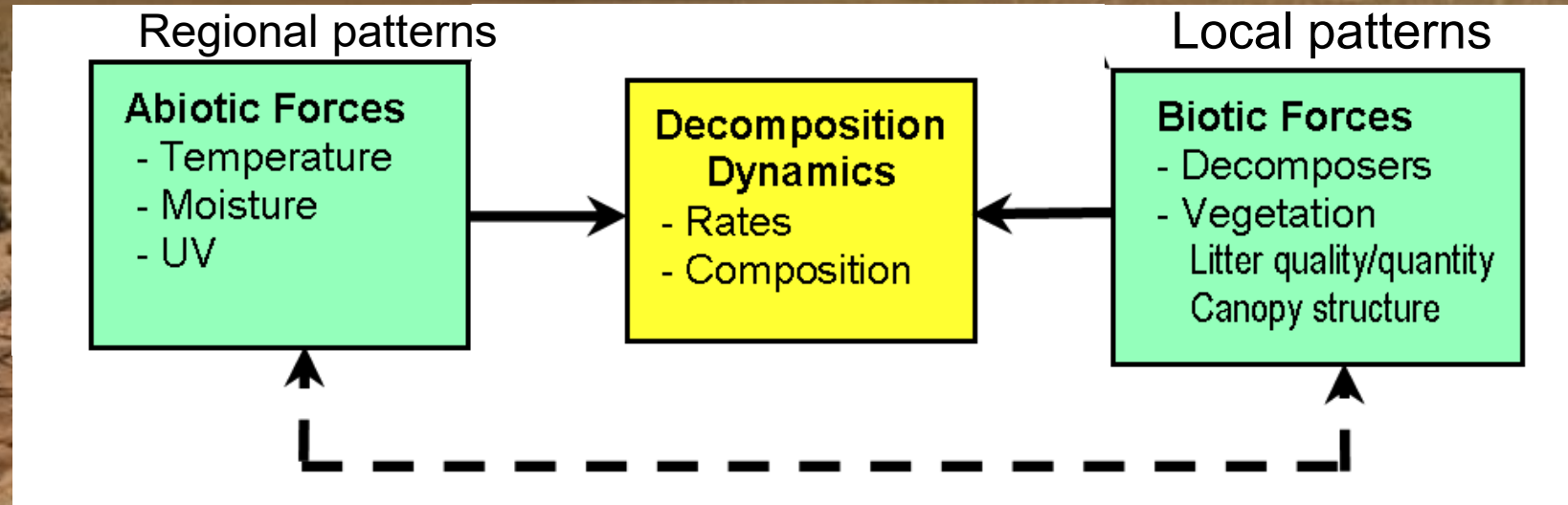
Simple Decomposition Models Typically Work Well in Mesic Systems.

Surface Litter Decomposition



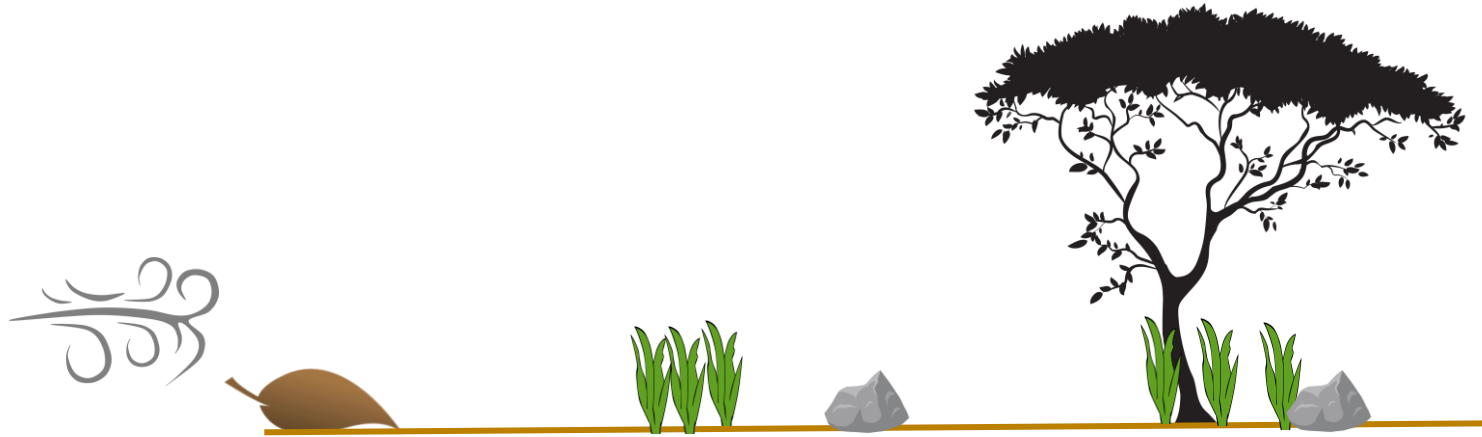
These Models Consistently Underpredict Decomposition in Drylands.

Surface Litter Decomposition



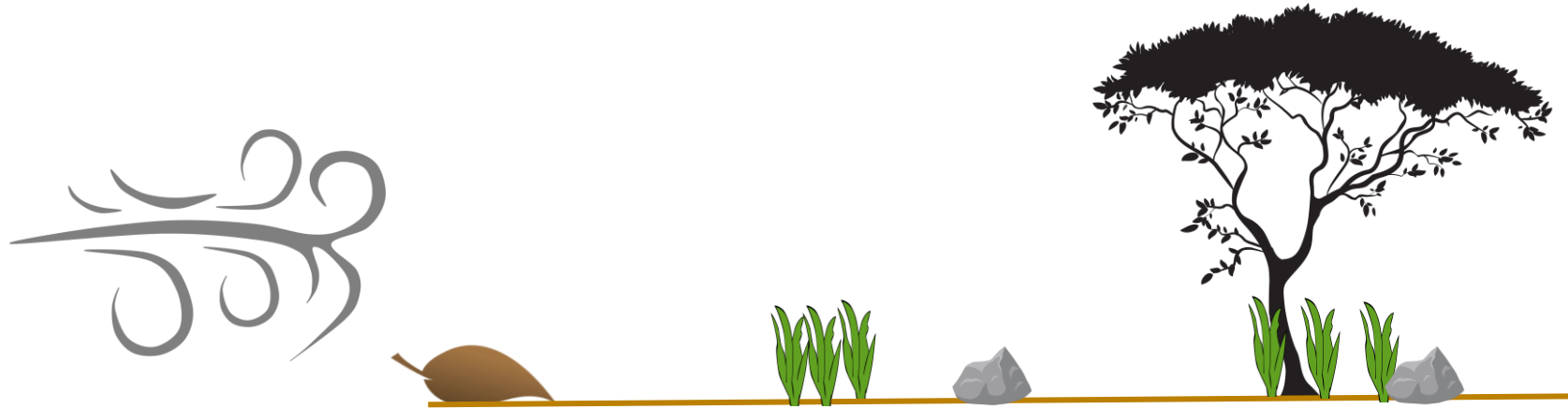
Bare ground: allows litter transport by wind, water, & animals

Litter accumulates next to objects that resist litter transport.



Bare ground: allows litter transport by wind, water, & animals

Litter accumulates next to objects that resist litter transport.



Big Problem:

Most dryland decomposition studies focus on bare areas between plant canopies...



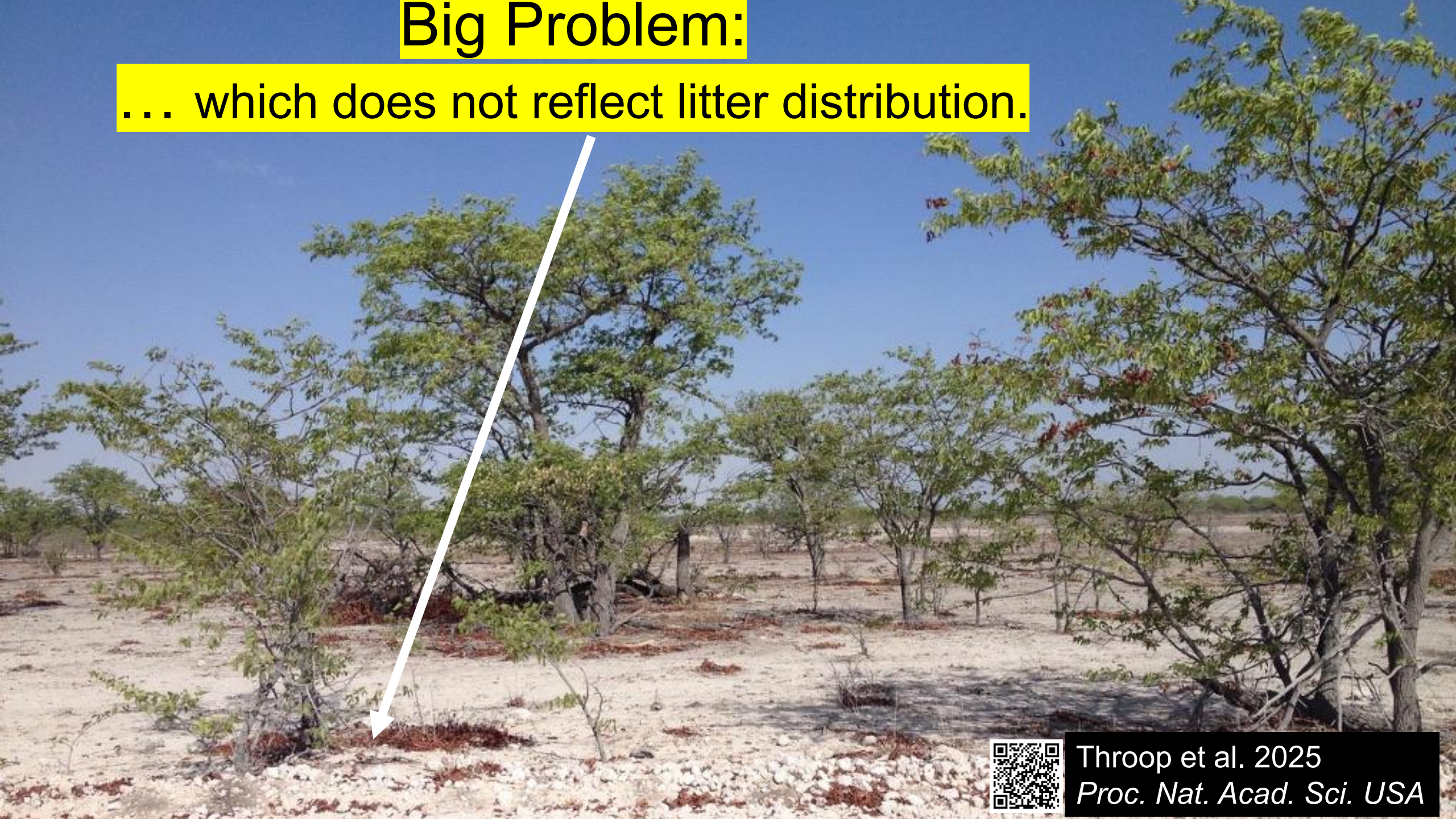
72% of studies



Throop et al. 2025
Proc. Nat. Acad. Sci. USA

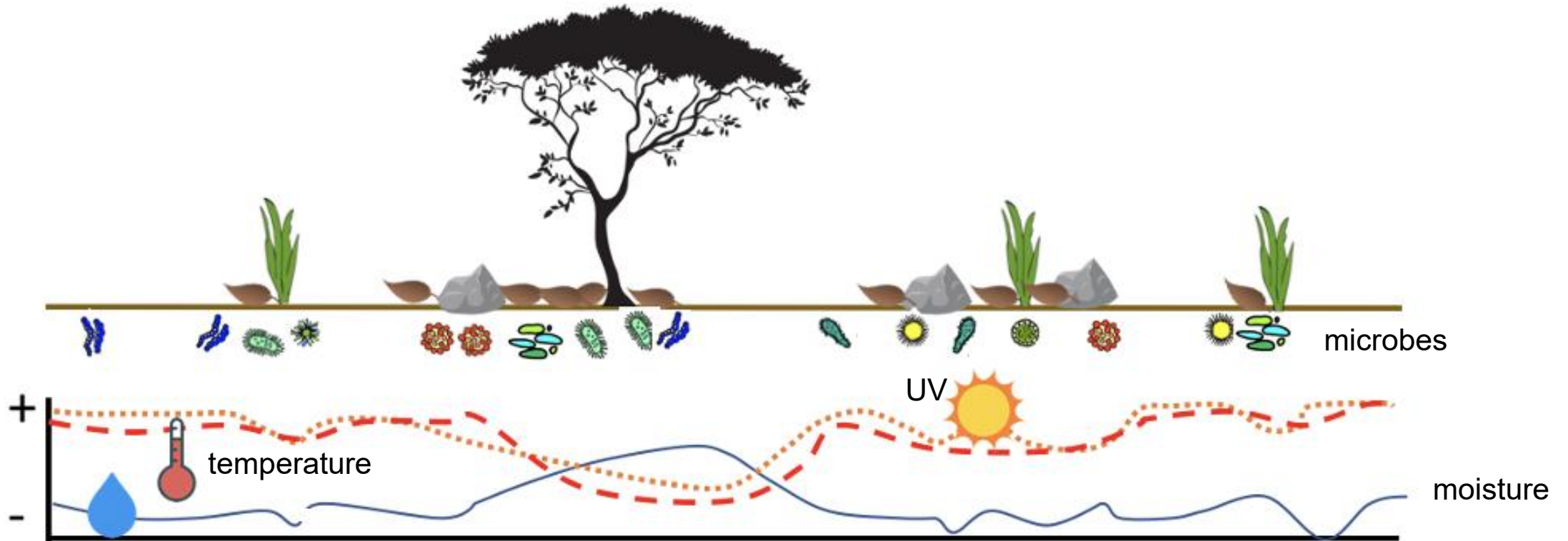
Big Problem:

... which does not reflect litter distribution.



Throop et al. 2025
Proc. Nat. Acad. Sci. USA

Decomposition rate depends on where litter accumulates



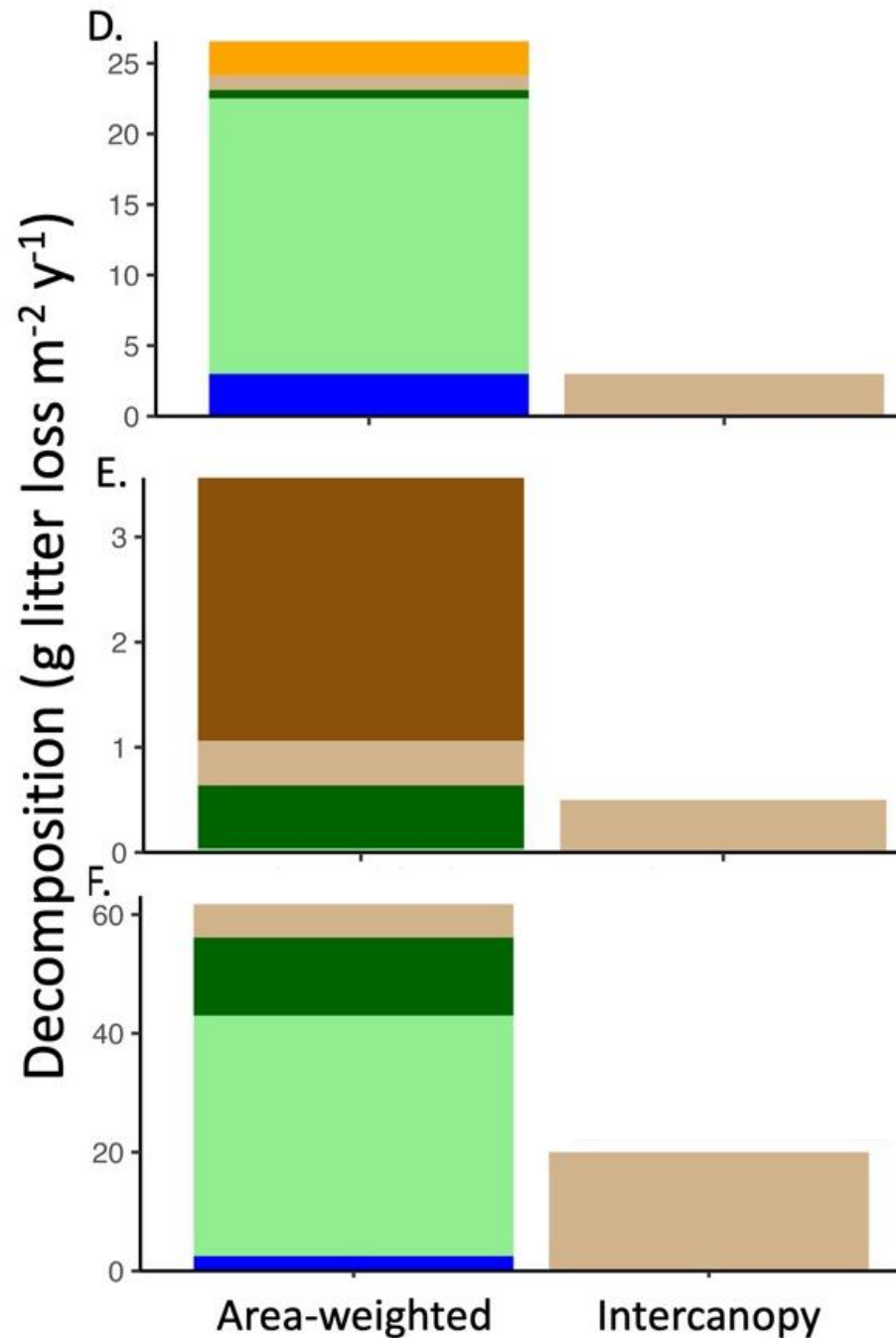
Colorado Plateau



Namib Desert



Sonoran Desert



Decomposition is underpredicted if microsites (litter amount & decomp rate) are not considered



NSF Macrosystems NEON-Enabled Science: Decomposition Across Drylands (DeAD)

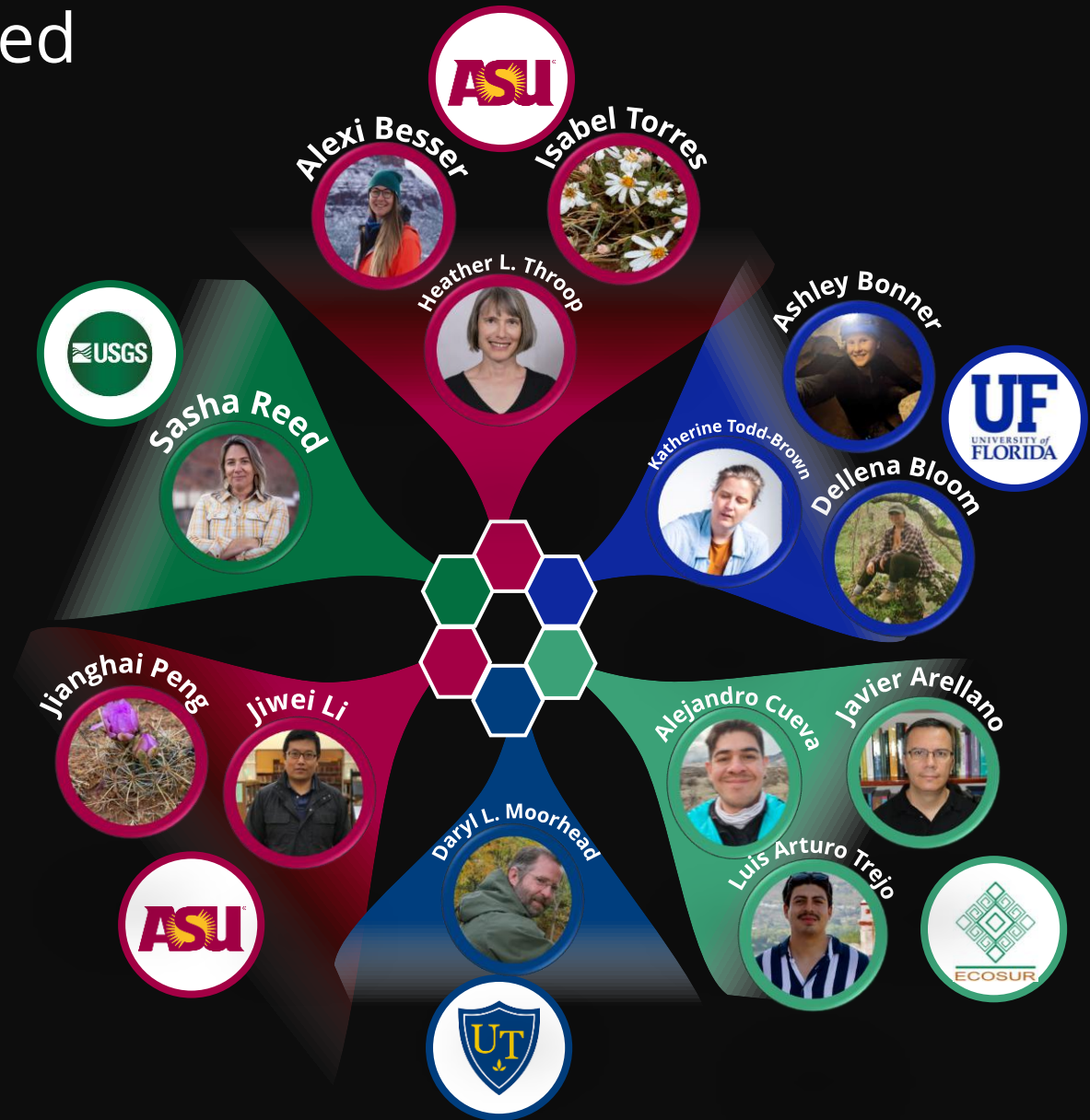
Website



Mailing List



drylands.asu.edu/DeADWeb/

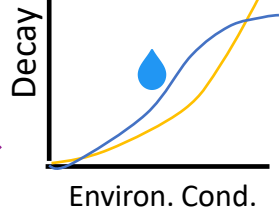


Process Understanding

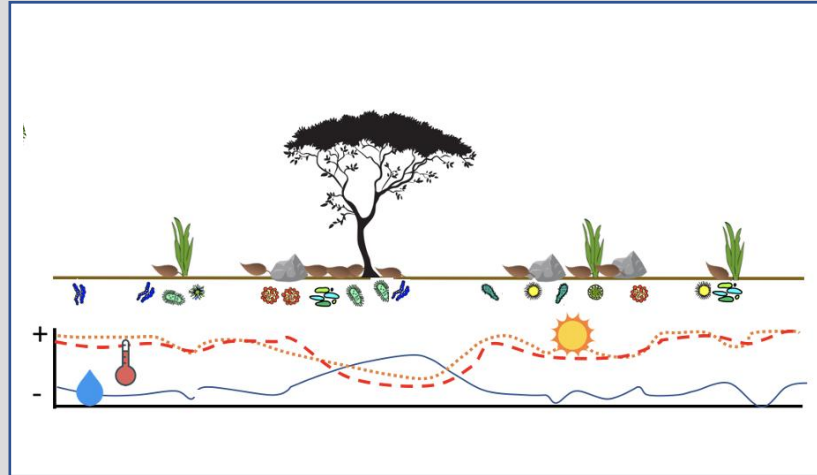
Literature Data

Field Data

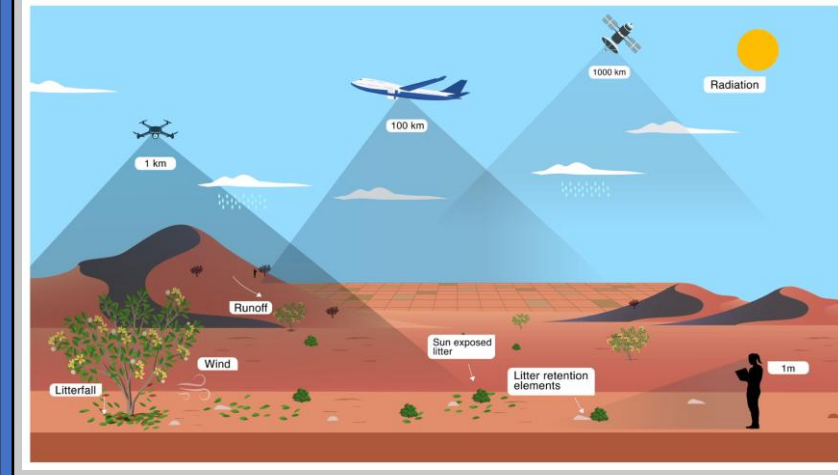
Process Hypoth.



Spatial Characterization

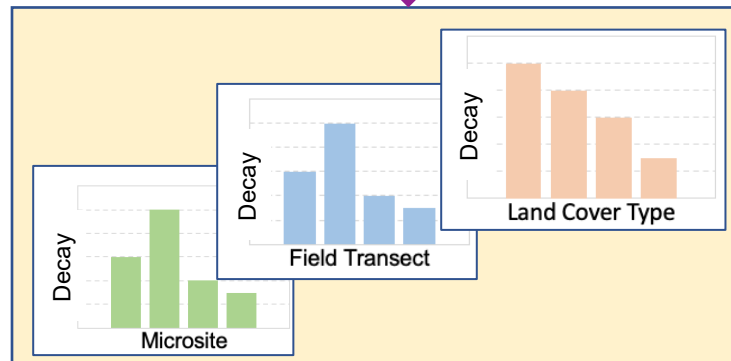


Regional Scaling



Hierarchical Continuum of Models

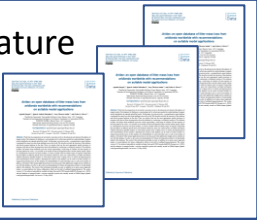
Initial Goal: Predict
Area-weighted
Decomposition in North
American Drylands



Future Goal: Scaling
from North American to
Global Drylands

Process Understanding

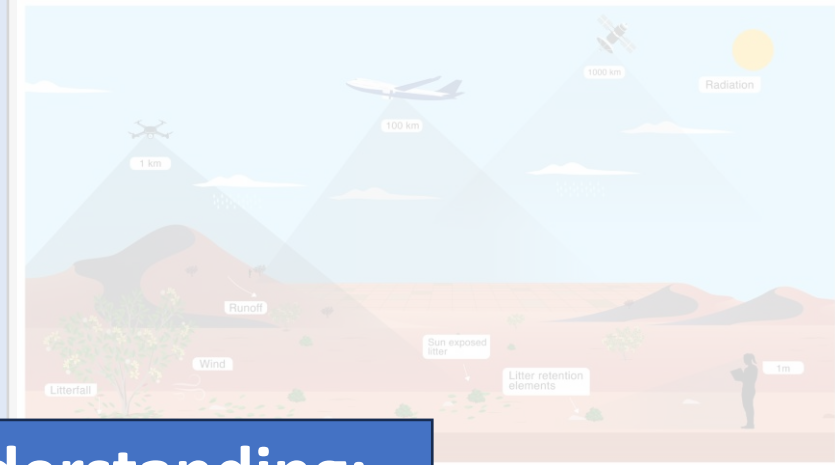
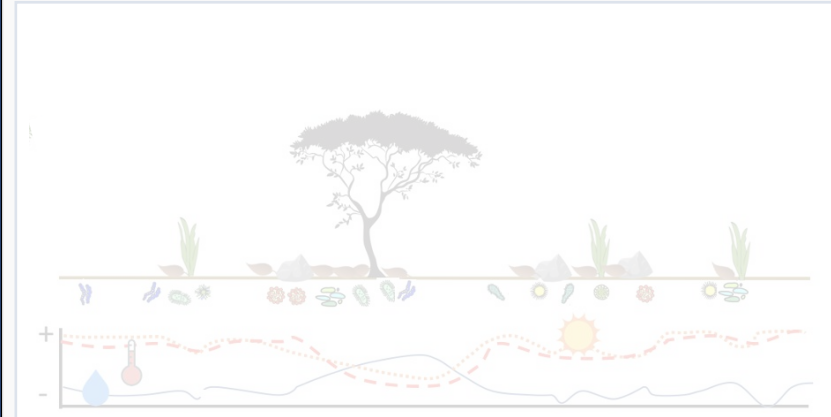
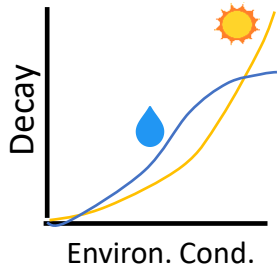
Literature Data



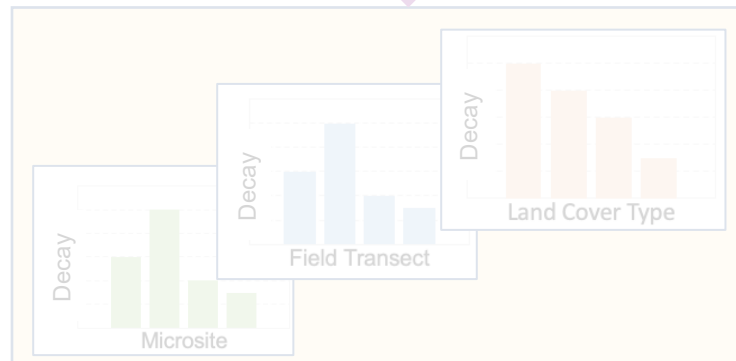
Field Data

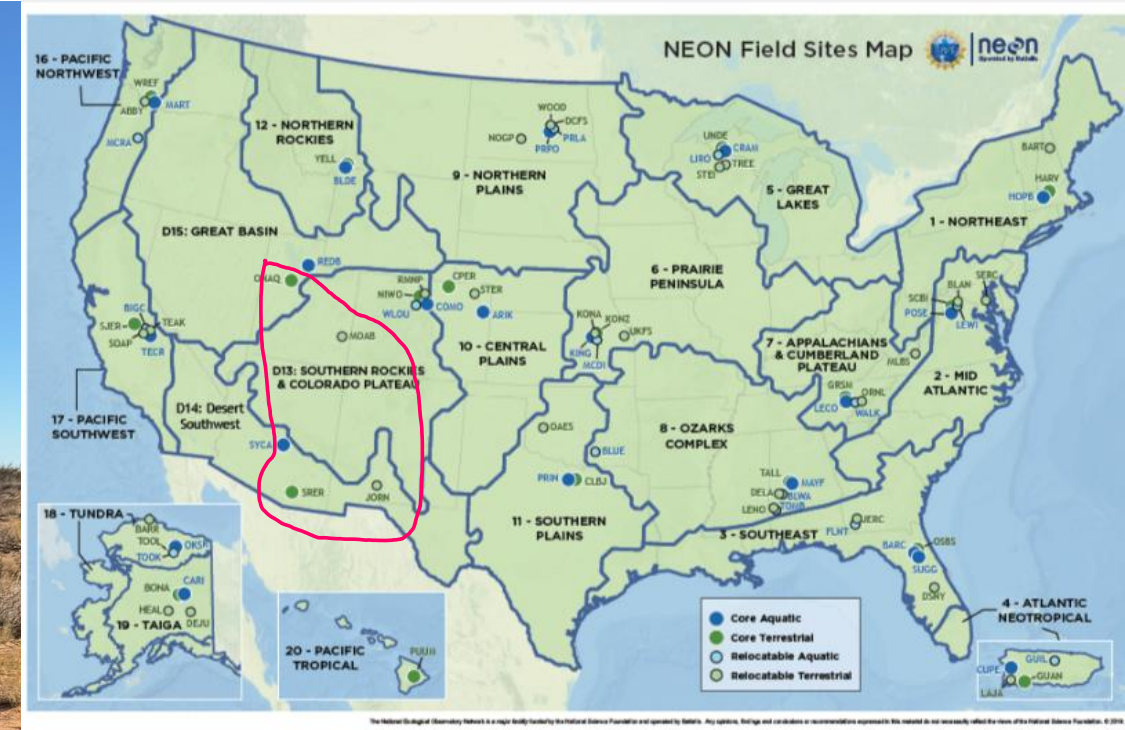


Process Hypoth.



**Improving Process Understanding:
Field & Lab Data**

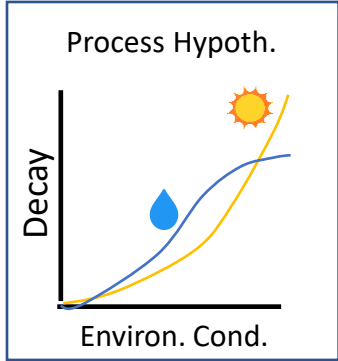




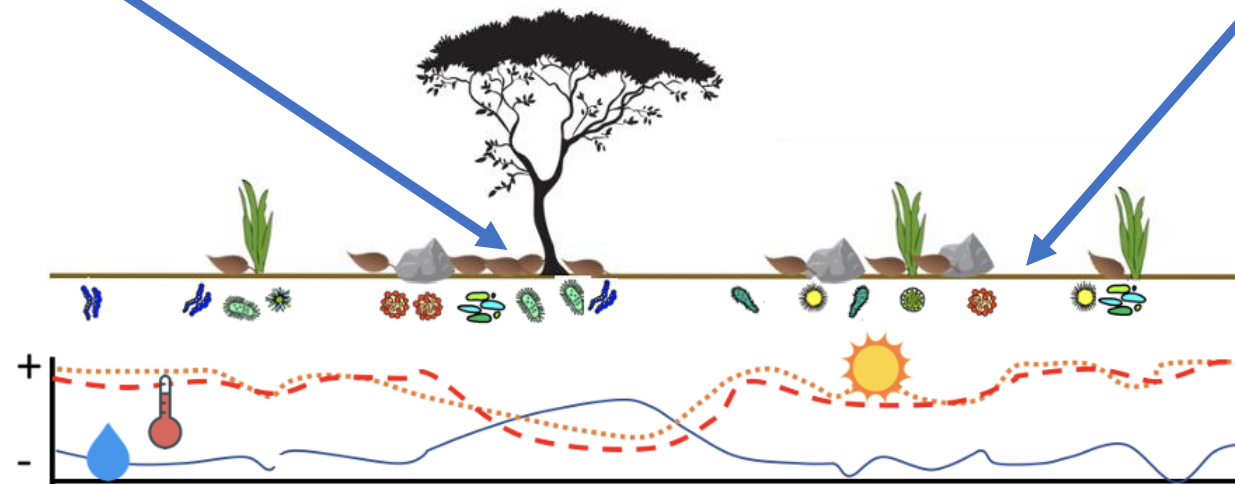
SRER:
primary of 4
dryland
NEON sites.

*Thanks to Abe
Karam & Team!*

Characterizing Decomposition: Across Microsites & North American Drylands



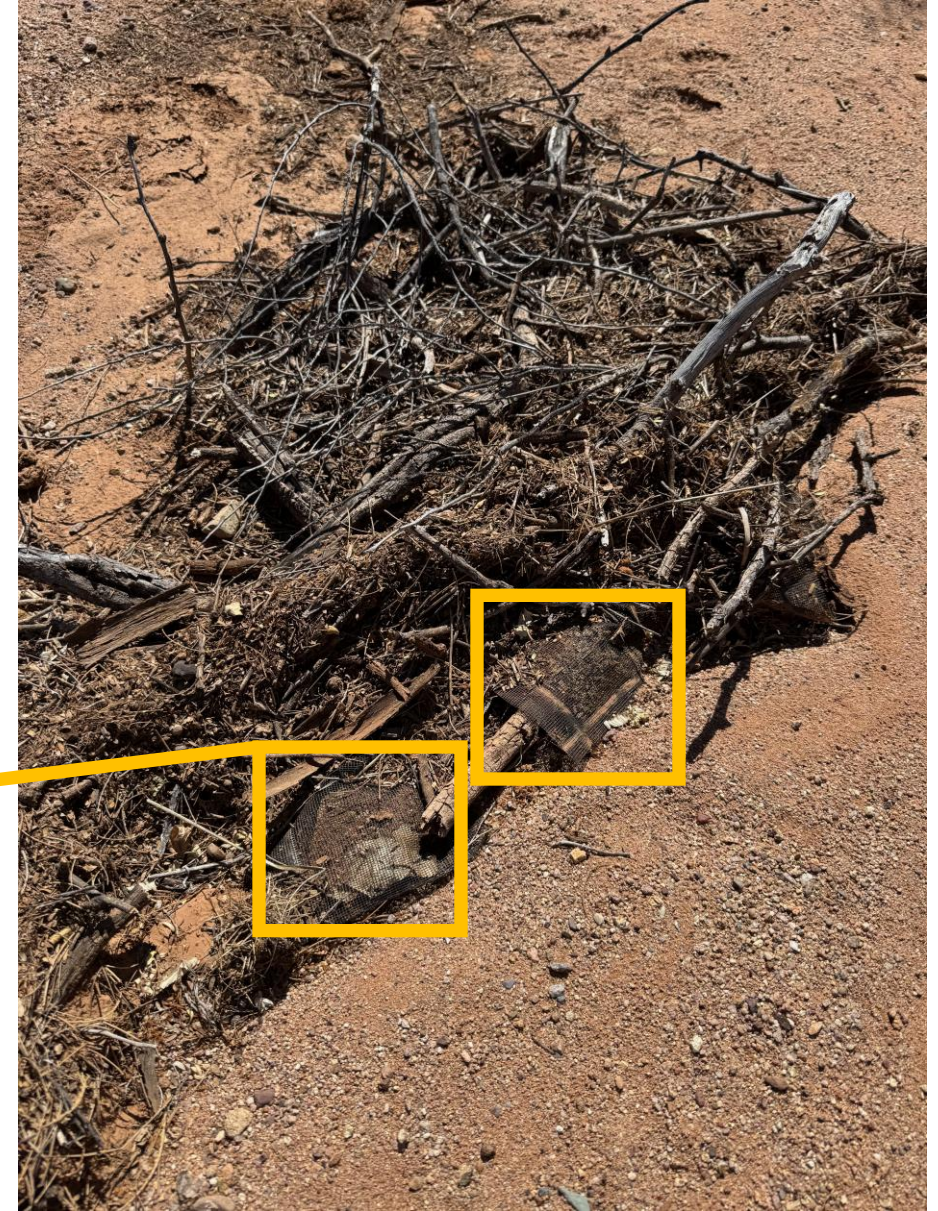
Mass Loss
C Fractions
Enzyme Activity
Microbial biomass



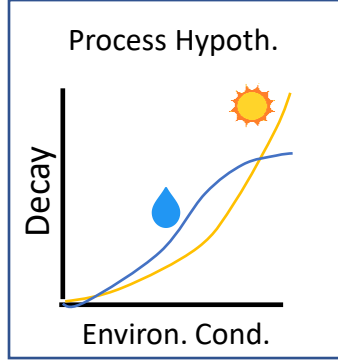
Solar Radiation
Temperature
RH

Characterizing Decomposition: Across Microsites & North American Drylands

A little
sporty!

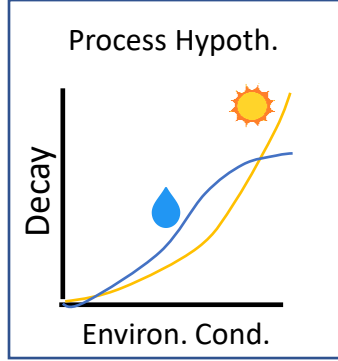


Characterizing Decomposition



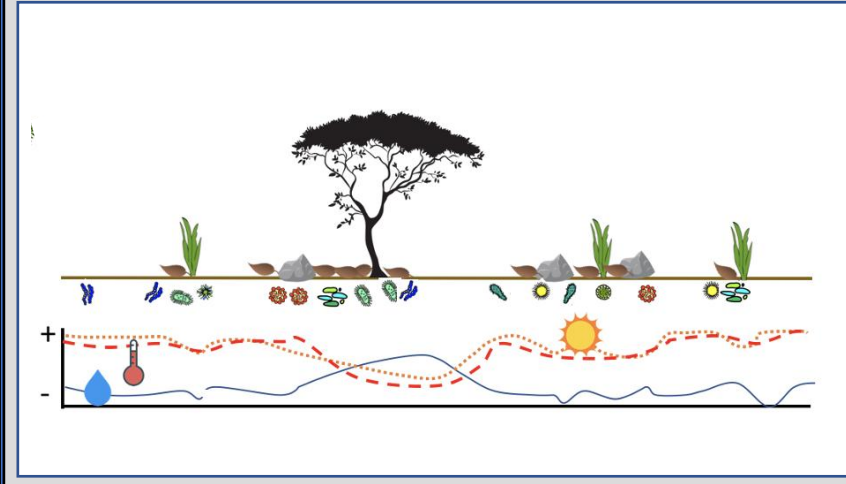
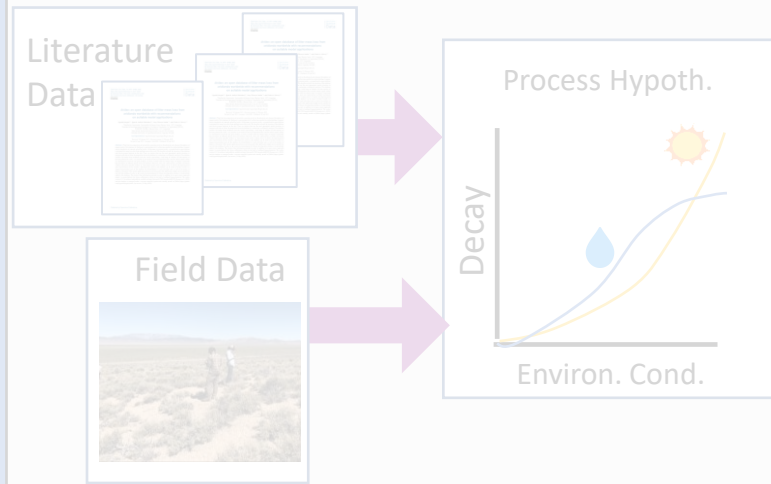
Lab incubations target knowledge gaps

Characterizing Decomposition

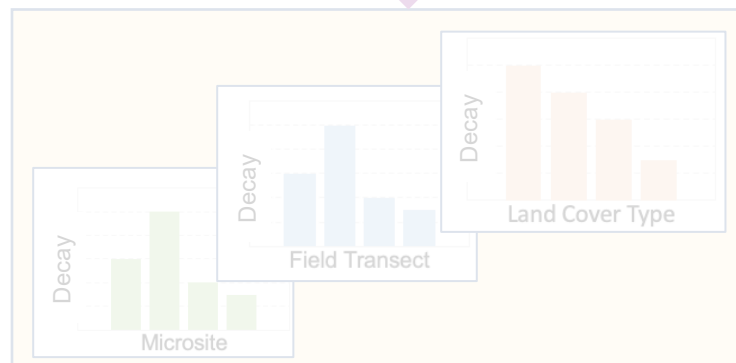


Please visit Dr. Alexi Besser's poster during lunch!

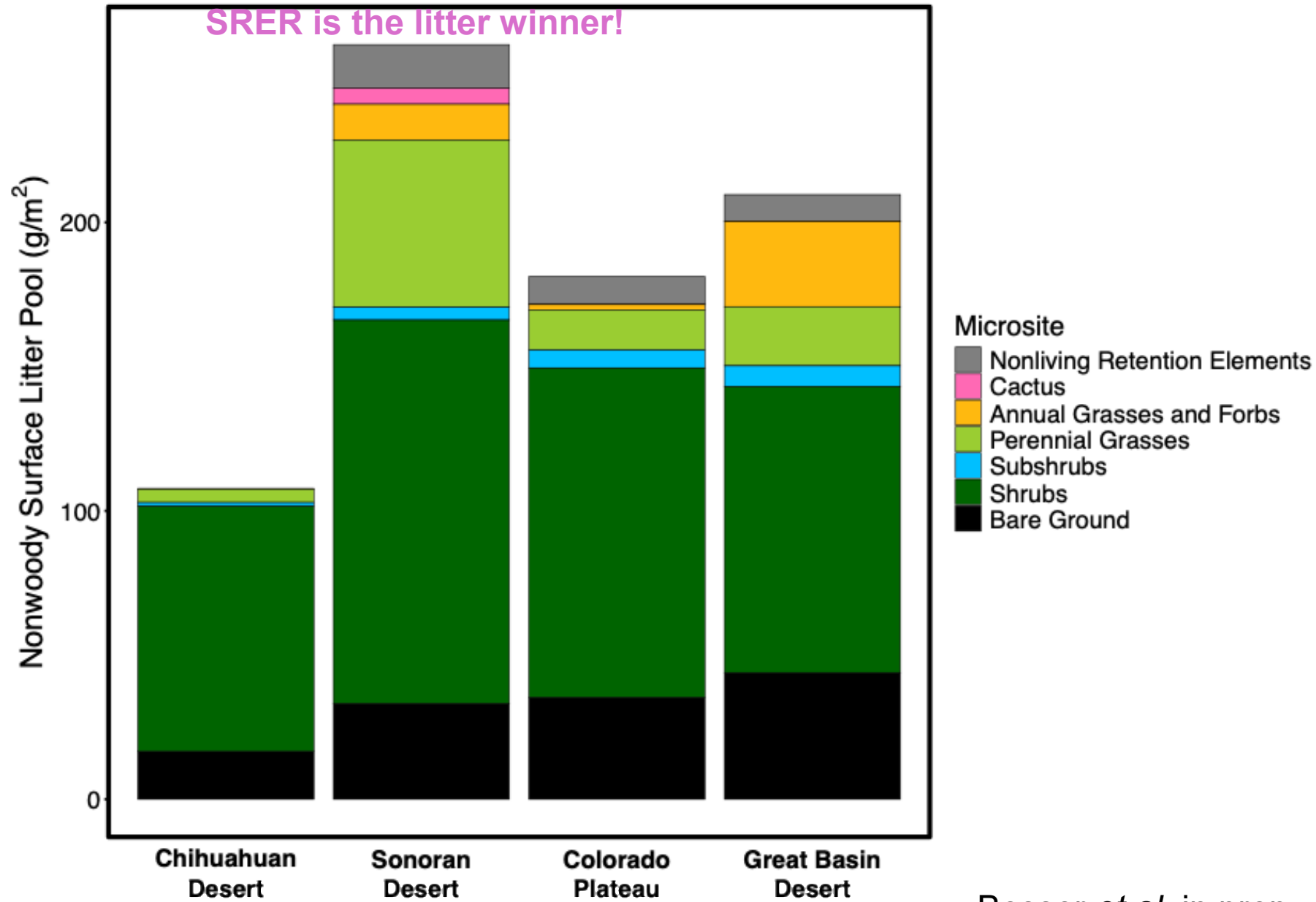




Characterizing Spatial Patterns: Litter & Environmental Drivers



All sites: 50 – 75% of surface litter is under shrubs



Chihuahuan Desert



Sonoran Desert

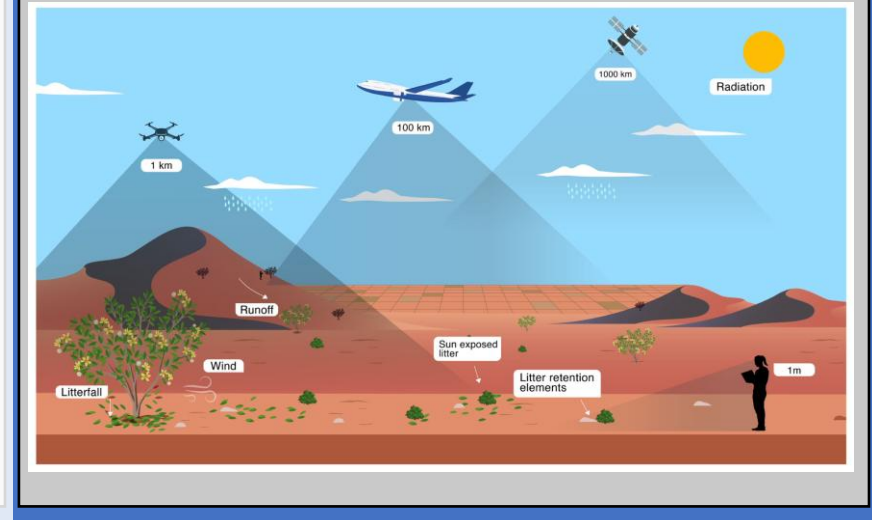
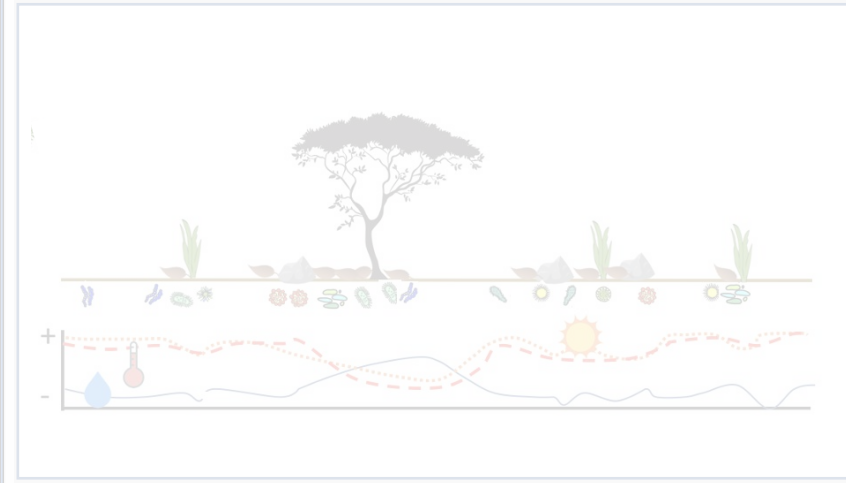
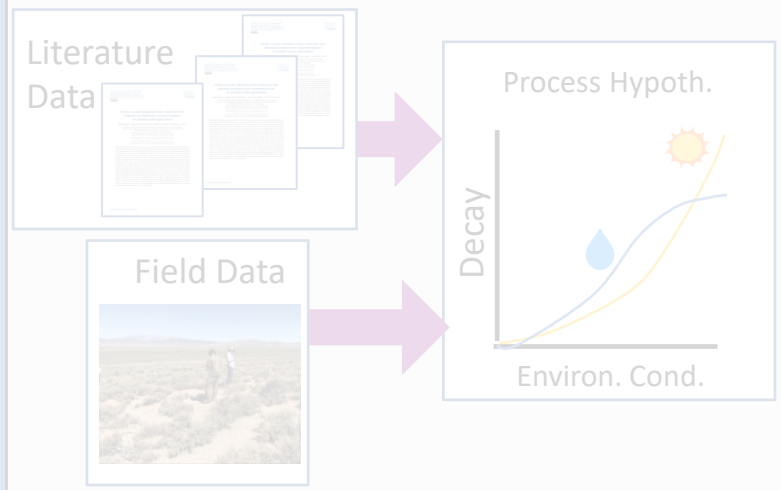


Colorado Plateau



Great Basin Desert

Besser *et al.* in prep



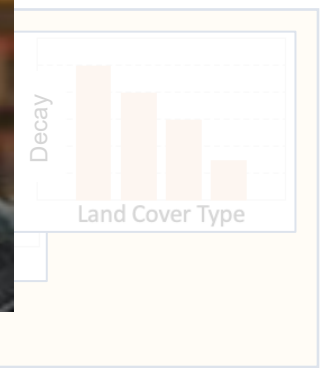
Jiwei Li



Arizona State University



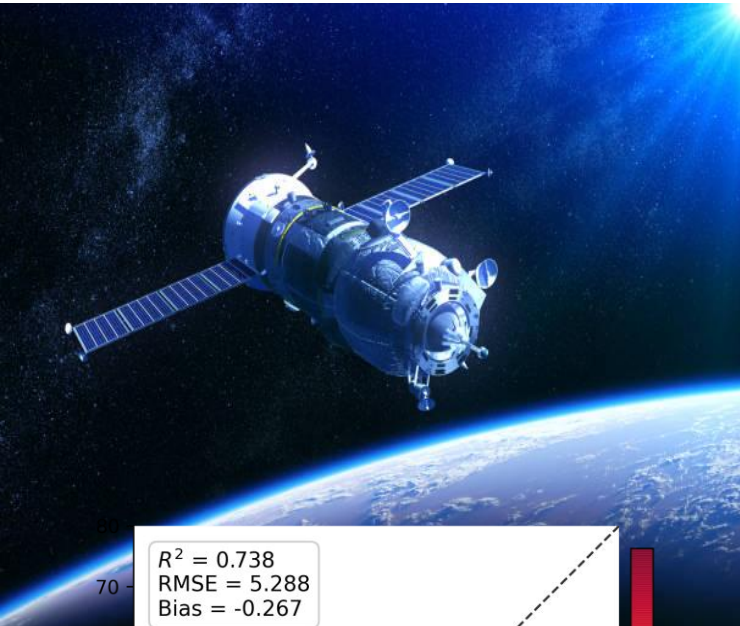
Regional Scaling



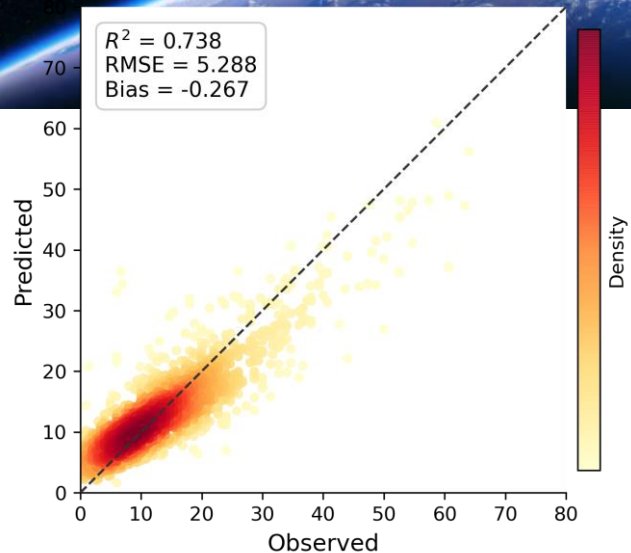
Microsite

Remote-Scaled Biomass Estimation → Litter Biomass

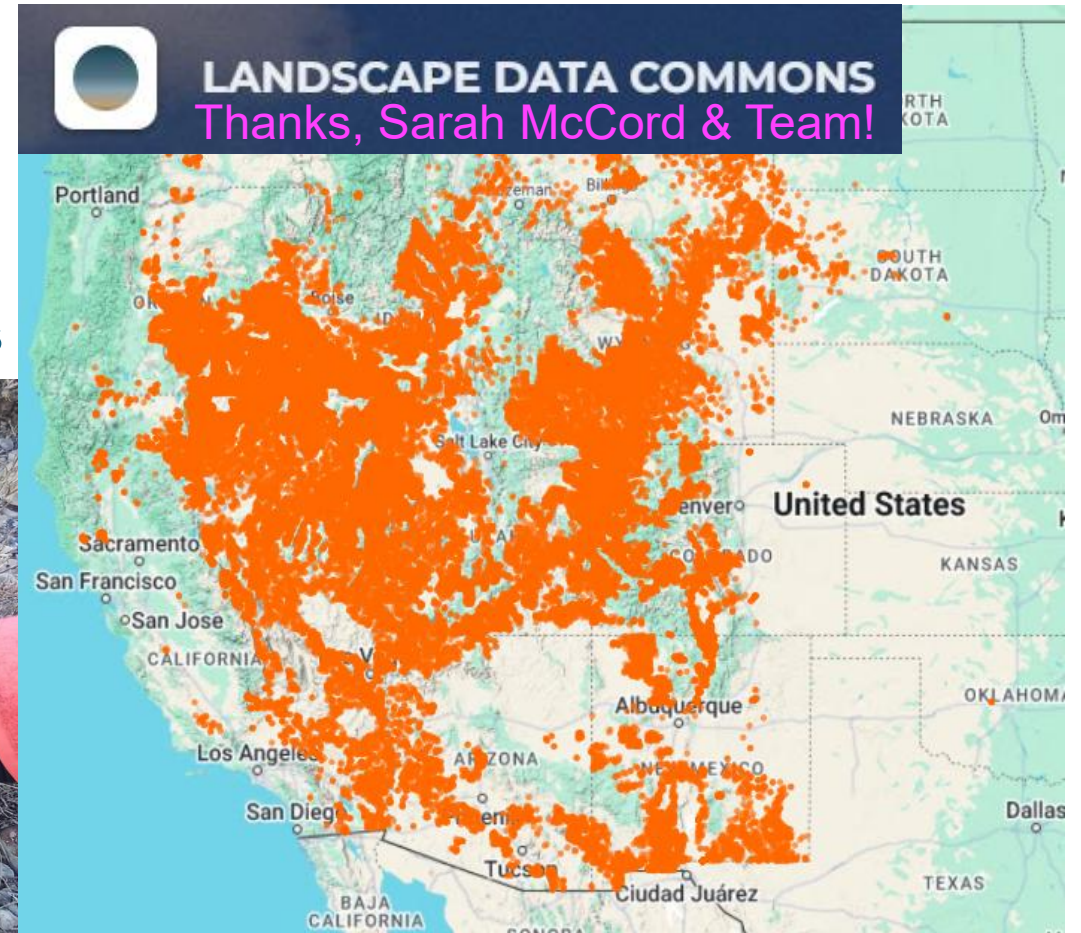
Litter Cover Proxies



Field-Based Litter Biomass Measurements

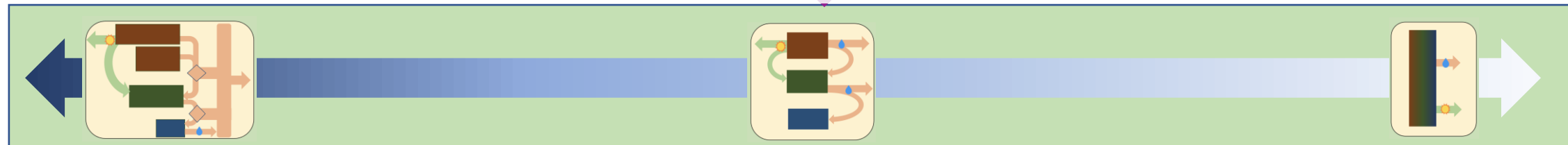
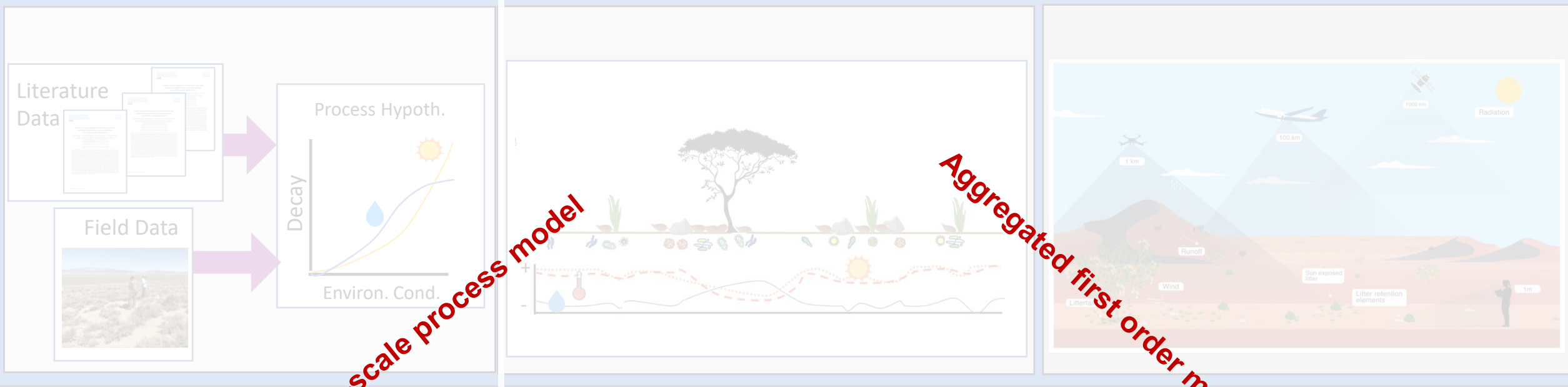


Field-Based Litter Cover Measurements



<https://landscapedatacommons.org/ldc-map>

Preliminary validation



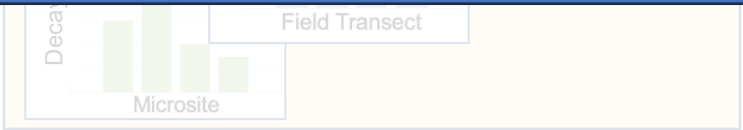
Daryl Moorhead



Kathe Todd-Brown



Hierarchical Continuum of Models



Emerging dryland decomposition network:

Decomposition Across Drylands Network (DeAD Net)

Please join us for:

- Distributed experiments
- Data rescue & synthesis efforts
- Other SRER collaborations!

Website



Mailing List



drylands.asu.edu/DeADWeb/

