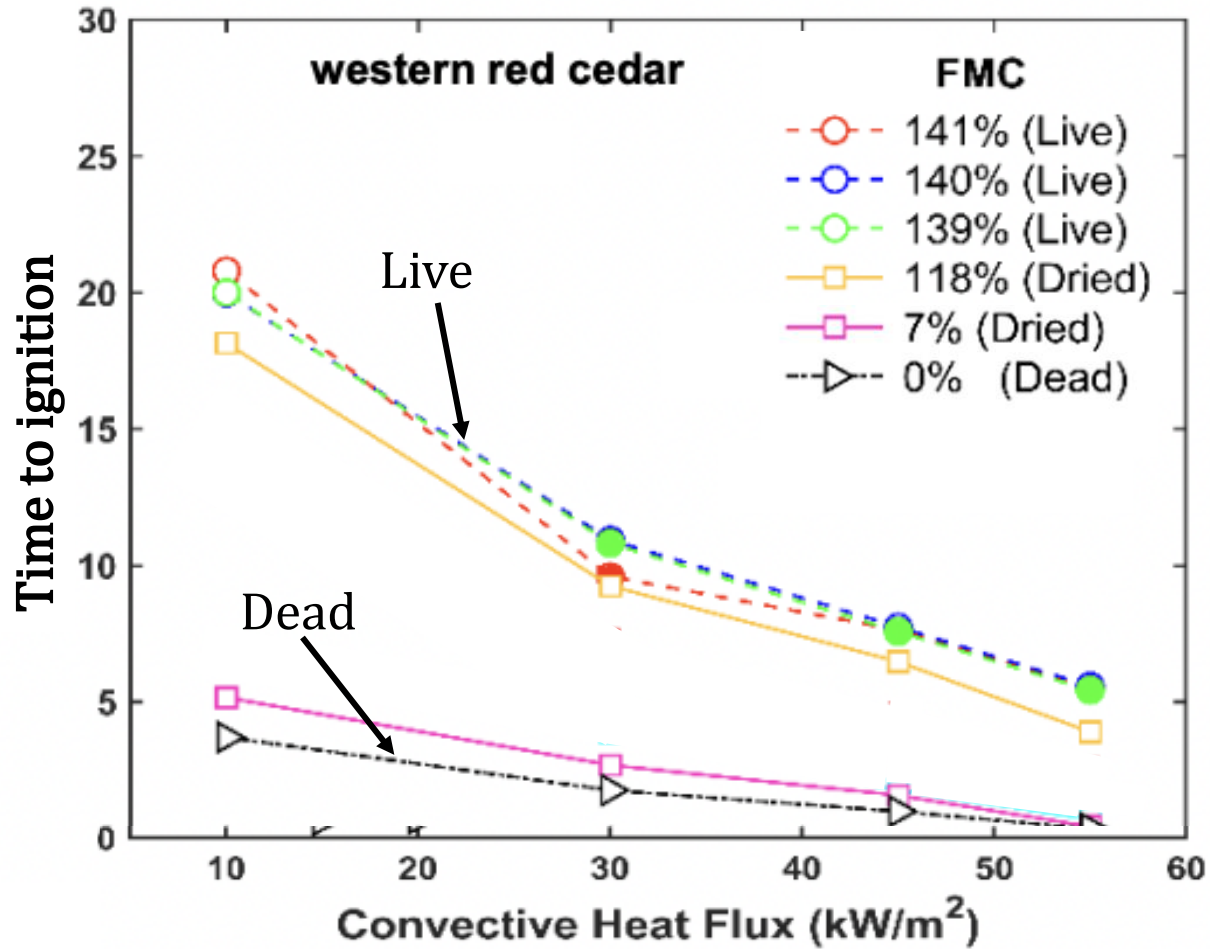


Effects of fuel moisture on fire spread change with grass curing

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- 1. Ecology & Evolutionary Biology, Yale University, New Haven, USA*
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But not all fuel moisture is created equal



Live (woody) fuels take longer to ignite than dead fuels

But not all fuel moisture is created equal

Live fuels take longer to ignite than dead fuels

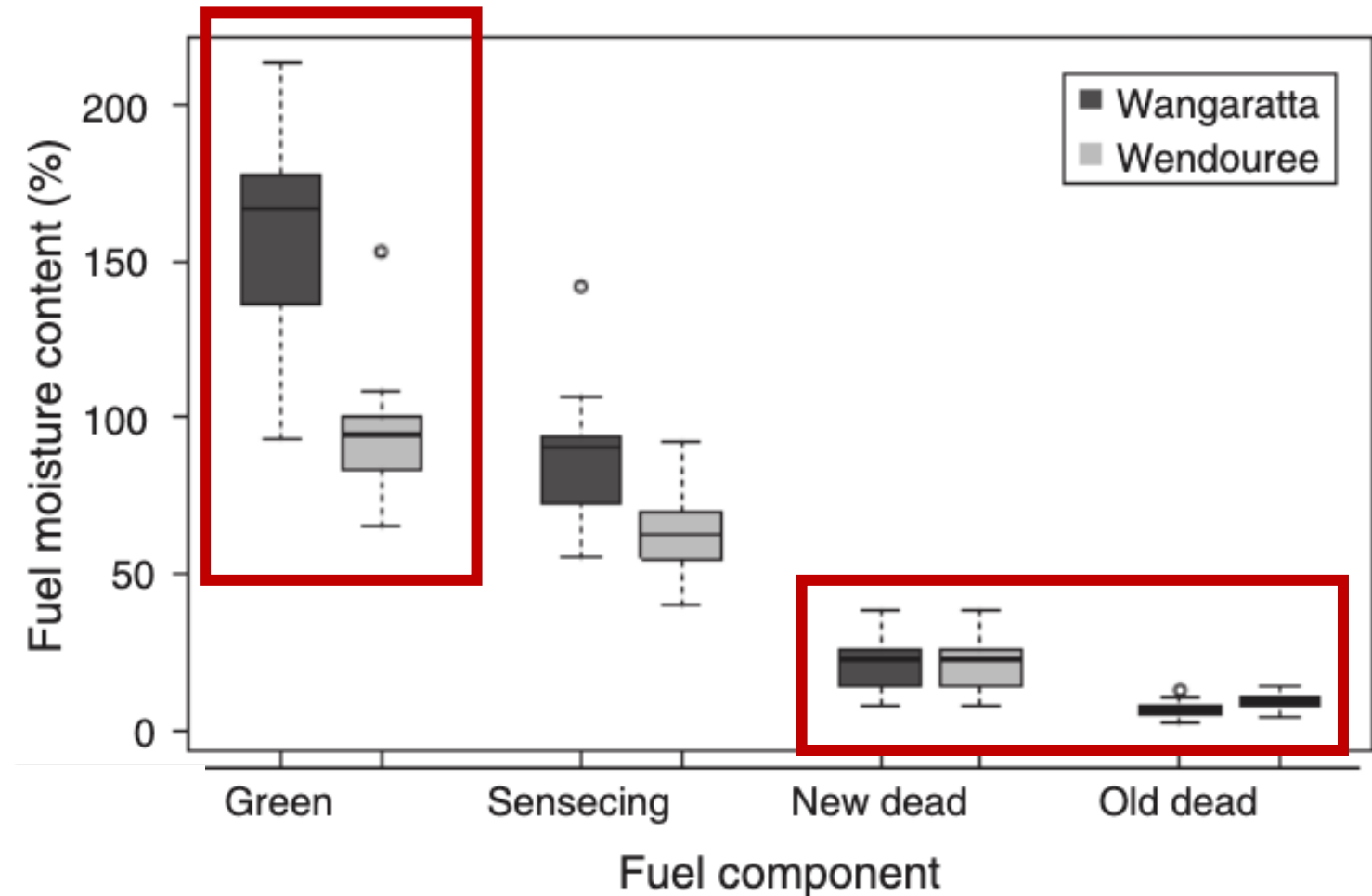
Why?

But not all fuel moisture is created equal

Live fuels take longer to ignite than dead fuels

Why?

a. They're wetter



But not all fuel moisture is created equal

Live fuels take longer to ignite than dead fuels

Why?

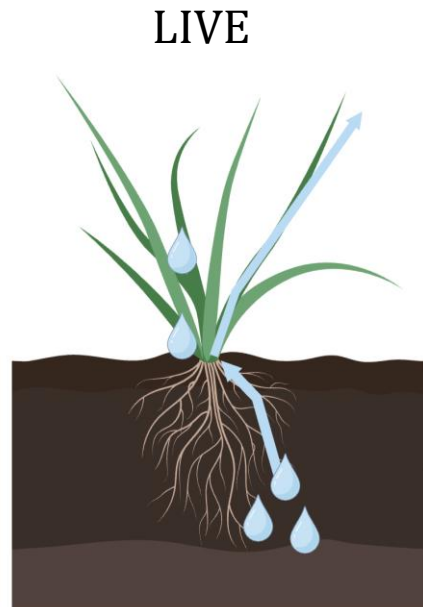
- a. They're wetter
- b. They store (and release?) water differently

But not all fuel moisture is created equal

Live fuels take longer to ignite than dead fuels

Why?

- a. They're wetter
- b. They store (and release?) water differently

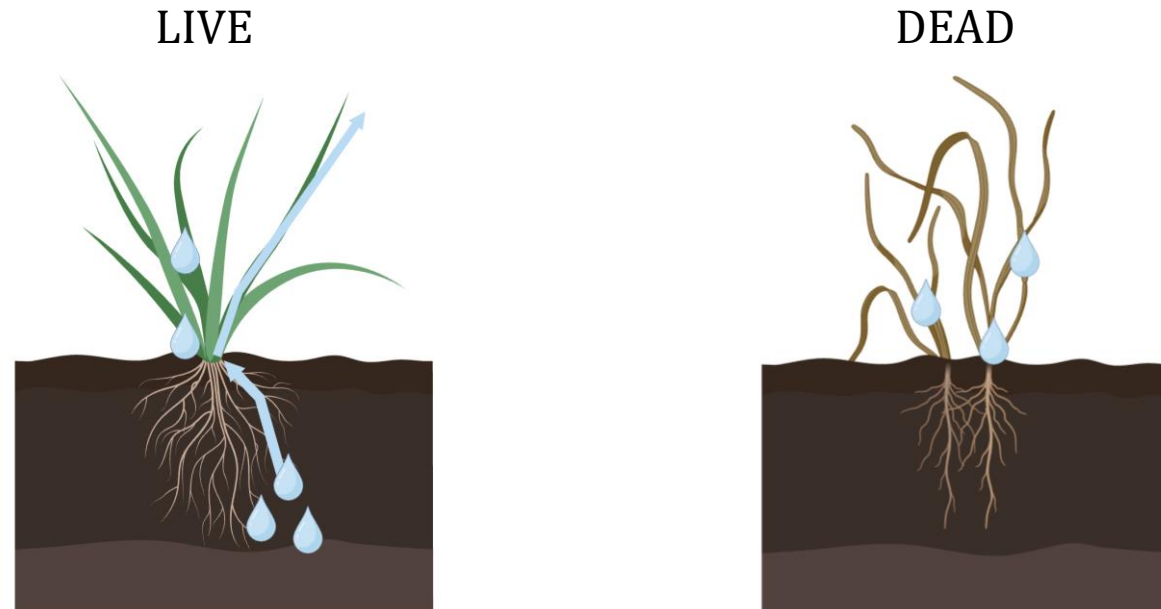


But not all fuel moisture is created equal

Live fuels take longer to ignite than dead fuels

Why?

- They're wetter
- They store (and release?) water differently



Model frameworks differentiate between live and dead fuels

Dead fuel moisture content values (percent) for the dead fuel moisture scenarios.

	D1 Very low	D2 Low	D3 Moderate	D4 High
1-hr	3	6	9	12

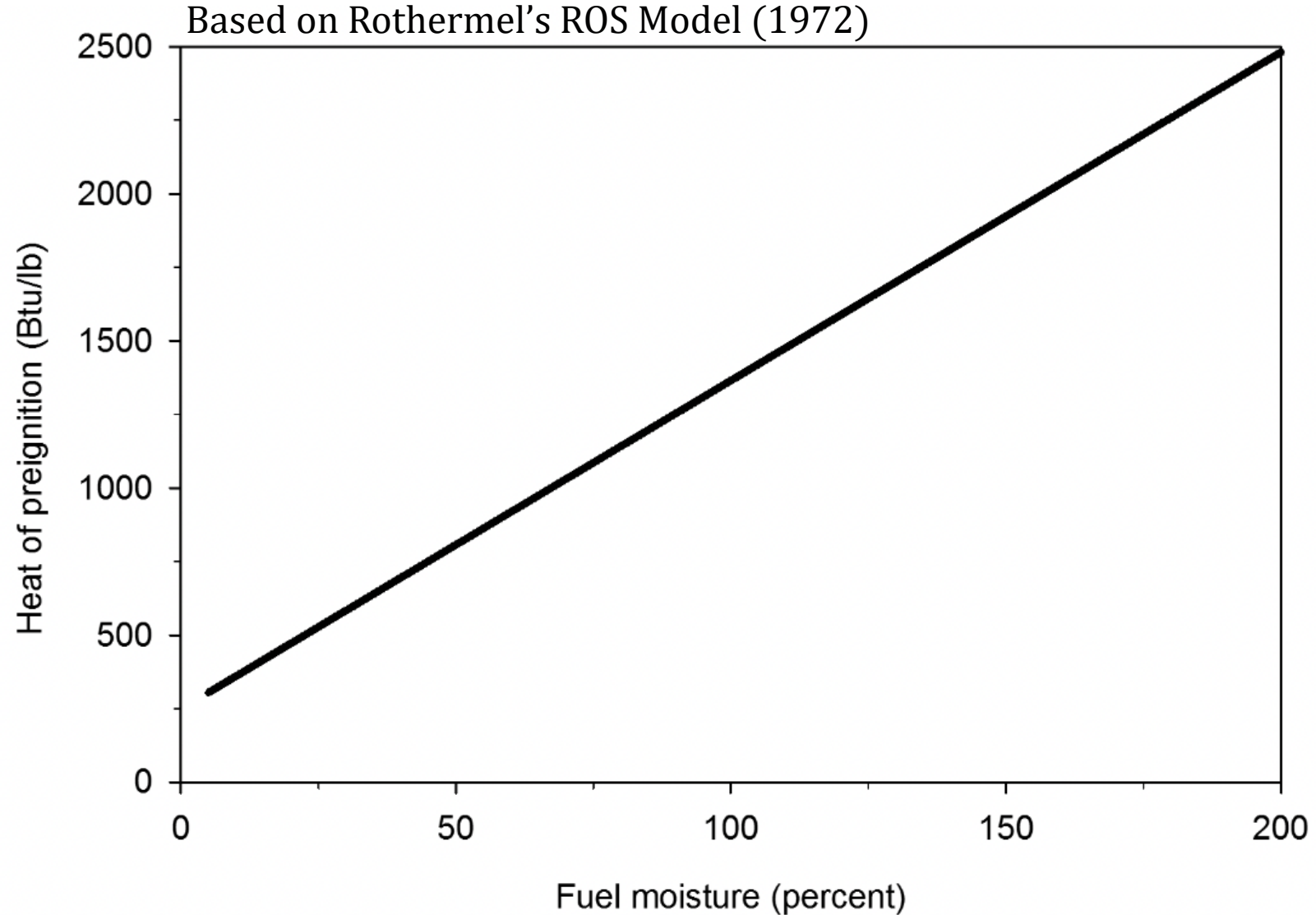
LFMC values are higher than DFMC

Live fuel moisture content values (percent) for the live fuel moisture scenarios.

	L1 <u>Fully cured</u> Very low	L2 <u>Two-thirds cured</u> Low	L3 <u>One-third cured</u> Moderate	L4 <u>Fully green (uncured)</u> High
Live herbaceous	30	60	90	120

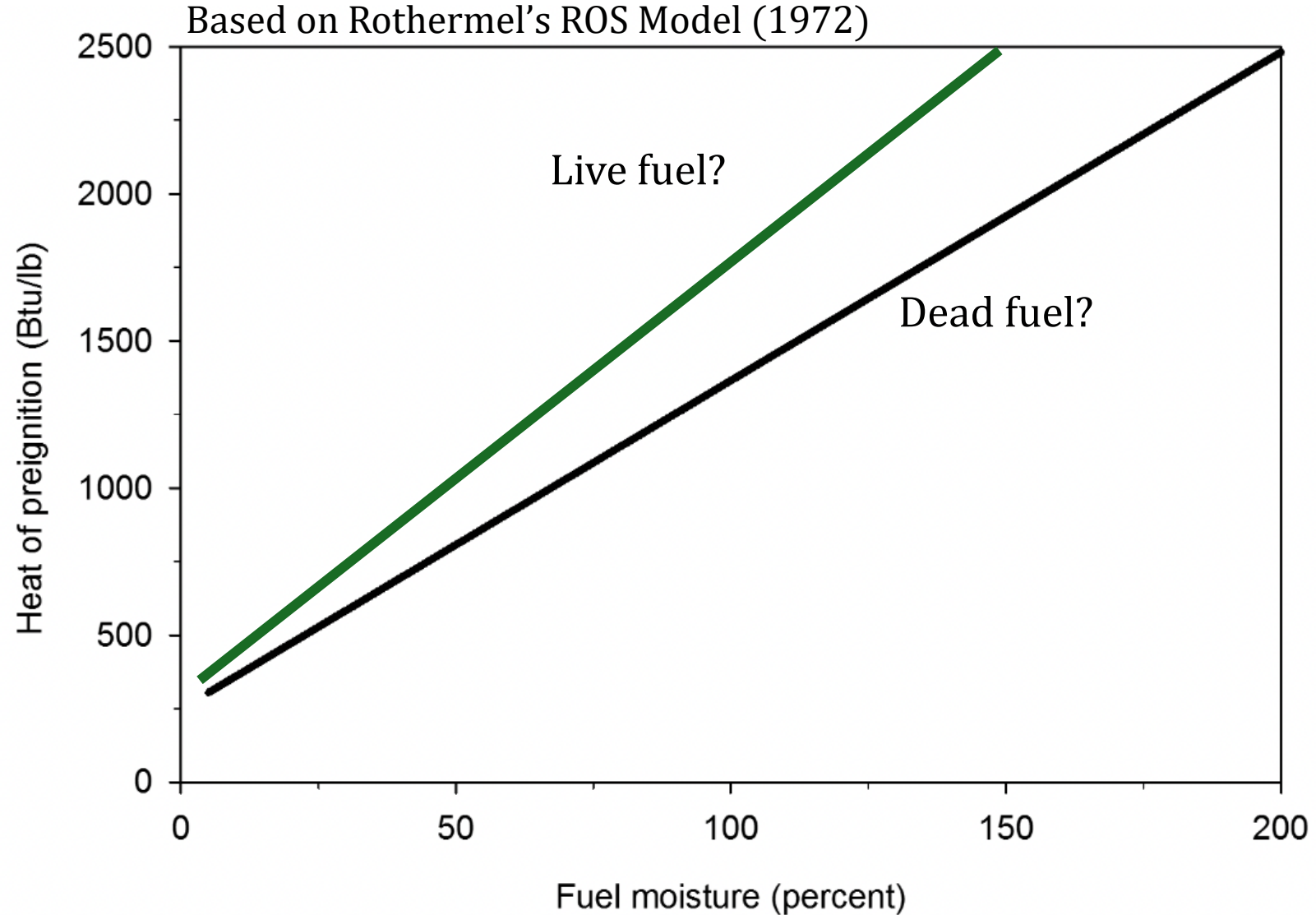
The impact of different water storage is less recognized

Live and dead fuel moisture have the same relationship to the heat needed to ignite fuels



The impact of different water storage is less recognized

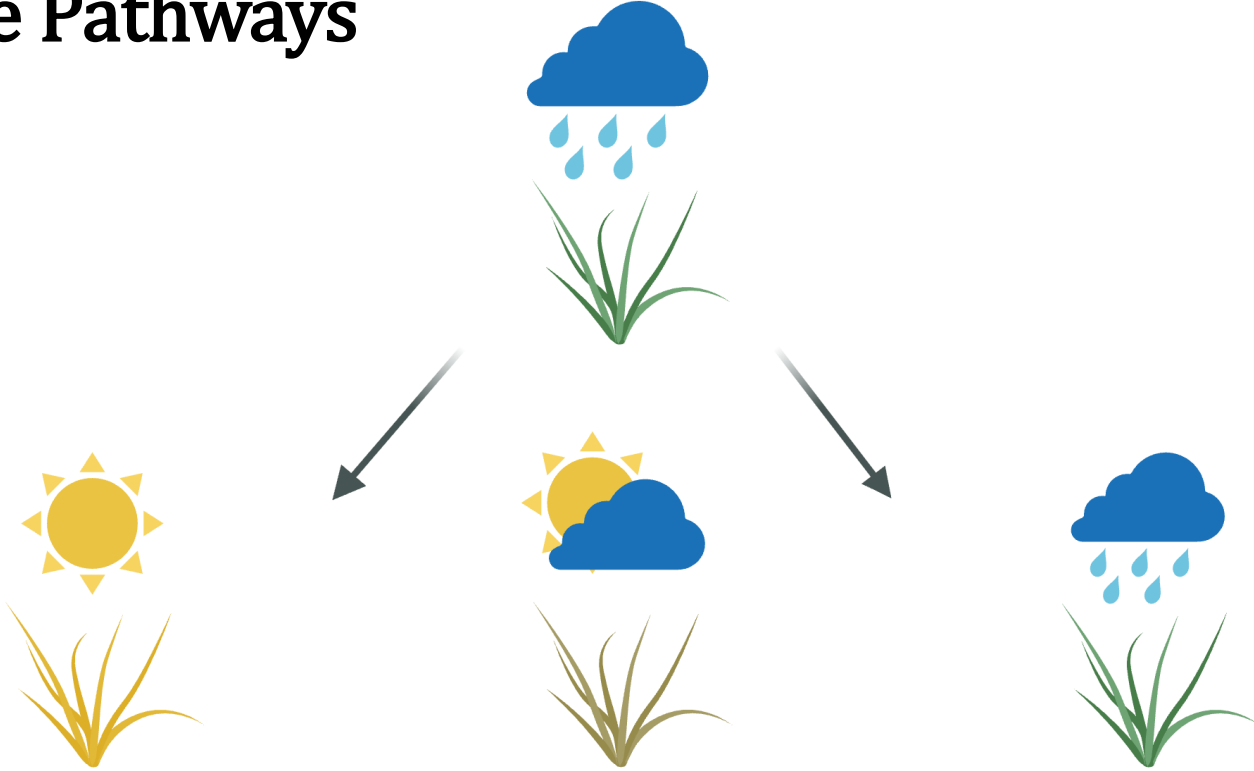
Should we differentiate between live fuels (water inside cells) and dead fuels (water outside)?



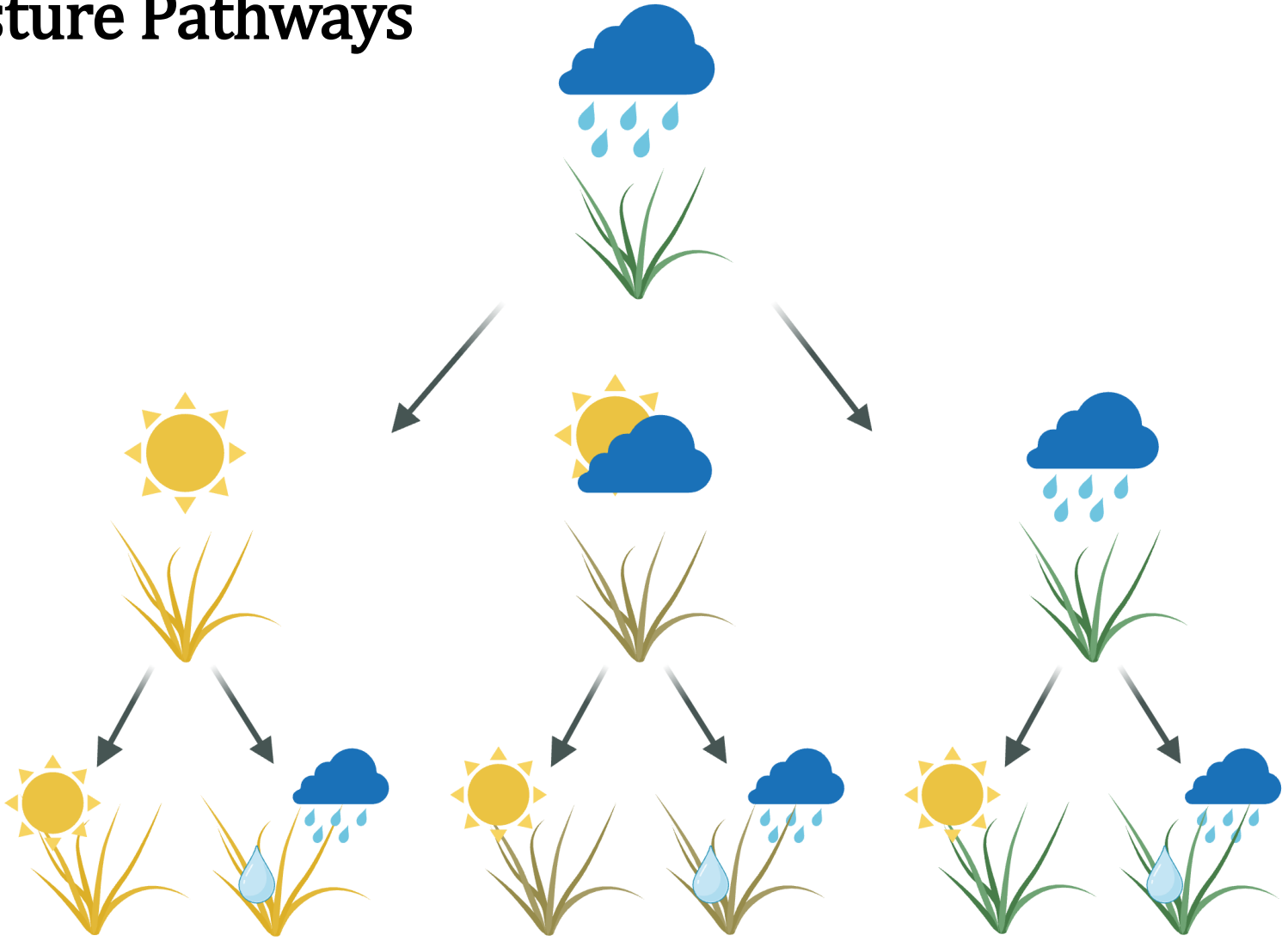
Potential Moisture Pathways



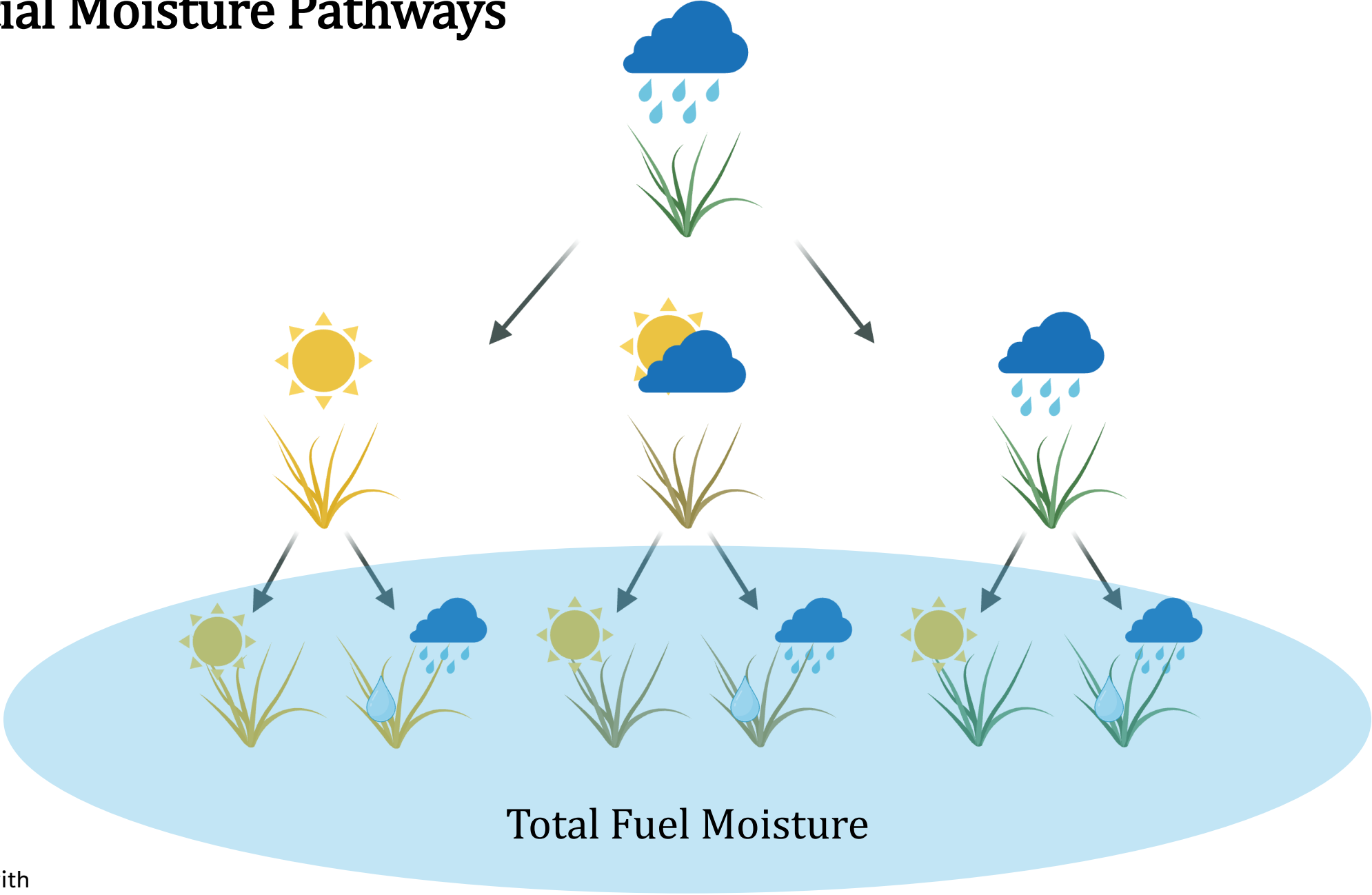
Potential Moisture Pathways



Potential Moisture Pathways



Potential Moisture Pathways



Potential Moisture Pathways

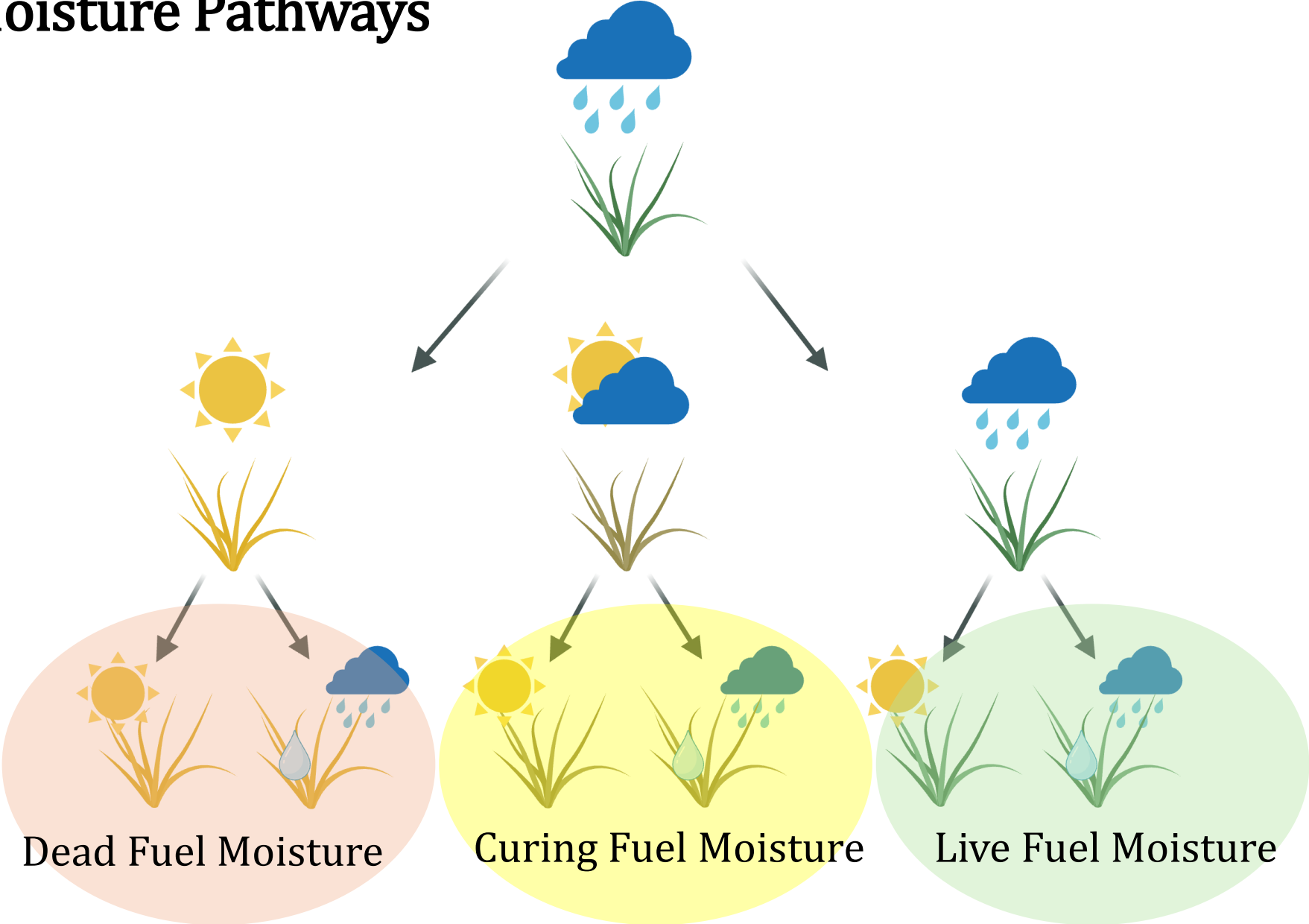


Figure created with BioRender.com

Potential Moisture Pathways

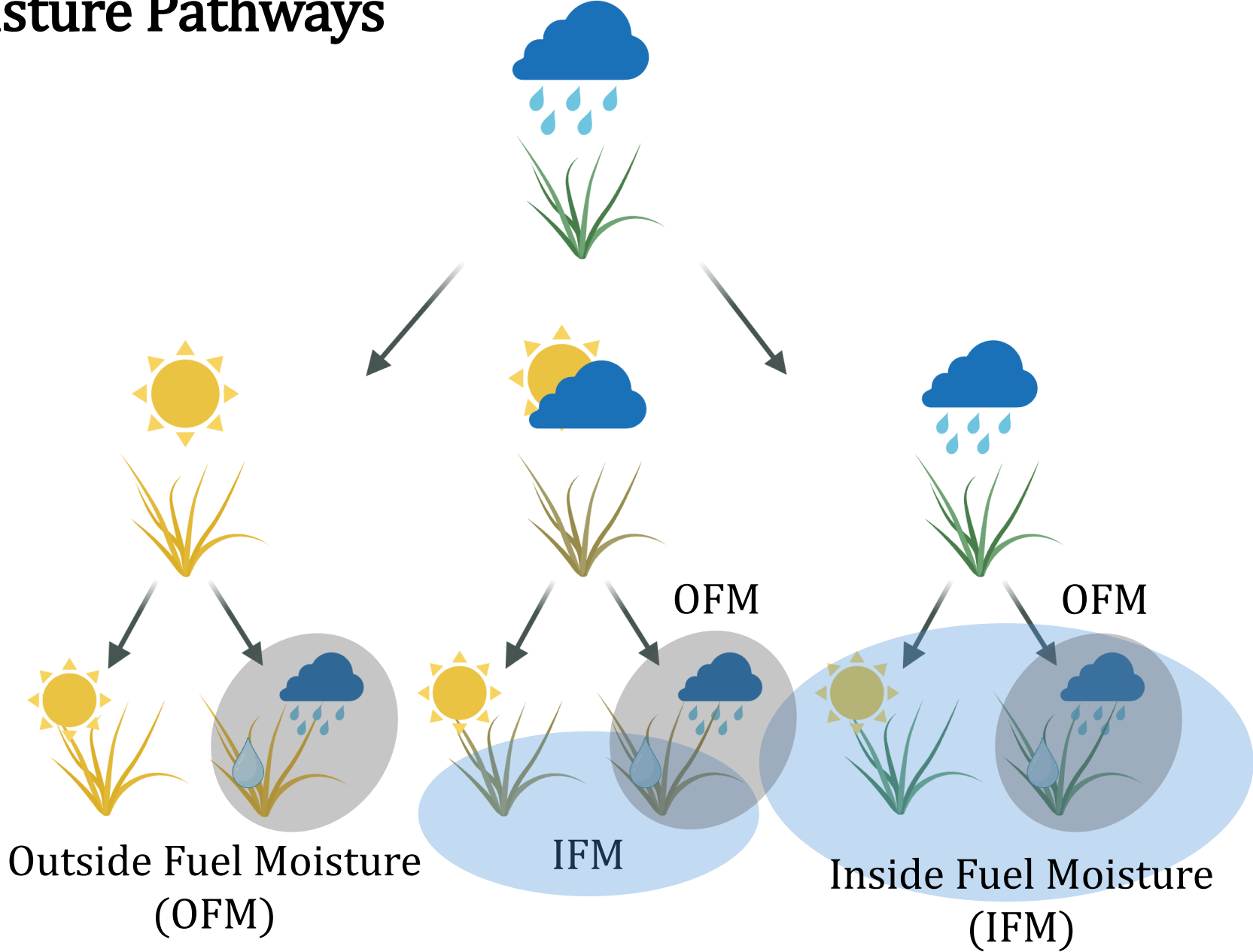
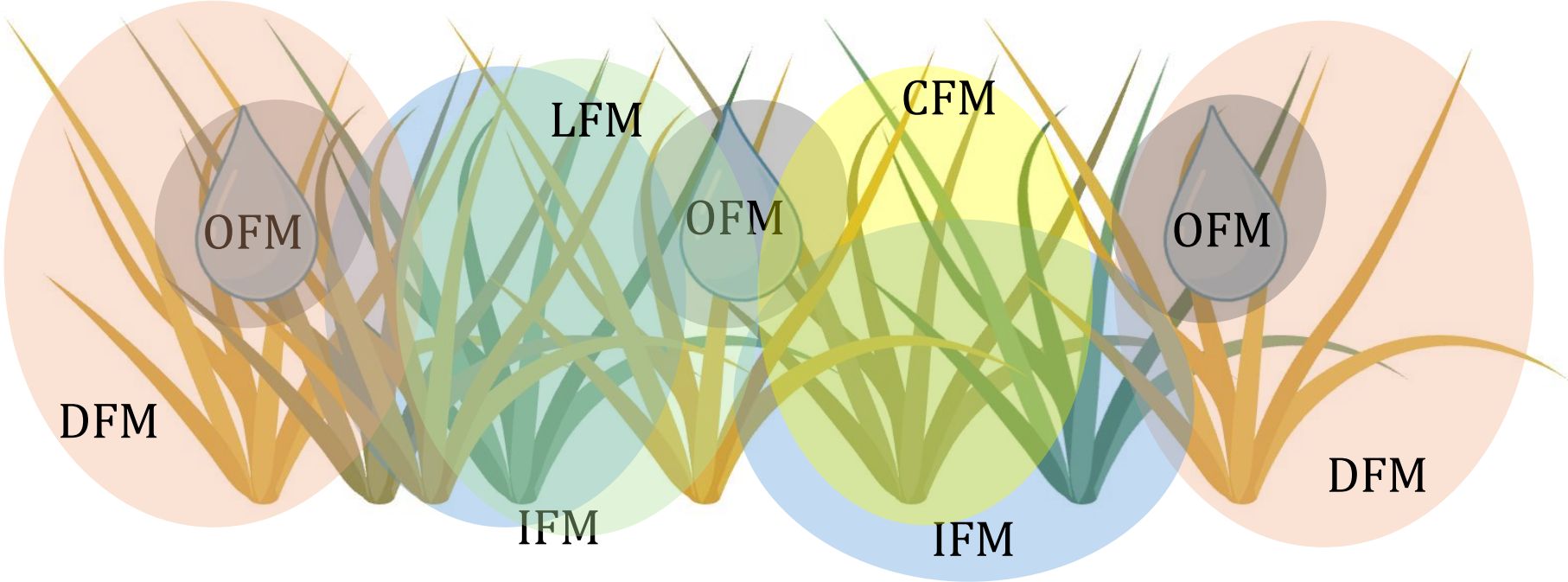


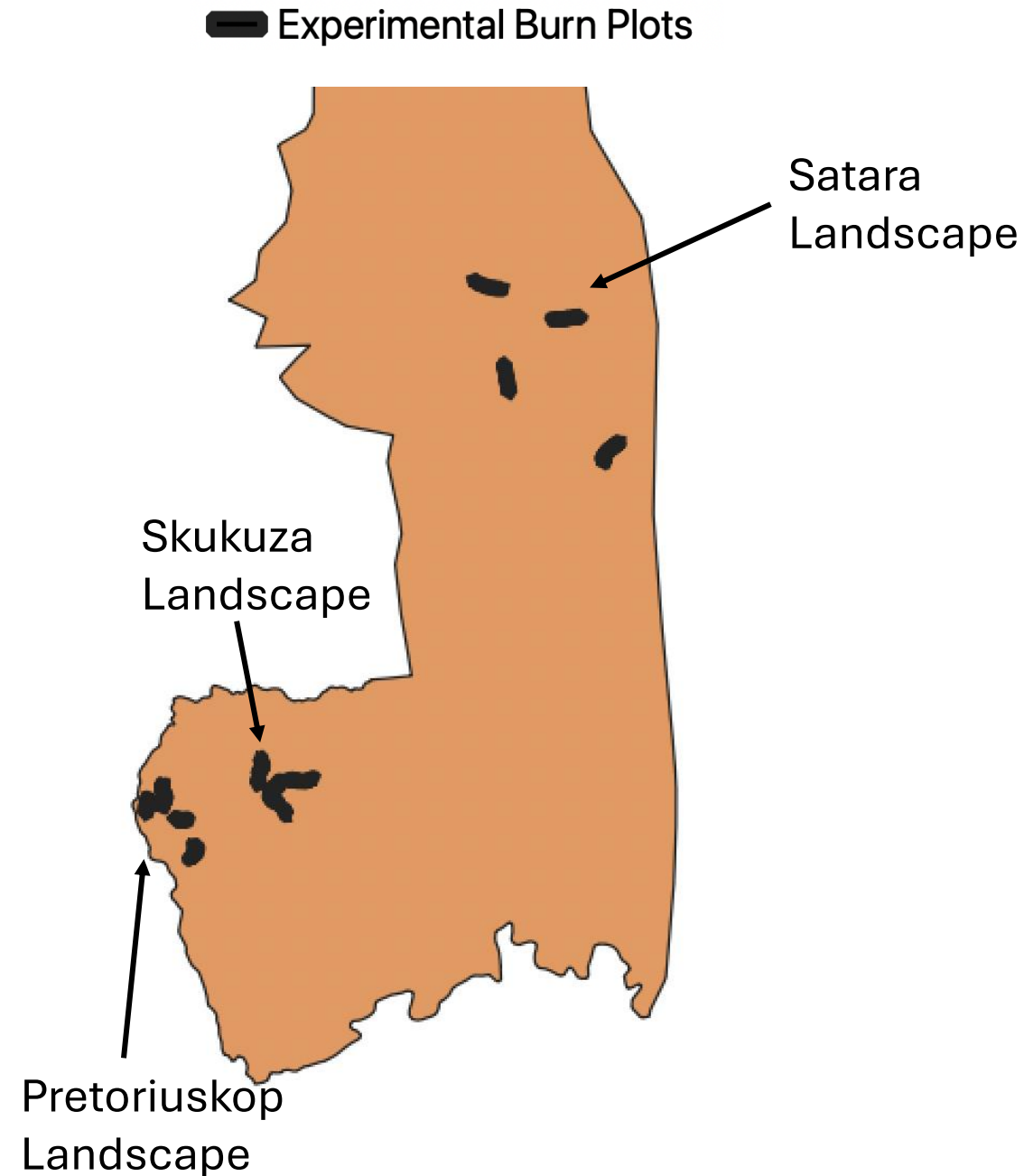
Figure created with BioRender.com

Potential Moisture Pathways

In the field, categories are mixed
Sort them to identify individual categories



Sampling Location



Fuel Variables:

- Biomass (DPM)
- Fuel Moistures

Weather Variables:

- Relative Humidity (%)
- Wind Speed (m/s)

Fire Variables:

- Maximum Fire Temperature
- Average Fire Temperature
- Rate of Spread
- Residence Time



Fuel Variables:

- Biomass (DPM)
- Fuel Moistures

Weather Variables:

- Relative Humidity (%)
- Wind Speed (m/s)

Fire Variables:

- **Maximum Fire Temperature**
- Average Fire Temperature
- **Rate of Spread**
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Determining inside and outside moisture

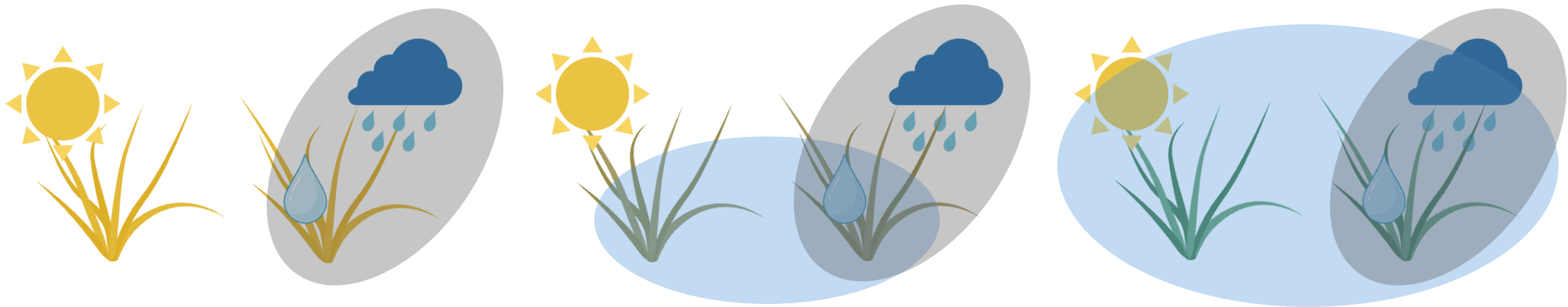
Sample Outside Water (%) = Dead Fuel Moisture (%)



Determining inside and outside moisture

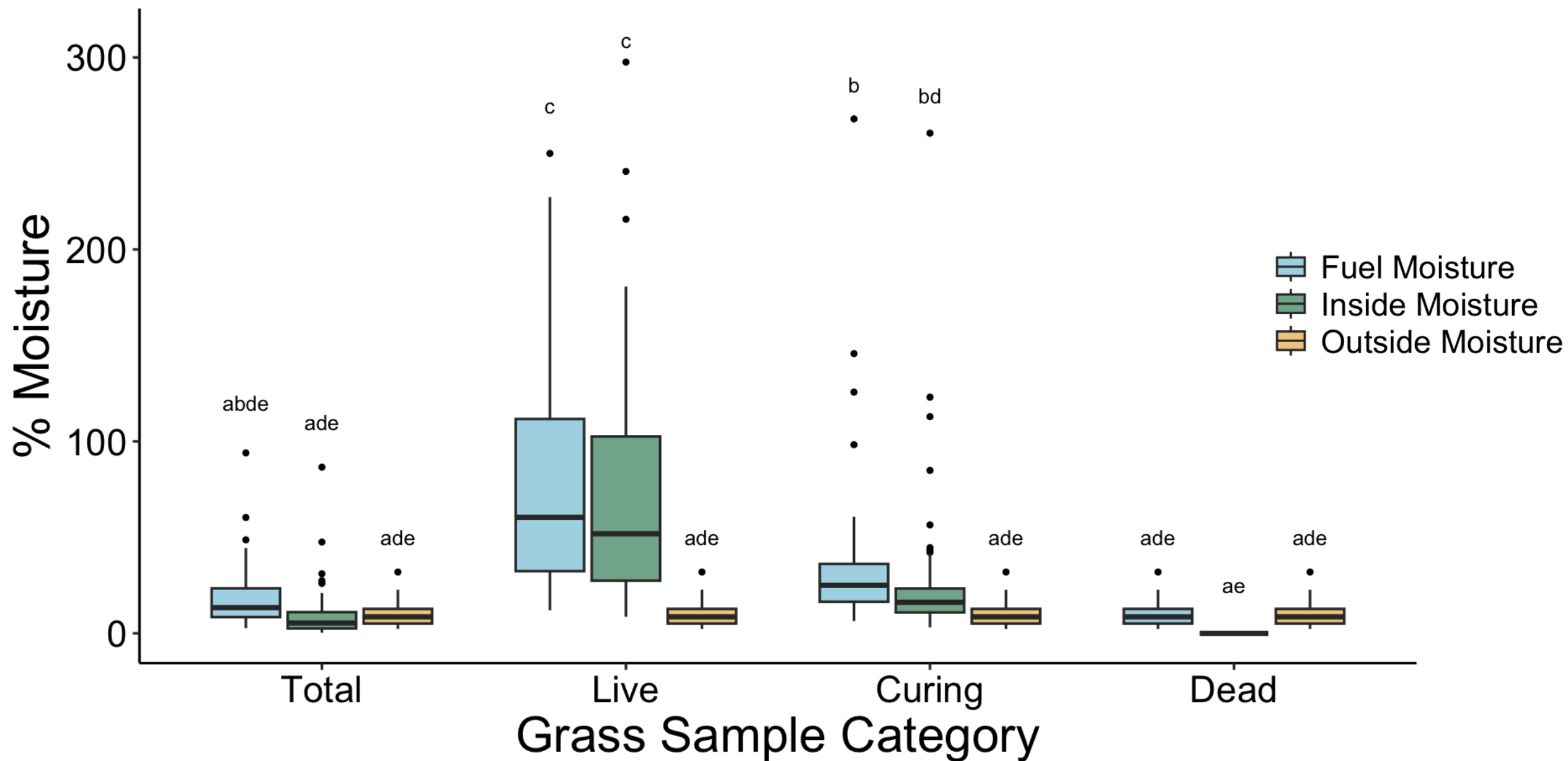
Sample Outside Water (%) = Dead Fuel Moisture (%)

Sample Inside Water (%) = Sample Fuel Moisture (%) – Dead Fuel Moisture (%)



Total live moisture > Total curing moisture > Total dead moisture

Plot excludes 2 live > 300 % FM



Modeling Framework

Multiple Linear Regression

Fire Characteristic ~

Log(Biomass) +

Total Outside Water + Log(Total Inside Water) +

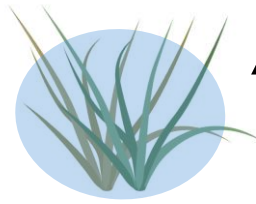
Total Fuel Moisture + Live Fuel Moisture + Curing Fuel Moisture + Dead Fuel Moisture +

Live Inside Moisture + Senescing Inside Moisture +

RH + Wind Speed

Model Selection Criteria

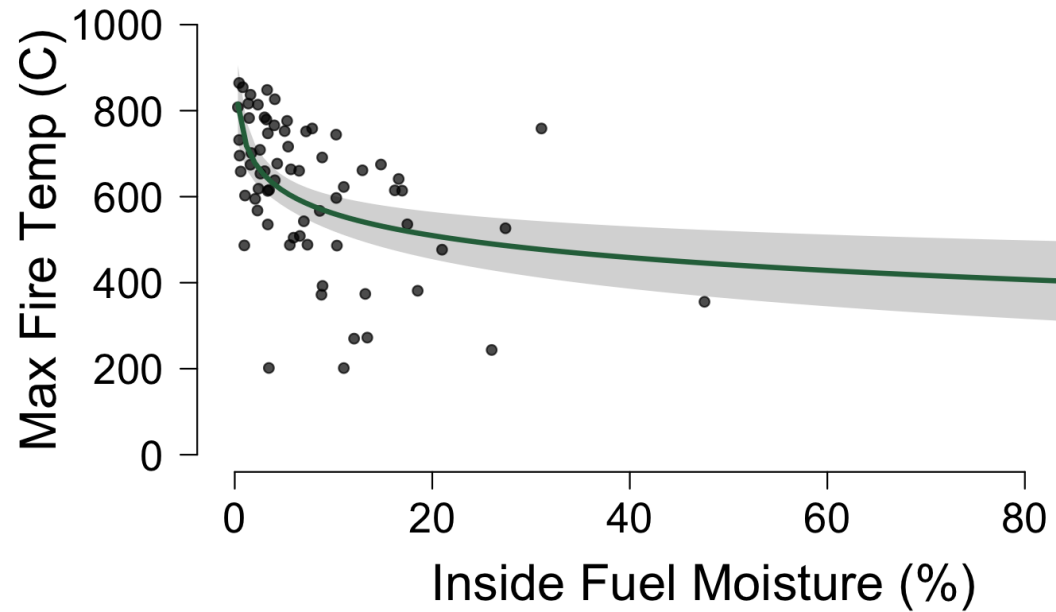
Lowest AICc within 2 and fewest degrees of freedom



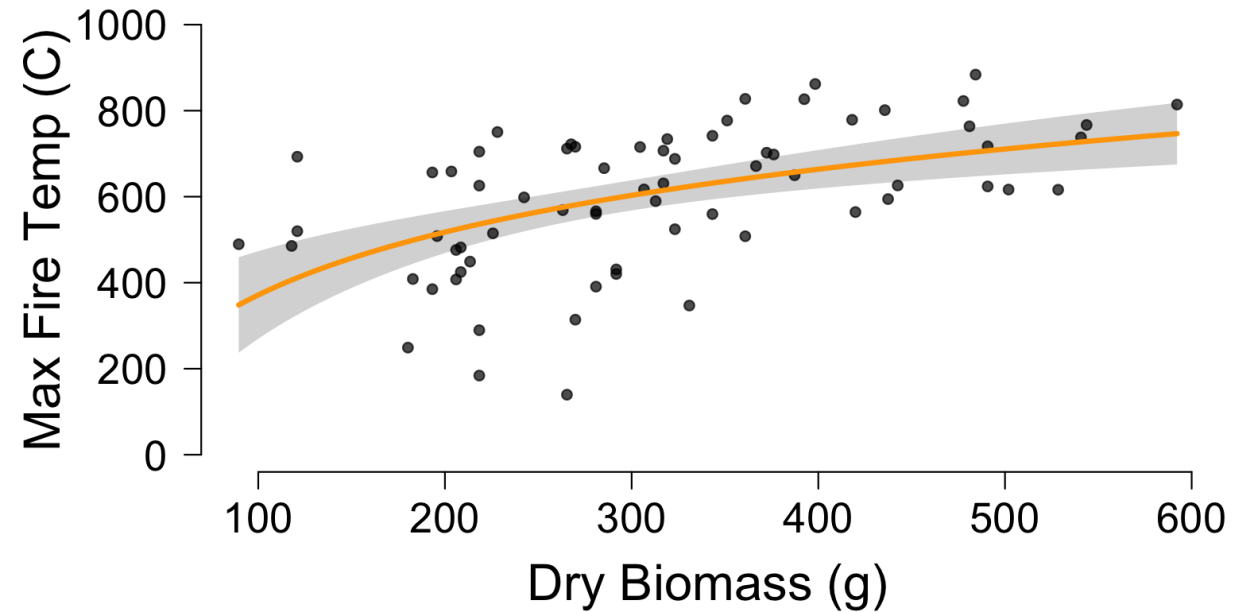
↑ Inside fuel moisture = ↓ Max Fire Temp

Partial Residuals:

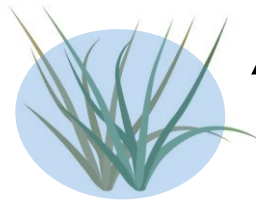
Inside moisture



Biomass



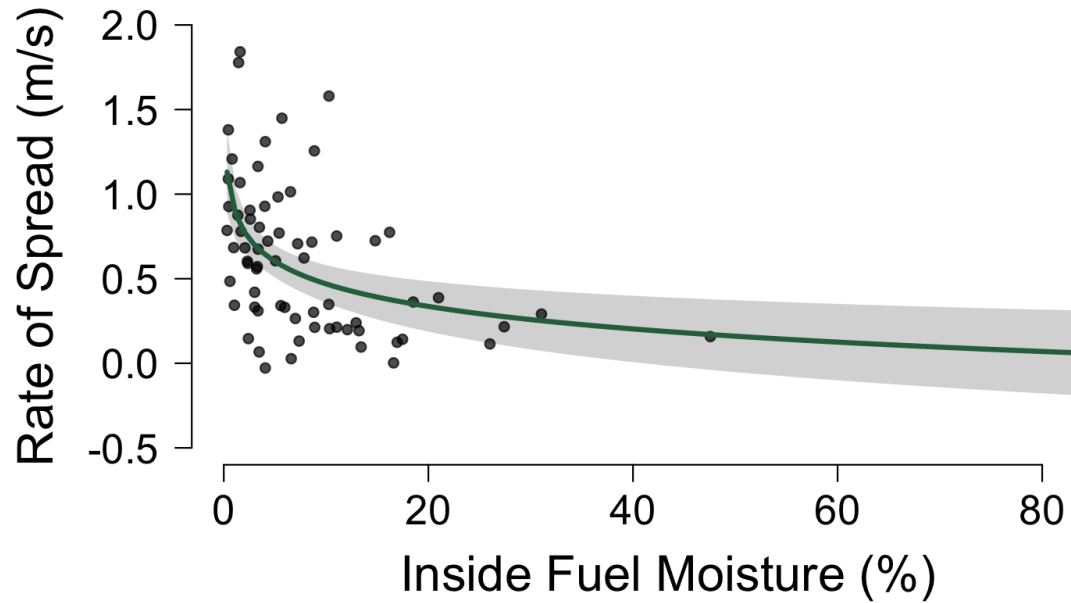
$R^2 = 0.39$
 $df = 4$
 $p \ll 0.05$



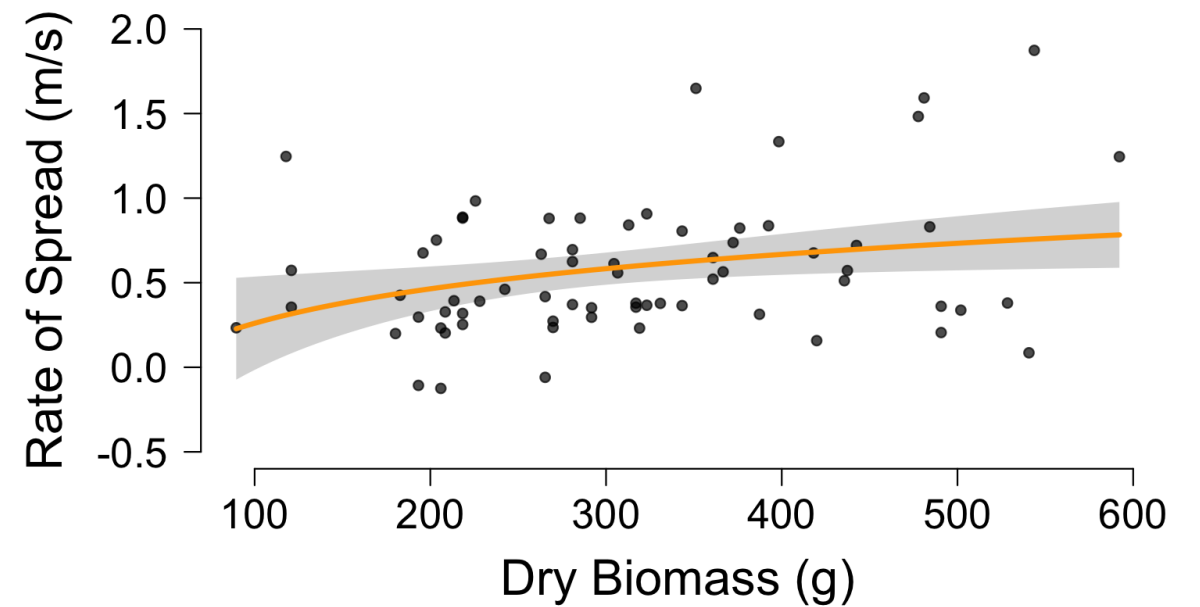
↑ Inside fuel moisture = ↓ Rate of spread

Partial Residuals:

Inside moisture



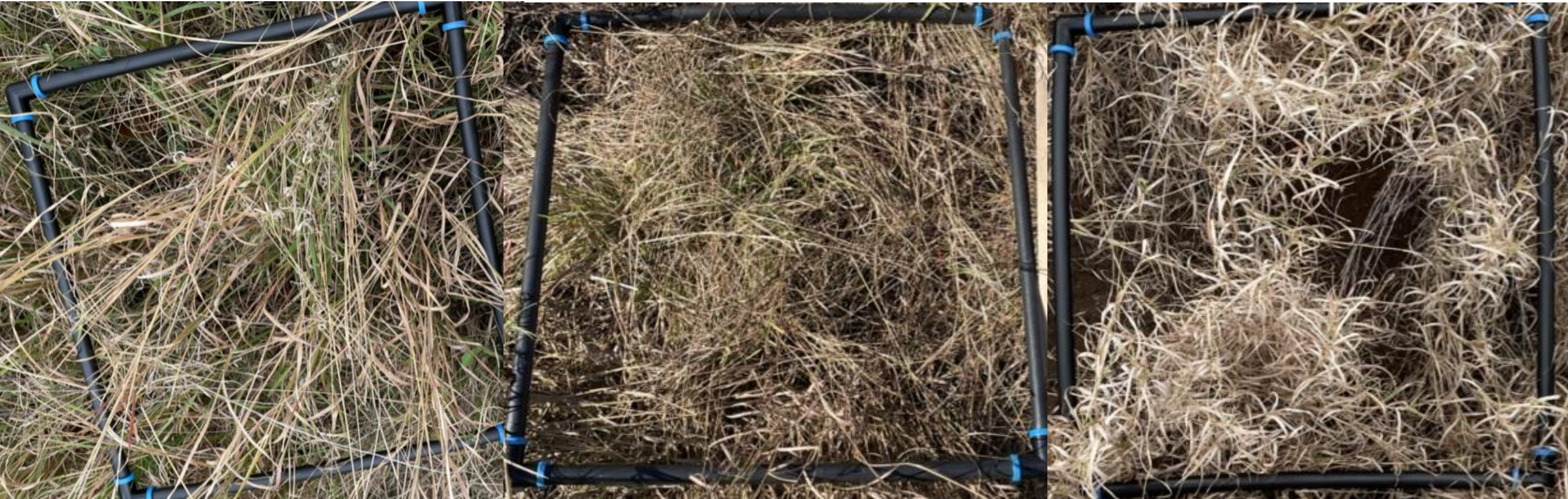
Biomass



$R^2 = 0.27$
 $df = 4$
 $p \ll 0.05$

Takeaway

Inside fuel moisture (within live and curing grasses) better explains fire maximum temp. and rate of spread compared to overall or outside fuel moisture



Potential Implications

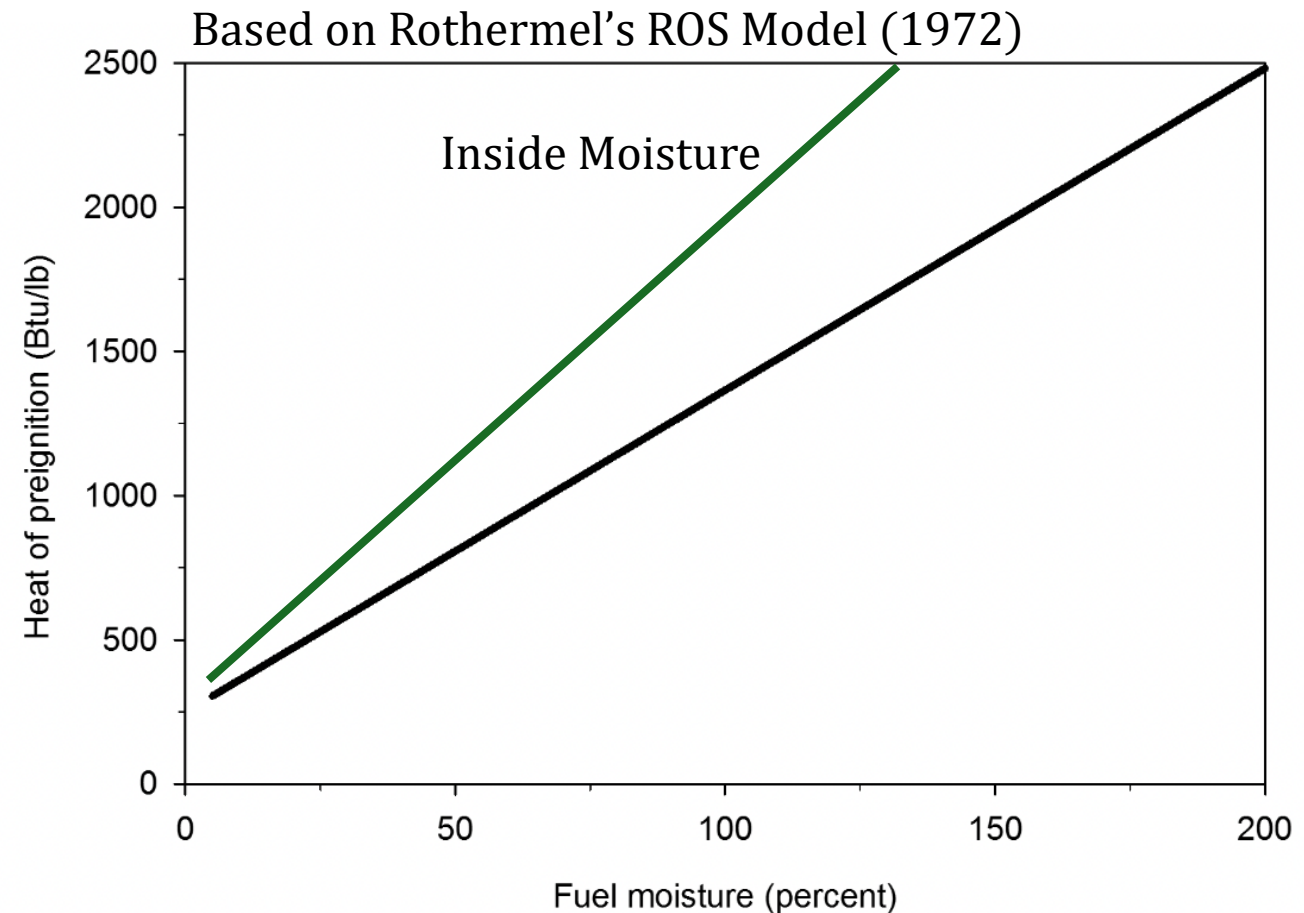
Should we determine heat of preignition differently for inside and outside water?

$$Q_{ig} = f(\text{Overall Fuel Moisture})$$



$$(Q_{ig})_{\text{Inside Water}} = f(\text{Inside Moisture})$$

$$(Q_{ig})_{\text{Outside Water}} = f(\text{Outside Moisture})$$



Potential Implications

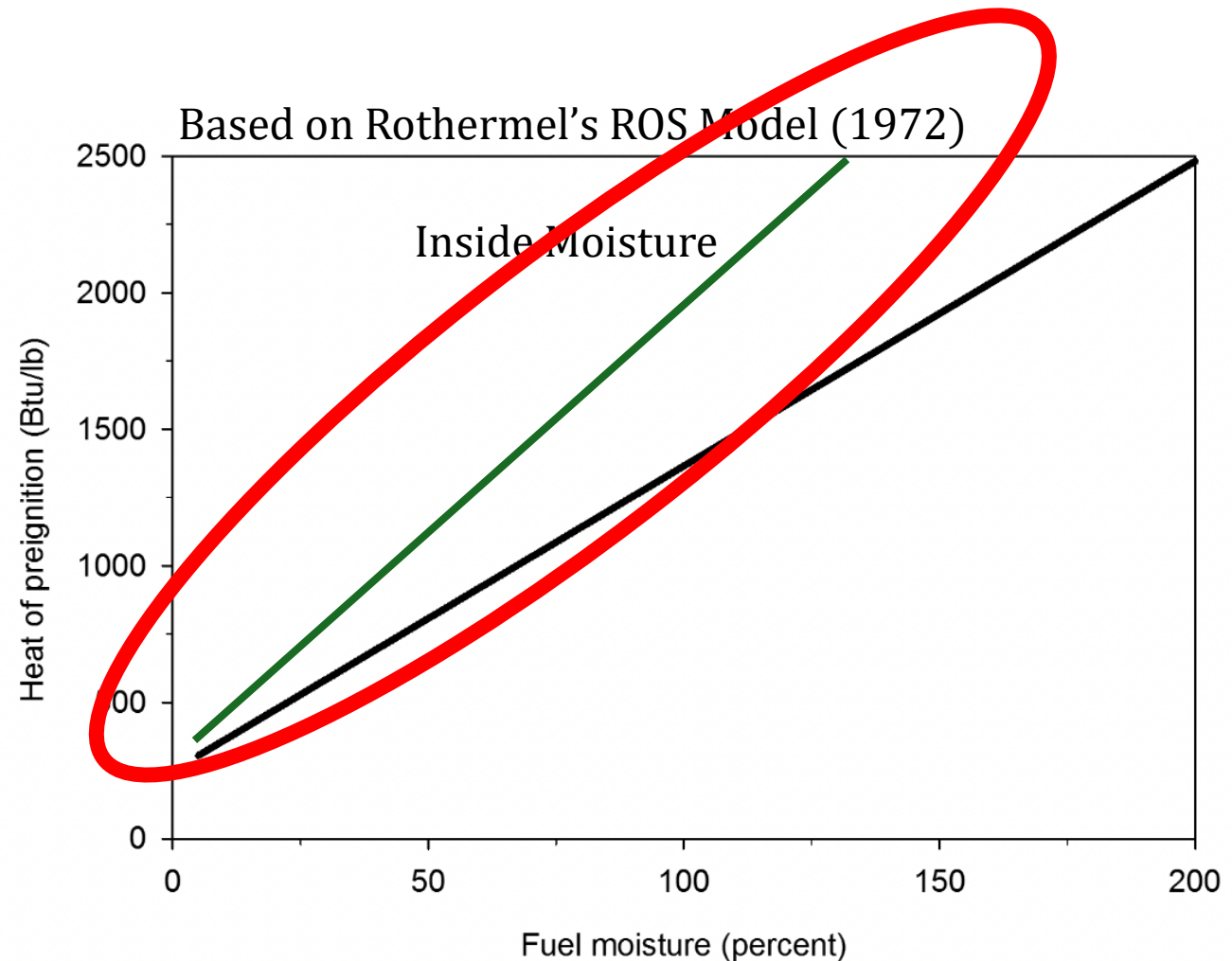
Should we determine heat of preignition differently for inside and outside water?

$$Q_{ig} = f(\text{Overall Fuel Moisture})$$



$$(Q_{ig})_{\text{Inside Water}} = f(\text{Inside Moisture})$$

$$(Q_{ig})_{\text{Outside Water}} = f(\text{Outside Moisture})$$



Questions?

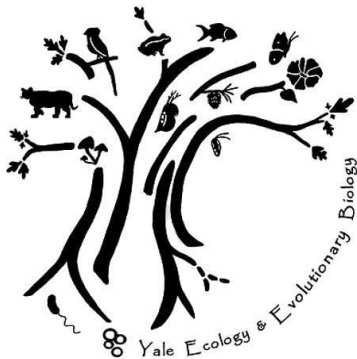
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