Diurnally varying drivers of dry season decomposition

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Allison Lab

Traditional Model

Three primary parameters:

- Temperature
- Moisture
- Litter quality

Meentemeyer 1978, Parton et al. 1987

$$Y_1 = -1.31369 + 0.05350 \cdot x_1 + 0.18472 \cdot x_2$$

Y_1 = % mass loss
x_1 = annual AET
x_2 = annual AET / % lignin of litter

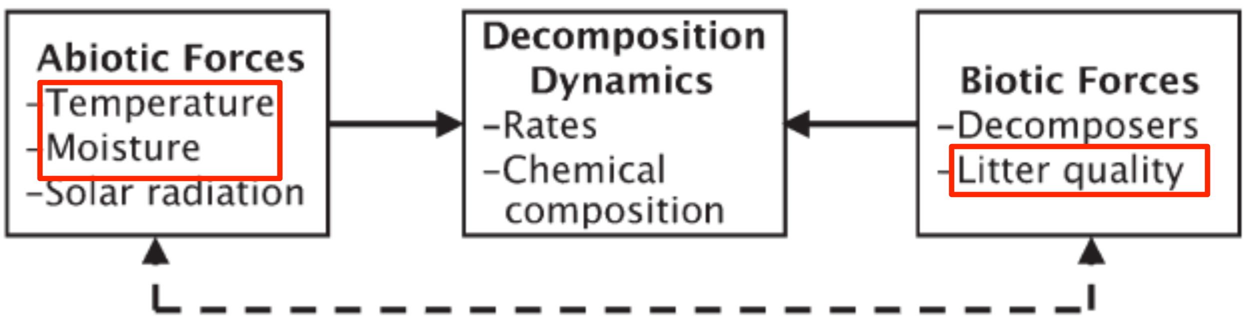


Fig. 1 Direct and indirect drivers of decomposition as traditionally addressed by decomposition studies. Biotic and abiotic facts are assumed to affect decomposition dynamics either directly (*solid lines*) or indirectly by affecting other processes (*dashed lines*)

Throop & Archer 2009, *Progress in Botany 70*

Lack of fit for drylands

The failure of nitrogen and lignin control of decomposition in a North American desert

Douglas Schaefer[1], Yosef Steinberger[2], and Walter G. Whitford
Department of Biology, New Mexico State University, Las Cruces, NM 88003, USA

Schaefer et al. 1985, *Oecologia*

	Actual	Predicted
Annuals	61.7 ± 7.8	15.7
Flourensia cernua	40.8 ± 4.6	16.0
Larrea tridentata	35.1 ± 12.6	15.6
Prosopis glandulosa	30.6 ± 4.9	17.0
Chilopsis linearis	76.5 ± 11.5	14.4
Yucca elata	64.3 ± 18.5	15.9

Actual and predicted percent mass loss

EXCEPTIONS TO THE AET MODEL: DESERTS AND CLEAR-CUT FOREST[1]

W. G. Whitford[2], V. Meentemeyer[3], T. R. Seastedt[4], K. Cromack, Jr.[5], D. A. Crossley, Jr.[4], P. Santos[2,7], R. L. Todd[4], and J. B. Waide[6]

Whitford et al. 1981, *Ecology*

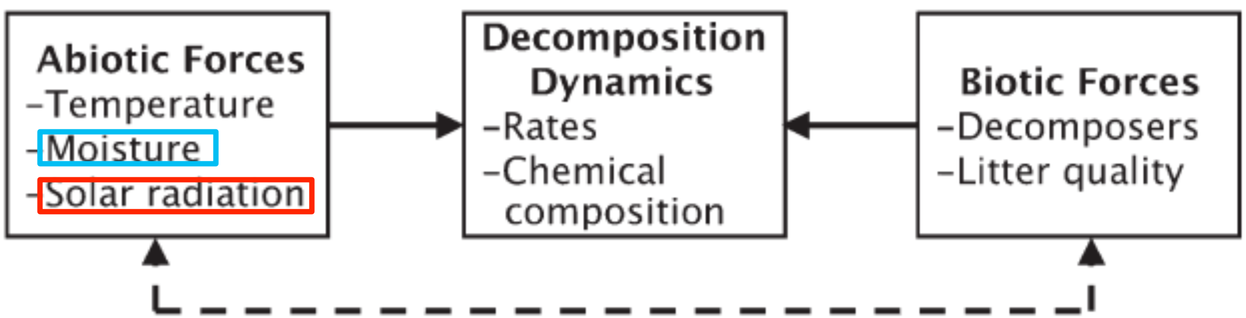
Duration of experiment	Loss of mass (%)	AET (mm)
January–February (59 d)	19.6	32.0
March–April (61 d)	25.5	5.4
June–July (61 d)	30.4	39.0
15 July–October (102 d)	38.7	93.4
November–February (120 d)	30.1	102.6
		272.4

Mass loss and AET

Why the discrepancy?

Added importance of two drivers:

- Photodegradation during day
- Decomposition facilitated by overnight humidity



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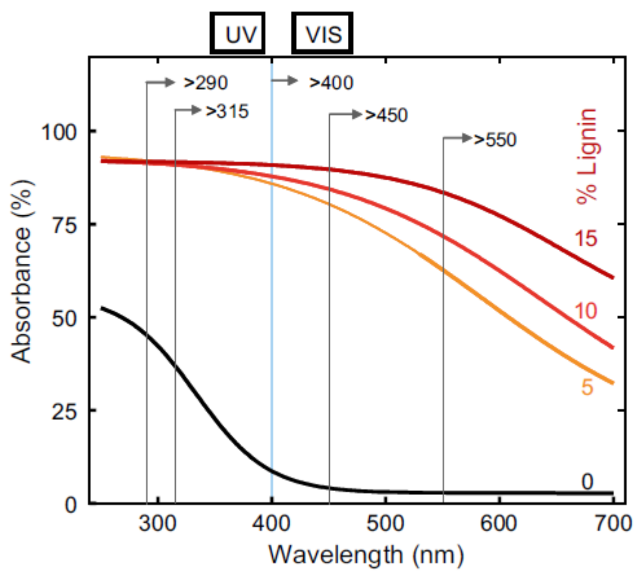
Throop & Archer 2009, *Progress in Botany 70*

Photodegradation

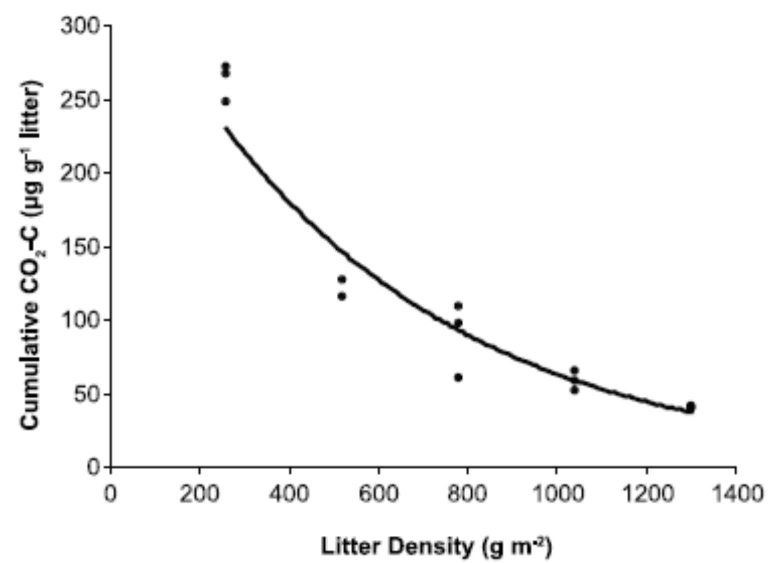
Absorption of UV radiation → free + peroxy radicals

- Preferentially affects lignin? (Moorhead & Callaghan 1994, Day et al. 2007)
- Preferentially affects labile C? (Austin and Vivanco 2006, Kieber et al. 1989)

Linear function of exposed surface area



Austin & Ballare 2010, *PNAS*

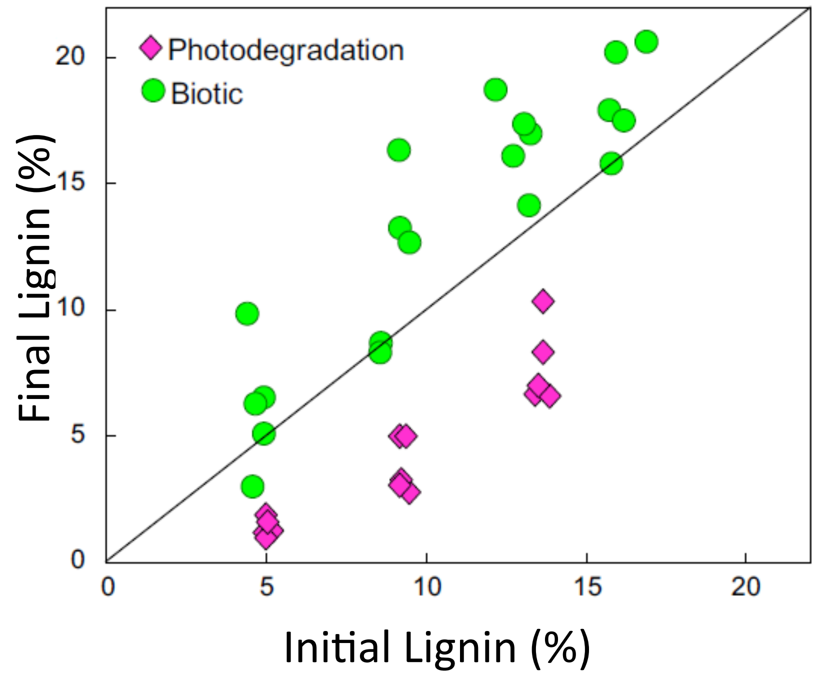


Brandt et al. 2009, *J. of Geophysical Research*

Suppression vs. Priming

UV radiation may:

- suppress microbial activity
- decrease extracellular enzyme stability (Gallo et al. 2009)



(Austin and Ballare 2010, *PNAS*)

Possible priming for wet season

- Breakdown of recalcitrant C
- Exposure of labile C behind cell walls

Diurnal priming for overnight decomposition?

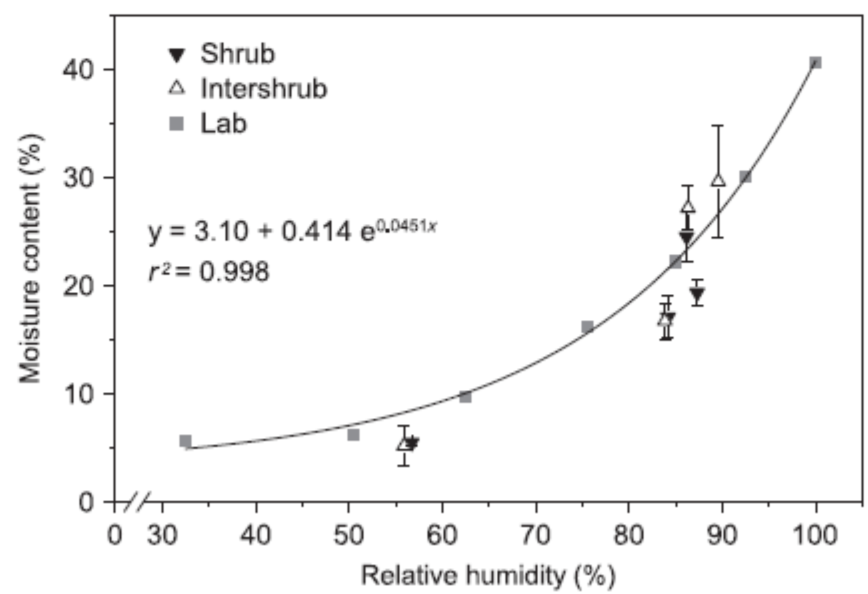
Nocturnal decomposition

Facilitated by high relative humidity at night

75% RH "threshold" for decomposition (Nagy & McCauley 1982)

- Exceeded most summer nights in Mediterranean study sites
- Water-vapor absorption may be indicator of litter "quality"

Exponential decay function of remaining mass



Dirks et al. 2010, *Global Change Biology*

Questions of Interest

What is the relative effect of photodegradation vs. biotic decomposition on dry season mass loss?

What fraction of the litter pool is preferentially broken down through photodegradation?

Does photodegradation “prime” recalcitrant C for wet season decomposition?

Is water-absorption capability an indicator of litter “quality” in Mediterranean ecosystems?

Does UV-radiation have an effect on extracellular enzyme expression and activity?

Isolating drivers

Litterbag study with two treatments:

1. UV-Pass vs. UV-Block (6 plots + 8 litterbags each)

Artist's rendition

2. Lignin-Rich vs. Lignin-Poor (4 bags in each plot)
   - Through preferential selection of litter pools

Sampling/Analysis

Sampling:

September (end-dry), January (mid-wet),
March (end-wet), June (begin/mid-dry)

Analyses of litter quality:

% Mass loss, C:N content, forage fiber analysis, water-absorption capacity,

Analyses of microbial response:

extracellular enzymes, microbial community composition, microbial cell counts, RNA expression

Autochamber Study

Litterbag in autochamber

– lined with HDPE

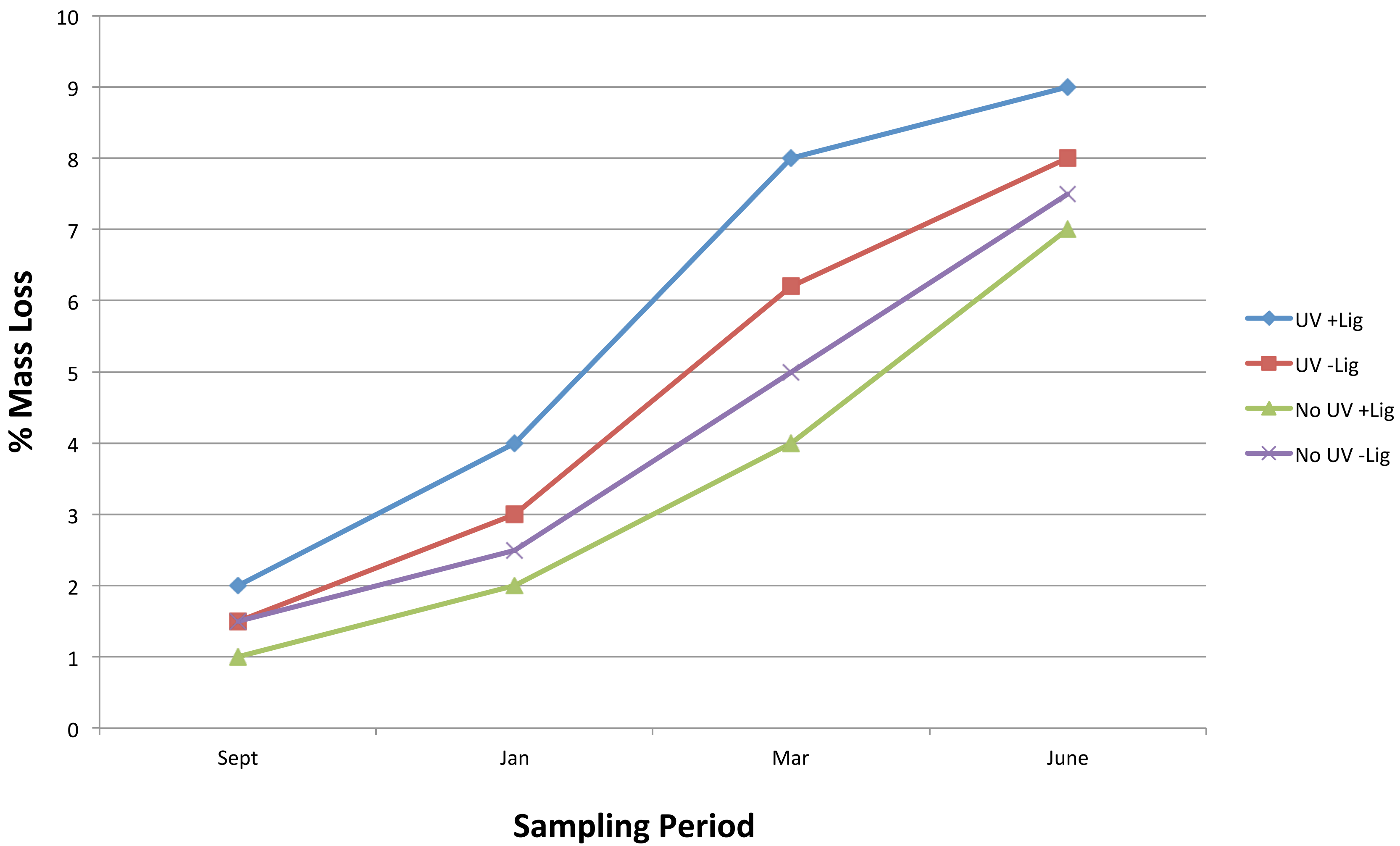
Allows for high resolution capture of CO_2 efflux vs. relative humidity at site

Direct link between RH and decomposition!

Litter quality predictions

- Mass loss will be greater in UV-pass treatments
  - Carryover to wet season due to priming effect
- Mass loss will be greater in lignin-rich treatments
  - Greater carryover to wet season

Litter Mass Loss Predictions



Litter quality predictions

Mass loss will be greater in UV-pass treatments

- Carryover to wet season due to priming effect

Mass loss will be greater in lignin-rich treatments

- Greater carryover to wet season

Lignin fraction will be more greatly reduced in UV-pass treatments

Mass loss will be correlated with water absorption capability of litter

Enzyme Response Predictions

UV-Pass treatments will have lower BG, CBH, and oxidative enzyme activity

- Greater turnover of enzymes
- Less need

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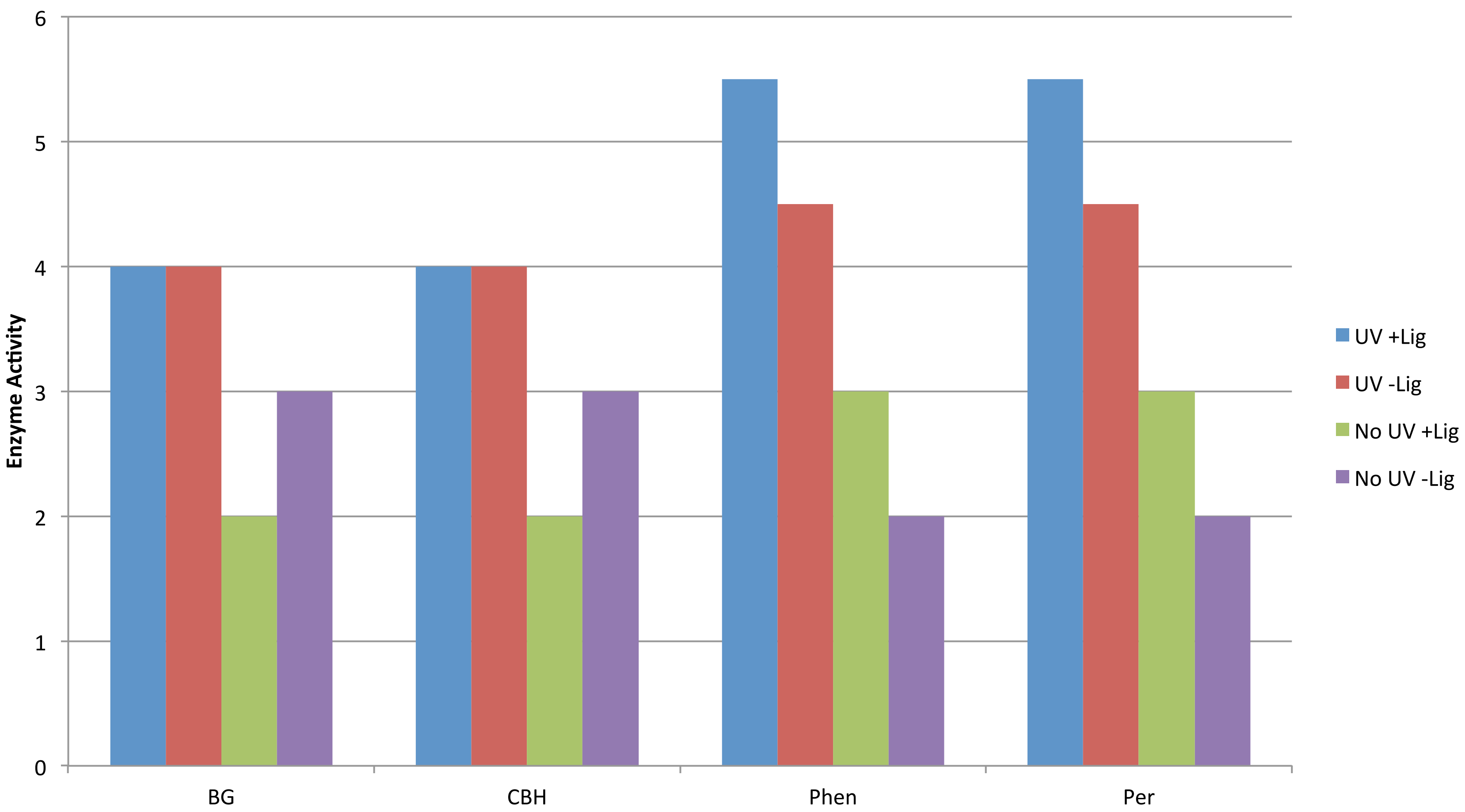
Alternatively: Greater activity as a result of increased efficiency of substrate use

Alternative Enzyme Activities



Enzyme Response Predictions

UV-Pass treatments will have lower BG, CBH, and oxidative enzyme activity

- Greater turnover of enzymes
- Less need

Alternatively: Greater activity as a result of increased efficiency of substrate use

UV-Pass treatments will have lower LAP activity at end of summer, greater during wet season

- Reduced microbial activity under UV
- Priming effect

RNA Expression Predictions

Fungal laccase expression will be elevated in UV-pass treatments

- Increased turnover of extracellular enzymes
- Increased efficiency when acting on pre-degraded substrate

Alternatively: Laccase expression could be reduced

- Preferential targeting of downstream products of lignin photodegradation

Fungal protease expression will mirror LAP activity for similar reasons

- UV suppression of fungal activity in dry season
- Priming provides labile substrate for added growth in dry season

http://www.socaltrailriders.org/forum/trailhead/56798-reminder-limestone-canyon-open-access-day-saturday-3-12-a.html