Amount, position, and age of coarse wood influence litter decomposition in postfire *Pinus contorta* stands

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Introduction

- Coarse wood (or CWD: Coarse Woody Debris, Fallen log) is an important structural feature across postfire (postdisturbance) forests.
- Density of CWD is variable; it ranges from <100 to 1600< stms/ha (Lyons & Romme, personal communication 2005)
- Few researchers have focused on the microclimatic effects of within-stand physical structures on decomposers.

CWD：粗大有機物。直径5㎝以上など。
ここでは20㎝以上を使用

Introduction

- The objectives of this study were

  (1.) to investigate "the role of CWD position and age on fine-litter decay," and

  (2.) to evaluate "how differences in the abundance of different CWD affect fine-litter decay."

- The authors hypothesized that litter decomposition (= mass loss) under some types of CWD is faster than open soil.

Study area

- Yellostone National Park
  Huge forest fires in1988 burned 25-30% of the area (9000km^2) (Knights & Wallace 1989, Harmon & Sexton 1995).
  Annual precipitation was 619mm (Western Regional Climate Center 2005).
  Monthly max. temp. was 9.6ºC (-2.0 in Jan., 23.6 in Jul.).

- *Pinus contorta* var. *latifolia* (lodgepole pine) forests
  Three 0.25ha plots (similar plots).
  Seventeen additional 0.25ha plots (CWD cover ranged).
  Three stands in mature forest (250 years).
  =total 23 plots.

Methods 1: Within-stand litter decomposition

- Litterbags and tongue depressors.
- Placed in six treatments in 3 plots.
  elevated log
  contact log
  below sapling
  open soil
  below legacy log (killed before the fires: highly decayed)
  above legacy log
- Detaloggers for temperature and moisture.

Methods 2: Among-stand litter decomposition

- Litterbags and tongue depressors were placed randomly in 20 plots.

- Estimated cover of CWD and vegetation.
  post-1988 CWD
  legacy CWD
  saplings
  graminoids
  fine wood (<7.5cm)
  open soil
  etc.

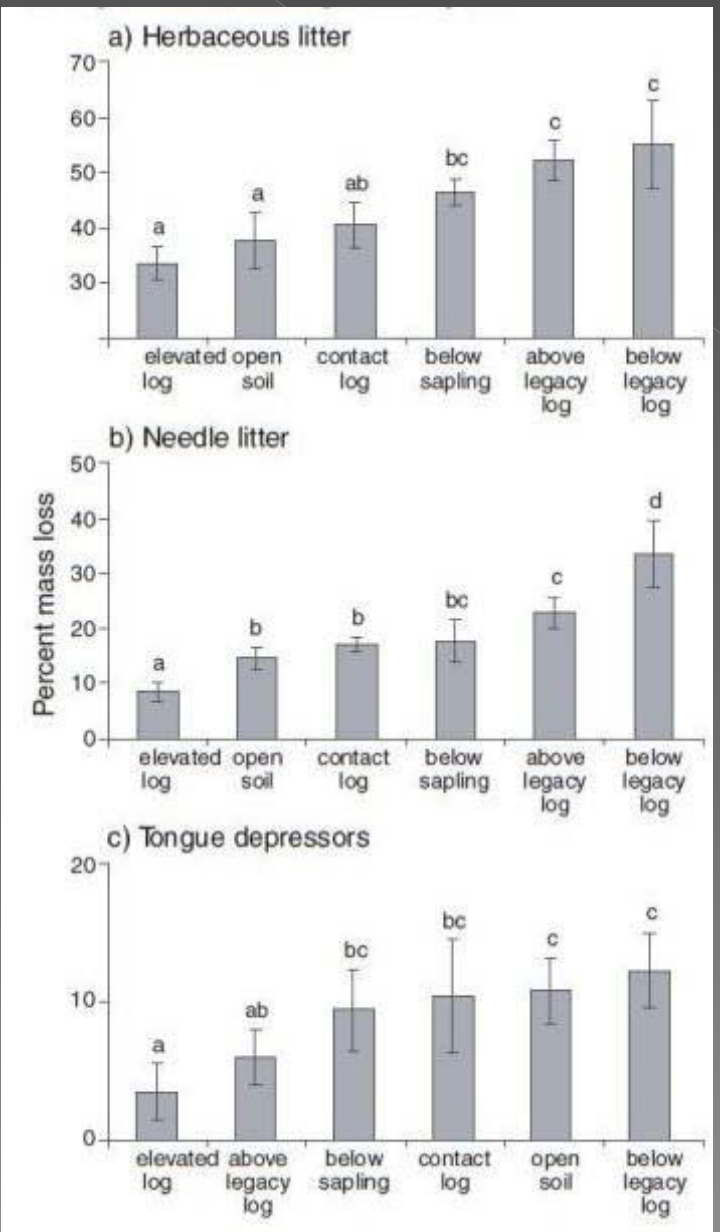
graminoid：イネ科草本？

Data analysis

- Decomposition
  Olson's (1963) single negative exponential decay model: percent remaining= e^{-kt}

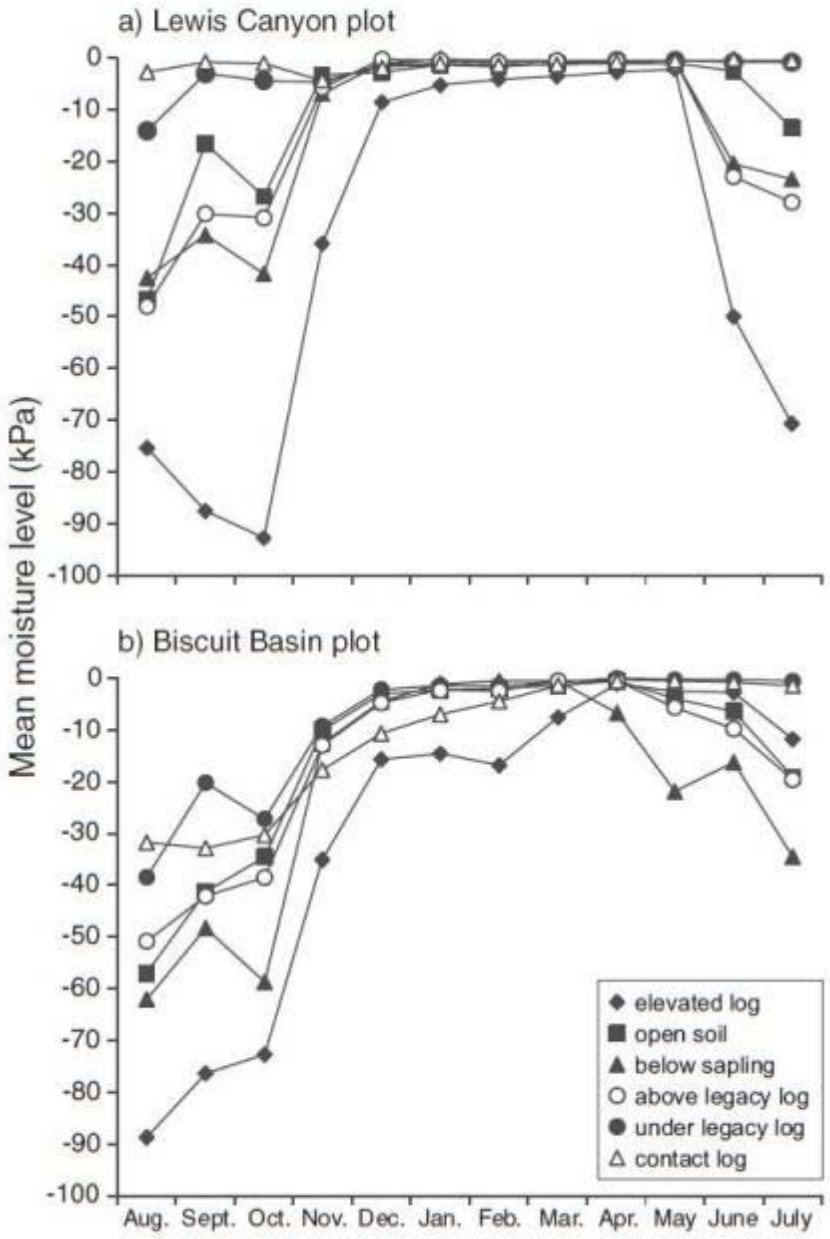
- Statistics
  - Two-way ANOVA (treatment × plot)
  - Tukey's HSD
  - Multiple linear regression (mass loss – litter lignin/N)
  - Welch's two-sample *t* test (Davenport & Webster 1975)
  - Multiple linear regression (cover – decay rate) ~ Stepwise selection (AIC_c) (Burnham & Anderson 2002)
  - Performed with R
  - $p<0.05$

Results



- Decomposition was slowest under elevated logs and fastest below legacy logs.

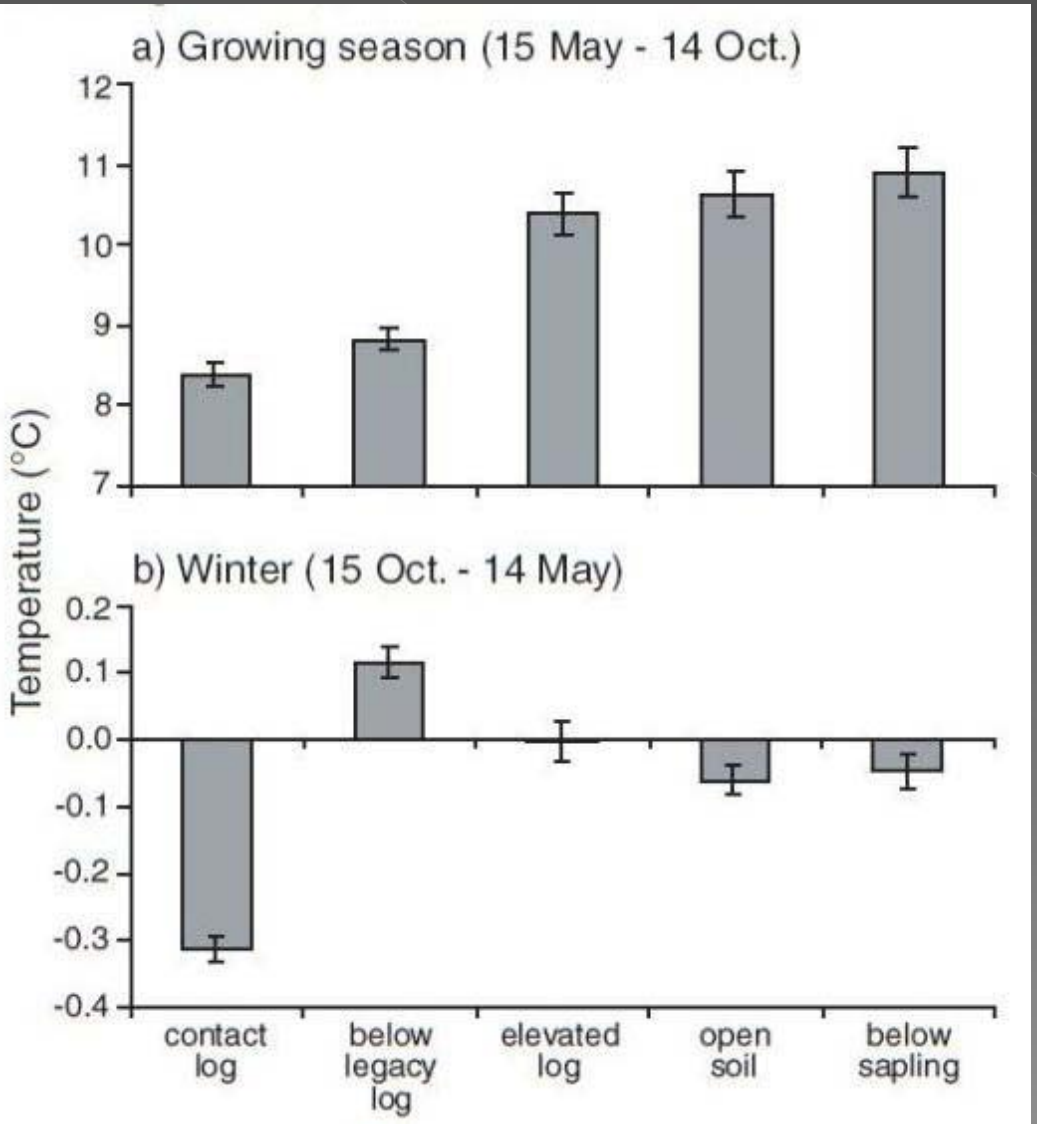
Fig. 2. Hourly water availability averaged by month (August 2003 – July 2004), illustrating microsite treatment differences. The six moisture probes were within 1 m of each other at the Lewis Canyon study plot (*a*) and Biscuit Basin study plots (*b*).



Results

- There was a moisture deficit below elevated logs.
- Soils under contact and legacy logs tended to be wetter.

Results



- Temperature during growing season was lowest and least variable below contact and legacy logs.
- In winter, soil beneath legacy logs appear to be warmer.

Results

	C	N	Lignin
Initial	43%(HL) 50%(NL)	1.2%(HL) 1%(NL)	3%(HL) 28%(NL)
After treatments	-0~20%(HL) -0~30%(NL)	+30~130%(HL) +10~40%(NL)	+370~730%(HL) +50~80%(NL)

Table 3. Results of multiple linear regression analyses relating 2-year litter-decomposition rates to final nitrogen and lignin contents (n = 48).

Response	Predictor variable	Parameter estimate	Partial R^2	p
Herbaceous litter decay	Nitrogen content	0.28	0.36	<0.001
	Lignin content	–0.49	0.10	0.08
Needle litter decay	Lignin content	1.07	0.38	0.003
	Nitrogen content	0.20	0.10	0.01

Note: The adjusted overall model R^2 values were 0.43 for herbaceous litter and 0.44 for needle litter.

- Lignin and nitrogen concentration increased through time.
- Decay rates of litter were positively related to nitrogen and lignin concentrations.

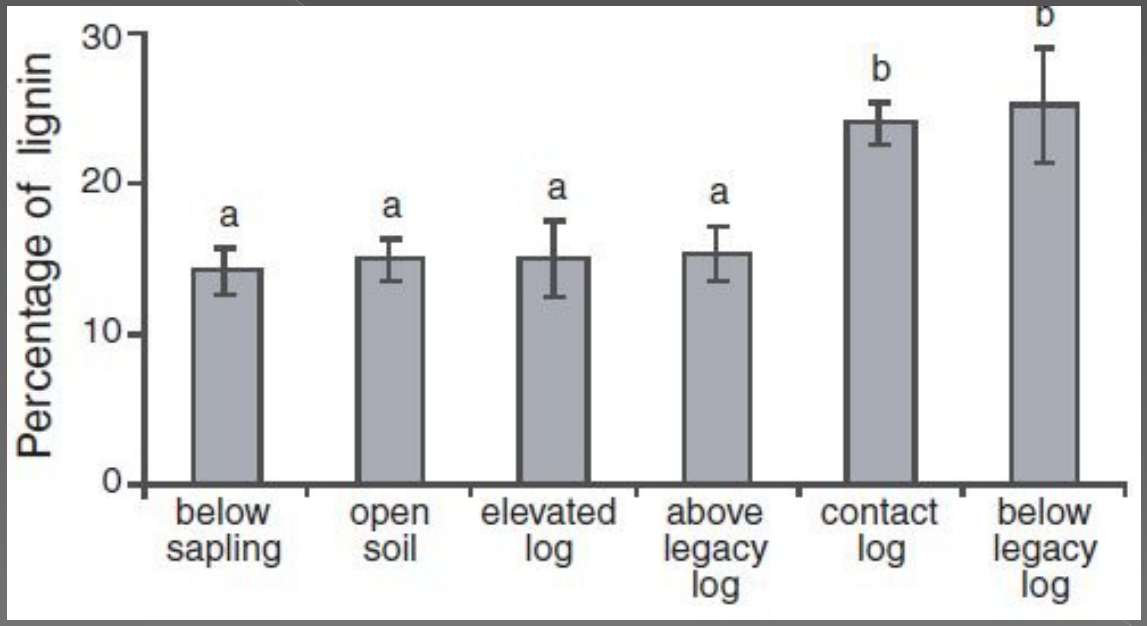
Results

- For the burned 17 stands, percent cover were; 0~18% saplings, 6~48% graminoids, 4~28% forbs/shrubs, 1~37% open soil, 3~28% fine wood, 3~13% legacy wood, 1~5% contact logs, 3~16% elevated logs.

- For mature 3 stands, percent cover of CWD was lower: 1~2% legacy wood , 2~3% contact logs, 4% elevated logs (18~49% forbs/ shrubs).

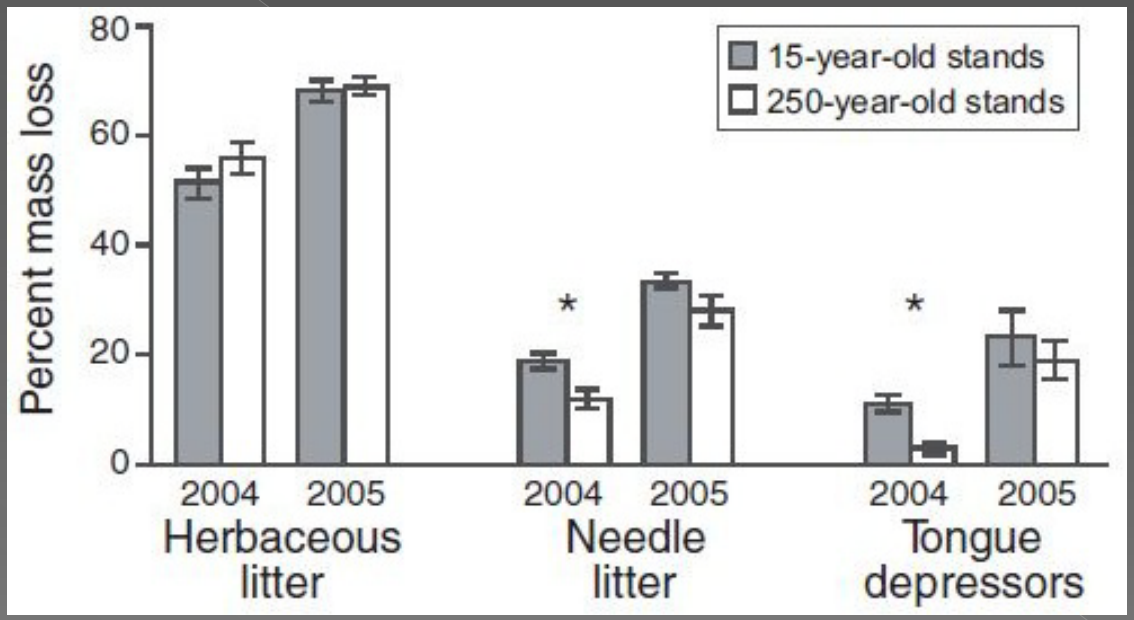
forb：イネ科草本でない草本（広葉）？
shrub：低木・灌木

Results



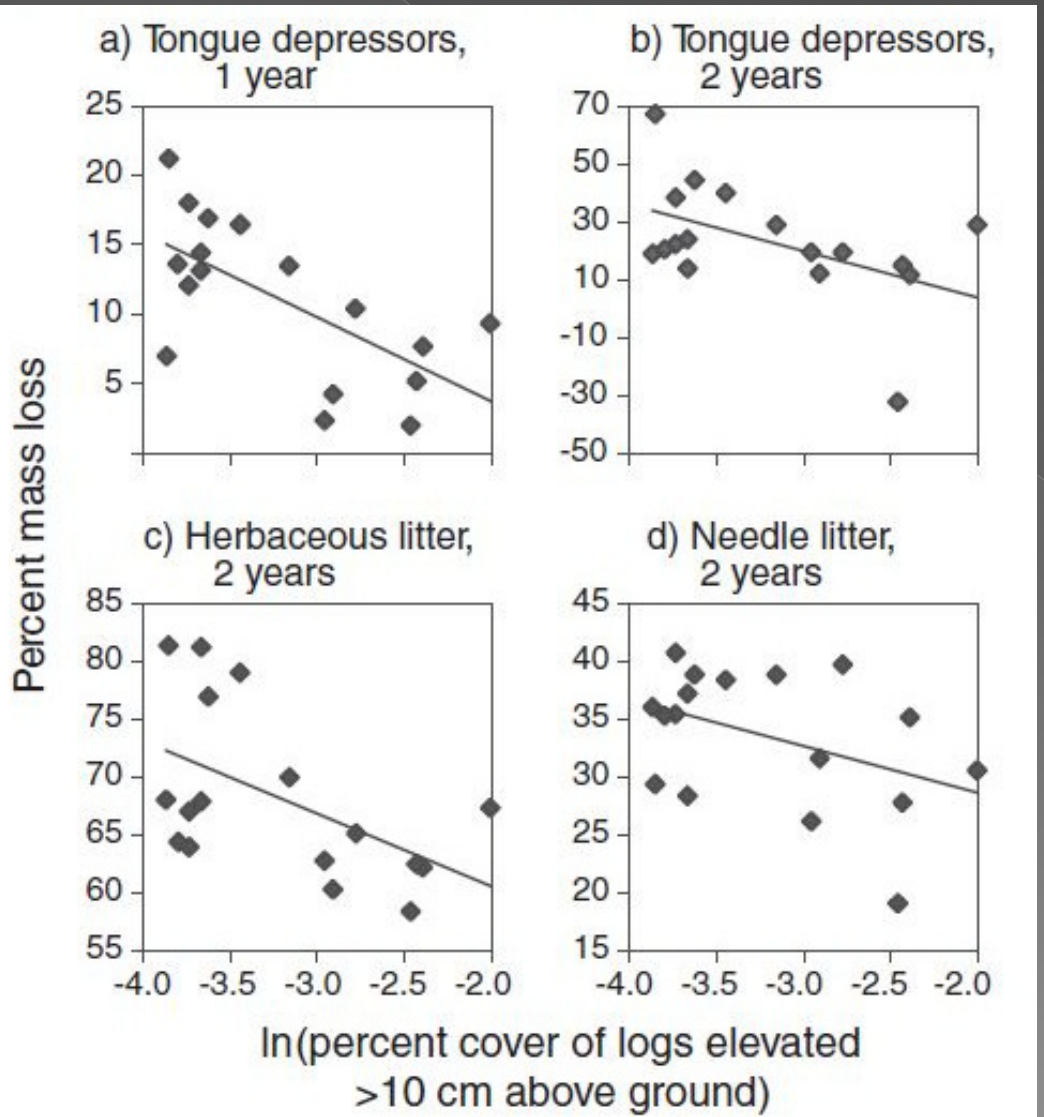
- The percentage of lignin remaining in HL was greater under legacy and contact logs.

Results



- Mean mass loss at burned stands was greater from NL and TDs only after 1 year.

Results



- Among burned stands, there are negative relations between decomposition and cover of elevated logs.

Results

Table 4. The best multiple linear regression models (with coefficients) chosen by second-order criterion Akaike's Information Criterion (AIC_c) from six stand-level percent-cover categories (all post-1988 coarse wood (elevated + contact logs), legacy wood, saplings, graminoids, fine wood, and open soil) to predict mean 2-year mass loss across stands (n = 17).

Model	Δ_i[a]	w_i[b]	Residual SE	Adjusted R^2
Herbaceous litter				
Mass loss = –(0.17)post-88 coarse wood + (0.42)graminoids – (0.40)fine wood + 0.690	0.61	0.03	0.78	
Needle litter				
Mass loss = –(0.57)fine wood + 0.45	0	0.47	0.05	0.30
Mass loss = –(0.57)fine wood + (0.16)open soil + 0.42	0.92	0.29	0.05	0.33
Birch (*Betula* sp.) tongue depressors				
Mass loss = –(2.46)fine wood + 0.75	0	0.34	0.14	0.50
Mass loss = –(2.31)fine wood + (0.45)new coarse wood + 0.86	1.32	0.18	0.14	0.52
Mass loss = –(2.46)fine wood + (0.31)open soil + 0.67	2.03	0.12	0.14	0.50

[a]Delta AIC (Δ_i) is the difference between the given model's AIC_c value and that of the model with the lowest AIC_c value.
[b]Akaike weights (w_i) sum to 1 for the set of candidate models compared (models with $\Delta_i < 5$); larger values indicate a greater probability that the ith model is better than the other candidate models (Burnham and Anderson 2002).

- Model selection identified which of the six cover categories best helped to explain 2-year decomposition rates among stands.
- There were more candidate models for TDs.
- For all litter types, decay rates were negatively related to percent cover of fine wood.

Discussion

- The results support
  that microclimates resulting from structural heterogeneity would have measurable effects on litter decomposition, including faster decay rates under decayed legacy wood,
  but not that elevated logs would facilitate decay by moderating temperature and evaporation.

- Moisture (> temperature) and bacteria (fungi?).

Discussion

- Small differences in decay between burned/unburned stands may related similar moisture levels.
  Higher temperature in burned stands may explain the differences in decay after 1 year.

- Negative correlations between stand decomposition rates and coverage of elevated wood suggest that relationships observed in the microsite experiment scaled up.

- Abundance of elevated logs could increase the spatial heterogeneity of available water, nutrient cycling, and soil biological activity within stands