The Role of Cones as Vectors for Duff Ignition

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INTRODUCTION

Smoldering combustion of forest floor duff (Oe and Oa organic soil horizons) can result in long duration soil heating and potentially cause tree mortality. The mechanisms for duff ignition and subsequent combustion, however, are poorly understood. Ignition vectors such as pine cones (Fig. 1) or woody fuels have been hypothesized to ignite duff horizons during prescribed or wild fires. Through laboratory experiments, we evaluate the role of pine cones as a potential vector for ignition of duff.

Objective:

Quantify the effect of pine cones on the ignition probability of duff from long-unburned longleaf pine (*Pinus palustris* Mill.) forests.

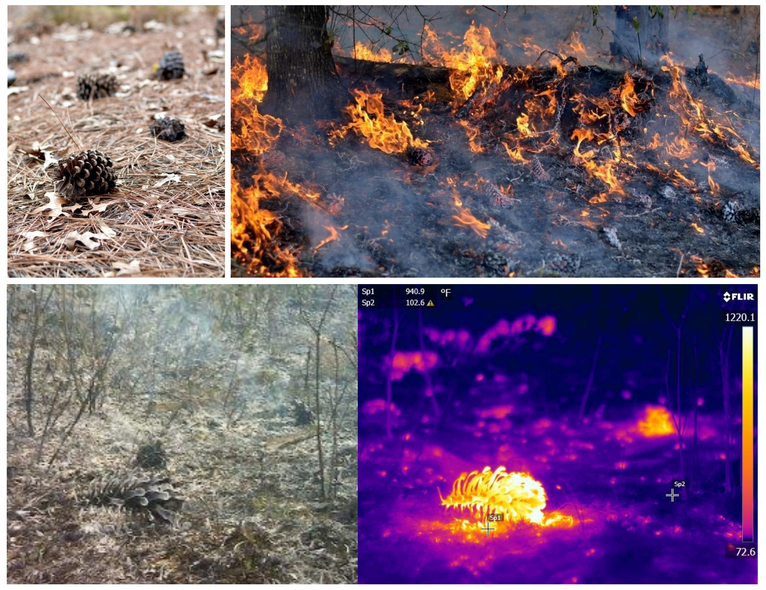

Figure 1. Pine cones may act as potential vectors for forest floor duff ignition when cones flame or smolder for long periods and heating of the forest floor beneath them occurs . Bottom: visual spectrum (left), thermal infrared (right).

RESULTS cont.

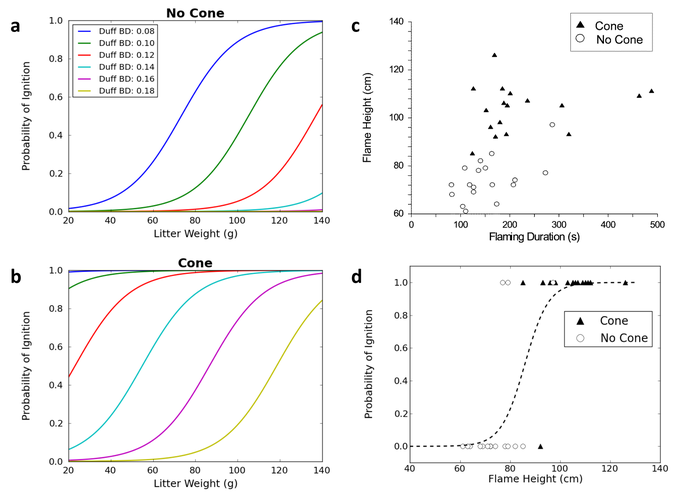

Figure 2. Probability of duff ignition as a function of litter mass and duff bulk density without (a) and with (b) a longleaf pine cone. Flame height and flaming duration with and without longleaf pine cones (c). Probability of duff ignition model as a function of flame height (d) with raw data (0, duff did not ignite; 1, duff ignited).

METHODS

Forest Floor Sampling

Eighteen intact forest floor (litter and duff) samples (50×30cm) and 9 longleaf pine cones were collected from a long-unburned (45 yrs) longleaf pine sandhill forest at Ordway-Swisher Biological Preserve (Florida).

Laboratory Burning Experiments

- Forest floor samples were split into two (25×30cm) samples (one assigned a cone treatment) and their litter (Oi organic soil horizon) was removed.
- Duff was wetted to reach 60% gravimetric moisture content (an ignition threshold observed in these fuels).
- Oven-dry litter was relocated onto fuelbeds, 1 oven-dry cone was place onto cone-treatment fuelbeds, and samples were ignited along one (15cm) edge.

Data Analysis

- Logistic regression was used to model probability of duff ignition using fuelbed properties (litter mass, duff bulk density, and cone presence) as predictor variables. AICc weights were used to determine a best model.
- Logistic regression was used to model probability of duff ignition using fire properties (flame height and flame duration) as predictors variables. AICc weights were used to determine a best model.

RESULTS

Table 1. Logistic regression models evaluating the effect of pine cones on the probability of duff ignition.

Model	N	Parameters	Log-likelihood	AICc	ΔAICc	AICc weight
$I_{L_{wt}+D_{bd}+C}$	35	4	-6.4317	22.1967	0.0000	0.7506
$I_{L_{wt}+C}$	35	3	-9.3688	25.5118	3.3151	0.1431
$I_{D_{bd}+C}$	35	3	-10.0979	26.9699	4.7732	0.0690
I_C	35	2	-11.9133	28.2016	6.0049	0.0373
I_O	35	1	-24.1314	50.3841	28.1873	<0.0001
$I_{L_{wt}}$	35	2	-23.1950	50.7650	28.5683	<0.0001
$I_{D_{bd}}$	35	2	-23.6016	51.5782	29.38153	<0.0001
$I_{L_{wt}+D_{bd}}$	35	3	-24.1314	55.0370	32.8403	<0.0001

Table 2. Logistic regression models evaluating the effects of flaming combustion on the probability of duff ignition.

Model	N	Parameters	Log-likelihood	AICc	ΔAICc	AICc weight
$I_{Fl_{ht}}$	35	2	-8.4606	16.9213	0.0000	0.8935
$I_{Fl_{ht}+Fl_d}$	35	3	-7.2027	21.1795	4.2582	0.1063
I_{Fl_d}	35	2	-17.005	34.0093	17.088	0.0002
I_O	35	1	-24.1314	48.2628	31.3416	<0.0001

I	Probability of Ignition
L_{wt}	Litter Weight (g)
L_{bd}	Litter Bulk Density (g cm^{-3})
C	Cone Presence
Fl_{ht}	Flame Height (cm)
Fl_d	Flame Duration (s)
I_o	Null Model

Results & Discussion

- Duff ignition was easily determined; duff was almost completely consumed when ignited.
- For logistic regression models with fuelbed properties as predictors, the model with all properties (litter mass, duff bulk density, and cone presence) was the best fitting model (75% AICc weight, Table 1) to predict ignition, however **cone presence overwhelmingly determined ignition** (Fig. 2).
- For logistic regression models with flame properties as predictors, the model with flame height only was the best fitting model (89% AICc weight, Table 2). Taller flames increased duff ignition, but results were confounded with cone presence; **ignition was predominantly cone-dependent** (Fig. 2).

CONCLUSIONS

Pine cones are likely to be important vectors for duff ignition where dense forest floor fuels have accumulated.

Heterogeneity of surface fuels (especially cones or other woody fuels) may contribute to forest floor duff consumption patterns and should be considered when burning for ecological restoration of long-unburned ecosystems.

Pine cones facilitate ignition of forest floor duff
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