Quantifying the combined effects of forest litter and aeolian dust deposition on snow surface albedo

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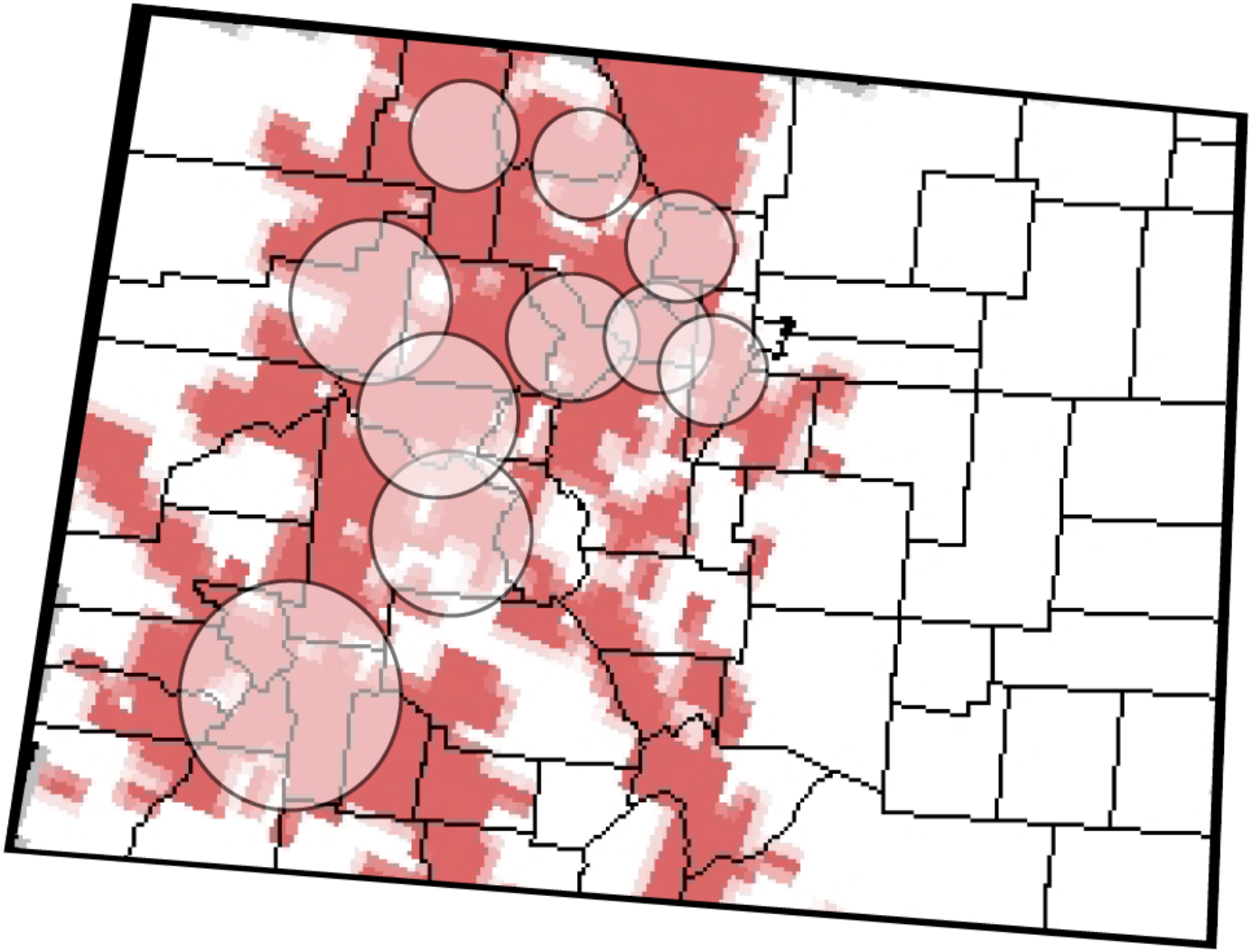
Two current environmental perturbations in the CO River Basin that affect the snowpack energy balance:

DUST DEPOSITION

MOUNTAIN PINE BEETLE

*How do **dust and litter** interact with energy at the snowpack surface?*



1996-2010
Tree Mortality
(USFS)

February 14-16,
2006 dust
deposition event
(observations
reported by CAIC)

DUST DEPOSITION

"Dust load levels **increased by 500%** above the late Holocene average following the increased western settlement of the United States during the nineteenth century" [Neff et. al, 2008]

83% of sources are REGIONAL :
Mojave Desert and Colorado Plateau

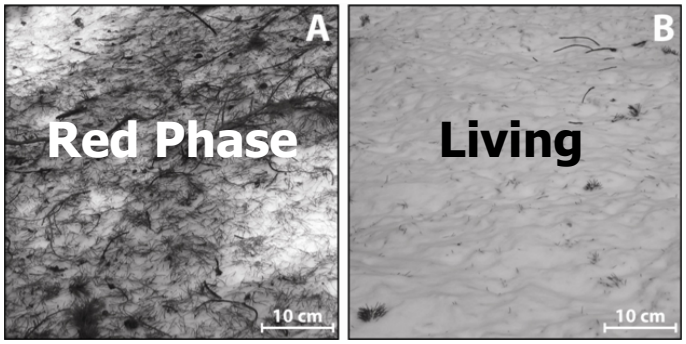
[Lawrence et. al., 2010]

Landry, C. (2008)

MPB OUTBREAK

Number of needles on snowpack in red phase stands 150% that of green phase stands [Pugh & Small, in review]

More rapid litterfall:
Natural lodgepole needle retention: 9-13 years [Schoettle, 1990, 1994; Vose et al., 1994]
Red phase trees lose their needles in <u>3 years</u> [Wulder et al., 2006]

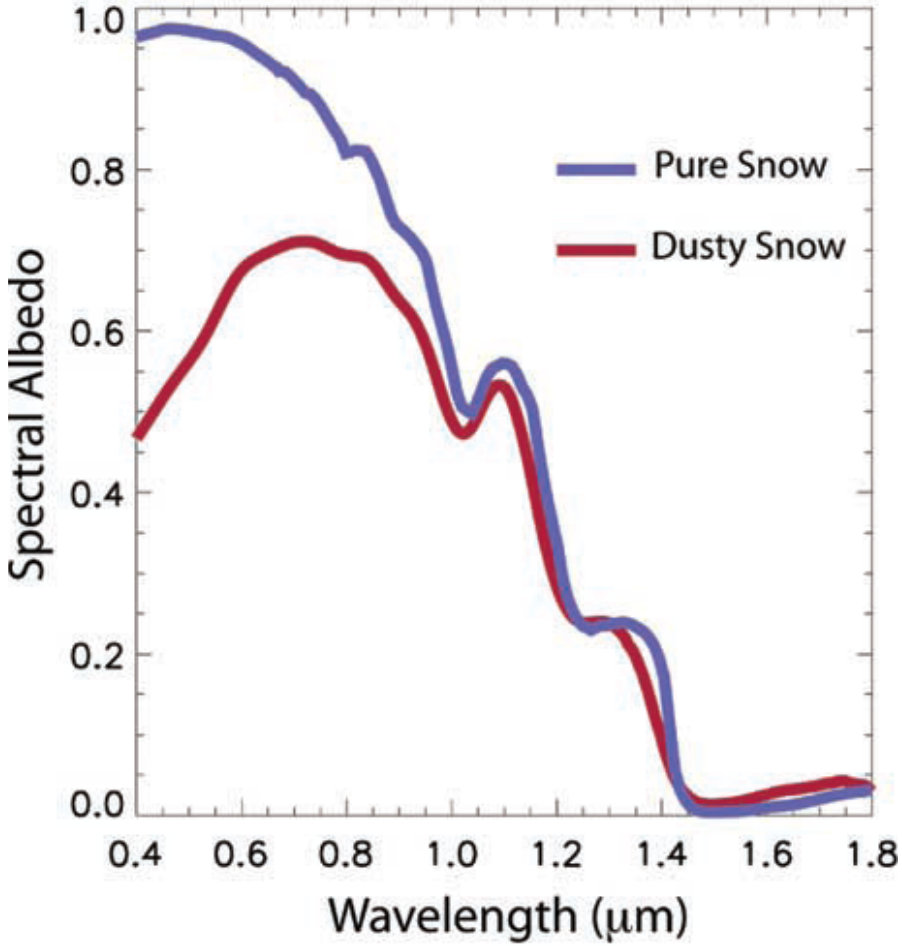


Pugh (2010)

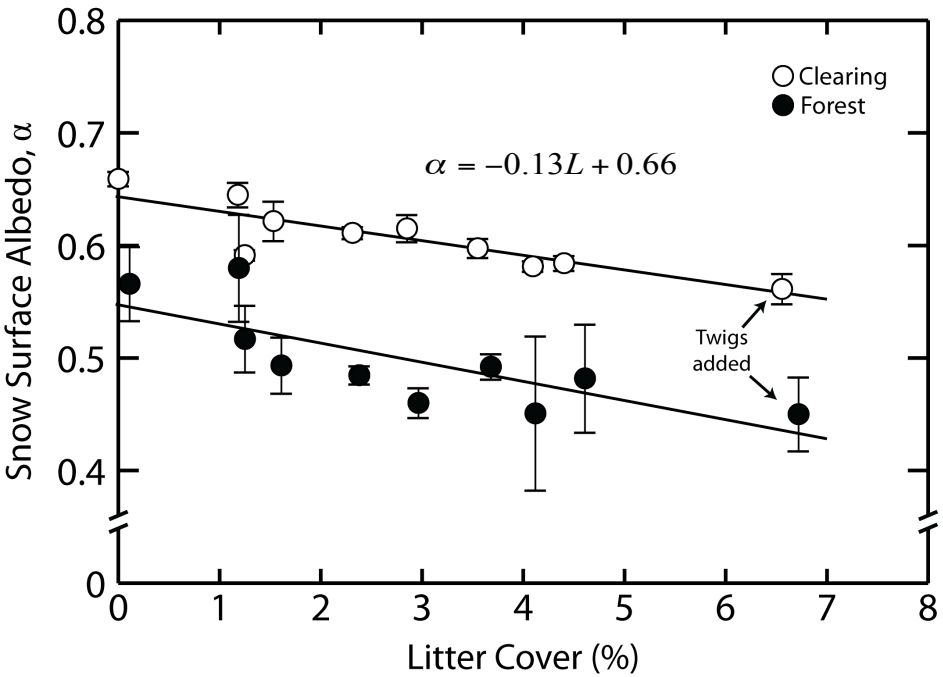
<u>EARLIER SNOW MELTOUT DATE (modeled and observed):</u>

3 weeks | **1 week**

Known changes in snow surface albedo due to dust deposition and MPB-associated increased litterfall

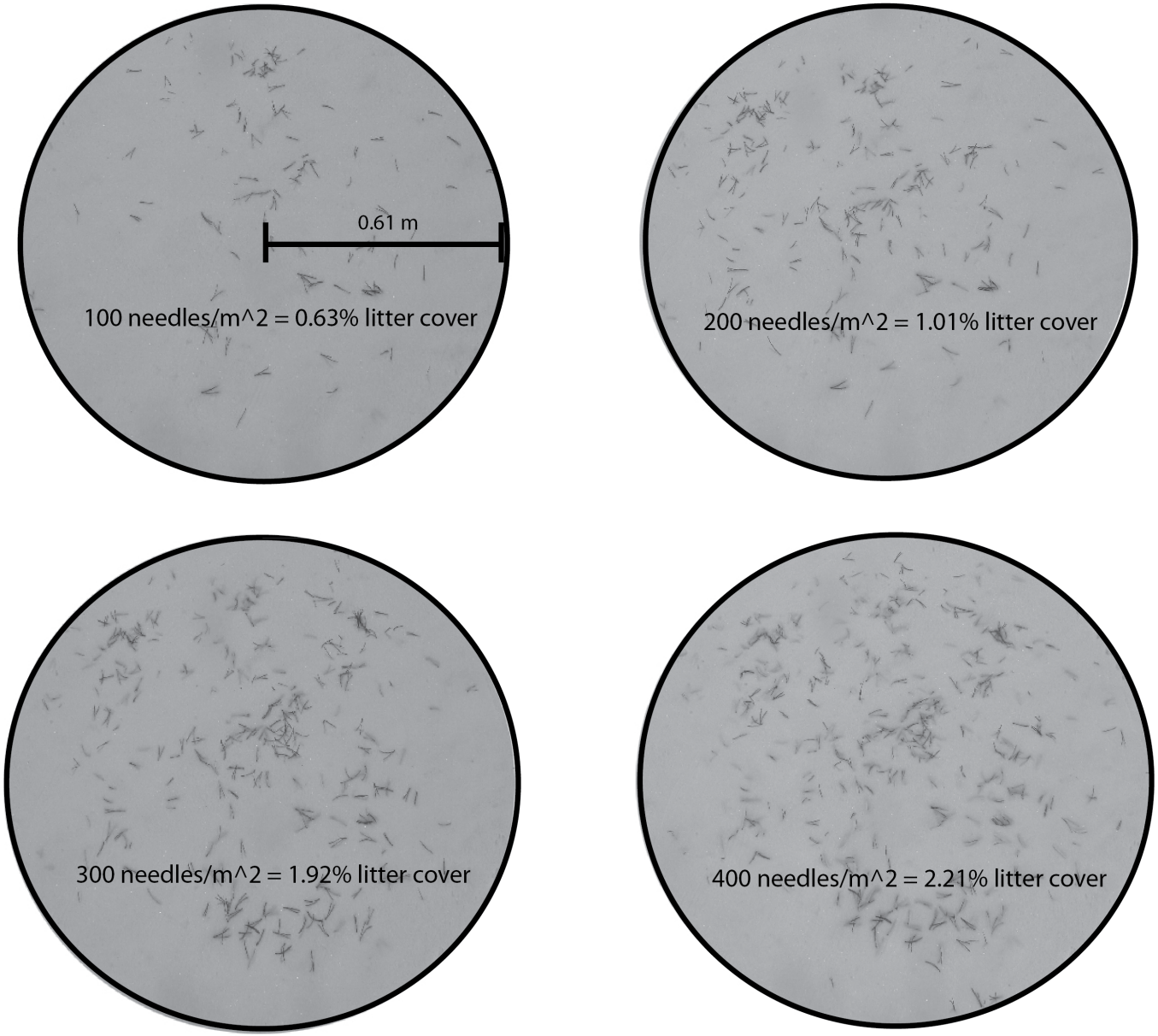


Painter et. al (2007)



Pugh & Small (in review)

Added **needles** and **dust** to fresh snow surface in known amounts and **directly measured albedo with paired pyranometers**



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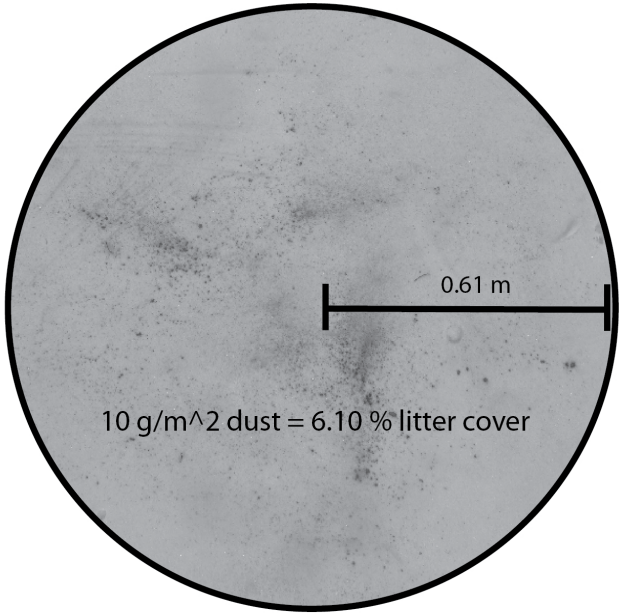
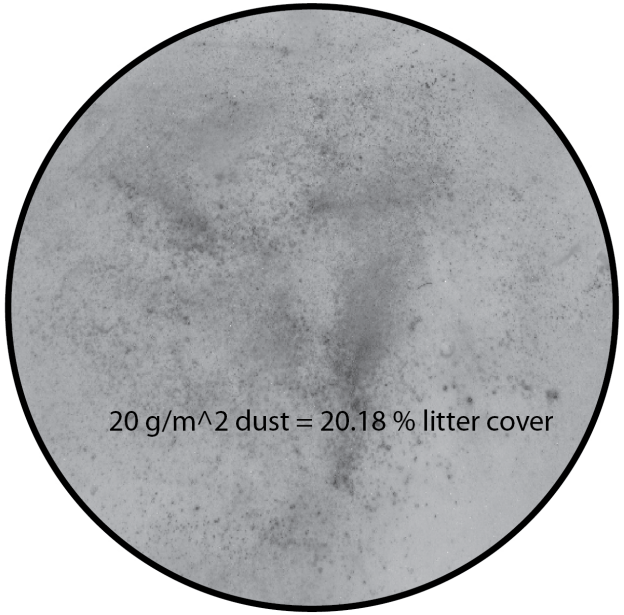
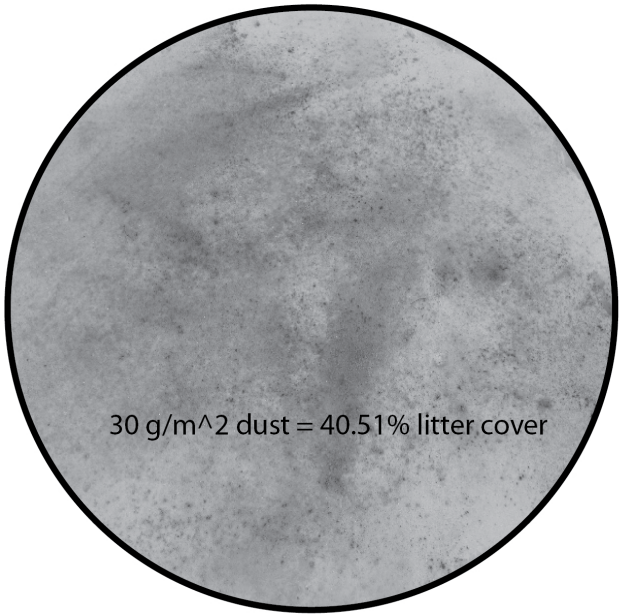
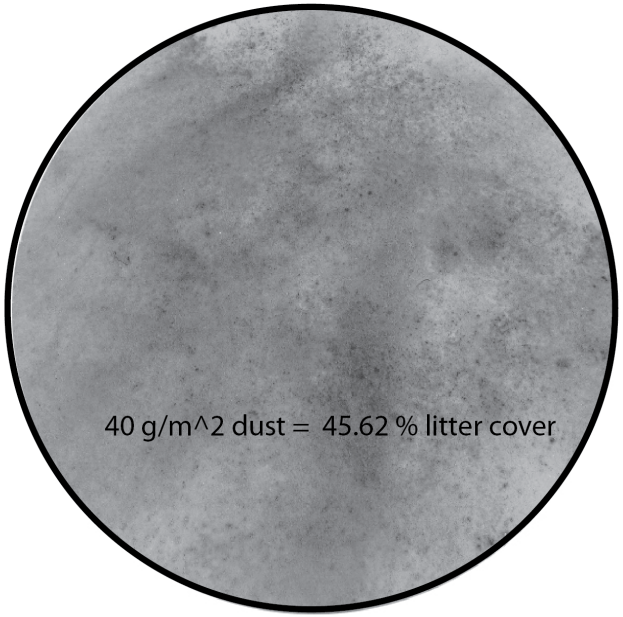
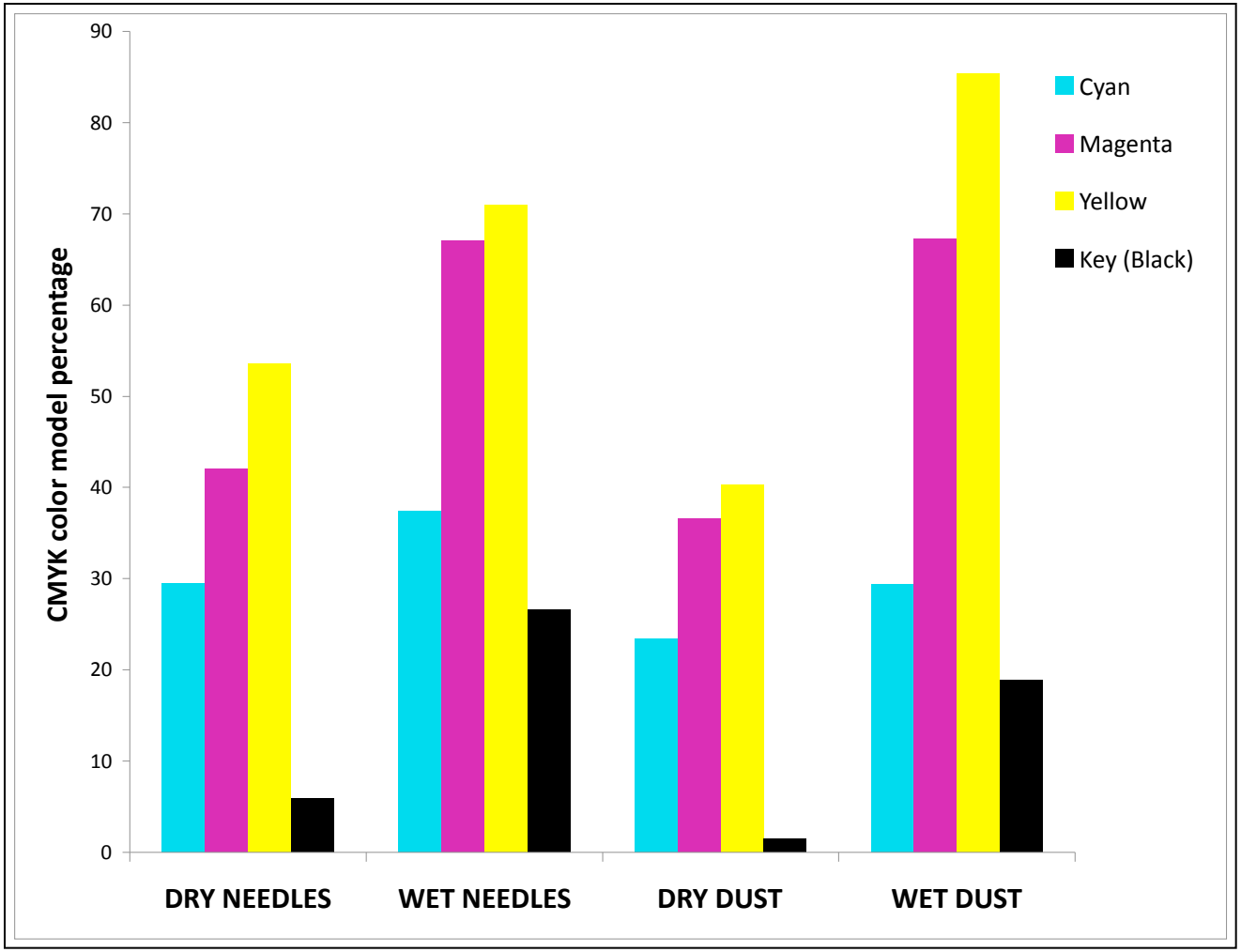




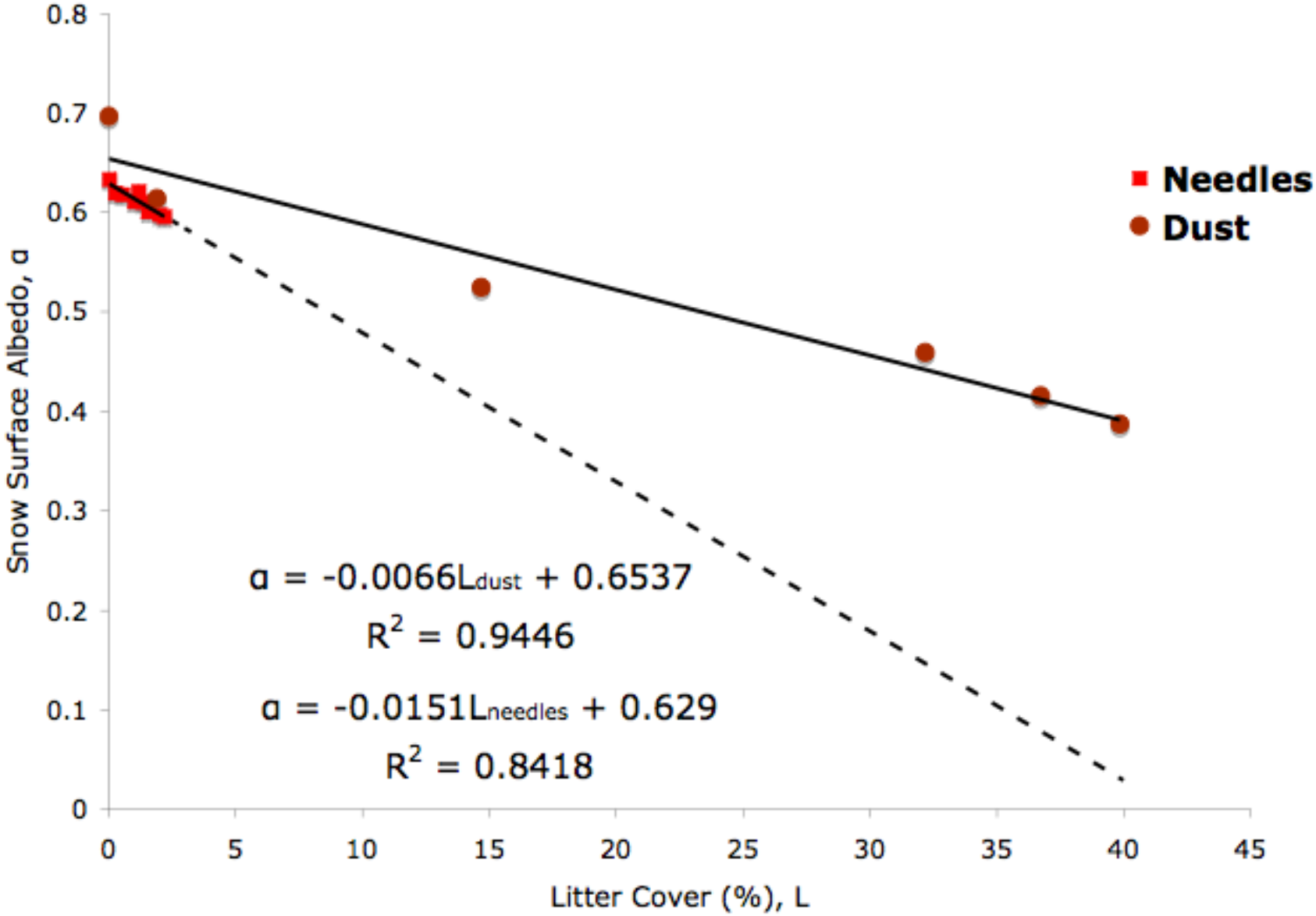


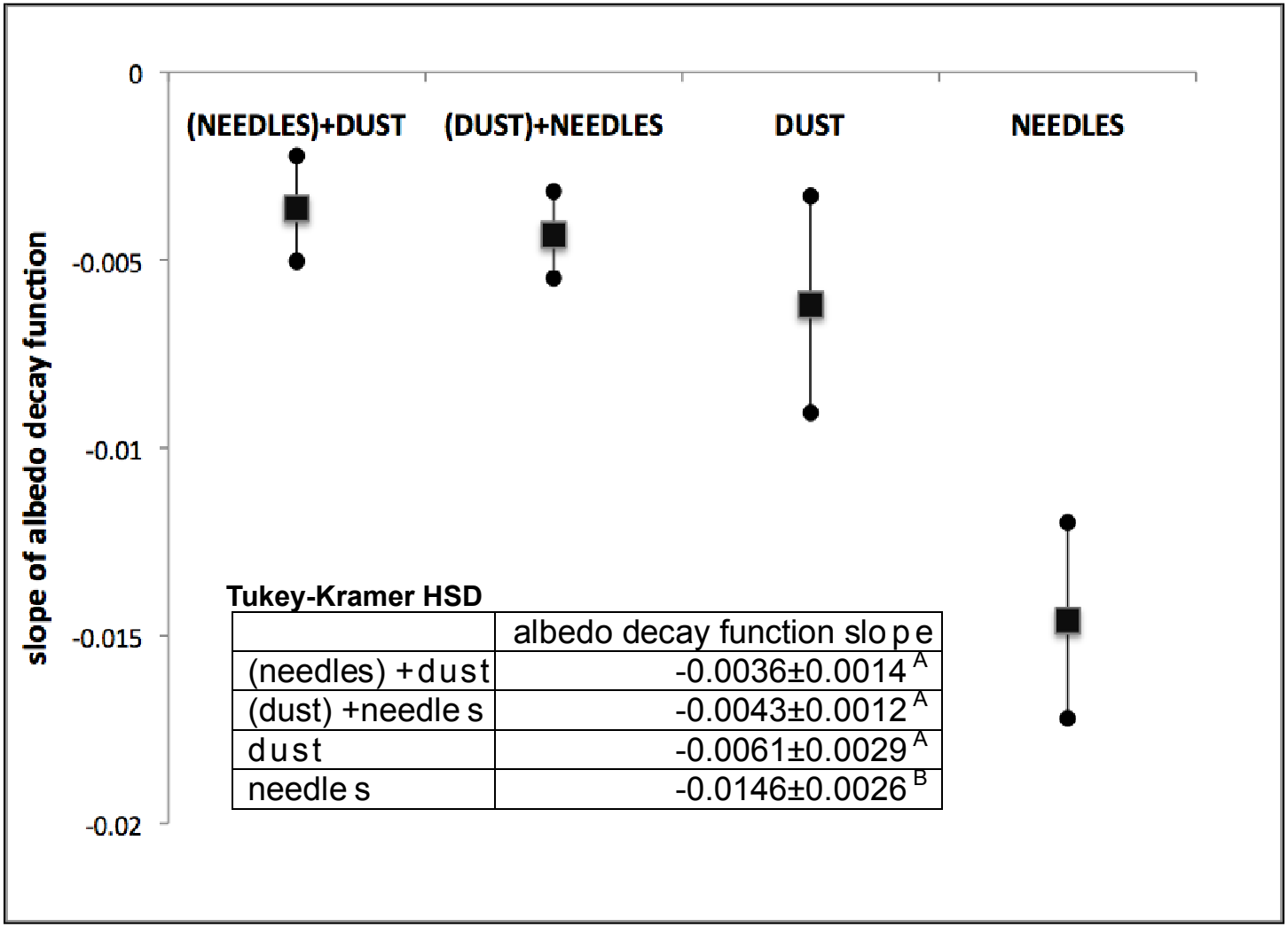




Tukey-Kramer HSD

	Needles		Dust	
CMYK Model	*Dry*	*Wet*	*Dry*	*Wet*
Cyan	29.5±8.8	37.4±6.8	23.5±6.9	29.4±2.6
Magenta	42.1±8.2	67.1±7.4	36.6±7.6	67.3±5.6
Yellow	53.6±17.6	71.0±11.6	40.3±19.4	85.4±11.4
Key (Black)	5.9±6.2 [C]	26.6±9.5 [A]	1.5±1.6 [C]	18.9±6.9 [B]


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Snow Surface Albedo, α
0
5
10
15
20
25
30
35
40
45
Litter Cover (%), L
Needles
Dust
α = -0.0066Ldust + 0.6537
R2 = 0.9446
α = -0.0151Lneedles + 0.629
R2 = 0.8418

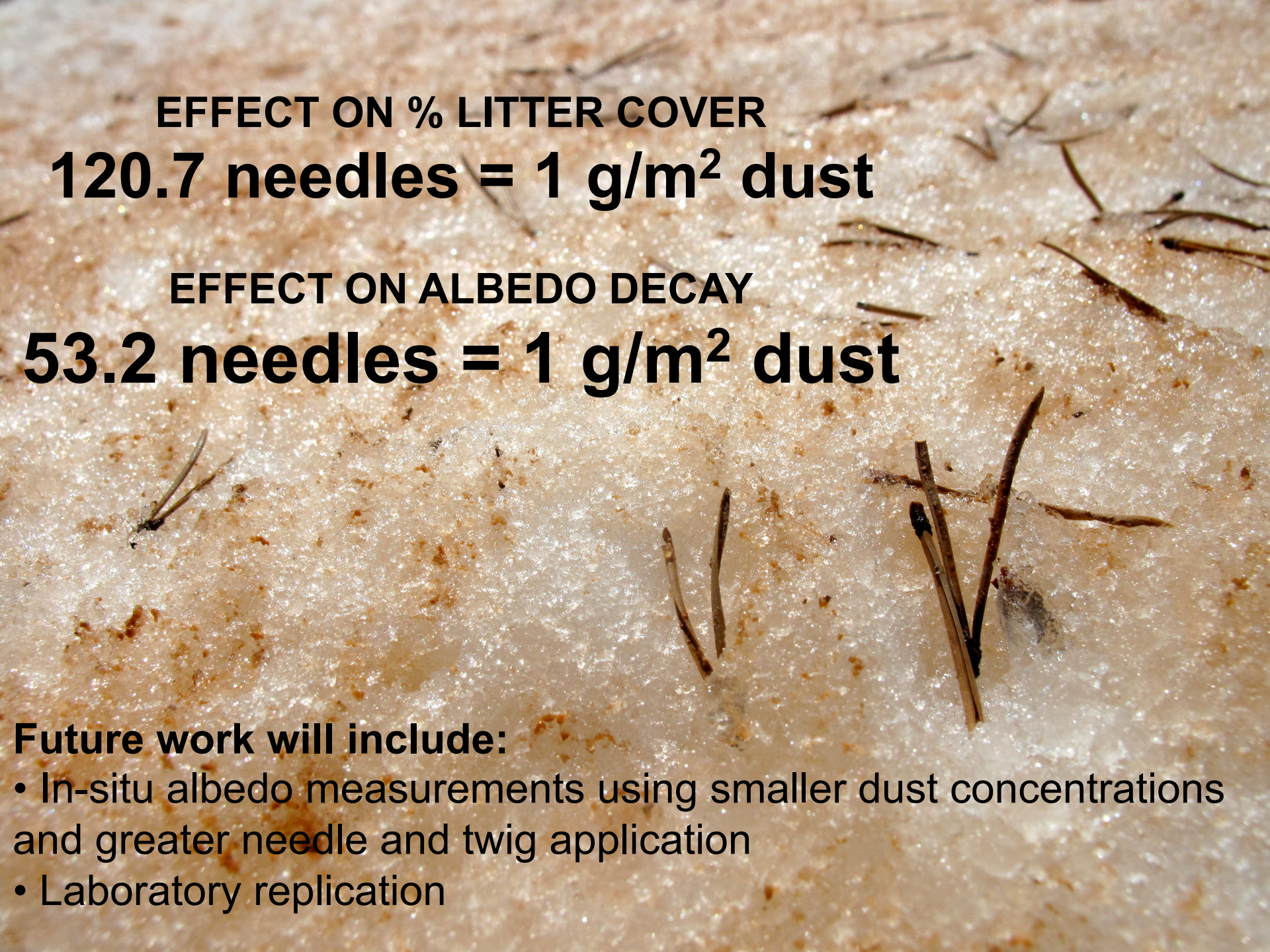


Tukey-Kramer HSD

	albedo decay function slope
(needles) +dust	-0.0036±0.0014 [A]
(dust) +needles	-0.0043±0.0012 [A]
dust	-0.0061±0.0029 [A]
needles	-0.0146±0.0026 [B]

ANCOVA

	ESTIMATE	STD ERROR	T VALUE	P VALUE
dust (slope)	-0.0051	0.0005	-9.295	3.21e-15***
difference in slope, **dust : [dust]+needles**	0.0027	0.0011	2.396	**0.01843***
difference in slope, **dust : needles**	-0.0248	0.0059	-4.172	**6.41e-05*** **
difference in slope, dust : [needles]+dust	0.0014	0.0007	1.901	0.06017



EFFECT ON % LITTER COVER

120.7 needles = 1 g/m^2 dust

EFFECT ON ALBEDO DECAY

53.2 needles = 1 g/m^2 dust

Future work will include:

- In-situ albedo measurements using smaller dust concentrations and greater needle and twig application
- Laboratory replication

A C K N O W L E D G E M E N T S

Eric Small Research Lab
Paul Boni and the CU Geology Department
Wendy Freeman and the Sed Lab at INSTAAR

Kurt Chowanski and the Niwot Ridge LTER

Leah Meromy, Morgan Zeliff, Patrick Kelly, Nate Rock, Scott Anderson, and Keith Musselman

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