Forest Canopy Effects on Snow Accumulation and Ablation

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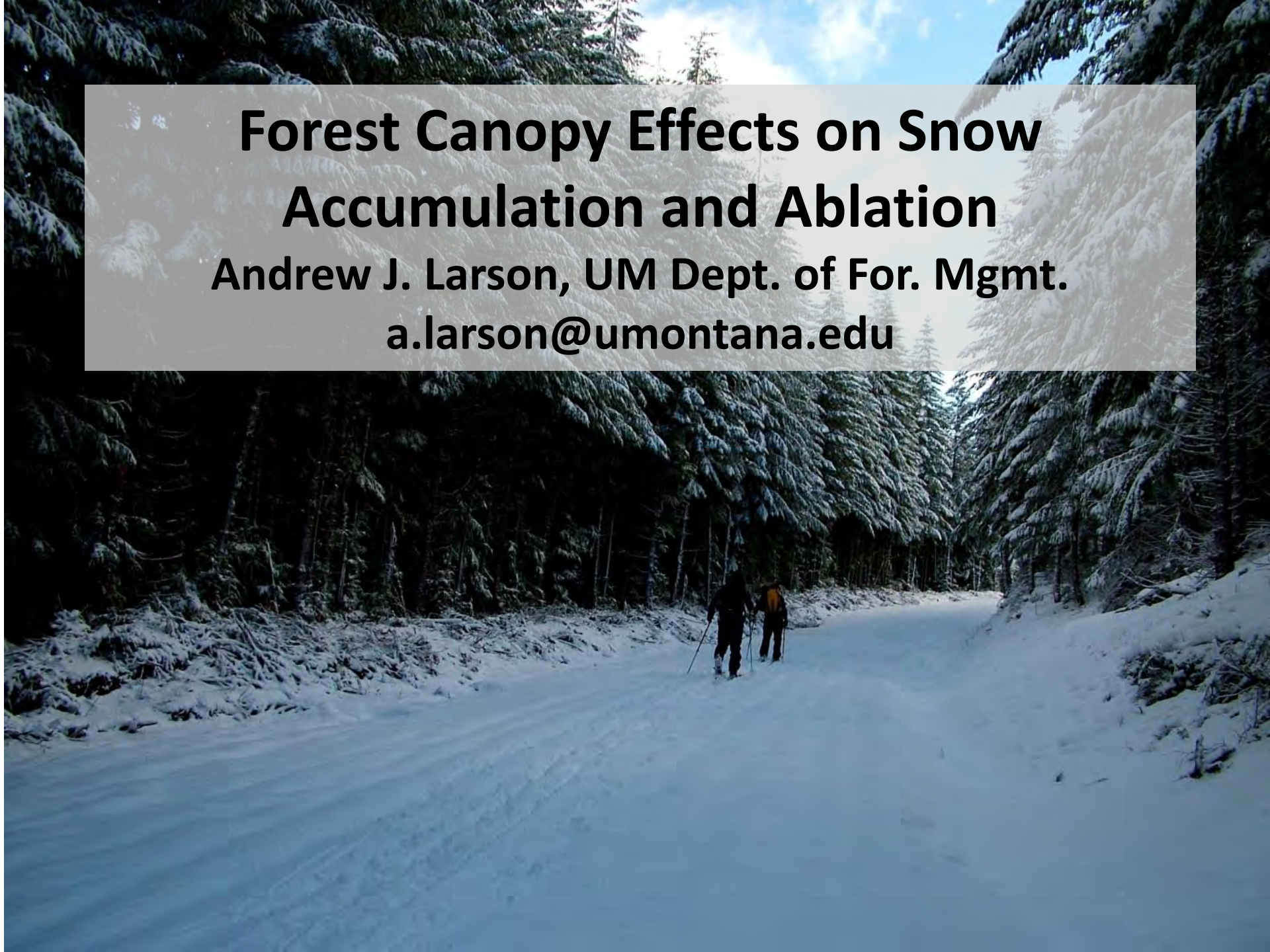
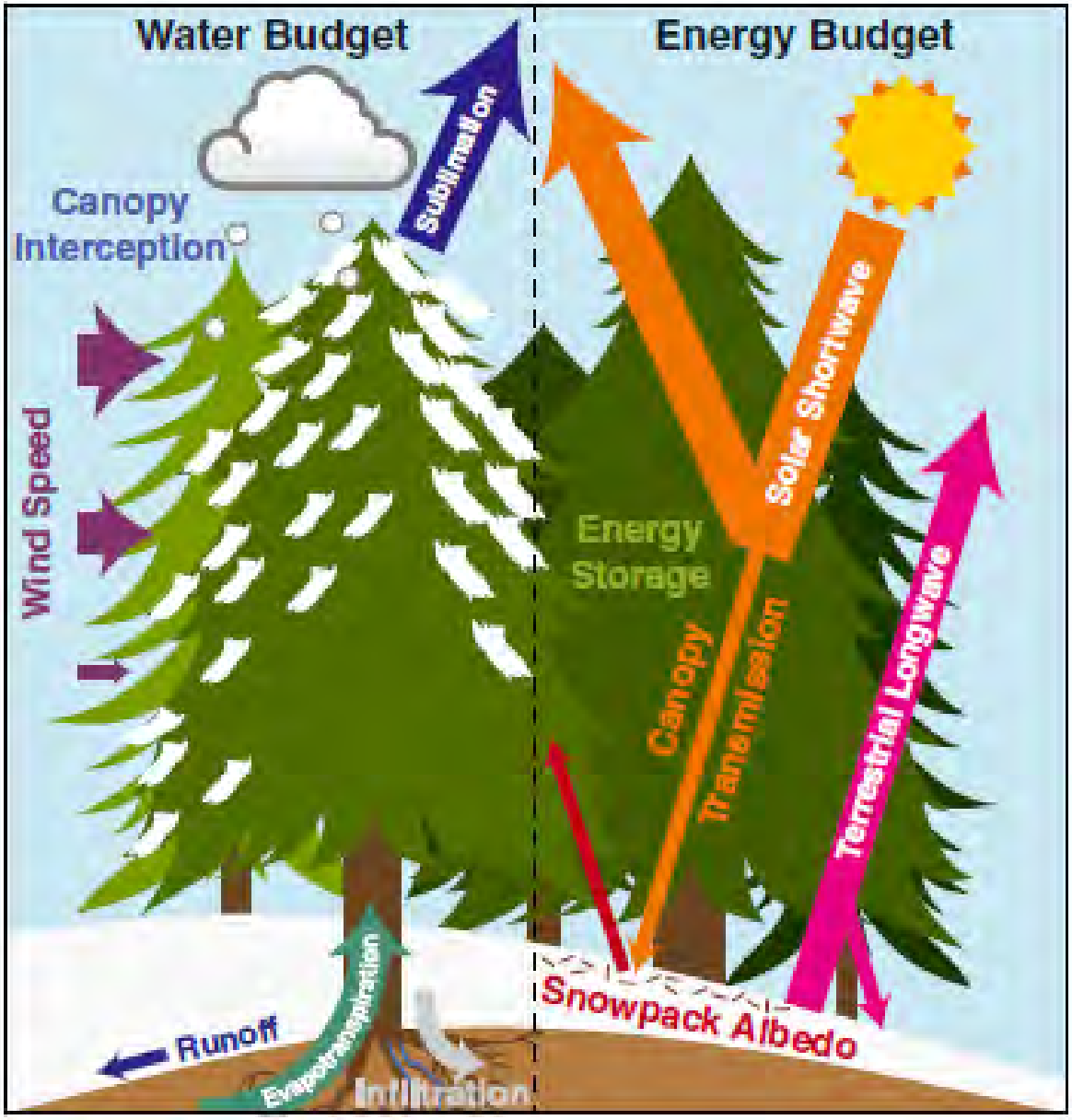


Major Topics

1. Brief review of forest canopy cover effects on water and energy budgets.
2. Forest disturbances and canopy structural development: fire, fire-exclusion, bark beetles.
3. Brief review of recently published research.
4. New forest-snow research in western MT.



HYDROLOGICAL PROCESSES
Hydrol. Process. (2012)
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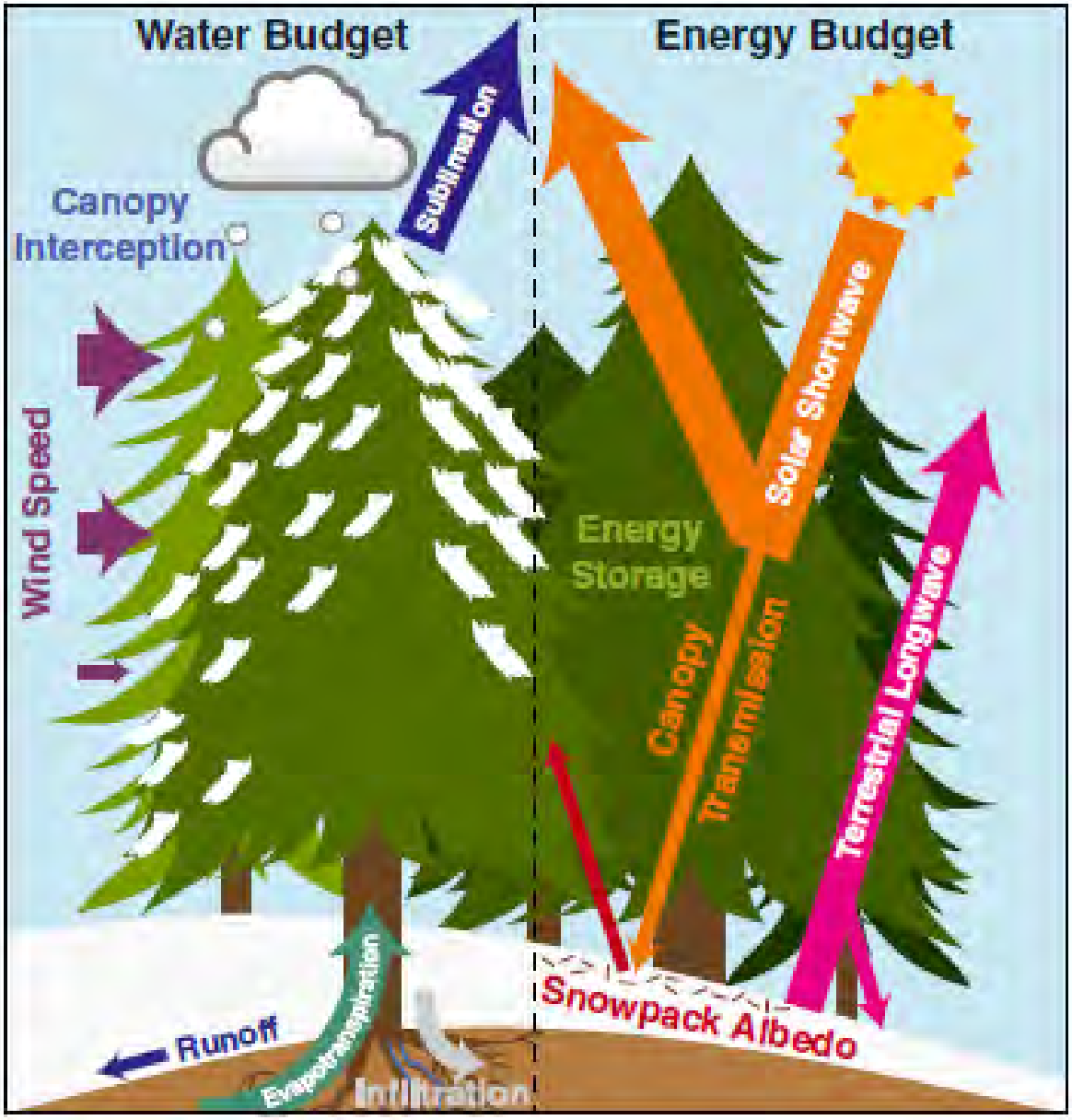
(wileyonlinelibrary.com) DOI: 10.1002/hyp.9312

A conceptual model of water yield effects from beetle-induced tree death in snow-dominated lodgepole pine forests

Evan Pugh[1]* and Eric Gordon[2]

Year-to-year climatic variation matters most, and determines the magnitude of forest canopy effects on many snow processes.

E.g., total precip, mid-winter melts, sunny vs. cloudy spring.



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Effects of Fire Exclusion: Bitterroot Valley, Montana

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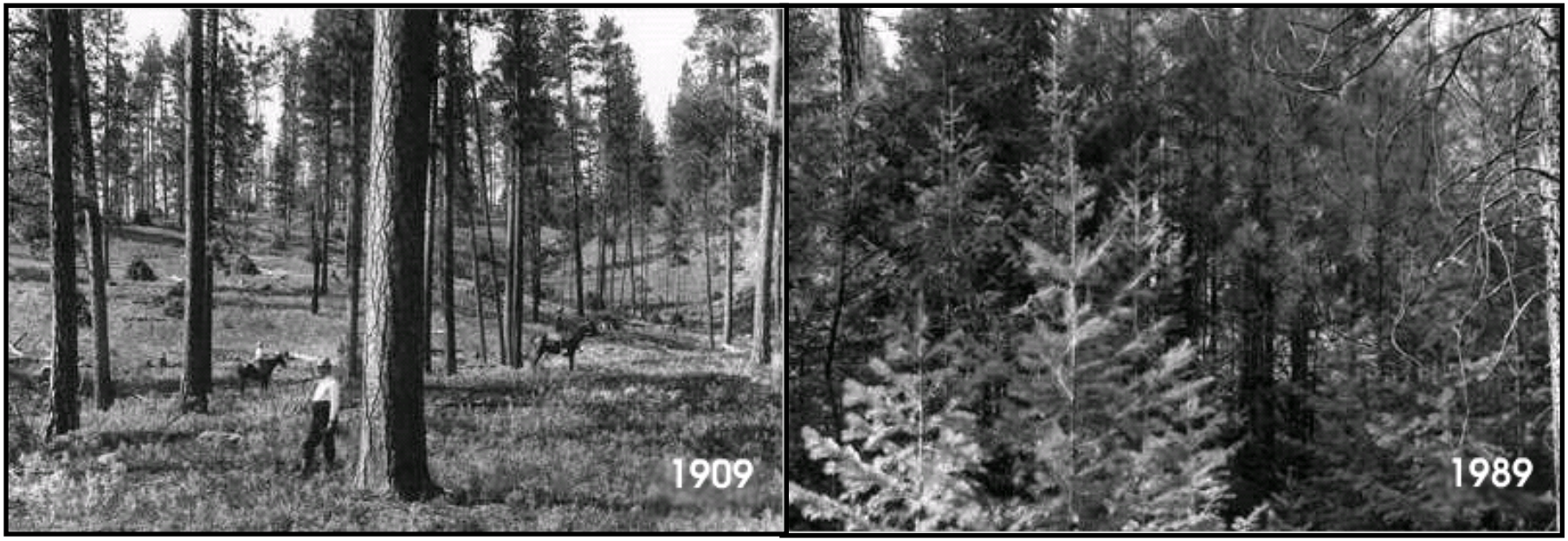
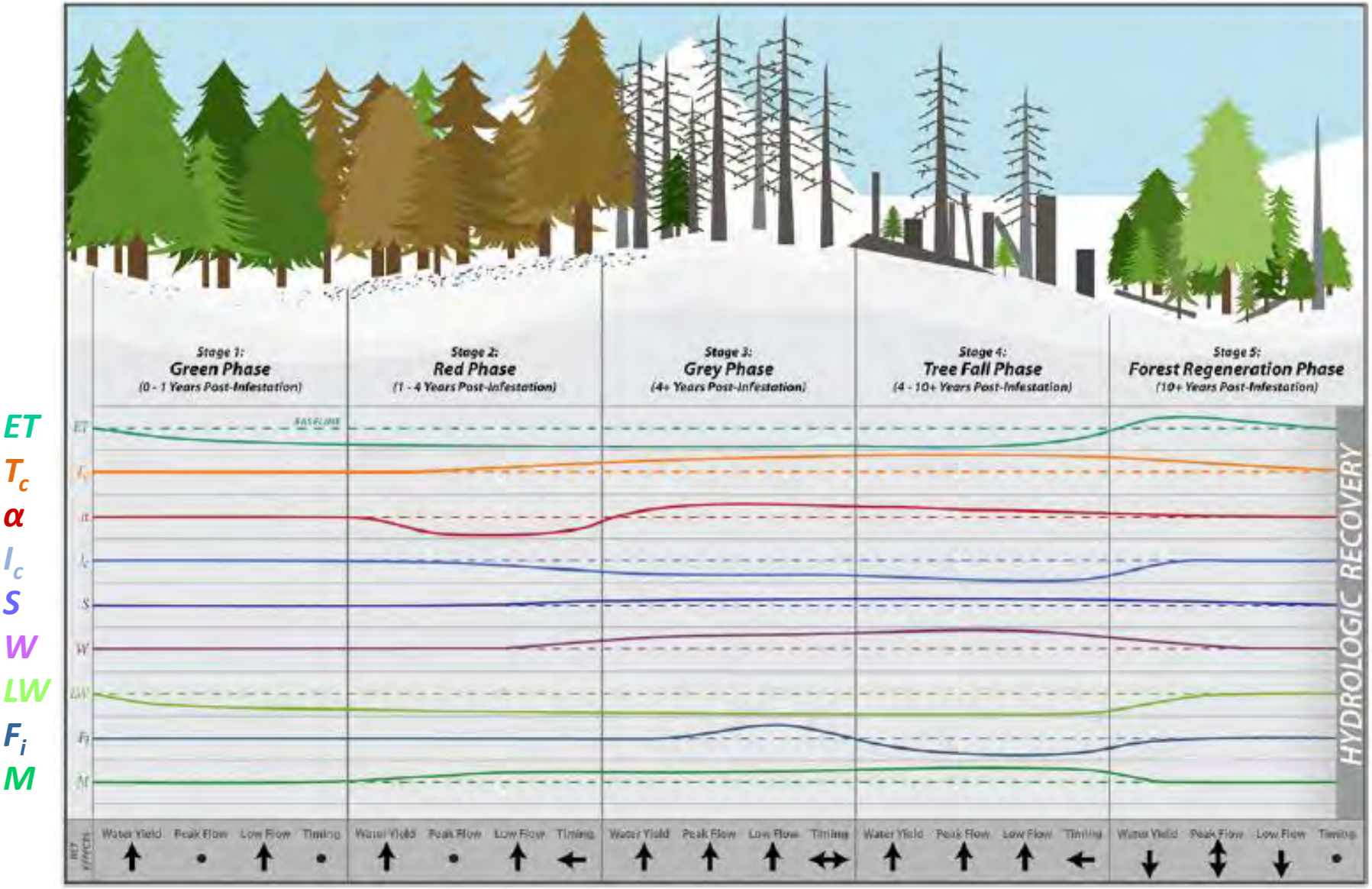


Fire exclusion:

- **Increased tree density**
- **Altered species composition (more shade tolerant species)**
- **Increased canopy cover**



ET – evapotranspiration; T_c – canopy solar transmission; ***α*** – snow surface albedo; I_c – canopy snow interception; ***S*** – snow sublimation; ***W*** – wind speed; ***LW*** - canopy long-wave reemission; F_i – soil infiltration; ***M*** – overall melt energy.

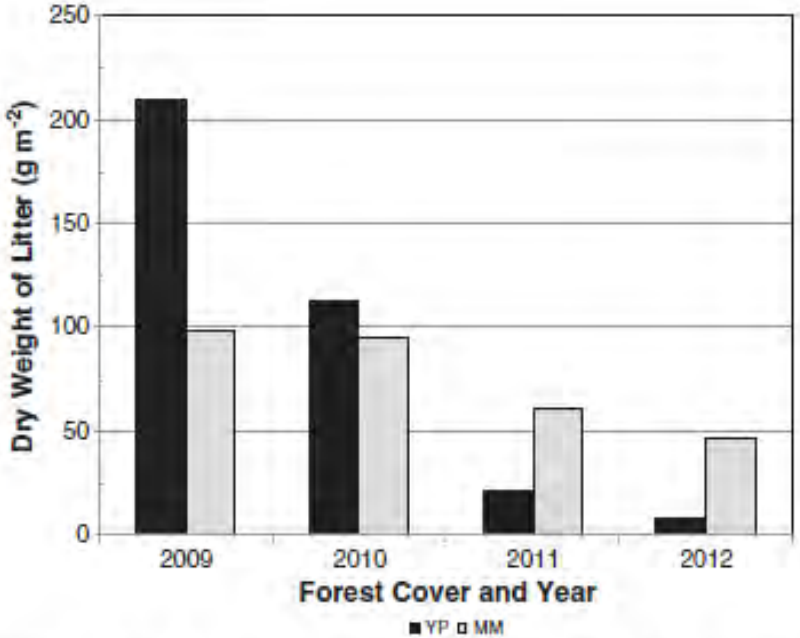


Figure 5. Total dry weight of forest litter collected from October through May in a young pine (YP) and mature mixed (MM) stand

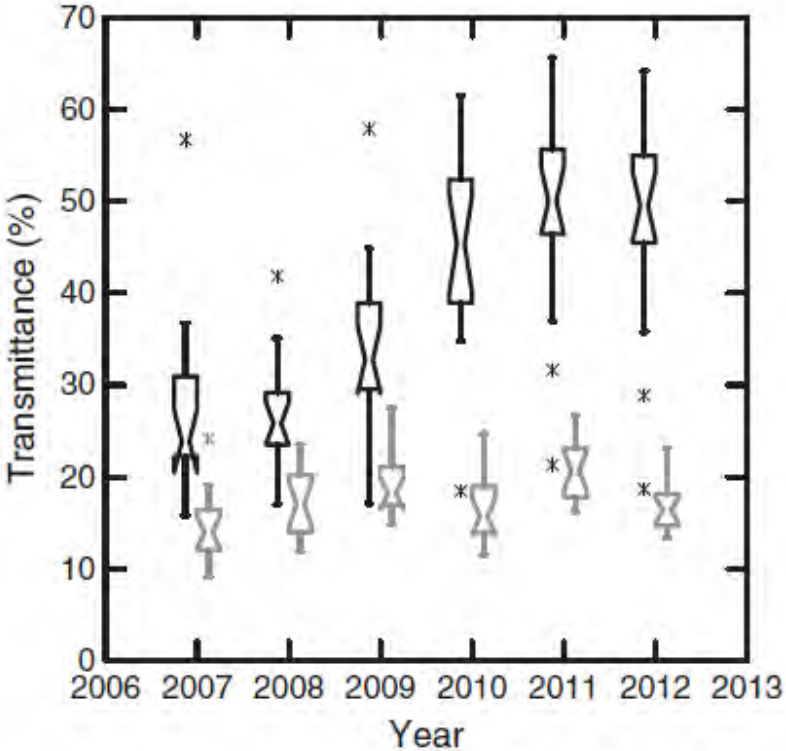


Figure 4. Percent transmittance in the pine (YP; black box) and mixed species (MM; grey box) stands prior to snowfall in 2007, and following snow disappearance each spring to 2012. Values are calculated from hemispherical photographs, $n = 16$ for each stand

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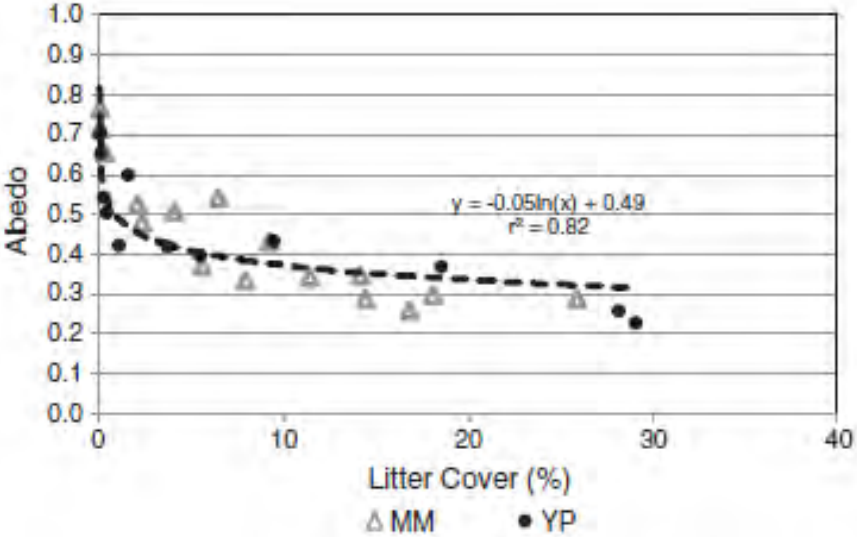
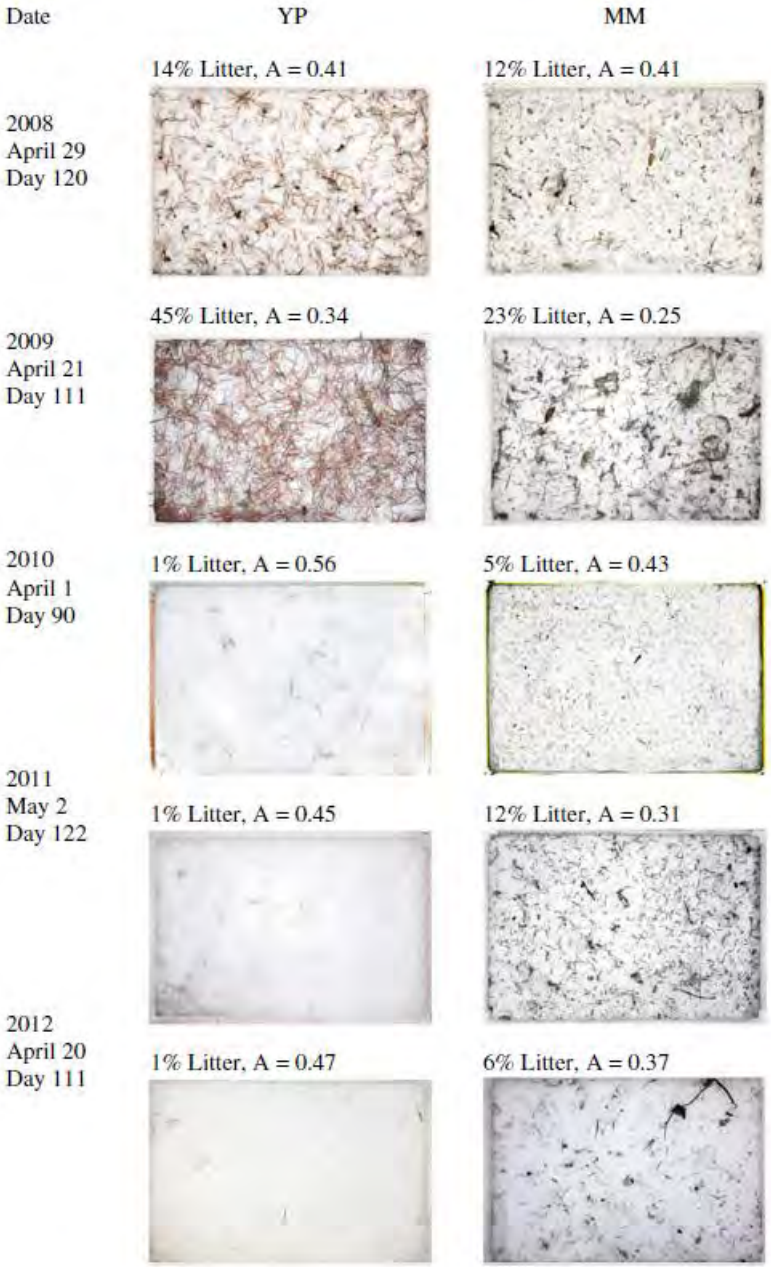
Snow accumulation and ablation response to changes in forest structure and snow surface albedo after attack by mountain pine beetle

Rita Winkler,[1]* Sarah Boon,[2] Barbara Zimonick[3] and Dave Spittlehouse[4]





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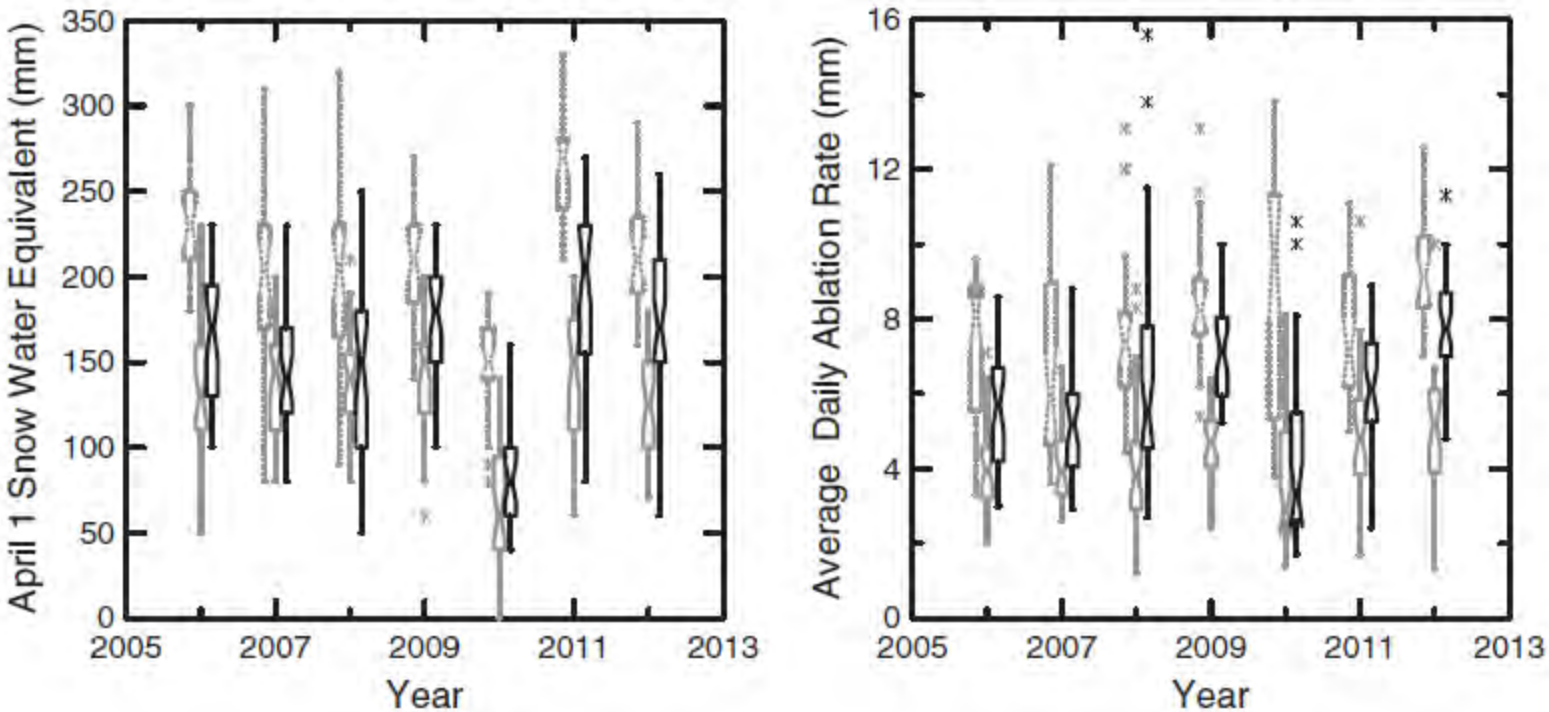

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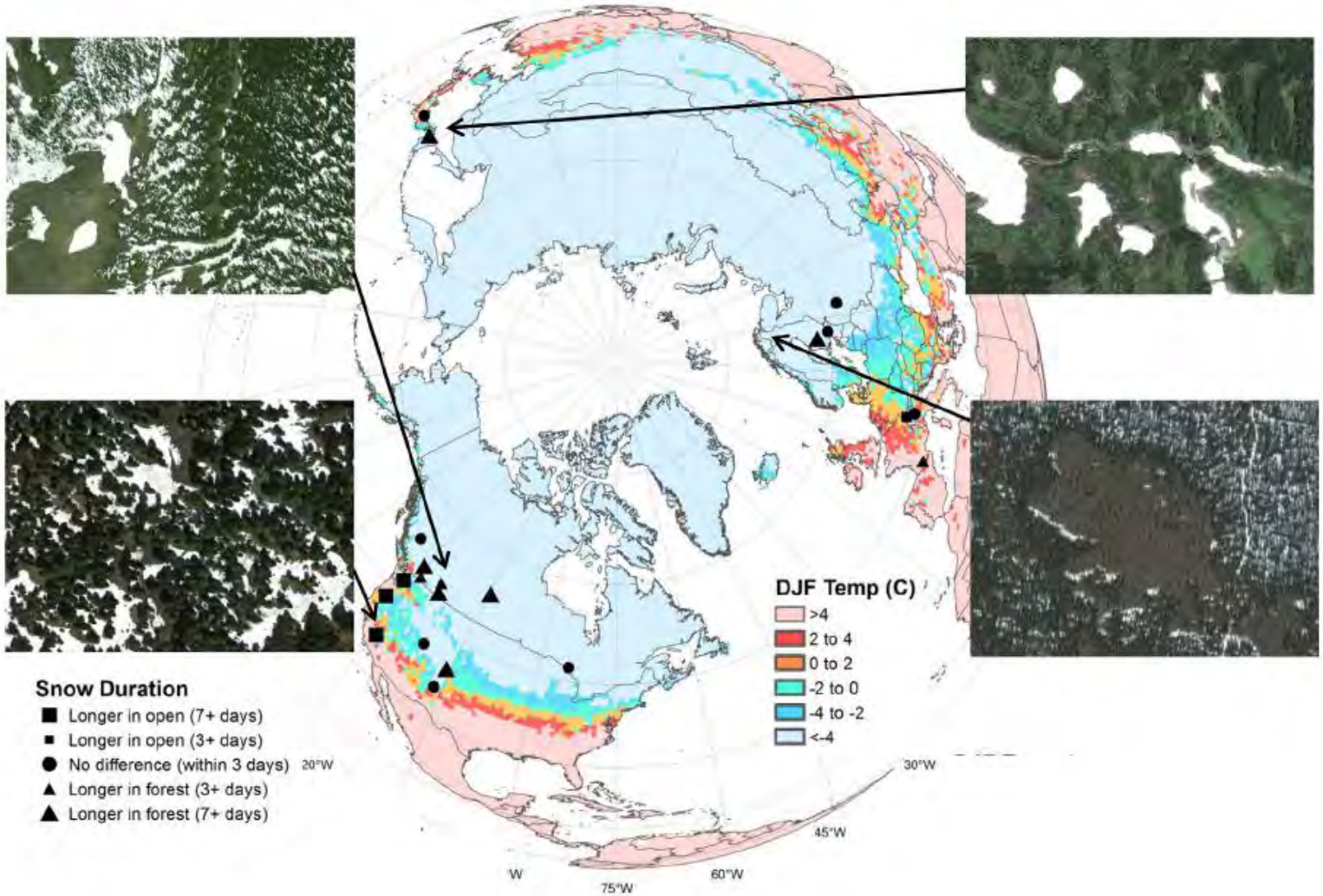
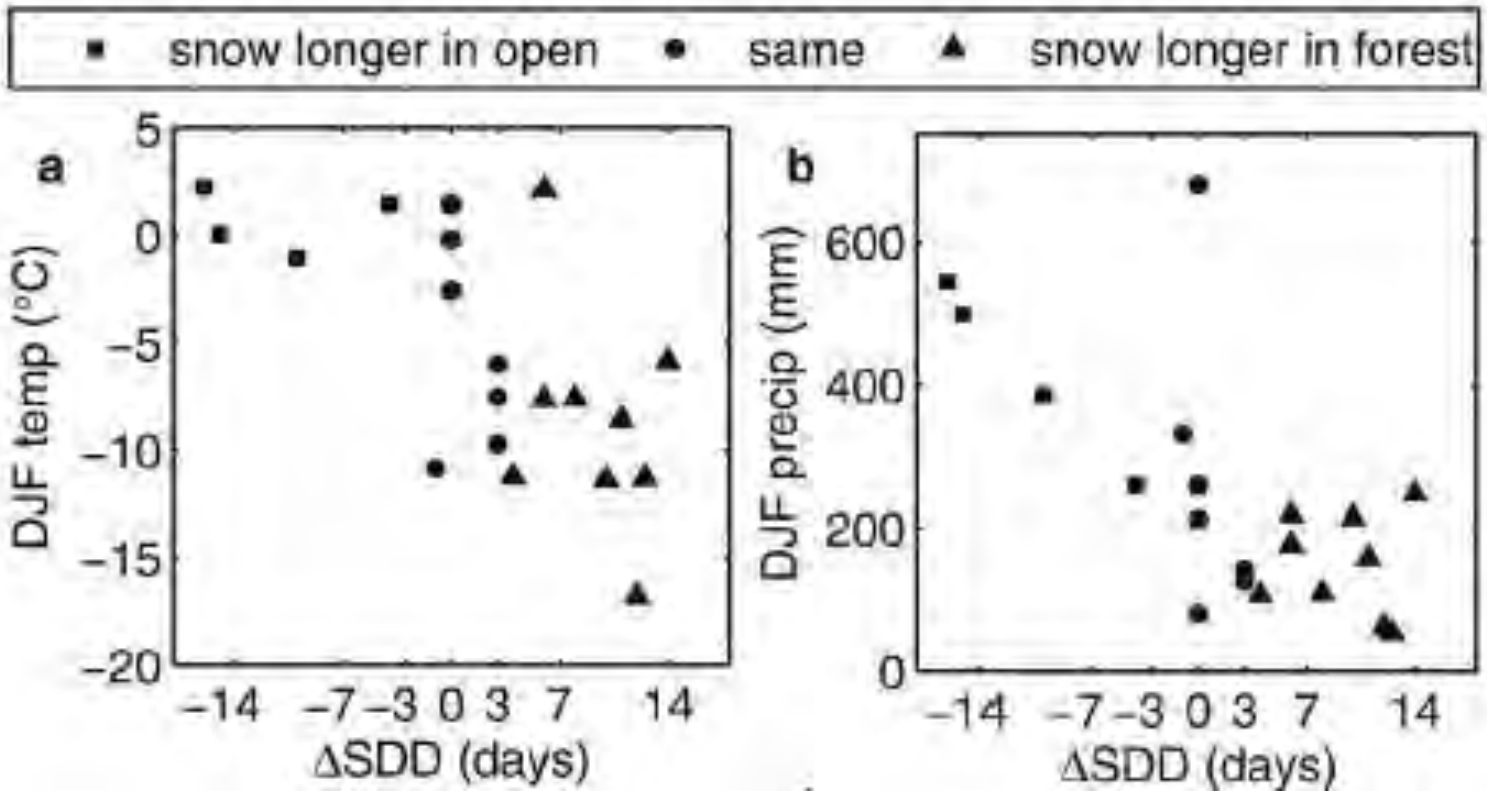


Lower forest density enhances snow retention in regions with warmer winters: A global framework developed from plot-scale observations and modeling

Jessica D. Lundquist,[1] Susan E. Dickerson-Lange,[1] James A. Lutz,[2] and Nicoleta C. Cristea[1]

WATER RESOURCES RESEARCH, VOL. 49, 1–15, doi:10.1002/wrcr.20504, 2013



Forest cover reduces snow duration by 1-2 weeks at sites with mean wither temperature > -1°C. This happens because the dominant canopy effect shifts from shading/wind blockage (cold sites) to accelerating snowmelt by increasing longwave radiation.

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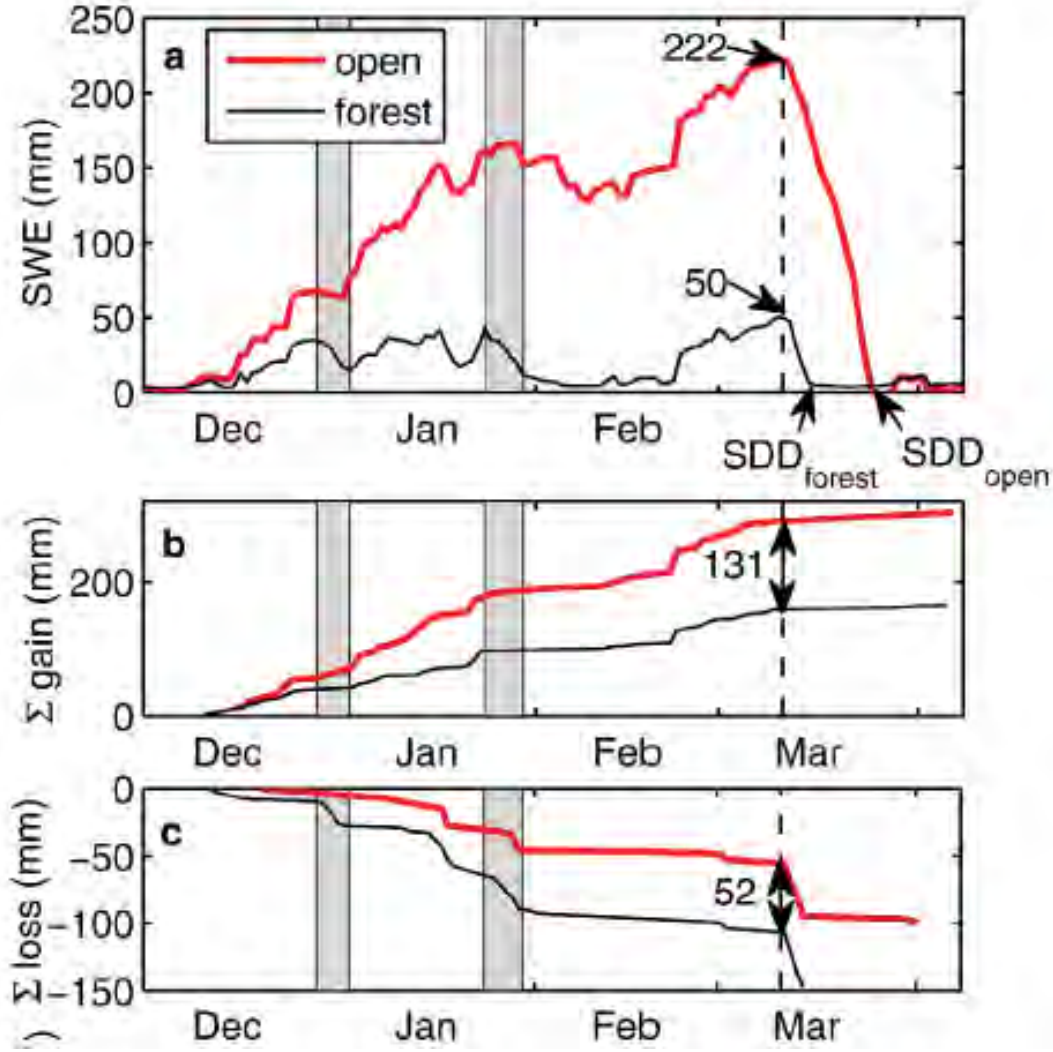

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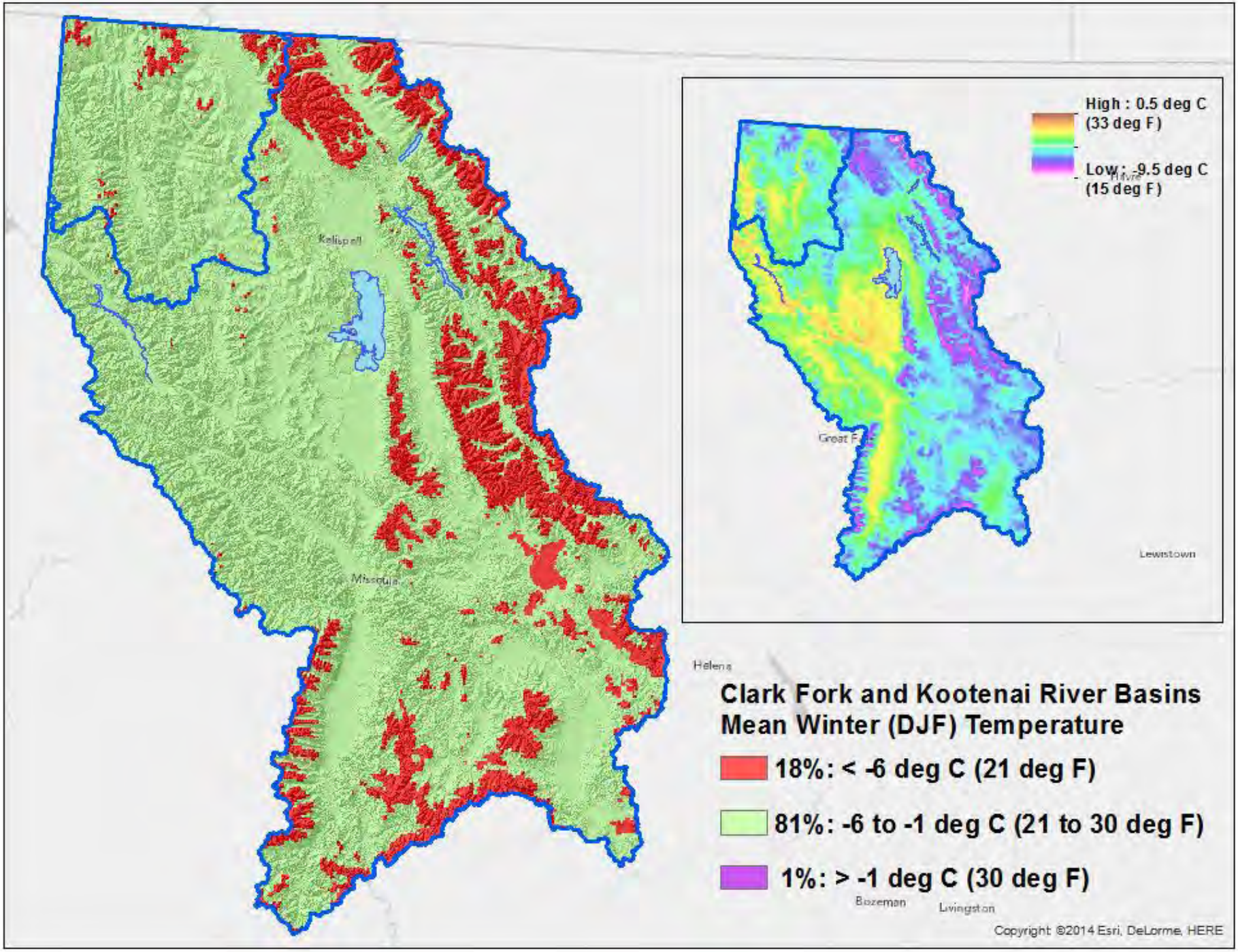
High : 0.5 deg C
(33 deg F)
Low : -9.5 deg C
(15 deg F)
Lewistown
Kalispell
Missoula
Helena
Bozeman
Livingston
Clark Fork and Kootenai River Basins
Mean Winter (DJF) Temperature
18%: < -6 deg C (21 deg F)
81%: -6 to -1 deg C (21 to 30 deg F)
1%: > -1 deg C (30 deg F)
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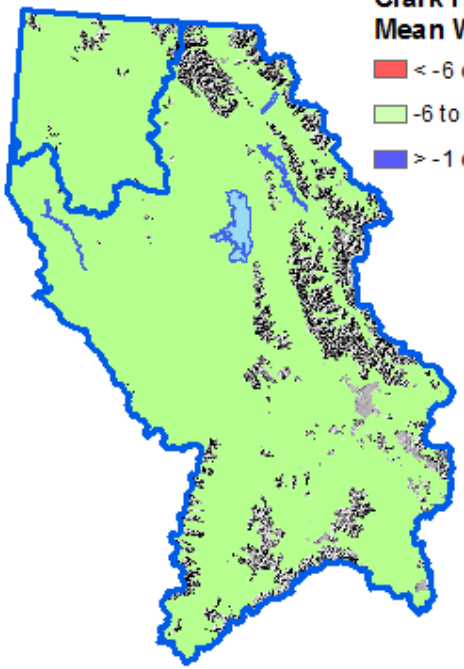


Clark Fork and Kootenai River Basins
Mean Winter (DJF) Temperature

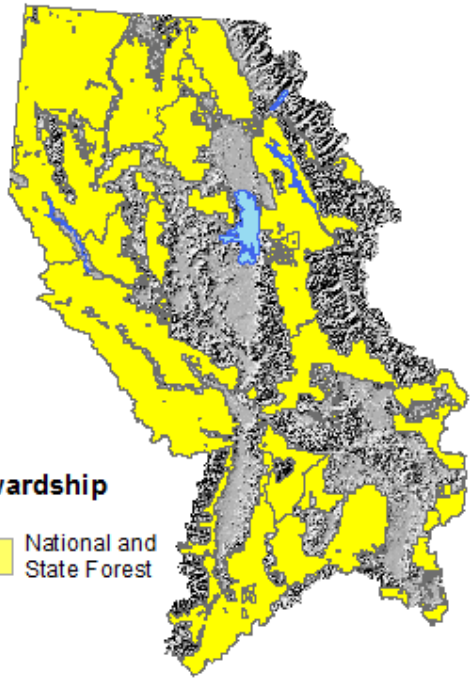
- < -6 deg C (21 deg F)
- -6 to -1 deg C (21 to 30 deg F)
- > -1 deg C (30 deg F)

81% of the total basin area is in the -6 to -1 deg C (21 to 30 deg F) class

Coniferous Forest

- Coniferous dominated forests

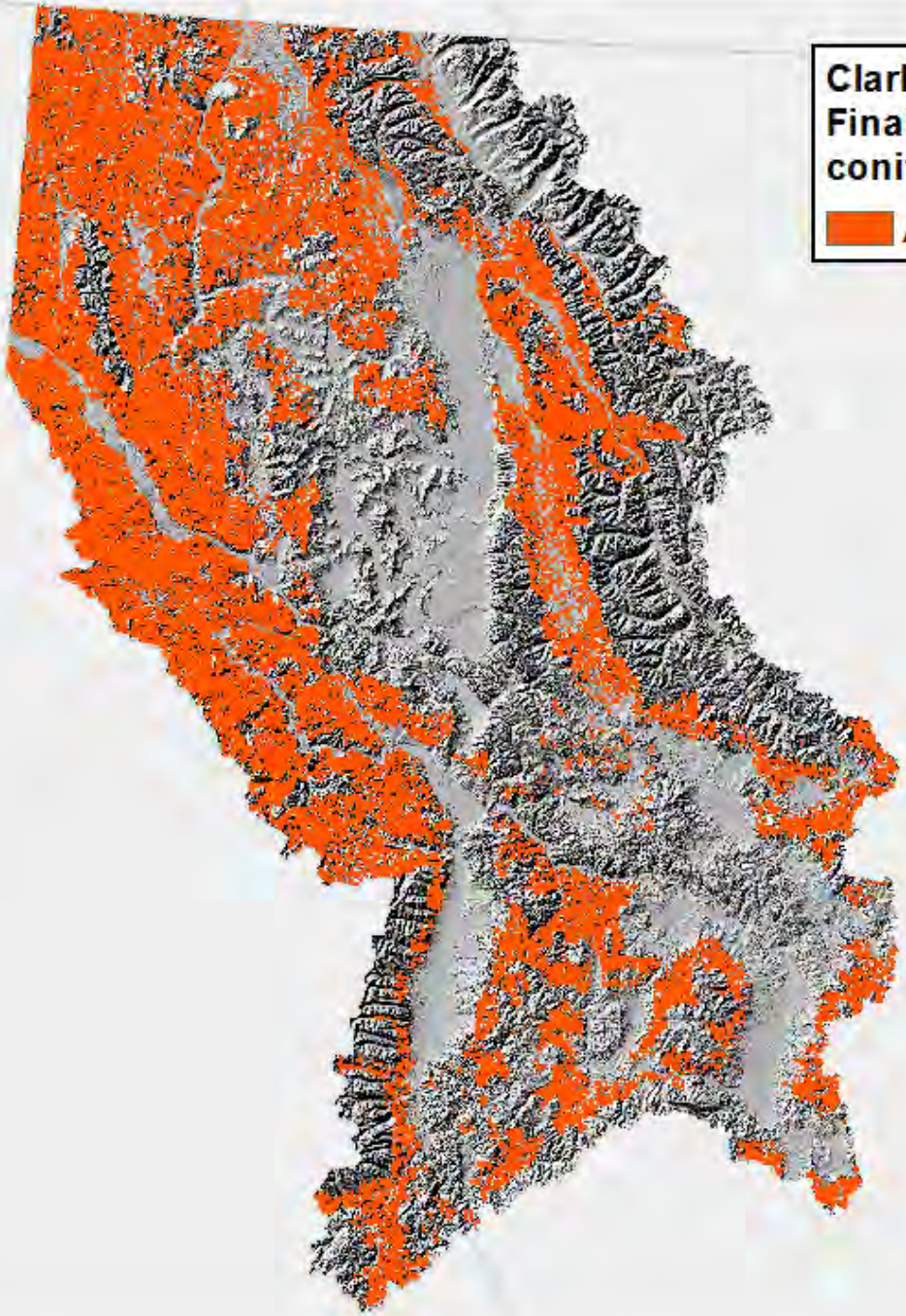
57% of the total basin area is in a coniferous forest type



Stewardship

- National and State Forest

52% of the total basin area is state or national forest



Clark Fork and Kootenai River Basins
Final classification (temperature, coniferous forest, stewardship)

All lands meeting criteria

32% of the basin is in the -6 to -1 deg C (21 to 20 deg F) class with a coniferous forest type and on State of Federal forest land.

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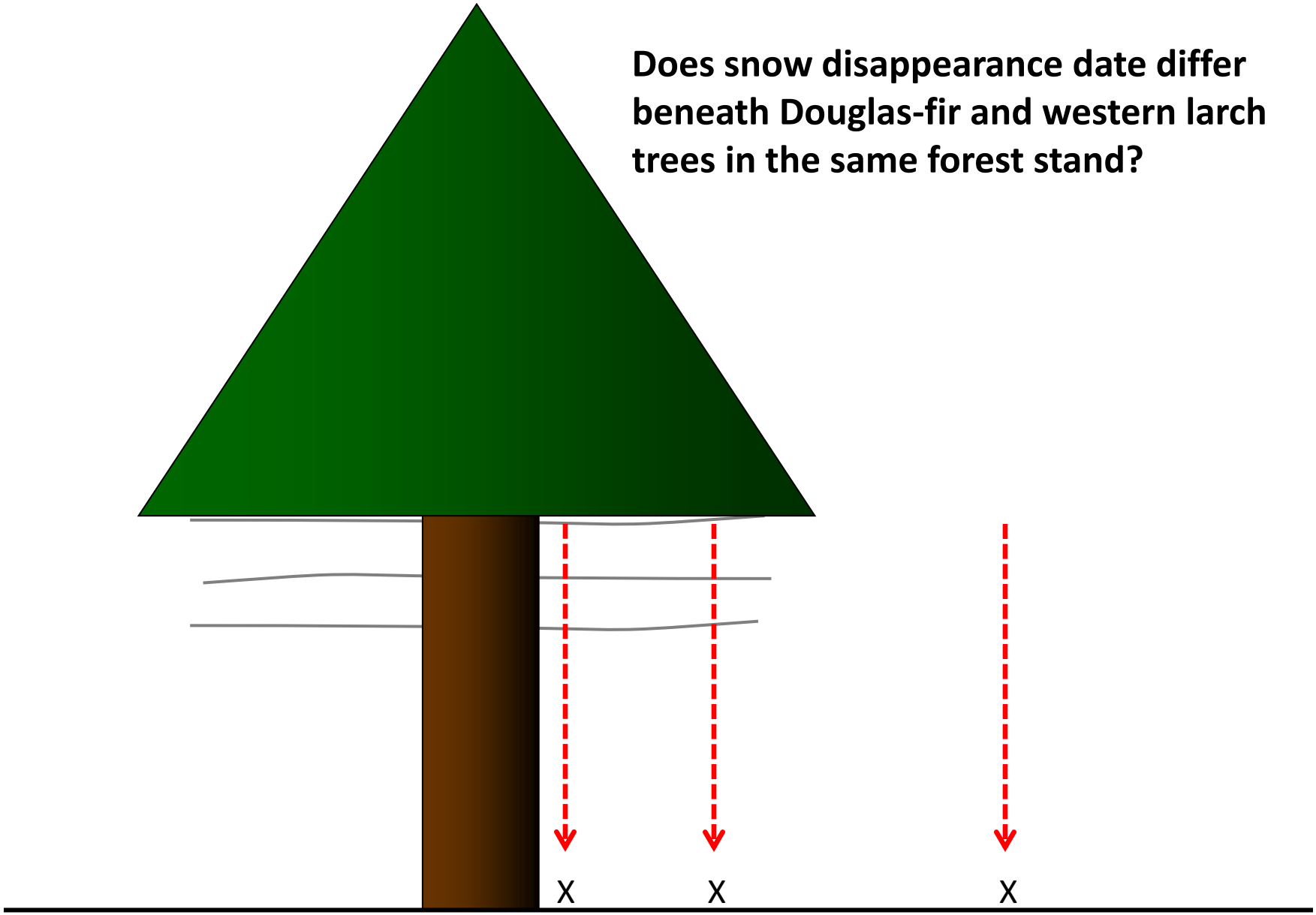
Douglas-fir **Western larch**

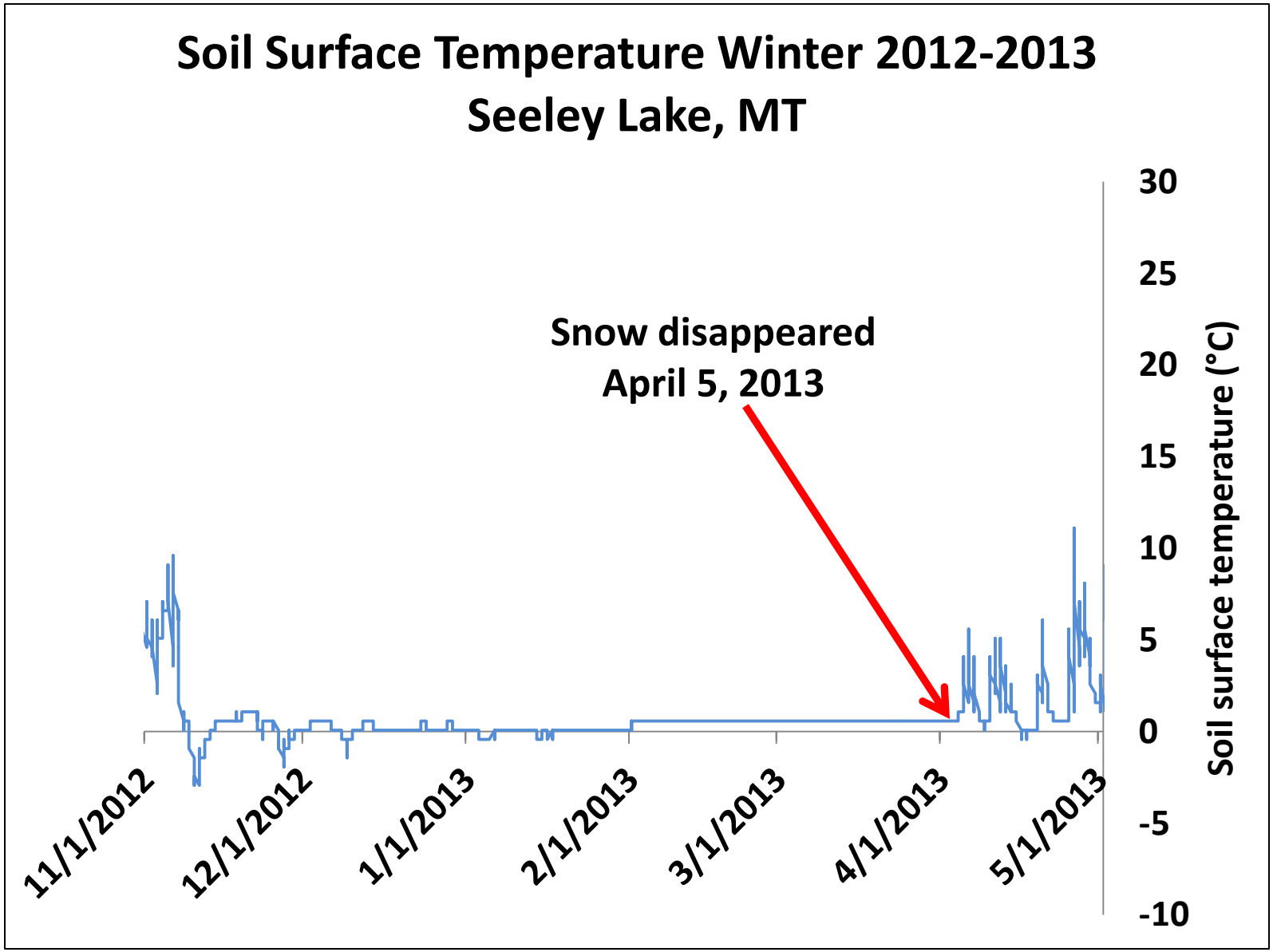
Western larch/mixed-evergreen conifer forests common at low and middle elevations in western Montana.

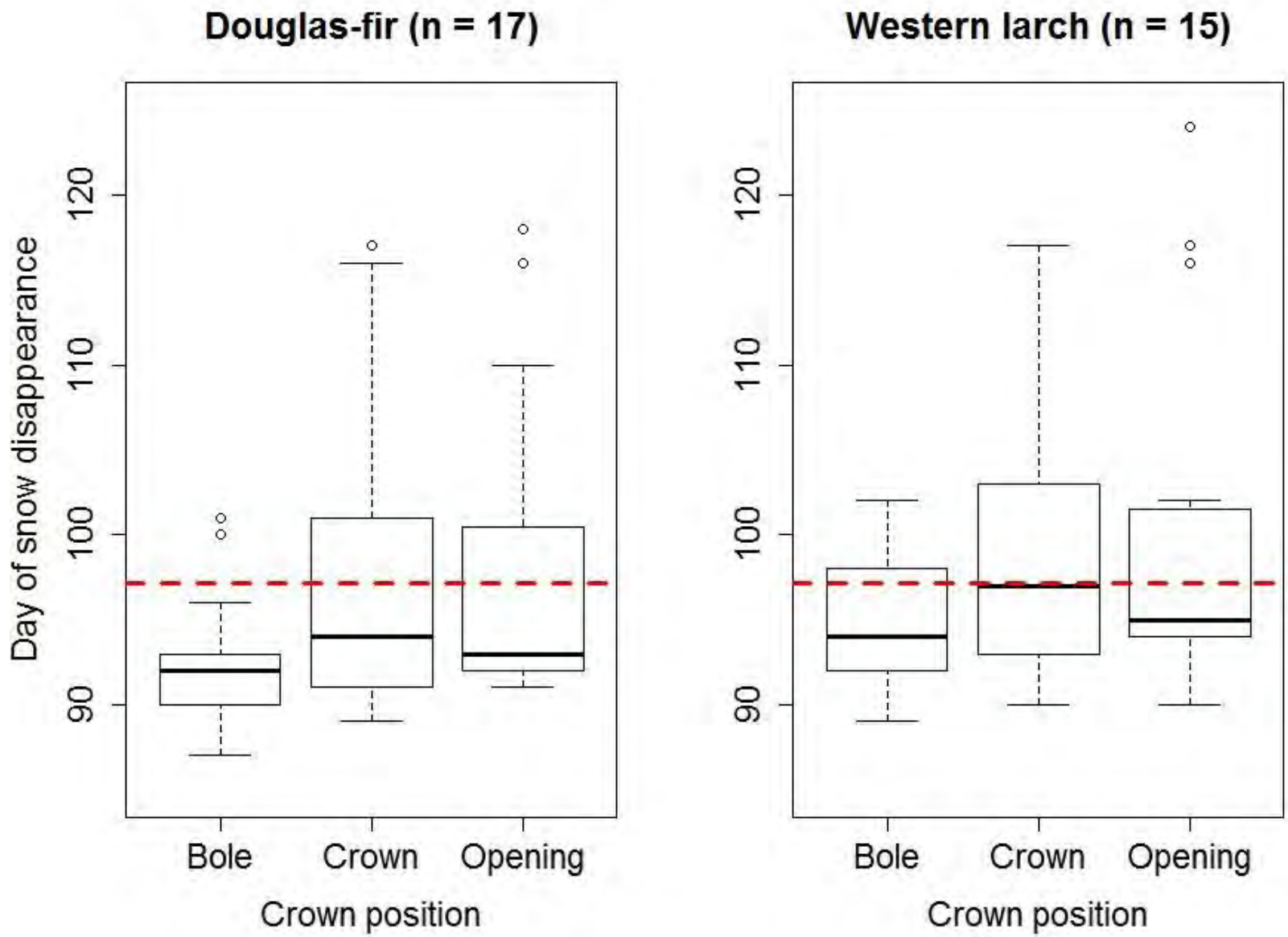
Does snow disappearance date differ beneath Douglas-fir and western larch trees in the same forest stand?

Does snow disappearance date differ beneath Douglas-fir and western larch trees in the same forest stand?

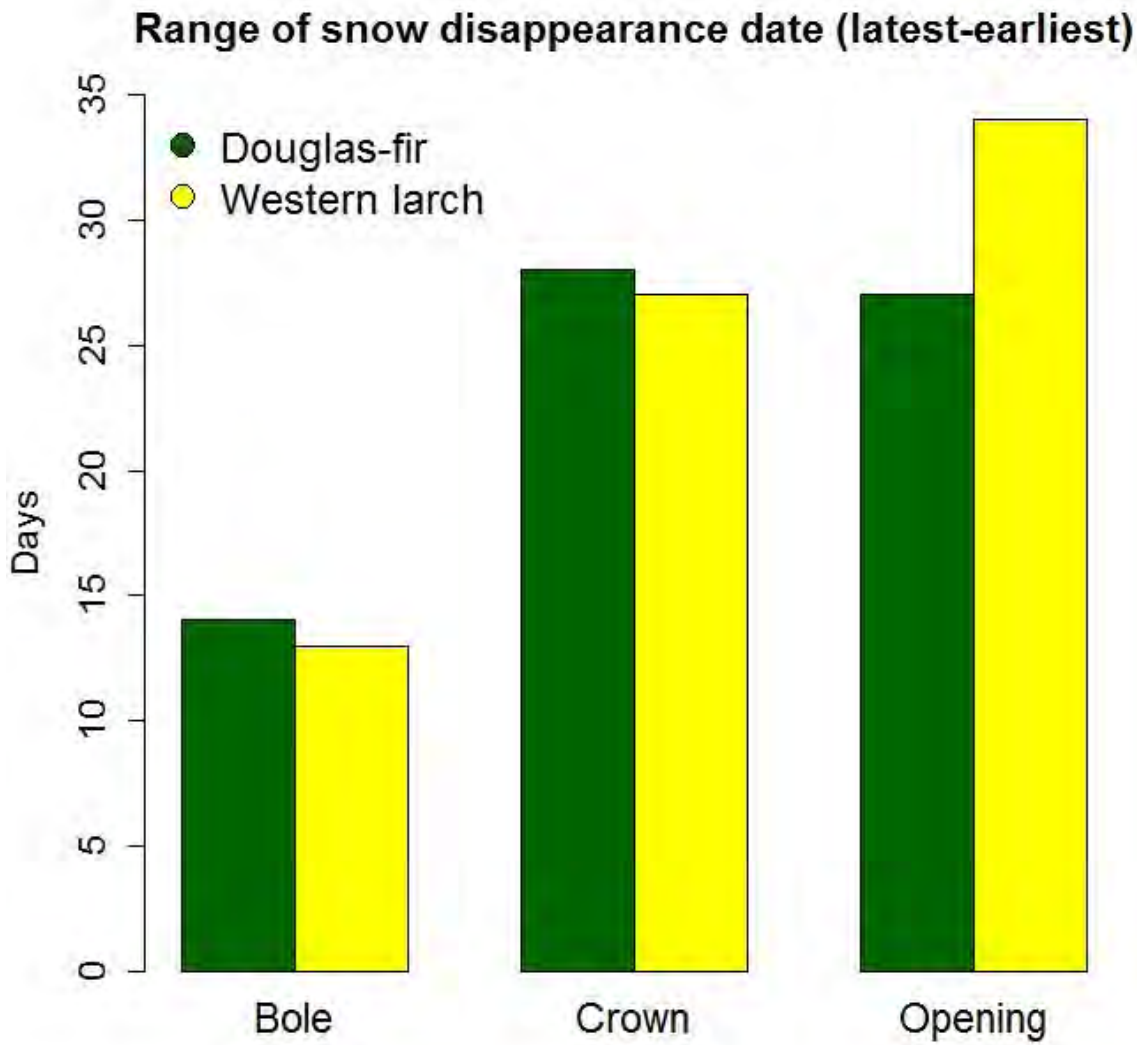


Temperature sensor locations with respect tree crown


Soil Surface Temperature Winter 2012-2013
Seeley Lake, MT
Snow disappeared
April 5, 2013
30
25
20
15
10
5
0
-5
-10
Soil surface temperature (°C)
11/1/2012
12/1/2012
1/1/2013
2/1/2013
3/1/2013
4/1/2013
5/1/2013

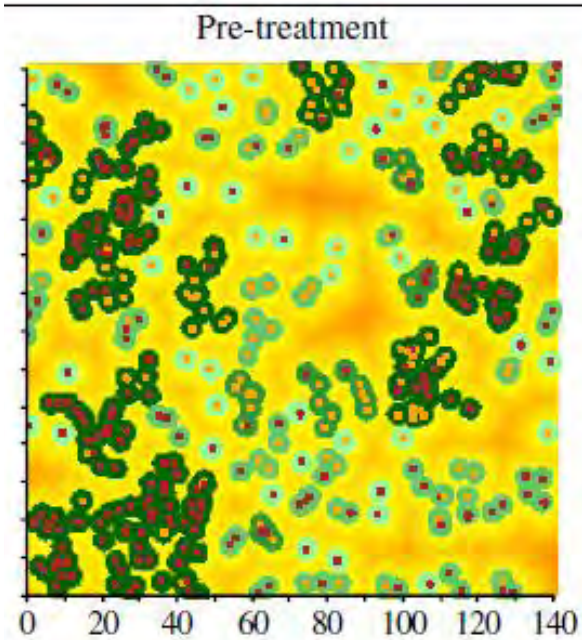

Douglas-fir (n = 17)
Western larch (n = 15)
Day of snow disappearance
90
100
110
120
Bole
Crown
Opening
Crown position

Significant tree well effect under Douglas-fir but not under western larch.



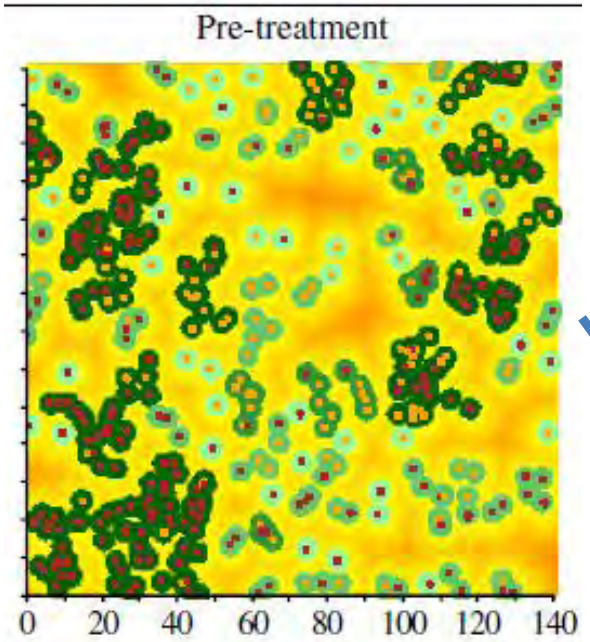
Earliest snow disappearance: March 28

Latest snow disappearance: May 4

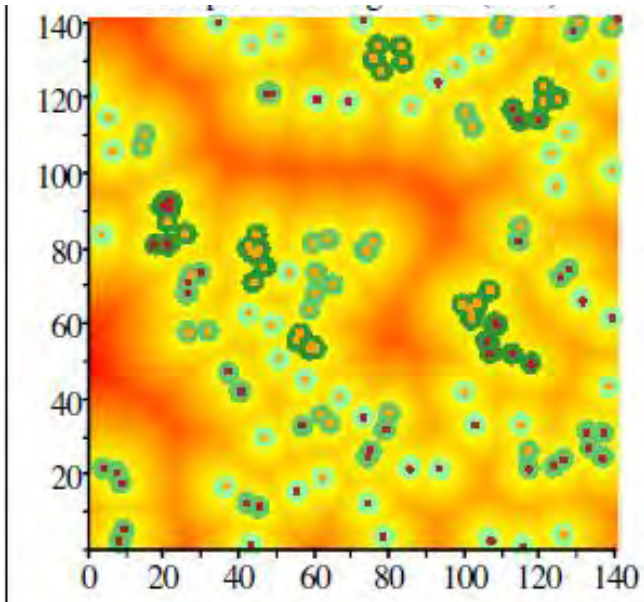


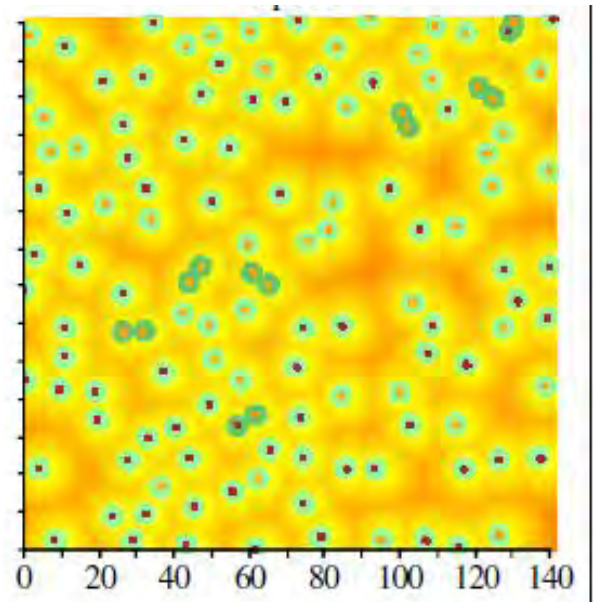
Does spatial variation in tree density, species composition, and canopy structure explain the 30+ day range in snow disappearance date observed within forest stands?

Clumpy-Gappy Thinning designed to emulate old-growth forest structure developed from frequent fire.



Spatially uniform thinning typical of fuel reduction and commercial timber production.





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