

Snow Response to Changing Forest Cover After Mountain Pine Beetle

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MFNRO Research Seminar Series, November 1, 2011



Acknowledgements

Tim Giles, Patrick Martin, Michael Ryan, Dave Maloney and Karen Baleschta

Ralph Adams
Jean Roach

BC Ministry of Forests
Weyerhaeuser Co. Ltd.
West Fraser Timber Co. Ltd.

FRBC, FSP, FFESC



Outline

1. Background
2. Overview of the Mayson Lake project: objectives, location and methods
3. Results
4. Summary



1. Background

- Extensive areas in BC forested with >80 year old lodgepole pine, susceptible to mountain pine beetle
- Infestation peaked in 2005, by 2010: 17.5 million ha affected
- Trees turn red ~1 year after attack, grey 2 – 4 years later
- Forestry concerns: leave standing dead or harvest, soil moisture
- Hydrology concerns: changes in hillslope water balance, runoff volume and timing







Shortwave radiation



Longwave radiation



Sensible heat



Latent heat



**Ground heat
(negligible)**





Shortwave radiation



Longwave radiation



Sensible heat



Latent heat



**Ground heat
(negligible)**



Precipitation



Interception

Throughfall and shedding



Evaporation and sublimation



Infiltration or storage



Shortwave radiation



Longwave radiation



Sensible heat (5-79%)



Latent heat (2-10%)



Ground heat
(negligible)



Snow



Interception (10-40%)

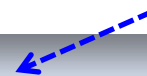
Throughfall and shedding

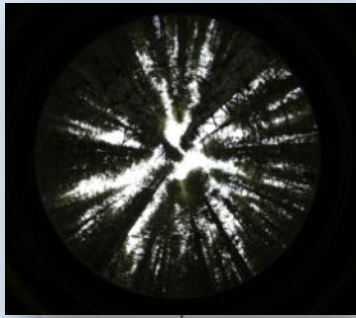


Sublimation



Storage and melt





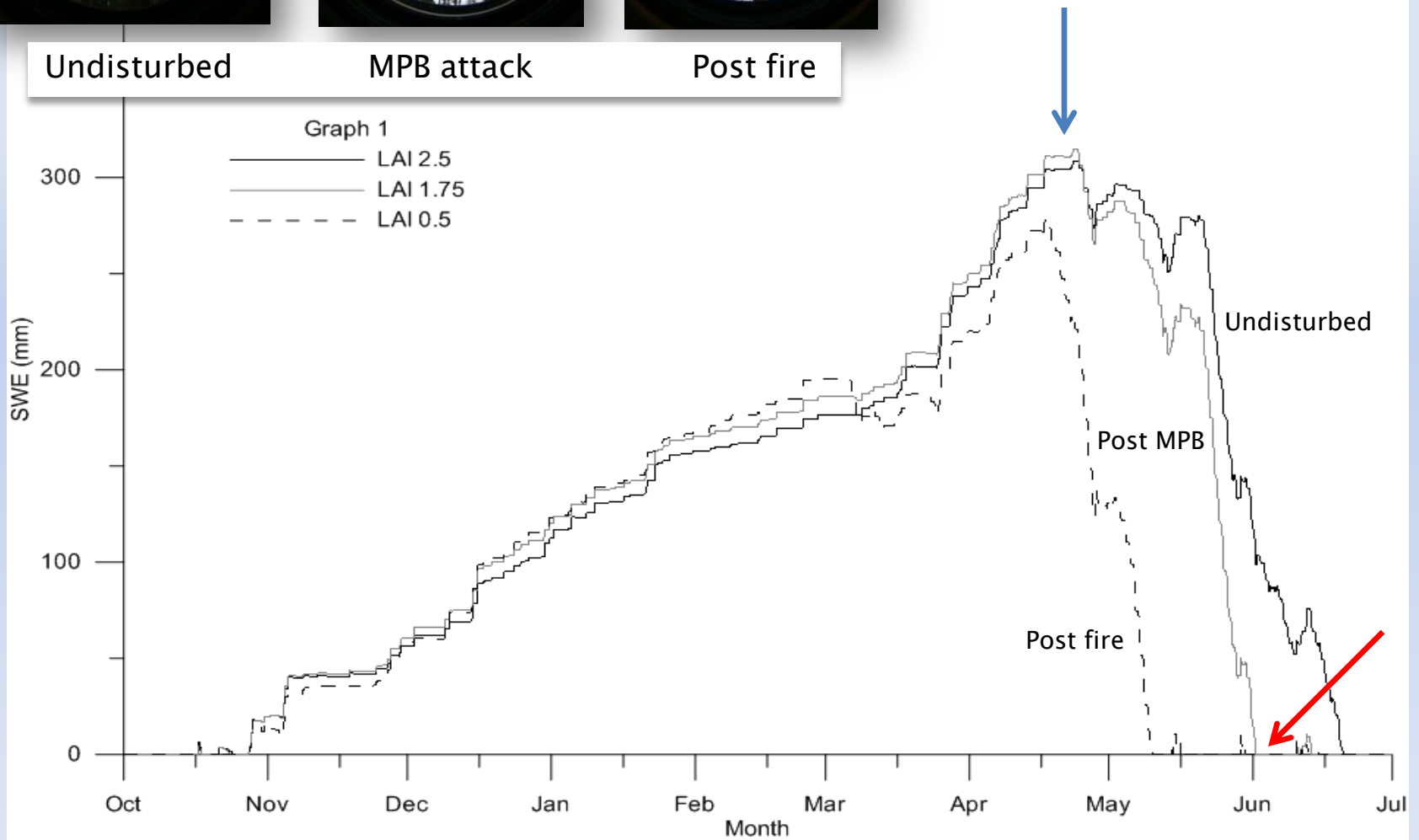
Undisturbed



MPB attack



Post fire



What we know from past research –

Green forest compared to the open

Snow accumulation (snow water equivalent (SWE)):

- 30 to 50% increase in peak SWE in the open relative to mature mixed pine, spruce/fir stands and 10 – 20% relative to mature pine (interior BC)
- 6% reduction in SWE for every 10% increase in crown closure (interior BC)
- 16% increase following 40% basal area removal (Montana) and 21% increase with 50% removal (Colorado)
- largest increases do not necessarily occur in the highest snow years



Snow ablation (interior, northwest Canada and US):

- 30 to >100% increase in ablation rates in the open
- rates increase exponentially with increasing canopy gap fraction
- snow disappears 1 to 2 weeks earlier in the open
- conditions most conducive to rapid melt in the absence of rain are:
 - delayed melt
 - clear days with cloudy nights
 - warm humid air combined with wind
 - low snow albedo
 - discontinuous snowpack
 - sources of longwave radiation (burned stems and logs, rocks)



Post MPB

- snow accumulation (as SWE) and ablation rates in CC > Grey > Forest
- in interior BC: max SWE reduced from that in a clearcut by 21–57% in green and 5–58% in grey; ablation rates reduced by 27–48% in green and 14–29% in grey
- in Colorado: snow accumulation same under green and red attack and 15% higher under grey; ablation higher in red and grey and onset of melt advanced
- effects of canopy loss highly variable with location, year and stand type



2. The Mayson Lake Project

Overview:

- stand-scale hydrologic processes study, established in 1994
- to understand linkages between forest cover and snow and quantify “hydrologic recovery” (1995–1997, 2003–2005)

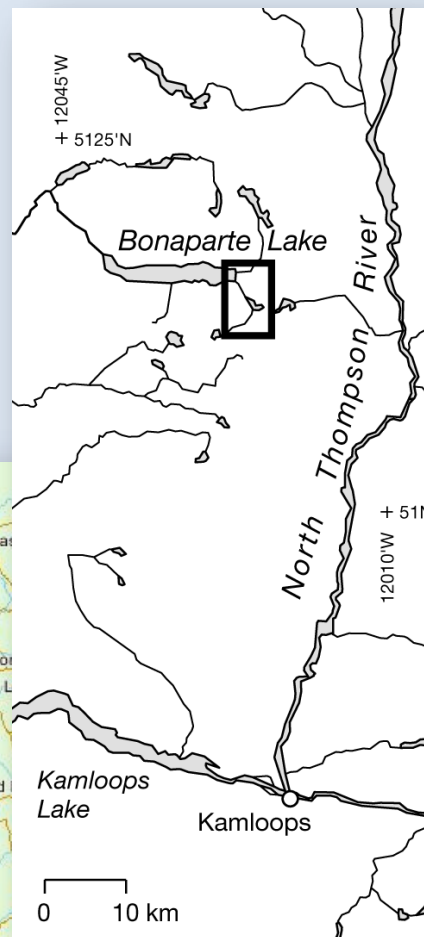
New study objectives for 2006 – 2011+:

- to quantify snow accumulation and ablation response to changes in forest cover, over-winter litter production and snow surface albedo following attack by mountain pine beetle (MPB)



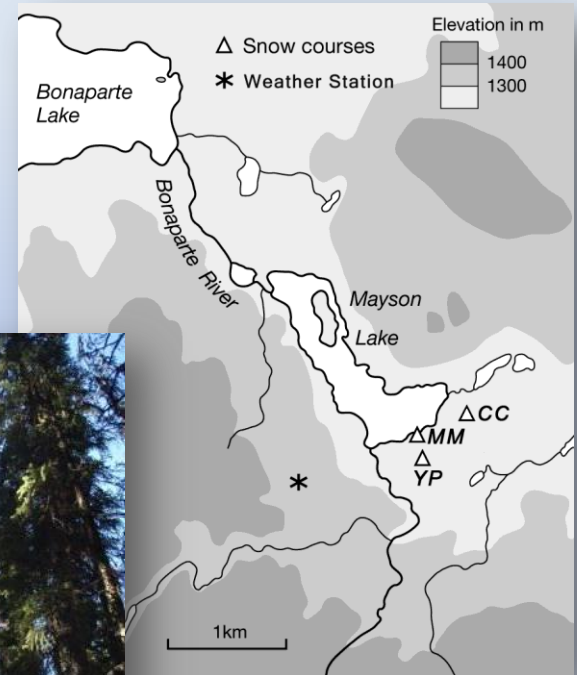
Study location:

- 50 km northwest of Kamloops
- 1280 m asl
- Montane Spruce dry mild biogeoclimatic zone
- 560 mm precipitation annually, ~40% as snow



Study sites and installations:

- 3 study stands
 - (MM) mature mixed lodgepole pine, Engelmann spruce and subalpine fir
 - (YP) young lodgepole pine
 - (CC) clearcut
- MPB attack in 2005
- 32 point, permanent sampling grids per site
- 4 weather stations



Measurements:

- **Forest cover and stand condition at all permanent sample points:**
 - standard inventory and tree condition: 2006, 2011
 - canopy transmittance, fall & spring 2007 – 2011 from hemiphotos and GLA
- **Litter at 3 litter traps per site and 16 snow stations (2008 – 2011):**
 - cover from downward-looking hemiphotos
 - weight at end of season (trap at base and at top of pack)
- **Albedo at 16 snow stations (2008 – 2011) :**
 - up- and down-facing LICOR pyranometers
- **Weather (2005 on):**
 - air temperature, snow temperature, snow depth, humidity
 - windspeed (CC), solar and reflected radiation (MM, CC)
- **Snow accumulation and ablation at all permanent sample points (2005 on):**
 - SWE with standard federal snow tube
 - surveys bi-weekly to weekly from March to end of melt

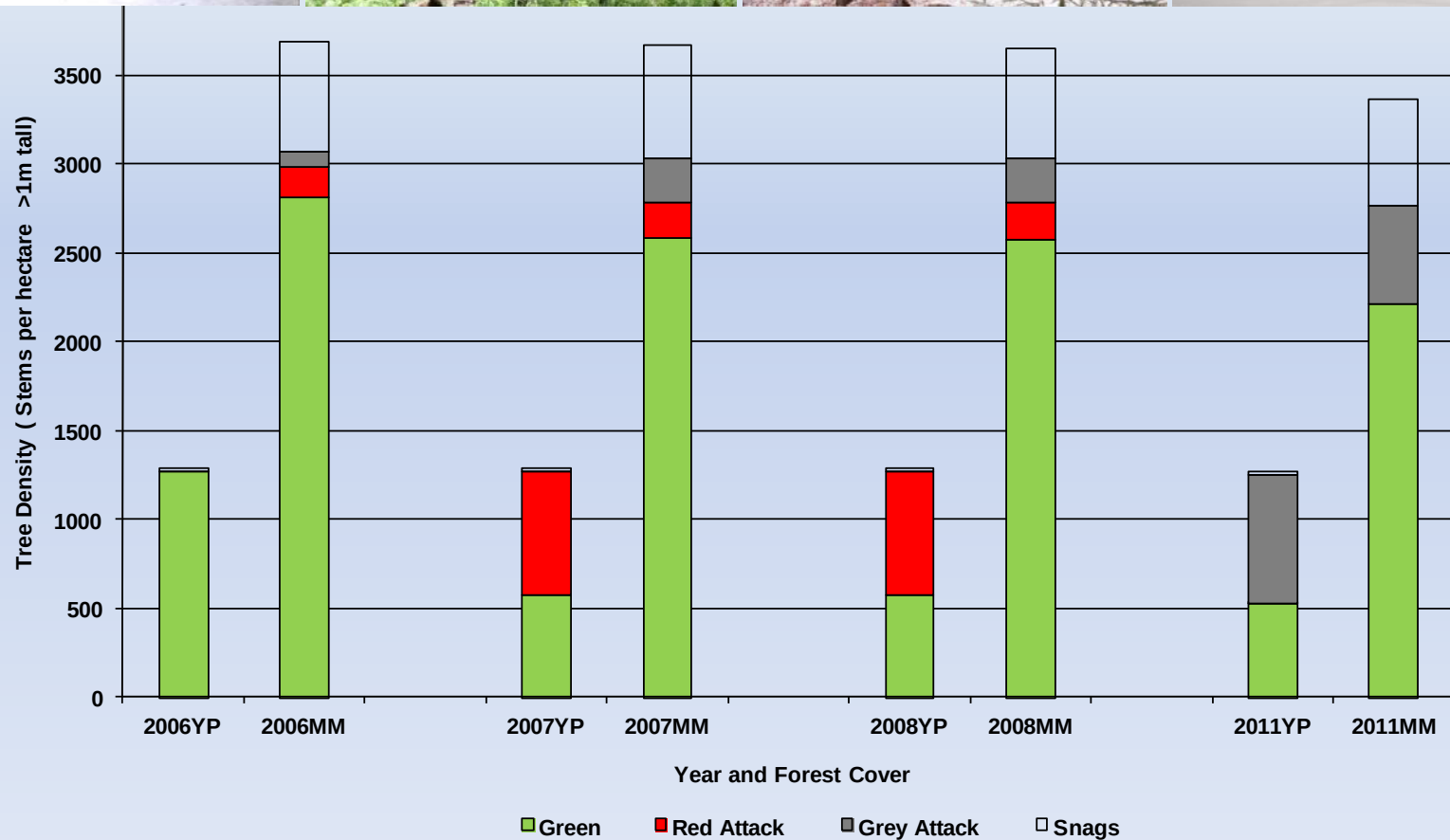


3. Results

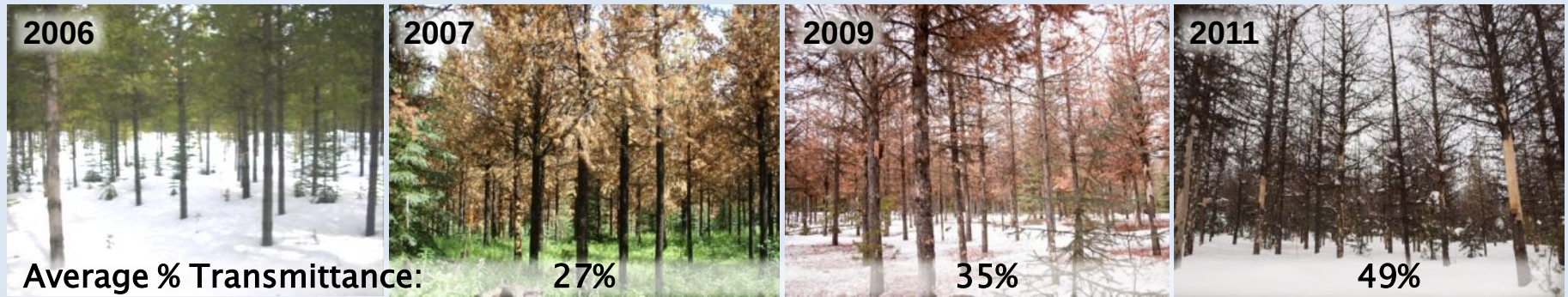
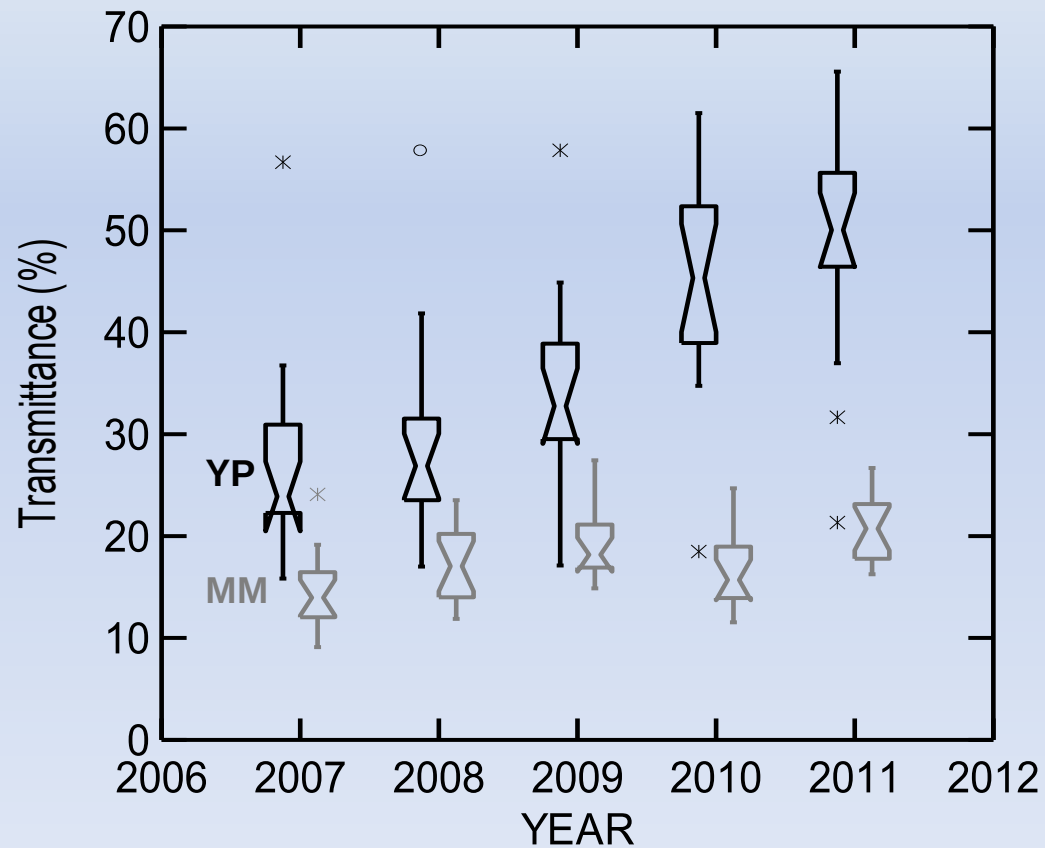
CC clearcut
YP young attacked pine
MM mature mixed



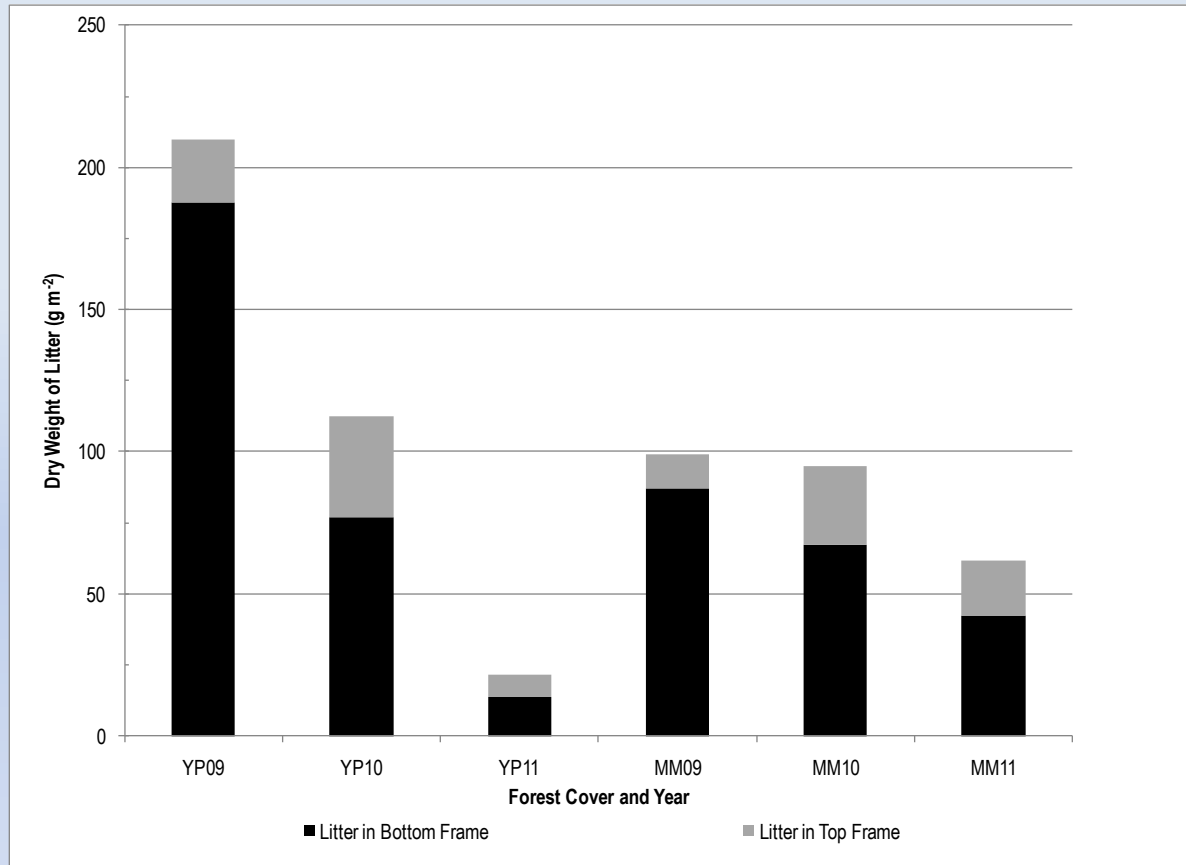
Stand condition:



Forest cover:



Litter:

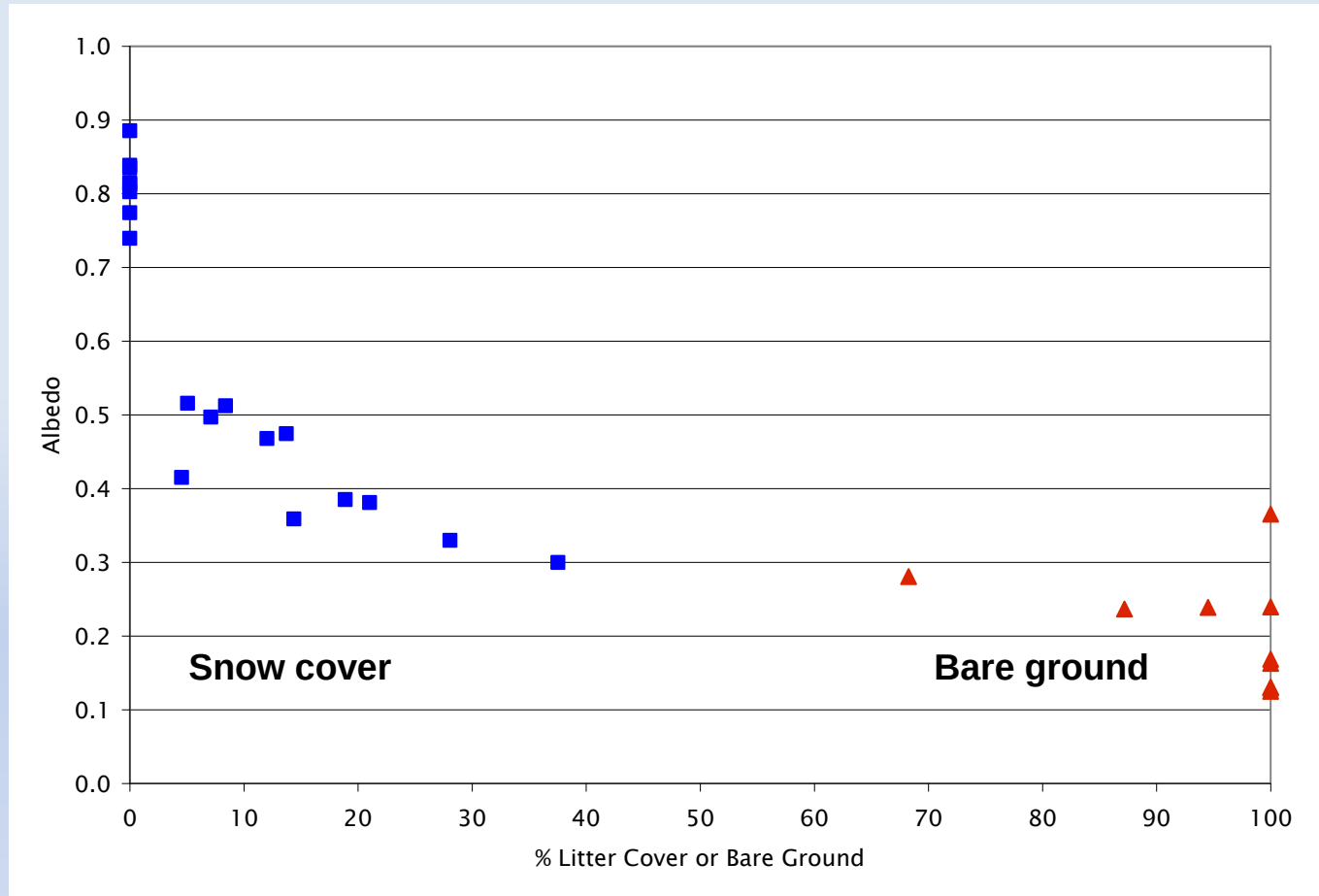


- no litter in CC
- 1 – 12% litter cover in MM

YP

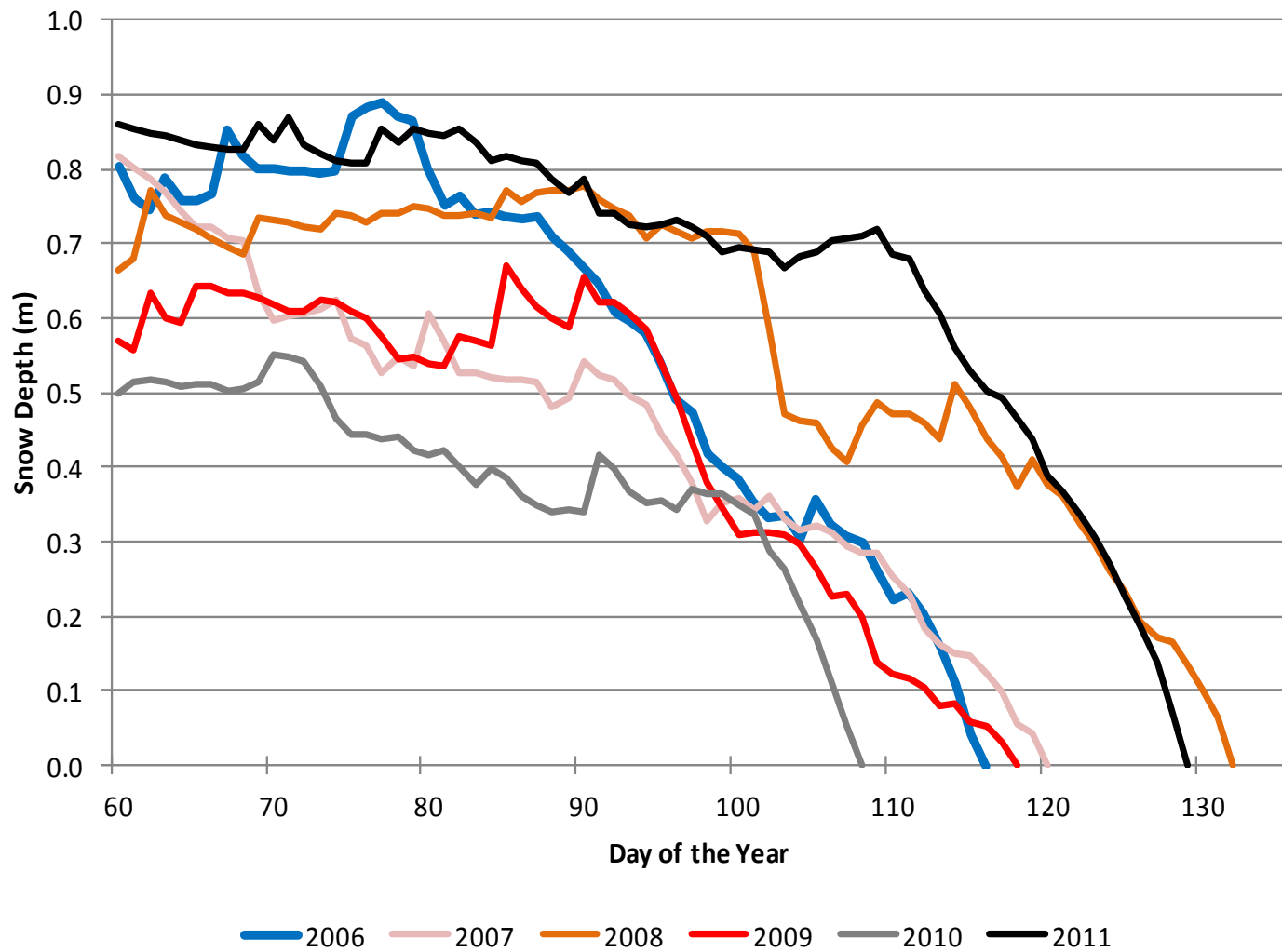


Albedo:

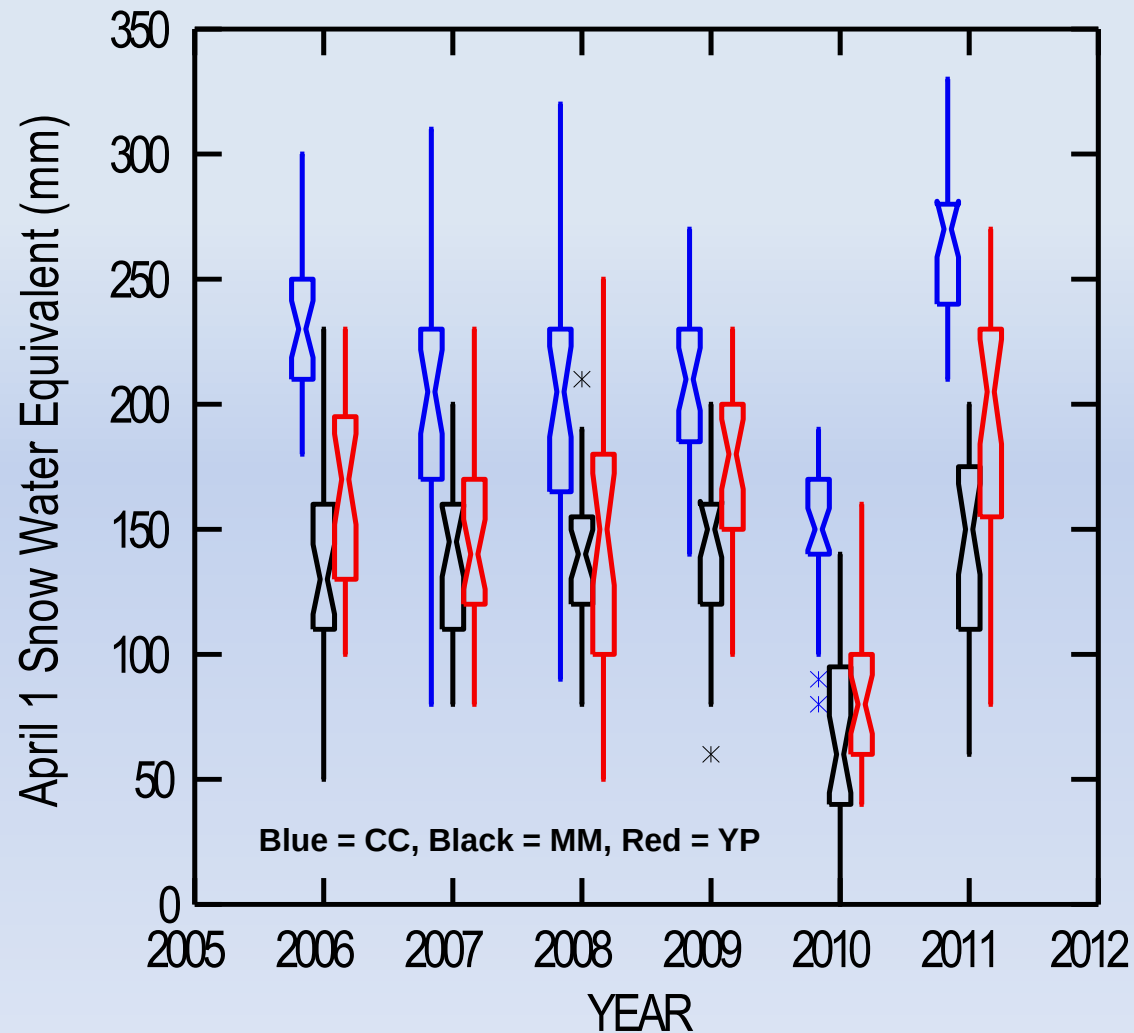


- snow surface albedo decreased exponentially with increasing litter cover
- effect in MM was slightly larger than in YP due to non-needle litter (Boon et al 2011)
- albedo also a function of snow depth and structure

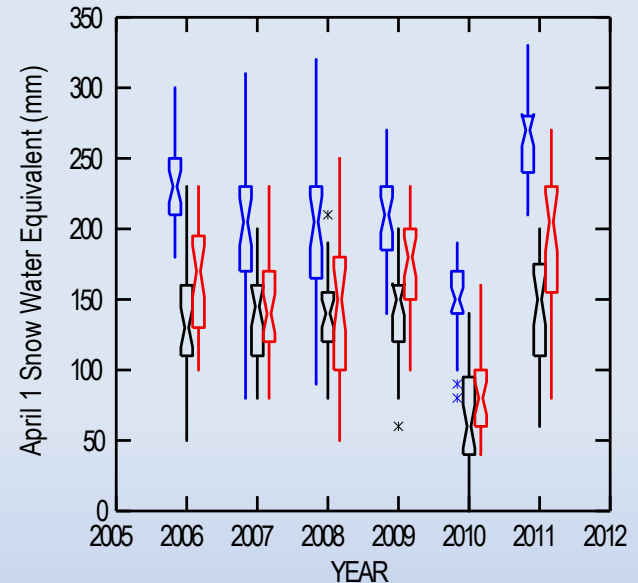
The weather:



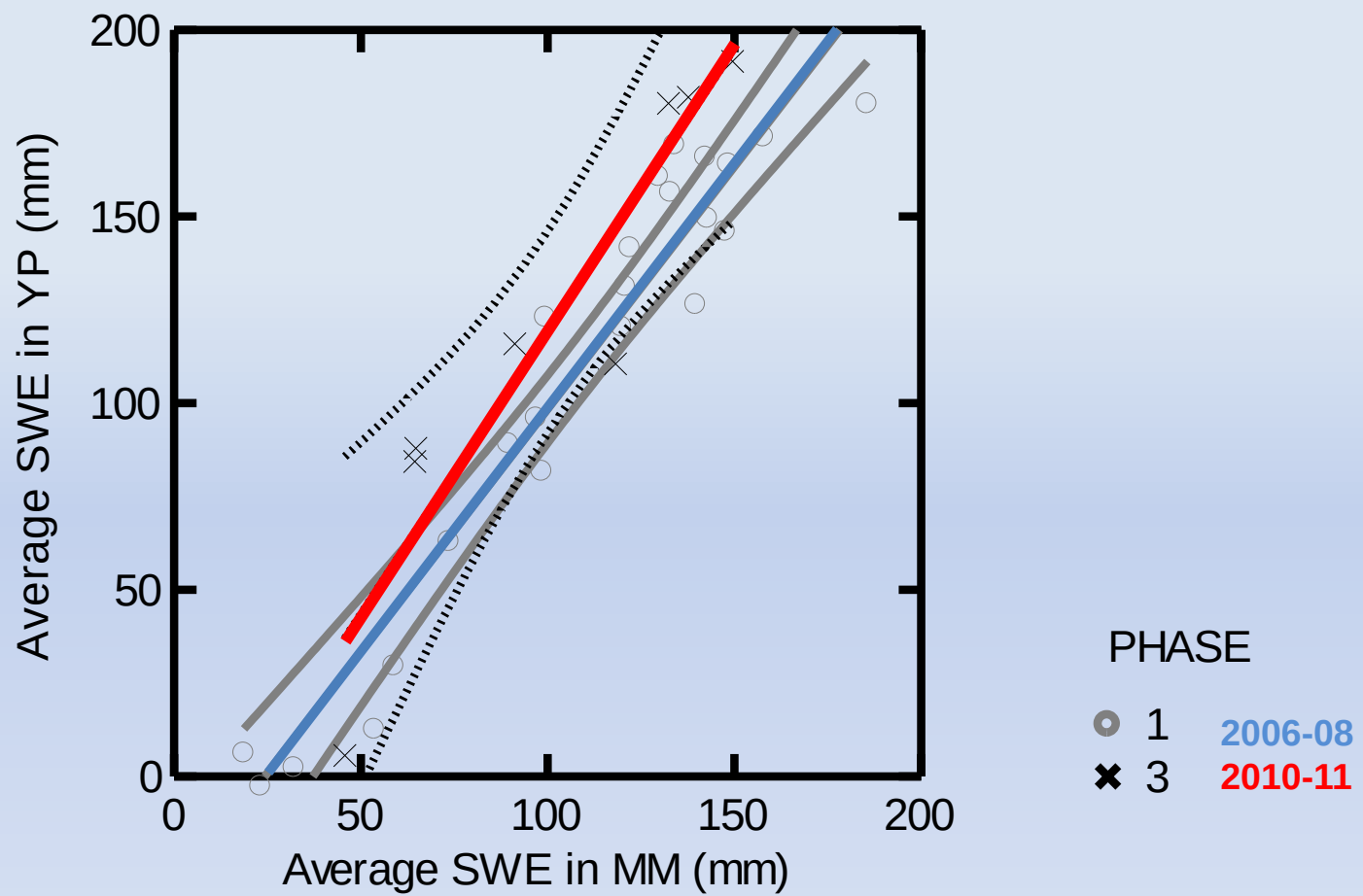
Snow accumulation:



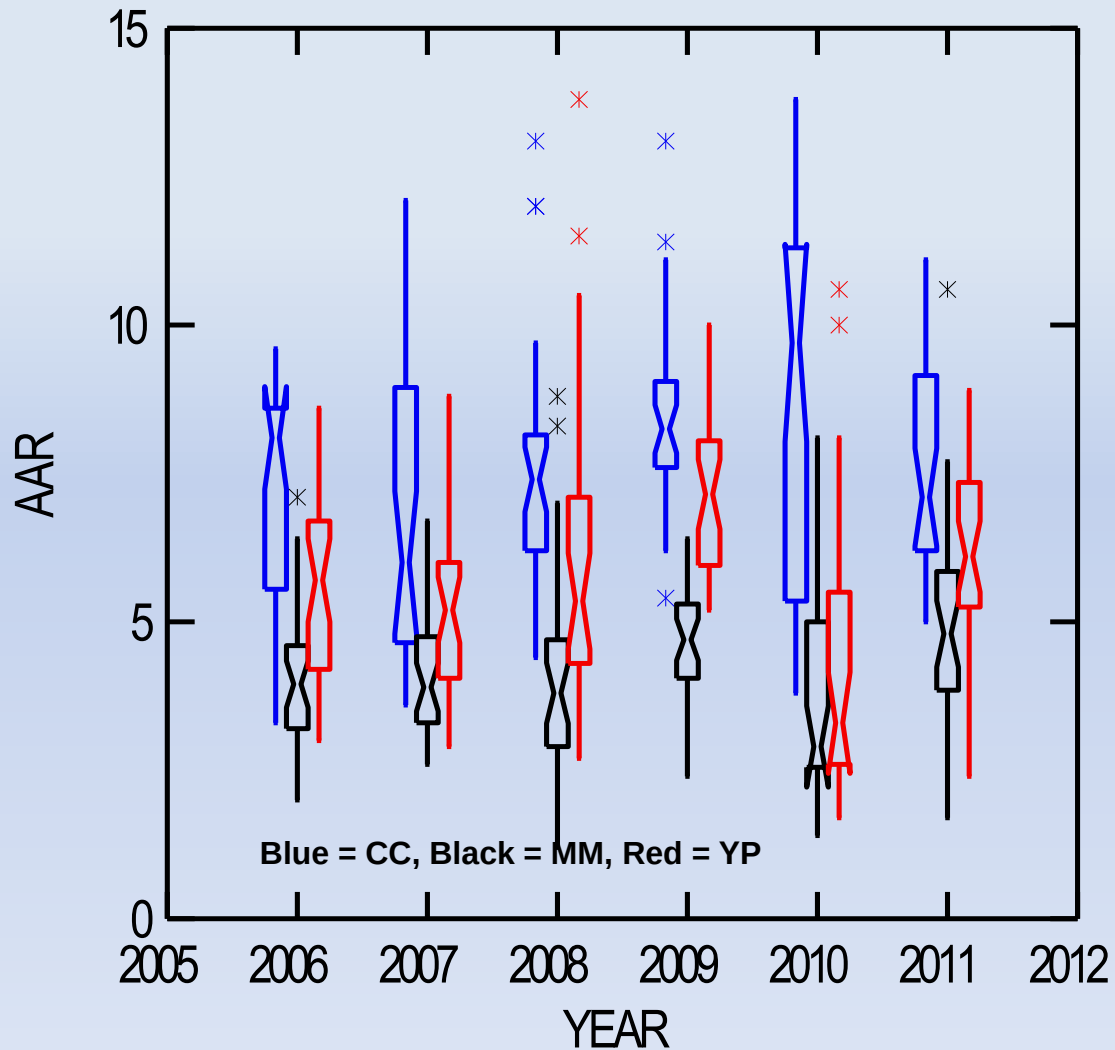
Snow accumulation:



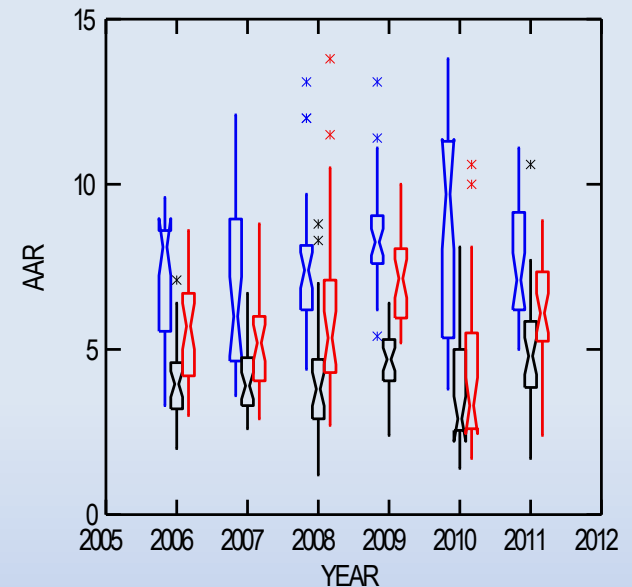
- on average, SWE:
 - 39% less in MM than CC
 - 28% less in YP than CC, prior to needle loss
- largest differences between forest and open in lowest snow year
- largest difference between YP and MM in year of heaviest snowfall, post needlefall
- SWE in YP most similar to CC in year of greatest needlefall



Snow ablation:



Snow ablation:



- on average, ablation rate:
 - 44% slower in MM than CC
 - 19% slower in YP than CC, prior to needle loss
- largest difference between YP and MM in year of greatest needlefall
- no difference between YP and MM in lowest snow year
- snow disappeared :
 - 1–4 days earlier in YP than CC and
 - 1–2 days earlier in YP than MM

4. Summary

- MPB infestation gradually reduces canopy cover, increasing transmissivity
- Pine needle litter, predominantly exposed from within the pack, has a significant but short-lived effect on snow surface albedo
- Snow accumulation and ablation in YP continued to be significantly different from the open 5 years after attack
- Snow accumulation differences between grey and green stands increased with time (ablation complicated by changes in the canopy, albedo and the weather)
- Non-pine species and an intermediate canopy layer may moderate the effects of pine overstory loss
- Interactions between forest cover and snow depend on the weather



Next Steps

- Finish publication
- Resurvey stands now that YP is 'grey'
- Link results to other work:
 - forest–snow interaction work at U. Penticton Creek
 - energy balance modelling
 - forest disturbance / climate change modelling at U. Penticton Creek



Additional Information

Winkler, R., Boon, S., Zimonick, B. and Baleshta, K. 2010. Assessing the effects of post-pine beetle forest litter on snow albedo. *Hydrological Processes* 24: 803–812.

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Thank you

