

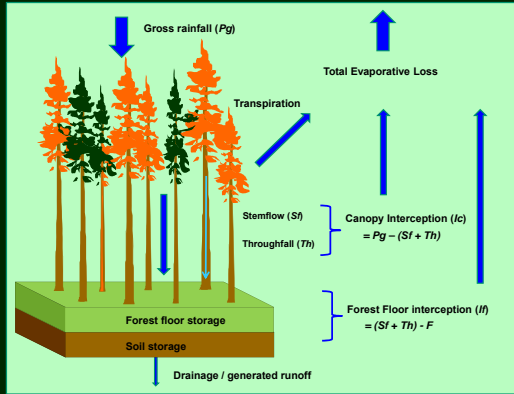
# Early impact of Mountain Pine Beetle on water balance of lodgepole pine in Alberta

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- Forest canopy & understory vegetation - Governs water cycling in lodgepole pine forests through interception and subsequent evaporation of precipitation, and transpiration (which control soil water storage and drainage)
- Landscape scale hydrologic impacts of MPB attack regulated by sequential changes in these evaporative processes after:
  - Red attack – crown mortality but dead foliage retained in canopy → early impact
  - Grey attack – foliage shed → change in microclimate → full hydrologic impact

- Large scale hydrologic impacts not easily predicted because changes in these components regulating water cycling have not been documented after MPB attack.



## Rainfall interception

- Canopy & forest floor rainfall interception strongly sensitive to distribution of rainfall event sizes.
  - Canopy, forest floor, & total interception was very high for rainfall events < 12 mm
  - 93 % of rainfall events were < 12 mm, but > 50% of total rainfall from storm > 12 mm
- Rainfall interception storage capacities were high
  - Canopy: 15.8 mm
  - Forest Floor: 5.6 mm
  - Total storage: 21.4 mm
- Rainfall interception accounted for ~70 of growing season precipitation
  - Canopy interception ~ 40% of growing season precipitation intercepted & evaporated
  - Forest floor interception ~ 30% of growing season precipitation intercepted & evaporated

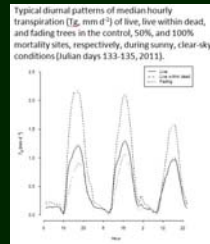
Growing season precipitation (Pa), throughfall (Tf), stemflow (Sf), & canopy interception (Ic) in control, 50-, and 100% mortality treatment units before (2008) and after (2010) MPB treatments. Values in brackets indicate % gross precipitation.

Year	Pa	Treatment	Tf	Sf	Ic
2008	397	Control	223 (56%)	1.3 (0.3%)	172 (43%)
		50% MPB	217 (55%)	1.4 (0.3%)	178 (45%)
		100% MPB	213 (54%)	1.1 (0.2%)	183 (46%)
2010	344	Control	182 (53%)	1.09 (0.3%)	160 (47%)
		50% MPB	170 (49%)	3.3 (0.9%)	170 (49%)
		100% MPB	171 (50%)	8.3 (2.4%)	165 (48%)

- No change in canopy interception after red-attack because of foliage retention.

## Transpiration

- Transpiration strongly affected by MPB treatments.
  - No transpiration in dead trees after treatment (*no surprise here*)
  - Transpiration of fading/chlorotic trees reduced by 35%
  - 33% *increase* in transpiration of healthy trees surrounded by dead/fading trees (live within dead) because of greater water availability



- Stand-scale changes in evaporative losses from transpiration reflect % composition of healthy, dead, fading, & healthy trees surrounded by dead/fading (live within dead) trees within the stand
  - 50% MPB treatment = 9% *greater* growing season transpiration
  - 100% MPB treatment = 47% *lower* growing season transpiration

## Soil moisture response

- Soil moisture response reflected gradient of canopy disturbance across treatments
  - Effects were greatest in surface soil layers (< 20cm deep)

### Change in soil water content (% increase or decrease)

Treatment	Soil Horizon			
	0-5cm	0-20cm	0-40cm	0-60cm
50% MPB	+10%	+25%	----	-7%
100% MPB	+13%	+31%	----	----
Harvested	+33%	+30%	+7%	----

## Scaling hydrologic processes Alberta's lodgepole pine region

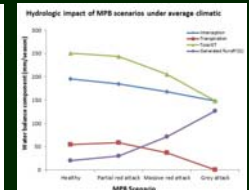
- Field measurements used to *develop* and *parameterize* a coupled water balance model (rainfall interception and transpiration) to predict hydrologic impact of MPB attack across the home range of lodgepole pine in Alberta



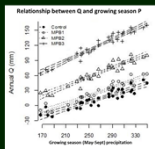
- Four scenarios of MPB attack
  - Control = Healthy stands
  - MPB1 = Partial red attack (23 % of trees fading/chlorotic or dead)
  - MPB2 = Massive red attack (100% of trees fading/chlorotic)
  - MPB3 = Grey attack (all trees dead, all needles shed)
- Assumed same (mature stand) conditions as field study
- Modeled across historic range of climatic conditions in region

Mean growing season canopy interception (Ic), forest floor interception (If), total forest interception (I), recharge into the mineral soil (P), evapotranspiration (E), and drainage (D) across the 48 climate stations. Mean growing season rainfall (Pg) was 272 mm. Values in brackets indicate the percentage of Pg.

Scenario	Component of water balance (mm/season)					
	Ic	If	I	P	E	D
Control	110 (40%)	87 (32%)	196 (72%)	73 (27%)	251 (93%)	20 (7%)
MPB1	95 (35%)	98 (36%)	193 (71%)	86 (32%)	244 (90%)	30 (11%)
MPB2	60 (22%)	106 (39%)	166 (61%)	105 (39%)	205 (75%)	71 (26%)
MPB3	31 (11%)	115 (42%)	146 (53%)	127 (47%)	148 (54%)	127 (47%)



- Linear/non-linear responses to increasing MPB attack (*interaction among components*)
- Increases in soil moisture & drainage (*compared to healthy stands*)
  - Partial red attack: 10 mm (↑50%) over growing season
  - Massive red attack: 51 mm (↑ 255%) over growing season
  - Grey attack: 107 mm (↑ 535%) over growing season
- Larger effects where growing season rainfall is greater



## Objectives & Approach

- Quantify changes in canopy/forest floor rainfall interception & canopy transpiration dynamics before- (2008) & after (2010/11) controlled simulation of MPB attack using glyphosate to produce variable intensity MPB attack
- 4 large plots (2.3 ha) in a large contiguous lodgepole pine stand (Robb, AB), 23-25 m high, 2000-2500 stems/ha, ~ 120 years old.
  - 100% MPB mortality treatment (all trees treated)
  - 50% MPB mortality treatment (half of trees treated in anticipation of "flashback")
  - Harvested stand (simulating post MPB salvage)
  - Untreated reference (control) stand

## Outcome: reproducing canopy scale effects of MPB attack



- Glyphosate simulation of variable intensity MPB attack produced approximately 29 to 58% mortality one year after treatments in the 50 and 100 % MPB treatments, respectively
- Mortality 1-2 yrs. after treatment was closer to 50% and 80% for the 50 and 100% MPB mortality treatments.

## Conclusions & Implications

- Changes in both rainfall interception of precipitation and transpiration are key drivers of hydrologic impact of MPB red attack
  - Both canopy & forest floor interception water losses more important than previously thought
  - Red attack not likely to have meaningful impact on canopy rainfall interception
  - Impacts of grey attack not yet documented but will likely drive much larger changes in stand hydrology.
- Effect of transpiration on total stand water loss smaller, but still important regulator of hydrologic impacts of MPB
  - Partial red attack (< 30% of stand) may produce little meaningful impact on transpiration or result in increased water use by the stand
  - Initial soil moisture responses in shallower soil horizons (medium textured soils)
- Gradient of MPB attack (partial red attack massive red attack grey attack) likely to produce increasing (non-linear) hydrologic impacts
  - These effects likely larger in regions where growing season precipitation is greater

## Contact Information

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## Acknowledgements

