



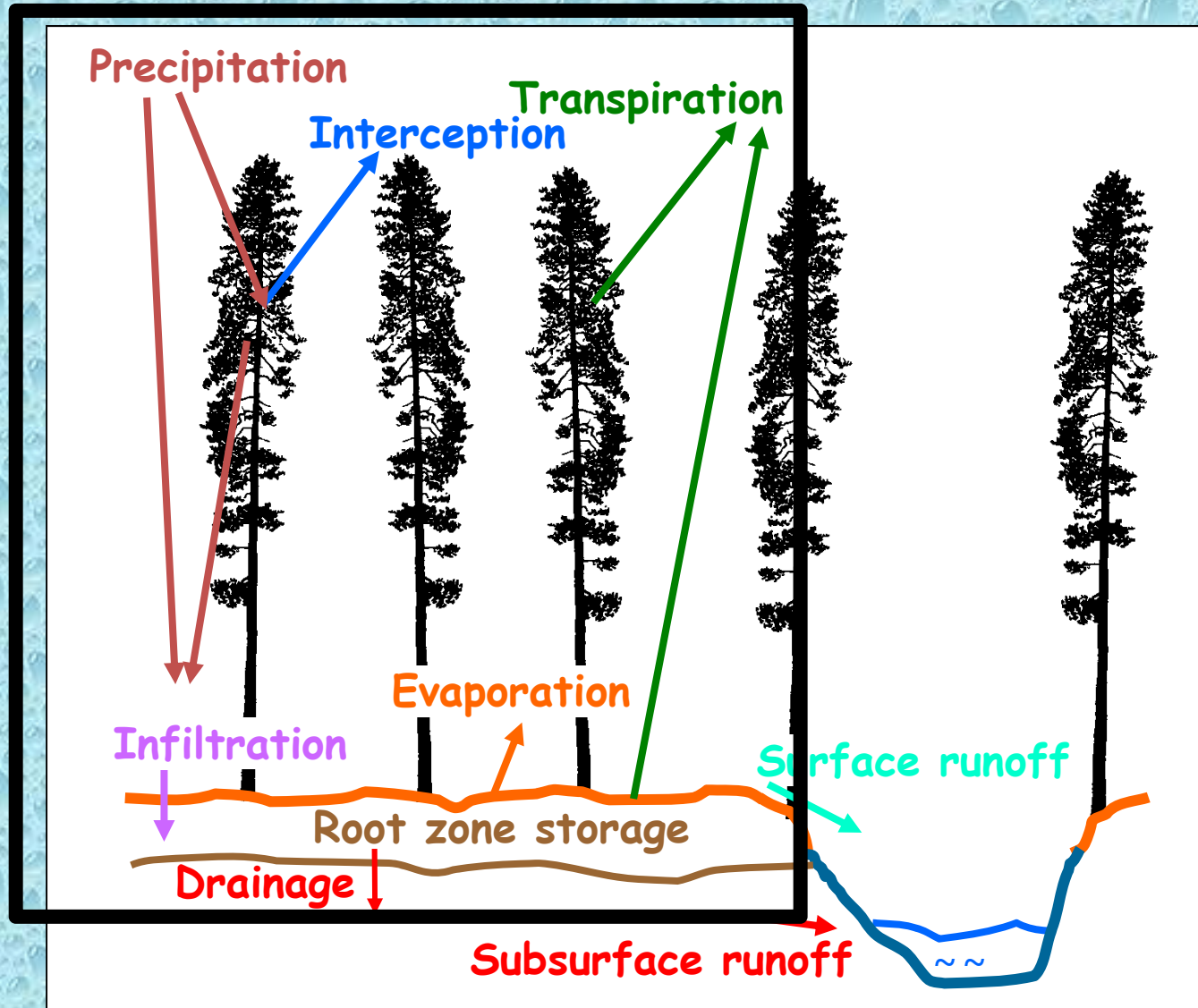
Influence of the Mountain Pine Beetle infestation on the water balance of a lodgepole pine stand

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&
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Mat Brown & Andy Black, Univ. BC, Vancouver

Objectives

- Determine changes in components of site water balance as MPB attack progresses
- Combine site specific data (weather data, evaporation, hemispherical photos...) and a water balance model (evaporation, interception, snow melt...)

Site Water Balance



2006



2007



Progression of MPB attack, lodgepole pine near Mackenzie, BC

2008



2009

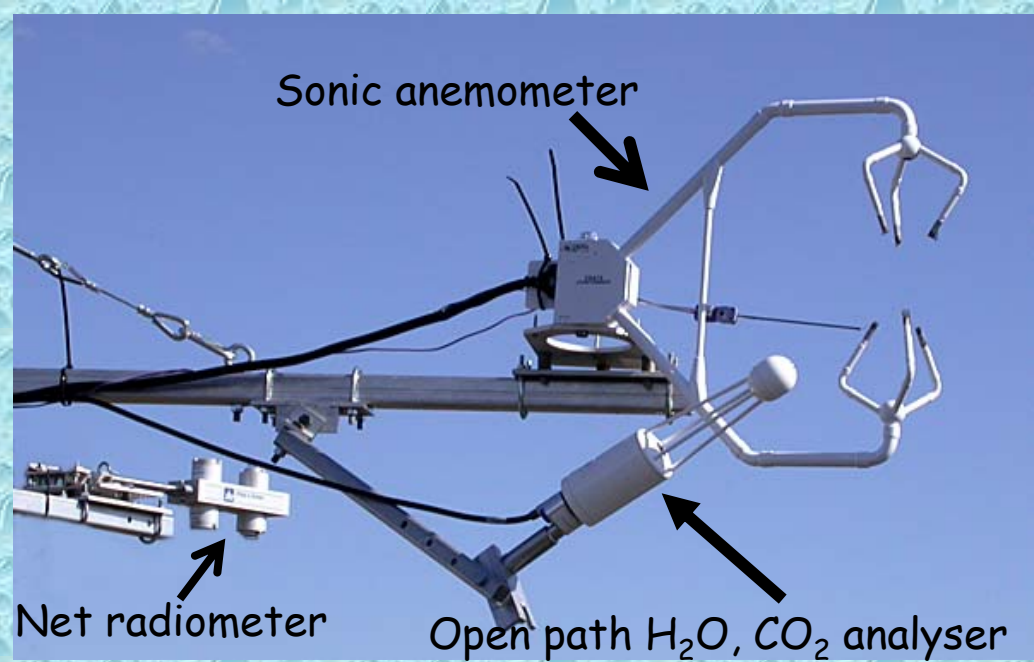




T.

C.

Measurements



Below the canopy



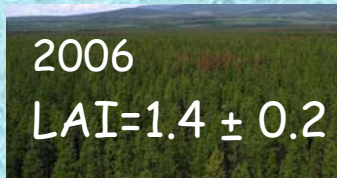
Understory cover ~30%
shrubs, pine seedlings, herbs

Moss & lichen cover 100%
(R. Bowler 2010)

Canopy leaf area and radiation transmissivity

Measurement accuracy

Variability (1 std)



Canopy photos, $n=8$

$\sim \pm 2\%$ cover

$\pm 6\%$ cover

$\text{LAI} \pm 0.1$



Hemispherical photos $n=24$ (6x4 lines)

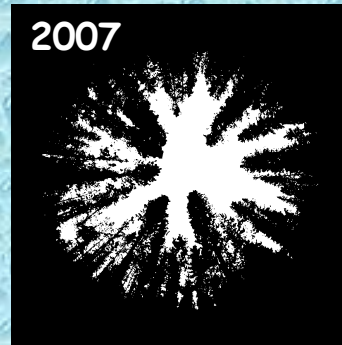
Transmissivity $\sim \pm 2\%$

$\pm 5\%$

Sky view factor $\sim \pm 0.04$

± 0.02

Below canopy radiation $\pm 15\%$

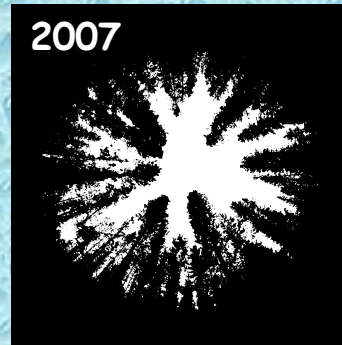
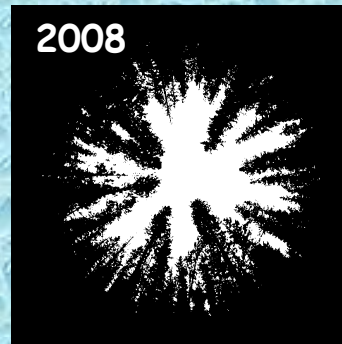


LAI		Transmissivity (%)		Sky vf
live	dead	Diffuse	Direct	

1.4	~0			
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		41	29	0.37
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0.4	1			
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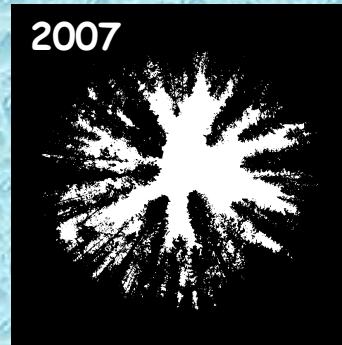
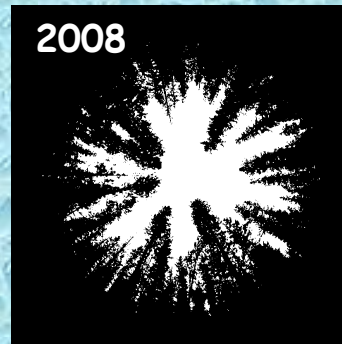
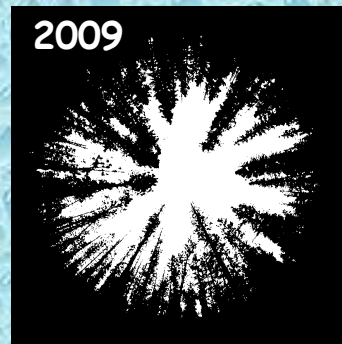
LAI		Transmissivity (%)		Sky vf
live	dead	Diffuse	Direct	

1.4	~0			
-----	----	--	--	--

		41	29	0.37
--	--	----	----	------

0.4	1			
-----	---	--	--	--

0.3	0.2	49	36	0.45
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LAI		Transmissivity (%)		Sky vf
live	dead	Diffuse	Direct	

1.4	~0			
-----	----	--	--	--

		41	29	0.37
--	--	----	----	------

0.4	1			
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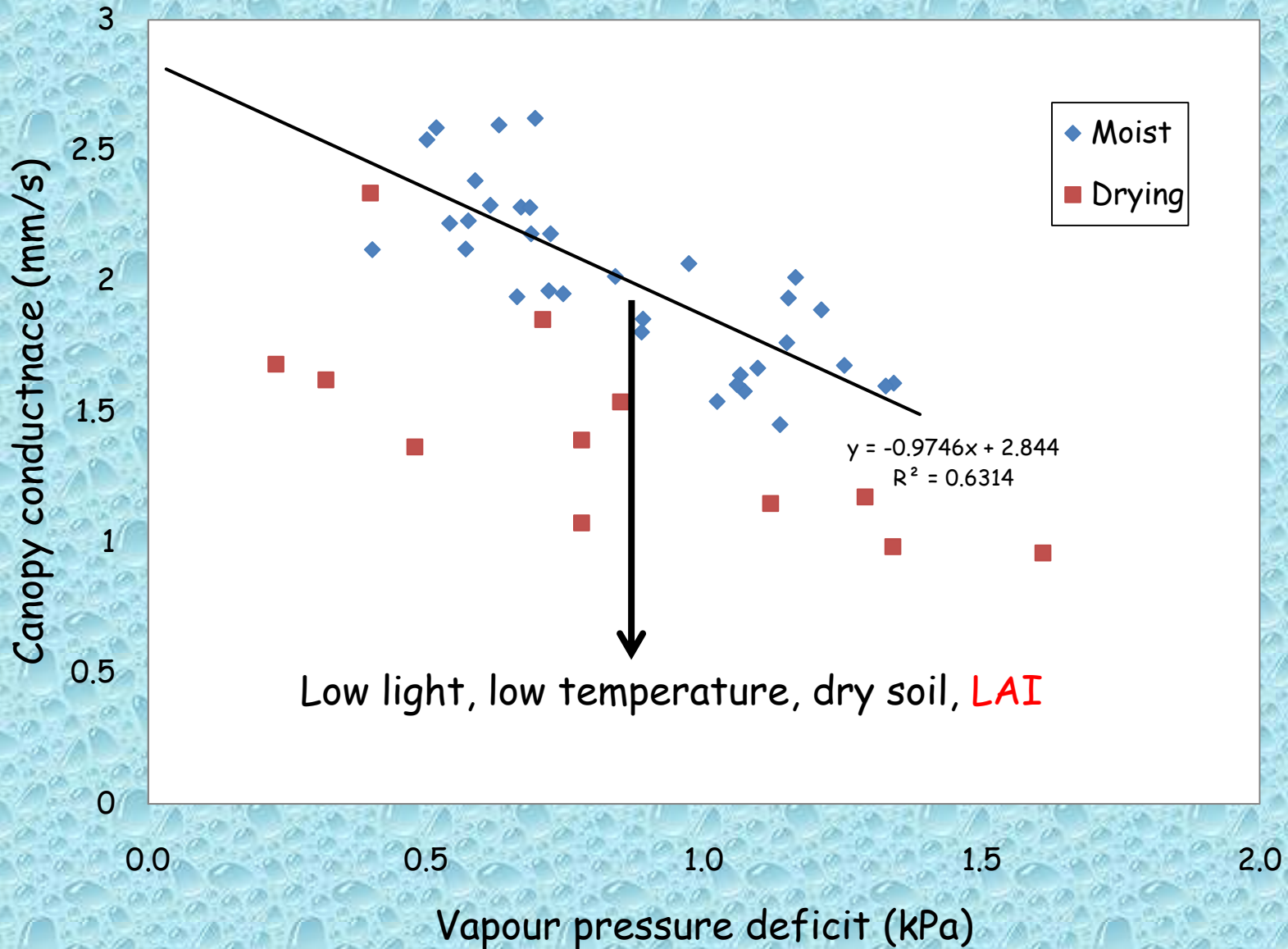
0.3	0.2	49	36	0.45
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0.3	0.02	51	44	0.48
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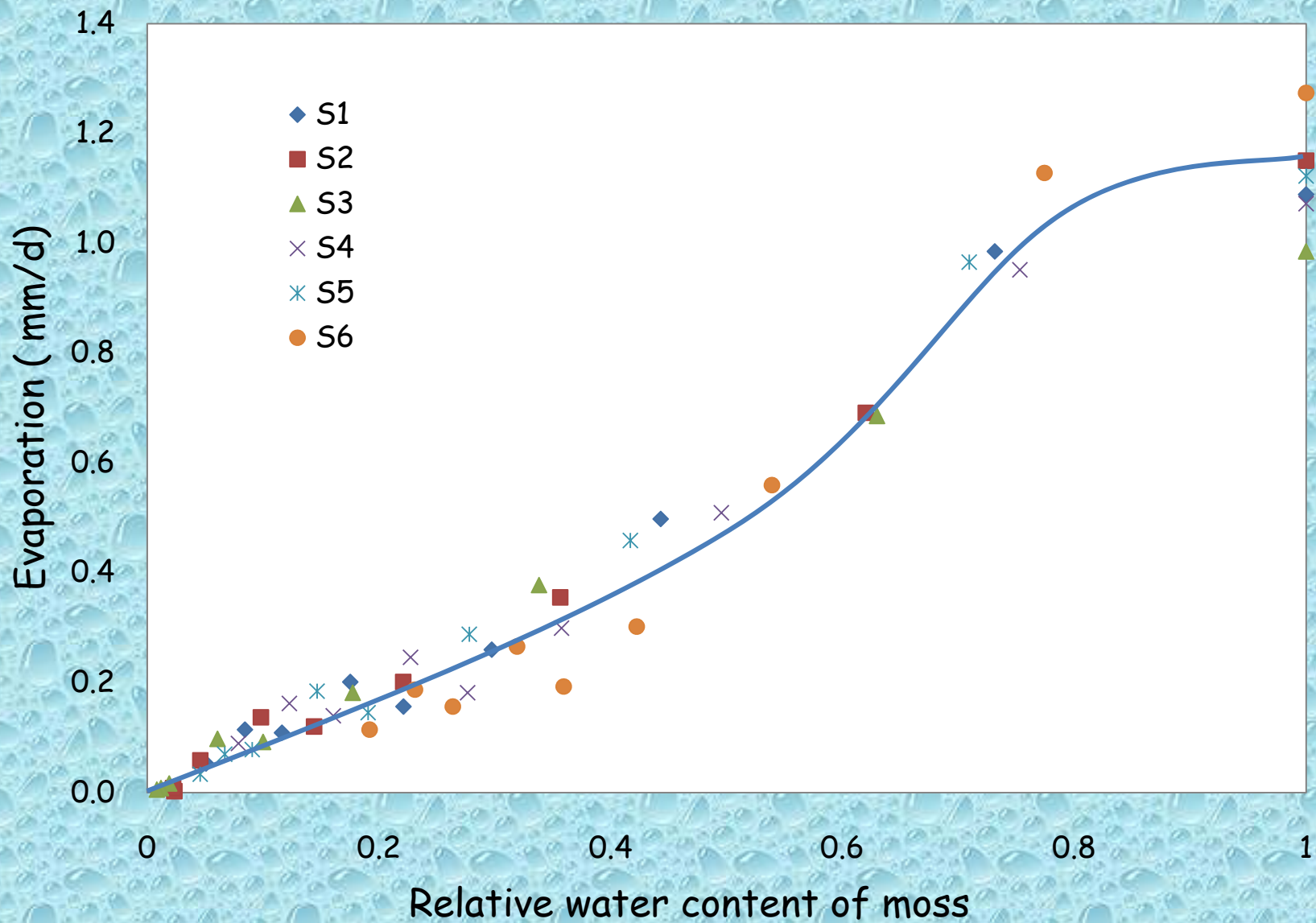
Evaporation model

- E Trees: $f(R_n, T_{air}, vpd, wind, g_s, LAI_{live})$
- E understory: $f(cover, energy/soil\ water\ limited, \alpha=1.26)$
- E moss/lichens: $f(cover, depth\ of\ layer, energy/moss\ water\ content\ limited)$
- Below-canopy radiation: Diffuse and direct transmissivity, sky v_f , solar radiation above canopy
- Rainfall interception

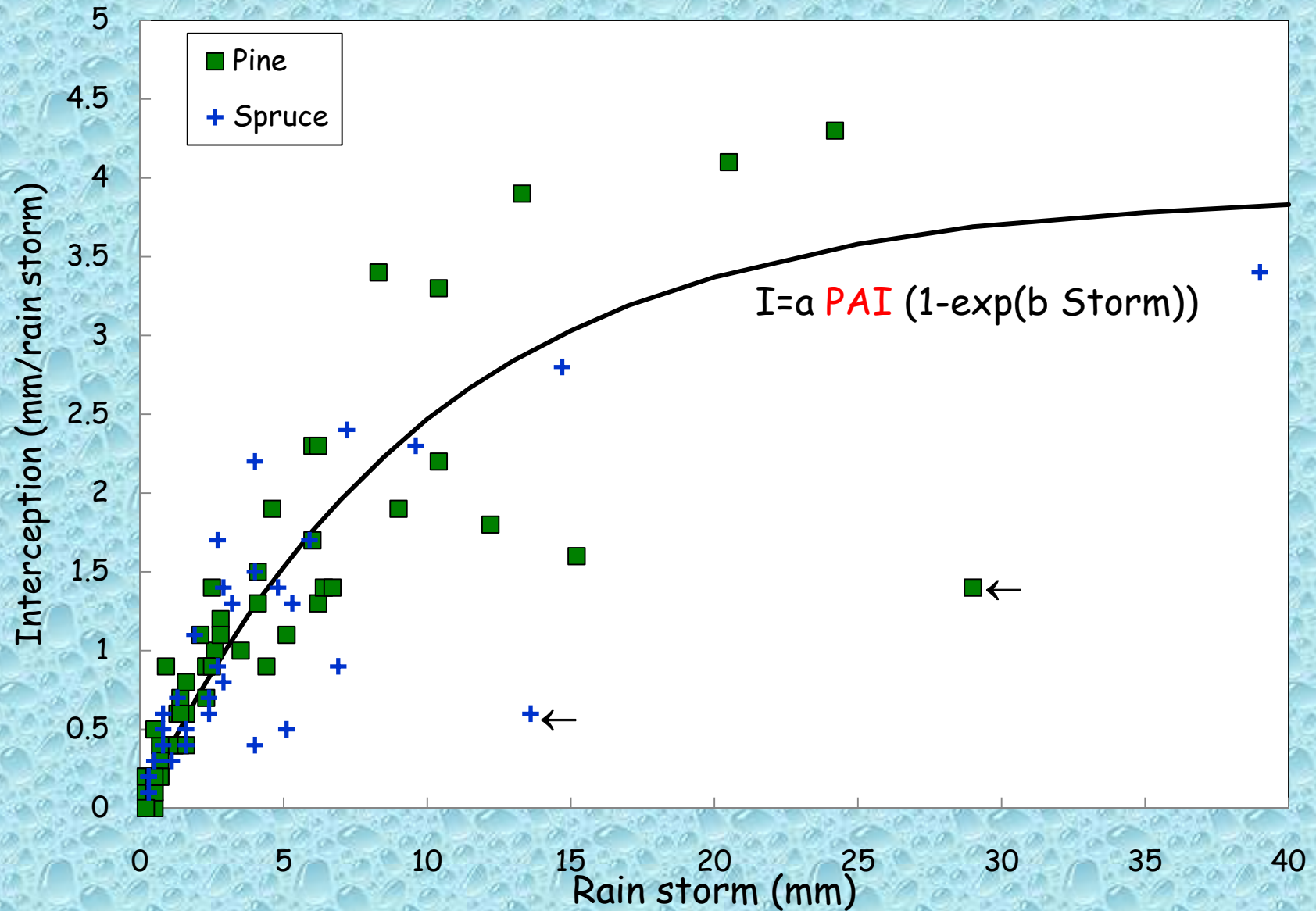
Reference canopy conductance - from UPC



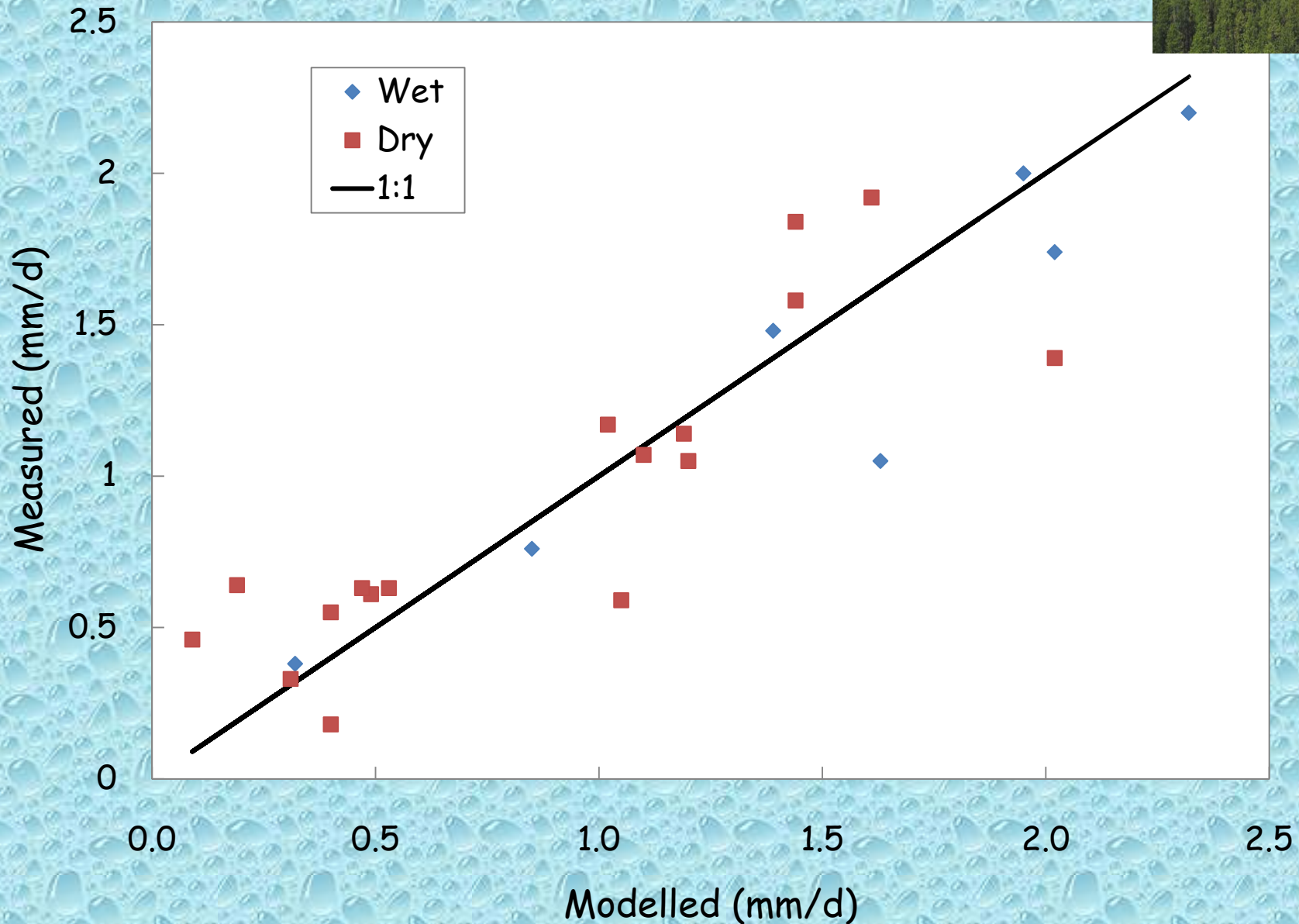
Evaporation from moss/lichen layer



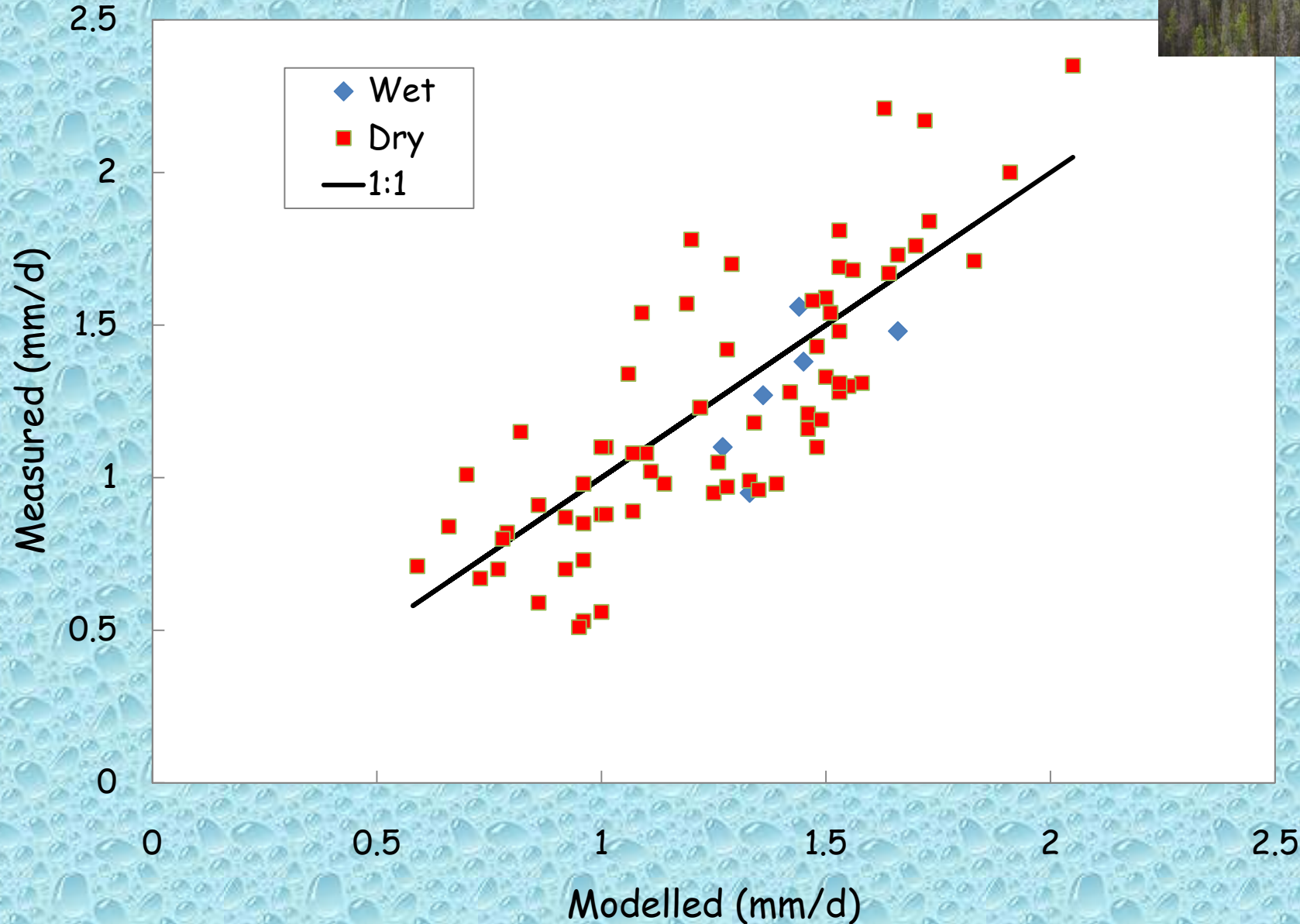
Rainfall interception - UPC



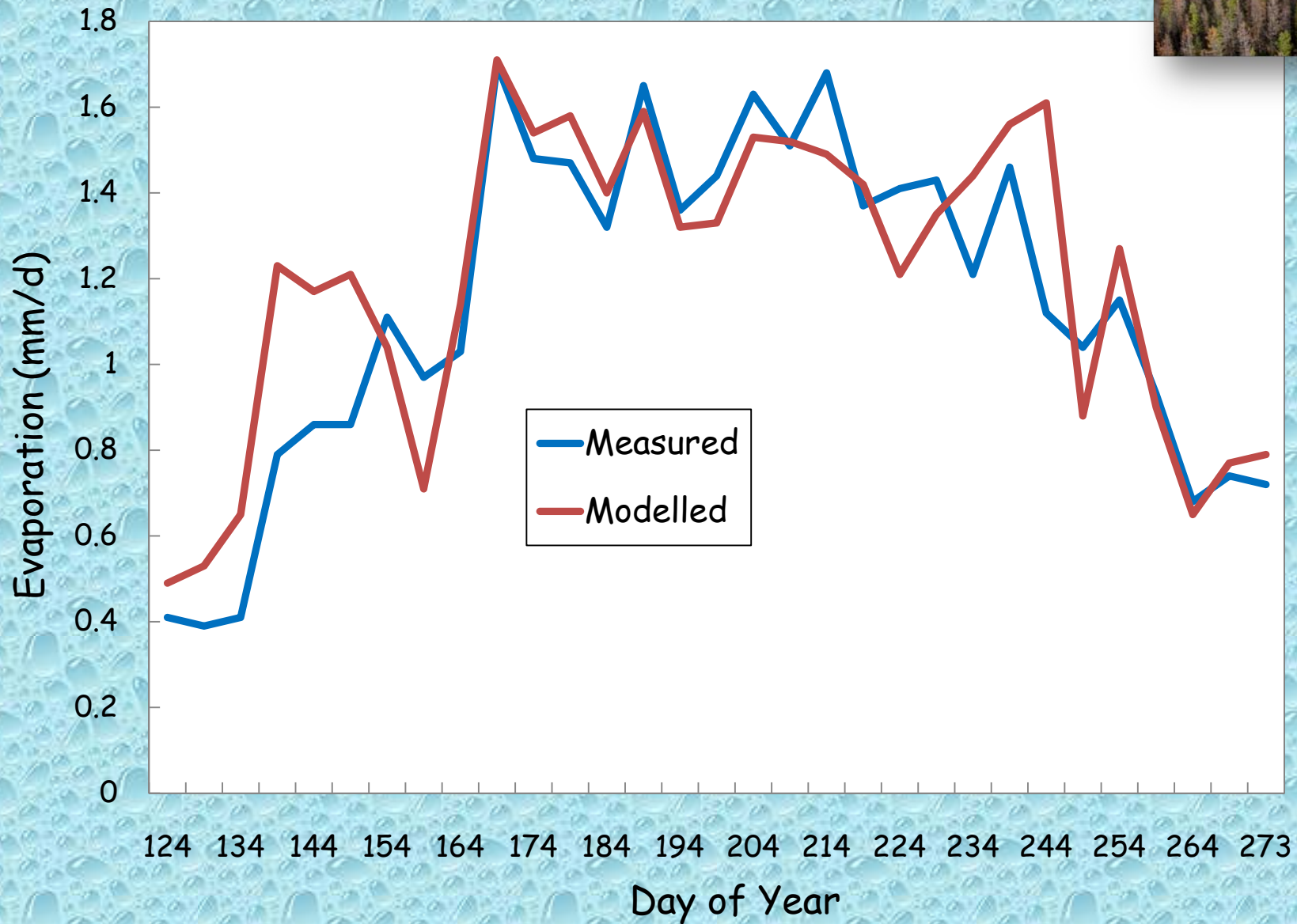
Daily evaporation August - September 2006



Daily evaporation May-September 2009



5-day-average evaporation, May-Sept. 2008



May to September Evaporation (mm)

	2006	2007	2008	2009
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Measured	N/A	170	175	185
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Modelled	270	195	180	195
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Uncertainty ± 20 mm

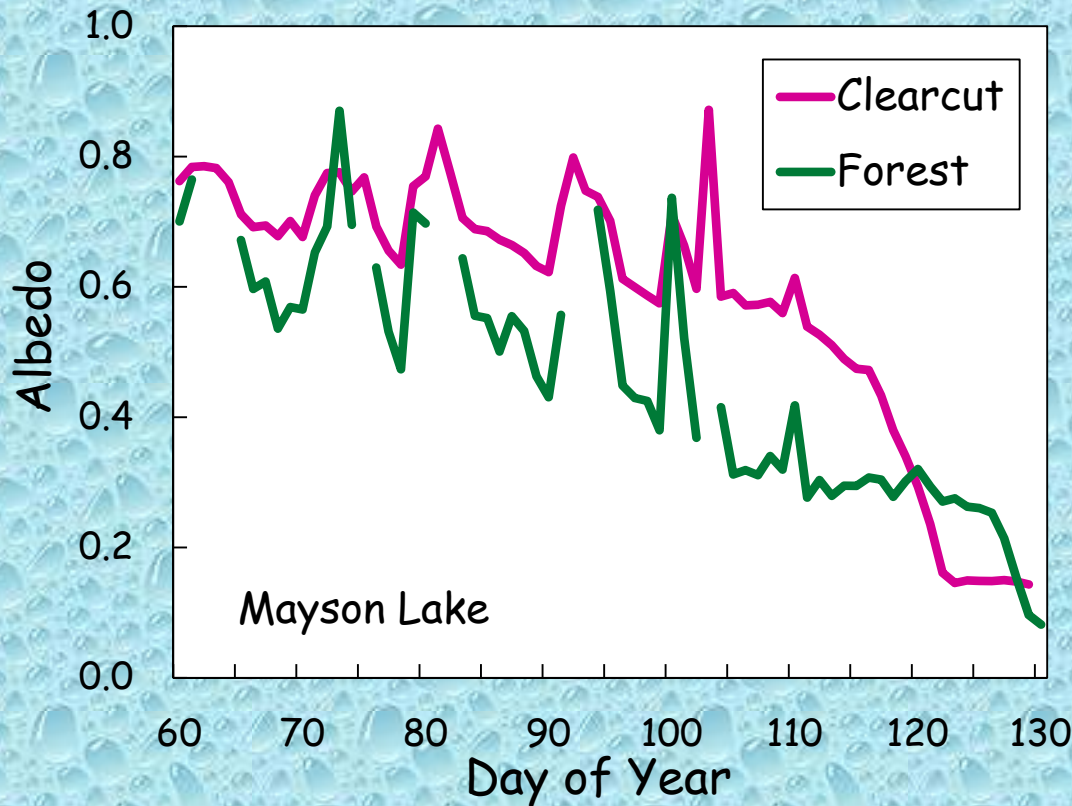
Snow accumulation and melt

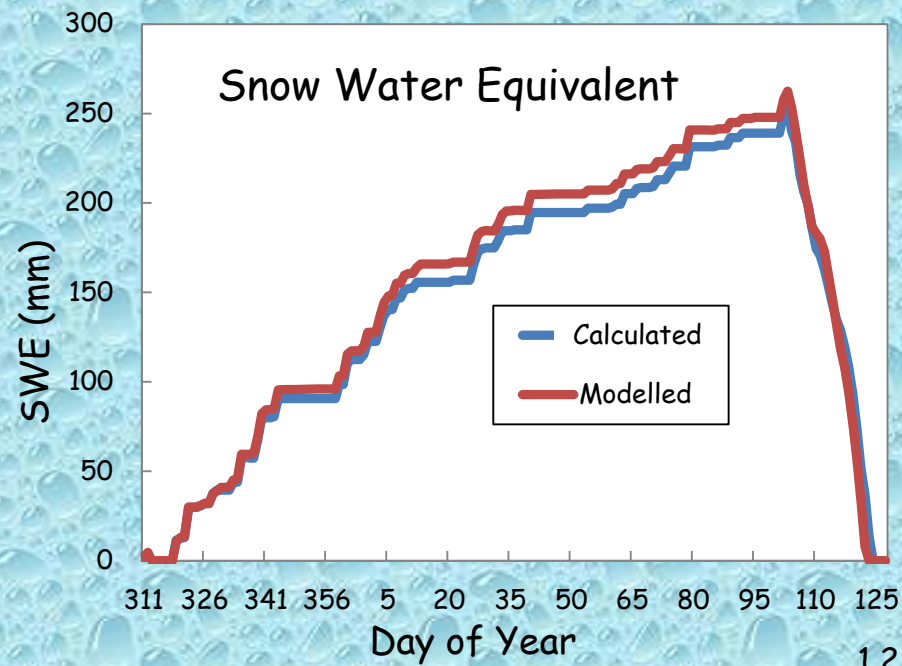
Canopy snow interception model - function of snow storm and amount of snow on the canopy based on UPC, Mayson Lake work

Energy balance of snow pack using measured and calculated values

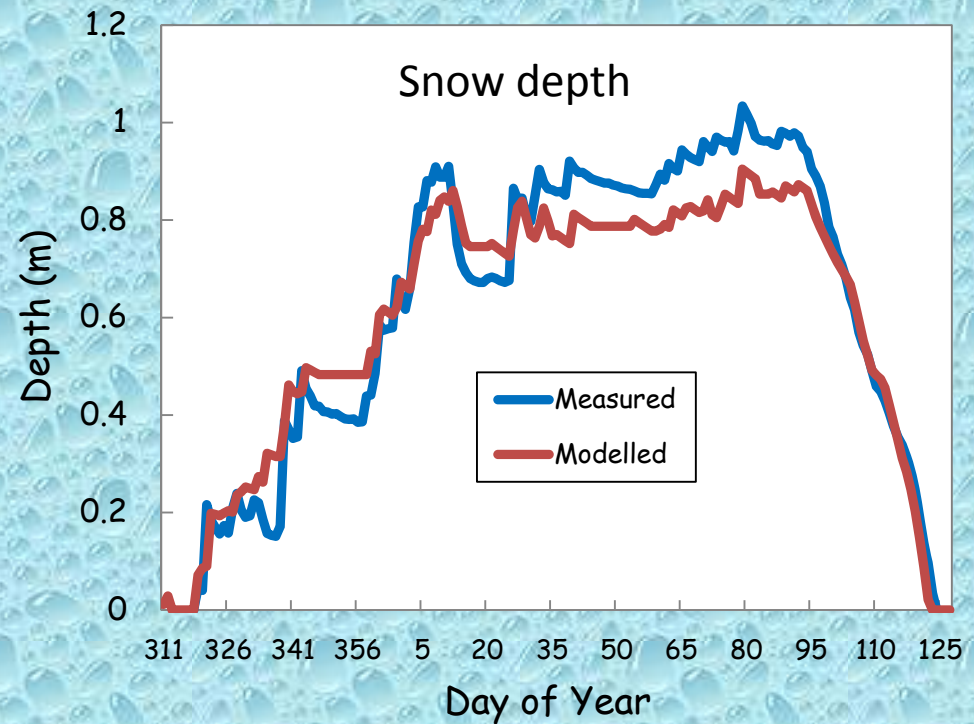
Short and longwave radiation, air temperature, RH, wind speed, albedo, snow surface temperature

Empirical model to determine albedo decay and readiness of pack to melt





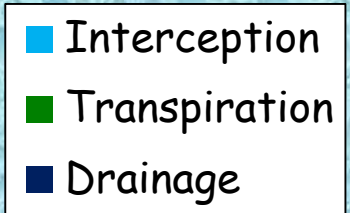
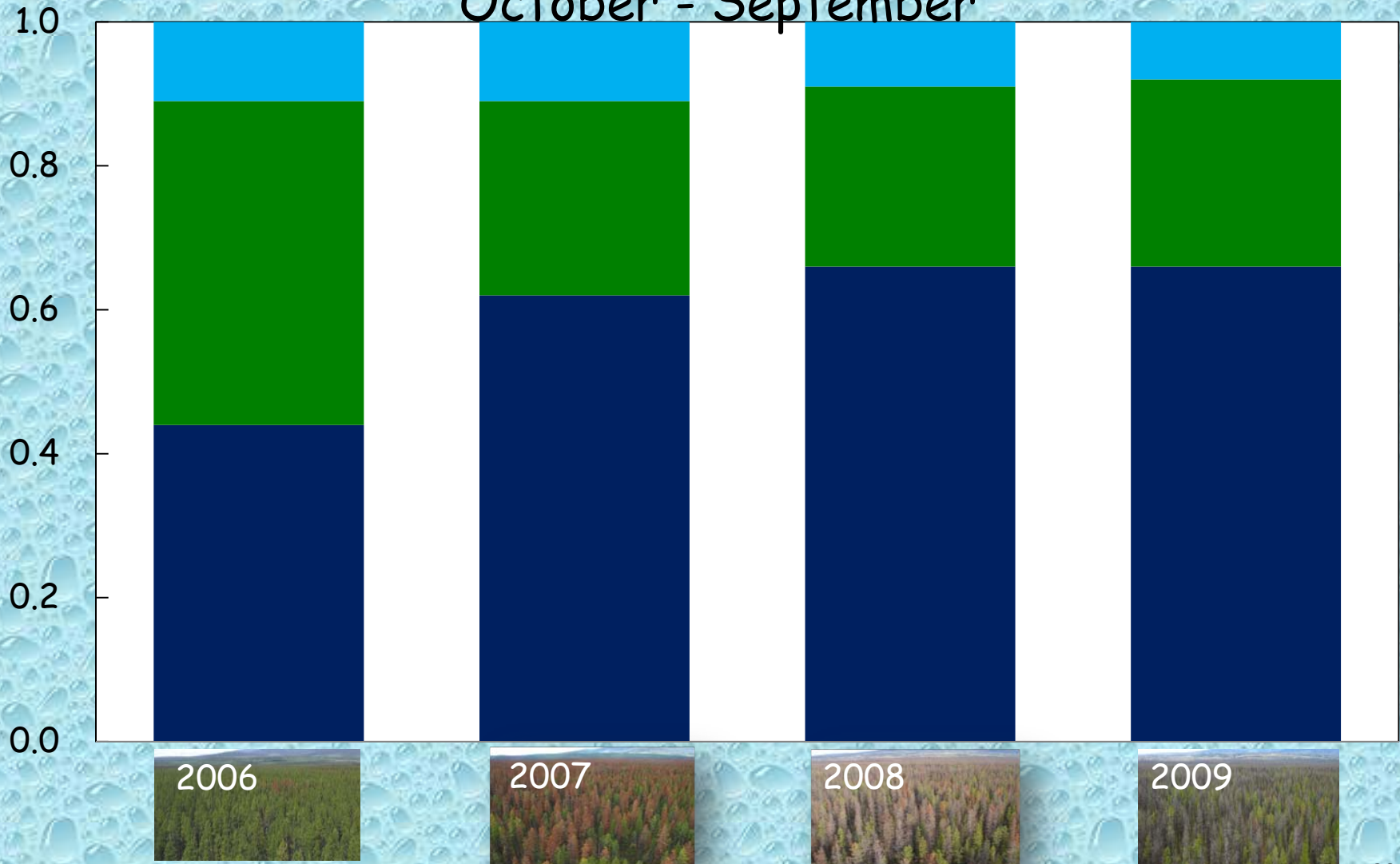
Winter 08/09



Annual water balance

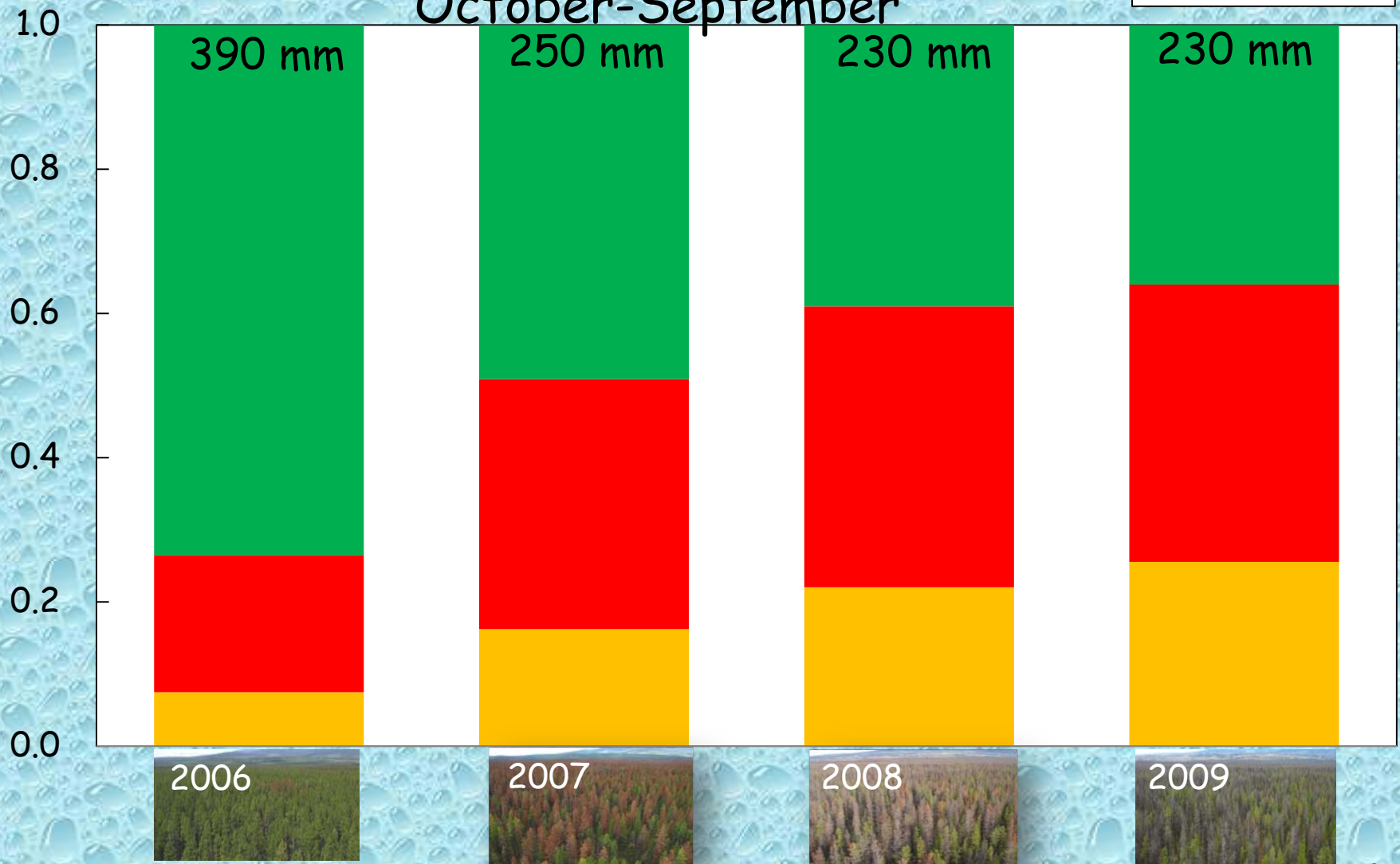
- Variation due to changes in canopy and weather
- Model the water balance over four years maintaining vegetation constant

Partitioning of annual precipitation 650 mm - average over 4 years October - September

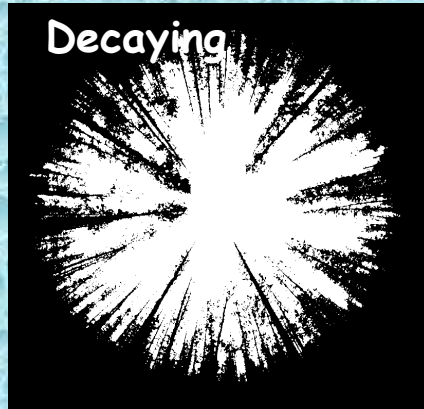


Partitioning of annual transpiration - average over 4 years October-September

- Trees
- Understory
- Moss/lichens



Decaying stand



LAI		Transmissivity (%)		Sky vf
live	dead	Diffuse	Direct	

0.1	0.2	74	58	0.69
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Understory cover 50%

Percent of precipitation

Interception 6%

Transpiration 29% (230 mm)

Drainage 65%

Percent of transpiration

Trees 10%

Understory 55%

Moss & lichens 35%

Summary

- Modelled of site water balance adequate for separating components of evaporation
- MPB infestation: Reduced evaporation by about 40%
- Decreased interception of precipitation
- Increased evaporation from understory and moss/lichens
- Increased drainage from root zone
- Snow melt rate increased (10-40%), shorter snow season (5-10 days)

2010

