THE TRIA PROJECT
Mountain Pine Beetle System Genomics

Role of drought in mediating interactions between different host trees and the mountain pine beetle

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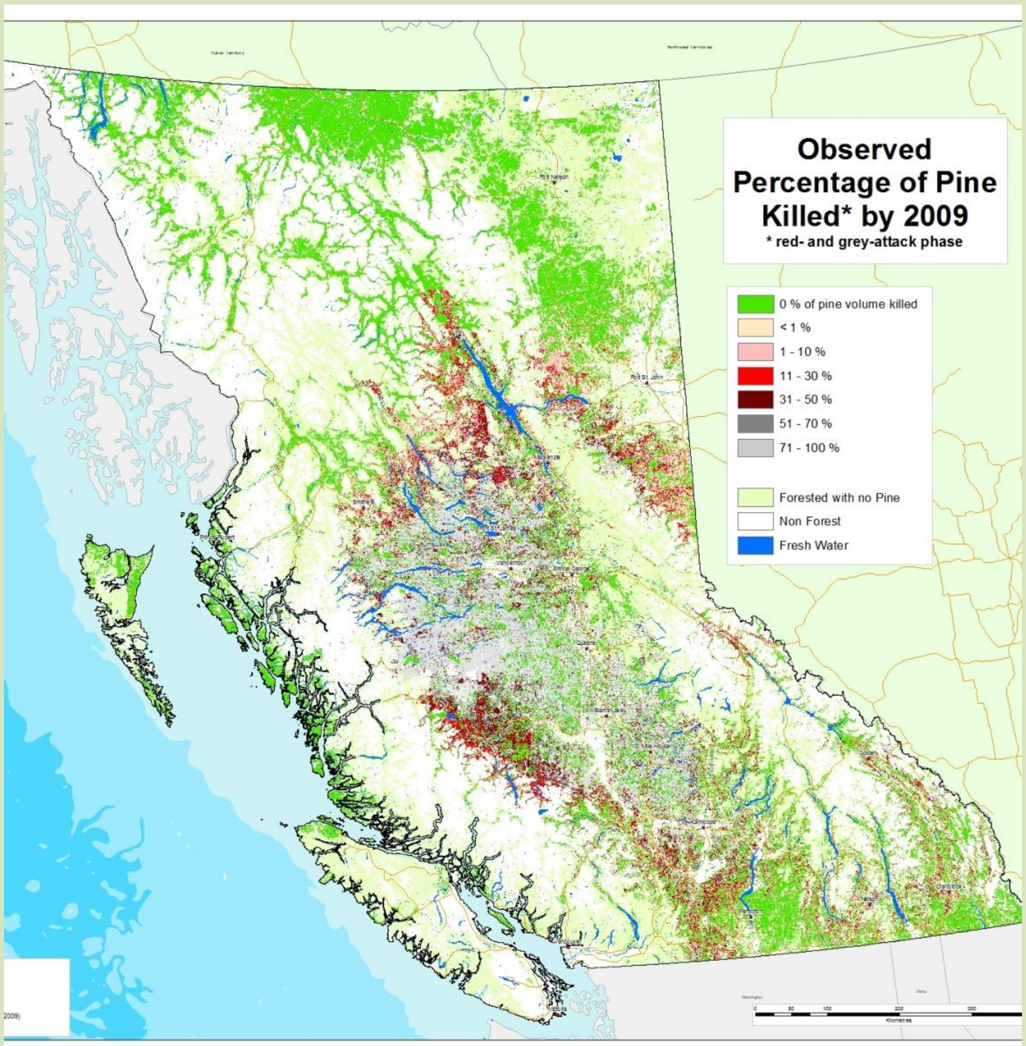
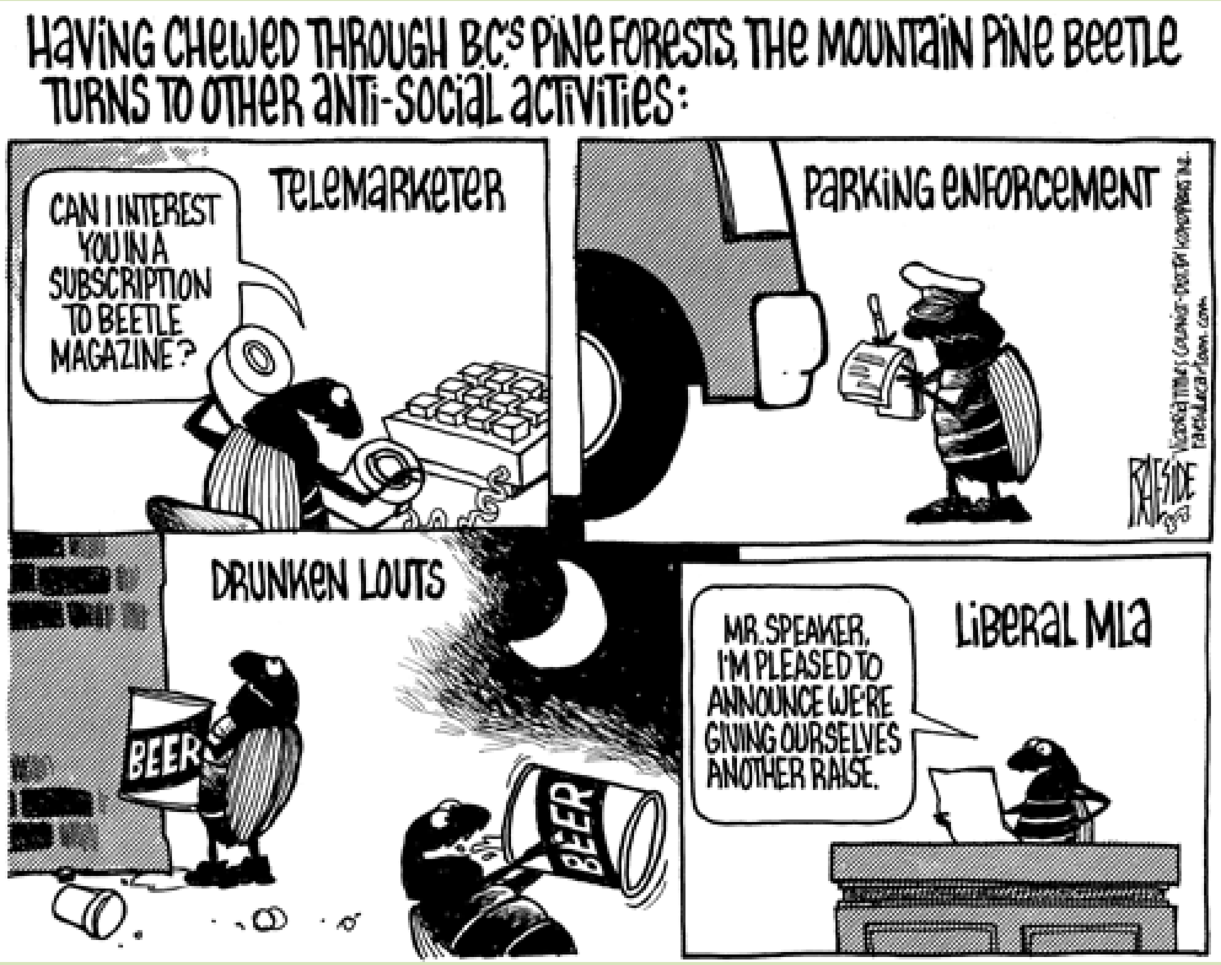
MPB success in B.C.



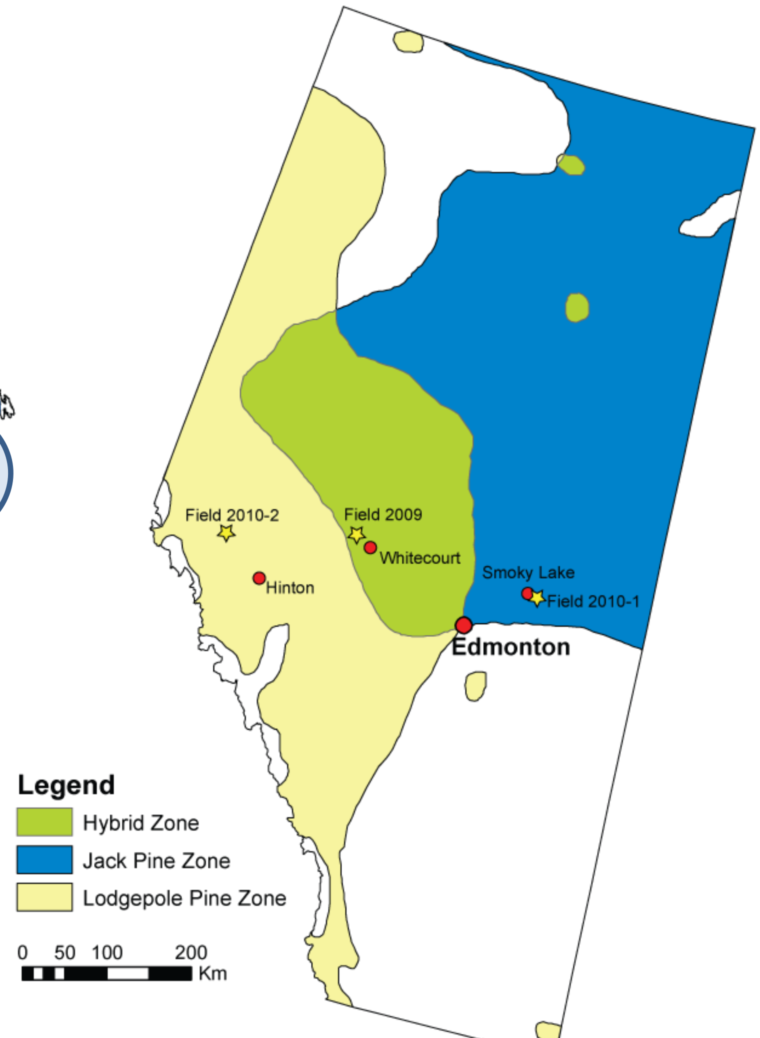
http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/maps.htm

MPB success

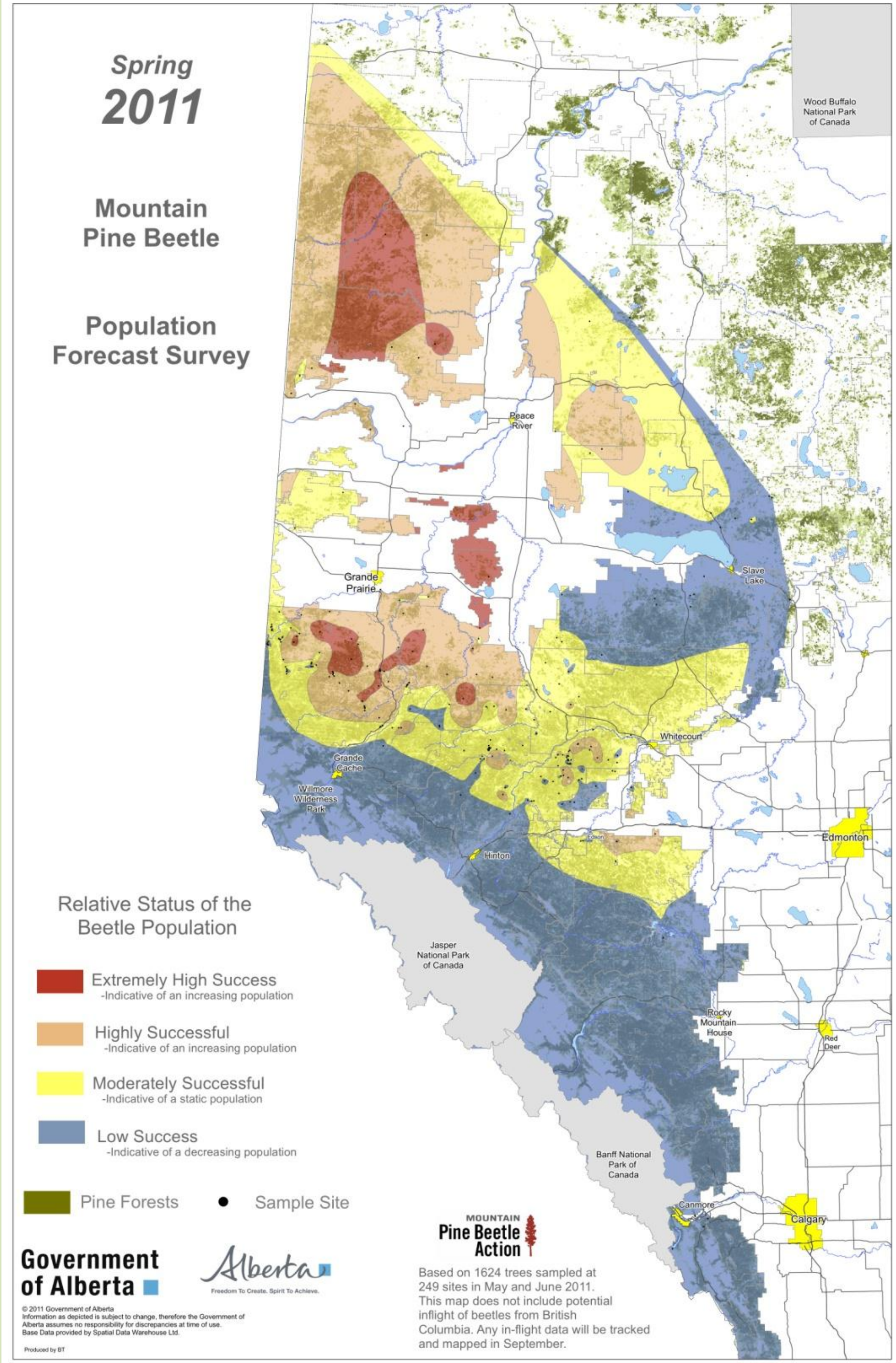


http://www.raesidecartoon.com/dbtest/images/2/3232.gif

Pine distribution in Canada

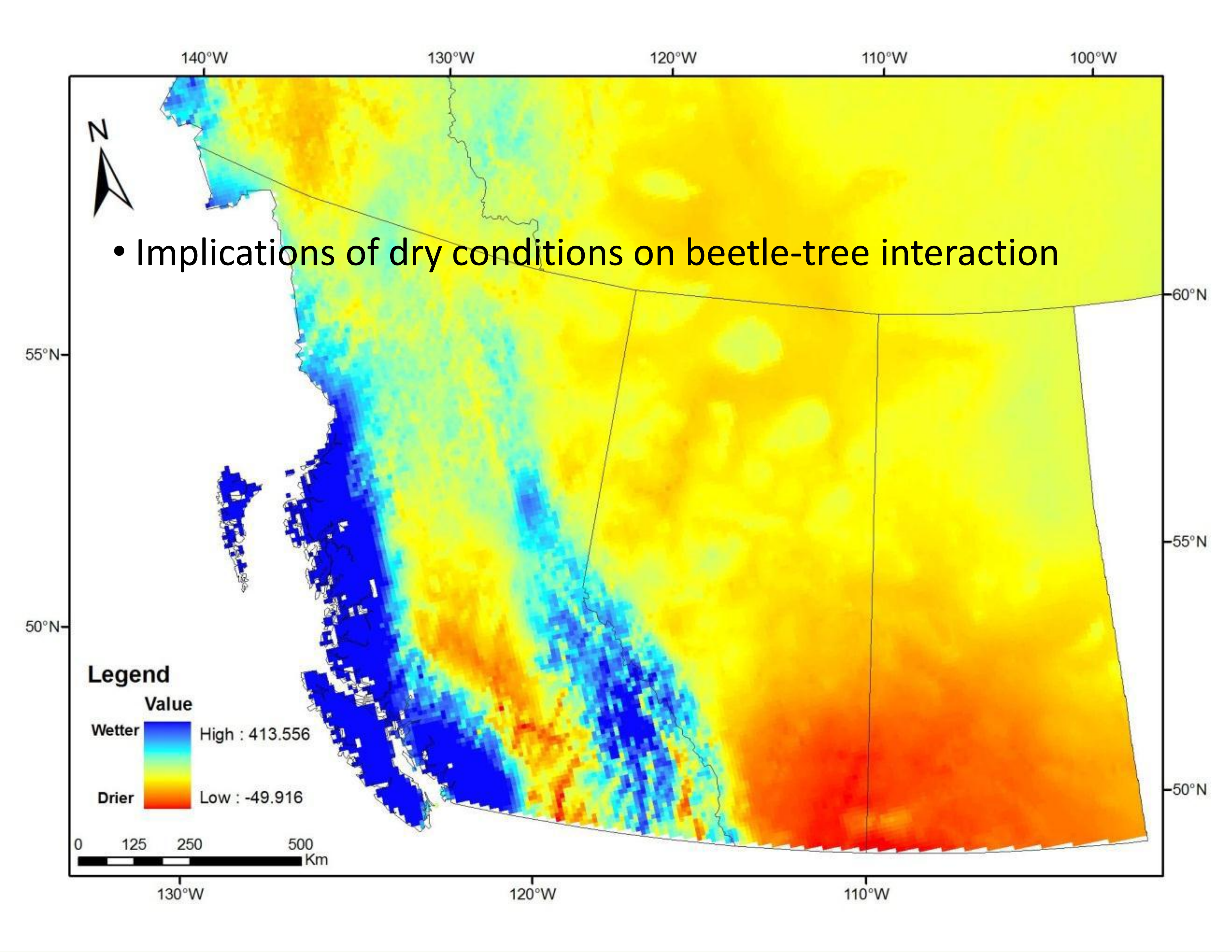


- MPB success in Alberta
- Colonization of hybrids
- Colonization of Jack Pine



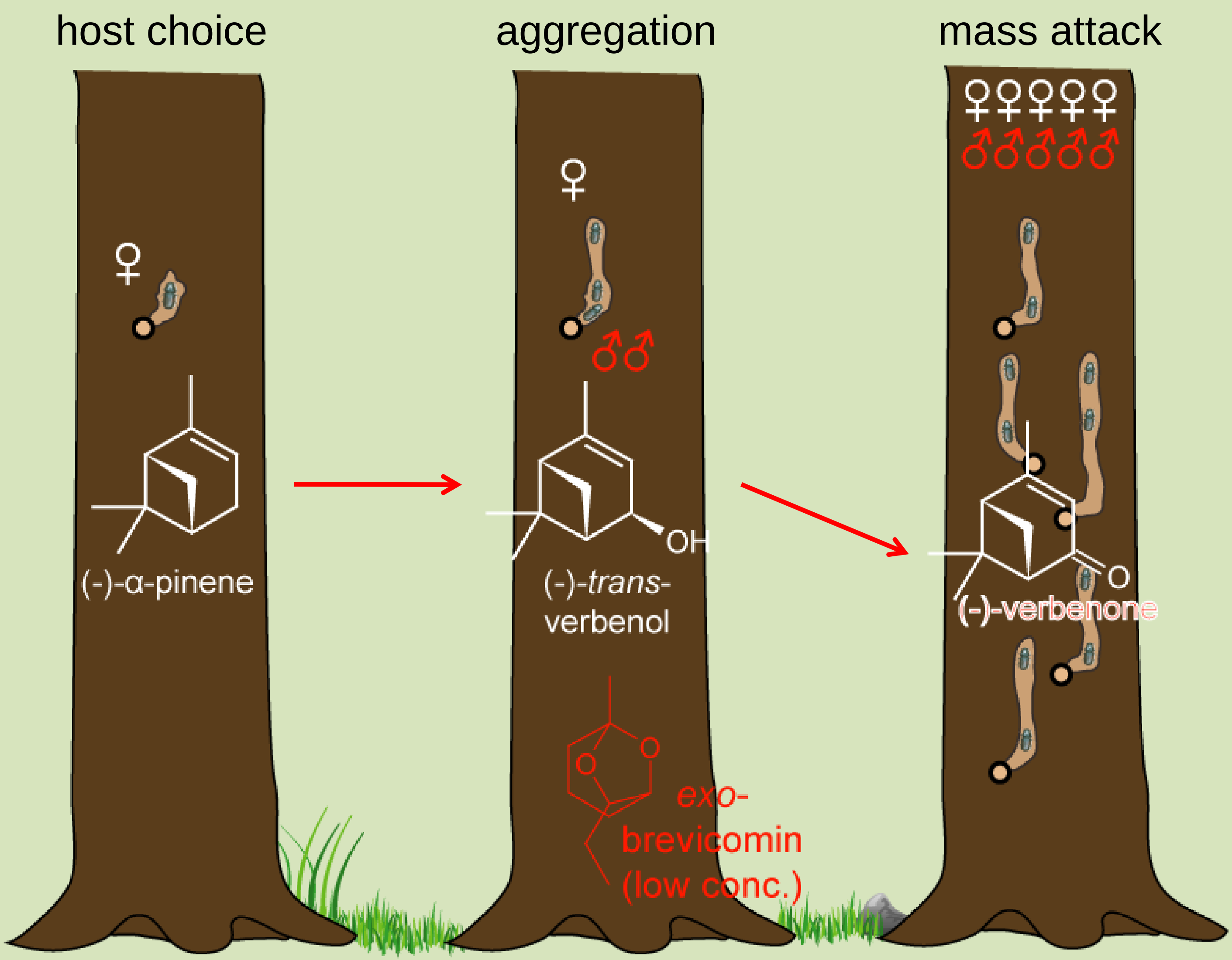
http://mpb.alberta.ca/Resources/maps.aspx

• Implications of dry conditions on beetle-tree interaction



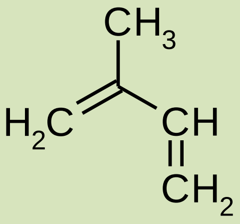
Climate Moisture Index (Hogg, 1997) output using BioSim (Barry Cooke)

Mass attack


host choice
aggregation
mass attack
♀♀♀♀♀
♂♂♂♂♂
♀
♀
♂♂
(-)-α-pinene
OH
(-)-*trans*-
verbenol
O
(-)-verbenone
O
O
exo-
brevicomin
(low conc.)

Terpenes

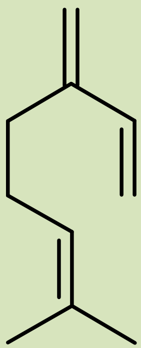
derived from five-carbon isoprene



Monoterpenes	2 isoprene units
Sesquiterpenes	3 isoprene units
Diterpenes	4 isoprene units

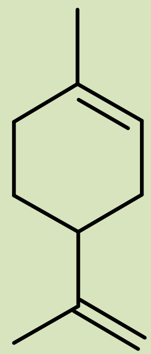
Examples from pine

acyclic

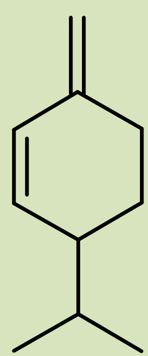


Myrcene

monocyclic

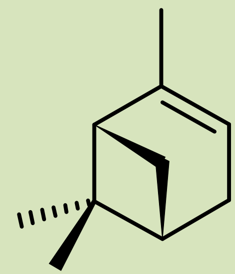


Limonene

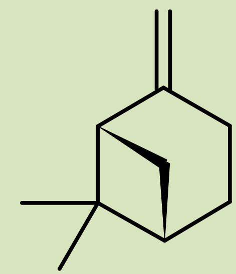


β- Phellandrene

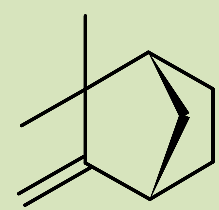
bicyclic



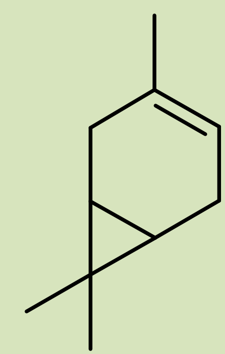
α- Pinene



β- Pinene



Camphene



3- Carene

Field experiment in hybrid zone

Objectives

1. To develop a chemical profile of volatile organic compounds (VOCs) and phloem and needle monoterpene content from mature pine host trees.

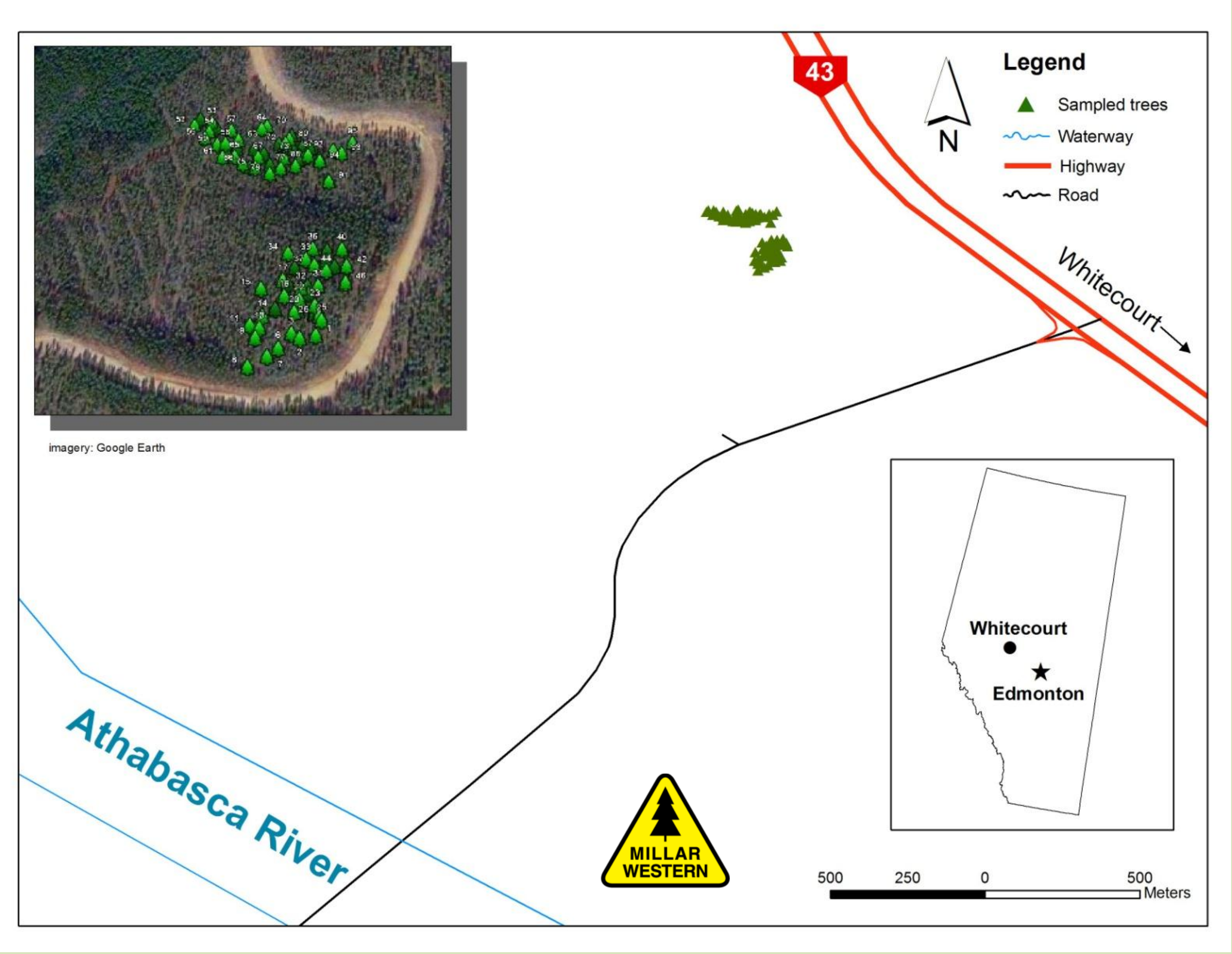
2. To evaluate if VOC profiles vary with different environmental (water vs. water deficit).

3. To evaluate if VOC profiles vary with biological treatments (fungal inoculation with *Grosmania clavigera*).

4. To link the host chemical response to beetle fitness.

Field 2009

- field site 25 km NW of Whitecourt
- hybrid zone
- 40 trees selected
- DBH~24 cm



Environmental treatments

(n=20)

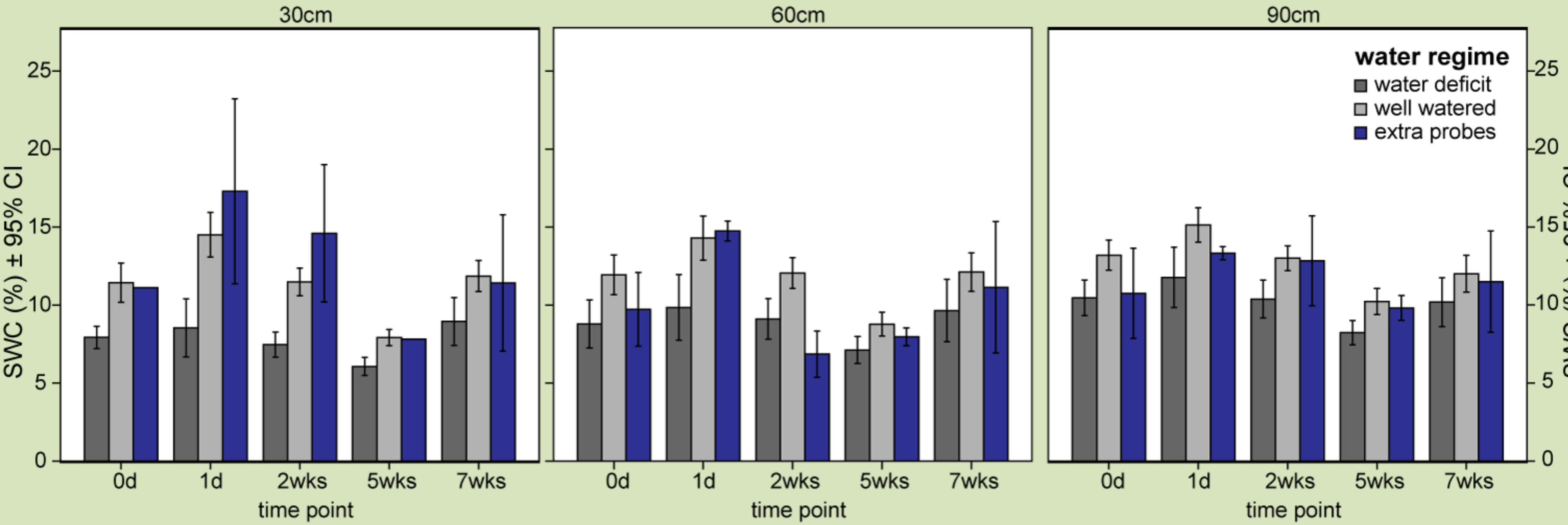
2, 160 L bladders filled every 2 wks (n=20)

Watering

Soil water content

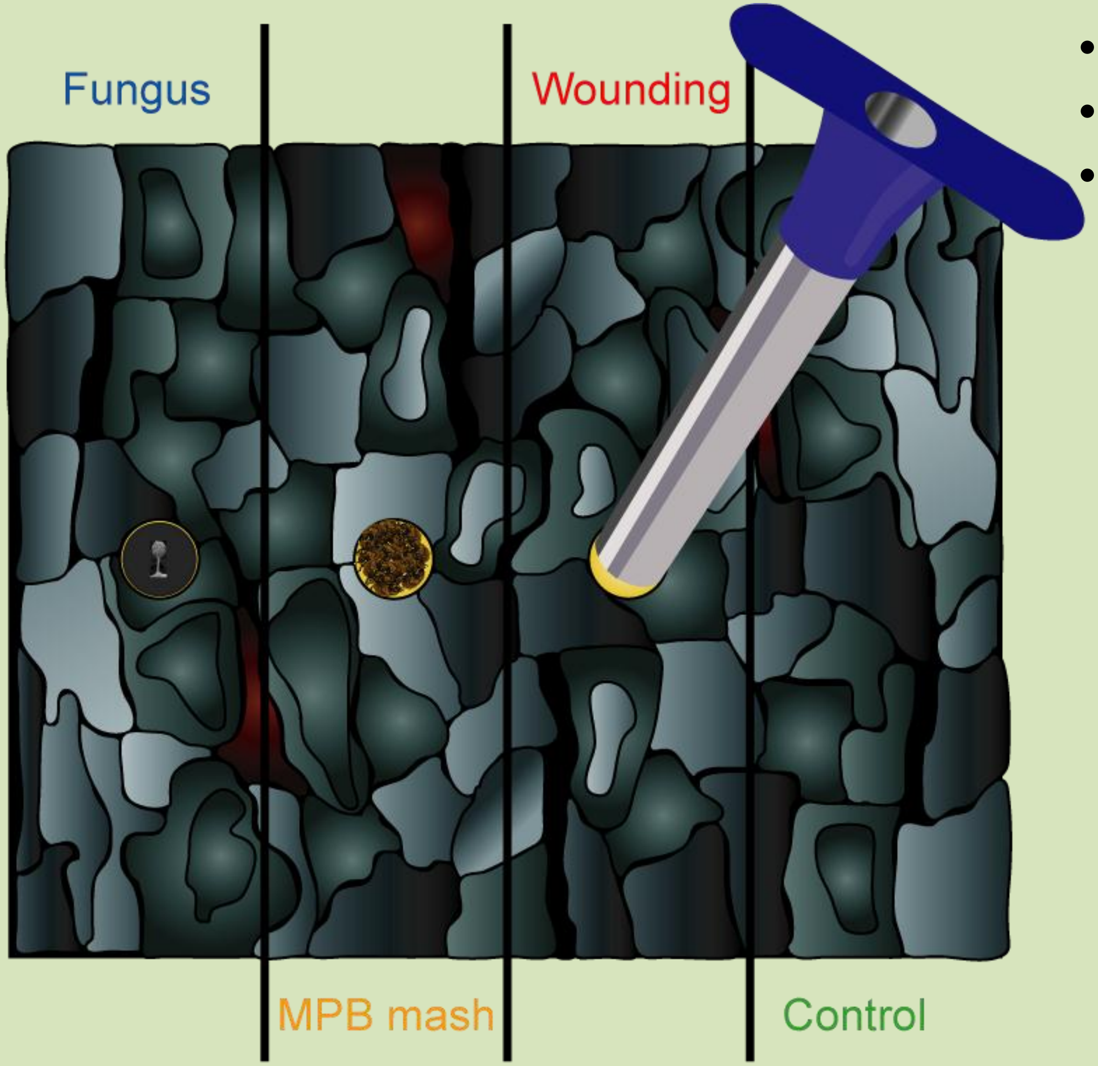
• soil water content measured with time domain reflectometry

Soil water content



significant difference in soil water content between water treatments ***p*= 0.008**

Biological treatments

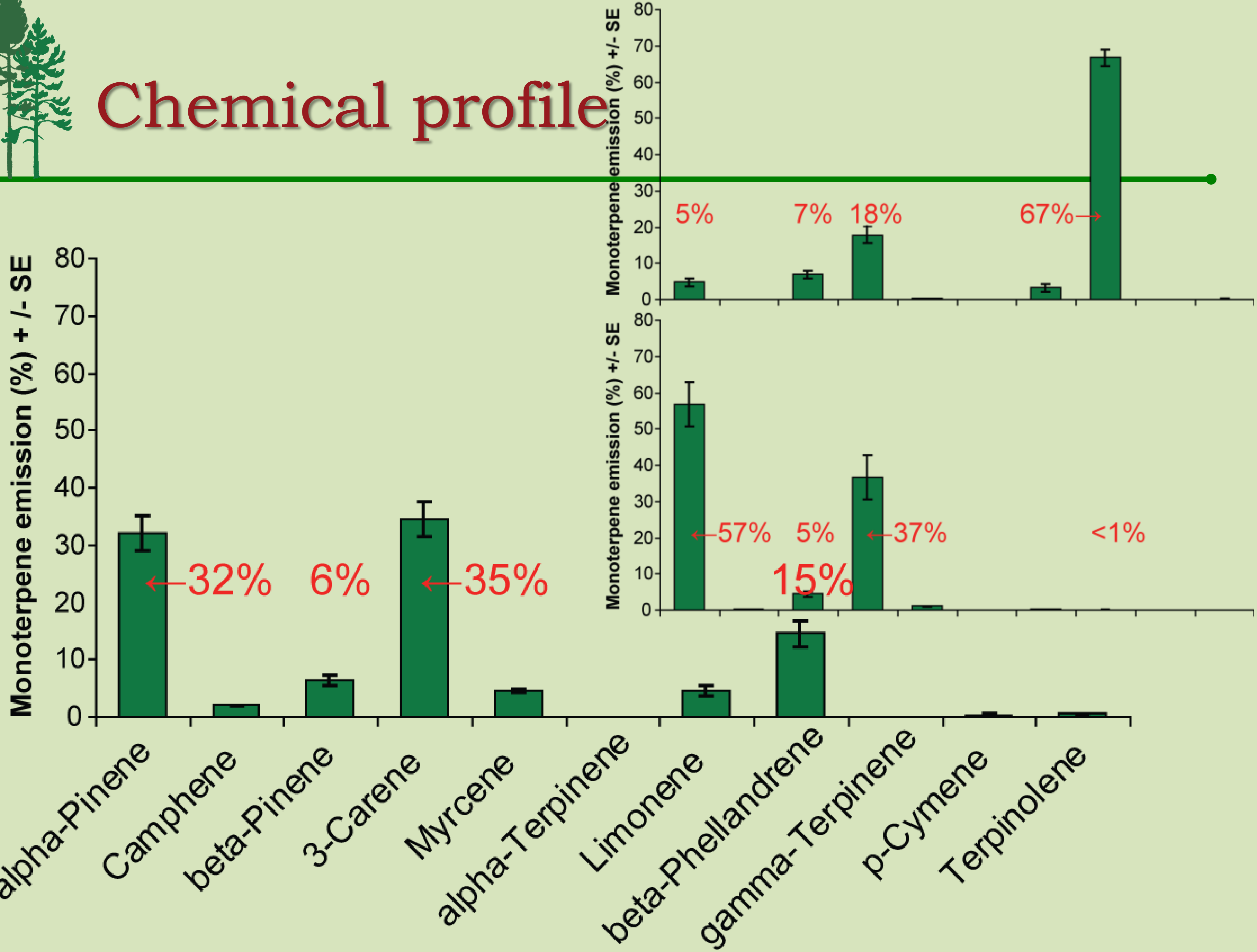


- 5 wks after water treatment
- 5 trees in each water treatment
- 4 biological treatments

VOCs collection

• VOCs collected from boles
• measured before and after biological treatments

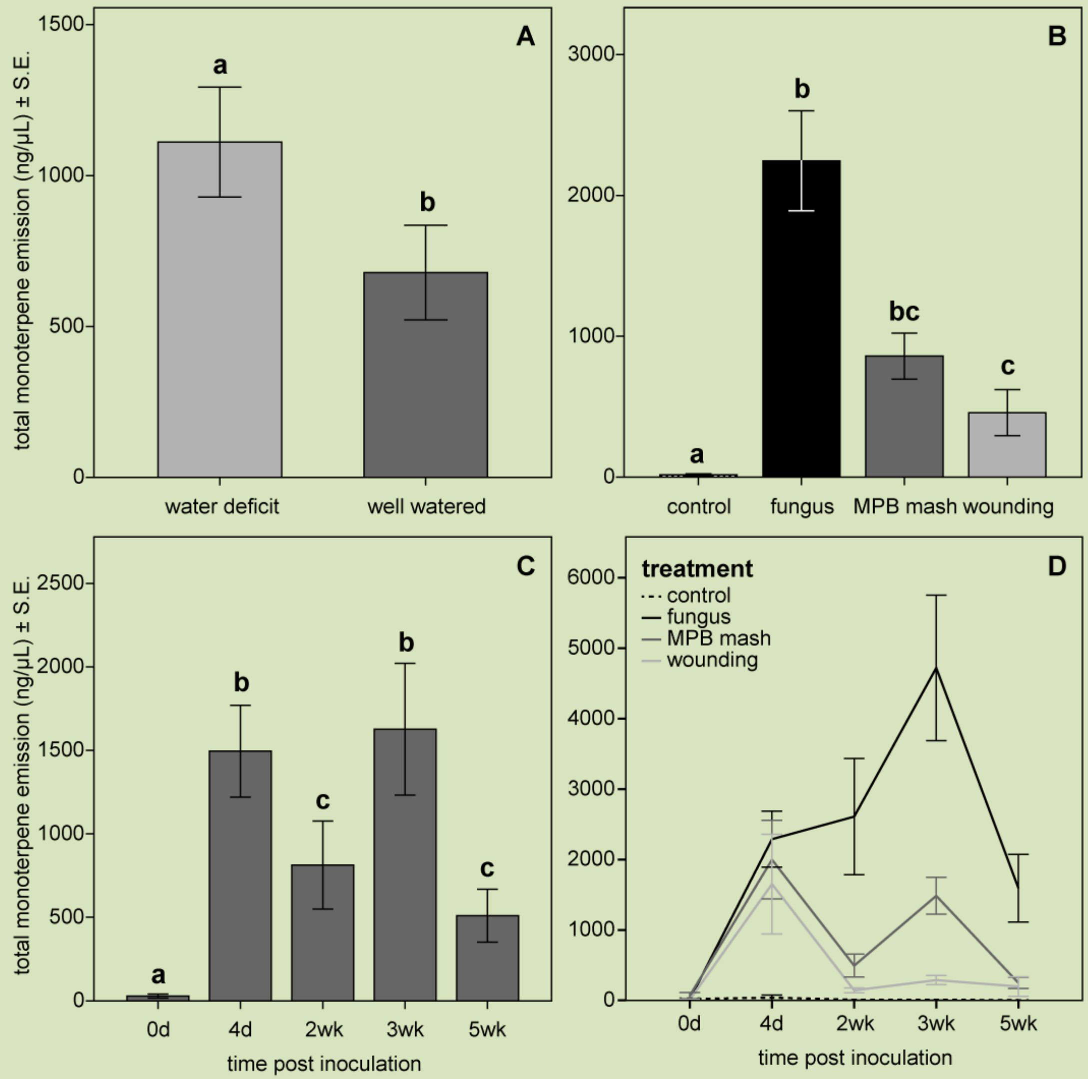
Chemical profile



Total monoterpene emission

p=0.029

p<0.001

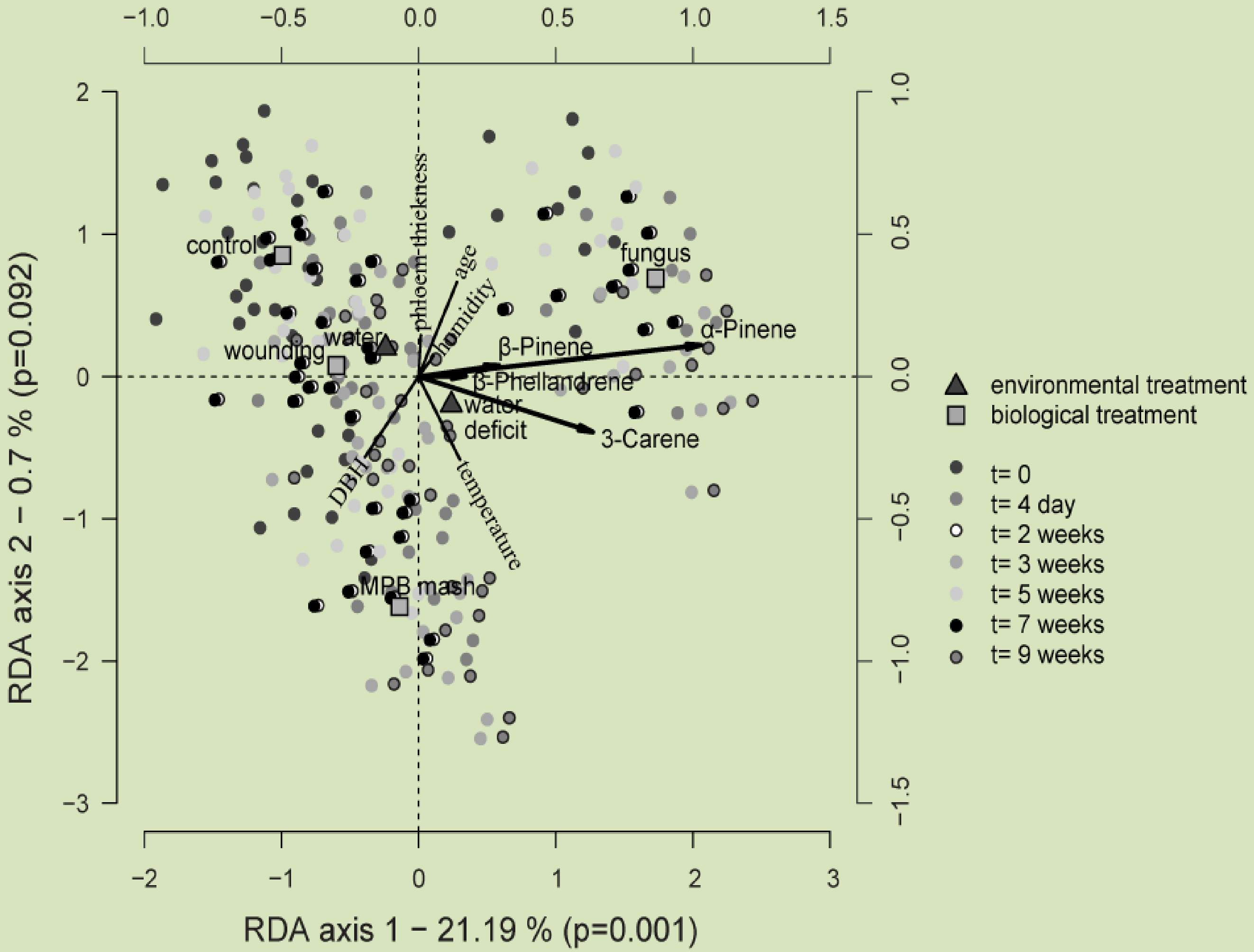


p<0.001

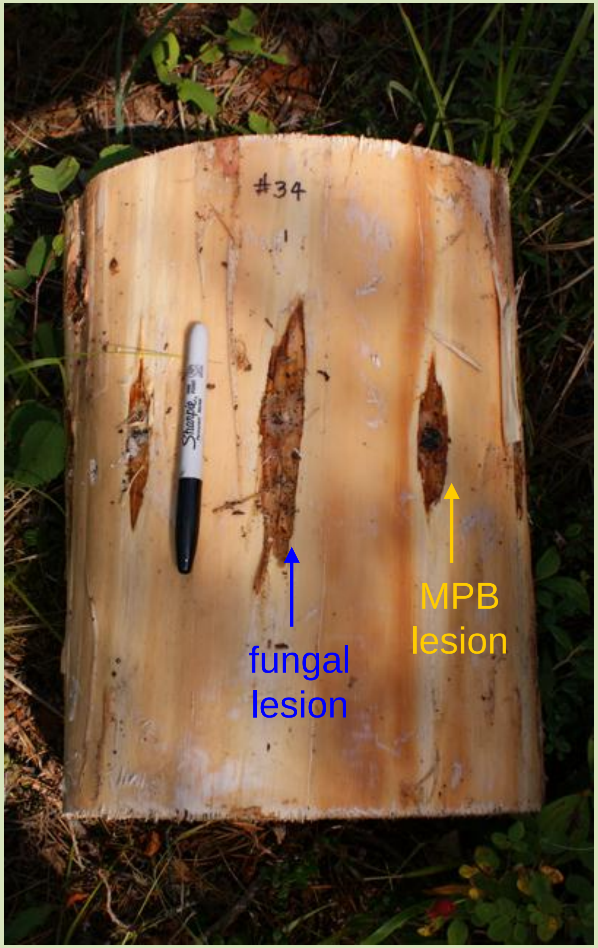
p<0.001

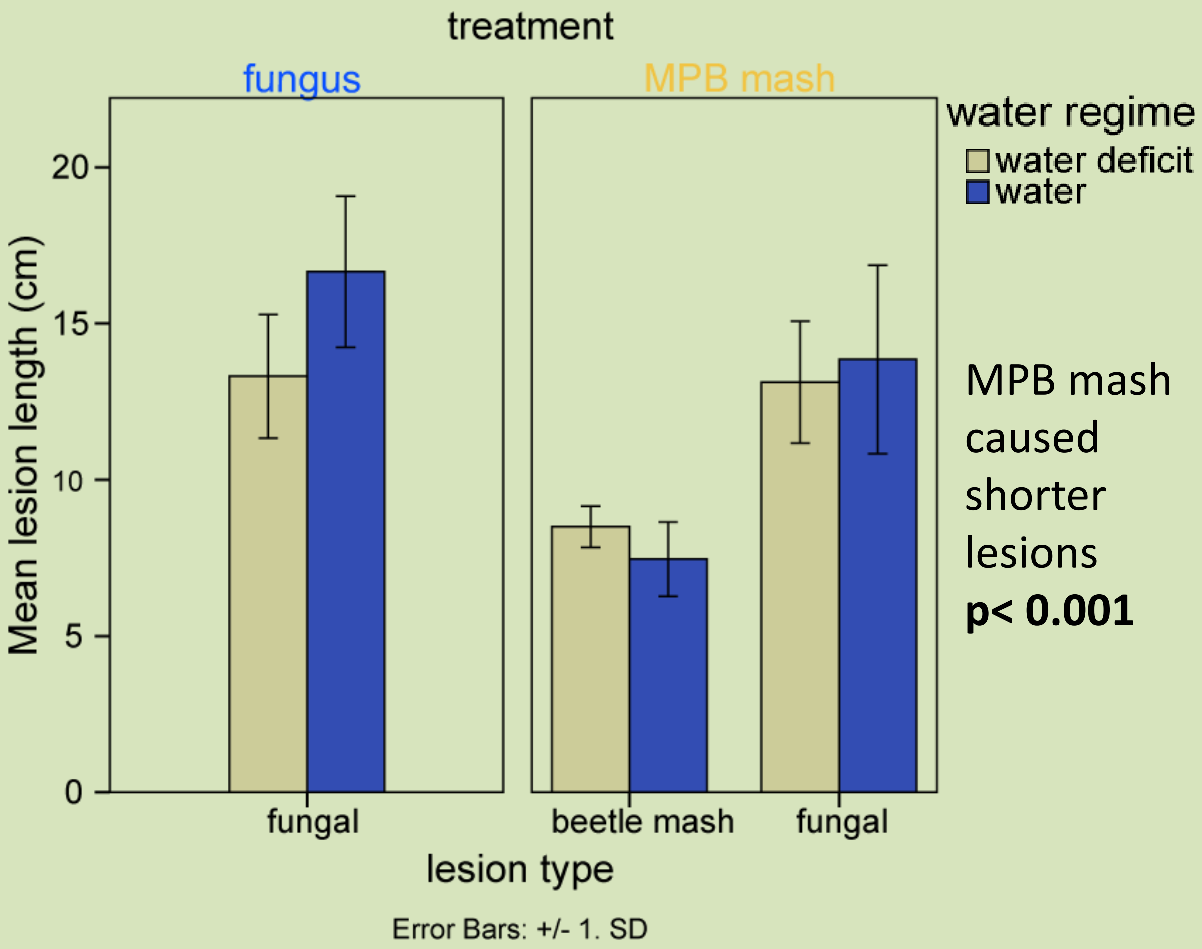
Individual monoterpene emission

- Redundancy Analysis
- Emission of α-Pinene, 3-carene, β-pinene and β-phellandrene correlated with fungal inoculation
- Volatile emission correlated with humidity and temperature



Beetle mash vs. fungal lesions

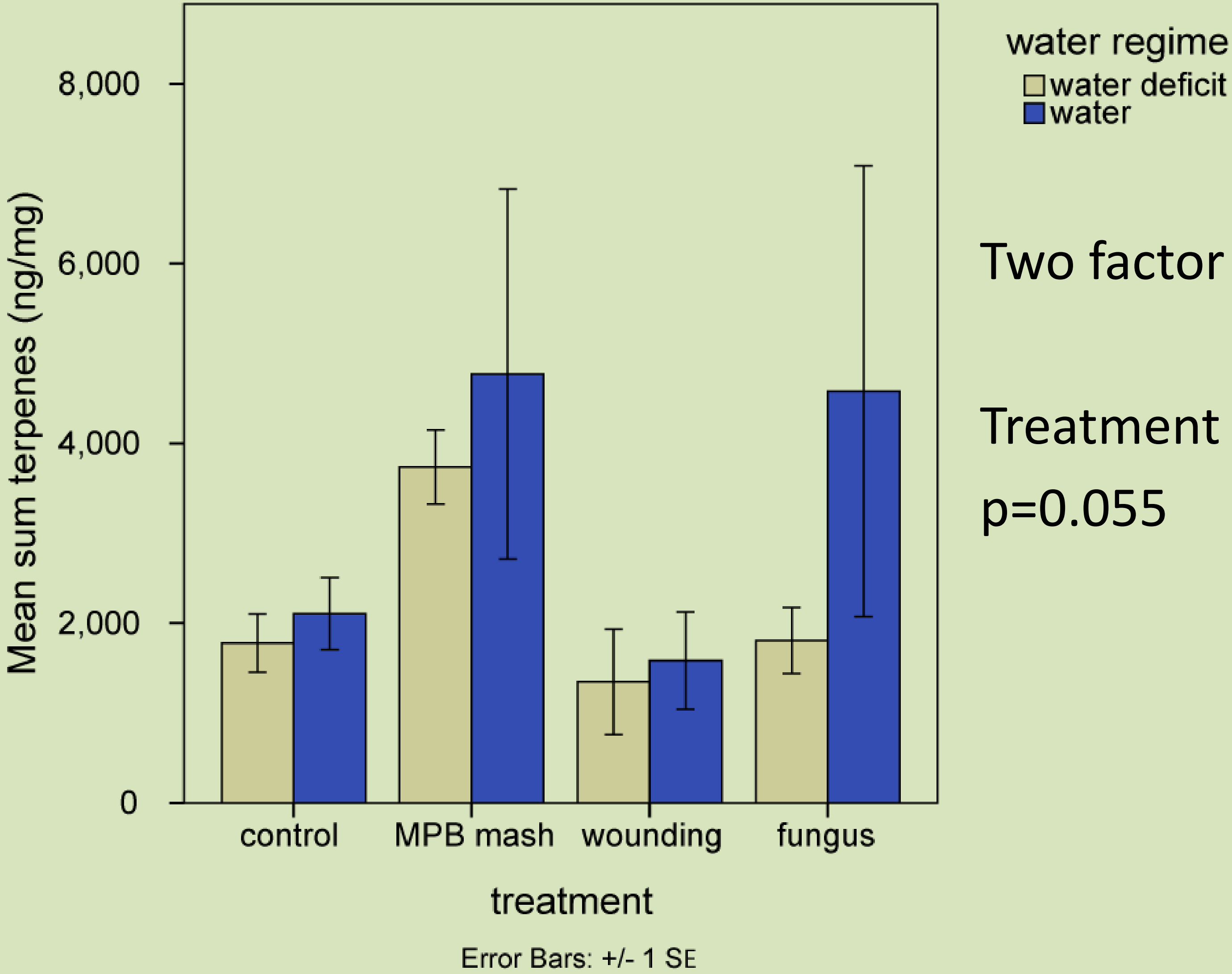




MPB mash caused shorter lesions

p< 0.001

Phloem monoterpenes



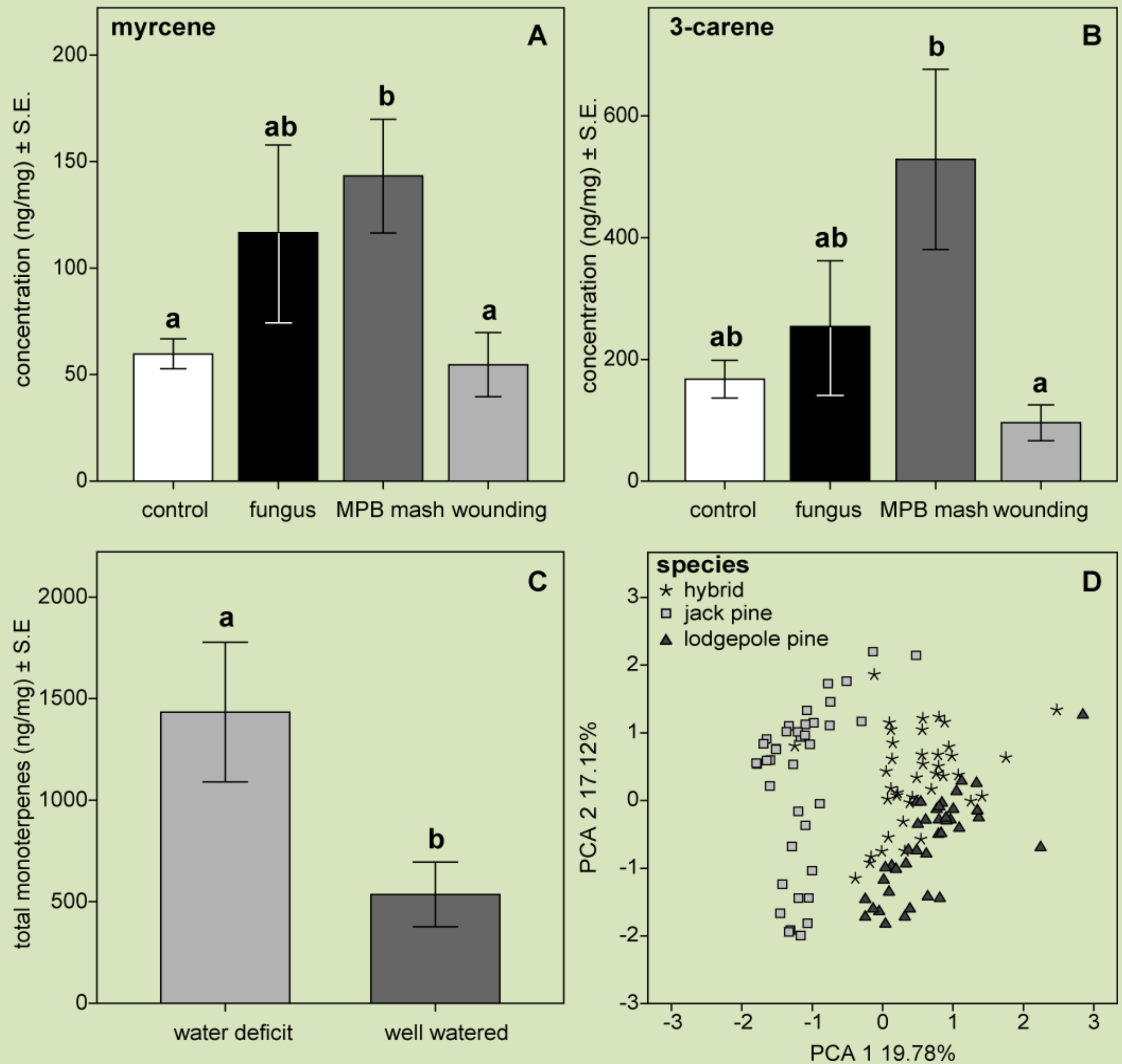
Two factor ANOVA:

Treatment

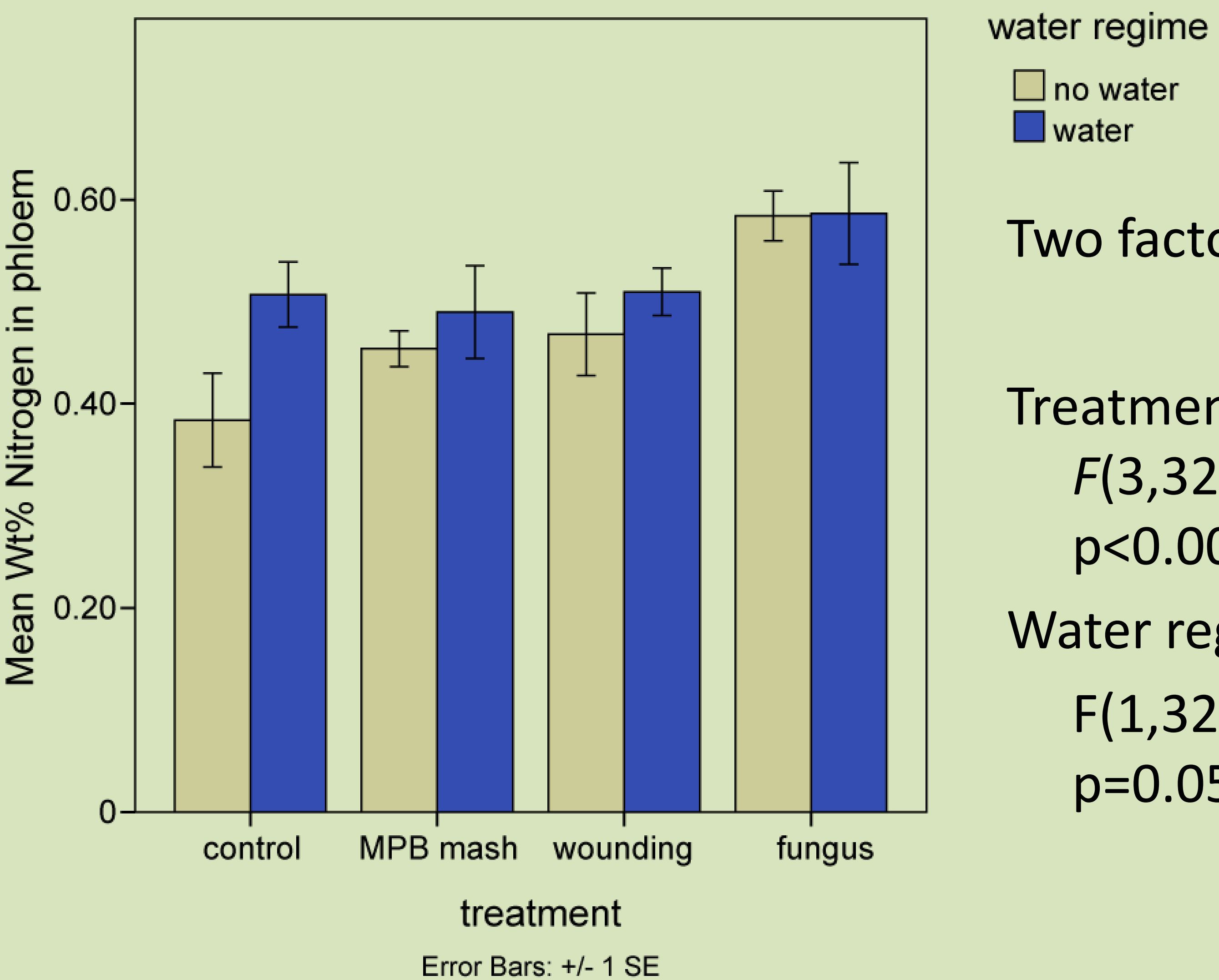
p=0.055

Phloem and needle monoterpenes

- Individual monoterpenes higher in beetle mash inoculated trees
- Higher concentration of total monoterpenes in needles from trees under water deficit
- PCA analysis of phloem chemistry shows hybrid trees clustering between jack and lodgepole pine



Treatment effect on N in phloem



Two factor ANOVA:

Treatment

F(3,32)=5.600, $p<0.005$

Water regime

F(1,32)=3.957, $p=0.055$

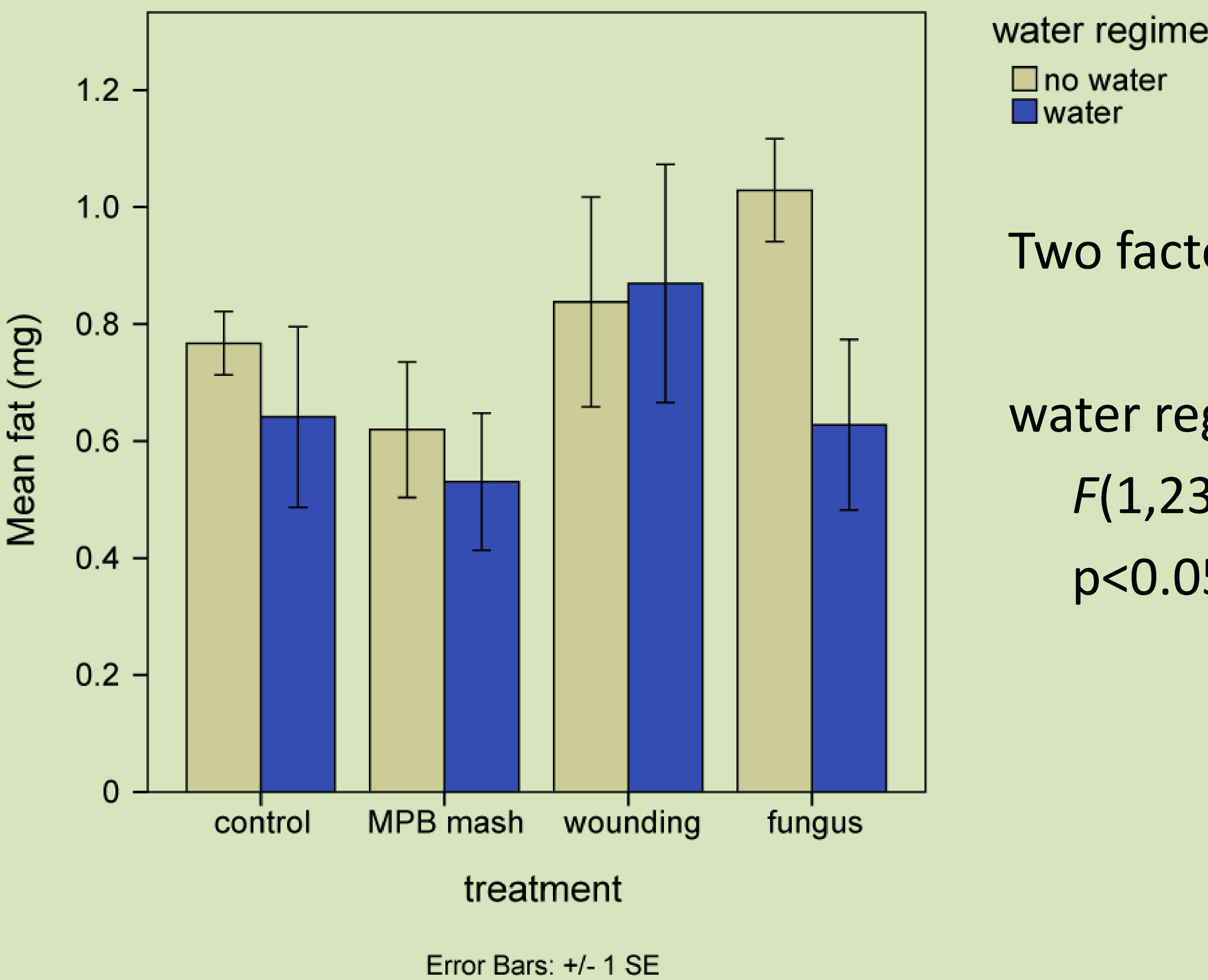
Beetle experiment

Bolts were inoculated with 4 pairs of MPB per bolt

Beetle condition

- Fresh weight
- Size
- Fat content

Treatment effect on fat content



Two factor ANOVA:

water regime

$F(1,23)=6.866$, $p<0.05$

Summary

1. The chemical profile of mature lodgepole x jack pine hybrids represents a mixture of both species’ bole VOCs profile.
2. Total monoterpene emission higher in water deficit trees.
3. Fungal inoculation increases VOCs emission.
4. Important individual monoterpenes elevated after beetle mash inoculation.
5. Increased level of Nitrogen in phloem in fungal inoculated trees outside of the lesion.
6. Beetles that emerged from water deficit bolts had a higher fat content.

Beetle Dispersal

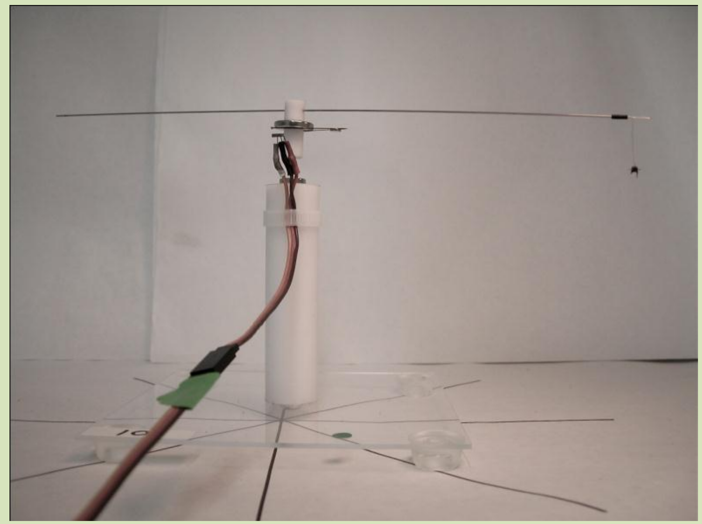
1. Determine flight capacity of MPB.

2. Evaluate the effect of beetle sex and age on flight capacity.

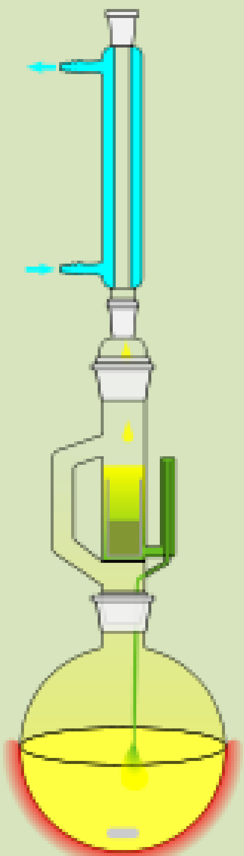
3. Quantify lipid content as a measure of energy use during flight.

Beetle Dispersal

1. Beetles reared from naturally infested lodgepole pine.



2. Three age groups tested:
    1. Young, 1-3 days old.
    2. Middle, 5-7 days old.
    3. Old, 9-11 days old.
3. Males and females flown for 24 h on different days.
4. Lipid content measured post flight.



Beetle Dispersal

Beetle Dispersal

Table 1. The effect of sex and age on flight performance of *Dendroctonus ponderosae*. Values are mean ± SE and sample size is stated in brackets.

	Proportion that flew	Total distance flown (km)	Longest single flight (km)	Longest single flight velocity (m/s^{-1})	Pre-flight weight (mg)
Female					
Young	0.66	3.34 ± 0.66 (59)	1.77 ± 0.46 (59)	0.50 ± 0.02 (39)	12.89 ± 0.31 (103)
Middle	0.72	3.56 ± 0.69 (54)	1.54 ± 0.35 (54)	0.51 ± 0.03 (39)	13.22 ± 0.34 (101)
Old	0.89	2.51 ± 0.68 (19)	0.96 ± 0.38 (19)	0.47 ± 0.05 (17)	12.58 ± 0.47 (43)
Male					
Young	0.82	3.81 ± 0.72 (49)	2.09 ± 0.56 (49)	0.54 ± 0.03 (40)	9.59 ± 0.26 (94)
Middle	0.80	3.12 ± 0.52 (51)	1.18 ± 0.31 (51)	0.50 ± 0.04 (41)	9.72 ± 0.24 (93)
Old	0.81	1.24 ± 0.52 (31)	0.80 ± 0.43 (31)	0.54 ± 0.09 (25)	9.79 ± 0.24 (63)

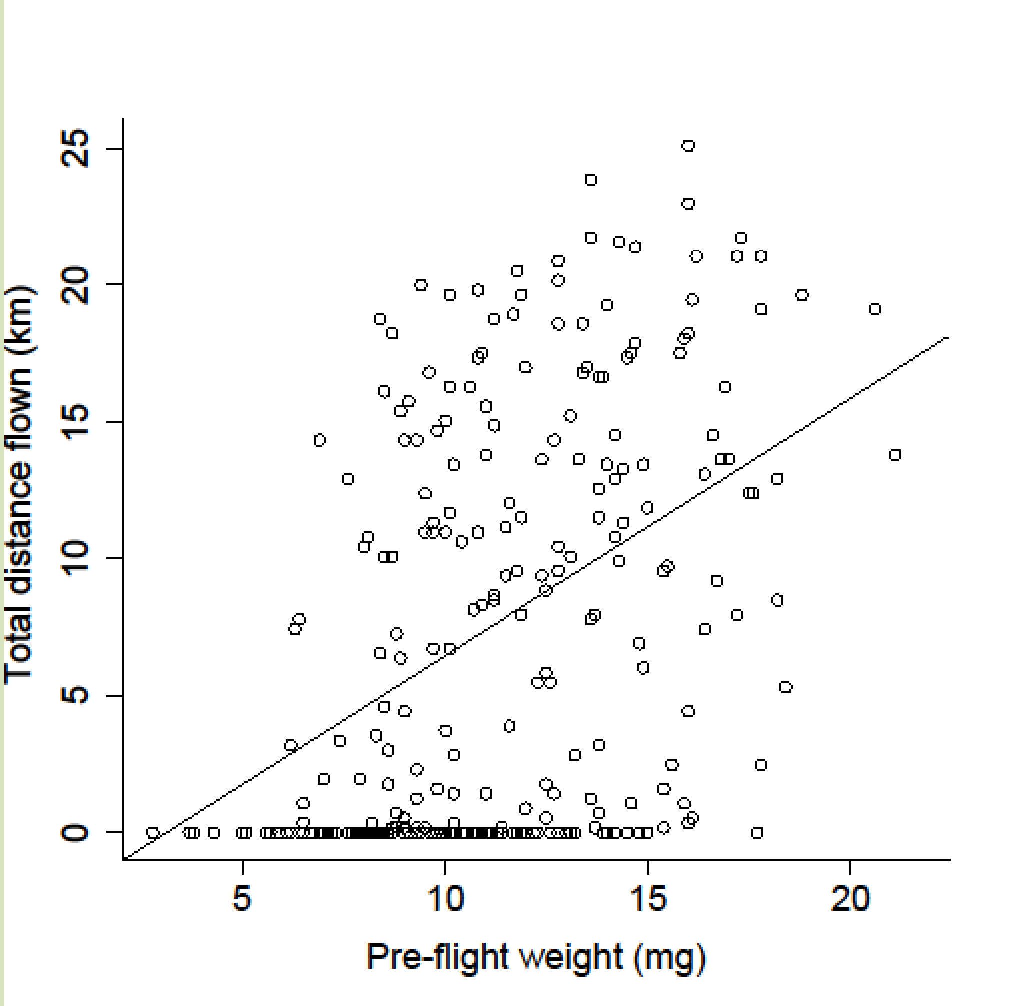
Longest flying beetle= 24 km!

Beetle Dispersal

- Total distance flown was positively correlated with beetle pre-flight weight (P<0.0001)

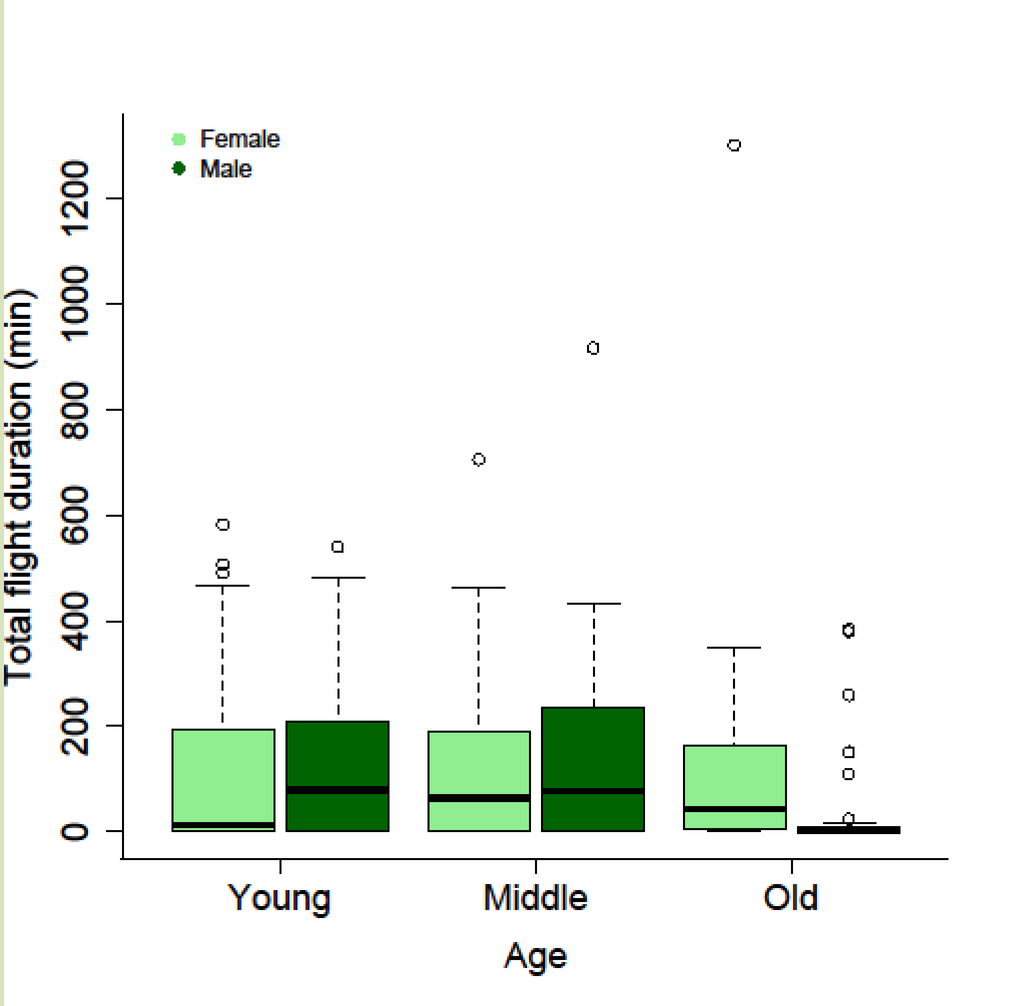
- Age significantly affected total distance flown (P<0.012)

- Middle-aged beetles fly the farthest and old beetles fly the shortest distances



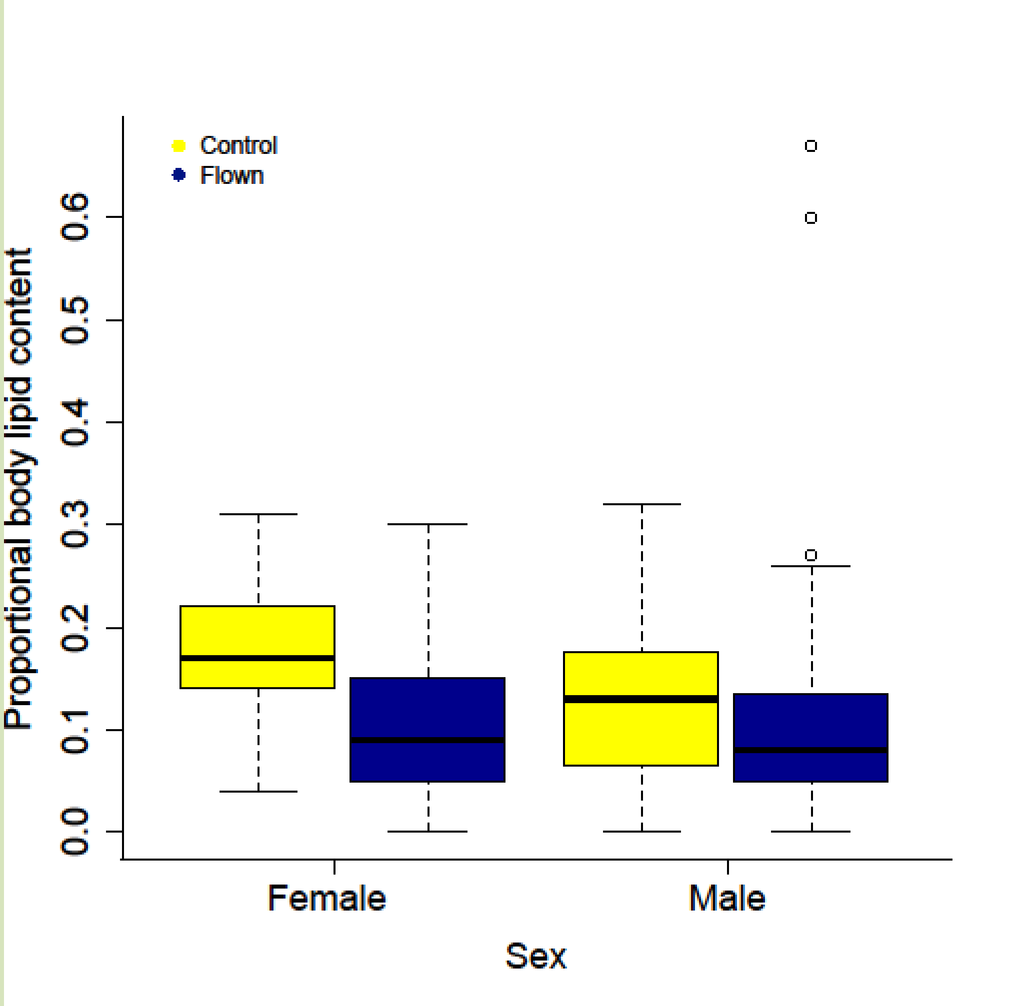
Beetle Dispersal

- Total flight duration increased with beetle pre-flight weight (P<0.0001)
- Significant interaction between sex and age affected flight duration
- Males spend more time in flight than females, except for old males



Beetle Dispersal

- Fat powers flight, unflown control beetles have more fat
- Females have more fat than males



Summary

1. Beetle weight dictates flight capacity by MPB.

2. Positive relationship between pre-flight weight and propensity to fly, flight distance, total time spent flying and flight velocity.

3. Propensity for flight, total flight distance and flight velocity were similar among male and female beetles.

4. Flight distance increased with beetle age until middle age and then decreased in old beetles.

5. Beetle sex and age affect time spent flying and body lipid content post flight.

6. Females have more fat and use more fat in flight than males.

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Patrick Welch
Miles Zurawell

West Fraser

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Questions?

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