# Predatory hymenopteran assemblages in boreal Alaska: associations with forest composition and post-fire succession

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# *Introduction: rationale*

# *Introduction: boreal post-fire succession*

black spruce → ↑ fire severity ↑ fire frequency → aspen/birch

black spruce → black spruce

"typical" black spruce succession

# *Introduction: palatability*

<u>aspen/birch leaves</u>
high palatability
diverse prey
abundant prey
high prey quality

<u>black spruce needles</u>
well-defended
specialist herbivores
fewer prey
poor prey quality

# *Introduction: extrafloral nectar*

<u>extrafloral nectar</u>
carbohydrate-rich
improves ant/wasp fitness
additional food source

# *Introduction: boreal post-fire succession*

↑ fire frequency
↑ fire extent

early-successional → mid-late successional

"typical" black spruce succession

# *Introduction: succession over time*

*11 years post-fire* *67 years* *~100 years*

<u>early-successional</u> → <u>mid-late successional</u>

open canopy: insolation warms soil
understory vegetation growth

closed canopy: limited insolation
buildup of leaf litter/dead wood

# *Research goal/hypotheses*

**Goal: characterize predatory hymenopteran assemblages in post-fire boreal forests of interior Alaska.**

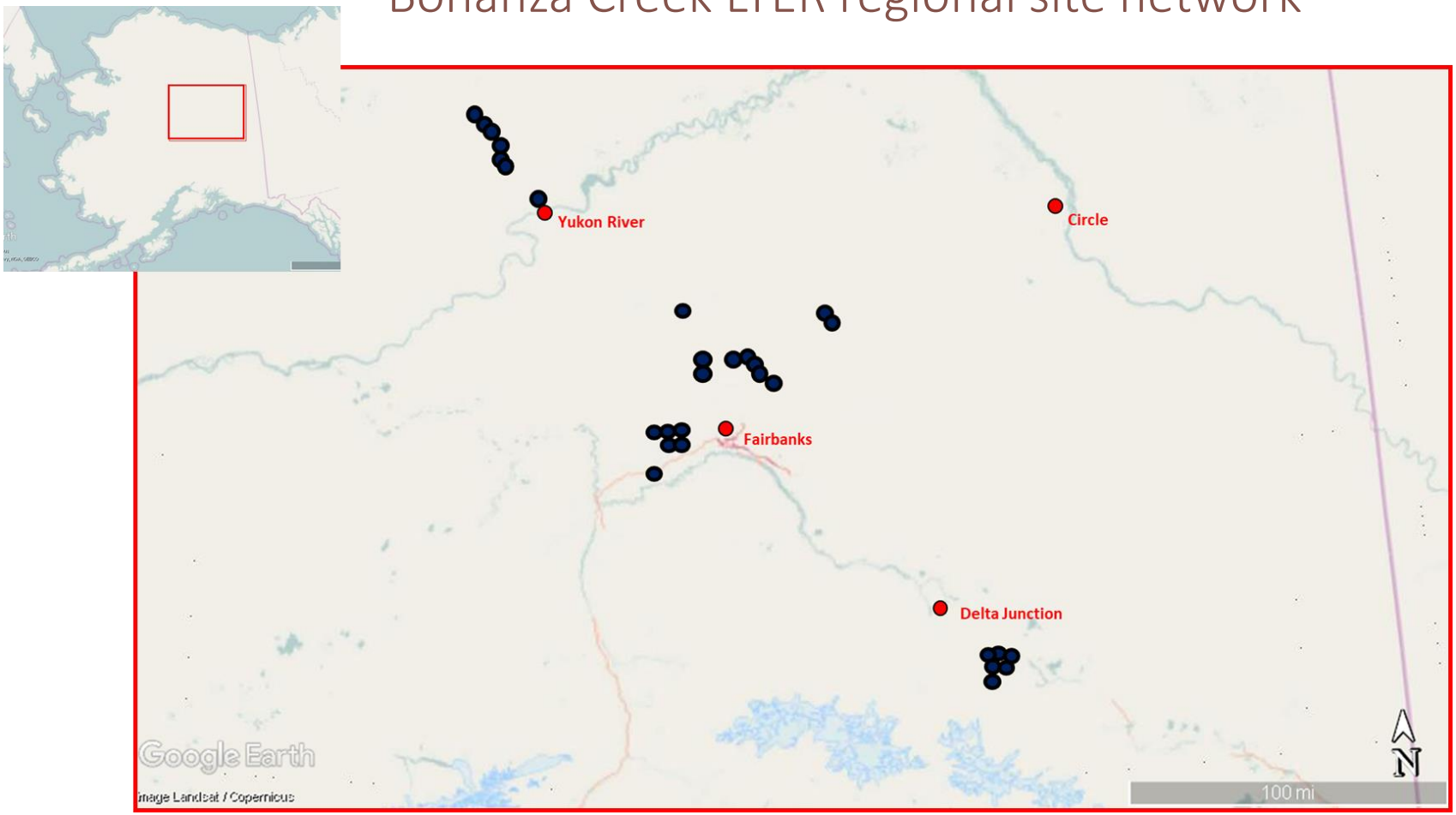
hypotheses:

1. Aspen stands – foster predatory hymenopteran assemblages – EFN and prey base.

2. Ants decline over time – shading/temperature
   Wasps increase over time – habitat complexity

# *Study sites*

## Bonanza Creek LTER regional site network

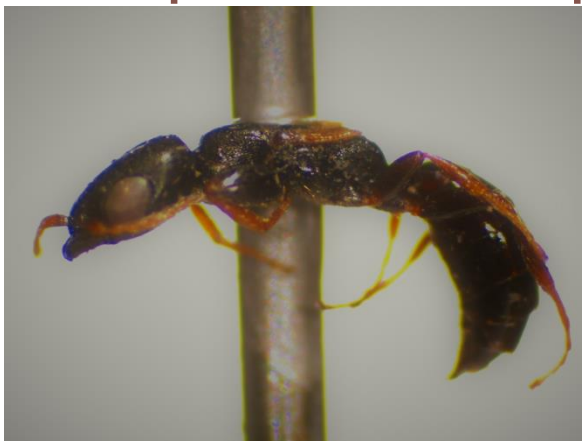


# *Study organisms*

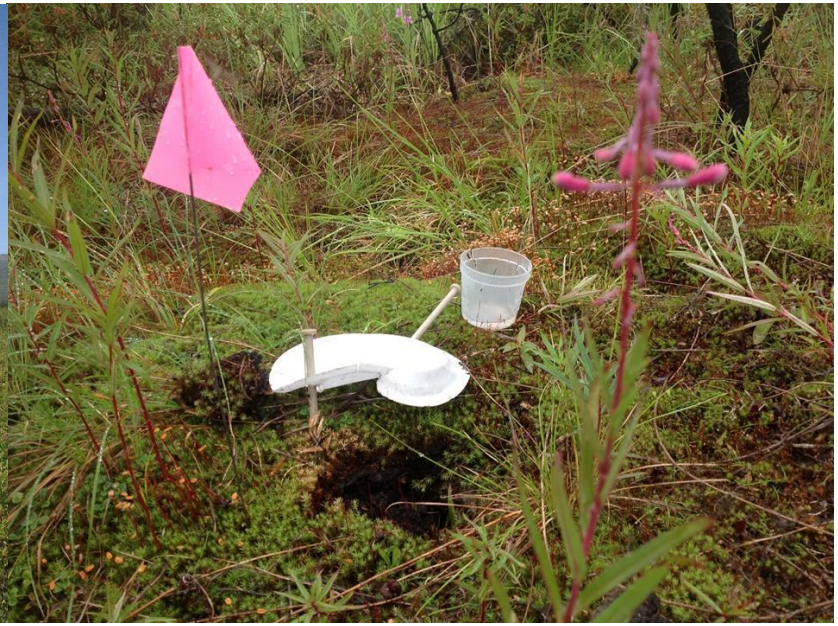
## ants

## macropterous wasps

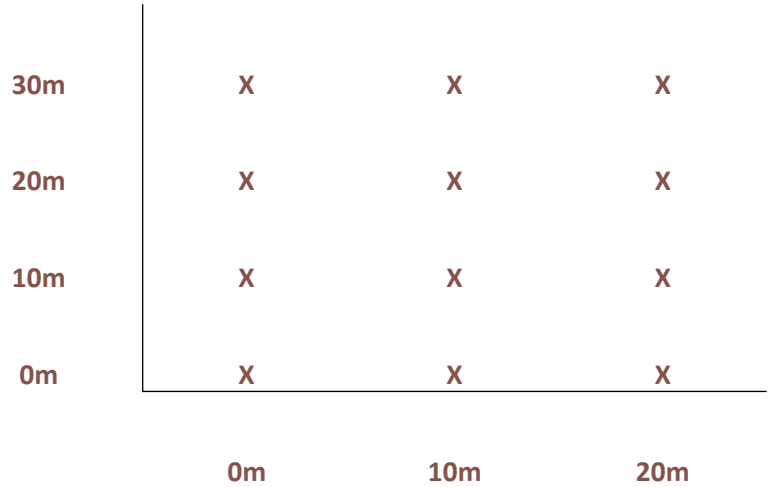
## micropterous wasps



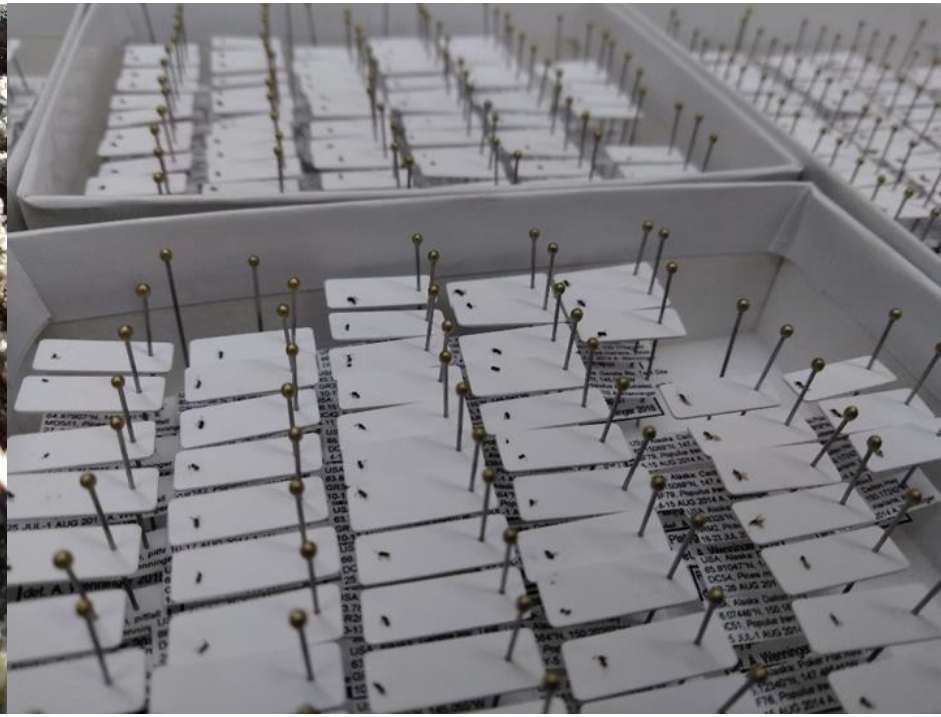
# *Methods: hymenopteran sampling*



Schematic of pitfall sampling layout. 3 transects, each 10 m apart, sampled every 10m along length.



# *Methods: hymenopteran assemblage metrics*



<u>Metrics used to characterize predatory hymenopteran assemblages:</u>

- species/morphospecies richness
- abundance (occurrence-based for ants in pitfalls)
- biomass - ants only

# *Results: hymenopterans sampled*

| Predatory hymenopteran assemblage metric | Pitfall collections | Sweep collections |
|---|---|---|
| Ant richness | 7 | 6 |
| Ant abundance | 2555 (939) | 104 (104) |
| Macropterous wasp richness | 146 | 199 |
| Macropterous wasp abundance | 496 | 357 |
| Micropterous wasp richness | 37 | 2 |
| Micropterous wasp abundance | 237 | 2 |

# *Methods: assessing forest composition using basal area*

overstory

understory

tree

sapling

seedling

dbh ≥ 2.5 cm

**bh = 1.37 m*

dbh < 2.5 cm

or <bh

# *Methods: forest composition analysis*

Goal: explore relationships between predatory hymenopteran assemblages and forest composition

Response variables:

- ant species richness
- ant abundance
- ant biomass
- macropterous wasp richness
- macropterous wasp abundance
- micropterous wasp richness
- micropterous wasp abundance

Predictor variables- basal area of each:

- aspen understory
- aspen overstory
- birch understory
- birch overstory
- black spruce understory
- black spruce overstory

Get conditional model-averaged parameters for each predictor variable.

# *Results: forest composition analysis*

| | Ant richness | | Ant abundance | | Ant biomass | |
|---|---|---|---|---|---|---|
| **Model parameter** | β | adj. SE | β | adj.SE | β | adj.SE |
| Aspen understory | 0.14 | 0.10 | 0.20 | 0.15 | 0.18 | 0.23 |
| Aspen overstory | **-0.02** | **0.01** | **-0.04** | **0.02** | -0.04 | 0.03 |
| Birch understory | 0.07 | 0.12 | 0.03 | 0.18 | 0.07 | 0.28 |
| Birch overstory | **-0.08** | **0.04** | **-0.22** | **0.06** | **-0.22** | **0.08** |
| Black spruce understory | 0.00 | 0.05 | 0.06 | 0.07 | 0.05 | 0.10 |
| Black spruce overstory | **-0.05** | **0.03** | **-0.07** | **0.04** | -0.08 | 0.06 |

Ants

richness and abundance (-) related to overstory tree structure

richness marginally (+) related to aspen seedlings and saplings

# *Results: forest composition analysis*

| | Macropterous wasp richness | | Macropterous wasp abundance | |
|---|---|---|---|---|
| **Model parameter** | β | adj.SE | β | adj.SE |
| Aspen understory | **4.12** | **1.43** | **0.71** | **0.28** |
| Aspen overstory | 0.13 | 0.20 | 0.04 | 0.04 |
| Birch understory | -1.04 | 1.92 | **-0.47** | **0.33** |
| Birch overstory | **1.38** | **0.48** | **0.20** | **0.09** |
| Black spruce understory | -0.19 | 0.66 | -0.09 | 0.12 |
| Black spruce overstory | 0.03 | 0.37 | -0.02 | 0.07 |

Macropterous wasps

richness and abundance (+) related to smaller aspen and birch trees

richness (-) related to birch seedlings/saplings.

# *Results: forest composition analysis*

| | Micropterous wasp richness | | Micropterous wasp abundance | |
|---|---|---|---|---|
| **Model parameter** | β | adj.SE | β | adj.SE |
| Aspen understory | 0.47 | 0.42 | **0.66** | **0.23** |
| Aspen overstory | 0.00 | 0.06 | -0.02 | 0.03 |
| Birch understory | -0.36 | 0.51 | **-0.74** | **0.26** |
| Birch overstory | 0.18 | 0.15 | **0.23** | **0.08** |
| Black spruce understory | -0.22 | 0.17 | **-0.17** | **0.09** |
| Black spruce overstory | **-0.15** | **0.09** | **-0.08** | **0.05** |

Micropterous wasps

richness and abundance (-) related to black spruce trees

abundance (+) related to small aspen and birch trees

abundance (-) related to birch and black spruce seedlings/saplings

# *Methods: successional time analysis*

Goal: to test whether predatory hymenopteran assemblages differ between successional stages

- ant species richness
- ant abundance
- ant biomass
- volant wasp richness
- volant wasp abundance
- nonvolant wasp richness
- nonvolant wasp abundance

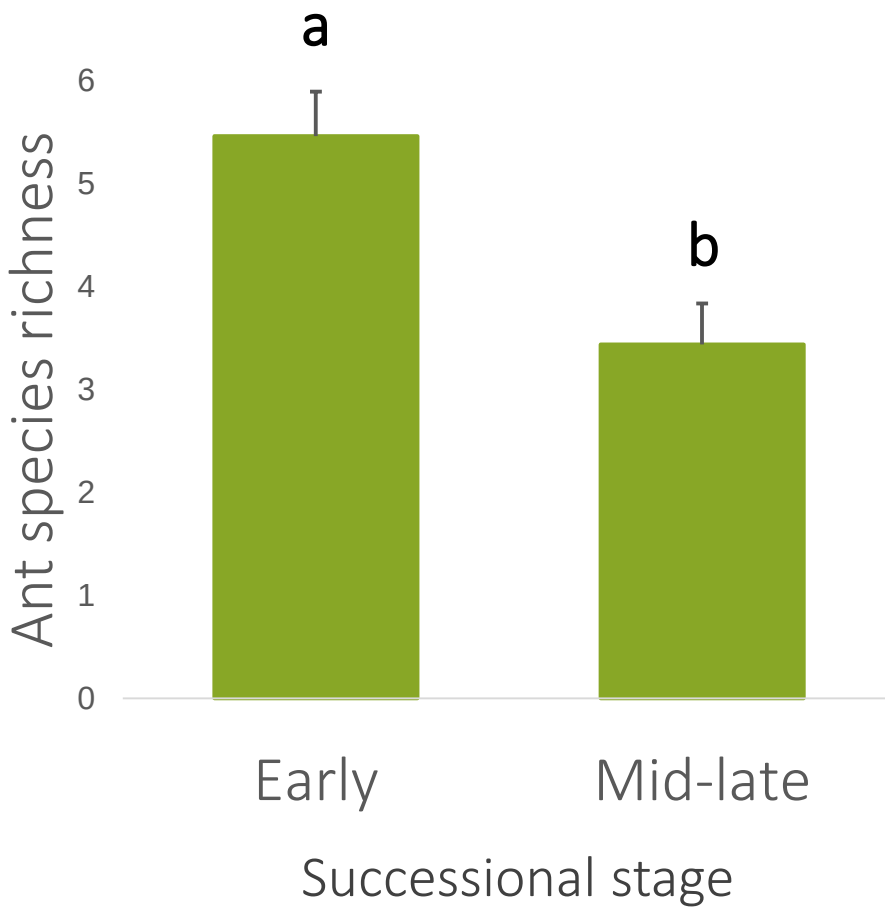
Early successional vs. Mid-late successional

- LTER "young" age class
  - < 25 years post-fire
    - N=13 sites

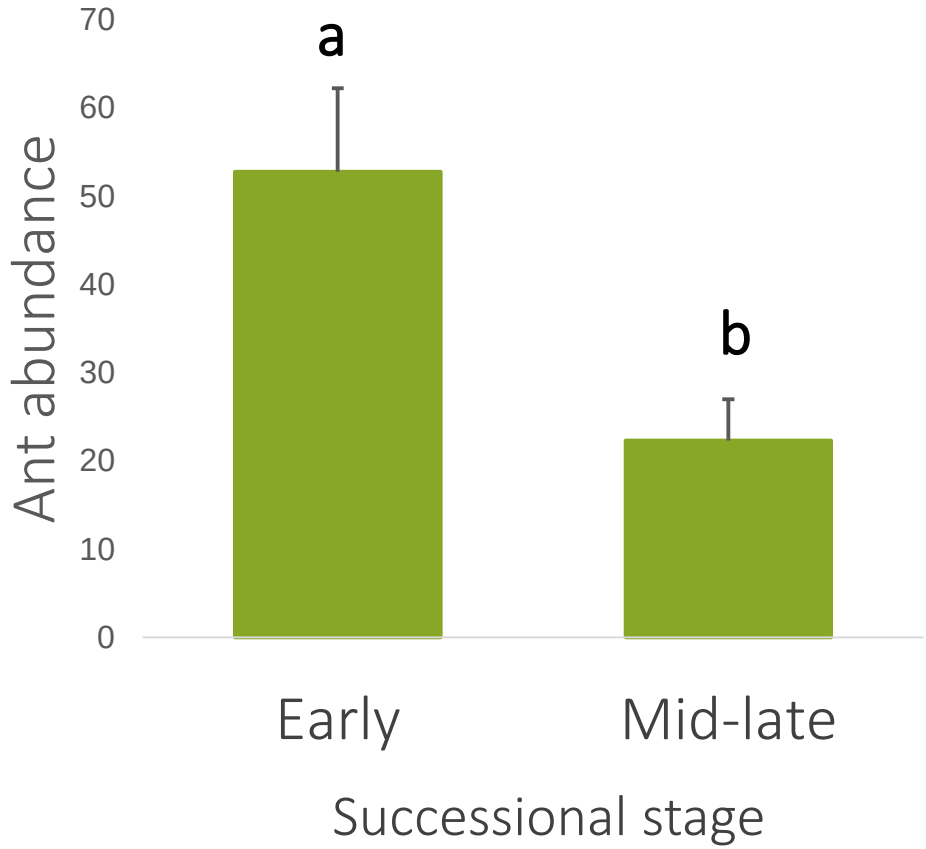
- LTER "intermediate" and "mature" age classes
  - 40+ years post-fire
    - N=16 sites

compare using two-sample *t*-tests
$\alpha$=0.05

# *Results: successional time analysis*



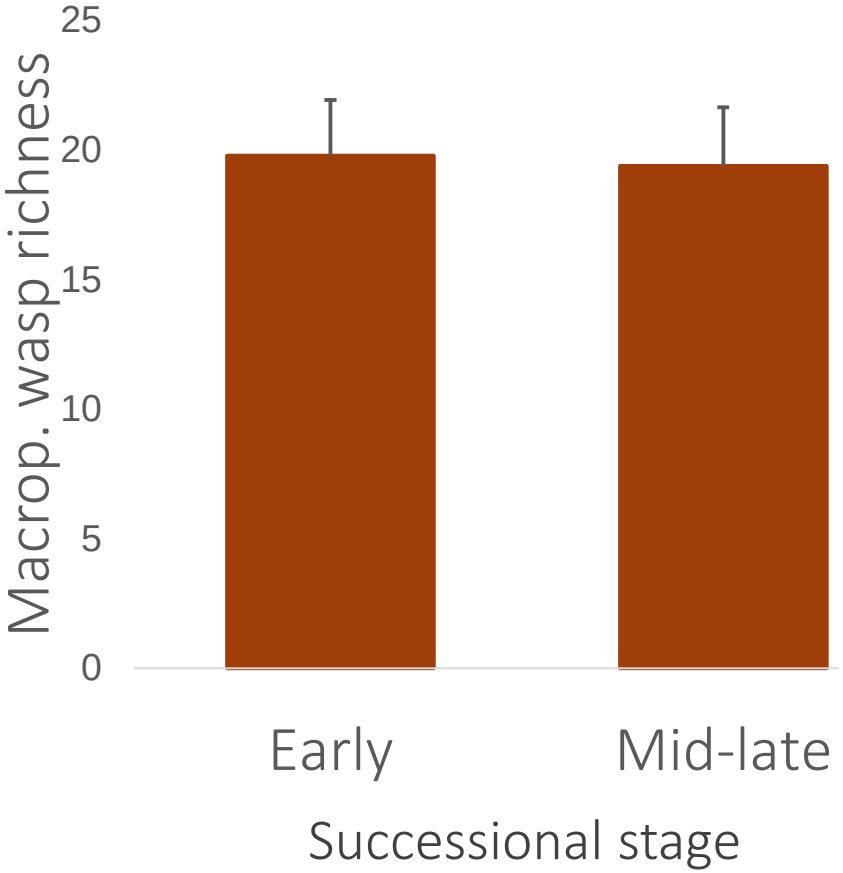

*p = 0.015*



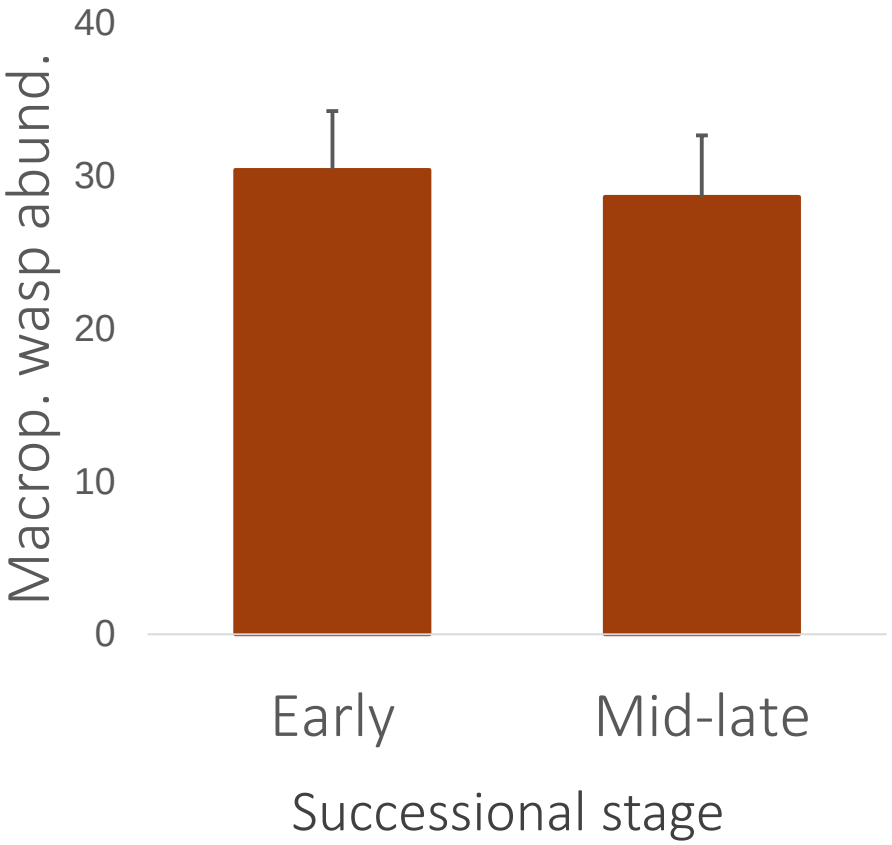

*p = 0.009*

Ant biomass, *p = 0.03*

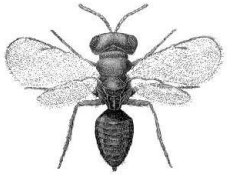
# *Results: successional time analysis*



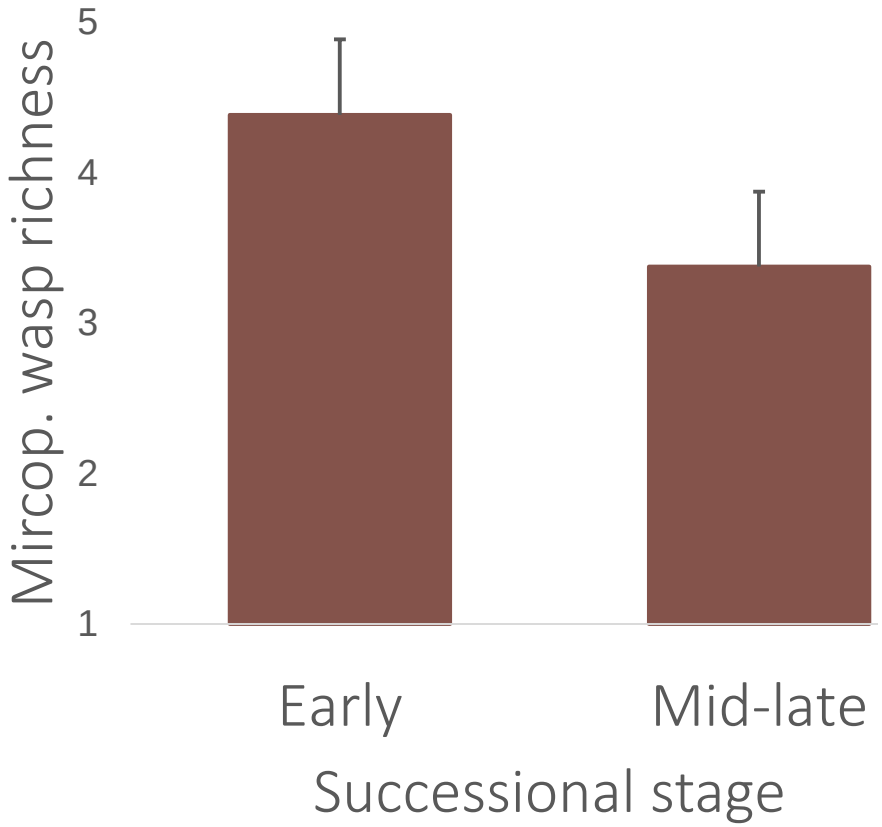

$p > 0.05$



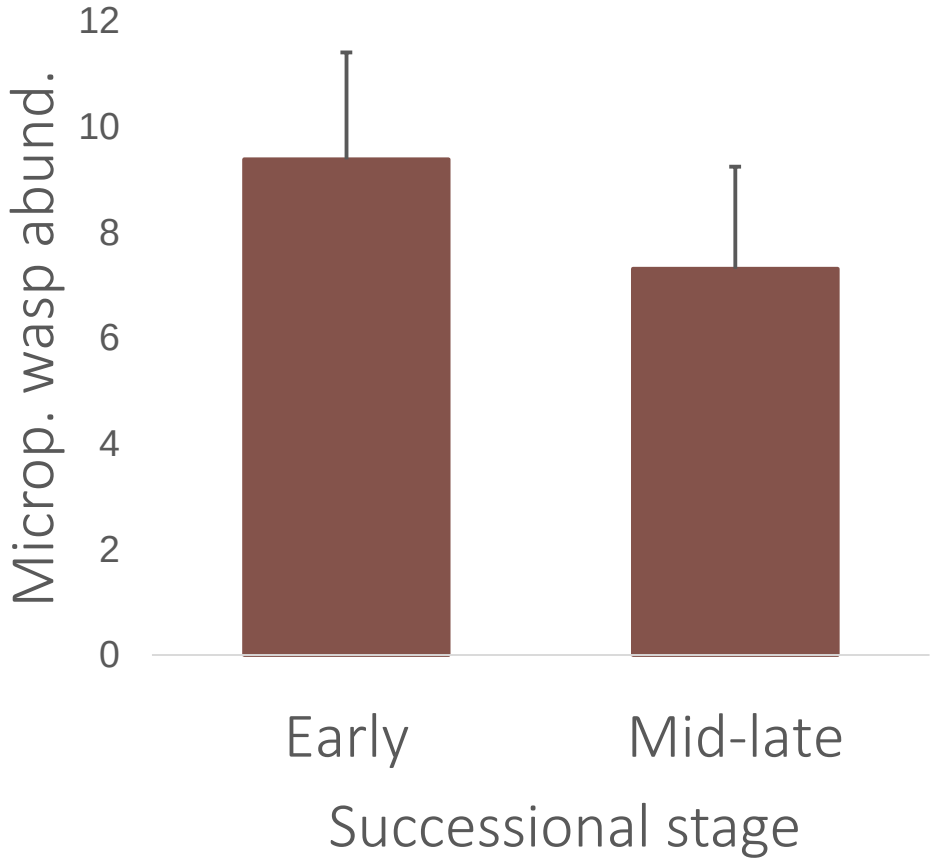

$p > 0.05$



# *Results: successional time analysis*

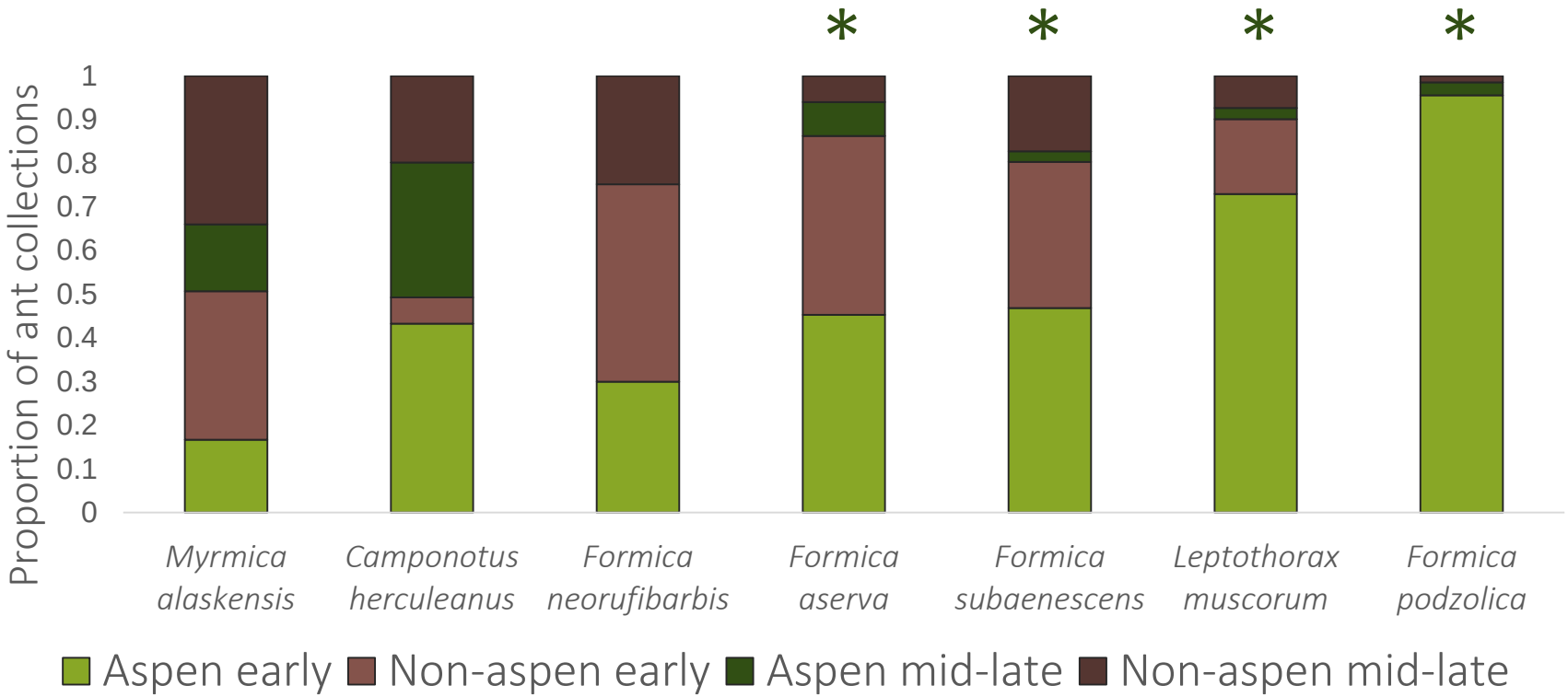



$p > 0.05$




$p > 0.05$

# *Results: assemblage composition*




# *Discussion: forest composition*

Ant assemblages were not strongly associated with aspen over other tree species.

Four of the seven ant species were significantly associated with early-successional aspen sites.

# *Discussion: forest composition*




## Extrafloral nectar provisioning

### consistencies

- (+) aspen seedlings/saplings

### inconsistencies

- (+) aspen seedlings/saplings for micropterous wasps

## Palatability/prey base

### consistencies

- (+) birch trees
- (-) birch seedlings/saplings

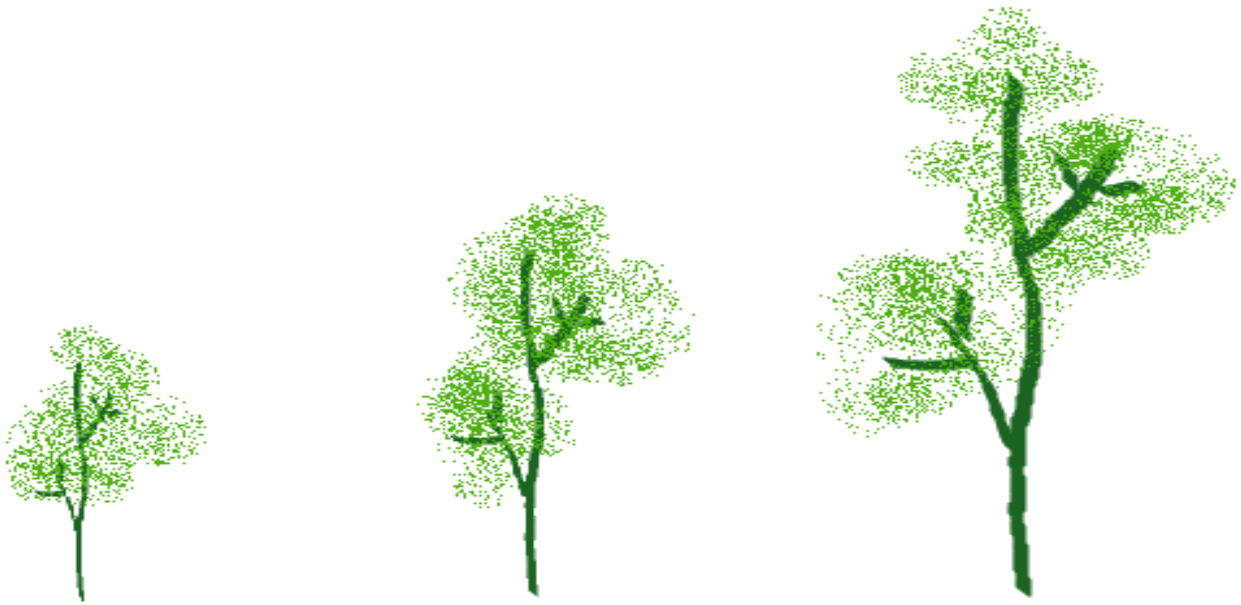
### inconsistencies

- (+) aspen seedlings/saplings (o/-) aspen trees

# *Discussion: successional time*

Ants were most species rich and abundant in early-successional forests.

# *Discussion: successional time*



There was no evidence that wasp assemblages change over successional time.

# *Future implications of a changing boreal climate*



Changing boreal <u>fire regime:</u>
↑ fire severity
↑ fire frequency

→

<u>Vegetation changes:</u>
↑ aspen/birch prevalence

→

Pred. hymenopteran <u>assemblage changes:</u>
↑ ant and macropterous wasp richness
↑ macropterous and micropterous wasp abundance

Changing boreal <u>fire regime:</u>
↑ fire frequency
↑ fire extent

→

<u>Successional changes</u>:
↑ early-successional habitat

→

Pred. hymenopteran <u>assemblage changes:</u>
↑ ant richness/abund.

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Committee members:
Derek Sikes
Teresa Hollingsworth

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# *Hymenopterans and environment*

| Predatory hymenopteran assemblage metrics | Environmental variables | | | | |
|---|---|---|---|---|---|
| | Soil moisture | Soil temp. (mean) | Soil temp. (min.) | Slope | Canopy cover |
| Ant richness | -0.04 | 0.27 | 0.06 | 0.11 | **-0.62** |
| Ant abundance | 0.13 | **0.30** | -0.04 | 0.01 | **-0.75** |
| Ant biomass | -0.15 | **0.37** | 0.14 | 0.03 | **-0.41** |
| Volant wasp richness | **-0.34** | 0.22 | 0.26 | -0.12 | 0.26 |
| Volant wasp abundance | **-0.42** | **0.36** | **0.46** | -0.18 | 0.22 |
| Nonvolant wasp richness | 0.02 | **0.33** | **0.32** | **-0.50** | -0.10 |
| Nonvolant wasp abundance | -0.03 | 0.18 | 0.28 | **-0.44** | 0.02 |

"moderate" correlation = $r \geq 0.30$ / "strong" correlation = $r \geq 0.50$

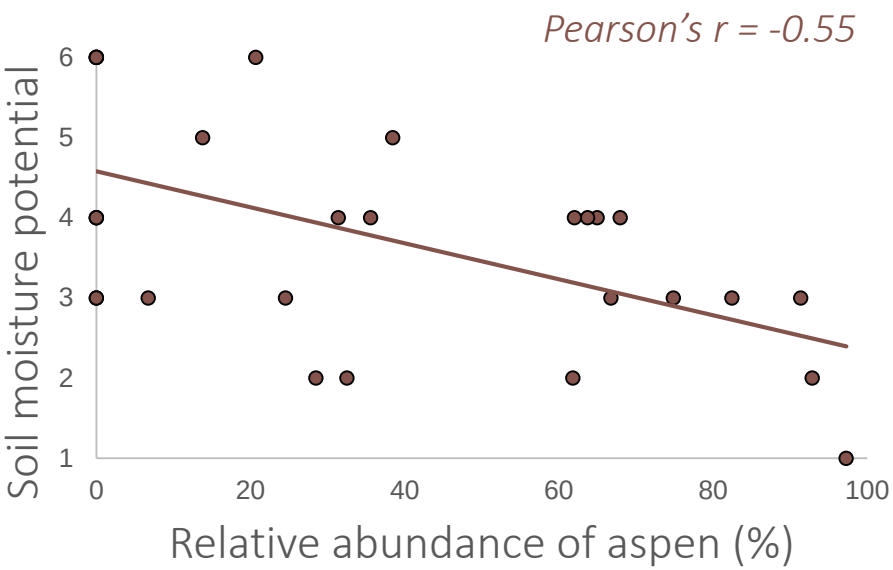
Ants: (-) canopy cover, (+) soil temperature

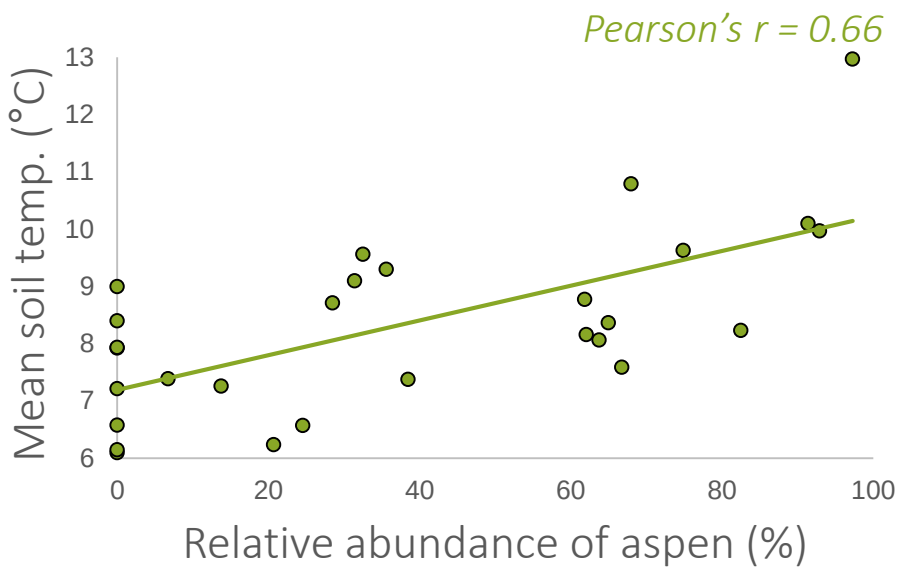
Volant wasps: (-) soil moisture, (+) soil temperature

Nonvolant wasps: (-) slope, (+) soil temperature

# *Microclimate by forest composition*

*aspen stands are drier/warmer than non-aspen stands

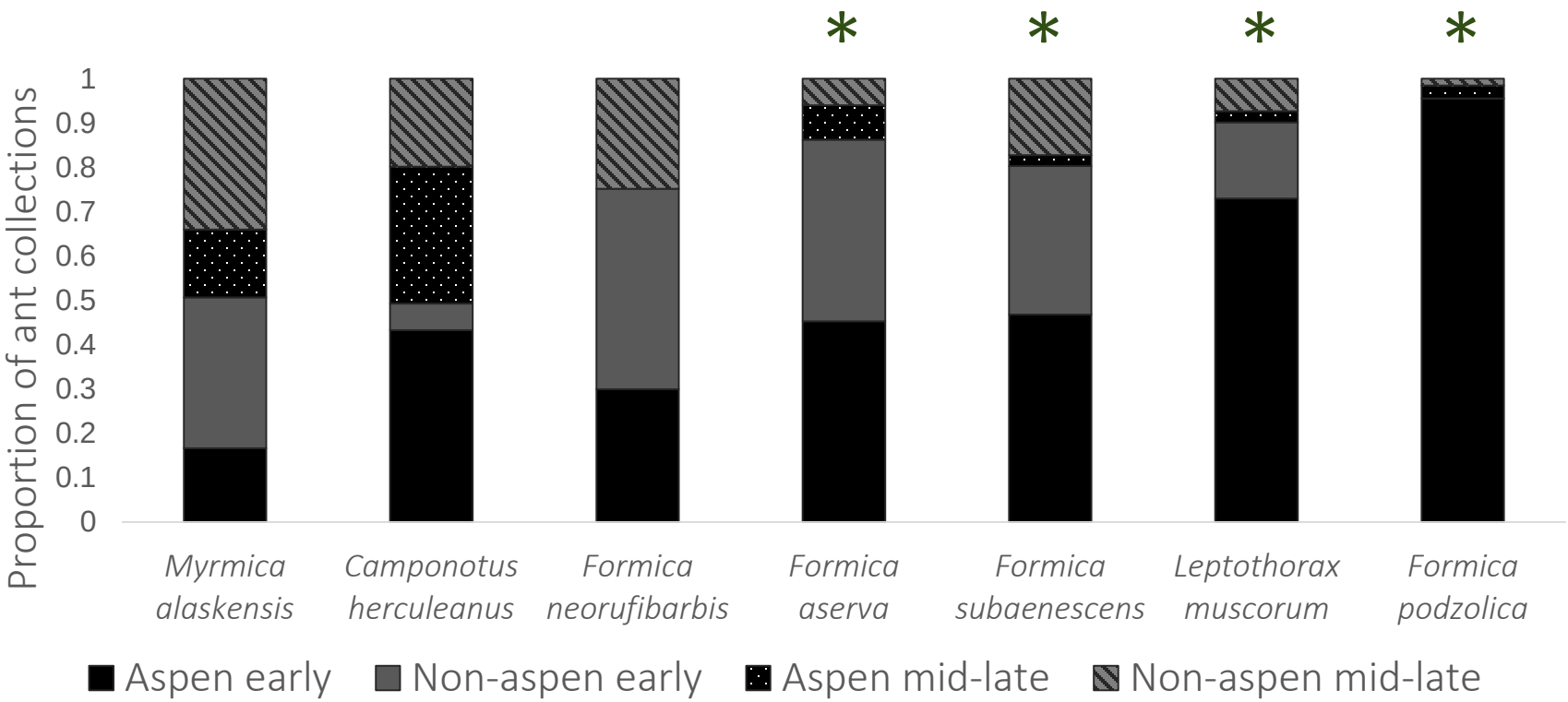



*Minimum soil temperature, Pearson's r = 0.79*

# *Results: assemblage composition*

| Ants | *T* | *A* | *p* |
|---|---|---|---|
| Early aspen vs early non-aspen | -1.33 | 0.03 | 0.102 |
| Mid-late aspen vs mid-late non-aspen | -2.15 | 0.06 | 0.037 |
| Early aspen vs mid-late aspen | -4.17 | 0.21 | **0.005** |
| Early non-aspen vs mid-late non-aspen | -0.94 | 0.02 | 0.159 |



# *Results: assemblage composition*

| Volant wasps | *T* | *A* | *p* |
|---|---|---|---|
| Early aspen vs early non-aspen | -2.25 | 0.02 | **0.024** |
| Mid-late aspen vs mid-late non-aspen | -5.72 | 0.04 | **0.000** |
| Early aspen vs mid-late aspen | -5.69 | 0.10 | **0.001** |
| Early non-aspen vs mid-late non-aspen | 0.20 | 0.00 | 0.546 |

| Nonvolant wasps | *T* | *A* | *p* |
|---|---|---|---|
| Early aspen vs early non-aspen | -0.31 | 0.01 | 0.327 |
| Mid-late aspen vs mid-late non-aspen | -0.93 | 0.01 | 0.165 |
| Early aspen vs mid-late aspen | 0.05 | 0.00 | 0.484 |
| Early non-aspen vs mid-late non-aspen | -2.27 | 0.03 | 0.030 |