Ants, Plants, and Seed Dispersal Ignorance: How do Ants Enhance Persistence?

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12:20 PM, 160 Plant Biotech Building

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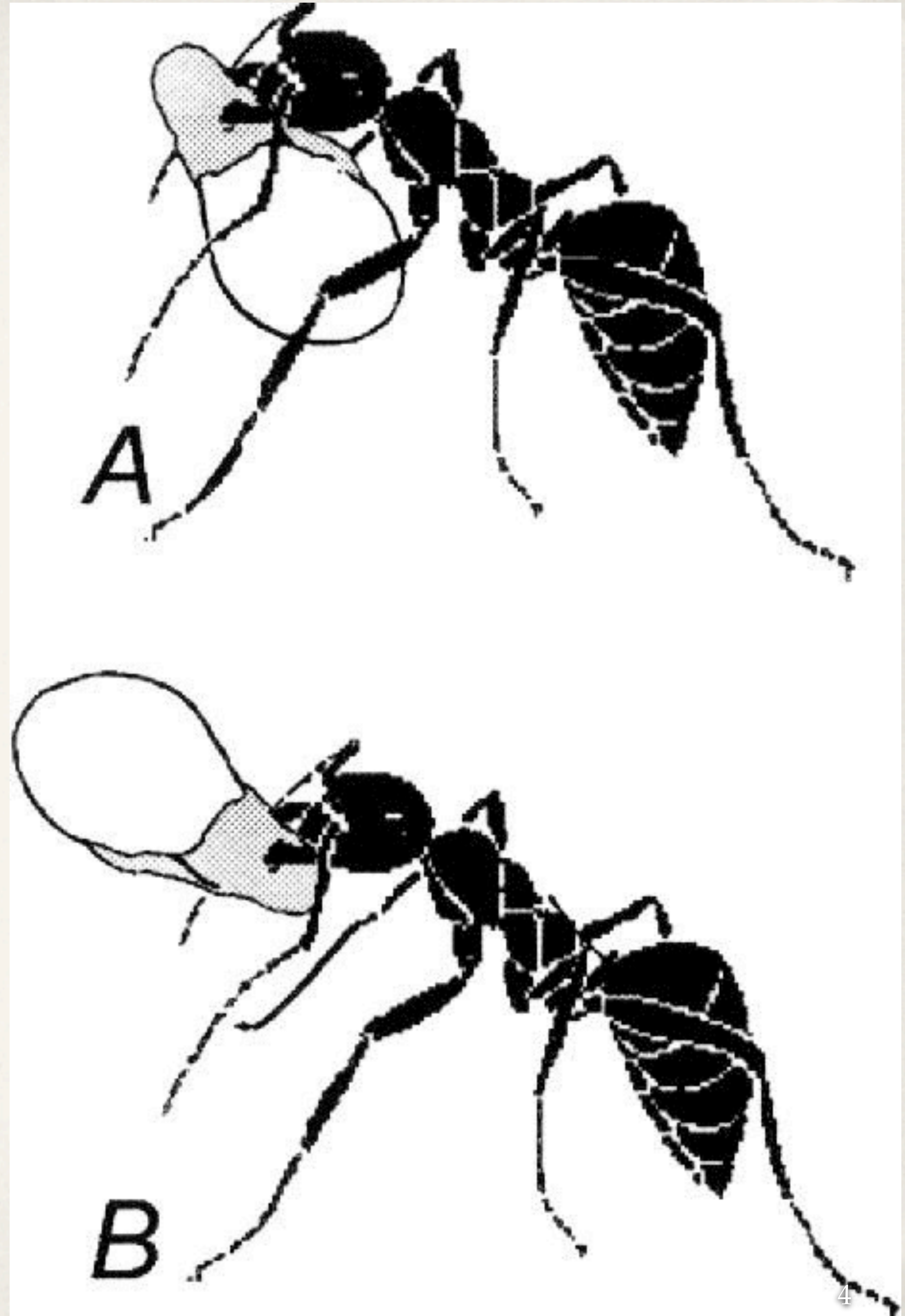
Outline

- Myrmecochory and ant-plant mutualism
- Ant "seed treatment" experiment
- New natural history information
- Ant "seed dispersal" experiment
- Future directions



Myrmecochory and ant-plant mutualism

- Seed dispersal by ants, aided by elaiosome
- Common phenomenon found in > 11,000 plant species (Lengyel et al. 2010)
- North temperate zone a myrmecochore hotspot (Lengyel et al. 2010)
- Ants most common seed dispersal agent of "our" woodland herbs (Whigham 2004)

Myrmecochory and ant-plant mutualism

- <u>Dispersal Advantages</u> (Rico-Gray & Oliveira 2007 citing Culver & Beattie 1978)
- Movement **away from parent plant** (to an ant nest)
- Placement of seed in appropriate germination site
    - **Below ground**
    - Away from predators
    - Probably in enriched soil

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Directed dispersal and nutrient enrichment hypotheses

Myrmecochory and ant-plant mutualism

- <u>Advantages of **elaiosome removal**</u>

- Decreased seed predation (Bond 2001; Christian & Stanton 2004; Garrido et al. 2009)

- Enhanced (quicker) seed germination (Gomez et al. 2003; Ohkawara 2005; Lopez-Vila & Garcia-Fayos 2005; Martins et al. 2006; Leal et al. 2007; Garrido et al. 2009; Soriano et al. 2012)

Myrmecochory and ant-plant mutualism

- <u>Things ants do</u>
- Move seeds away from parent plants
- Bury seeds
- Remove elaiosomes
- <u>These factors rarely experimentally investigated simultaneously to address seed survival</u>

Ant "seed treatment" experiment

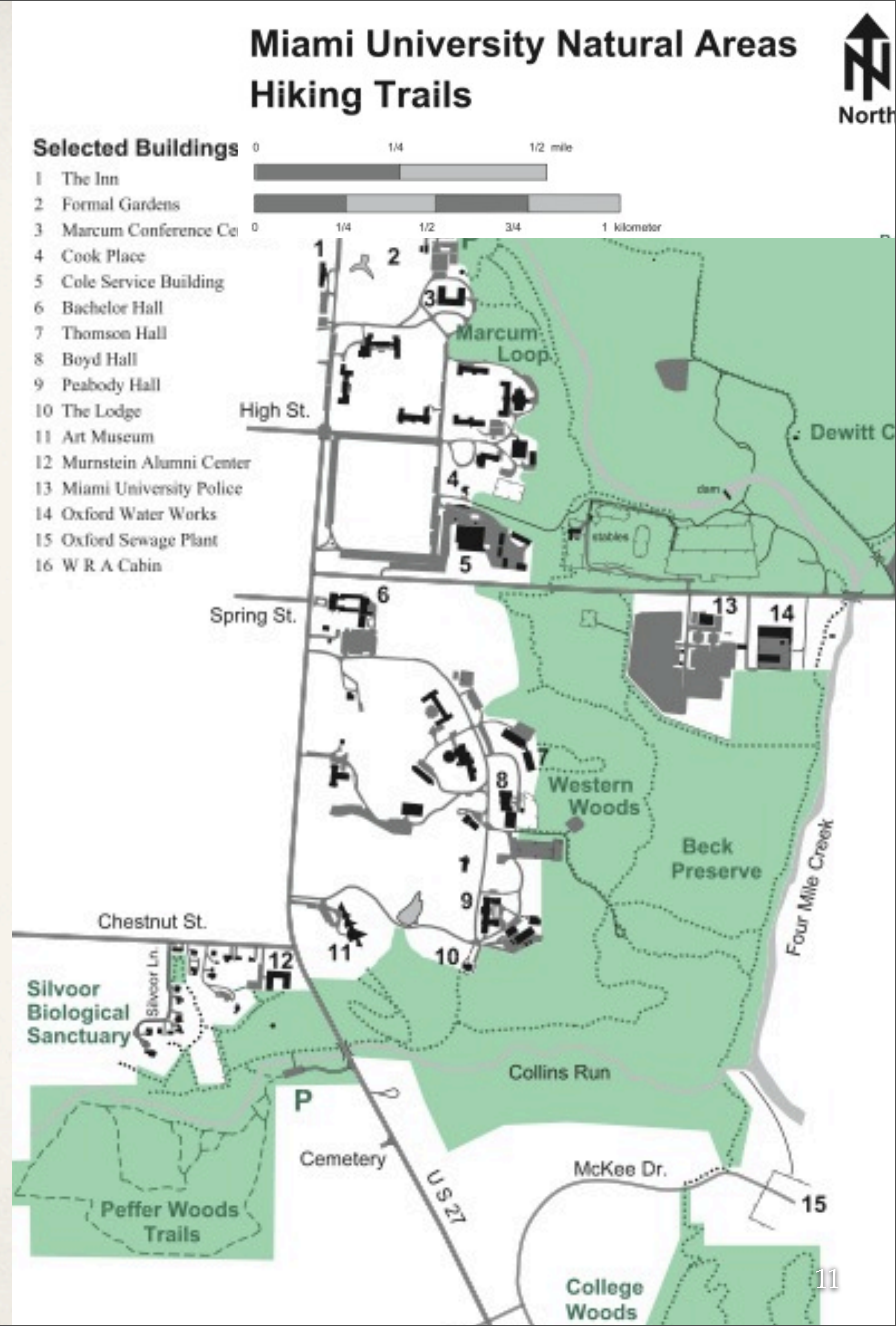
- **Objective:** experimentally investigate seed survival as a function of ant "treatments"
- Part 1
  - Field experiment objective: address effects of distance to parent plant, burial, and elaiosome removal on *Asarum canadense* seed survival
- Part 2
  - Lab experiment objective: address effects of elaiosome removal on buried *A. canadense* seeds

Ant "seed treatment" experiment

- ***Asarum canadense***
  - Perennial forest herb
  - Native to eastern North America
  - In Ohio, produces single flower mid-late April; single fruit matures late June (10-30 seeds/fruit)
  - Epicotyl dormancy; elaiosome removal does not enhance germination (Lobstein & Rockwood 1993)
  - *Aphaenogaster rudis* most likely disperser; *Peromyscus leucopus* most likely seed predator (Smith et al. 1989)

Ant "seed treatment" experiment (Part 1)

- <u>Study sites</u>
- Southwest Ohio
- Two populations within second-growth beech-maple and oak-sugar maple forest

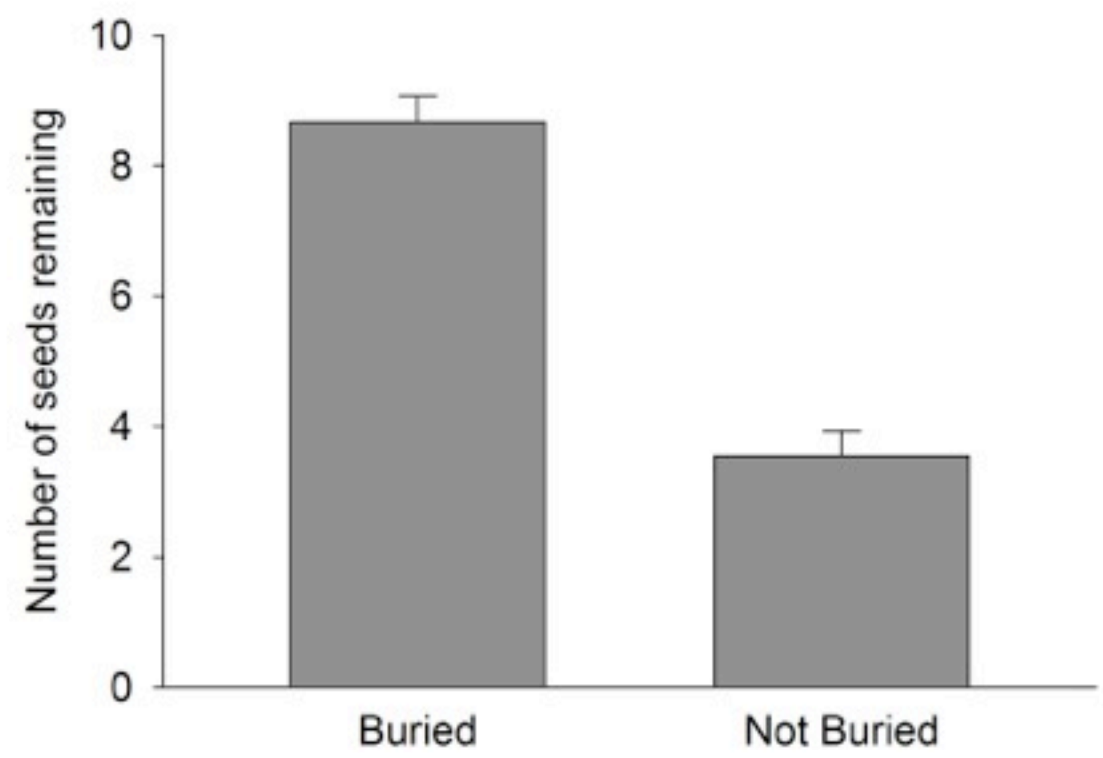


Ant "seed treatment" experiment (Part 1)

- Field methods at each study site
- 64 fruits collected from marked individuals
- 10 seeds from individual fruits were assigned to a treatment combination
  - 2 x 2 x 2 factorial: **distance** (beneath parent vs. 1 m away), **burial** (yes [2-4 cm below soil] vs. no), **elaiosome** removal (yes vs. no)
  - Dependent variable: number of seeds remaining after 3 days

Ant "seed treatment" experiment (Part 1)

- **Results**
  - Only significant treatment was burial
  - Twice as many seeds remained in buried settings



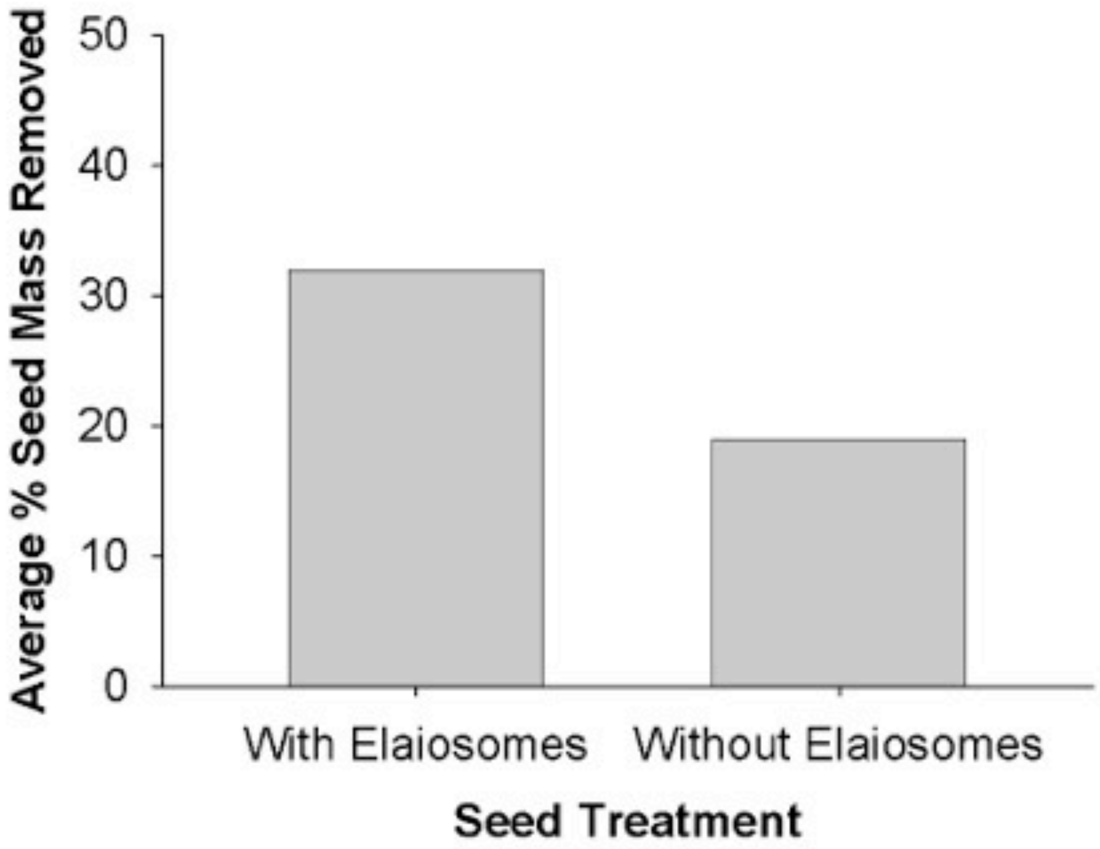
Independent variable	Num df	Den df	F-statistic	P-value
distance	1	7	0.54	0.4855
elaiosome	1	7	2.71	0.1438
burial	1	7	50.46	0.0002
d*e	1	7	0.91	0.3724
d*b	1	7	0.91	0.3724
e*b	1	7	0.02	0.9003
d*e*b	1	7	0.05	0.8347

Ant "seed treatment" experiment (Part 2)

- White-footed mouse (*Peromyscus leucopus*) feeding trials (Miami University IACUC permit #780)
    - Mice (N=9) presented with caches of ~3 g *A. canadense* seeds with elaisomes and ~3 g seeds without (several hundred seeds/treatment)
    - After 24 hr, % seed mass consumed (dependent variable) was compared between treatments (paired t-test)

Ant "seed treatment" experiment (Part 2)

- **Results**
  - Percent seed mass consumed was higher in the "seeds with elaiosomes" treatment ($t=2.93$, $df=8$, $P=0.02$)



Ant "seed treatment" experiment

- **Conclusions & Discussion**
    - Seed burial is the most important treatment ants provide for *A. canadense*
    - Elaiosome removal is important in buried situations with high seed densities
    - Not the first to experimentally illustrate importance of burial and elaiosome removal
    - First to illustrate in a *Aphaenogaster* system

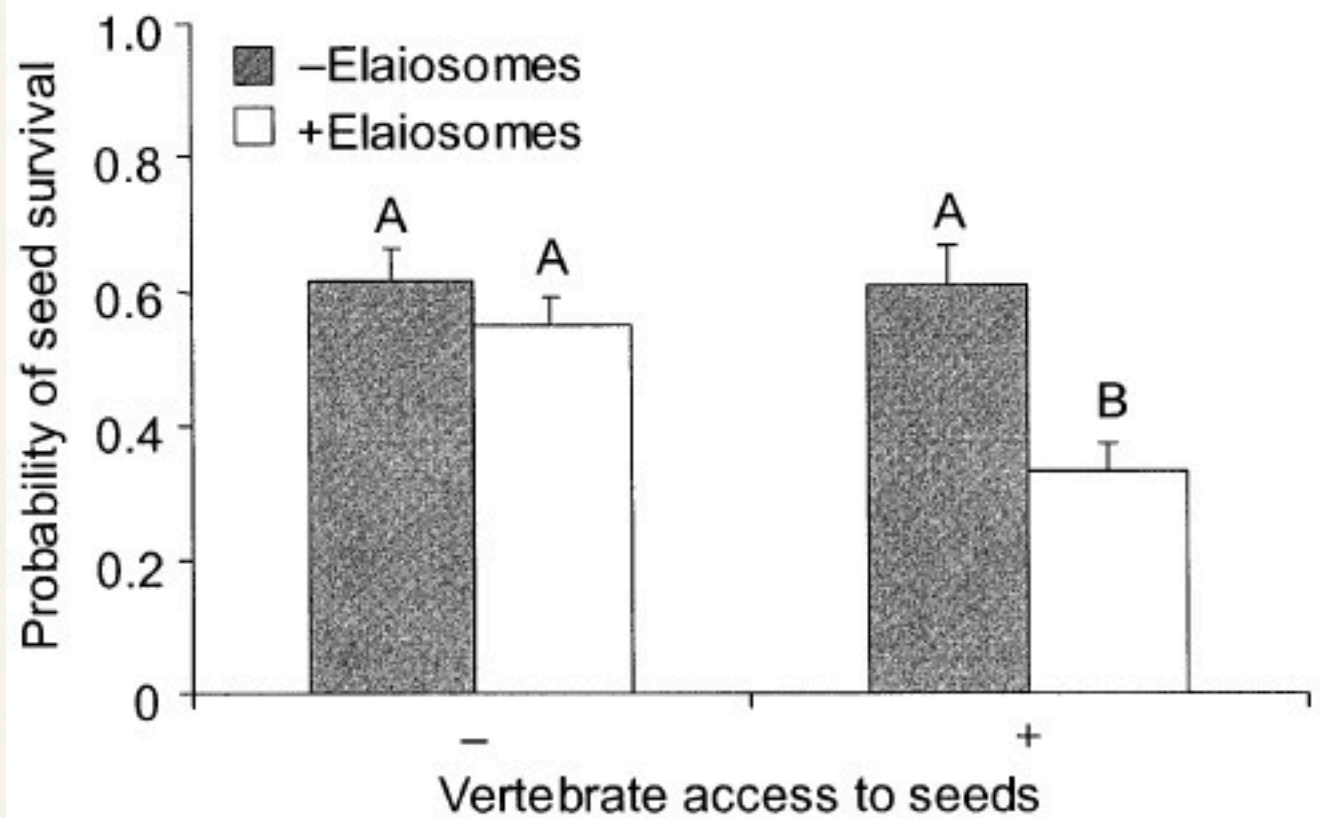


FIG. 2. Survival (means + 1 SE) of buried *Leucospermum truncatulum* seeds with and without elaiosomes in the presence or absence of vertebrate seed predators. Letters above bars correspond to results from pairwise comparison tests (Tukey-Kramer hsd).

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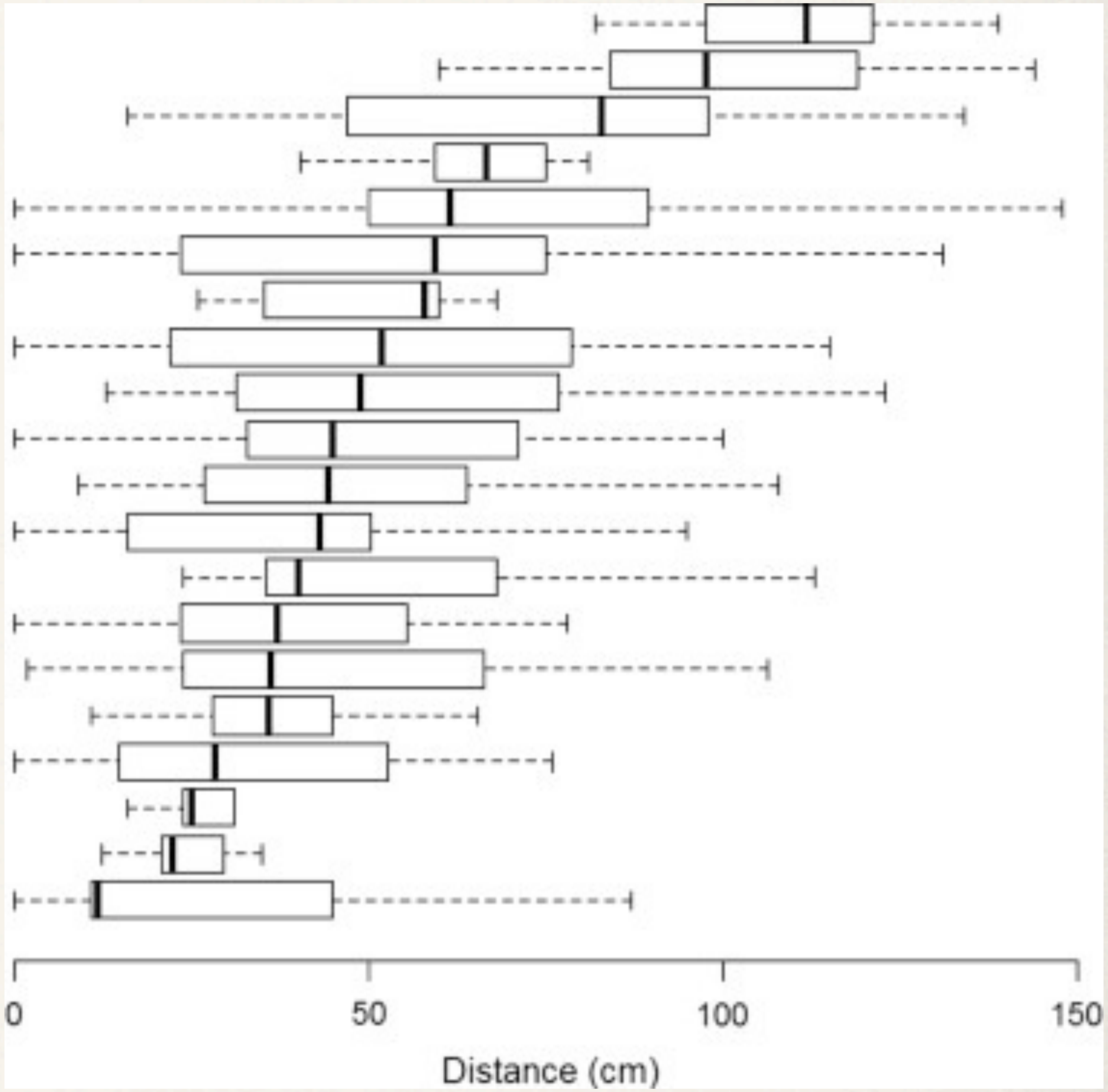
New natural history information

- *Aphaenogaster rudis* is the primary seed disperser of myrmecochorous plants in eastern North America (Ness et al. 2009)
- Small nests at > 1/m^2 in suitable habitat (Ness et al. 2009)

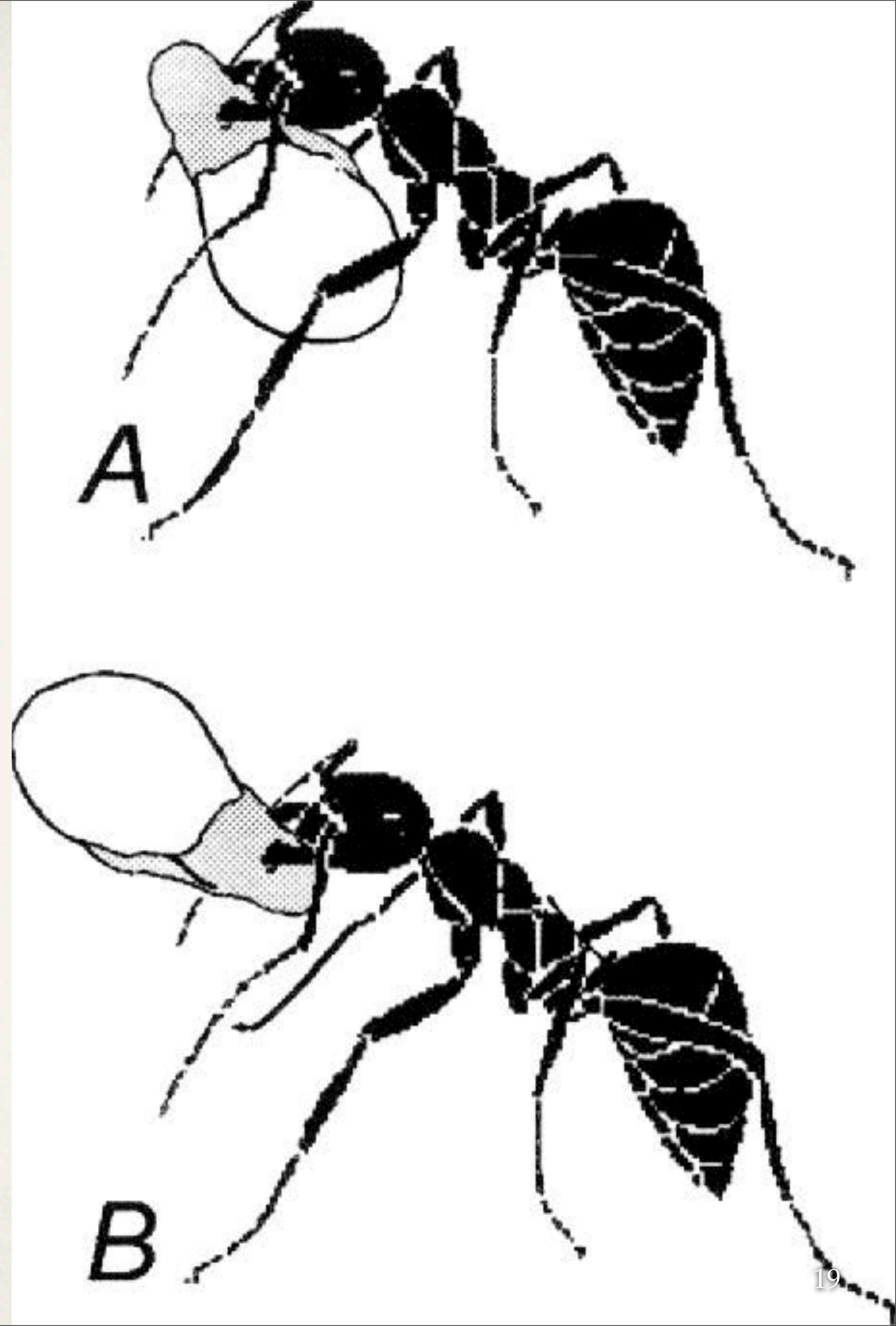
New natural history information

- *A. rudis* redisperse *Asarum canadense* seeds **out of their nests** (Canner et al. 2012)



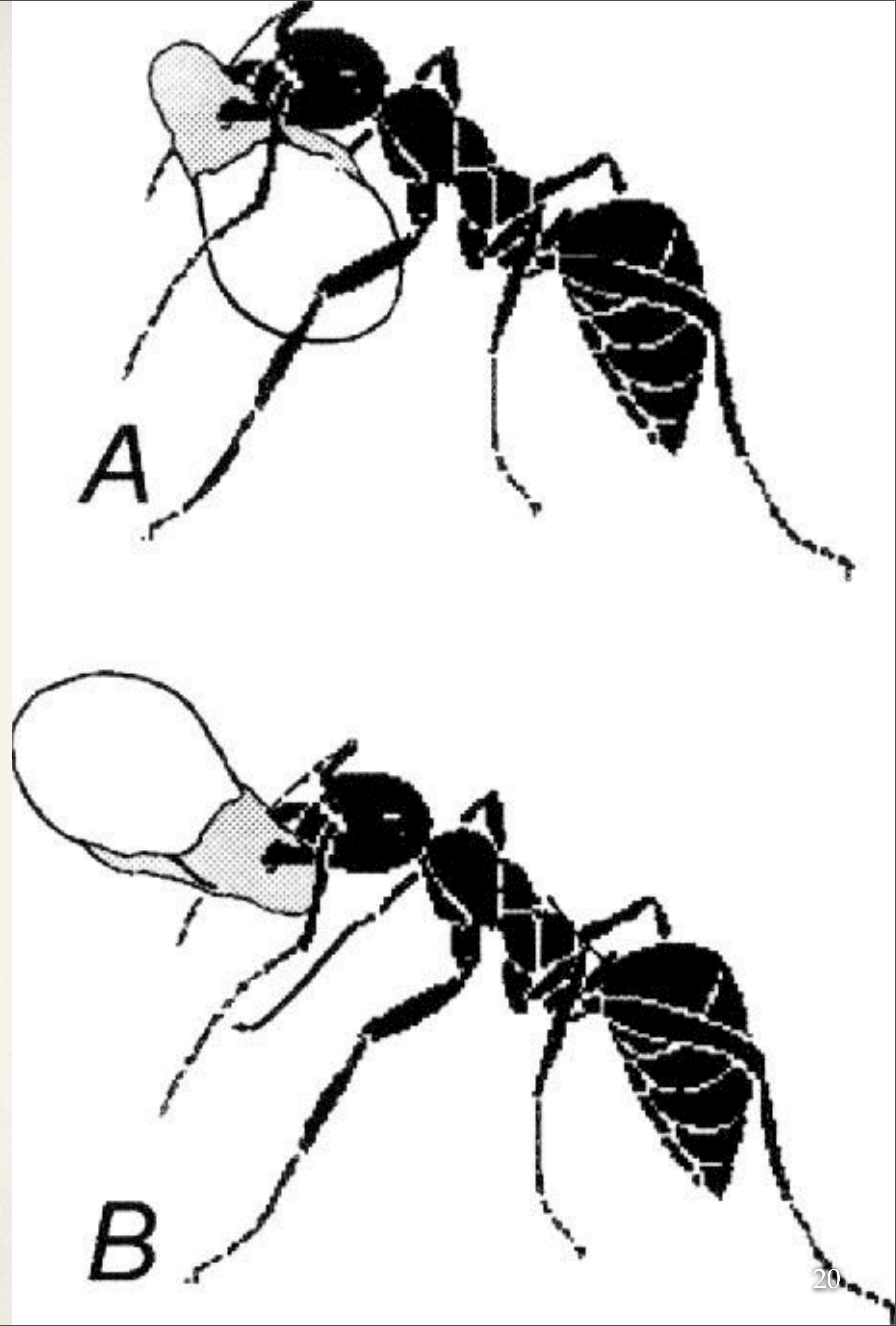
New natural history information

- Seeds of myrmecochorous species do not remain buried for long in eastern North American forests
- High seed densities are likely not common
- *A. rudis* nests are likely not a place to investigate directed dispersal with nutrient enrichment (despite Manzaneda & Rey's [2012] claim)



New natural history information

- So where do we go now?
  - Discard nutrient enrichment hypothesis in the *A. rudis*-directed dispersal system
  - Focus on areas near *A. rudis* nests
  - Focus on other things *A. rudis* may be doing



Ant "seed dispersal" experiment

- **Objective:** Quantifying the importance of the areas near (~20-30 cm away from) *A. rudis* nests, using *Jeffersonia diphylla*
- Part 1
    - Empirically test for environmental/**ecosystem** differences among 'near ant nest,' parent plant, and random locations
- Part 2
    - Experimentally test for differences in germination and seedling growth in the above locations

Ant “seed dispersal” experiment

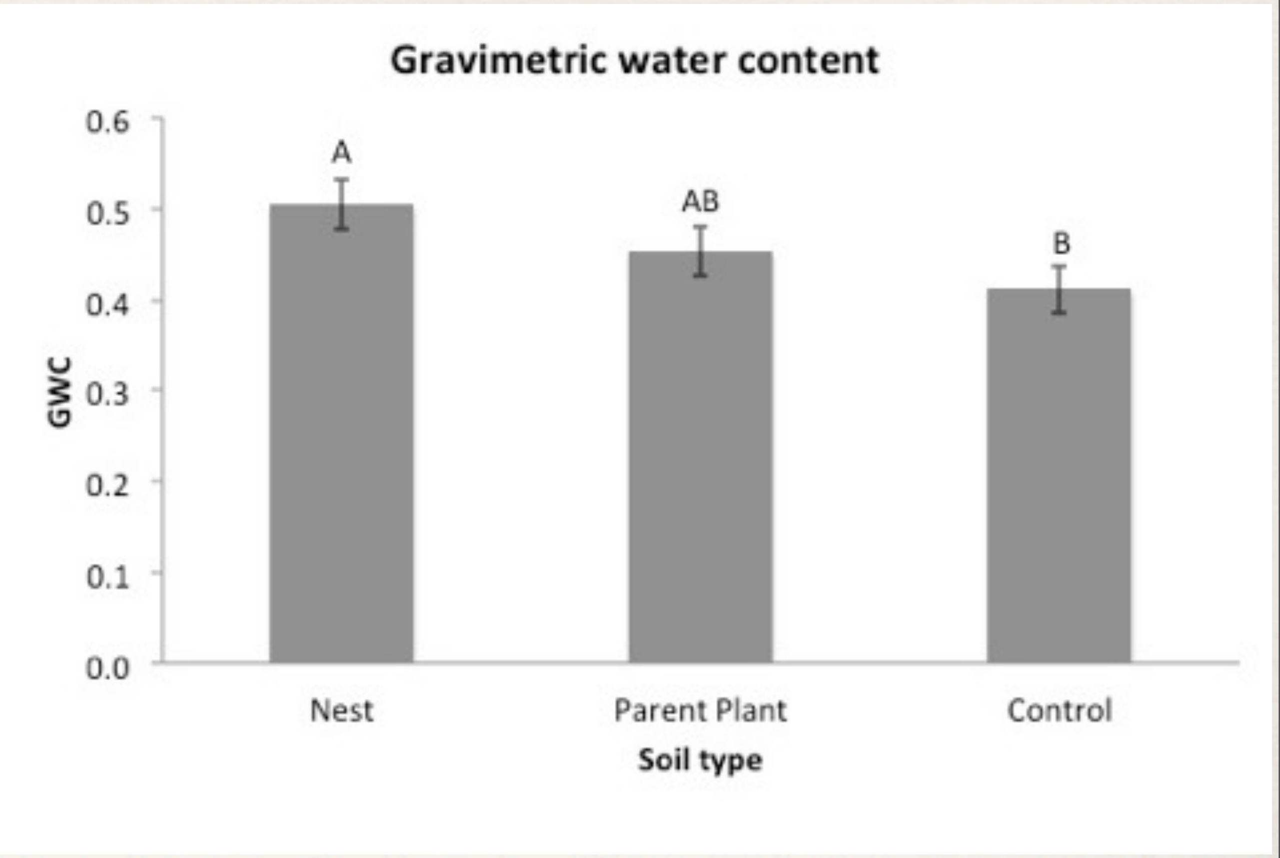
- ***Jeffersonia diphylla***
  - Perennial forest herb
  - Native to eastern North America
  - In Tennessee, produces single flower in April; single fruit matures in June (10-30 seeds/fruit)
  - Morphophysiological dormancy (Baskin & Baskin 1989)
  - *Aphaenogaster rudis* most likely disperser; *Peromyscus leucopus* most likely seed predator (Smith et al. 1989)

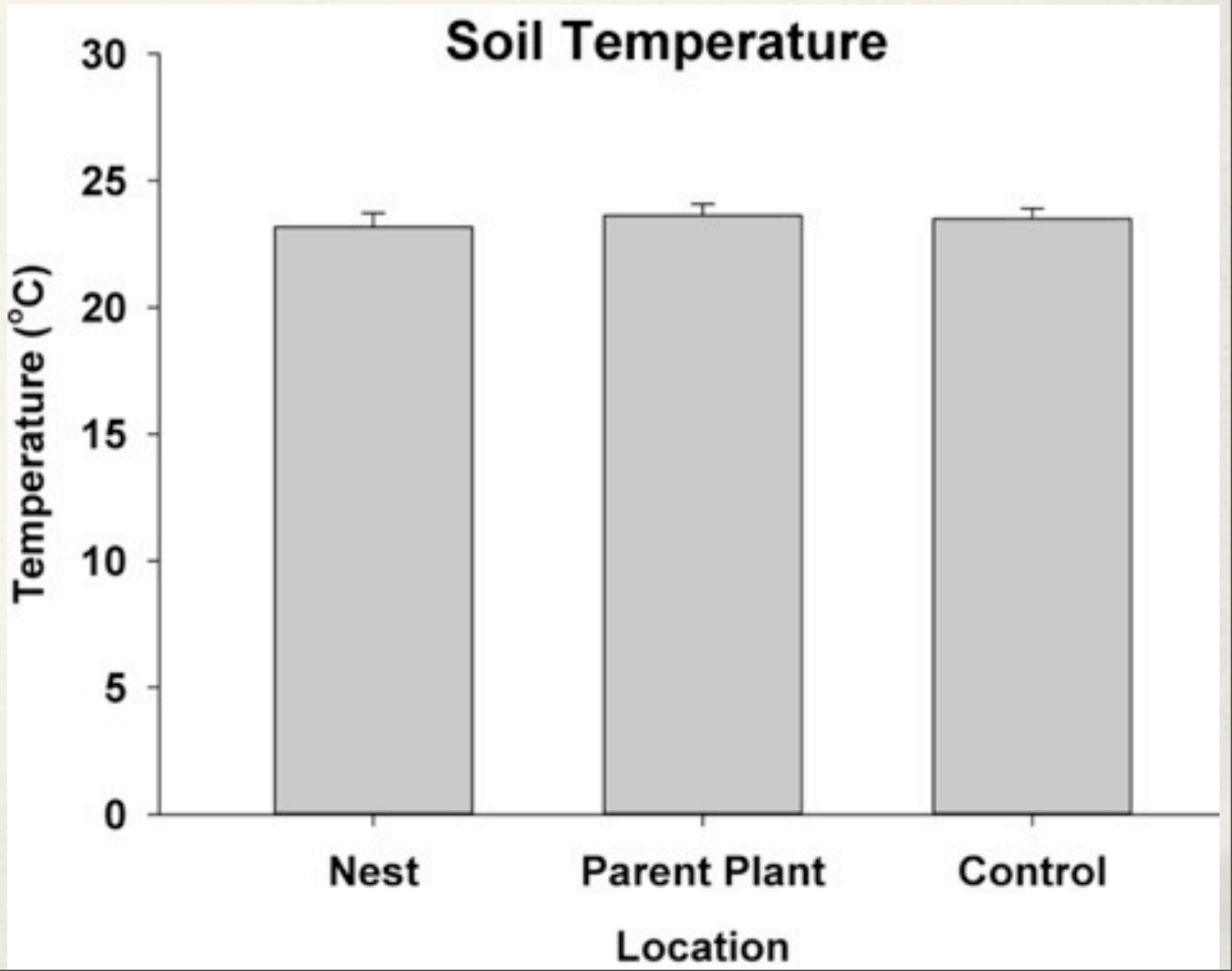
Ant "seed dispersal" experiment (Part 1)

- **Methods**
  - Study site: Forks of the River, June 2013
  - Soil samples (N=10) collected from (1) near *A. rudis* nests, (2) beneath fruiting *J. diphylla*, (3) random locations; lab analysis
  - Dependent variables: soil moisture, temperature, 3 potential enzyme activity measures; ANOVA

Ant "seed dispersal" experiment (Part 1)

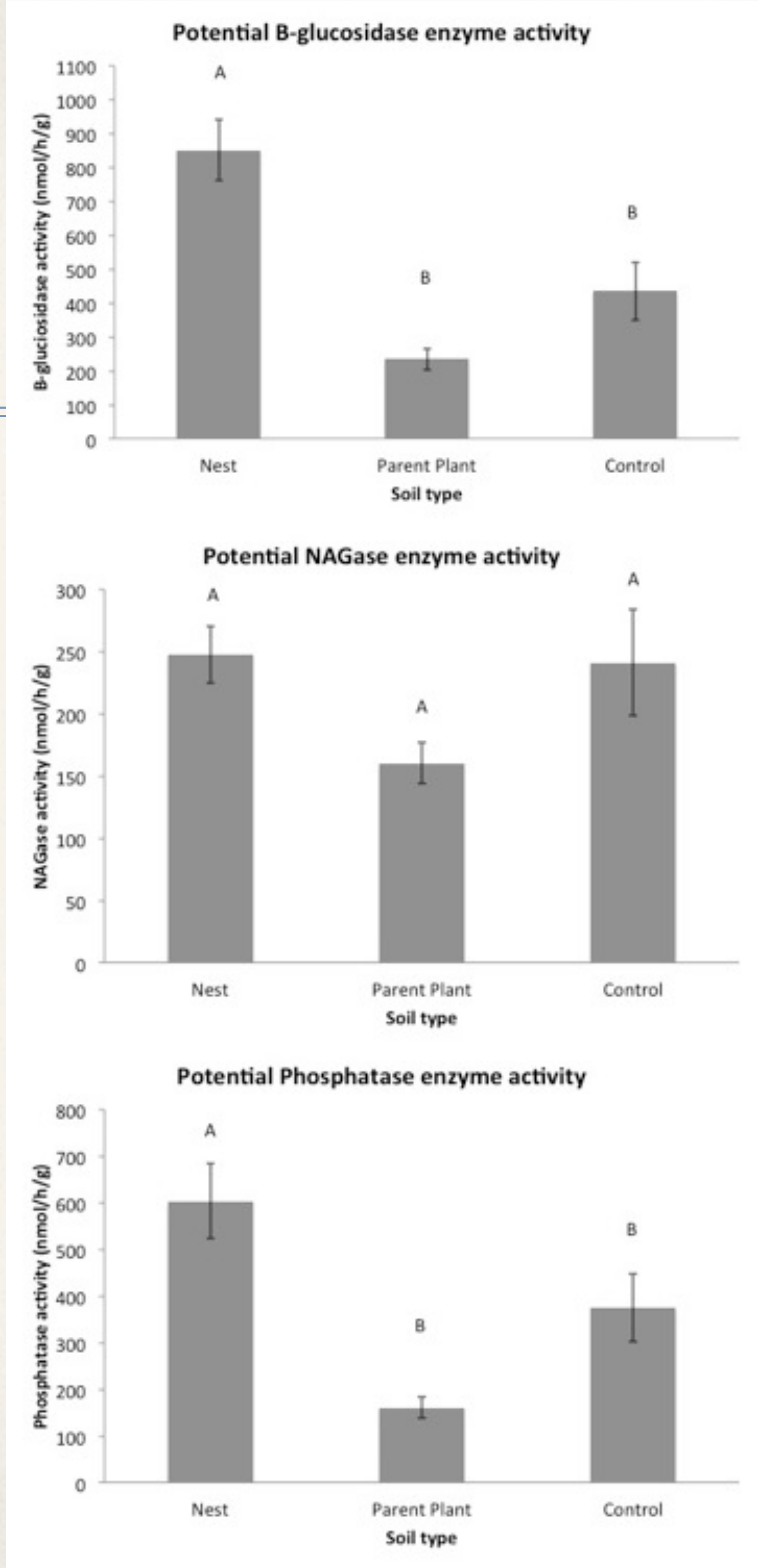
- **Results**
  - Water content marginally differed among treatments (P=0.06)
    - Areas near *A. rudis* nests were more moist than random locations
  - Soil temperature did not differ among treatments (P=0.10)





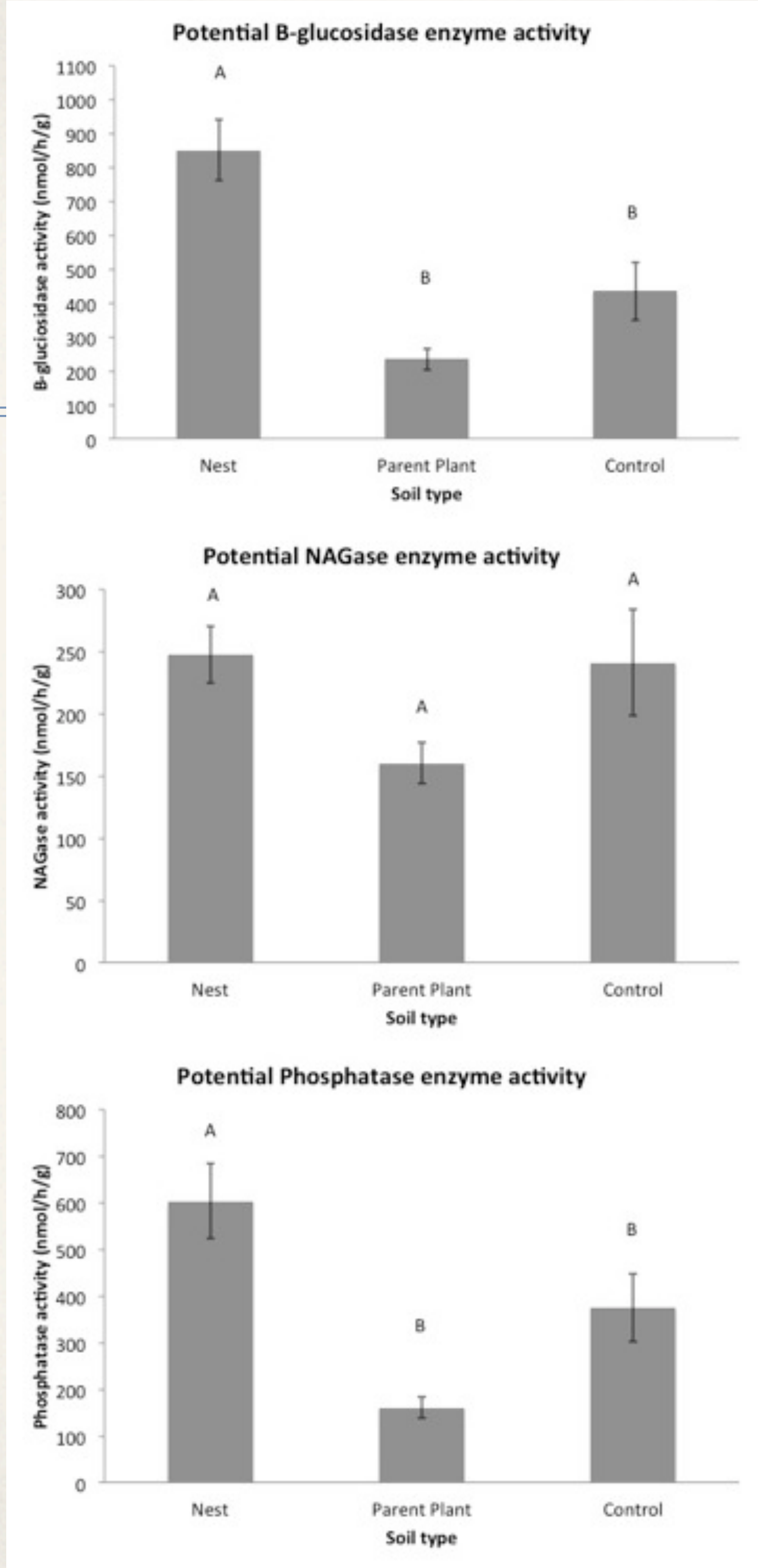
Ant "seed dispersal" experiment (Part 1)

- **Results (continued)**
- All 3 enzymes show similar patterns
  - Areas near *A. rudis* nests higher levels of potential enzyme activity
- B-glucosidase significantly highest near *A. rudis* nests
- Same for phosphatase



Ant "seed dispersal" experiment (Part 1)

- **Results (continued)**
- All 3 enzymes show similar patterns
  - Areas near *A. rudis* nests higher levels of potential enzyme activity
- B-glucosidase significantly highest near *A. rudis* nests
- Same for phosphatase
- **Areas near *A. rudis* nests are different...**



Ant "seed dispersal" experiment (Part 2)

- **Methods**
  - Study site: North Tract, Cumberland Unit, FRREC, June 2013
  - Soil samples (N=16) collected from (1) near *A. rudis* nests, (2) beneath fruiting *J. diphylla*, (3) random locations

Ant "seed dispersal" experiment (Part 2)

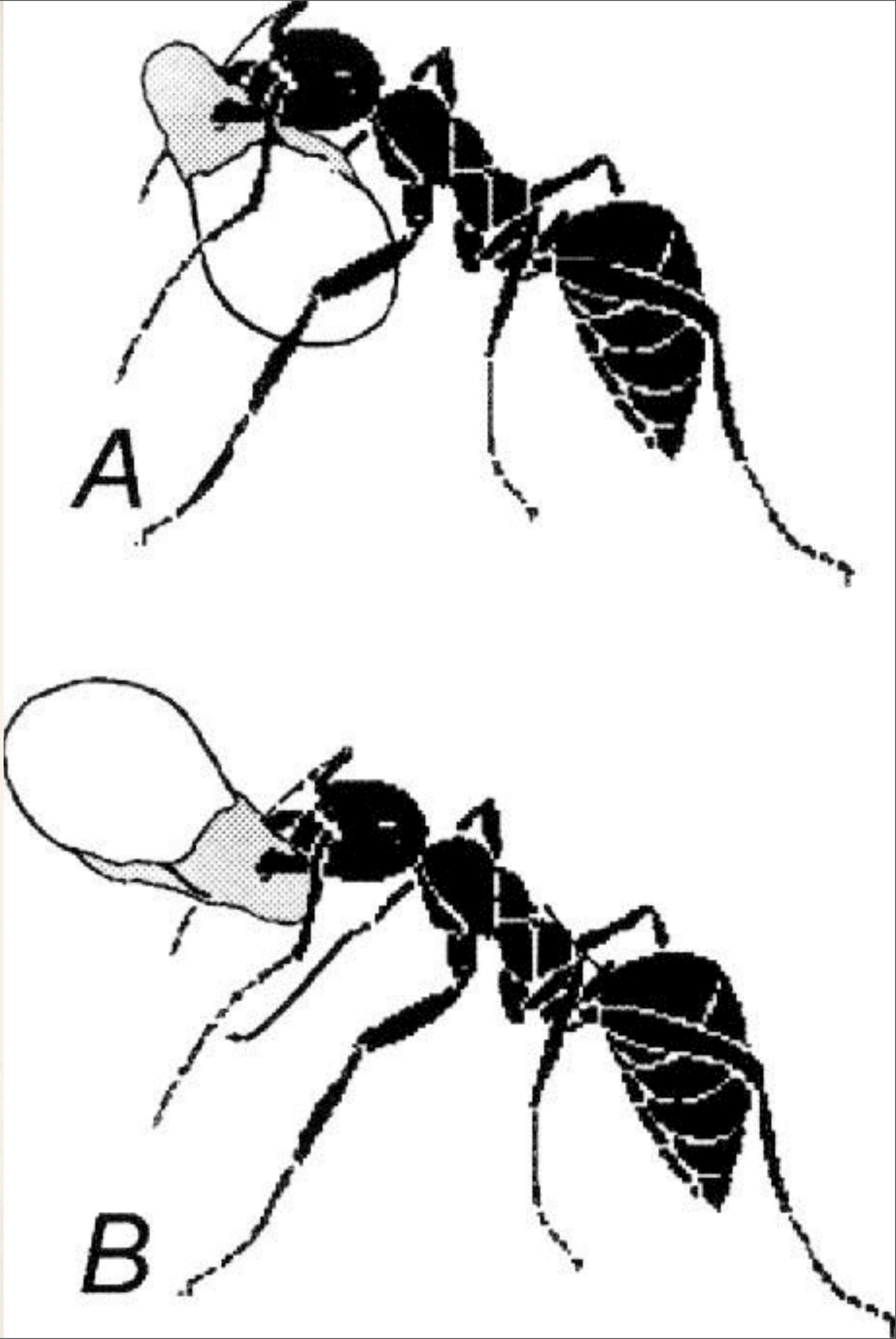
- **Methods (continued)**
  - Soil samples comprise 4 treatments (N=8): (1) near ant nest, (2) beneath parent plant, (3) random locations, and (4) parent plant-nest mixture
  - 10 *J. diphylla* seeds sown in each replicate
  - Dependent variables: probability of seed germination/survival; post-germination growth attributes

Future directions

- Depends on *J. diphylla* seed survival/germination and seedling growth results
    - If germination/survival mimics potential enzyme activity...
    - If germination is equal but growth is best in 'near ant nest' soils...
    - If no seeds survive...

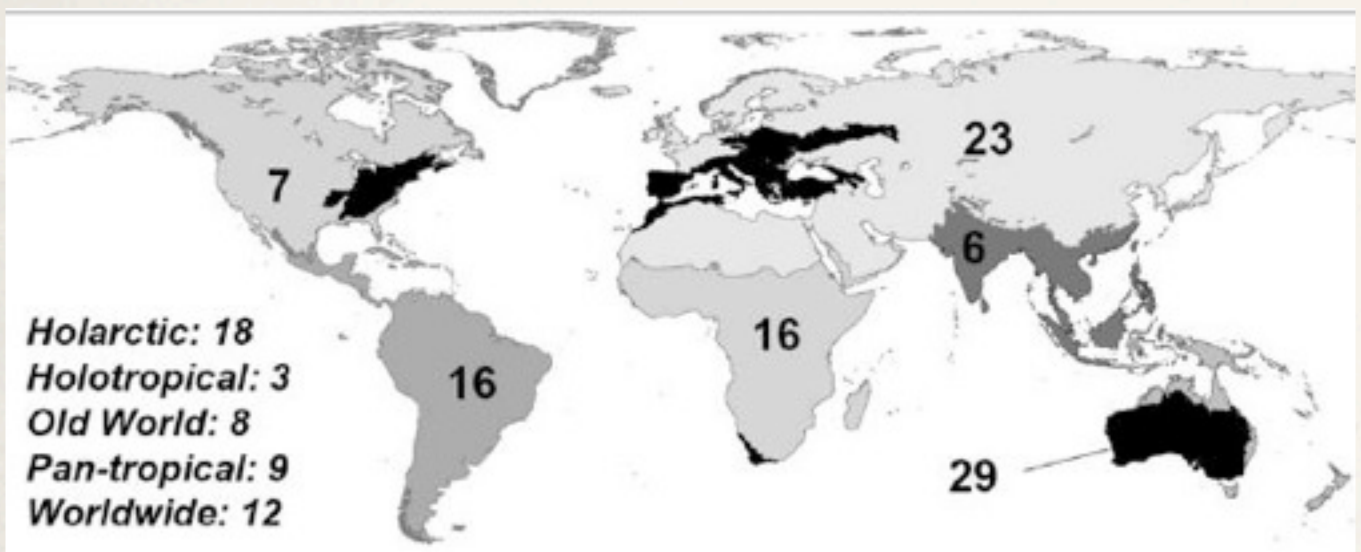
Future directions

- ...Ants may treat seeds that deter microbial predation

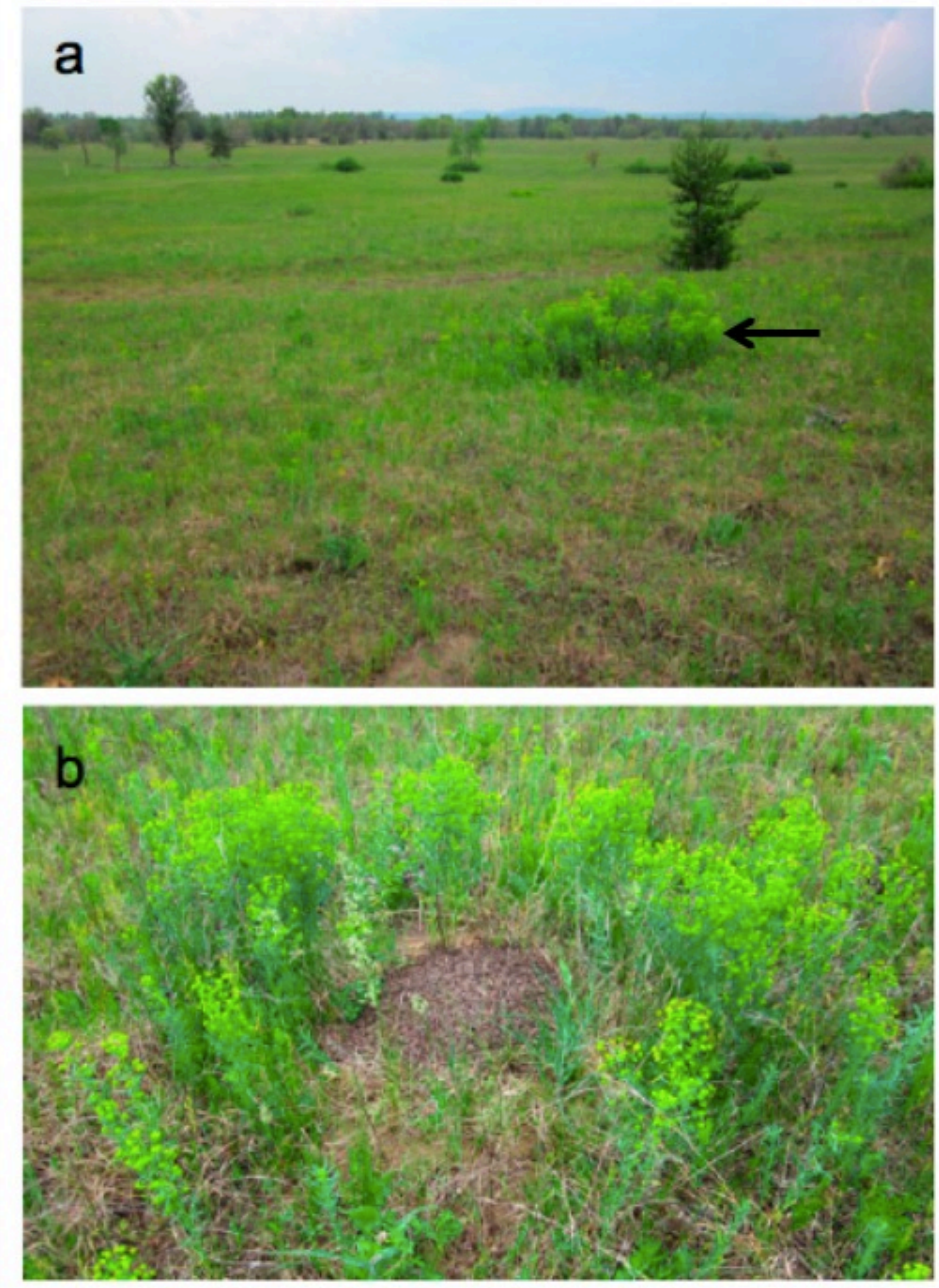


Future directions

- Move to another system where seeds remain in ant nests, mounds or middens



Lengyel et al. (2010)



Berg-Binder and Suarez (2012)

Questions?

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