Predictive provenancing: can southern sourced seeds be used in Midwest restoration efforts?
Christopher Woolridge
Chicago Botanic Garden and Northwestern University
How to best source seed?

▪ Managers make best attempt at obtaining local genotypes
  ▪ “Local” is different for everyone
  ▪ Chicagoland report: 25 – 200 mile radius (Saari et al. 2011)

▪ Local adaptation

▪ With changing climate and restricted gene flow, need to provide for adaptive potential

▪ National Native Seed Strategy – Objective 2.1
  ▪ Characterize genetic variation of restoration species to delineate seed zones and provide seed transfer guidelines for current and projected environmental conditions
Predictive provenancing

- Transfer of plants adapted to environments with similar predicted conditions of recipient site
  - Potential to foster climate adaptive populations
  - Not much empirical testing for non-timber species

- How will they perform in current conditions?
  - Extreme weather events
  - Frosts, differing phenology (pollinator mismatch)

*Pinus albicaulis* – Whitebark pine
Bower & Aitken (2008)
Study objectives

- Are southern sources suitable to use? If so, how much?
- Compare fitness and phenology of potential sources for three short-lived prairie species

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Germination (Lab) → Emergence → Seedling survival → Survival to flowering → Seed set

Seed → Seedling → Flowering adult
Species

- **Chamaecrista fasciculata** (Partridge pea)
  - Fabaceae
  - Annual

- **Rudbeckia hirta** (Black-eyed Susan)
  - Asteraceae
  - Biennial or short-lived perennial

- **Lobelia inflata** (Indian tobacco)
  - Campanulaceae
  - Annual
Common garden

▪ Rollins Savanna
  ▪ Lake County Forest Preserves, IL

▪ 3 replicate plots for each species x source combination
  ▪ Seeded at ~500 PLS/m²
  ▪ December 2015
Common Garden Experiment
Grayslake, IL

Chamaecrista fasciculata
Rudbeckia hirta
Lobelia inflata

Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-60 to -50 1 -51.1 to -45.6
-50 to -40 2 -45.6 to -40
-40 to -30 3 -40 to -34.4
-30 to -20 4 -34.4 to -28.9
-20 to -10 5 -28.9 to -23.3
-10 to 0 6 -23.3 to -17.8
0 to 10 7 -17.8 to -12.2
10 to 20 8 -12.2 to -6.7
20 to 30 9 -6.7 to -1.1
30 to 40 10 -1.1 to 4.4
40 to 50 11 4.4 to 10
50 to 60 12 10 to 15.6
60 to 70 13 15.6 to 21.1
Methods and preliminary results

- Germination success
- Phenology
  - Germination
  - Flowering
- Survival to flowering
- Fitness
  - Biomass – and density
  - Inflorescences
Germination

▪ Germination tests in Illinois conditions
  ▪ Cold, moist stratification: 10 weeks
  ▪ Incubation at 20/10 °C
▪ Seedlings grown up in growth chambers
  ▪ 8 weeks at 25 °C
▪ Transferred to greenhouse

Germination (Lab)

Emergence
Seedling survival
Survival to flowering
Seed set
Germination

Chamaecrista fasciculata

Rudbeckia hirta

Proportion germinated

Source
- Local
- Northern
- Southern

Days
Germination

Lobelia inflata

Proportion germinated

Days

Source
Local
Northern
Southern
Emergence and seedling survival

- Backtrack through 10 weeks of pictures
- Track emergence (success and timing) and seedling survival

Germination (Lab)
Emergence
Seedling survival
Survival to flowering
Seed set
Survival to flowering

**Chamaecrista fasciculata**

- Northern: 60
- Local: 80
- Southern: 70

**Rudbeckia hirta**

- Local: 35
- Source: 30
- Southern: 40
Survival to flowering

Chamaecrista fasciculata

Flowering adults per plot

Proportion germinated

Days

Source
Local
Northern
Southern

Germination
Emergence
Seedling survival
Survival to flowering
Seed set
Biomass and Density

Chamaecrista fasciculata

- Biomass (g)
- Log (g) Biomass
- Plants per 0.1 m

Source
- Northern
- Local
- Southern
Seed set

**Ongoing**

Pod processing

Head cleaning

- Germination (Lab)
- Emergence
- Seedling survival
- Survival to flowering
- **Seed set**
Flowering phenology (Flowering length)
Flowering phenology (Flower to pod ratio)

Chamaecrista fasiculata

Flower to Pod Ratio (19-Aug - 28 Aug)

Northern
Local Source
Southern
Conclusions

▪ **Germination**: Northern sources were slower and had lower success

▪ **Phenology**: Southern sources have delayed flowering in both species
  ▪ Differences in phenology = effects on fitness?

▪ Greater differences seen in *C. fasiculata* than *R. hirta*
  ▪ *C. fasiculata*: Northern had highest survival; lowest biomass
  ▪ *R. hirta*: No differences in biomass or inflorescences
Next steps

Aster analysis – connect all life stages
- Seed mix design

What effect will phenology have on fitness?

Emergence timing and seedling survival in field are critical part of story

Phenology
- Compare time to germination in lab with time to emergence in field

Examine weather records from growing season
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• Laura Steger
• Bernard Woolridge
• Jacob Zeldin
Assumptions and limitations

▪ Limited replication of provenance and common garden site

▪ Weather is extremely variable
  ▪ Only measuring fitness in one or two growth years
  ▪ Not a stressful year in Chicago

▪ Commercial seed providers
  ▪ Reliable in geographic source
  ▪ Genetically diverse seeds (not growing clones)
Assisted gene flow

▪ Translocation of individuals to facilitate adaptation to anticipated climate conditions

▪ Previously used for small, fragmented populations of threatened species

▪ Historic prairie was large, continuous landscape
  ▪ 1% of historic cover
  ▪ Remnants and restorations are heavily fragmented (agriculture, development)

*Map credit: Roger C. Anderson
# Species and sources

<table>
<thead>
<tr>
<th>Species</th>
<th>Northern</th>
<th>Local</th>
<th>Southern</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Allium cernuum</em></td>
<td>Carver Co. MN – Collected</td>
<td>Cook Co. IL – Collected</td>
<td>Franklin Co. MO – Missouri Wildflowers</td>
</tr>
<tr>
<td><em>Chamaecrista fasciculata</em></td>
<td>Wright Co. MN – Minnesota Native Landscapes</td>
<td>Grant Co. WI – Prairie Moon</td>
<td>Cole Co. MO – Missouri Wildflowers</td>
</tr>
<tr>
<td><em>Lobelia inflata</em></td>
<td>Vernon Co. WI – Prairie Moon</td>
<td>Lafayette Co. WI – Dixon Seed Bank</td>
<td>Bond Co. IL – Dixon Seed Bank</td>
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<tr>
<td><em>Rudbeckia hirta</em></td>
<td>*</td>
<td>Kenosha Co. WI – Prairie Moon</td>
<td>Barton Co. MO – Missouri Wildflowers</td>
</tr>
<tr>
<td><em>Sisyrinchium campestre</em></td>
<td>Winona Co. MN – Shooting Star</td>
<td>Vernon Co. WI – Prairie Moon</td>
<td>Cole Co. MO – Missouri Wildflowers</td>
</tr>
</tbody>
</table>

* Northern source could not be obtained in time for planting
Expected results

▪ Phenology
  ▪ Earlier flowering and emergence should be correlated with shorter growing seasons

▪ Fitness
  ▪ Earlier flowering onset = higher seed set?
  ▪ Biomass may be higher in southern sources due to growing season
Local adaptation varies by species

<table>
<thead>
<tr>
<th>Stronger local adaptation</th>
<th>Weaker local adaptation</th>
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</thead>
<tbody>
<tr>
<td>▪ More prone to maladaptation</td>
<td>▪ More robust to transplantation</td>
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<tr>
<td>Selfing</td>
<td>Wind-pollinated</td>
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<tr>
<td>Gravity-dispersed</td>
<td>Seed-dispersed</td>
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<tr>
<td>Annuals</td>
<td>Recent range expansion</td>
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<tr>
<td>Wide range</td>
<td>Uniform habitats</td>
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<tr>
<td>Long-term occupants</td>
<td></td>
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</tbody>
</table>
Conclusion

- In *C. fasciculata*,
  - Results of germination tests and survival to flowering differ
    - Tracking individuals through pictures will clarify
  - Impacts of differing phenology on fitness
    - Germination
    - Emergence
    - Flowering (Onset and duration)
Outlook for Chicago area

- Chicago will become warmer and wetter
- Evolutionary constraints may prevent populations from keeping pace with change
  - Fragmented populations
  - Restricted gene flow

http://www.illinoisinfocus.com/northerly-island.html
Conclusion – *Chamaecrista fasiculata*

- **Fitness**
  - **Germination**: southern source more than 2 times the amount of the northern source
  - **Survival to flowering**: northern source had 4 times higher rate than the southern source

- **Phenology**
  - **Germination**: All fairly equal
  - **Flowering**: southern source ratio was 25 times the northern source
Conclusion – *Rudbeckia hirta*

- **Fitness**
  - **Germination**: both sources low, not different
  - **Survival to flowering**: both sources low, not different

- **Phenology**
  - **Germination**: *southern* source occurred an average of 9 days earlier
  - **Flowering**: *southern* source began an average of 6 days earlier

 Both in line with adaptation to longer growing season
The preceding presentation was delivered at the

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This and additional presentations available at http://nativeseed.info