Are plant populations evolving during the process of seed increase for restoration?

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Are plant populations evolving during the process of seed increase for restoration?

1. Why is it a problem?
2. How does it happen?
3. How can we test for it?
4. How can we avoid it?
1. Why is it a problem?

- Genetic diversity fuels evolution into the future
- Traits that are inadvertently selected for in an agronomic setting may be disadvantageous when planted back into a restoration site
1. Why is it a problem?

Domestication traits

- Loss of shattering
- Uniform phenology
- Loss of seed dormancy
- Suppressed branching
- Fewer larger seed heads
- Bigger seeds
- Low genetic diversity
1. How does it happen?

• Sampling
Sampling

*Nassella viridula*,
Green needlegrass
Sampling

Nassella viridula,
Green needlegrass
Nassella viridula, Green needlegrass

Sampling
1. How does it happen?

- Sampling
- Selection
1. How does it happen?

- Harvesting once or few times per year
- Mechanical harvesting may favor non-shattering seed heads
- Repeated harvesting of perennials over years as plants die and/or are replaced by their offspring
- Replanting annuals from the same garden population

Harvesting corn

Harvesting native grasses
Timing of seed set
early late
Source
Propagules collected from wild population
early late
Propagation
Plants growing on production farm
early late
Planting at Restoration Site
Restoration Materials: Seeds from production farm
early late
Timing of seed set
Sampling reduces variation
Timing of seed set
Selection reduces variation & changes traits
Sampling reduces variation
Selection reduces variation & changes traits
3. How can we test for it?

**Wild**

 Measure plants where they are growing

**Propagation farm**

 Plant seeds in the same place and then measure them

**Restoration site**
3. How can we test for it?

**Wild**

- Not enough time and money for this?
  - Keep good records, collect seed, and donate it to your local academic institution
  - jetterso@d.umn.edu
  - We have students that would love to do the work!
  - Partnerships are valuable

**Propagation farm**

**Restoration site**
Is propagation for seed increase altering the genetic base of the source material?

**Partnership**
- Bryce Christiansen and Rebecca Shoemaker of Native Ideals Farm, Arlee MT
- Erin Espeland USDA Agricultural Research Service
- Julie Etterson, U of MN Duluth
Is propagation for seed increase altering the genetic base of the source material?

Clarkia puchella, deer horn clarkia
Is propagation for seed increase altering the genetic base of the source material?

Clarkia puchella, deer horn clarkia
Is propagation for seed increase altering the genetic base of the source material?

Clarkia puchella, deer horn clarkia

Has repeated sampling and/or selection altered the gene pool?

8th generation on the farm
## Species that will be tested

<table>
<thead>
<tr>
<th>Genus</th>
<th>Species</th>
<th># of generations on farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerastium</td>
<td>arvense</td>
<td>F4</td>
</tr>
<tr>
<td>Gaillardia</td>
<td>aristata</td>
<td>F4</td>
</tr>
<tr>
<td>Penstemon</td>
<td>eriantherus</td>
<td>F4</td>
</tr>
<tr>
<td>Lewisia</td>
<td>rediviva</td>
<td>F2</td>
</tr>
<tr>
<td>Camassia</td>
<td>quamash</td>
<td>F1</td>
</tr>
</tbody>
</table>
Evolution on interim reclamation sites

The oil patch

Montana

North Dakota

Soils: high pH, salts, and compaction

Ft. Berthold Indian Reservation
Evolution on interim reclamation sites

Ft. Berthold Indian Reservation

The oil patch

North Dakota

Soils: high pH, salts, and compaction
Cultivars planted into reclamation sites

<table>
<thead>
<tr>
<th>Species</th>
<th>Cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bouteloua curtipendula</em></td>
<td>Butte and Pierre</td>
</tr>
<tr>
<td><em>Elymus trachcaulus</em></td>
<td>Pryor and Revenue</td>
</tr>
<tr>
<td><em>Bouteloua gracilis</em></td>
<td>Bad River and Native</td>
</tr>
<tr>
<td><em>Nassella viridula</em></td>
<td>Lodorm</td>
</tr>
<tr>
<td><em>Pascopyrum smithii</em></td>
<td>Rosana</td>
</tr>
<tr>
<td><em>Schizachyrium scoparium</em></td>
<td>Aldous</td>
</tr>
<tr>
<td><em>Koeleria macrantha</em></td>
<td>Blue Mtn</td>
</tr>
</tbody>
</table>
Original cultivar seed source

Ft. Berthold Indian Reservation
Seed collections from 6 sites after one year in the restoration sites
Seed collections from 6 sites after one year in the restoration sites
4. How to avoid evolution during the process of seed increase?

- Sample multiple populations within a region
- Sample many mother plants per pop (>100)
- Harvest several times during seed maturation or collect fruits that appear to have matured at different times
- Allow recruitment into gardens of later-germinating seed
- If using mechanical harvesting methods, consider hand harvesting early and late individuals
- Preserve a diversity of seed sizes during cleaning
- Periodically augment gardens with seed (or pollen) from wild populations
- Do a common garden experiment and find out if there is a problem!
A fruitful agency, academic, business partnership – Questions?
**Source**
- Wild
- From Production Farm
- From Restoration Site

**Selective Pressures**
- Collection Timing
  - Year, Season, Day within season
- Collection Method
  - Harvest method (machine vs. hand), Propagule size bias
- Climate, Soil, Interacting Species

**Propagation**
- **Seeding**
- **Production**
- **Harvest**

**Cultural Practices**
- Dormancy-breaking, Mechanized vs hand-planting, Harvest method/timing

**Abiotic Environment**
- Field conditions, Climate, Propagule storage

**Biotic Environment**
- Interacting species such as Soil biota, Other Plants, Predators, Pathogens, Pollinators

**Planting at Restoration Site**
- Prepared Rangeland Site
- Prepared Wetland Site

**Seed and Seedbed Preparation**
- Planting Method
- Abiotic Environment
  - Establishment year climate, Soil chemistry, Soil physics
- Biotic Environment
  - Interacting species
Table 1. Seeding rates (PLS/ac) of the perennial grass mixes used in 2014. (Seeding rate doubled if broadcast.) The oat cover crop was planted at 10 PLS/ac. PLS/ac rate doubled if broadcast.

Percent frequency (freq) of species occurrence measured in 2015, numbers in parentheses are one standard deviation.

<table>
<thead>
<tr>
<th>Species</th>
<th>MHA rate</th>
<th>BIA rate</th>
<th>MHA freq</th>
<th>BIA freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW</td>
<td>2.4</td>
<td>2.4</td>
<td>95.8 (8.3)</td>
<td>97.5 (5.0)</td>
</tr>
<tr>
<td>GNG</td>
<td>1.5</td>
<td>1.2</td>
<td>73.3 (28.3)</td>
<td>57.5 (37.7)</td>
</tr>
<tr>
<td>SOG</td>
<td>1.5</td>
<td>0.6</td>
<td>56.7 (39.7)</td>
<td>30.0 (35.6)</td>
</tr>
<tr>
<td>SWG*</td>
<td>1</td>
<td>0.5</td>
<td>73.8 (12.5)</td>
<td>85.0 (12.9)</td>
</tr>
<tr>
<td>LBS</td>
<td>1</td>
<td>0.4</td>
<td>17.1 (15.3)</td>
<td>20.0 (16.3)</td>
</tr>
<tr>
<td>BG</td>
<td>1</td>
<td>0.2</td>
<td>56.7 (27.9)</td>
<td>57.5 (33.0)</td>
</tr>
<tr>
<td>PJG</td>
<td>0.1</td>
<td>0.1</td>
<td>39.2 (34.4)</td>
<td>42.5 (22.2)</td>
</tr>
</tbody>
</table>

* Significant difference in SWG frequency between the two planting mixes (p < 0.05)
Planting methods

Table 2. Seeding protocols of the 14 experimental units (sites): timing (planting month and year), perennial grass seed mix (Table 1), cover crop type, and planting method along with perennial grass density (plants/m²) measured in August 2015.

<table>
<thead>
<tr>
<th>Site</th>
<th>Timing</th>
<th>Mix</th>
<th>Cover crop</th>
<th>Method</th>
<th>Plants/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGB</td>
<td>Oct 2014</td>
<td>MHA</td>
<td>Oats</td>
<td>Broadcast</td>
<td>25 (8.8)</td>
</tr>
<tr>
<td>BRU</td>
<td>Oct 2014</td>
<td>BIA</td>
<td>None</td>
<td>Broadcast</td>
<td>38 (0.5)</td>
</tr>
<tr>
<td>COY</td>
<td>Sep 2014</td>
<td>BIA</td>
<td>Oats</td>
<td>Drilled</td>
<td>32 (6.6)</td>
</tr>
<tr>
<td>DAB</td>
<td>Oct 2014</td>
<td>MHA</td>
<td>None</td>
<td>Broadcast</td>
<td>33 (4.8)</td>
</tr>
<tr>
<td>FBIR</td>
<td>Oct 2014</td>
<td>BIA</td>
<td>None</td>
<td>Drilled*</td>
<td>22 (6.6)</td>
</tr>
<tr>
<td>MAS</td>
<td>Aug 2014</td>
<td>MHA</td>
<td>Oats</td>
<td>Broadcast</td>
<td>35 (5.0)</td>
</tr>
<tr>
<td>MRS</td>
<td>Aug 2014</td>
<td>BIA</td>
<td>None</td>
<td>Hydroteed</td>
<td>20 (10.0)</td>
</tr>
<tr>
<td>OLS</td>
<td>Aug 2014</td>
<td>MHA</td>
<td>Oats</td>
<td>Broadcast</td>
<td>26 (4.3)</td>
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<tr>
<td>EGB</td>
<td>Jun 2015</td>
<td>MHA</td>
<td>Oats</td>
<td>Broadcast</td>
<td>7 (0.2)</td>
</tr>
<tr>
<td>EGB</td>
<td>Jun 2015</td>
<td>MHA</td>
<td>Cocktail</td>
<td>Broadcast</td>
<td>6 (1.8)</td>
</tr>
<tr>
<td>SYW</td>
<td>Jun 2015</td>
<td>MHA</td>
<td>Oats</td>
<td>Broadcast</td>
<td>31 (3.7)</td>
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<tr>
<td>SYW</td>
<td>Jun 2015</td>
<td>MHA</td>
<td>Cocktail</td>
<td>Broadcast</td>
<td>29 (11.0)</td>
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<tr>
<td>MBL</td>
<td>Jun 2015</td>
<td>MHA</td>
<td>Oats</td>
<td>Broadcast</td>
<td>24 (14.0)</td>
</tr>
<tr>
<td>IND</td>
<td>Jun 2015</td>
<td>MHA</td>
<td>Cocktail</td>
<td>Broadcast</td>
<td>17 (1.6)</td>
</tr>
</tbody>
</table>
### SCENARIO 1:
Genetic drift followed by weak, directional selection with no gene flow

Wild Population

Source
Propagules collected from wild population

Propagation
Plants growing on production farm

Planting at Restoration Site
Restoration Materials: Seeds from production farm

### SCENARIO 2:
Genetic drift followed by weak, stabilizing selection with no gene flow

Source

Propagation

Planting at Restoration Site

### SCENARIO 3:
Genetic drift and selection followed by directional selection with no gene flow

Source

Propagation

Planting at Restoration Site

### SCENARIO 4:
Genetic drift and selection followed by directional selection and gene flow

Source

Propagation

Planting at Restoration Site
Looking for seed?
Select your project area
Restoration is normally conducted with the goal of creating plant populations that establish, survive, successfully reproduce, contribute to ecosystem function, and persist in the long term. For large-scale restorations, it is often necessary to rely upon plant materials that have undergone agronomic increase to produce a sufficient number of seeds. During this propagation process, restoration populations are subject to genetic sampling as well as natural and artificial selection that could result in adaptation contrasting sharply with that of native populations. In this seminar, I will draw on insights from the evolutionary and agricultural literature to illustrate how changes in the amount and type of genetic variation in agronomically produced seeds could affect plant performance in restoration. The consequences of intentional and/or inadvertent evolutionary modification of restoration materials will be discussed with respect to population viability and ecosystem function. I will describe two feasible methods to test for evolutionary change in plant materials using neutral molecular markers and/or field observations and six practices decrease the potential for unintentional evolution and maladaptation. Julie Etterson (Department of Biology, UM-Duluth) is an ecological geneticist whose research is focused on understanding whether wild plant populations will be able to adapt fast enough to keep pace with climate change and how restoration can be used as a tool to ameliorate the negative effects of climate change. TUESDAY 10:00 A.M. – 12:00 P.M. CABINET PLANT MATERIALS
Western wheatgrass
The preceding presentation was delivered at the

2017 National Native Seed Conference
Washington, D.C. February 13-16, 2017

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