

# **Building Blocks of Restoration:**

## **PLANT BREEDING AND GENETICS**

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# Topics To Be Considered

- Perennial native grass species
- Genetic considerations
- Types of populations
- Native grass breeding
- Genetic diversity comparisons



# GENOTYPE

- The genetic makeup of an organism or individual
- The inherited map that an individual carries in its genetic code
- We often refer to one's genotype with regard to a particular gene of interest
- The genotype, and environmental effects, determine the phenotype of an individual – i.e. what it looks like

# Genetic Considerations: Self-Pollinating Species

- Most of our crop species are predominantly self-pollinating
- Wild populations of these species are a mixture of mostly homozygous genotypes
  - May be highly variable
- Modern cultivars are composed of mostly one genotype
  - Small % of cross pollination results in a low % of heterozygous genotypes
  - Plants are identical in morphology and physiology
- Are some self-pollinating native grass species
  - eg. *Elymus trachycaulus* – slender wheatgrass







# Genetic Considerations: Cross-Pollinating Species

- Most perennial grasses are cross-pollinated
- Individual plants within a population have different genotypes and many gene loci are heterozygous
  - Individual plants show variation in morphology and physiology
- Self-incompatibility is common
- Inbreeding depression occurs when selfed or closely related genotypes crossed
- Many grass species are polyploids – genetically complex
- Most populations show a high degree of genetic variation







# Type of Populations of Perennial Native Grass Species

- Cultivars (Varieties)
  - Most intensively selected
- Ecological varieties
  - Also known as pre-variety germplasm, multi-site composites, ecovars<sup>TM</sup>
  - Collections from wide area, little selection carried out
- Ecotypes
  - One or more collections from a geographic area
- Wild harvest
  - Seed collected from a specific location



# Cultivars of Cross Pollinated Species

- Selected by plant breeders
- Selection usually done for specific characters
  - Forage yield, seed yield, forage quality, regrowth etc.
- Selection reduces genetic variation from wild populations
  - But cultivars are still genetically diverse
  - Must select a number of plants in cultivar formation to avoid inbreeding
- Cultivars are available for some native grass species

## Initiative to develop Canadian adapted seed sources of native grass species: Ecological varieties

- Began in early 1990s
- Partners
  - a) Ducks Unlimited Canada (DUC)
  - b) Agriculture and Agri-Food Canada (AAFC)
  - c) University of Manitoba
  - d) University of Saskatchewan
- Goals
  - a) To have adapted, genetically diverse seed sources available for many species of native grasses



# Users of native grass seed in Canada

- Crown corporations, private companies
- Reclamation companies
- Conservation organizations
  - a) Eg. Ducks Unlimited Canada (DUC)
- Livestock producers

# Native Grasses: Constraints to wider use

- Lack of reliable sources of adapted seed
- Difficulty of seed production
- Expense of seed



# Methodology

- DUC biologists collected seeds or plants across range of adaptation of species
- Seeds or plants delivered to AAFC or universities
- Plants propagated and field nurseries established
- Evaluation for several years and limited selection carried out
  - a) Wanted to maintain high genetic diversity
- Basic seed stocks produced (G0)
- Seed increased under Canadian pedigreed seed production system
  - a) Two generations of increase (G1 and G2)
  - b) Standards for purity and germination









AAFC Swift Current

# Roles of partners

- DUC
  - a) Establish priority species for conservation
  - b) Collect plants or seeds of these species in native stands
- AAFC and universities
  - a) Propagate, select and produce basic seed



# Pre-variety germplasm or ecovar™

- “native plant material derived from a composite of germplasm collected throughout the area of adaptation and that contains the natural genetic diversity of the species”
- Ecovar (i.e. ecological variety) is a trademarked term of Ducks Unlimited Canada
- Are “multi-site composites”
- Not as highly selected as a cultivar so less uniform

# Species for which pre-variety germplasm is available

- Western wheatgrass WR Poole
- Northern wheatgrass AC Polar
- Green needlegrass AC Mallard
- Needle and thread grass AC Sharptail
- Awned wheatgrass AC Sprig & Pintail
- Little bluestem Taylor
- Nodding brome AC Marten



**Awned wheatgrass seed production field**





**Meadow Brome**

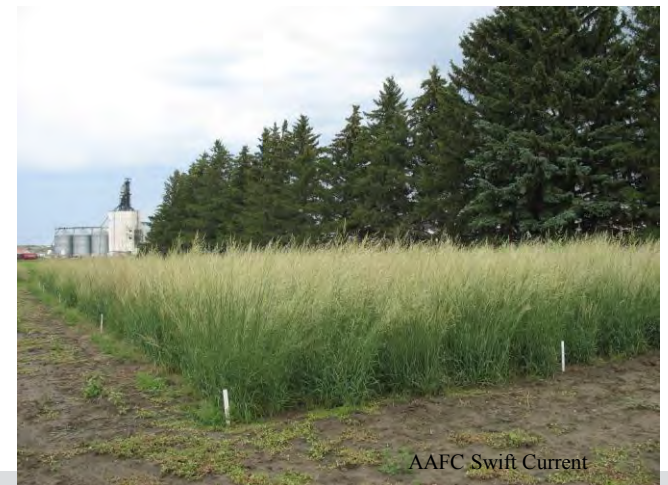
**Richardsons Brome**  
**10 -14 days later**

**Smooth brome**



# Species Under Development

- Program lead M. Schellenberg  
AAFC Swift Current
- Northern Wheatgrass
- Side-oats Grama
- Prairie Sandreed
- Purple Prairie Clover
- White Prairie Clover
- Nuttall's salt meadow grass







**Nuttall's Salt Meadow Grass**



# Classes of pedigreed grass seed

- Standards and procedures under supervision of Canadian Seed Growers' Association
- Cultivars (require registration by CFIA):
  - Breeder - produced by plant breeder
  - Foundation - grown from breeder seed by seed grower
  - Certified - grown from foundation seed by seed grower
    - Is seed of commerce – sold to farmers for forage production
- Pre-Variety Germplasm (no registration):
  - G0 – produced by plant breeder
  - G1 – grown from G0 seed by seed grower
  - G2 – grown from G1 seed by seed grower
  - G3 – grown from G2 seed by seed grower

# Questions

- How do the various types of native grass populations compare in genetic diversity?
- Is there genetic drift or loss of genetic variation over generations of seed increase?
  
- Studies of genetic variation of several grass species were conducted using molecular markers (AFLP)
  - a) Random assessment of variation across the genome



# Why do we want high genetic variation?

- Will allow established populations to be adapted to a wide range of environmental conditions
  - Some genotypes will survive, others will not
- Potentially greater adaptation to climate change

# Genetic diversity of blue grama (*Bouteloua gracilis*)

- Cross-pollinating species
- Four populations compared
  - a) An ecovar (pre-variety germplasm), G0, G1 and G2
  - b) Two ecotypes – Minnesota and South Dakota
  - c) A native seed collection – southern Manitoba
- Greatest AFLP variation in the ecovar
- No genetic drift or loss in genetic variation in the ecovar across two seed multiplication generations
- Crop Science 44: 283-288 (2004)



# Genetic diversity of awned wheatgrass (*Elymus trachycaulus subsp subsecundus*)

- A self-pollinating species
- Two populations
  - a) AC Pintail ecovar - a multisite composite – G0, G1 and G2
  - b) AEC Hillcrest – a cultivar
- AC Pintail showed much higher AFLP variation than AEC Hillcrest
- AC Pintail lost 8% of original variation over two seed multiplications, but was still highly variable
- Crop Sci. 45: 1064-1068 (2005)

## Genetic Diversity Studies on Native Grass Populations from Manitoba and Saskatchewan

- Big bluestem – 6 populations
  - Within populations – 91% of variance; Among – 9%
  - Association of AFLP variation with geographic distance – i.e. the more distant collections more genetically different
- Nuttall's salt meadow grass – 24 collections
  - Within populations – 96% of variation; Among – 4%
  - No association of variation with geographic distance
- Plain's rough fescue – 6 populations
  - Within population – 90% of variation; Among – 10%
  - Association of variation with geographic distance -



# Implications of Genetic Diversity Studies on Cross-Pollinating Native Grasses

- Ecovars more genetically variable than other available populations
  - Expected because of broad range of collections
- Little loss of genetic variation over seed increase generations
  - Ecovar commercial seed contains most of original variation
- All native seed collections have a large reservoir of genetic variation
- In Nuttall's salt meadow grass, an ecovar of a few collections may capture the total variation
- For rough fescue and little bluestem, more collections across the range would be required to capture the total variation in an ecovar.

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