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Oak Lake Field Station 30th Anniversary Retreat Presentations

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2019

# Native Grass and Legume Biology and Establishment

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# **Native Grass and Legume Biology and Establishment**

**SDSU  
NORTHERN PLAINS  
BIOLOGICAL  
FIELD STATION**

**Arvid Boe, Bioenergy Crop Genetics and Breeding  
and  
Paul J. Johnson, Insect Biodiversity  
AHPS Department  
South Dakota State University**

# Areas of Research I

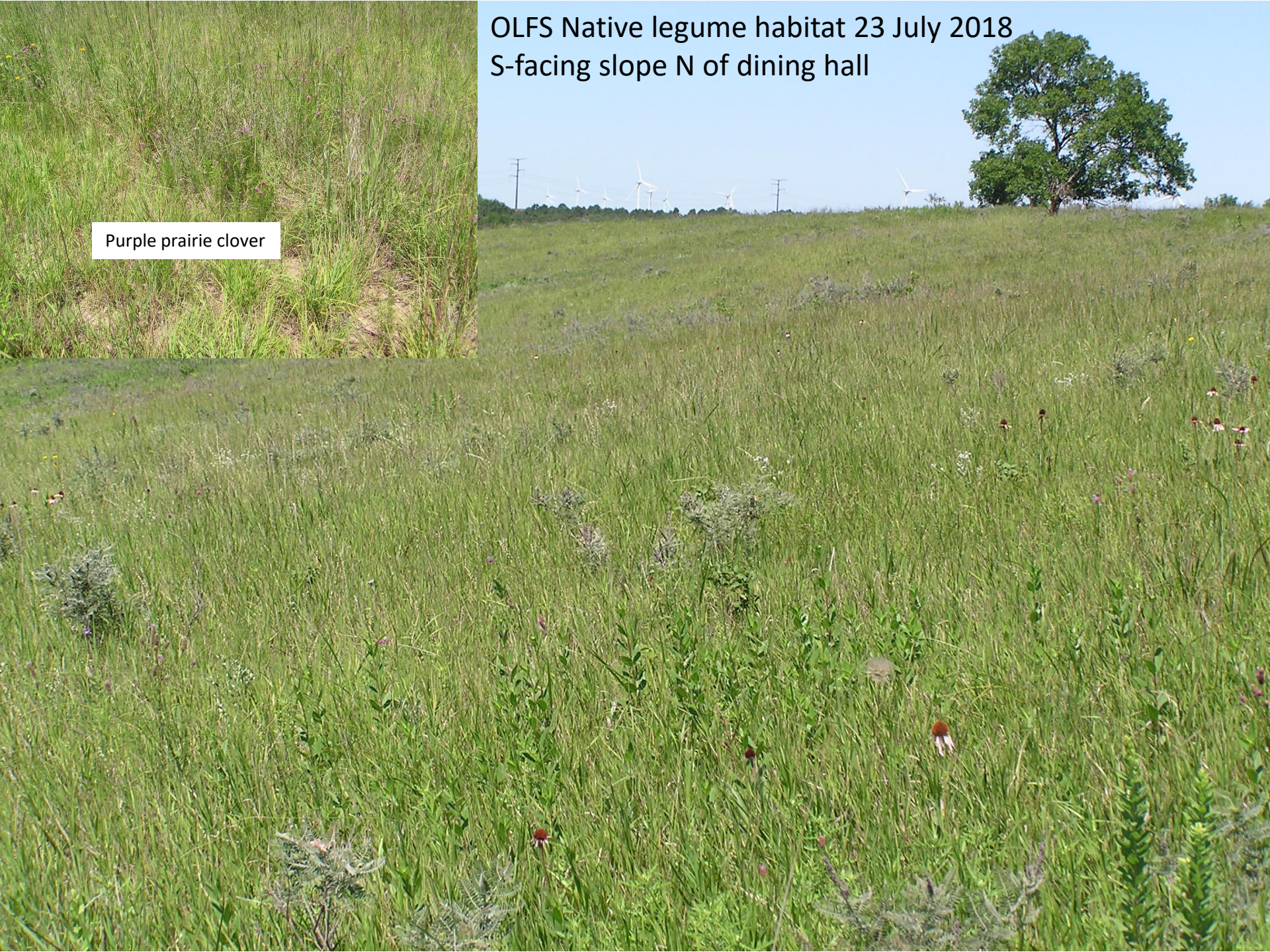
- Reproductive biology of native legumes
- Rationale
  - Candidate biofuel species are native warm-season grasses
  - Sustainable production system should be low input (e.g., N fertilizer), with environmental benefits (e.g., pollinators)
  - Introduced legumes, such as alfalfa, incompatible with warm-season grasses
  - Native legumes compatible
  - Seed production in native legumes generally low
    - Factors not well understood, but insects major players
    - So, determine impacts of insects and other factors in natural setting; provide guidelines for potential commercial scale

# Areas of Research I

- Reproductive biology of native legumes
- Activities at OLFS:
  - 1999-present
  - Data: Seed set/production (i.e., fates of ovules)
  - Identifications: Seed predators (beetles, midges, and phytophagous wasps)
    - Large negative impacts on natural and commercial seed production
  - Identifications: Parasitoids of seed predators
    - Abigail P. Martens MS (wasps, esp Braconidae, in progress)
  - Legume species studied
    - Purple prairie clover
    - False indigo
    - American licorice
    - *Astragalus*
      - Canada milk-vetch
      - Ground plum milk-vetch
      - Pliant milk-vetch
      - Field milk-vetch

OLFS Native legume habitat 23 July 2018  
S-facing slope N of dining hall

Purple prairie clover





Purple prairie clover (*Dalea purpurea*)



*Kissingeria capitone*



*Aprostocetus marylandensis*



*Lyrus incertus*



# False Indigo (*Amorpha fruticosa*)



*A. submuticus*

*Lyrceus  
incertus*

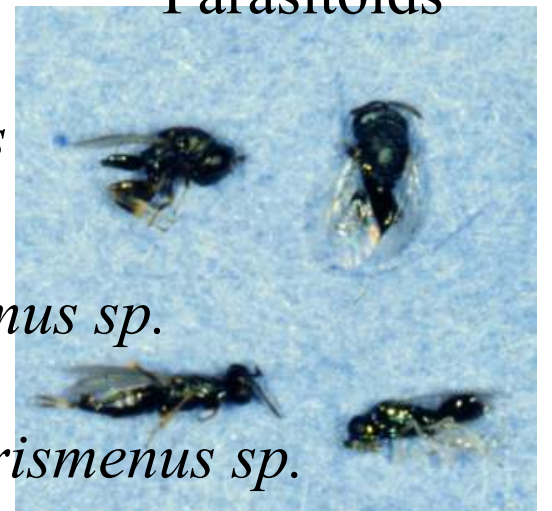


Parasitoids

*Dinarmus  
acutus*

*Eupelmus sp.*

*Horismenus sp.*



Exit Holes

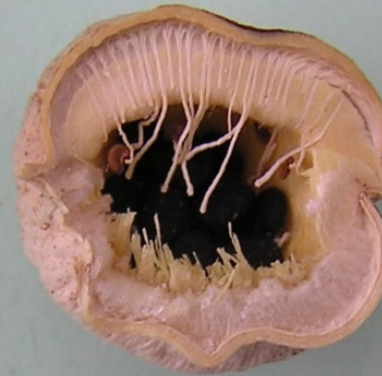
Groundplum Milk-vetch (*Astragalus crassicarpus*)





# Fates of Ovules?

Best if indehiscent pod  
with persistent valves or  
bracts



Placentae attached to ovary wall with ovules 'dangling' into chamber of valve

Normal seed (lt), predated seed (ctr) and unfertilized ovules (rt) of  
ground plum milk-vetch

'Intact Crime Scene'



# Fates of ovules in two populations of groundplum milk-vetch at OLFS

Population	Ovule Fate (No. Valve <sup>-1</sup> )			
	Normal seed	Aborted seed	Unfertilized ovules	Predated seed¶
OLFS South	13.2 (0.9)	1.7 (0.2)	10.9 (2.1)	2.9 (0.8)
OLFS North	10.7 (0.6)	3.5 (0.3)	8.8 (0.4)	0.6 (0.3)

¶ *Acanthoscelides fraterculus* (Coleoptera: Chrysomelidae: Bruchinae)



Immurement---~25% of adults



## Areas of Research II

- Establishment, productivity, and ecosystem goods and services of native plant communities for biofuel
- Rationale
- Prior, no farm-scale replicated trials comparing diverse mixture of native grasses and forbs to monocultural switchgrass on marginal crop land in the northern Great Plains for:
  - Ease of establishment
    - Requires multiple planting years
    - Reaction of switchgrass to maize nurse crop
      - Income in planting year
  - Fluctuation in stand density and morphology
  - Long-term biomass production

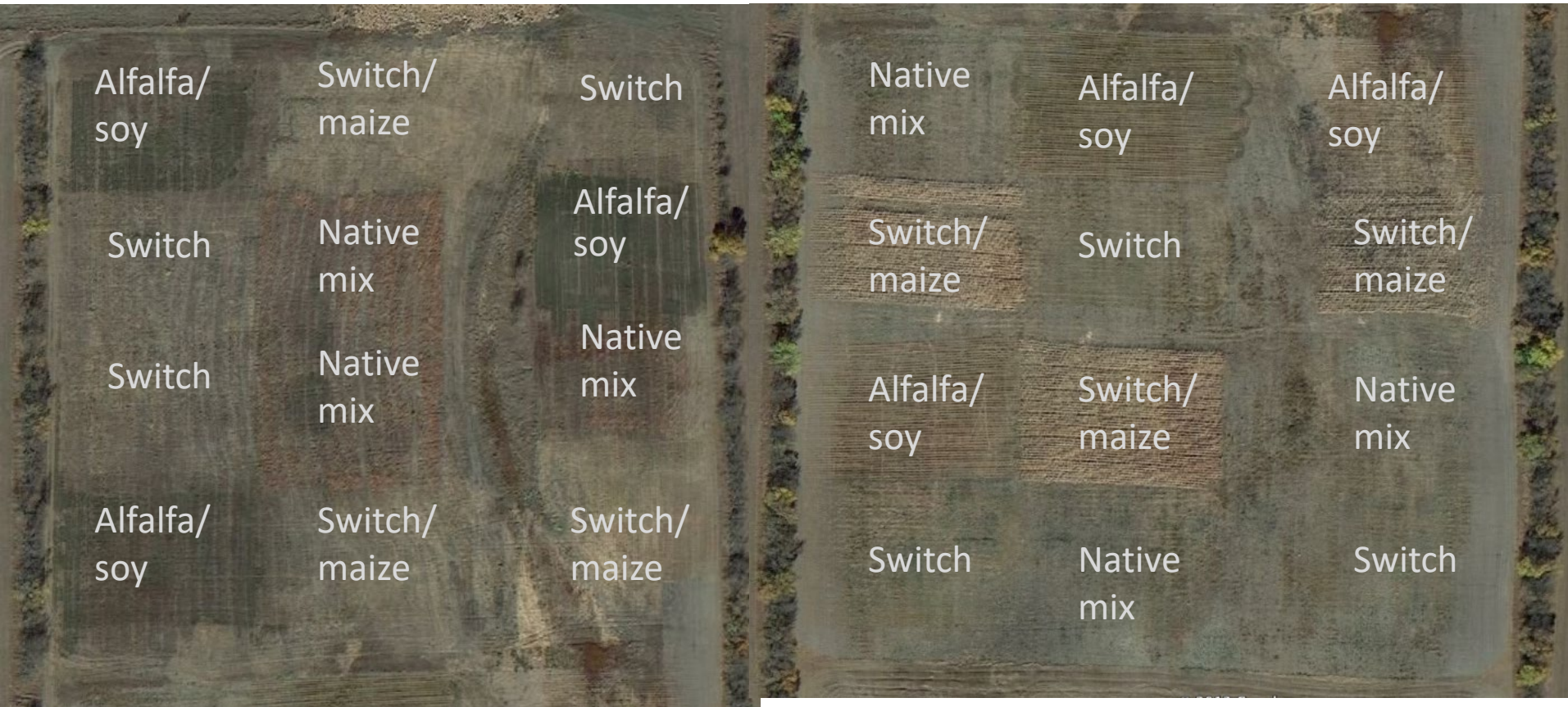
# Areas of Research II

- Establishment, productivity, and ecosystem goods and services of native plant communities for biofuel
- 2011-present
- **Agronomy (low input)** No fertilizer, spot herbicide and mowing as needed; burning not allowed
  - Treatments
    - Switchgrass monoculture
    - Diverse grass-forb mixture (16 species)
    - Alfalfa (non-native check)
  - Data: biomass yield, ground cover, biodiversity
- **Ecology**
  - Mammal diversity---Ben Carroll, MS
  - Insect diversity
    - Veronica Calles-Torrez, MS (PhD NDSU completed)
    - Abigail P. Martens, MS (in progress); parasitic hymenoptera (Braconidae)
    - Kendal Davis, MS (in progress); endangered lepidoptera (Skippers)

# Experimental Design

Field 1 (N), planted May 2011

Field 2 (S), planted May 2012



Soil on upland at OLFS susceptible to wind and water erosion and not well suited for annual crop production



# Maize Productivity

## 2012 data from 2012 planting

Trait	Mean (SE)
Biomass ( kg ha <sup>-1</sup> )	4907.9 (301.7)
Ears ha <sup>-1</sup>	57,384 (4781.2)
Ears acre <sup>-1</sup>	23,232 (1935.7)
Kg grain ha <sup>-1</sup>	3269.9 (309.0)
Bushels acre <sup>-1</sup>	52.0 (4.9)
Kg Cobs hectare <sup>-1</sup>	593.7 (51.6)
Harvest index¶	0.36 (0.01)

¶ Harvest index =  $\text{kg grain ha}^{-1} / (\text{kg grain ha}^{-1} + \text{kg stover ha}^{-1} + \text{kg cob ha}^{-1})$

- **Total biomass was 8.6 tonnes per hectare. Grain yield was very low (< 3.5 tonnes per hectare).**
- **Important Factor: 2012 had driest summer on record.**





Planted May 2011  
20 June 2013

Switchgrass/Maize Nurse Crop



Native Mixture  
Alfalfa (back)





OLFS  
Mixture (above) planted May 2012  
Photos: 24 October 2018

Planted May 2012  
Photos: 20 June 2013

Switchgrass Alone



Major competitor in 2012 and 2013 was woolly cupgrass (*Eriochloa villosa*)

Switchgrass w/Maize Nurse Crop





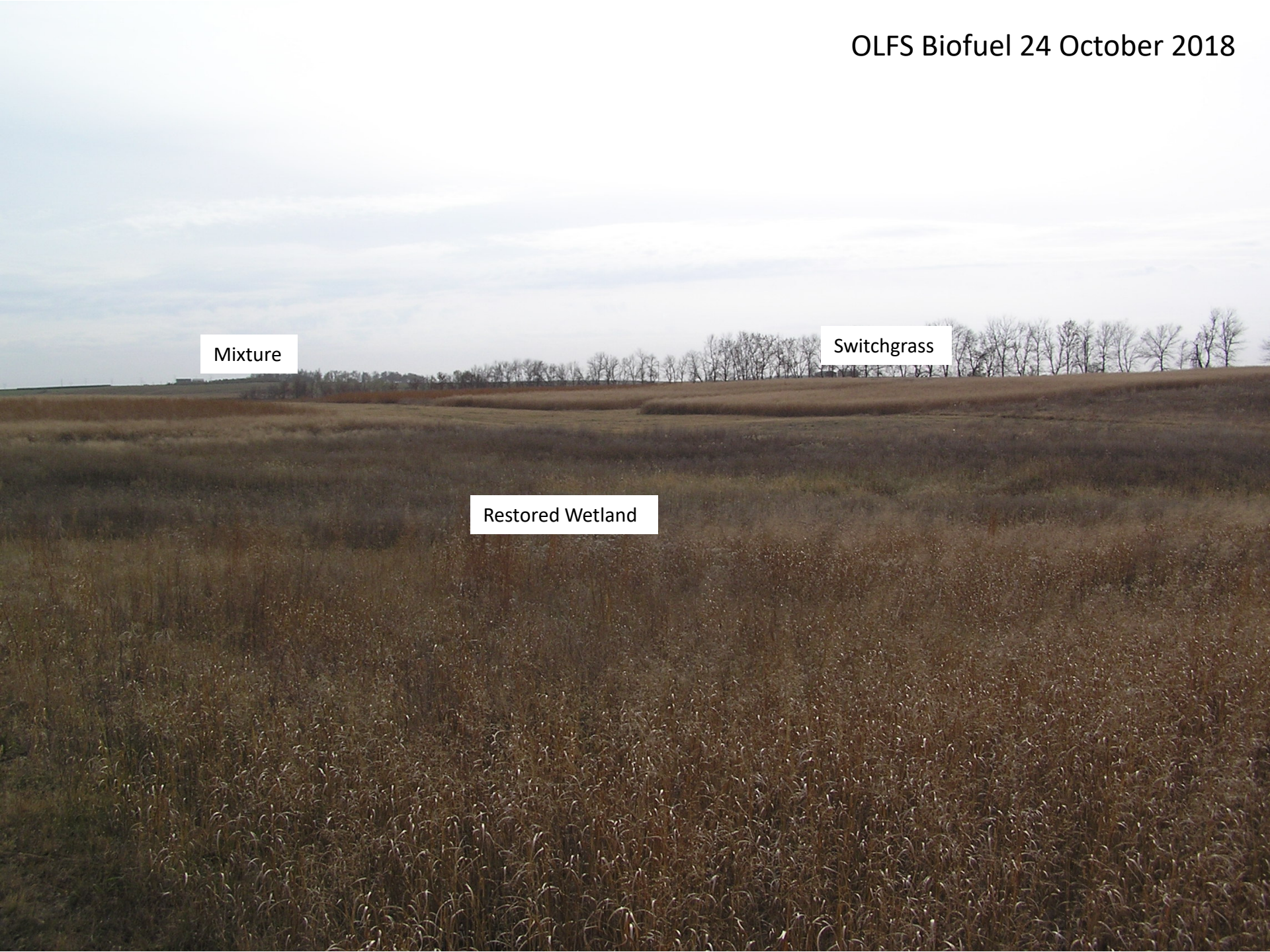
OLFS Biofuel  
Switchgrass planted May 2012  
Photos: 24 October 2018



Mixture

Switchgrass

Restored Wetland



OLFS 31 October 2015

Mixture 4,507 kg ha<sup>-1</sup>



Switchgrass 4,550 kg ha<sup>-1</sup>



West Side Backslope

Switchgrass/Corn 2011 Planting  
30 October 2015



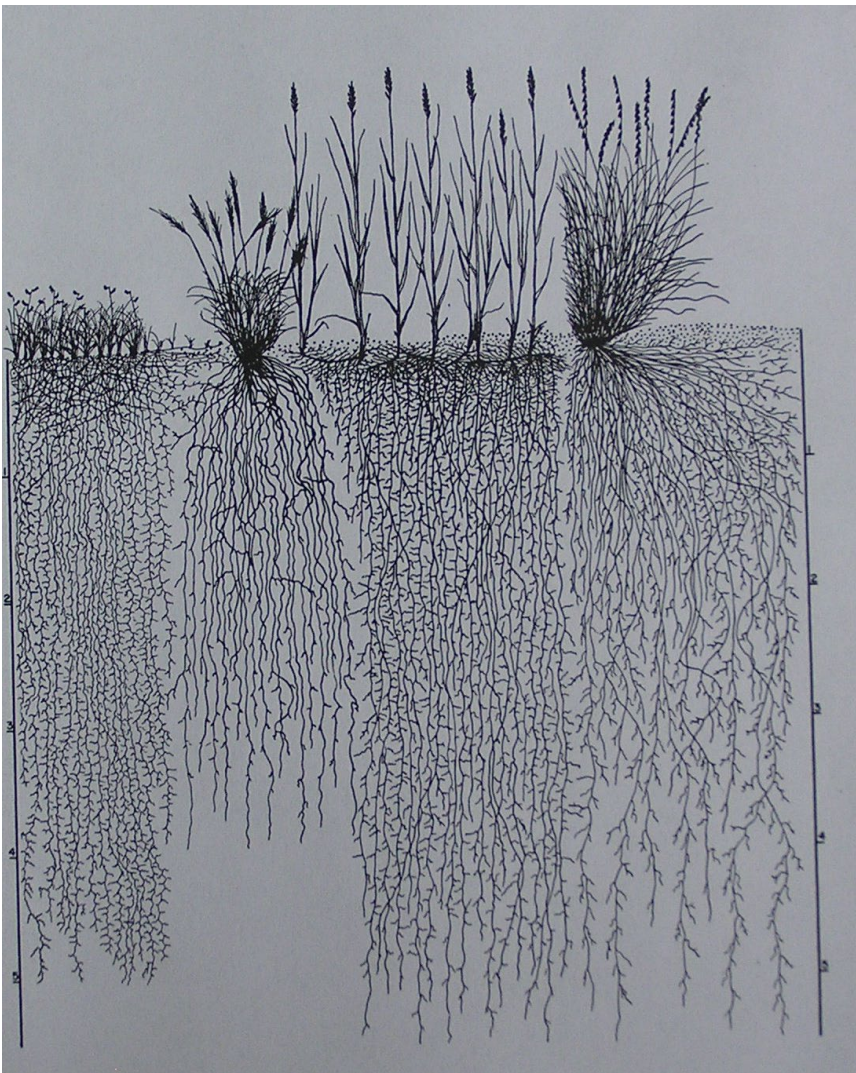
Native Mix 2011 Planting  
30 October 2015



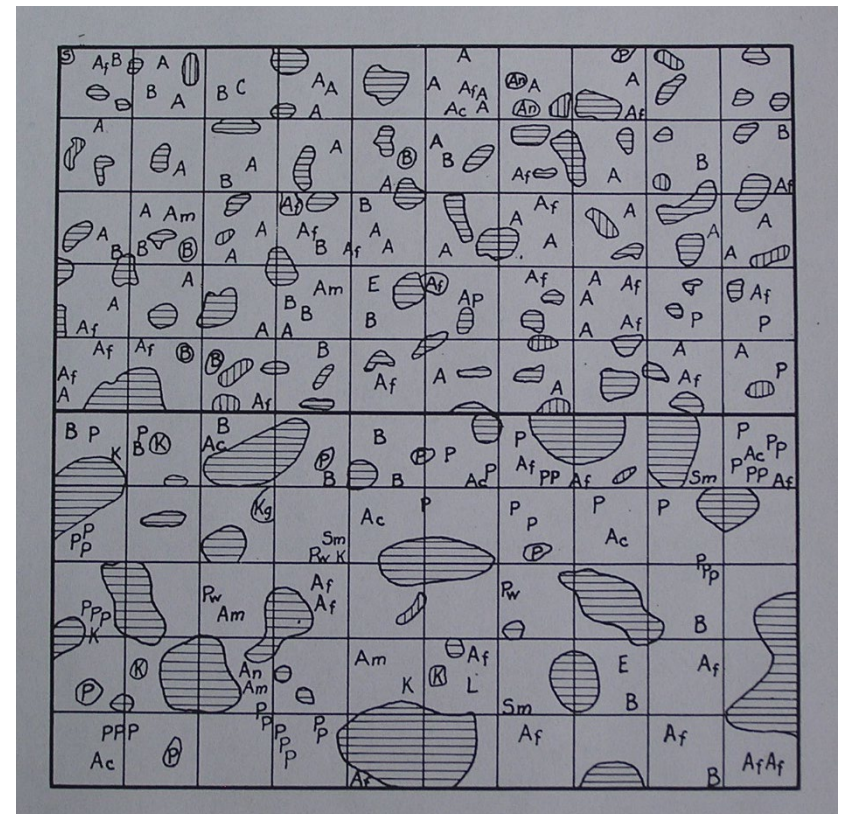
Weaver JE. 1968. Prairie plants and their environment. UN Press.

M<sup>2</sup> quadrat in little-bluestem dominated natural prairie

- Basal cover **very stable** (<15%)
- Foliage cover 55-100%, related to precipitation
- INTERESTING!



Tillers and roots of mixed-grass prairie grasses  
-Roots difficult, time-consuming,  
expensive to study





## Status of Plant Community Establishment/Productivity October 2018

YEAR PLANTED	SG/CORN	SG	NATIVE MIX	ALFALFA/SB
2011	Excellent	Excellent	Excellent	Deteriorated¶
2012	Excellent	Excellent	Excellent	Deteriorated
2013	----	Poor	Good	Fair

¶ Still valuable: refuge sites for recruitment/seed production of migrant native forbs that were in original Native Mix

Why we stockpile biomass over winter



# Some Outcomes/Outputs

- Outcomes
  - Elucidation of life histories/insect guilds associated with seed production in native legumes
    - Casting is done; now we start filming
  - Quantification of various factors that impact seed set and seed production in native legumes
    - Tools for better understanding why seed production fields fail
    - Agencies and private producers are aware of our findings
  - Successful establishment of perennial native grass/forb communities with minimal inputs on marginal crop land
    - Replicated, farm-scale, across landscape----Great Demonstration Site!
- Outputs
  - 12 refereed journal articles
    - Including 3 new species descriptions
  - Numerous presentations at national and regional meetings
- Impacts
  - USDA-NRCS considers OLFS Biofuel plots showcase for education/training
  - Biofuel plots are suitable for additional ecological/agronomic research
    - The hard part has been done!

# Acknowledgements

- Funding:
  - USDOE through Sun Grant Initiative, North Central Sun Grant Center, SDSU
  - Oak Lake Field Station Faculty Research Grant Program
- We are indebted to Dr. Nels Troelstrup, Director, Oak Lake Field Station, for his support of these projects
- Other Co-PIs that started on biofuel project in 2010 were Dr. Susan Rupp, formerly NRM, and Dr. Vance Owens, AHPS (now Director, NC Sun Grant, SDSU)

QUESTIONS?



**BIODIVERSITY**

Lichen Flora at OLFS is Spectacular!!

East Side Shoulder/Summit

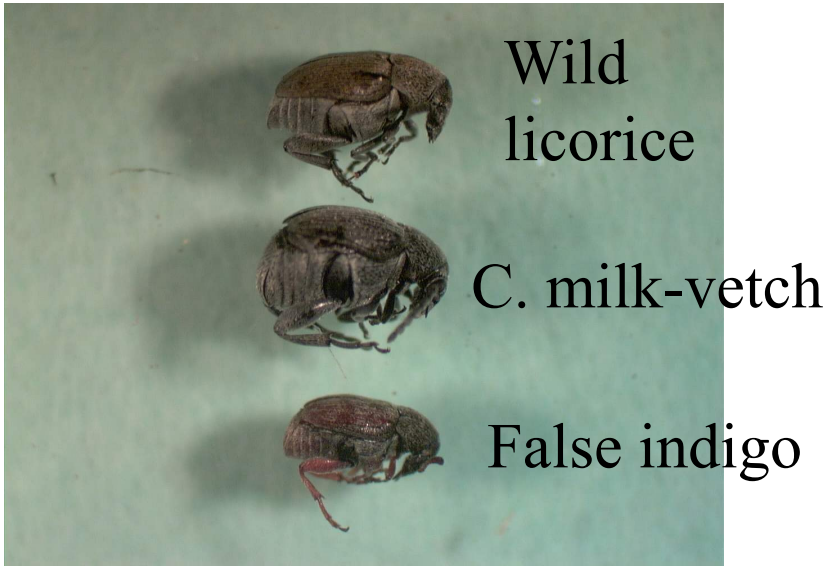
Switchgrass 2011 Planting  
30 October 2015



Native Mix 2011 Planting  
30 October 2015



# Bruchid (Seed) Beetles:(Bruchidae) (*Acanthoscelides*)



*Acanthoscelides aureolus*,  
*perforatus*, *submuticus*



*Amblycerus robiniae* emerging  
from seed of honey locust  
(*Gleditsia triacanthos*)

# Canada Milk-vetch



*A. perforatus*



*T. liljebladi*



Parasitoids



## Areas of Research III

- Biology of impactful insects of native and tame grasses
  - Veronica Calles-Torrez and Juan Manuel Perilla López, MS (PhD Wright State in progress)



Gall midges have major impact on seed production in native and tame grasses

- 3 new species
- 1 new continental distribution records
- 3 new host/parasitoid relationships



*Stenodiplosis geniculati*  
ex *Alopecurus arundinaceus*

Gall midges have major impact on seed production in native and tame grasses

- 3 new species
- 1 new continental distribution records
- 3 new host/parasitoid relationships

# Purple Prairieclover



Seed Beetles (top);  
Parasitoids (bottom)

## Groundplum milk-vetch



Geographical variation for pod morphology: top row, Oak Lake Field Station near Astoria, SD; bottom row, Grand River National Grassland near Lodgepole, SD

# Overwinter Stockpiled Biomass Production (kg ha<sup>-1</sup>)

	Planting Year			
	2011		2012	
	Production Year			
Treatment	2013	2014	2013	2014
Alfalfa/Soy	726 a†	2696 a	414 a	3010 a
Switchgrass/Maize	759 a	2602 a	915 b	1853 b
Switchgrass	2078 b††	2489 a††	1109 b	4065 c
Native Mix	1849 b	2588 a	583 a	1734 b

† Means followed by different letter significantly different at P=0.05 by Fisher's LSD.

†† Plots were dominated by weedy species. Less so in 2014 compared to 2013.

**Harvest Dates:** for 2013 production, 21 May 2014; for 2014 production 11 June 2015