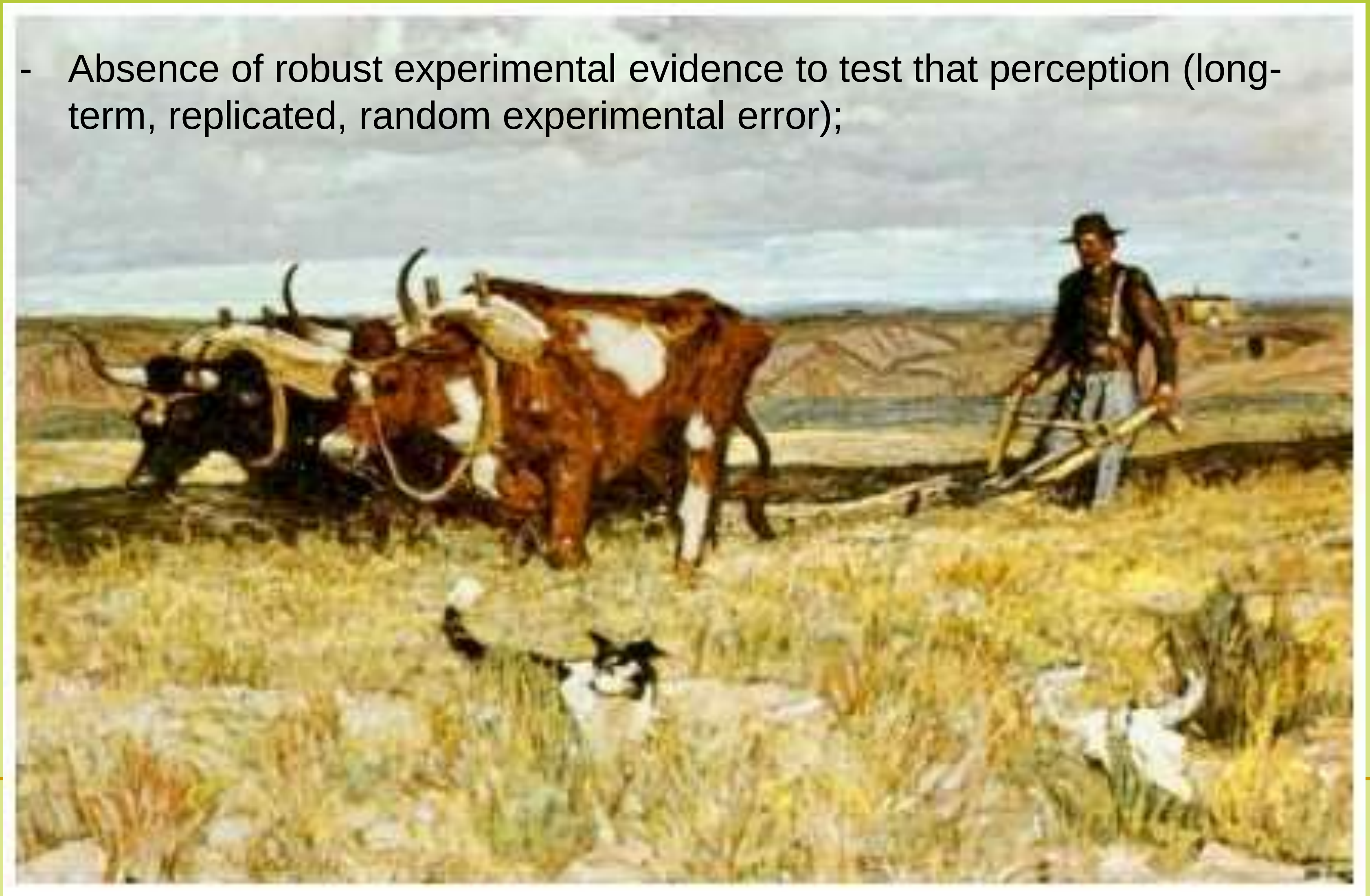
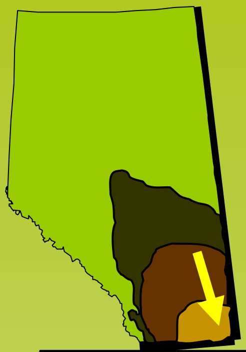
**Effects of disturbances on soil carbon in the Mixed Prairie of southern Alberta**

**Rationale:**

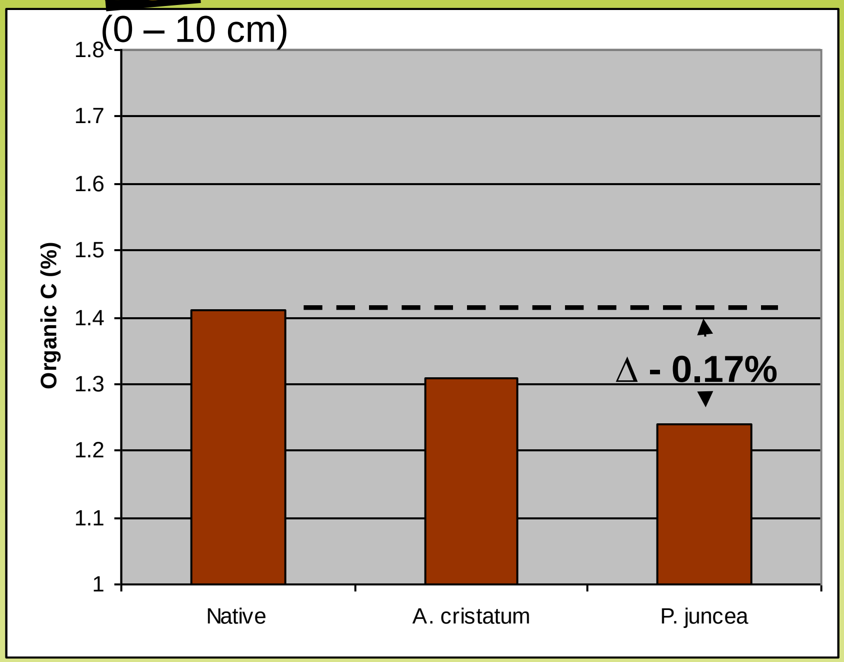
- Perception that replacing native grassland with introduced species was degrading soil quality (contrary to the "Improved" designation of those areas);
- Absence of robust experimental evidence to test that perception (long-term, replicated, random experimental error);



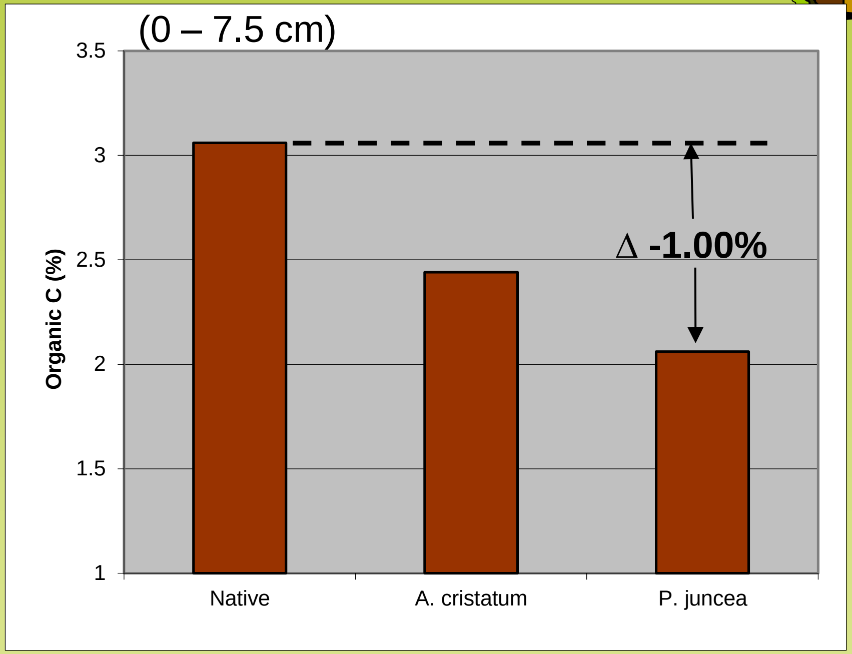
# Evidence challenging the "Improved" designation



Concentration (%) of soil organic carbon in a Stipa-Bouteloua community in relation to native and seeded communities



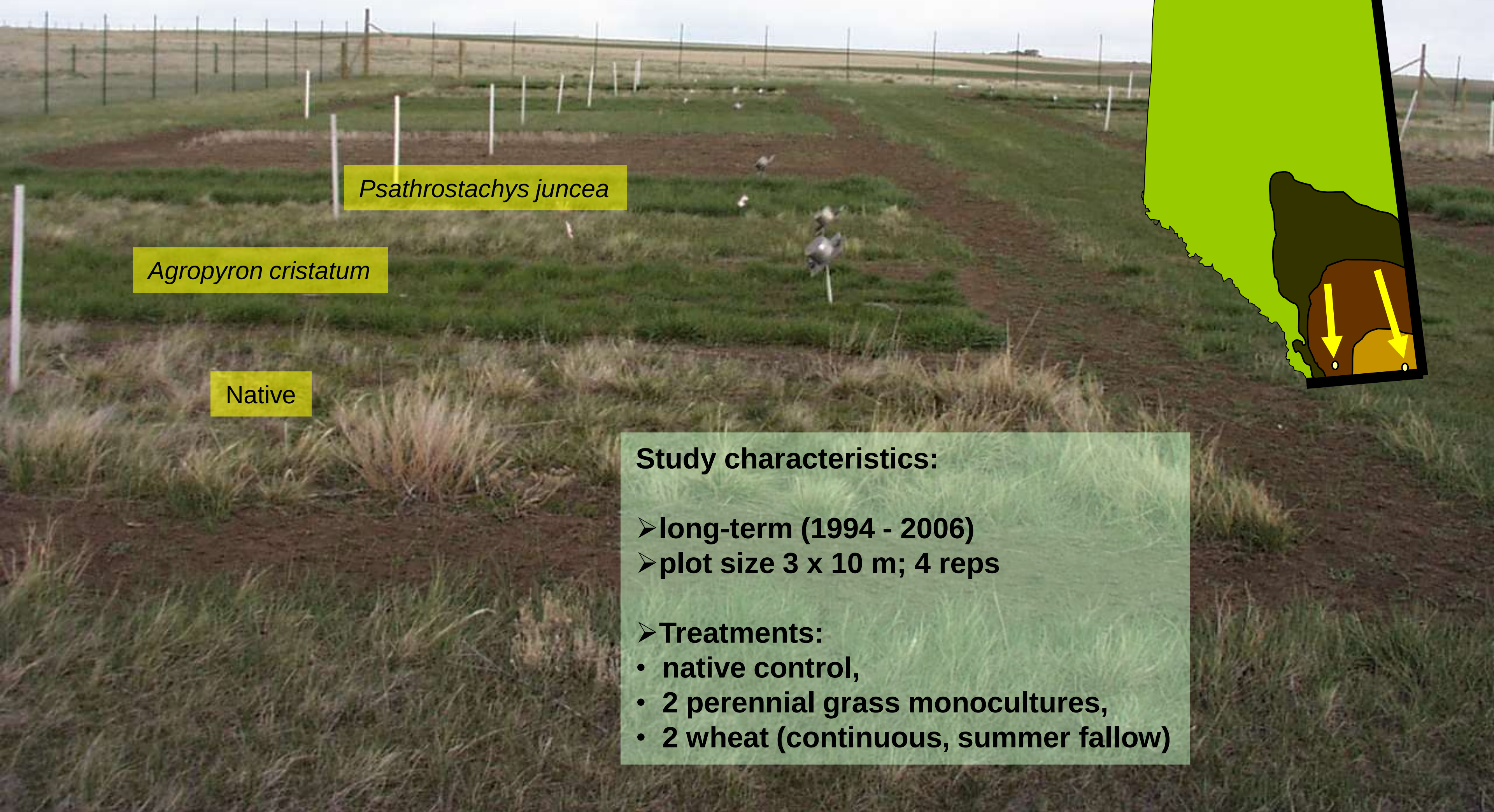

Smoliak, S. and J.F. Dormaar. 1985. Productivity of Russian wildrye and crested wheatgrass and their effect on prairie soils. J. Range Manage. 38:403–405.




Derived from: Dormaar, J.F., M.A. Naeth, W.D. Willms, and D.S. Chanasyk. 1995. Effect of native prairie, crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) and Russian wildrye (*Elymus junceus* Fisch.) on soil chemical properties. J. Range Manage. 48:258–263.

## Controlled studies to test plant-soil carbon relationships

Experiment: Do introduced species degrade soil organic C?

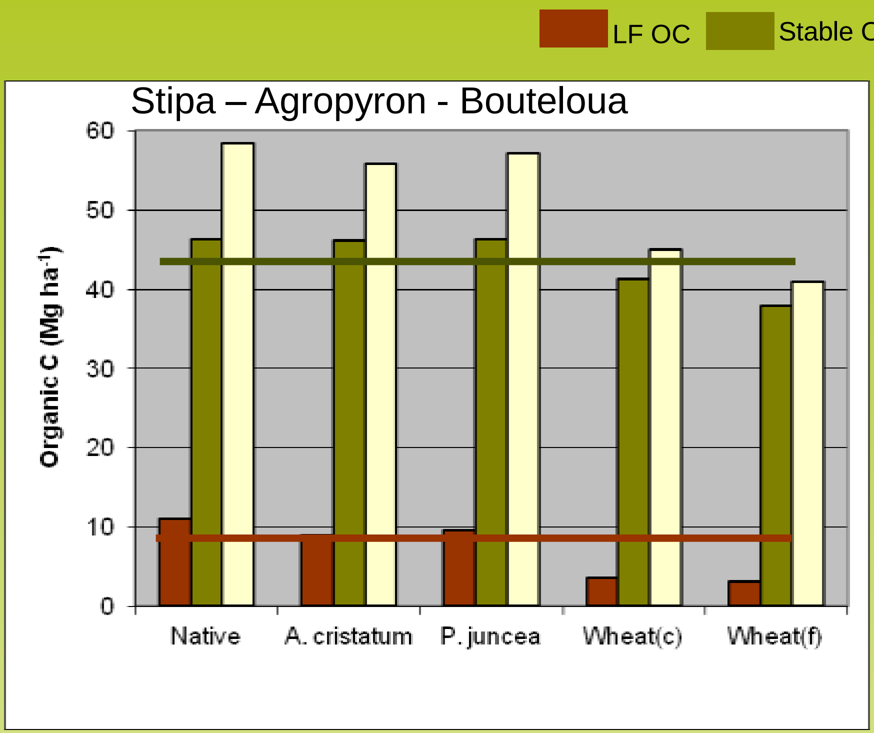


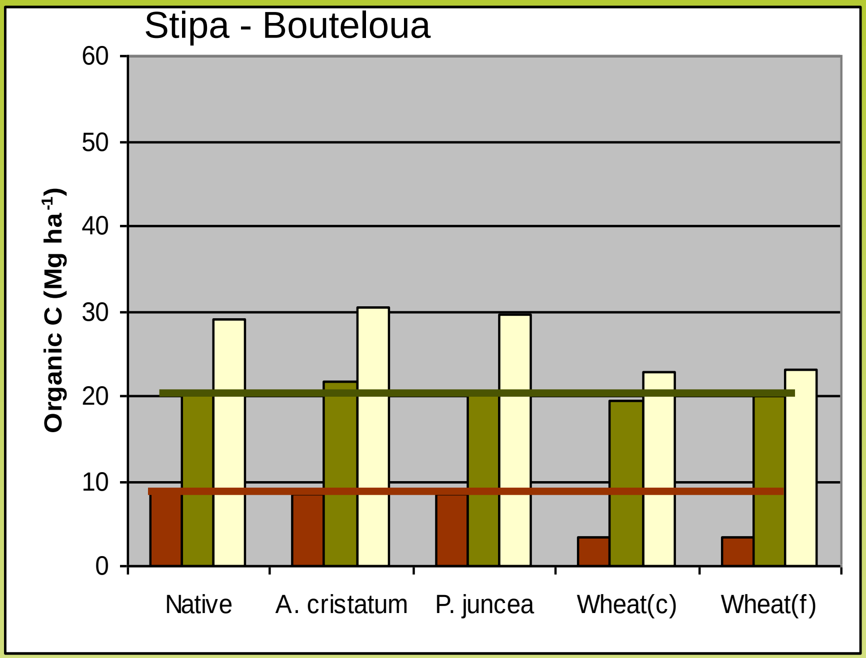

**Study characteristics:**

➢**long-term (1994 - 2006)**
➢**plot size 3 x 10 m; 4 reps**

➢**Treatments:**
- **native control,**
- **2 perennial grass monocultures,**
- **2 wheat (continuous, summer fallow)**

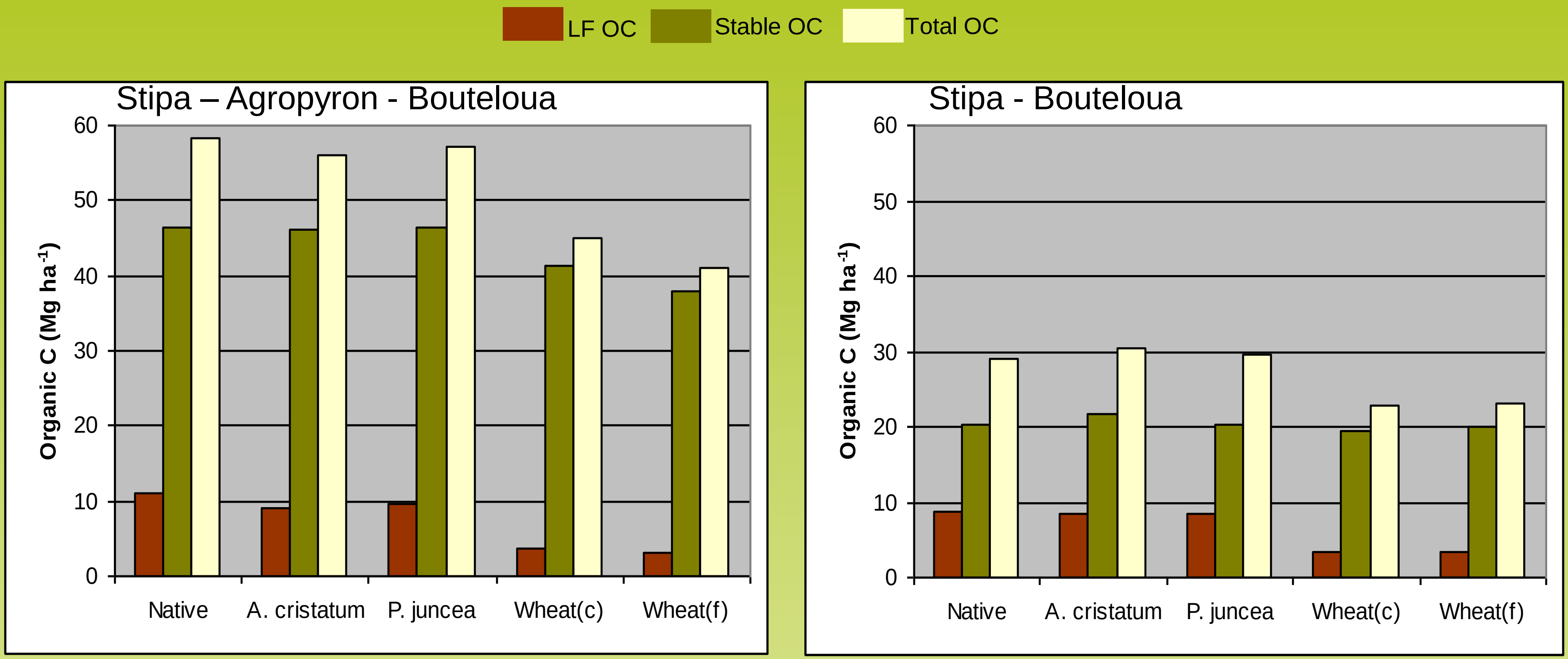
# Soil organic C (light, stable and total) 13 years after establishment (0 – 15 cm)



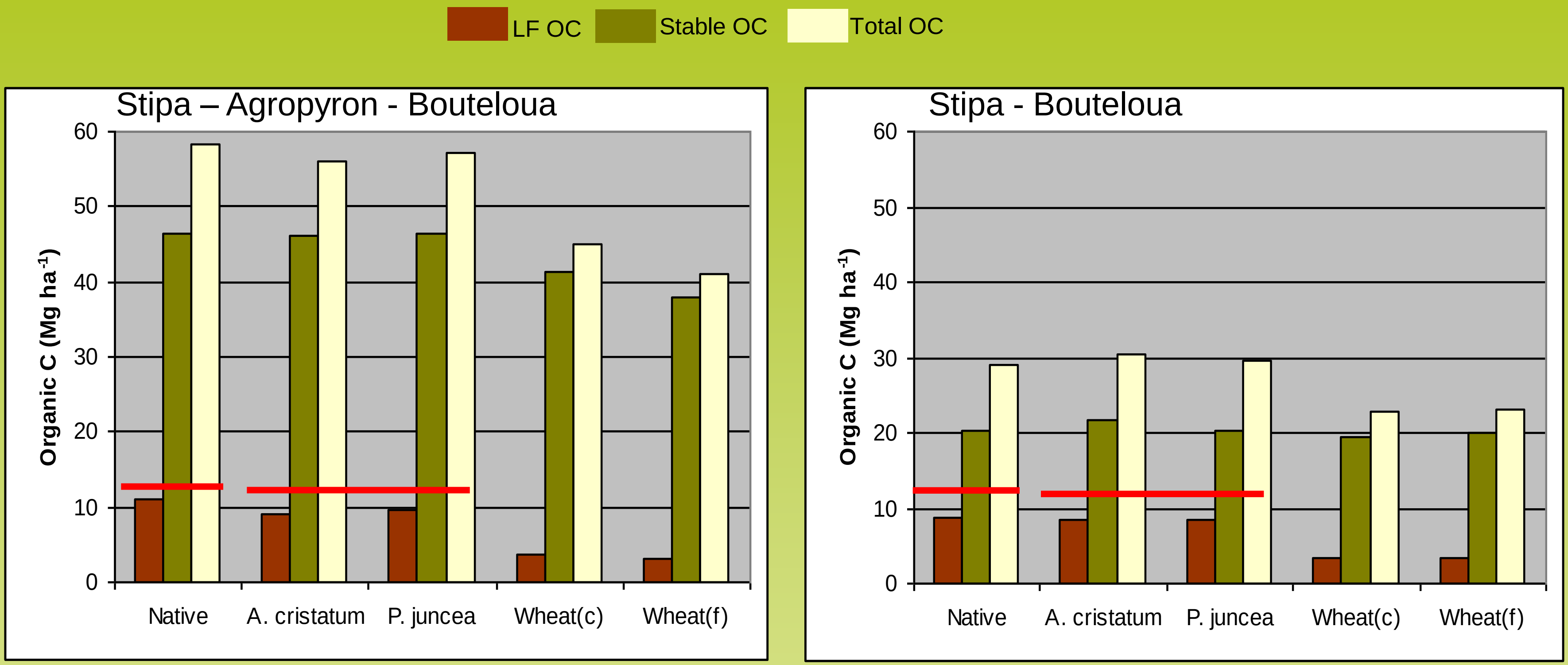

- Site differences expressed by stable fraction;
- The light fraction is almost equal between sites

# Soil organic C (light, stable and total) 13 years after establishment (0 – 15 cm)



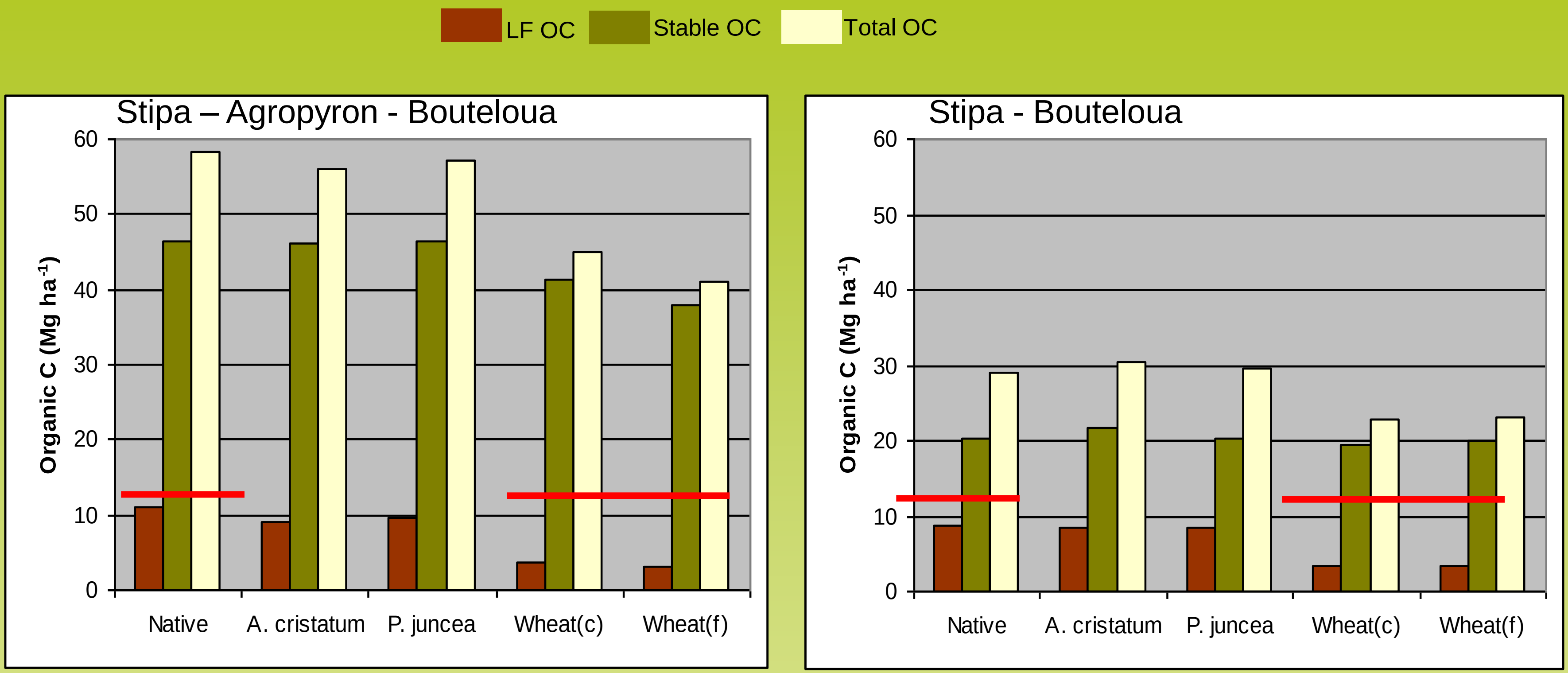

•Treatment effects were similar between sites.

# Soil organic C (light, stable and total) 13 years after establishment (0 – 15 cm)




- The perennial species had no effect on soil organic C

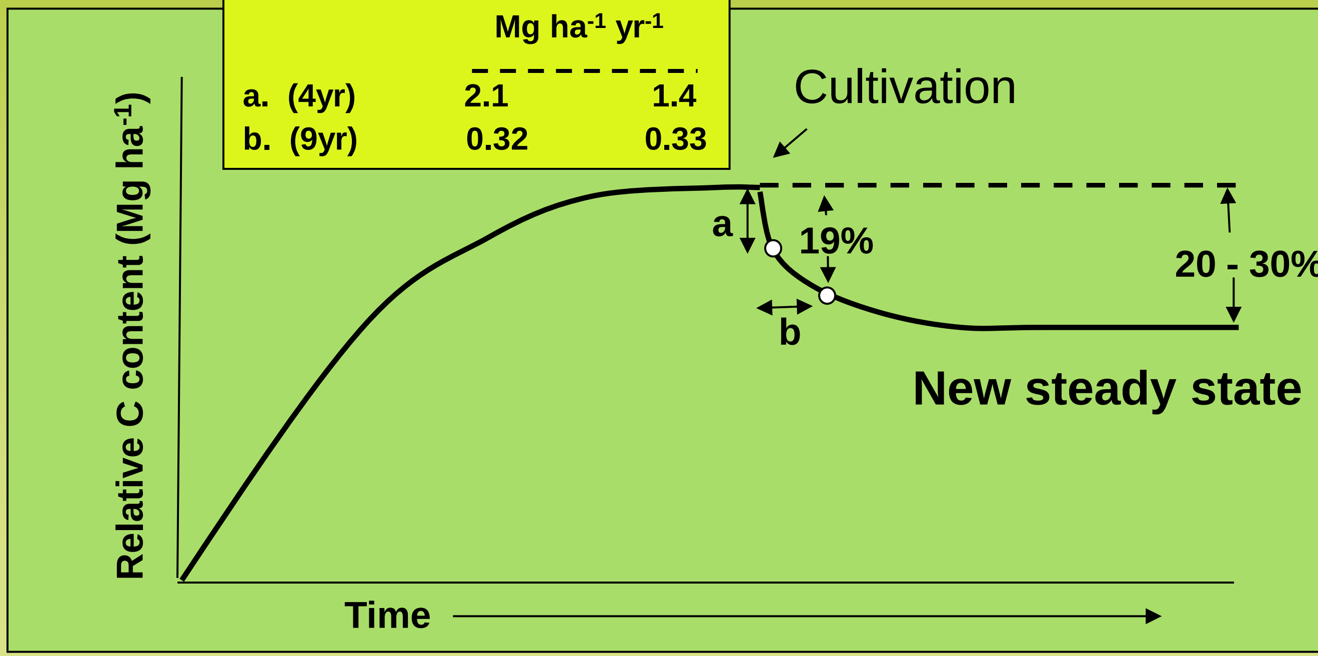
# Soil organic C (light, stable and total) 13 years after establishment (0 – 15 cm)




- Only wheat had an effect on soil organic C;
- The effect was expressed primarily in the light fraction.

# Average rate of C loss resulting from wheat cropping on two Mixed Prairie sites: Stipa – Agropyron – Bouteloua (SAB) and Stipa – Bouteloua (SB)

| Duration | SAB | SB |
|---|---|---|
| | Mg ha$^{-1}$ yr$^{-1}$ | |
| a. (4yr) | 2.1 | 1.4 |
| b. (9yr) | 0.32 | 0.33 |




Adapted from: Janzen et al. 1998. Soil and Tillage Research

## Rationalizing results with those of Dormaar et al.

Hypothesis: Dormaar’s sites lost soil organic C through erosion.
(sites were grazed by cattle, row orientation not considered)

Other factors may be present (ie sampling Ah, fenceline, reporting concentration rather than  stock)

## Observations of soil erosion from a simulated rainfall study

Soil characteristics of treatments

| Treatment | Bulk density | Water stable aggregates | Erosion (kg $ha^{-1}$) |
|---|---|---|---|
| Native | 0.72 a | 74.7 a | 41 |
| *A. cristatum* | 0.99 b | 44.4 b | 110 |
| *P. juncea* | 0.87 b | 36.1 b | 53 |

Exudates help in the formation of water stable aggregates

| | **Exudates (mg C $g^{-1}$)** |
|---|---|
| ***A. cristatum*** | **65** |
| ***A. smithii*** | **120** |
| ***B. gracilis*** | **123** |

From: Biondini et al. 1988. Soil Biol. And Biochem.

# Controlled studies to test plant-soil carbon relationships

Experiment:

a. How is soil carbon affected by monocultures of introduced and native species?

b. Do seeded mixtures of native species affect soil carbon?

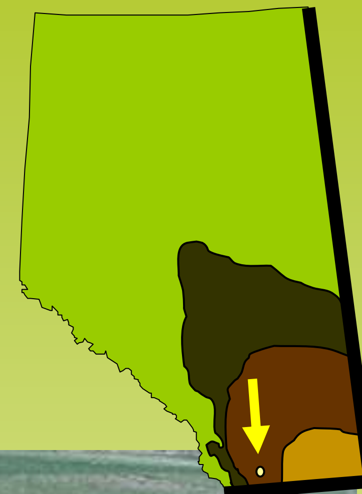
**Study characteristics:**

**•ten years (est. 1995)**

**• plot size 4 x 10 m**

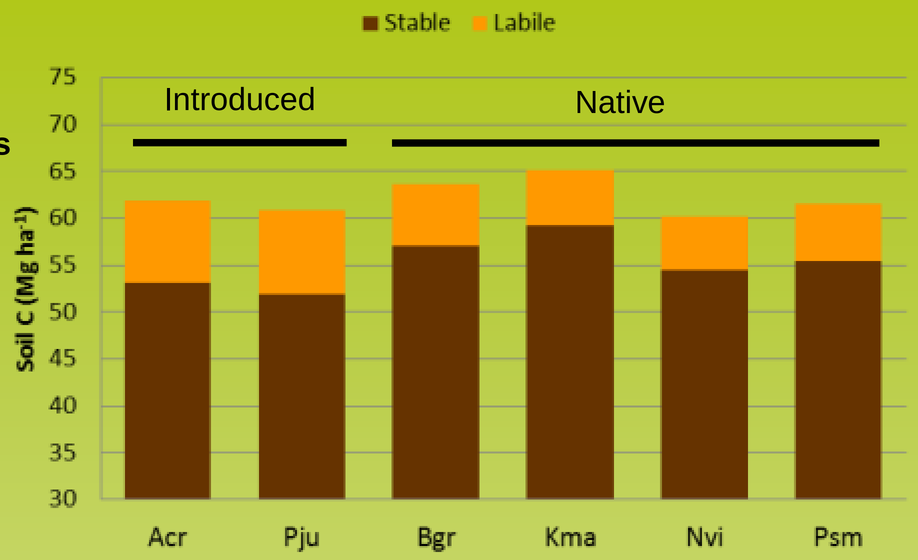
**•5 native, 2 introduced**

**•monocultures/mixtures**

**Mass-equivalent C in the stable and labile fraction (0 to 30 cm depth) on a Dark Brown Chernozemic soil.**

**Monocultures**




**<u>Contrasts:</u>**

**Monocultures: introduced vs native**

Labile fraction < 0.01
Stable fraction 0.02

**Native: monocultures vs mixtures**

<u>Bgr, Nvi vs (Bgr, Nvi)</u>
Labile fraction 0.02
Stable fraction >0.05

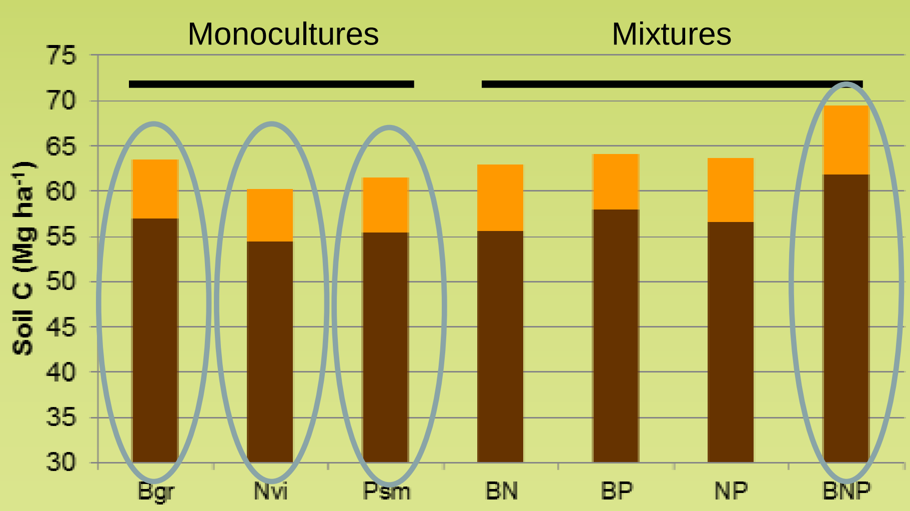
<u>Bgr, Psm vs (Bgr, Psm)</u>
Labile fraction >0.05
Stable fraction >0.05

<u>Nvi, Psm vs (Nvi, Psm)</u>
Labile fraction 0.03
Stable fraction >0.05

<u>Bgr, Nvi, Psm vs (Bgr, Nvi, Psm)</u>
Labile fraction < 0.01
Stable fraction < 0.01

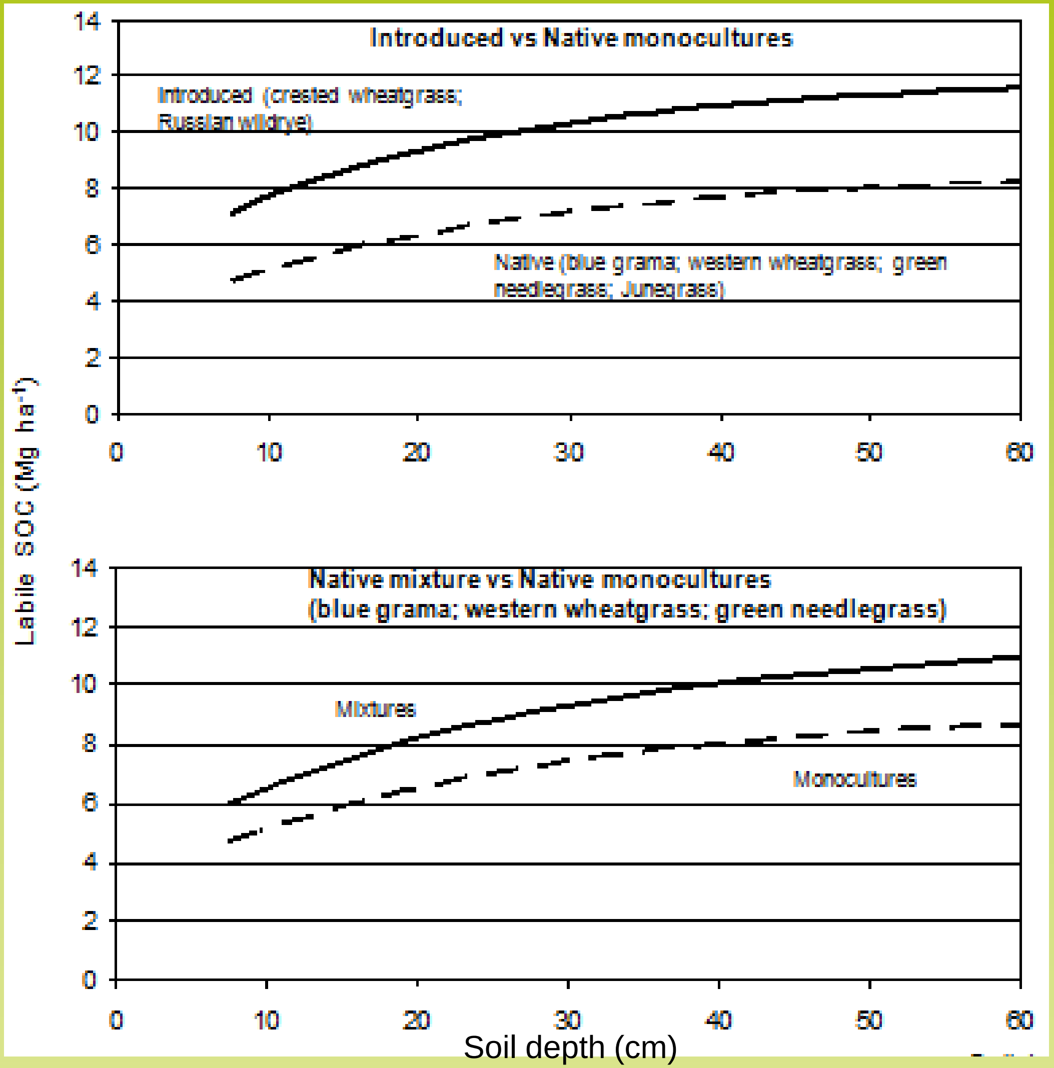
Total OC i(n all cases) >0.05

**Native**



**Labile SOC of seeded grasses in the Dark Brown Chernozemic soil 10 yrs after establishment**

Differences in labile C are determined near the surface



## Conclusions – 10 years after establishment:

- Total SOC not affected by species or mixtures;
- Introduced species yielded more labile C but less stable C;
- Native mixtures tended to yield more labile and stable C than their monocultures;
- Differences mostly expressed near the surface.

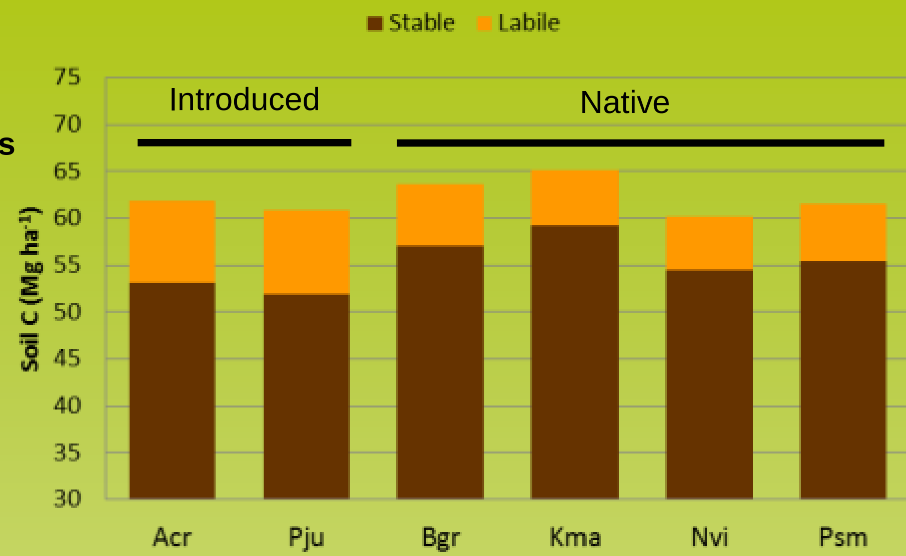
**Conclusions:**

In the Mixed Prairie:

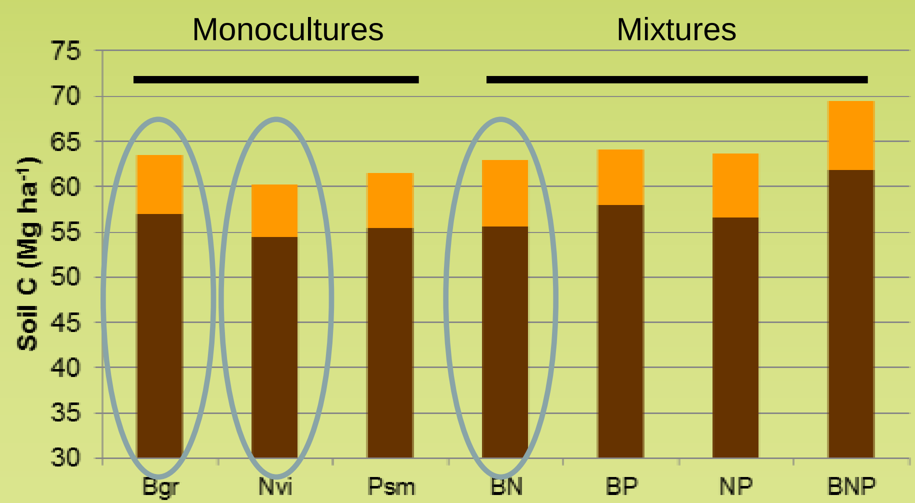
- no clear evidence that monocultures of introduced species degrades soil organic carbon;
- replacing native grasslands with introduced forages increased the risk of soil erosion without compensatory benefits;
- a monoculture provides limited management options compared with a well managed native grassland

**Mass-equivalent C in the stable and labile fraction (0 to 30 cm depth) on a Dark Brown Chernozemic soil.**

**Monocultures**




**Native**




**Contrasts:**

**Monocultures: introduced vs native**

Labile fraction <0.01
Stable fraction 0.02

**Native: monocultures vs mixtures**

Bgr, Nvi vs (Bgr, Nvi)
Labile fraction < 0.02
Stable fraction >0.05

Bgr, Psm vs (Bgr, Psm)
Labile fraction >0.05
Stable fraction >0.05

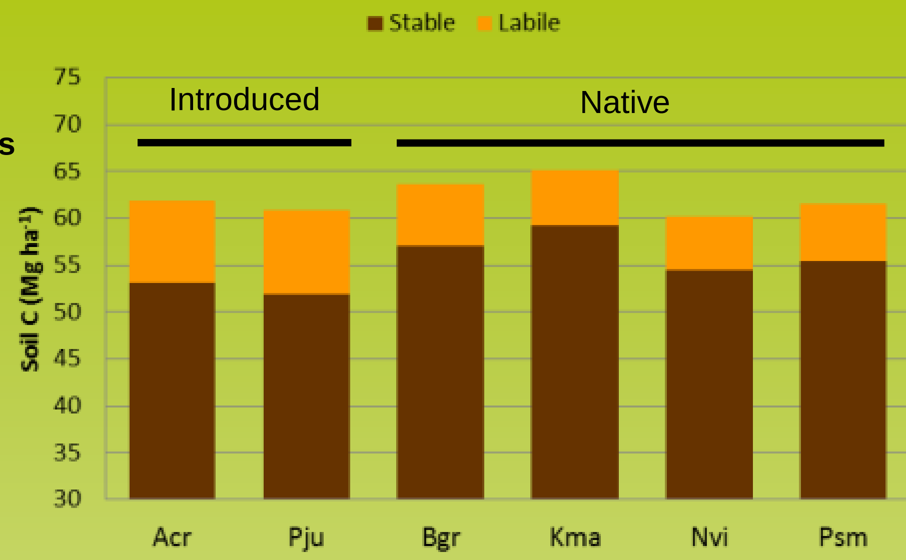
Nvi, Psm vs (Nvi, Psm)
Labile fraction 0.03
Stable fraction >0.05

Bgr, Nvi, Psm vs (Bgr, Nvi, Psm)
Labile fraction 0.01
Stable fraction 0.01

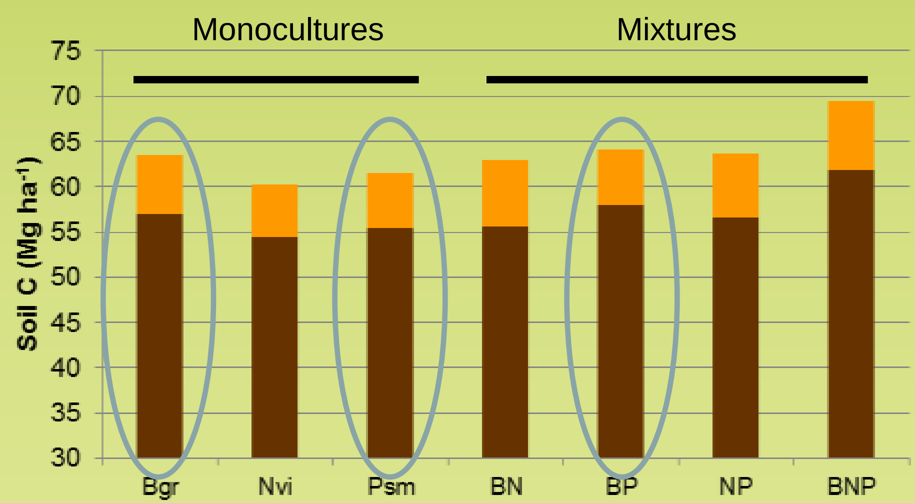
Total OC i(n all cases) >0.05

**Mass-equivalent C in the stable and labile fraction (0 to 30 cm depth) on a Dark Brown Chernozemic soil.**

**Monocultures**




**Native**




**<u>Contrasts:</u>**

**Monocultures: introduced vs native**

| | |
|---|---|
| Labile fraction | <0.01 |
| Stable fraction | 0.02 |

**Native: monocultures vs mixtures**

<u>Bgr, Nvi vs (Bgr, Nvi)</u>

| | |
|---|---|
| Labile fraction | 0.02 |
| Stable fraction | >0.05 |

<u>Bgr, Psm vs (Bgr, Psm)</u>

| | |
|---|---|
| Labile fraction | >0.05 |
| Stable fraction | >0.05 |

<u>Nvi, Psm vs (Nvi, Psm)</u>

| | |
|---|---|
| Labile fraction | 0.03 |
| Stable fraction | >0.05 |

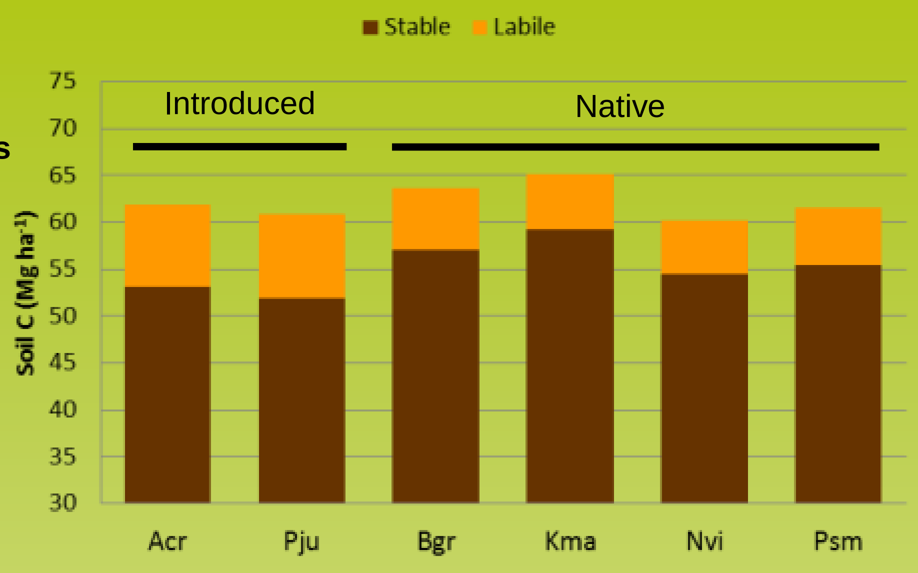
<u>Bgr, Nvi, Psm vs (Bgr, Nvi, Psm)</u>

| | |
|---|---|
| Labile fraction | 0.01 |
| Stable fraction | 0.01 |

Total OC i(n all cases) >0.05

**Mass-equivalent C in the stable and labile fraction (0 to 30 cm depth) on a Dark Brown Chernozemic soil.**

**Monocultures**




**<u>Contrasts:</u>**

**Monocultures: introduced vs native**

Labile fraction <0.01
Stable fraction 0.02

**Native: monocultures vs mixtures**

<u>Bgr, Nvi vs (Bgr, Nvi)</u>
Labile fraction 0.02
Stable fraction >0.05

<u>Bgr, Psm vs (Bgr, Psm)</u>
Labile fraction >0.05
Stable fraction >0.05

<u>Nvi, Psm vs (Nvi, Psm)</u>
Labile fraction < 0.03
Stable fraction >0.05

<u>Bgr, Nvi, Psm vs (Bgr, Nvi, Psm)</u>
Labile fraction 0.01
Stable fraction 0.01

Total OC i(n all cases) >0.05

**Native**