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The Positive Effects of Shelterbelts on C Sequestration, Biodiversity and Crop Yields

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Agriculture and Agri-Food Canada

Canada


INTERSTELLAR

April 12, 1935

The National Times

The Dust Bowl

Disaster continues in Western Canada as the Drought Worsens

The drought is continuing in western Canada and it doesn't look like it's going to end anytime soon. The dust storms are becoming more frequent and it isn't very safe for families to keep living in these conditions. Despite these unsafe circumstances many families are choosing to stay in their homes and are trying to make a living off of the infertile ground, despite the dust and disappointment.

By now almost all of the crops have been destroyed by the drought. The soil is no longer capable of sustain crops due to the lack of moisture. This issue is partially blamed on the fact that in the last decade farmers have been plowing the virgin topsoil, displacing the grasses which would keep the moisture and soil in place, even during droughts. Due to this, the soil has all completely dried out and turned to dust, and when winds blow it gets displaced.

The dust storms are completely destroying houses, leaving people both homeless and without their farms, so many farmers are choosing to leave behind their homes and look for work in the cities. Of course, the unemployment rates in cities are sky rocketing so the cities aren't helping the farmers much.

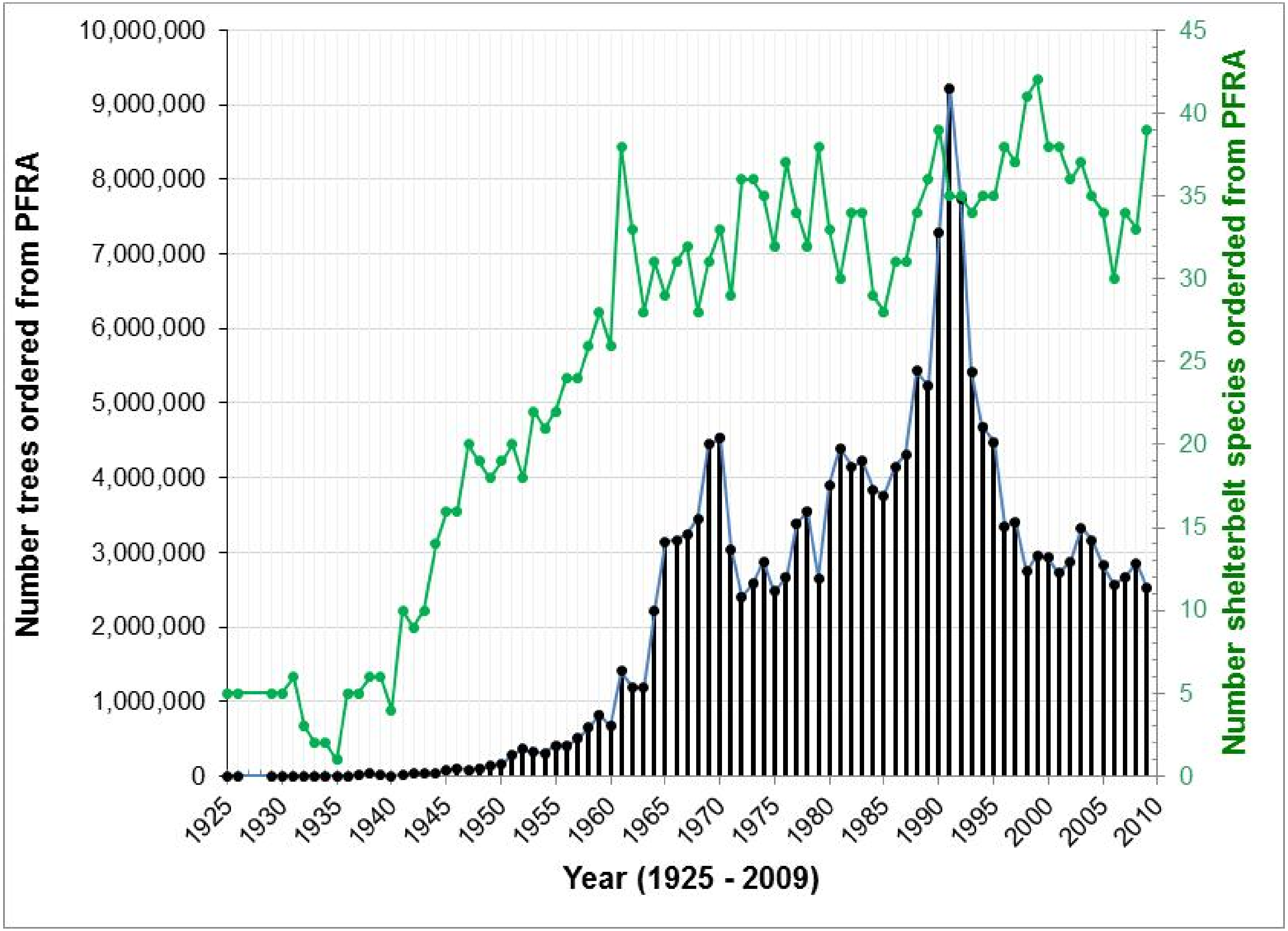
Our economy in only worsening from this natural disaster as we are quite reliant on farm exports. While Canada's economy would still be in a poor state without the drought, it's safe to say that this natural disaster is making our economic depression much worse.

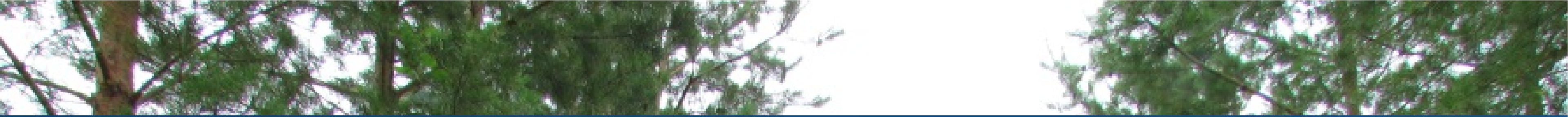
Shelterbelts in the Prairie

- **Is there a need to retain these areas?**
- **Do these areas impact crop yield and quality?**

https://www.country-guide.ca/

Annual (1925 to 2009) record of shelterbelt trees sent to farmers across Saskatchewan through the Prairie Shelterbelt Program



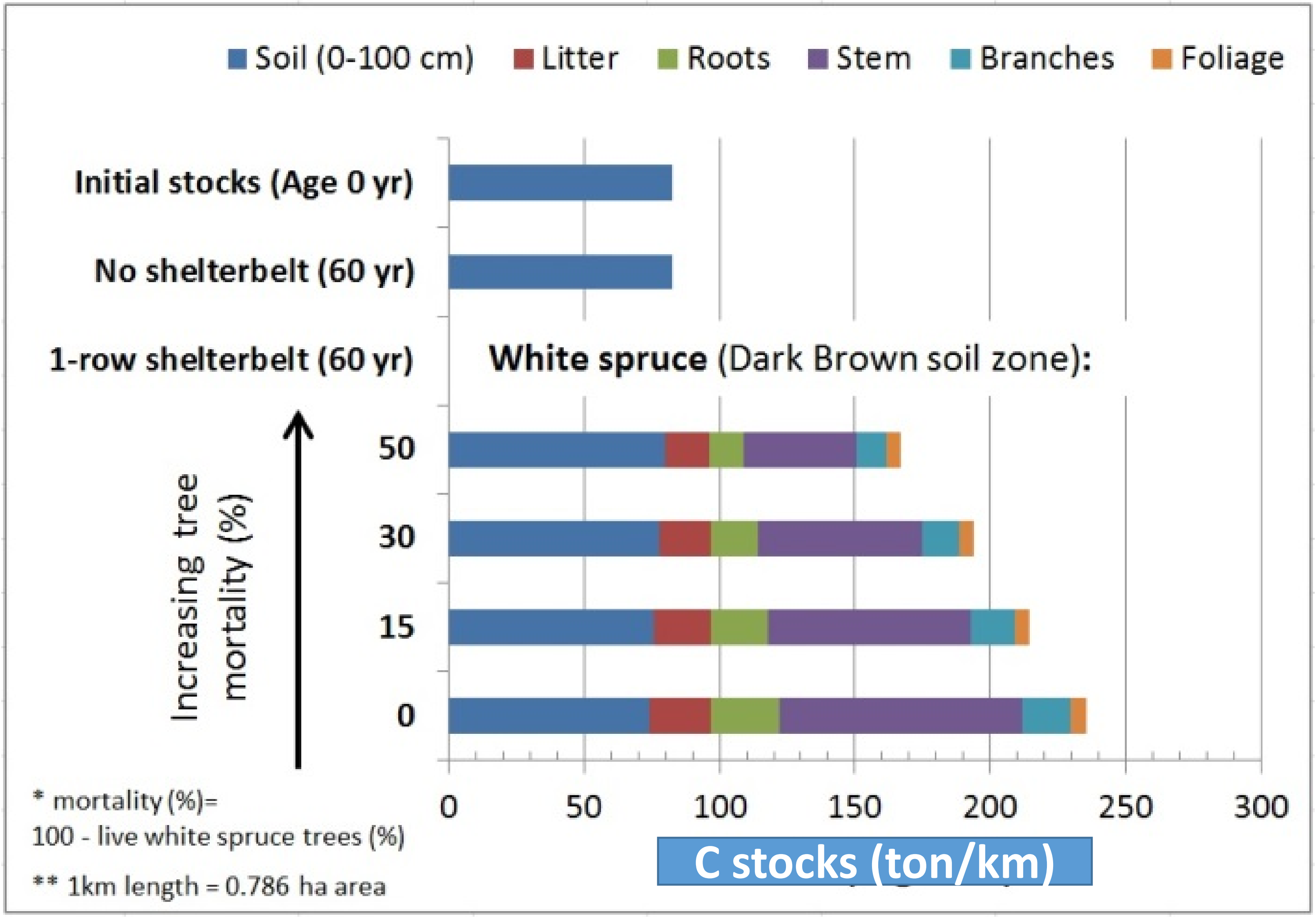


- **60,000 km Shelterbelt in SK**
- Provincial C stocks for 6 common shelterbelt species: ~11 Tg C
- Worth $600 million @ $15/ton C

Source: AAFC AGGP-1

AGGP-1

Shelterbelt C stocks by ecosystem component

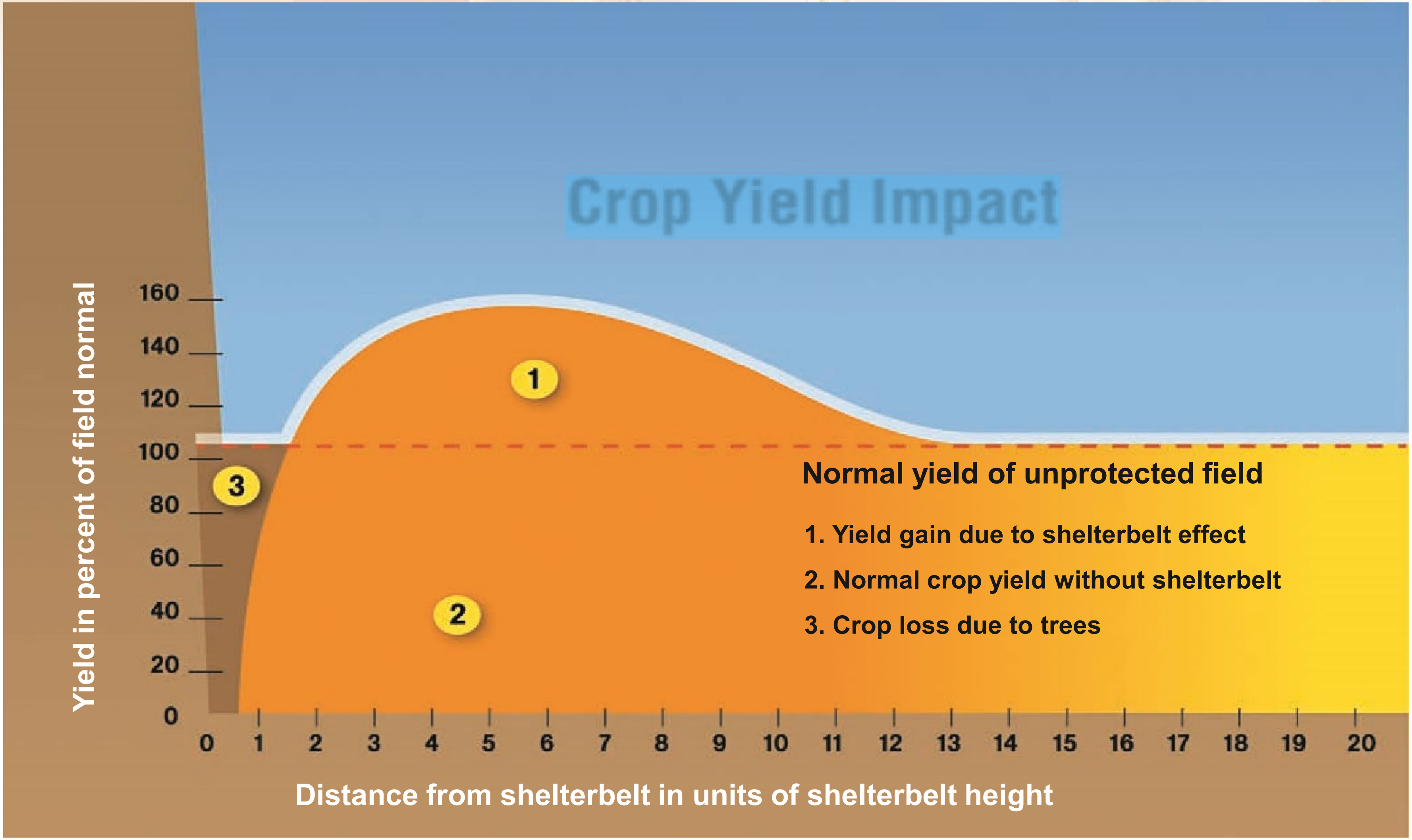


Management Support Toolbox for Carbon Sequestration Strategies Using Agroforestry Shelterbelt Systems in Saskatchewan

- **Ongoing AGGP-2 project (2017-21)**
  - Will create a farmer-oriented, **interactive toolbox (for web and smart phone use)** for practical knowledge dissemination to farmers when planting new shelterbelts or renewing existing ones.
  - Knowledge **to enhance GHG mitigation on farm land by shelterbelt establishment and using beneficial management practices;**
  - Expand the shelterbelt awareness among farmers in regard to the **carbon sequestration potential of shelterbelts,** including carbon credit analysis;
  - Assist farmers in their own **crop production and shelterbelt management operations.**

Source: AAFC AGGP-2

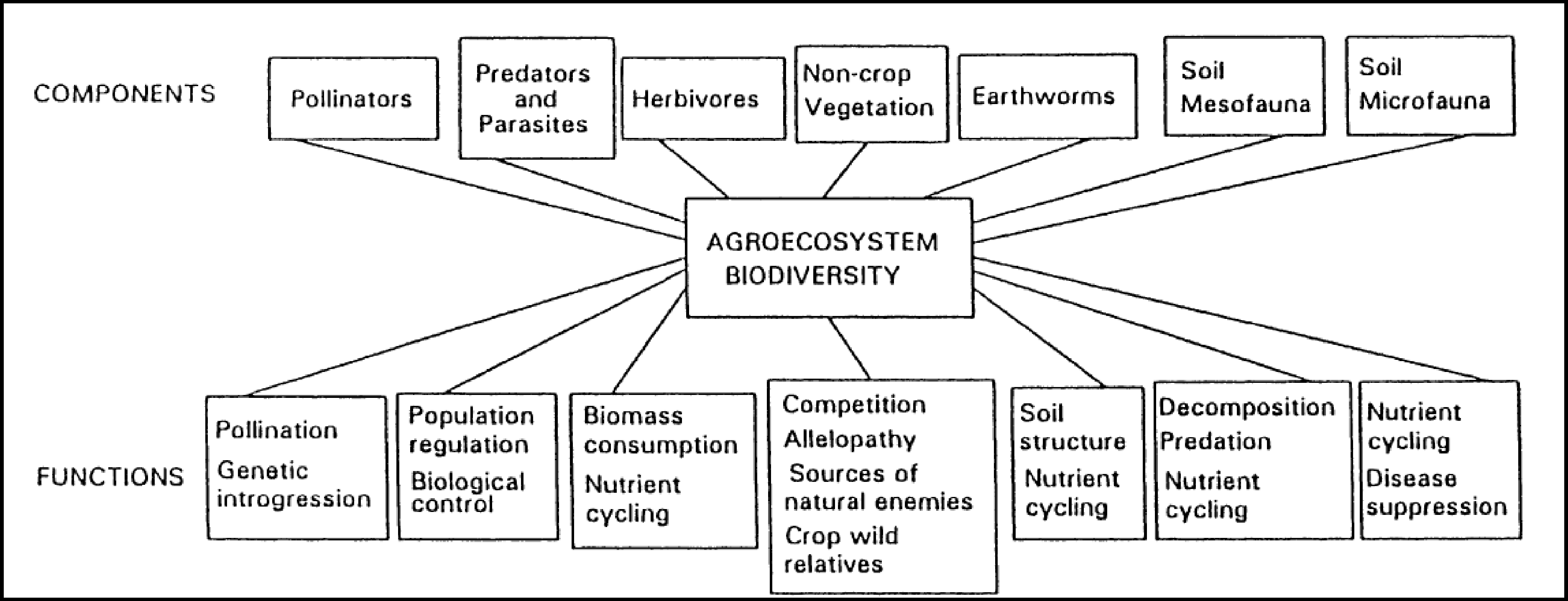
Shelterbelts and Crop Yield



Shelterbelts and Crop Yield

- 1 acre shelterbelt with a 30-year lifespan costs only $56/year
- Increase yield by 10-12% on the **15 acres that the shelterbelt affects**
- Avg. canola yield: 36 bu/acre. Shelterbelt could increase yield up to 54 bu/15 acre (at 10%)
- Net benefit: $216 (after excluding yield loss due to shelterbelt)
- Benefits outweigh the yearly cost

Shelterbelts and Agro-ecosystem



Altieri, et al., 1999

Prairie-specific information is limited on the…

- ✓ Abundance
- ✓ Diversity

- Organisms that occupy shelterbelts and other field boundaries, and
- How their presence influence biodiversity in the broader agricultural landscape

Hypothesis of the study

Non-cropped field boundaries provide a mixture of habitats that contribute to the diversity of the agro-ecosystem particularly with respect to biodiversity, pollination services, carbon sequestration and soil biological activity with minimum negative impact on adjacent crops

Objectives

1. Analyze Yield adjacent to FBH using an unmanned aerial vehicle with multispectral with RGB Sensors
2. Determine the potential benefits/risks to adjacent field crops
3. Determine the weed ecology within field boundaries and the extent of distribution of weed species into adjacent field
4. Develop design guideline and demonstrate the feasibility of constructed FBH integrated with different cropping system
5. Conduct economic and environmental analysis to determine overall benefit of FBH

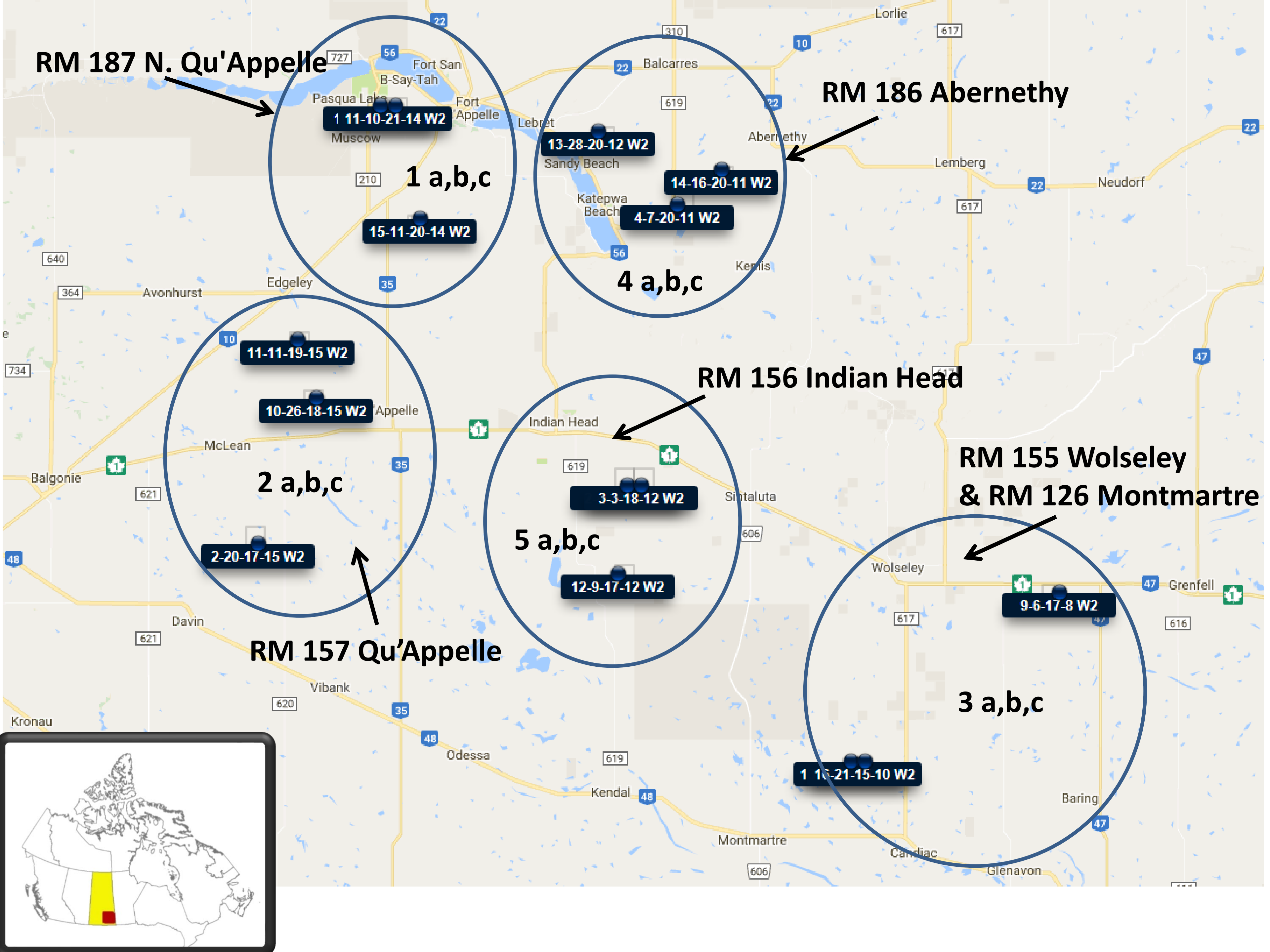
FBH (Field Boundary Habitat)

Site selection

Planted shelterbelt

Natural hedgerow

Open field


RM 187 N. Qu'Appelle
RM 186 Abernethy
RM 156 Indian Head
RM 155 Wolseley
& RM 126 Montmartre
RM 157 Qu'Appelle
1 a,b,c
4 a,b,c
2 a,b,c
5 a,b,c
3 a,b,c
1 11-10-21-14 W2
15-11-20-14 W2
13-28-20-12 W2
14-16-20-11 W2
4-7-20-11 W2
11-11-19-15 W2
10-26-18-15 W2
2-20-17-15 W2
3-3-18-12 W2
12-9-17-12 W2
9-6-17-8 W2
1 16-21-15-10 W2
Lorlie
Fort San
B-Say-Tah
Pasqua Lake
Fort Appelle
Muscow
Lebret
Balcarres
Sandy Beach
Katepwa Beach
Lemberg
Neudorf
Edgeley
Avonhurst
Balgonie
McLean
Indian Head
Wolseley
Grenfell
Davin
Vibank
Kronau
Odessa
Kendal
Montmartre
Baring
Glenavon

- Canola - an economically important crop in Canada
- Largest area of crop planted in 2017 with 9.3m ha of planted in 2017

Source: Canola Council of Canada (www.canolacouncil.org)

Objective 1

Analyze Yield adjacent to FBH using an unmanned aerial vehicle with multispectral with RGB Sensors

Collaborator:
Kim Hodge, AAFC

- How can we develop tools, processes, algorithms, methods for agricultural producers to utilize UAV-derived data to improve their production
- Influence of trees/shelterbelts on canola yield






Field Boundary Habitats Data Collection Points – Planted & Native

(Open field is the same without trees)

= Drone Targets

= Yield Sampling Points

<u>Sampling #s/site x 15 sites:</u>

Yield: 15 x 15 = 225 x1

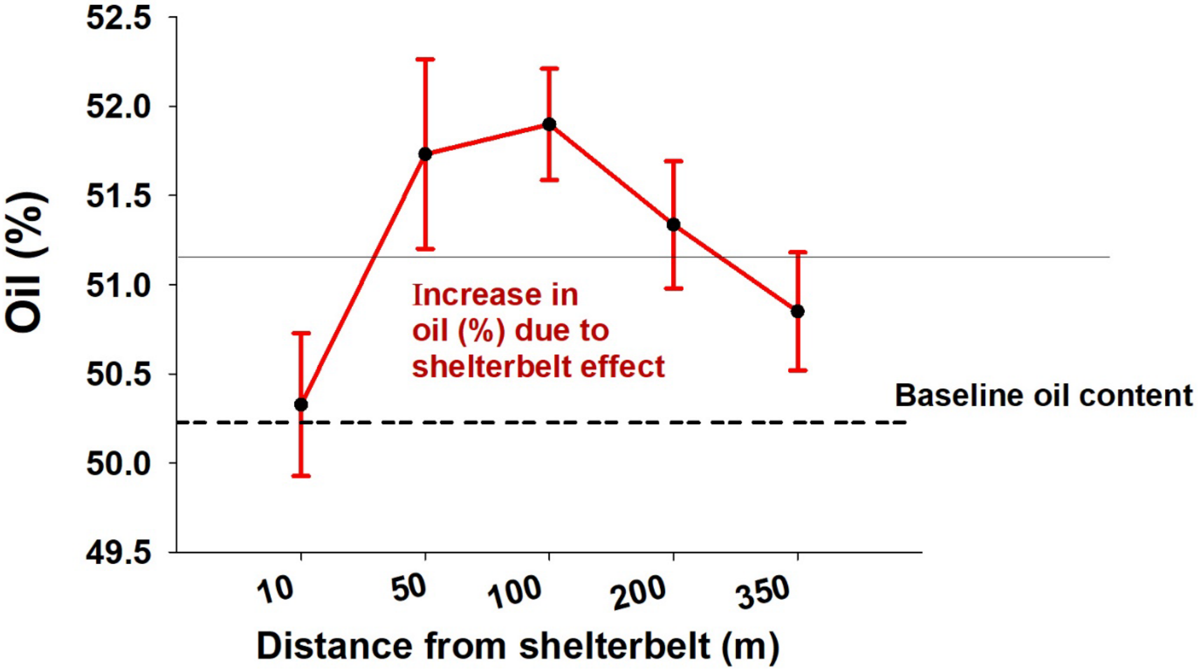
Results (Includes only 3 sites out of 15, 2017 year)

	Yield (t/ha) totals from 3 transects		
Distance from Shelterbelt	4A Planted	4B Natural	4C Control
10m	8.6	10.4	7.7
50m	8.7	7.6	7.9
100m	8.8	8.2	7.5
200m	8.4	9.1	8.4
350m	8.7	7.9	10.1
Total Yield along Transect	43.2	43.2	41.6

Results – oil production

(based on 2017 sites data)

Shelterbelt site



Oil production

Shelterbelt sites: 1321.22 kg/ha

Open field sites: 1286.12 kg/ha

2.7% increase in yield in terms of oil production

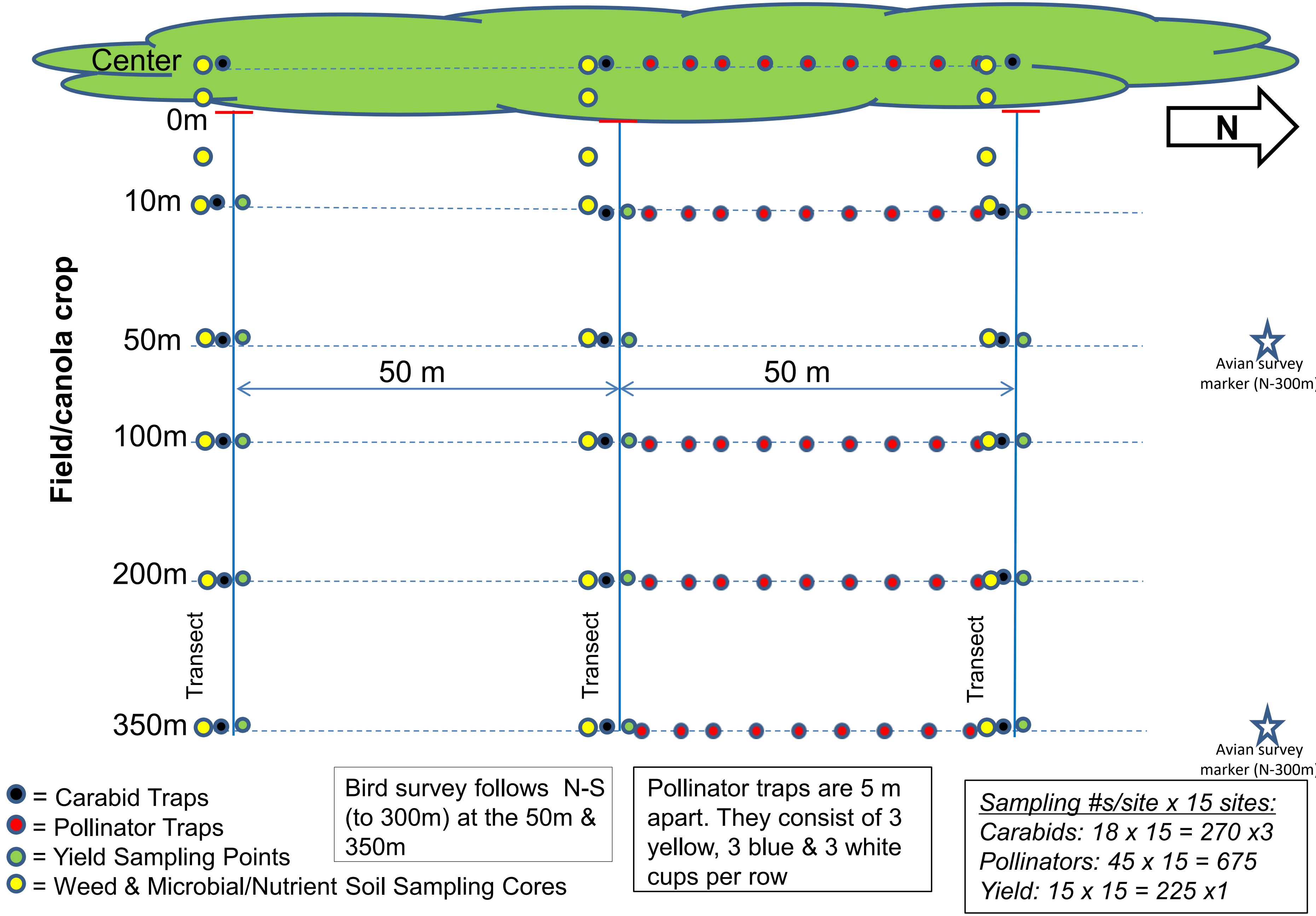
Objective 2

Determine the **potential benefits/risks** to adjacent field crops

- **Pollinators**
- **Carabids beetles**
- **Soil microbes, Nutrients**
- **Bird survey**

Field Boundary Habitats Data Collection Points – Planted & Native

(Check is the same except with 'no Center' collection points & collection at the '0m')



Objective 2

Determine the **potential benefits/risks** to adjacent field crops

Crop pollination

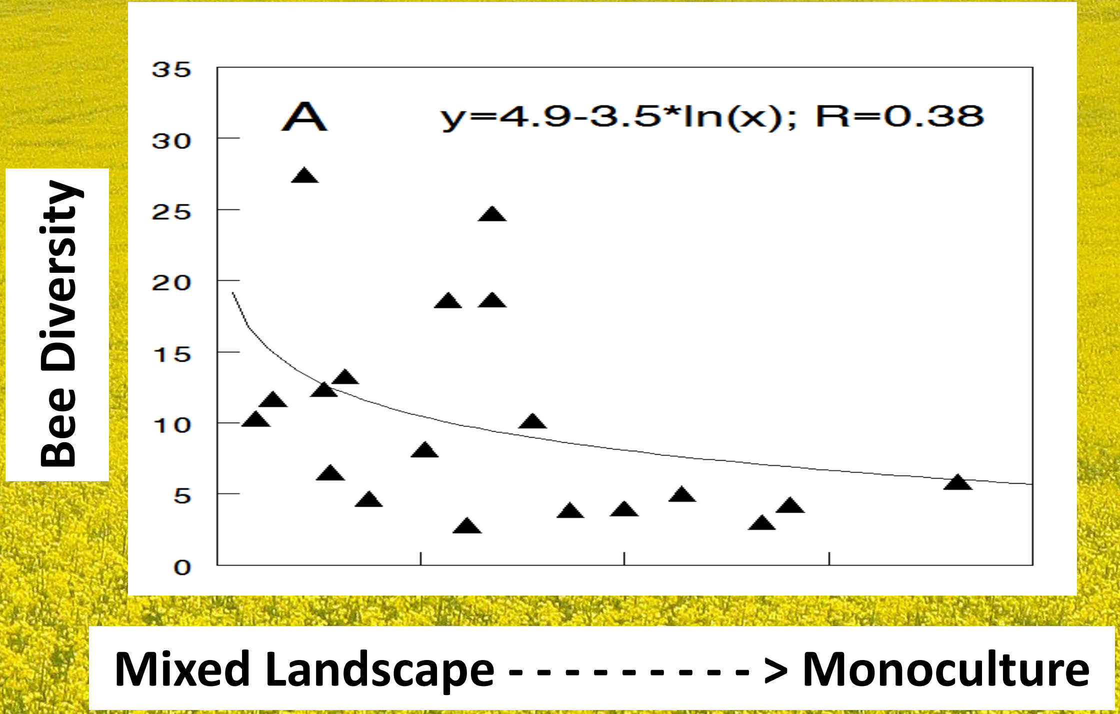
Dr. Cory Sheffield, Royal Saskatchewan Museum





Bee Communities in Landscapes

- Bee abundance and diversity is typically higher near field edges with natural borders



Solitary bees are small-bodied and typically do not travel far from the nest

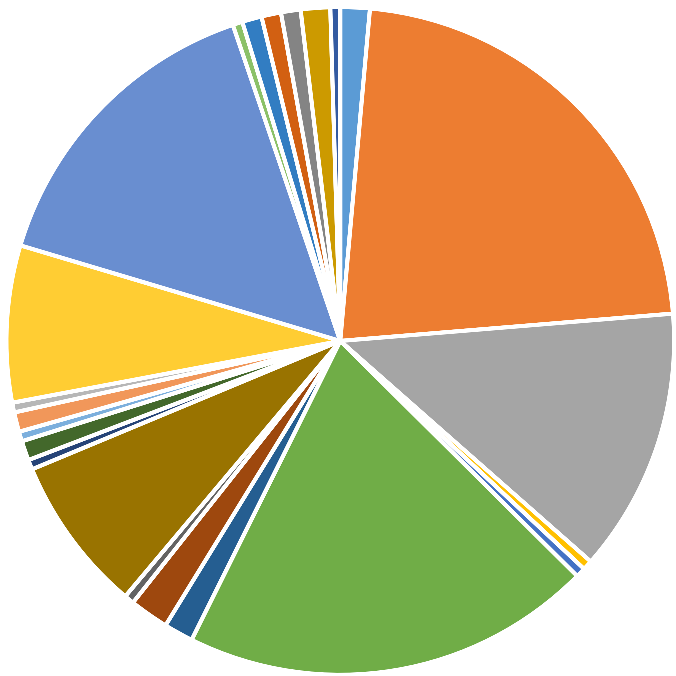
Social bees are larger-bodied and can travel much greater distances from a nest or colony

Bumble bees (*Bombus*); Honey bee (*Apis*)

Bombus rufocinctus (image credit: L.R. Best; Paul Galpern, U of Calgary)

Consider Bee Body Size and Foraging Distance

Relative Proportions of Bee Species in FBH Project (so far…)

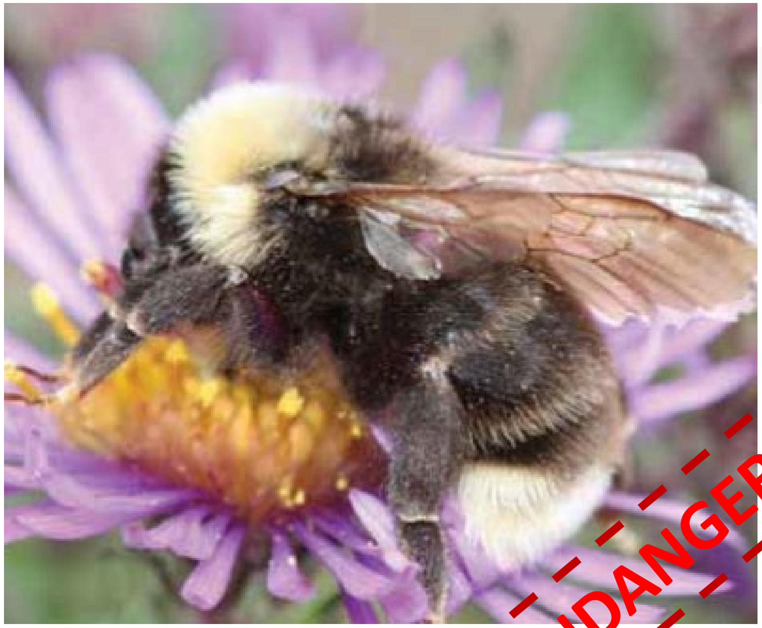


Very Preliminary Patterns

- The majority of species are solitary ground nesting species
  - Found at all distances (FHB-200m)
- The few cavity nesting species (i.e., some leafcutter bees, mason bees) tend to be at FHB
- A few oligolectic species (i.e., species that specialize on a narrow range of non-crop plants)
- Which are the canola pollinators?

Bombus terricola

Bombus bohemicus



Canada

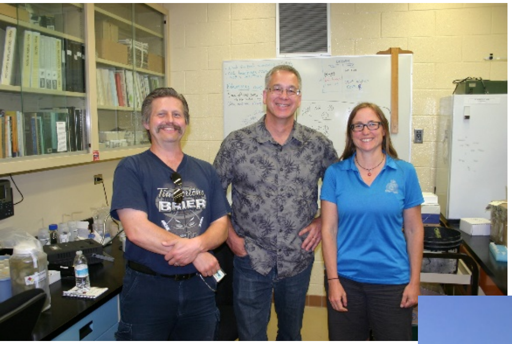
Species At Risk Act
May 2018

<u>Image credits (L to R)</u>
S. Johnson, COSEWIC
Paul Galpern, U of Calgary

Objective 2

Determine the **potential risk/benefits** to adjacent field crops

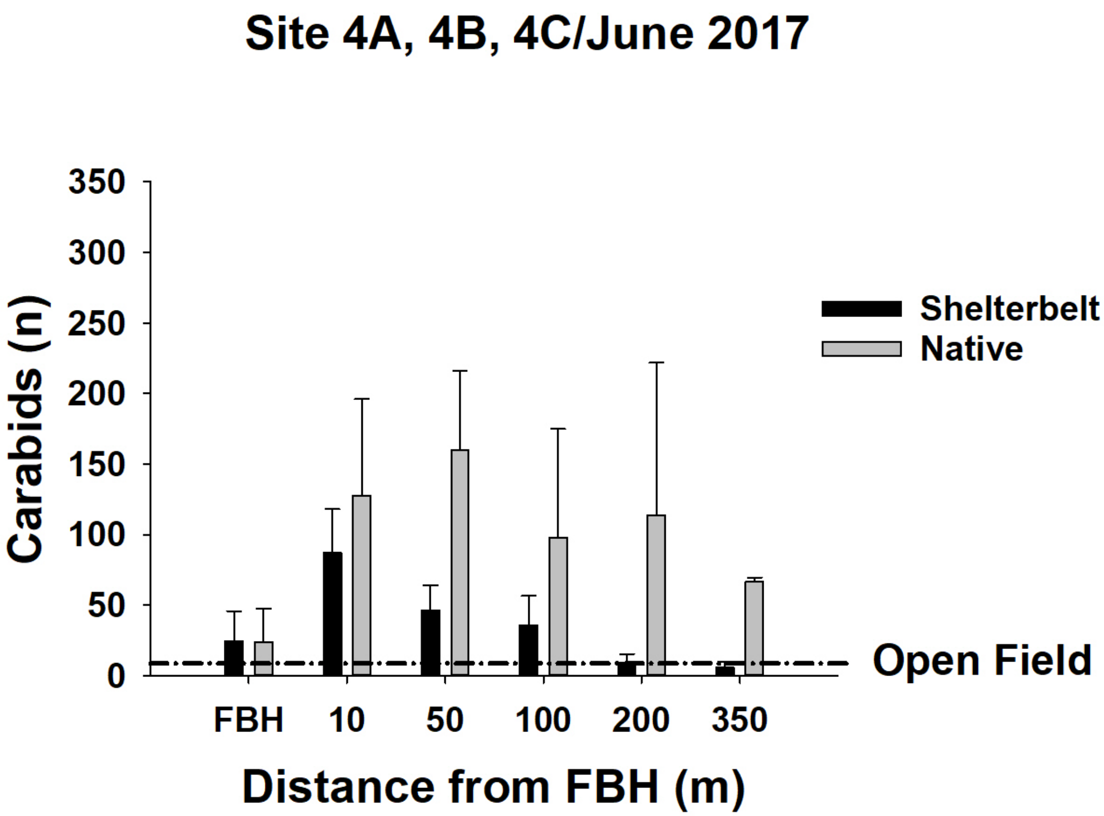
Carabids



Objective 2

Determine the **potential risk/benefits** to adjacent field crops

Carabids



Objective 2

Determine the **potential benefits/risk** to adjacent field crops

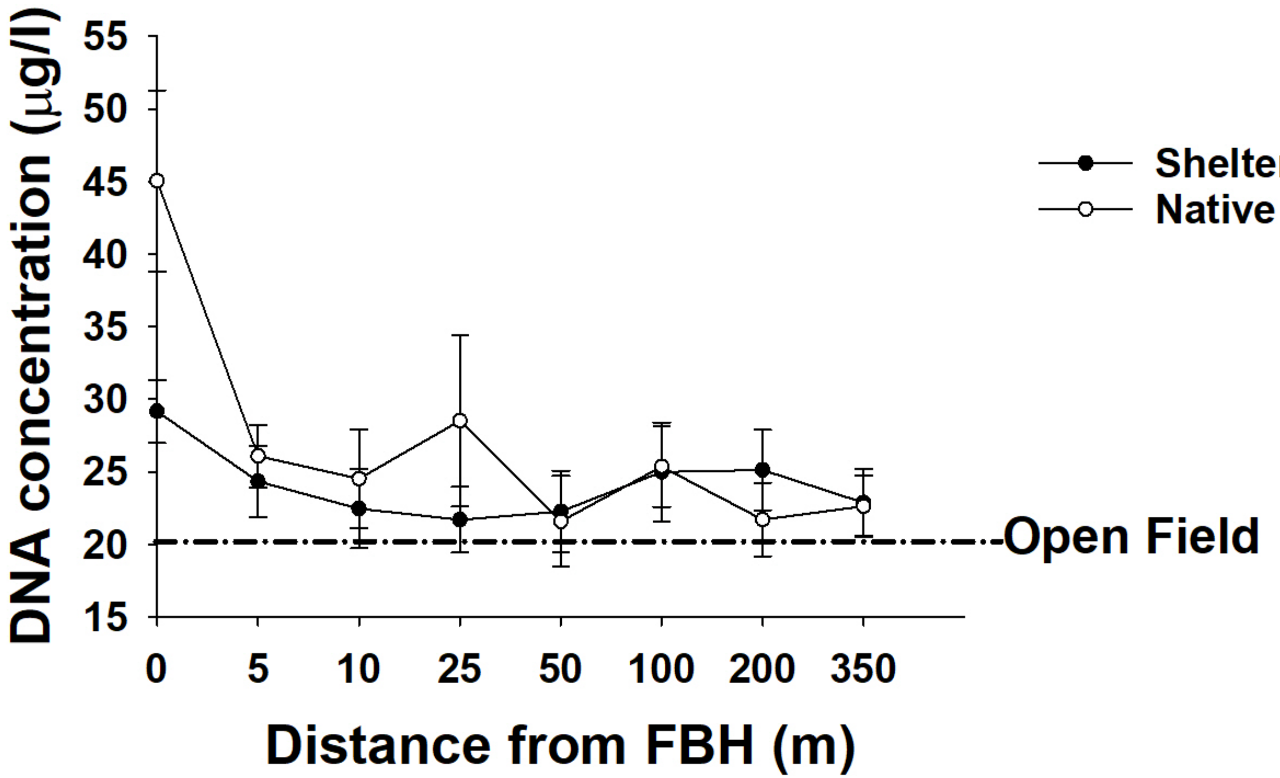
Soil Microbes, Nutrients

- Microbial biomass and sequencing
- Macro- and micro-nutrient suite

Objective 2

Determine the **potential benefits/risk** to adjacent field crops

Soil Microbes



Objective 2

Determine the **potential benefits/risks** to adjacent field crops

Bird survey







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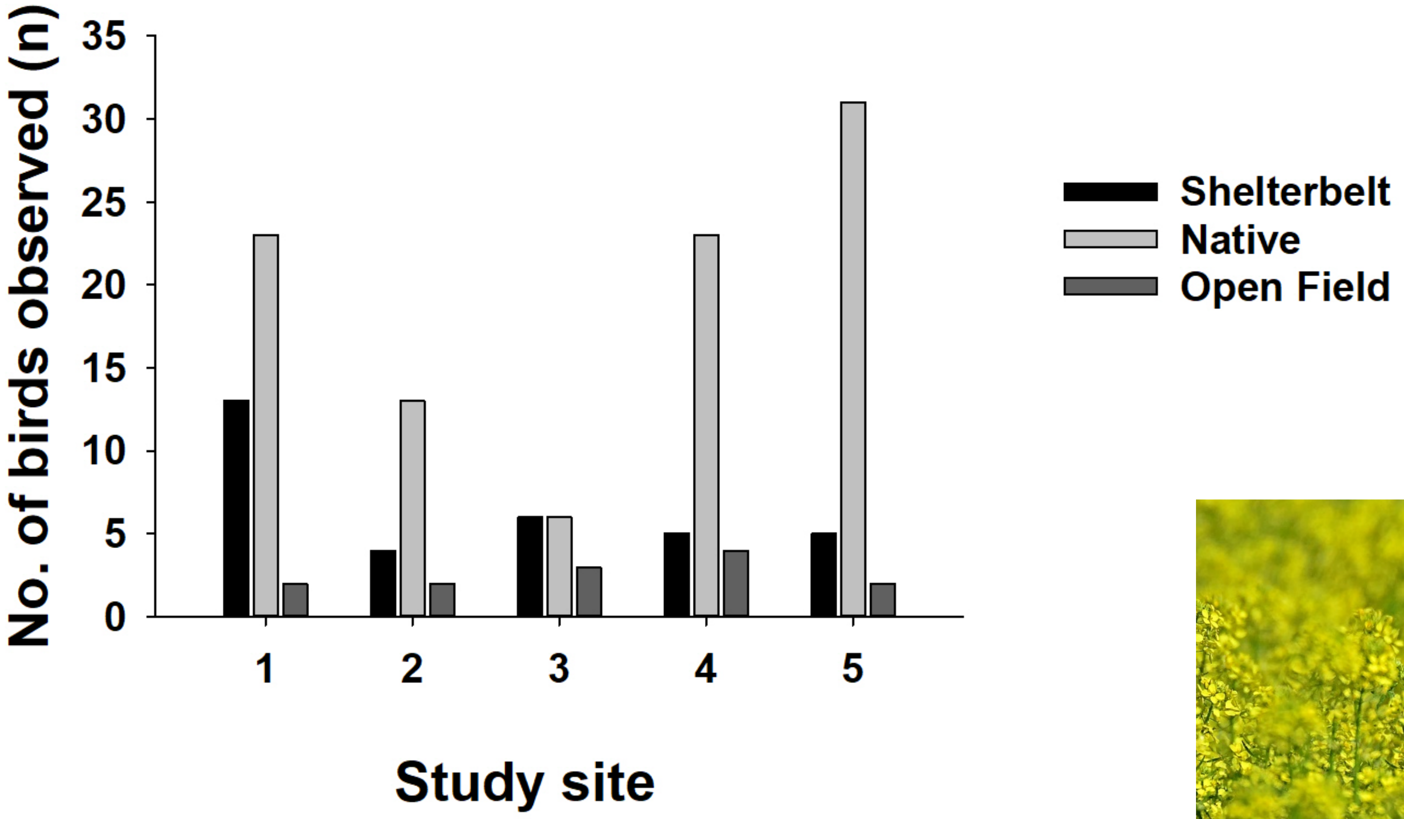
Determine the **potential benefits/risks** to adjacent field crops

Bird survey



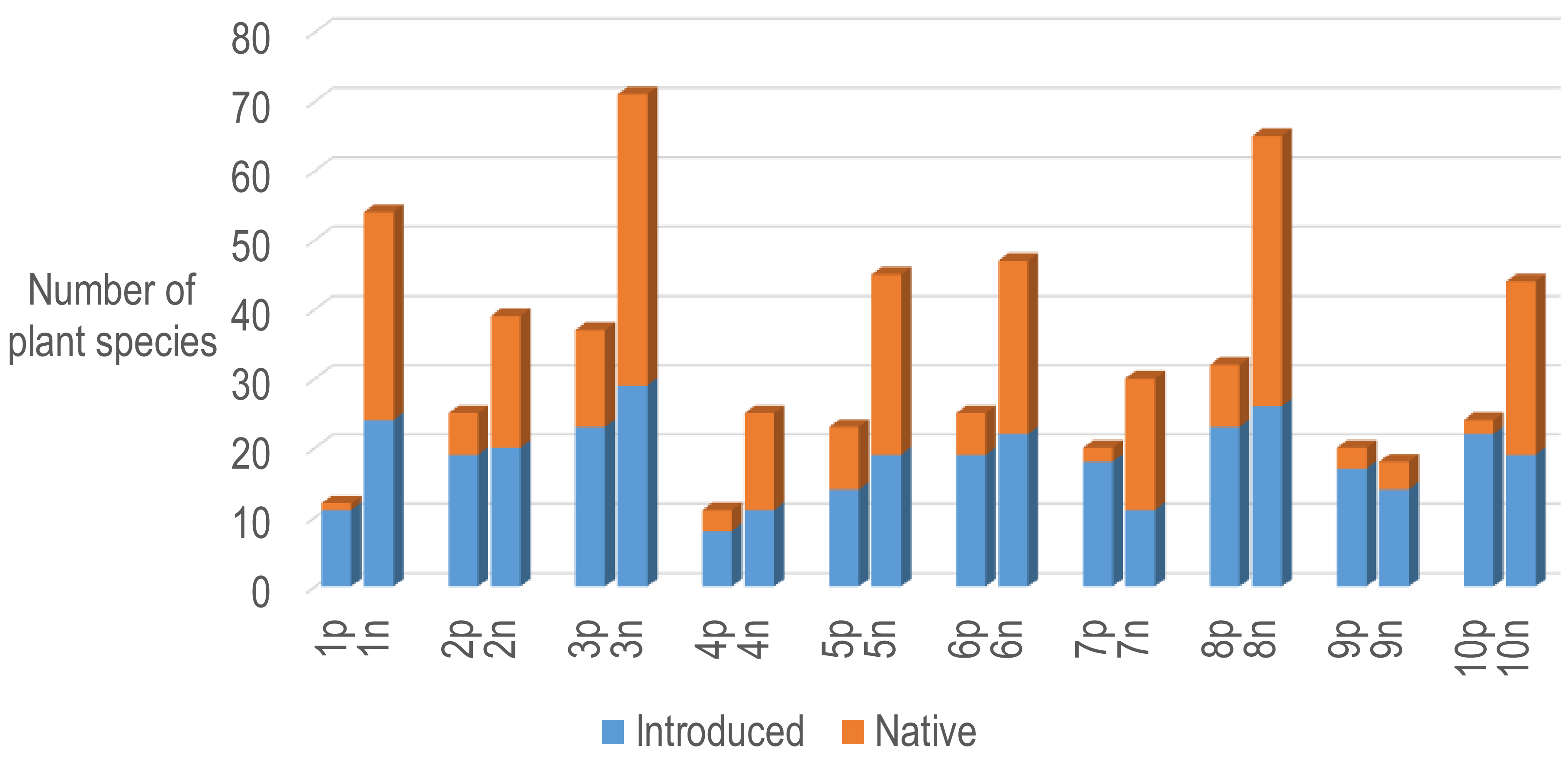
Objective 3

Determine the **weed ecology** within field boundaries and the extent of distribution of weed species into adjacent field

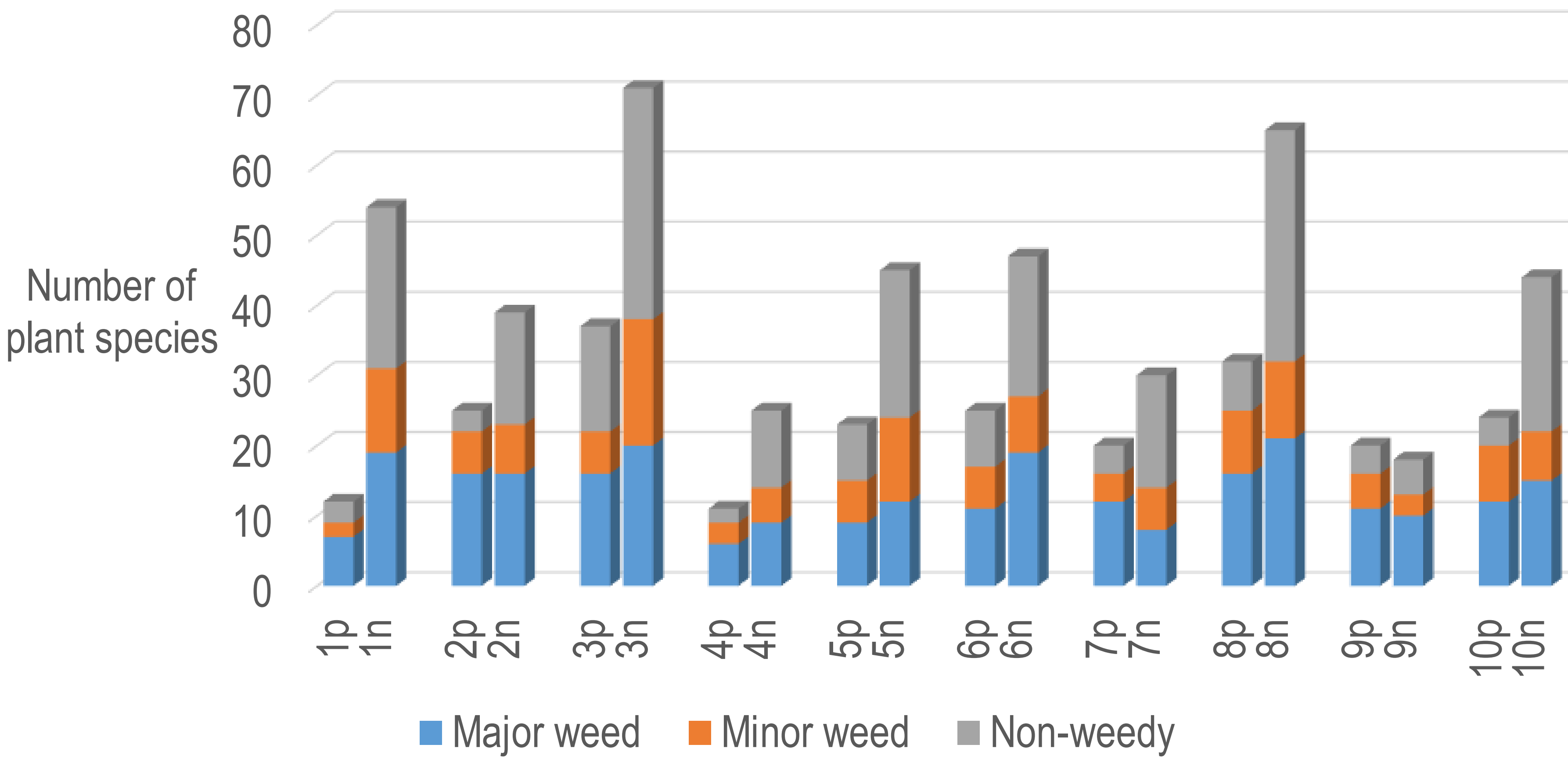
Collaborator: Julia Leeson, AAFC Saskatoon

1. **Vegetation survey to characterize field boundaries**
2. **Vegetation survey along transects to determine the impact of distance from boundary on vegetation in the canola crop**
3. **Seedbank survey along transects to determine the potential impact of the field boundary on weeds**

Vegetation Survey – Boundary



Vegetation Survey – Boundary



Seedbank – Soil cores

Seedbank – Greenhouse

Objective 4

Develop **design guideline** and demonstrate the feasibility of constructed FBH integrated with different cropping system

Alley Cropping using Shrubs to Promote Ecological Diversity in an Agricultural Production System

Buffaloberry

Seabuckthorn


Indian Head, SK 2016


Brandon, MB 2015

Data Collection – bio-physical interactions

- Yield
- Carabids (ground beetles)
- Leafcutter bee cell construction & leaf observations
- Soil temperature
- Baseline Soil nutrients
- Weather station
- Tree biometrics/measurements
- Native pollinators
- Soil Microbes
- Soil GHG

LeafCutter Bees


© 2008 Peter O

Shrub Measurements

Objective 5

Conduct **economic and environmental analysis** to determine overall benefit of FBH

Collaborator:

Dr. Edmund Mupondwa, Bio-economist, AAFC Saskatoon

- Crop yield and quality (oil content, disease severity)
- Economic and environmental analysis

Economic Farm Inputs
Conventional vs Non-conventional

INPUTS

- Seed
- Fertilizer
- Herbicides
- Insecticides
- Fungicides
- Machinery
- Labour

OUTPUTS

CROP YIELD

$ per Tonne

Modified Economic Production System
Conventional vs Non-Market Inputs

INPUTS

- Seed
- Fertilizer
- Herbicides
- Insecticides
- Fungicides
- Machinery
- Labour

- Pollinators
- Other beneficials
- Biodiversity
- Soil resources
- Other ESS

Non-Market Goods provided by Agriculture

OUTPUTS

CROP YIELD

xply
$ per Tonne

Can the value of Ecosystem Services be estimated? What do past studies show?

Example: Pollinators

- Honey bees are the most economically valuable pollinator worldwide
- Many high-value crops such as almonds and broccoli are entirely reliant upon pollination services
- Of the 100 crops that provide 90 percent of the world's food, over 70 are pollinated by bees
- Globally, 9.5% of the total economic value of agricultural production for human consumption comes from insect pollination
- Approx $200 billion

Can the value of ESS be estimated? What do past studies show?

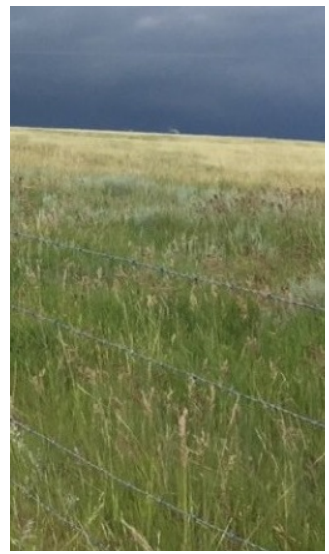
- Example: Pollinators
- Honey bees are estimated to be responsible for about half of the pollination that makes the production of hybrid canola seed possible (with alfalfa leafcutter bees primarily responsible for the other half).
- Total farm cash receipts for producers of canola were $7.3 billion in 2013.
- If honey bees are credited with making 50% of the production of canola seed possible (for a contributed value $3.66 billion).

Non-farmed spaces as habitat for beneficial insects

stream margins

field margins

wetlands



perennial grassland

in the crop?

Image credit: Paul Galpern, U of Calgary

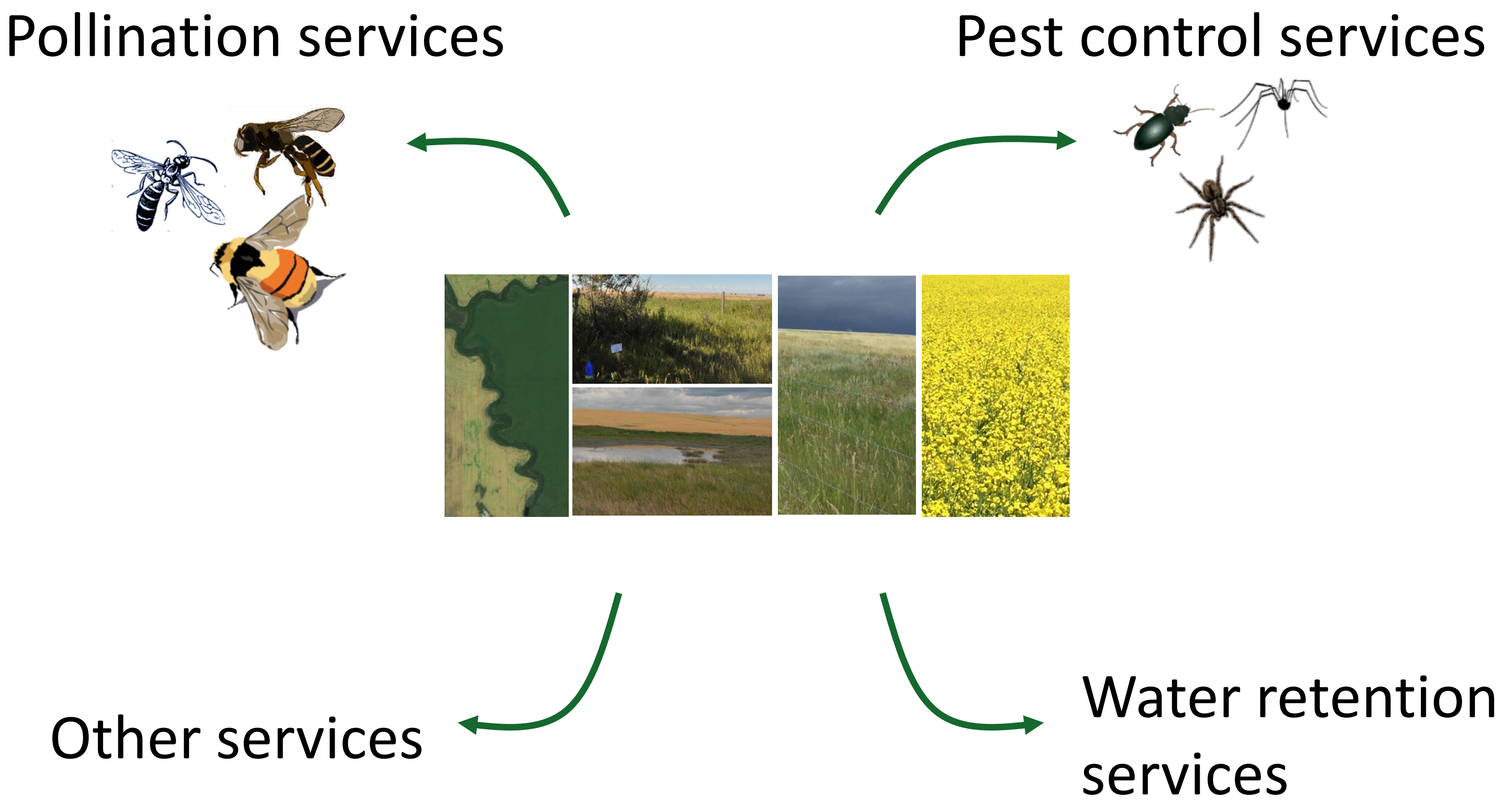
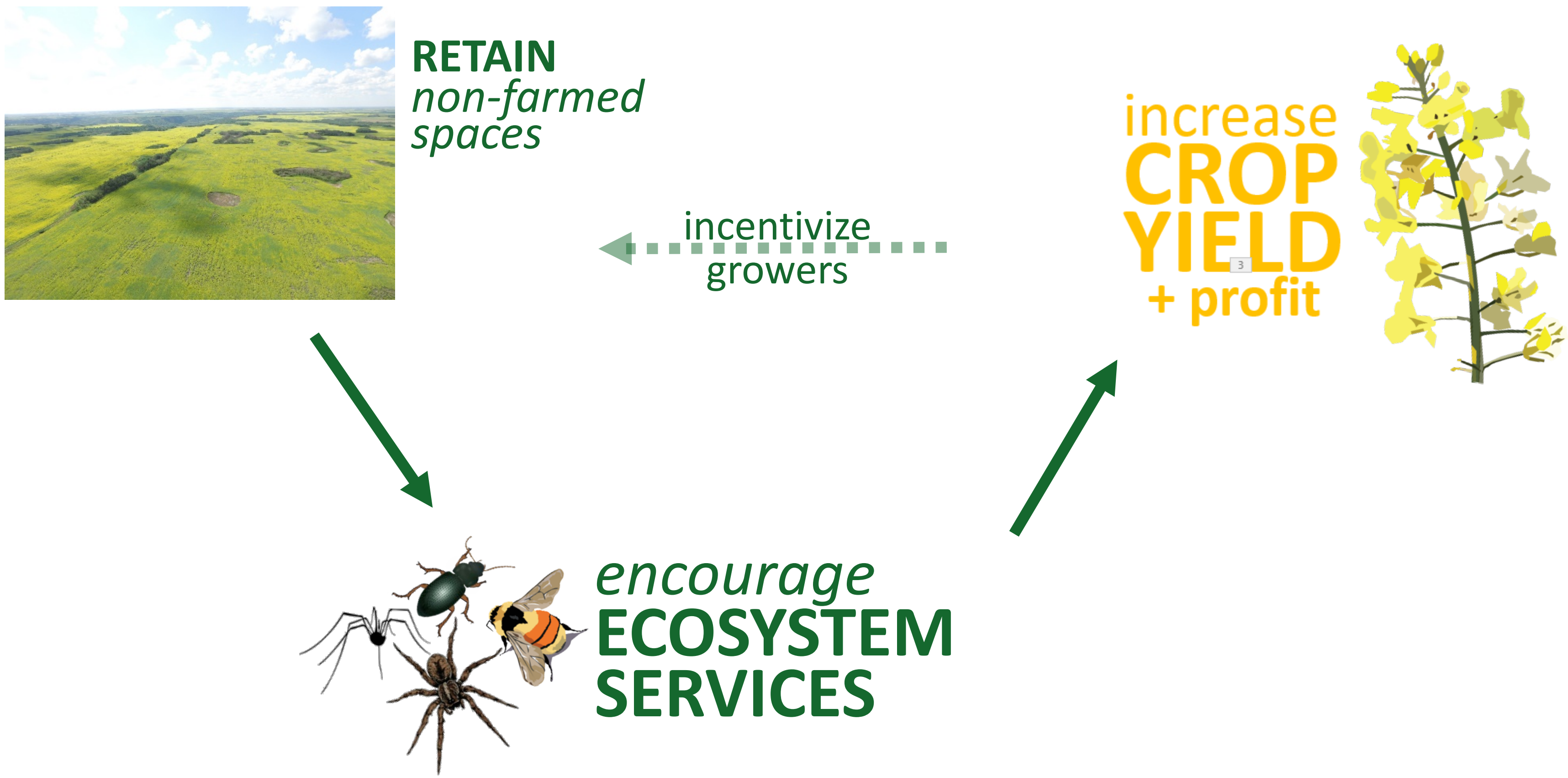


Image credit: Paul Galpern, U of Calgary


RETAIN
non-farmed
spaces
incentivize
growers
increase
CROP
YIELD
+ profit
encourage
ECOSYSTEM
SERVICES

Acknowledgements – Project Collaborators

Luke Bainard's – Soil Microbial team

Kim Hodge – Drone/geomatics

Bill Bristol – Bird survey

Julia Leeson's - Weed ecology team

Tricia Ward – Disease survey

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