BEE POLLINATOR HEALTH: A COMPLEX AND MULTI-FACETED ISSUE

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ses
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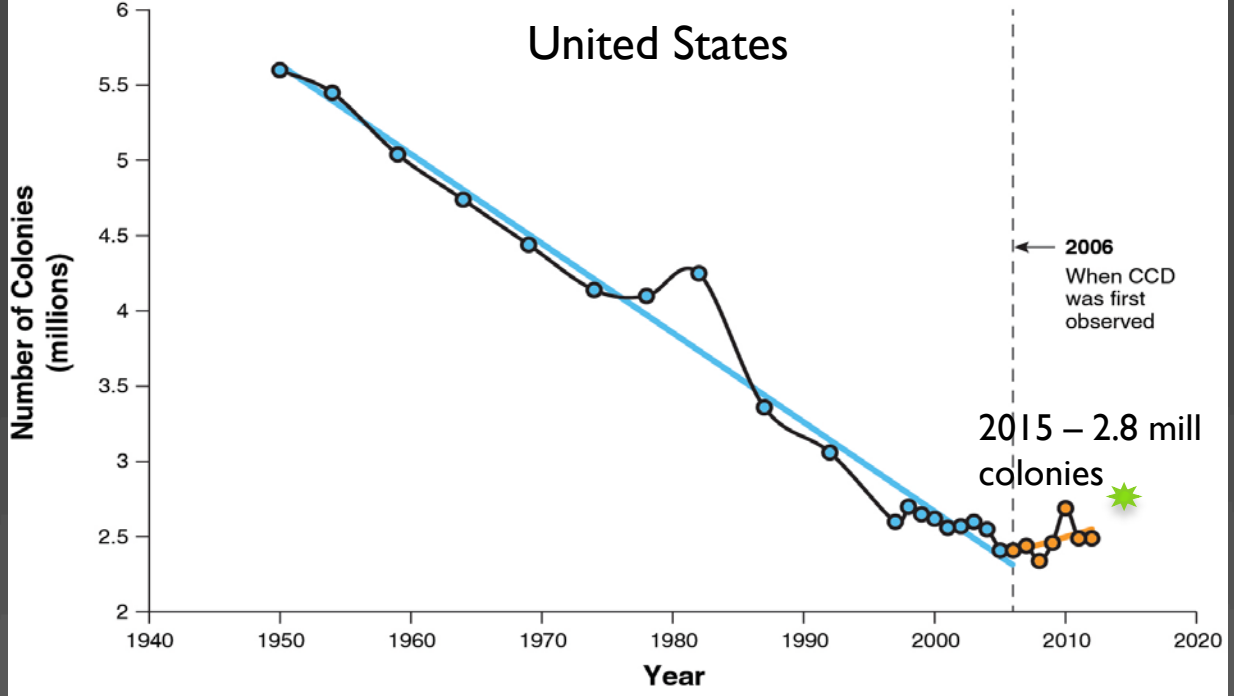
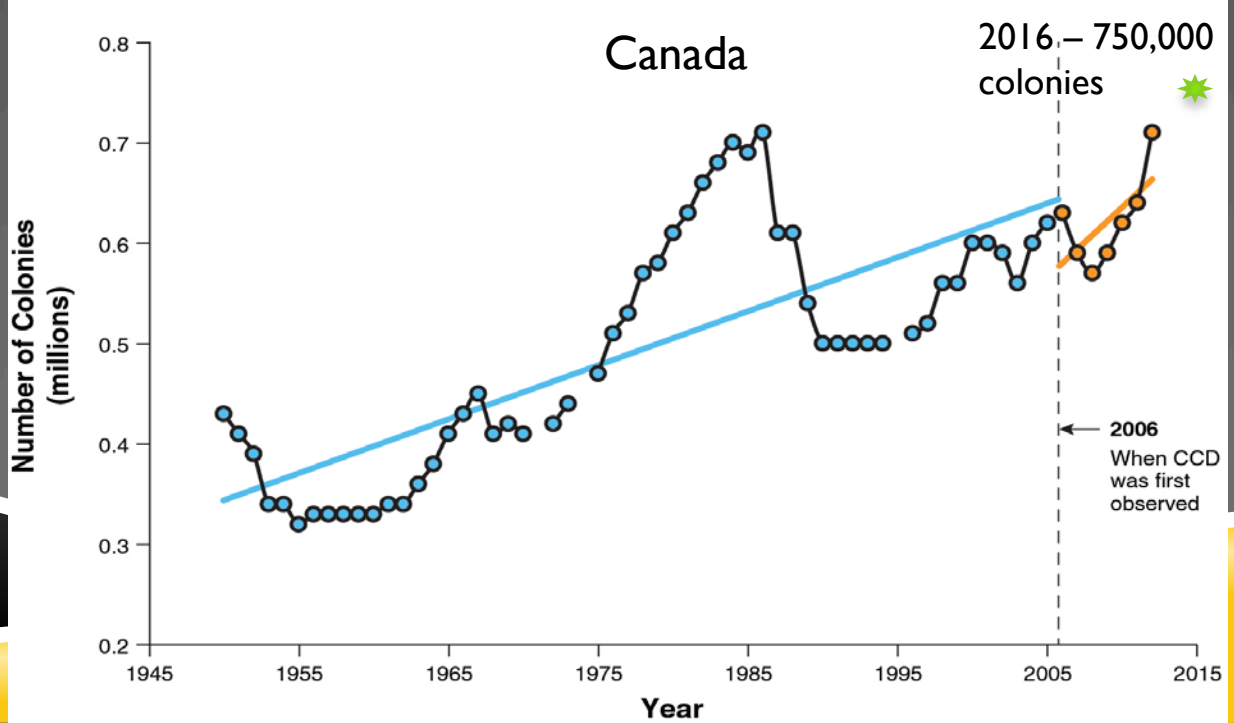
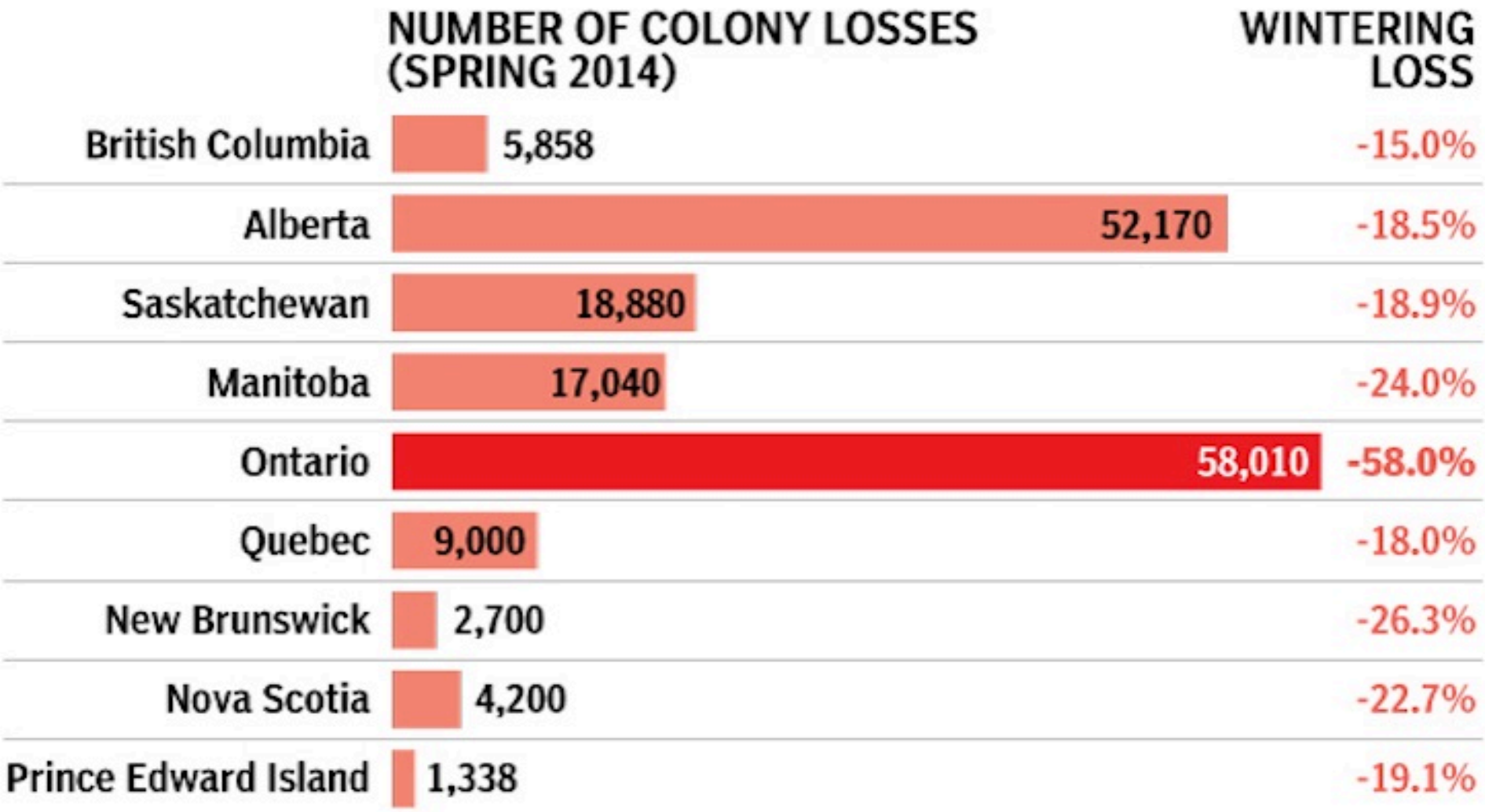

United States
Number of Colonies (millions)
6
5.5
5
4.5
4
3.5
3
2.5
2
1940
1950
1960
1970
1980
1990
2000
2010
2020
Year
2006
When CCD was first observed
2015 – 2.8 mill colonies


Canada
2016 – 750,000 colonies
Number of Colonies (millions)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1945
1955
1965
1975
1985
1995
2005
2015
Year
2006
When CCD was first observed

GROSS WINTERING LOSSES OF CANADIAN HONEY BEE COLONIES, BY PROVINCE



NOTE: Data unavailable for Newfoundland and Labrador.

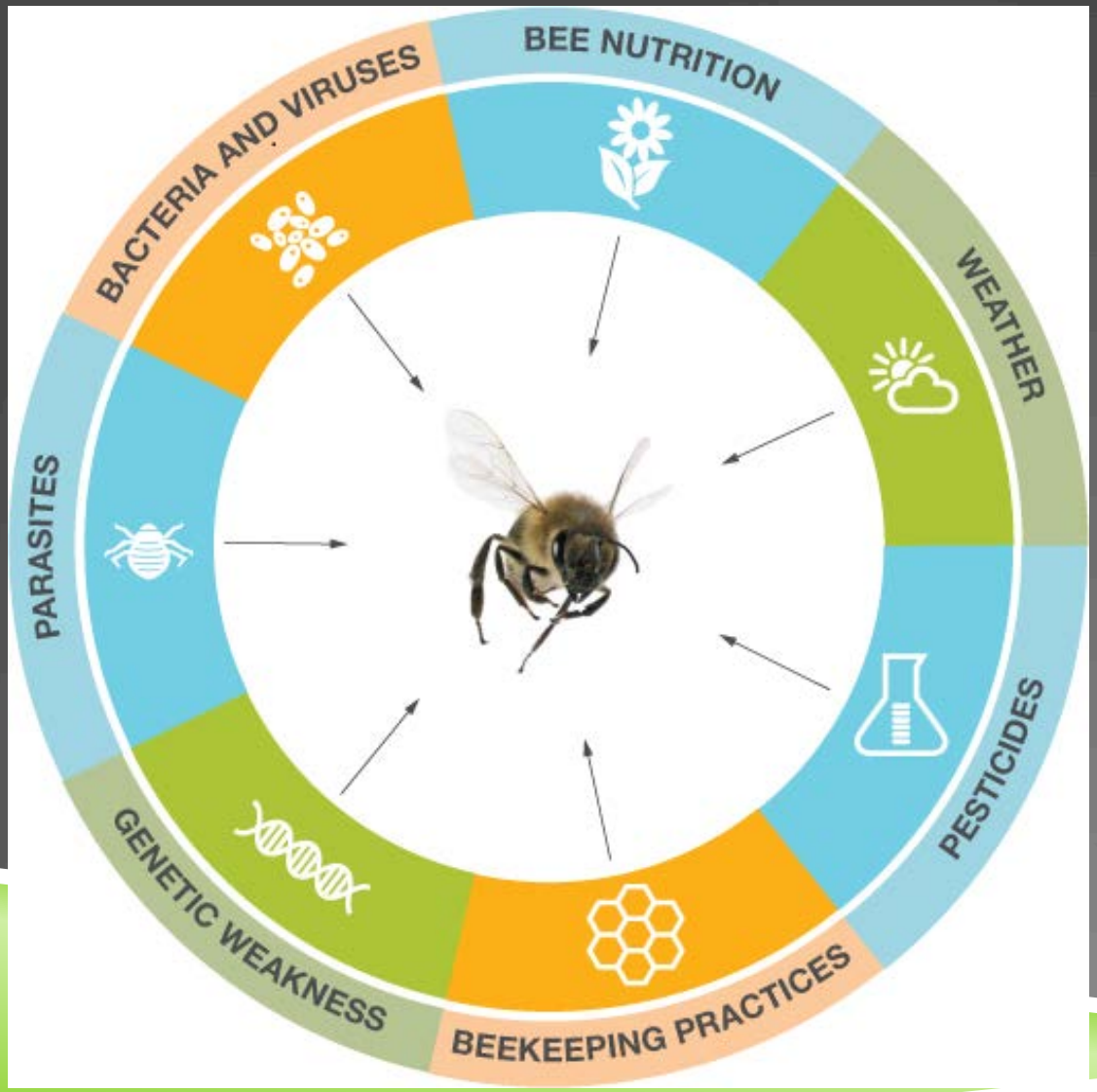
SOURCE: STATISTICS CANADA, CANADIAN ASSOCIATION OF PROFESSIONAL APICULTURISTS

JONATHON RIVAIT / NATIONAL POST

OVERWINTER COLONY LOSSES

Province	Overwinter Colony Losses		
	2013/14	2014/15	2015/16
Newfoundland			7.7
PEI	19.1	17.6	24.4
Nova Scotia	22.7	15.1	14.5
New Brunswick	26.3	22.8	16.7
Quebec	18.0	18.7	15.6
Ontario	**58.0**	**37.8**	**17.9**
Manitoba	24.0	14.0	21.3
Saskatchewan	18.9	10.4	15.4
Alberta	18.5	10.6	15.2
BC	15.0	12.0	20.0
CANADA	24.5	16.4	16.8

LIKELY CAUSES OF BEE LOSSES



Pesticides:

- Chemical medicants
- Neonicotinoid seed treatments

BEES AND NEONICOTINOIDS

- That neonicotinoids are toxic to bees has ***never*** been debated
  - demonstrated through any number of endpoint measures

- What is debated is whether or not exposure to these compounds in the field poses an ***unacceptable risk*** to pollinators

Toxicology – The Study of Poisons

- *"All things are poison and nothing is without poison, only the dose permits something not to be poisonous"*
- OR *"the dose makes the poison"*

- Dose/Response Relationship

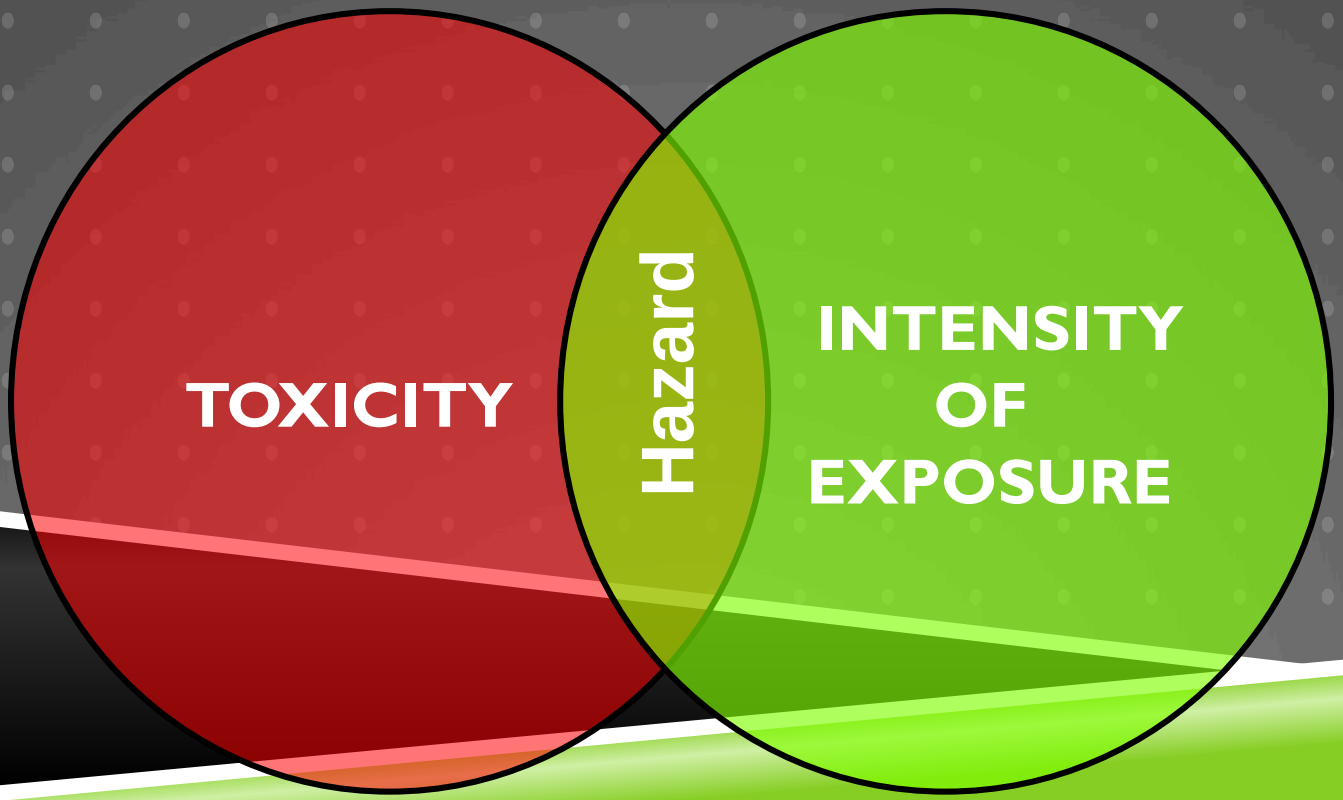
Concentration (Dose) + Length of Exposure (Duration) = Effect

Toxicology – The Study of Poisons

- **"Toxic" substances can be benign; "Benign" substances can be deadly**
- Alcohol, table salt, nicotine, caffeine, aspirin, botulinum toxin and gasoline
  - High doses - all are toxic
  - Med doses – useful effect
  - Low doses – no detectable toxic effect

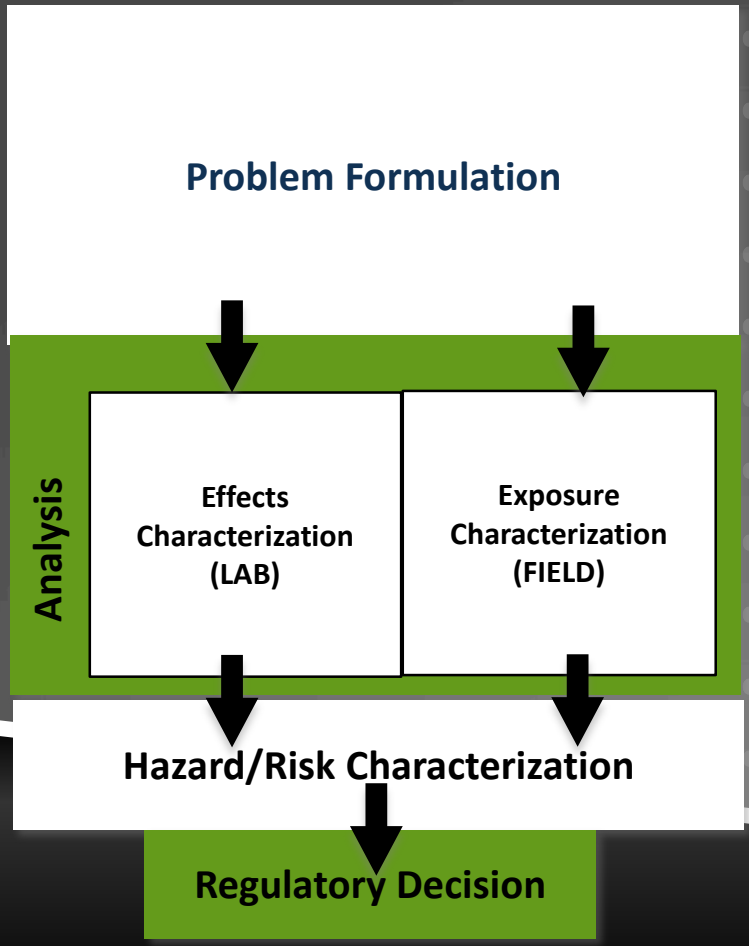
Hazard Assessment

Increased exposure (dose or duration) = Increased **hazard**



Risk Assessment

Effect & Exposure Characterization



During analysis we need to characterize:

Effect – what doses/concentrations cause an *effect*?

Exposure – to what doses/concentrations will the organism be *exposed*?

LAB TO FIELD STUDY LINKAGES

Effect	Exposure	Exposure
Tier 1	Tier 2	Tier 3
Models/Lab	**Semi-field**	**Field**
Strict lab tests Well defined ***Individual bees***	Tunnel (enclosed) tests Well defined, 'quasi-real' ***Whole colonies (small)***	Realistic conditions Hard to control, higher variability ***Whole colonies (large)***

BEES AND NEONICOTINOIDS

- Exposure may occur:
  - Foliar applications (direct contact, residues on plant)
  - Contaminated exhaust dust produced during pneumatic planting of neonic treated seed
  - Nectar or pollen of crops grown from seeds treated with neonicotinoids

Is this a problem?

LARGE SCALE FIELD GLP STUDY EXAMINING HONEY BEE EXPOSURE TO CLOTHIANIDIN SEED-TREATED CANOLA IN ONTARIO (2012)

C. Scott-Dupree,
C. Cutler, M. Sultan,
A. McFarlane and
L. Brewer

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GOOD LABORATORY PRACTISE

- Rules - planning, management, performance, monitoring, recording, reporting and archiving of non-clinical safety studies on pharmaceuticals, pesticides and industrial chemicals
- Impetus - developed following concerns in the US in 1970s about the validity of non-clinical safety data submitted to the FDA
  - Incompetent execution of studies, insufficient documentation of methods and results, and even outright fraud
- Goals – ensure the quality, veracity, repeatability and relevance of study data; while providing a framework for mutual acceptance across jurisdictions
- Amount of planning, oversight, and QA of GLP studies far exceeds that of non-GLP studies

2012 GLP FIELD STUDY

- 5 treated, 5 untreated fields;

4 hives/field

- ≥ 10 km apart
- 2 ha fields – attractive variety, high seeding rate
- Colonies in middle of field for

2.5 weeks (drought)

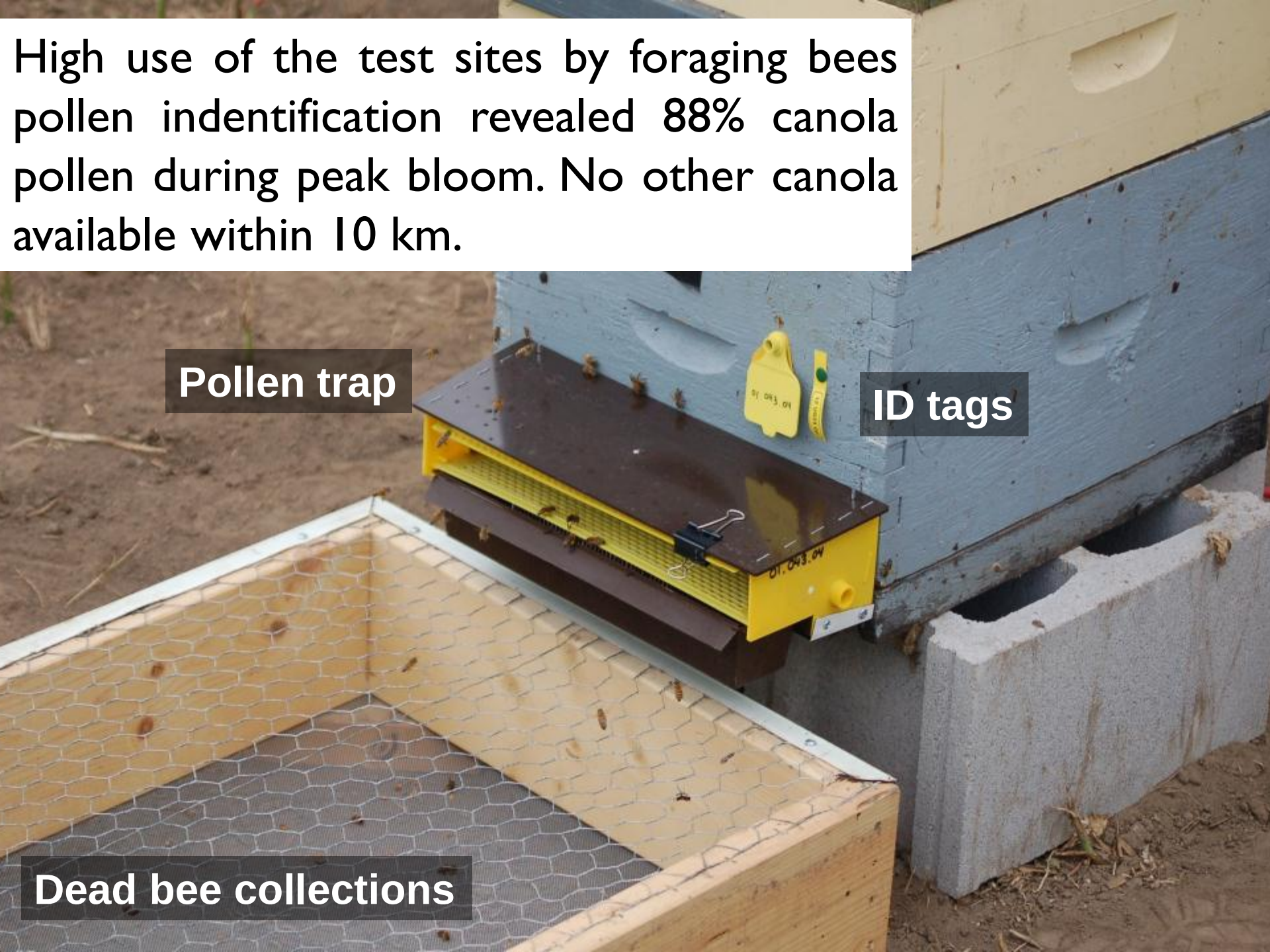
- Moved out of canola

at end of bloom

OTHER ASSESSMENTS

- Weight gain while in canola
- Honey yield – from July to mid-October
- Crop "ground truthing" – by plane (aerial truthing)
- Adult mortality – "Drop Zone" dead bee traps
- Pest, disease and queen assessments
- Nectar, honey, pollen and beeswax samples for residue analysis
- Samples analyzed for clothianidin residues LC/MS-MS

High use of the test sites by foraging bees pollen indentification revealed 88% canola pollen during peak bloom. No other canola available within 10 km.



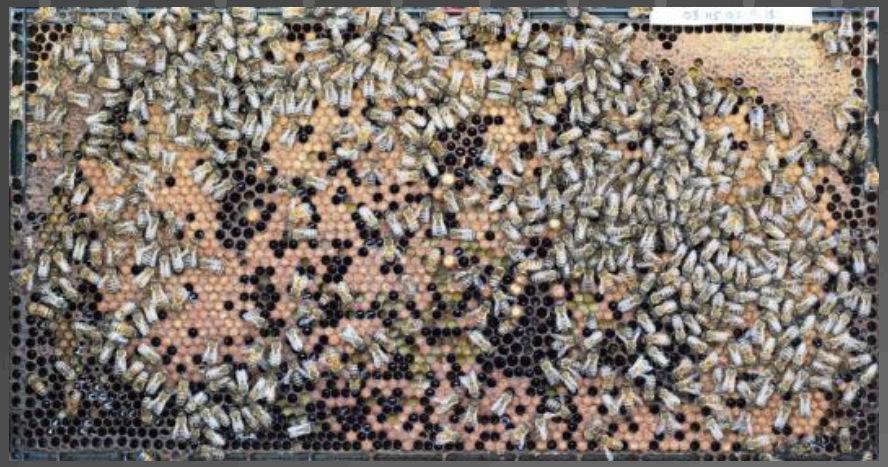
Adult and Sealed Brood Assessments

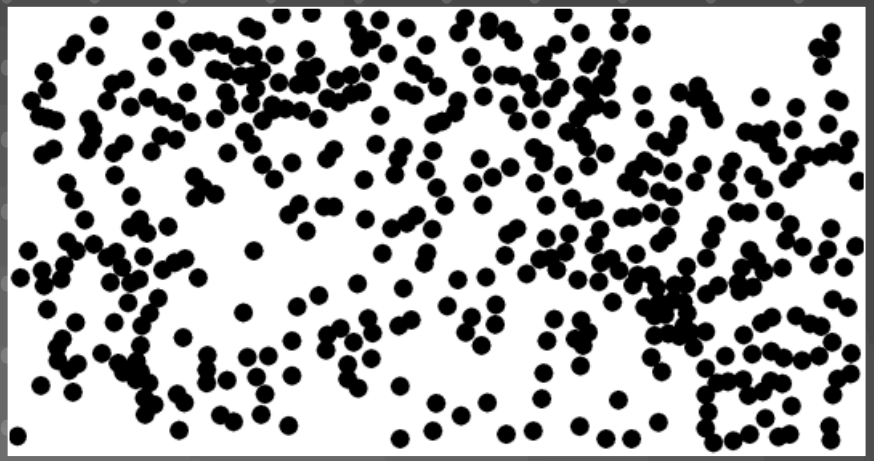
- Digital photography
- IndiCounter software

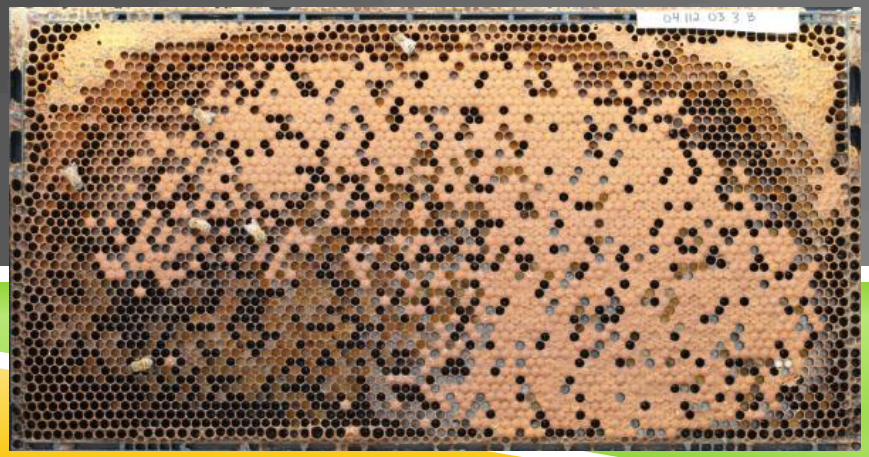
Measurements – Image Processing

ADULTS

Automatic Processing using IndiCounter©



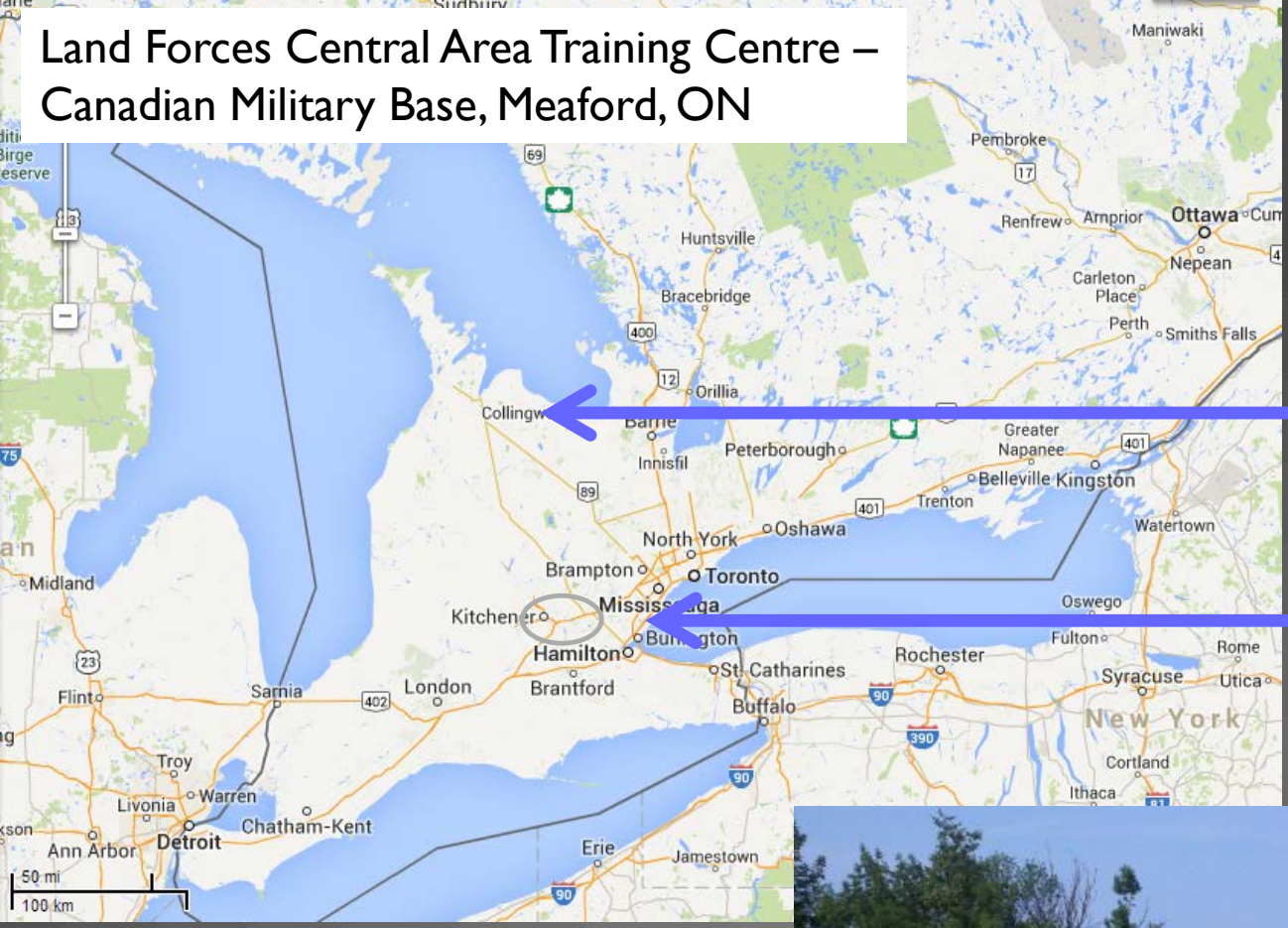




BROOD

POST TREATMENT HOLDING YARD

Land Forces Central Area Training Centre – Canadian Military Base, Meaford, ON



Non - agricultural landscape for post - exposure

Field site area

Post - exposure bee yard pasture

RESULTS

Colony Weight and Honey Yield (kg)

Endpoint	Control	Treatment	*P-value*
Colony Weight (kg)	14.7	14.2	*0.87*
Honey Yield (kg)	51.0	52.8	*0.84*

Average Ontario Honey Yield 2012 (6 months) = 37 kg

HIVE ENDPOINTS

- No significant difference in number of dead bees - TREATMENTS
- No significant difference in number of adults bees – TREATMENTS
- No significant difference in number of brood cells - TREATMENTS

RESIDUE ANALYSIS

- Initial analysis by USDA (multi-residue analysis)
  - Few detections overall (4) and less sensitivity (LOQ = 1.0 ppb)
- Subsequent pollen analysis done by BCS
  - LOQ = 0.5 ppb, LOD = 0.35 ppb
- Week 1 pollen samples
  - Control no detections; 0/5 fields
  - Treatment 0.6-1.1 ppb; 5/5 fields
- Week 2 pollen samples
  - **Control 0.35-1.3 ppb; 3/5 fields (2/5 ≥ LOQ)**
  - Treatment 0.5-1.9 ppb; 4/5 fields

At least 10- to 50-fold below the 20 ppb NOAEC

Residue analysis –explanations?

- Movement of control bees to treatment fields?
  - Unlikely; >10 km away
- Carry-over in soil from previous years?
  - If an issue, would expect to see in week 1 control pollen
- Planter contamination? Seed or sample mix up?
  - Very unlikely
- Pollen from other neonic treated plants? → Likely
  - Some sweet corn and soybean within foraging distance (<5% total pollen trapped
  - Thiamethoxam sprays?

CONCLUSIONS

- No effects or “poor performance” in treatment colonies
- Follows other lines of evidence
  - Honey bees doing well in canola, soybean, and corn on the prairies and mid-west
  - Recent reviews, monitoring in Europe, risk assessments, etc.
- Few instances of exposure of “control” colonies despite ***extensive*** efforts to isolate treatment and control sites
- Illustrates the difficulty doing controlled field studies with free-flying bees in an agricultural landscape

PUBLICATION OF GLP STUDY

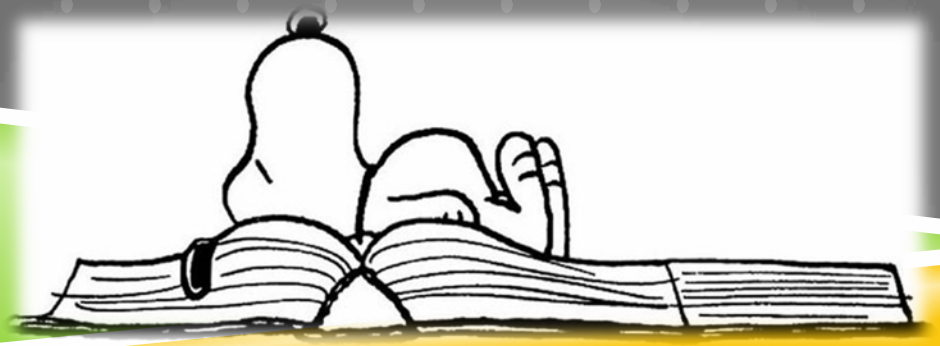
Sensational bedtime reading:

A large-scale field study examining effects of exposure to clothianidin seed-treated canola on honey bee colony health, development, and overwintering success

Chris Cutler, Cynthia Scott-Dupree, M. Sultan,
A. McFarlane and L. Brewer

PeerJ DOI 10.7717/peerj.652 (October 30, 2014)

Raw data is archived in PeerJ



A FIELD STUDY EXAMINING THE EFFECTS OF EXPOSURE TO NEONICOTINOID SEED-TREATED CORN ON COMMERCIAL BUMBLE BEE COLONIES IN SOUTHERN ONTARIO

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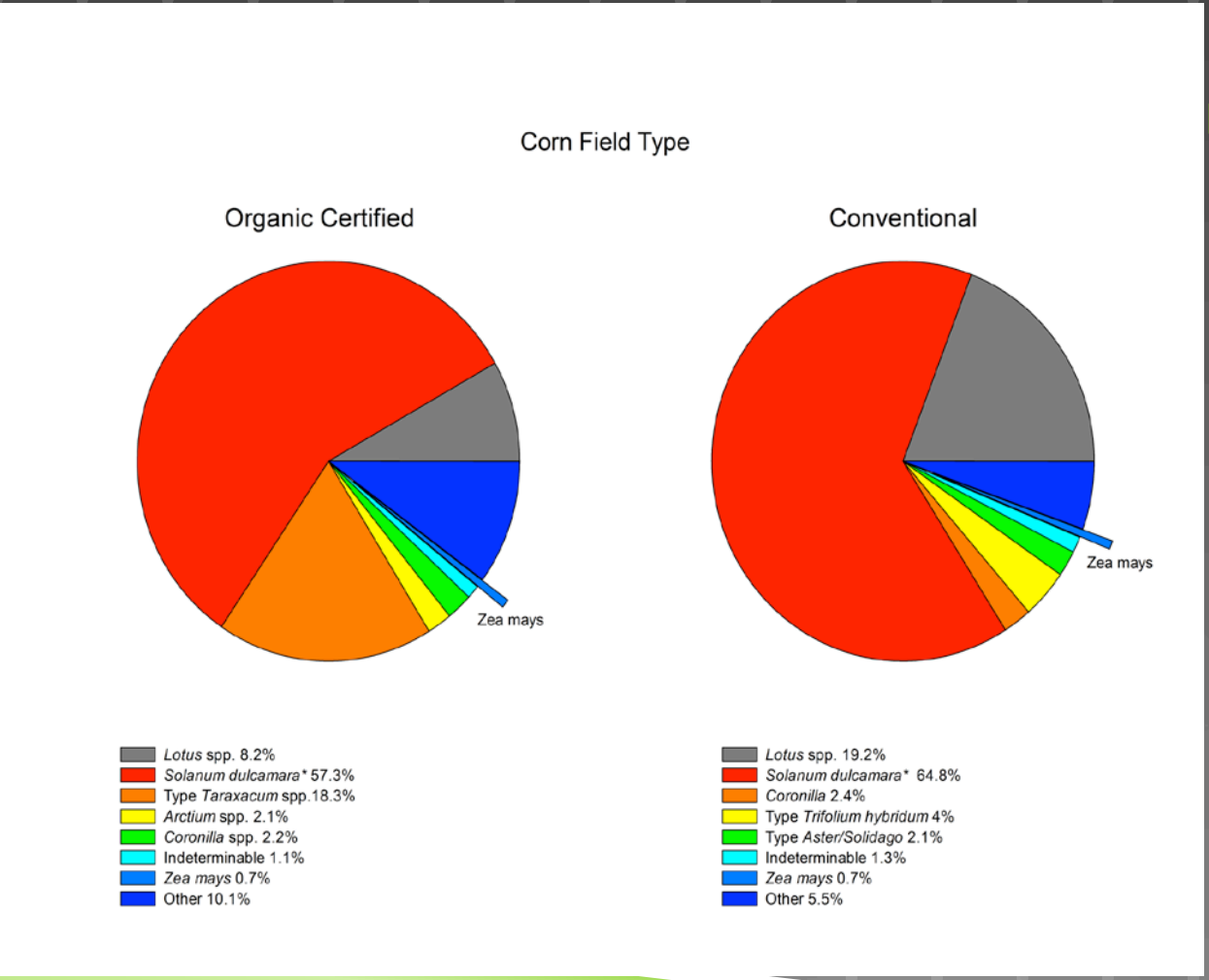
CORN FIELD STUDY

- Multi-hives (3-in-1) of *Bombus impatiens* in grower fields
- 4 certified organic fields- untreated seed
- 4 conventional fields
  - Bt, clothianidin and/or thiamethoxam seed treatment, fungicides (8)
- Hives placed next to corn fields during pollen shed (5-6 days)
- Then to an “ag-free” apiary for 4 wk (Land Forces Central Area Training Facility, Meaford, ON)

POLLEN COLLECTED BY *B. IMPATIENS*



- Pollen from returning foragers (18 bees/hive)
  - only 3/8 samples contained corn pollen
  - Mean = 0.7% corn pollen -

  low exposure
  - *Solanum dulcamara*

  primary pollen source

Bittersweet Nightshade – *Solanum dulcamara*

CONCLUSIONS

- Exposure to corn grown from neonicotinoid-treated seed during pollen shed poses LOW RISK to *B. impatiens*
  - significant given that neonics have been suggested as possible culprits in ongoing bumble bee declines – crop specific
  - A bee may not choose to forage upon a particular crop - constraints of floral anatomy, poor nutritional value or more favoured floral resource in close proximity
    - *Solanum dulcamara* (bittersweet nightshade) primary pollen collected by *B. impatiens* in this study

PUBLICATION

- A field study examining the effects of exposure to neonicotinoid seed-treated corn on commercial bumble bee colonies.

Cutler, C. and C. Scott-Dupree. 2014. Journal of Economic Entomology – Ecotoxicology 23:1755-1763.

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