Pollination reservoirs support wild bees and wild bees support growers:

Examples from Maine wild blueberry

Eric Venturini

Assistant Research Scientist, University of Maine
Owner of Grow Wild Bees consulting

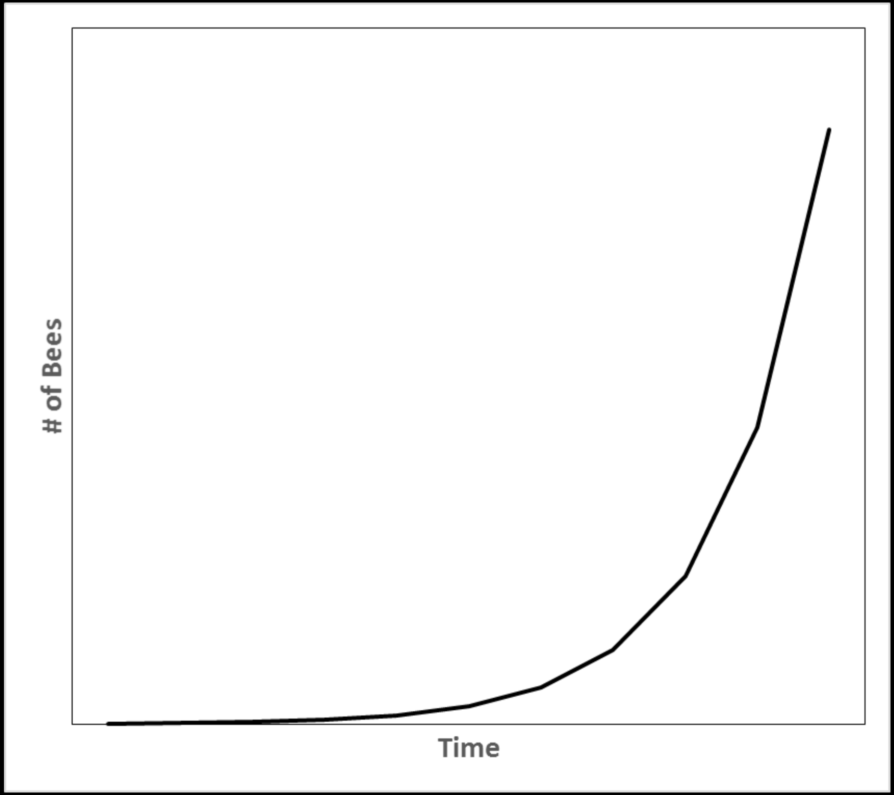
Photo credit: Audrey Maddox

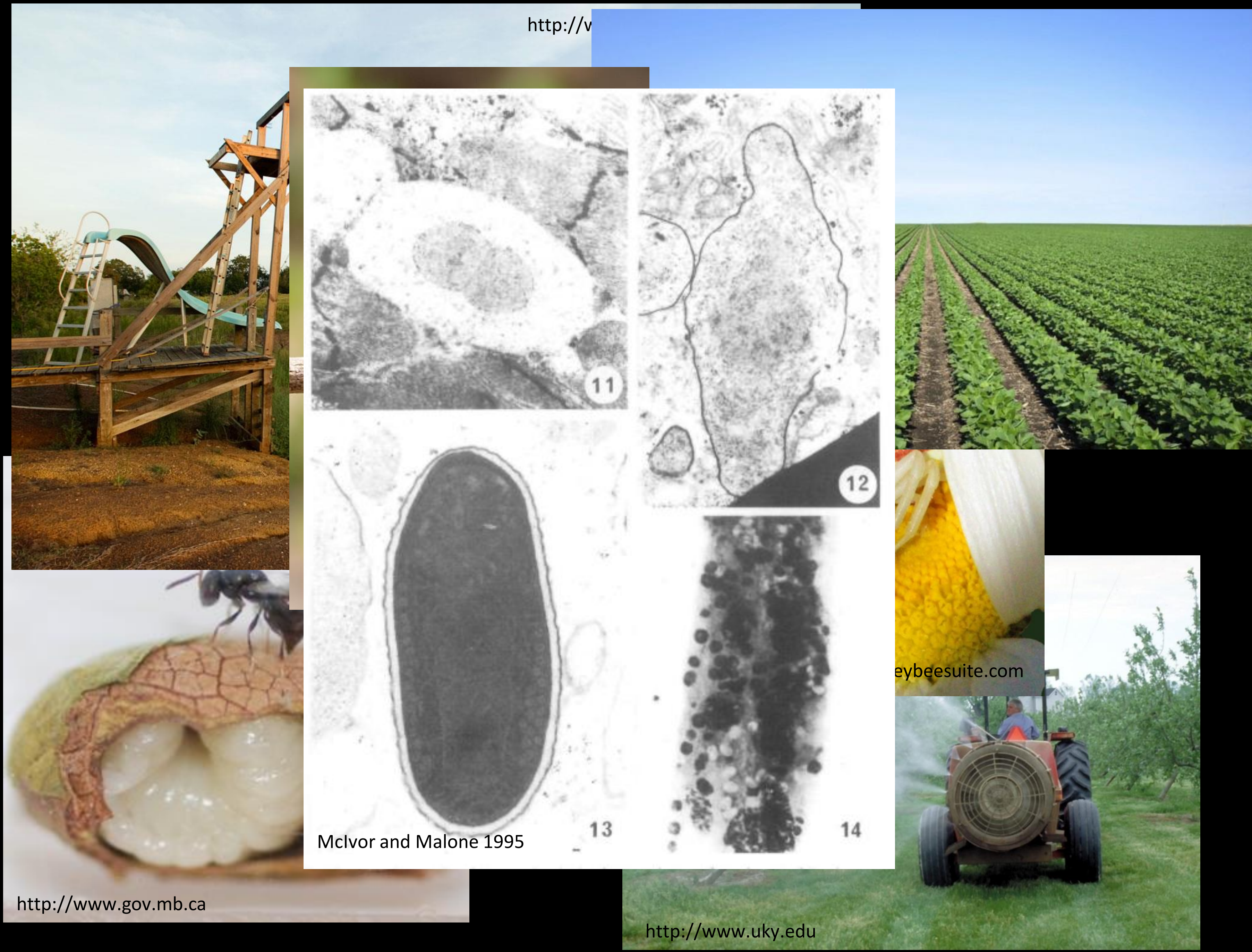
Part I: Playing the habitat manager

Pollination Reservoir –

An area of pollen and nectar rich bee forage plants intended to support or boost populations of wild bees for increased pollination services

Exponential population growth





http://v
11
12
13
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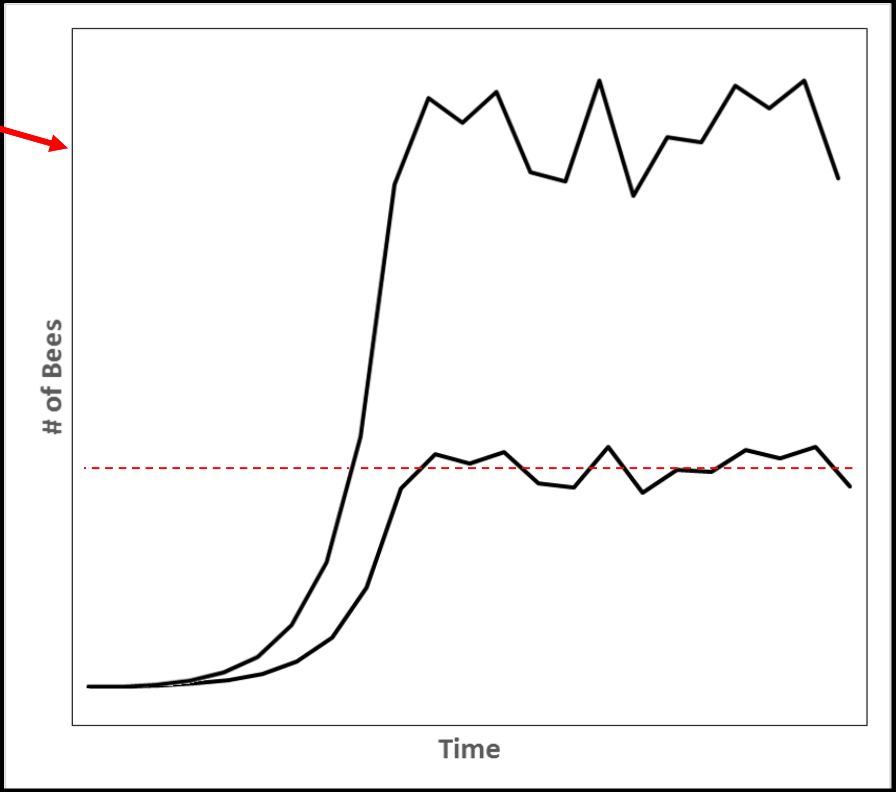
McIvor and Malone 1995
eybeesuite.com
http://www.gov.mb.ca
http://www.uky.edu

Carrying capacity

# of bees we want!



Part II: Does it work?

Can PRs be effective tools to increase wild bee abundance and diversity?

Photo credit: Dr. Richard Pywell, Copyright, Centre for Ecology & Hydrology

Ecological Applications, 25(6), 2015, pp. 1557–1565

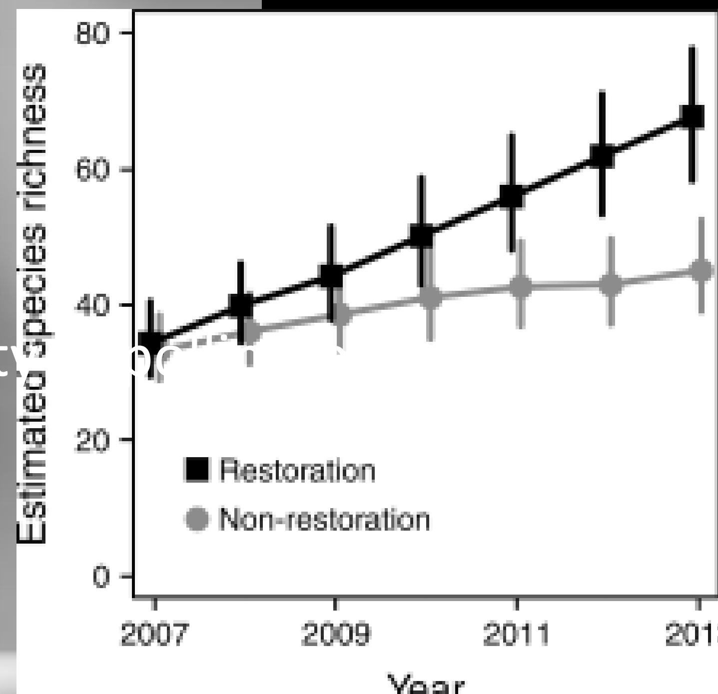
Habitat restoration promotes pollinator persistence and colonization in intensively managed agriculture

Leithen K. M'Gonigle,[1,2,3] Lauren C. Ponisio,[1] Kerry Cutler,[1] and Claire Kremen[1]

a 94720 USA

Major findings:

- Hedgerows increased stability
  populations over time

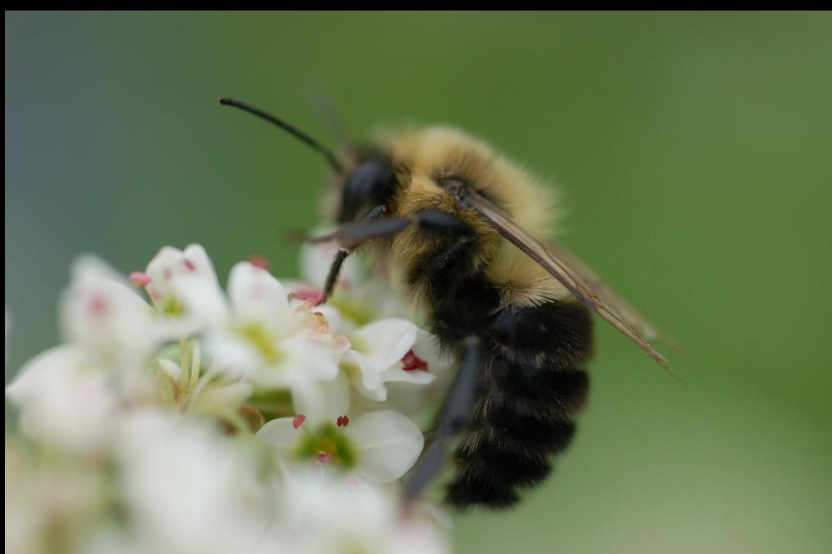


Ecological Applications
Volume 25, Issue 6, pages 1557-1565, 1 SEP 2015 DOI: 10.1890/14-1863.1
http://onlinelibrary.wiley.com/doi/10.1890/14-1863.1/full#i1051-0761-25-6-1557-f04

MOLECULAR ECOLOGY
Molecular Ecology (2015) 24, 1668–1680 doi: 10.1111/mec.13144

Targeted agri-environment schemes significantly improve the population size of common farmland bumblebee species

THOMAS J. WOOD,* JOHN M. HOLLAND,† WILLIAM O. H. HUGHES* and DAVE GOULSON*
*School of Life Sciences, The University of Sussex, Falmer, East Sussex BN1 9QG, UK, †The Game and Wildlife Conservation Trust, Burgate Manor, Fordingbridge, Hampshire SP6 1EF, UK



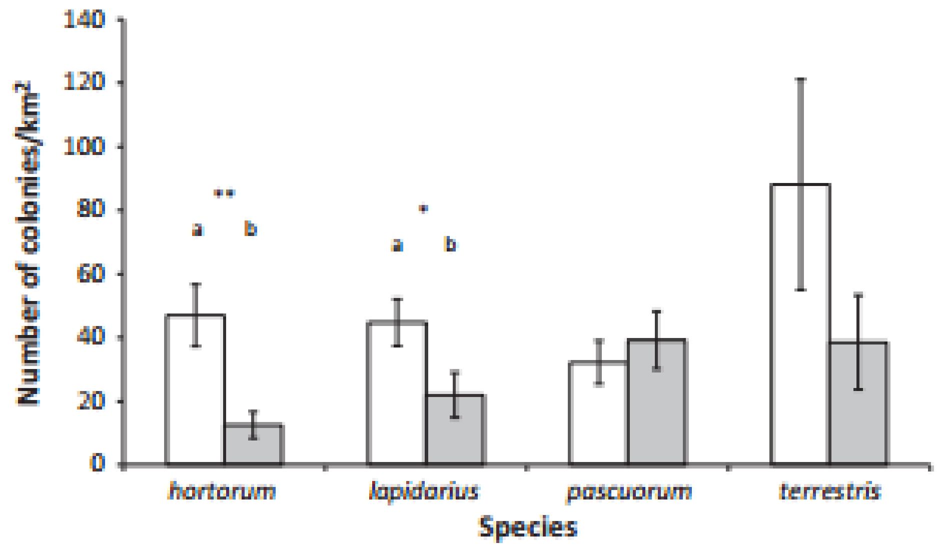


Fig. 4 Differences in the nesting density of four bumblebee species between Higher Level Stewardship farms (white bars) and Entry Level Stewardship farms (grey bars). Errors bars are ±1 standard error of the mean. Different letters above columns indicate farm types which differed significantly in a sampling round. *P < 0.05; **P < 0.01.

JOURNAL ARTICLE

Hedgerow restoration promotes pollinator populations and exports native bees to adjacent fields

Lora A. Morandin and Claire Kremen

Ecological Applications
Vol. 23, No. 4 (June 2013), pp. 829-839

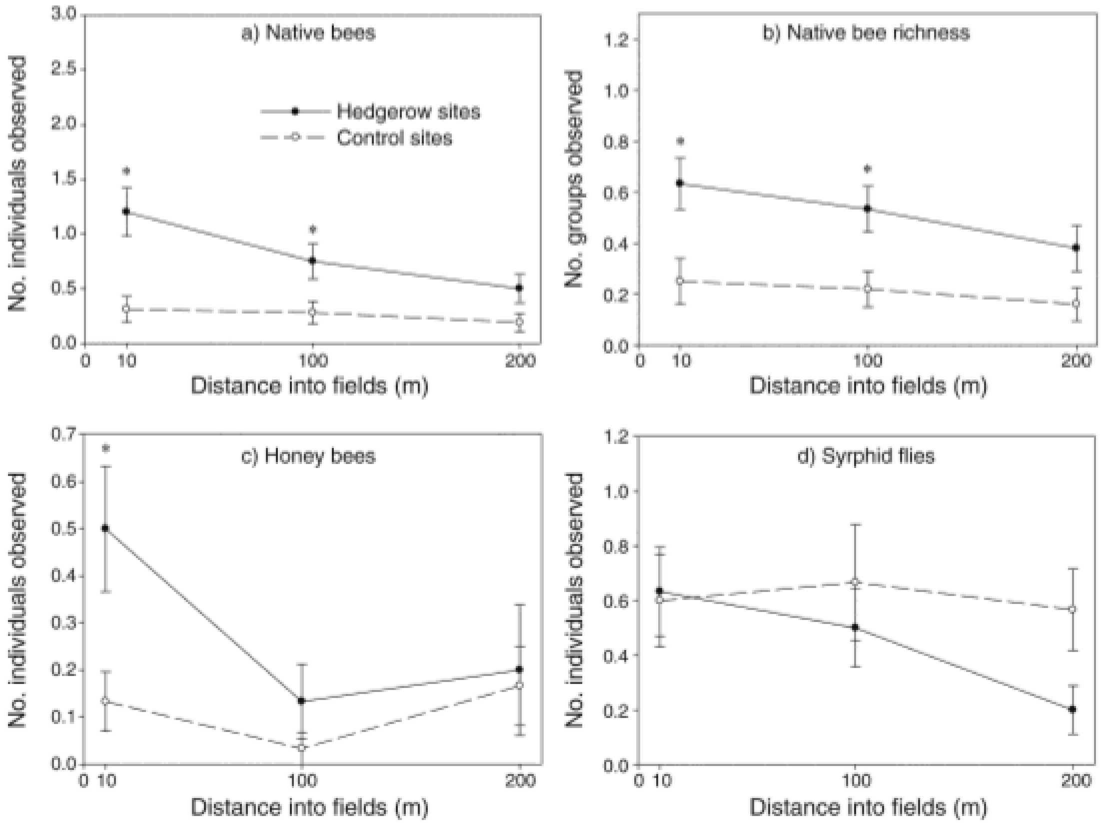


FIG. 4. Observed numbers (mean ± SE) of (a) individuals of native bees, (b) species of native bees, (c) individuals of honey bees, and (d) individuals of syrphid flies at three distances into fields that were adjacent to hedgerow or control edges, in 2009 and 2010.

ut increased their

to the crop field


What can PRs do for your crop?
Can PRs be effective tools to increase wild bee abundance and diversity? **Absolutely Yes!!**
Photo credit: Dr. Richard Pywell, Copyright, Centre for Ecology & Hydrology

Ecology and Evolution
Open Access

Experimental evidence that wildflower strips increase pollinator visits to crops

Hannah Feltham[1], Kirsty Park[1], Jeroen Minderman[1] & Dave Goulson[2]
[1]School of Natural Sciences, University of Stirling, Stirling FK9 4LA, UK
[2]School of Life Sciences, University of Sussex, Brighton BN1 9RH, UK

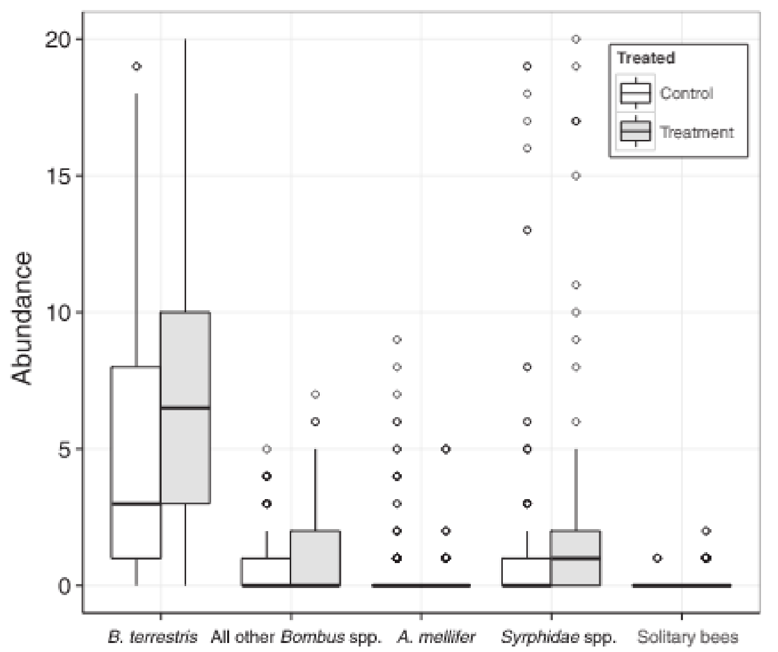


Figure 1. The abundance of pollinators on strawberry crops with and without a flower strip treatment. The box plots depict the median and interquartile range, with circles representing outliers. Whiskers represent the highest and lowest values excluding outliers.

Major Findings:

- Flower strips increased bumble bee abundance in strawberry polytunnels by 25%
- If 5% increase in top quality strawberries, growers gross $470 more per tunnel per year

J Insect Conserv
DOI 10.1007/s10841-015-9768-3

ORIGINAL PAPER

The management of bee communities by intercropping with flowering basil (*Ocimum basilicum*) enhances pollination and yield of bell pepper (*Capsicum annuum*)

Ana Lúcia C. Pereira[1] · Tainá C. Taques[1] · Janete O. S. Valim[1] · Ana P. Madureira[1] · Wellington G. Campos[1]

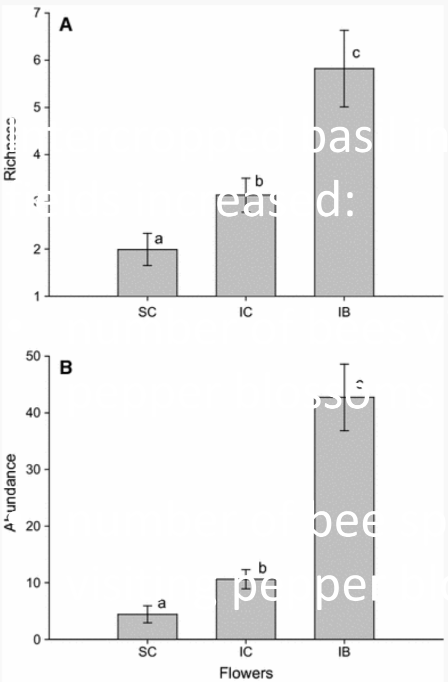


Fig. 1
Average ± SD of the numbers of bee species (A) and ind
sampled for 30 min in flowers of single-cropped bell pe
flowers of bell pepper intercropped with basil (*Ocimum*
inflorescences of basil mixed in the bell pepper field (IB
significant differences ($P < 0.0001$) by the Tukey–Kram

Table 1 Characterization of fruits and seeds of bell peppers (*Capsicum annuum*) produced in intercropping with basil (*Ocimum basilicum*) and in single cropping systems

Characteristics of fruits and seeds	Cropping systems[a]		$F_{27\text{-}2}$	*p*
	Intercropped pepper	Single pepper		
Fruit length (mm)	84.1 ± 4.3	74.9 ± 5.4	25.8	<0.0001
Basal circumference (mm)	22.2 ± 0.9	18.4 ± 0.8	186.9	<0.0001
Apical circumference (mm)	19.6 ± 1.2	16.8 ± 1.3	63.0	<0.0001
Pulp weight (g)	128.2 ± 21.1	83.1 ± 12.3	61.0	<0.0001
Number of seeds per fruit	311.5 ± 31.5	269.6 ± 41.6	15.2	<0.001
Weight of seeds per fruit (g)	4.3 ± 0.5	3.8 ± 0.7	10.0	<0.01
Fruits per plant (≥60 mm)	16.2 ± 1.4	16.7 ± 1.9	0.7	=0.42
Fruits per plant (≤60 mm)	3.7 ± 0.7	3.5 ± 0.8	0.3	=0.61

[a] Average ± SD. Comparisons using linear mixed models, with 25 *df* residual

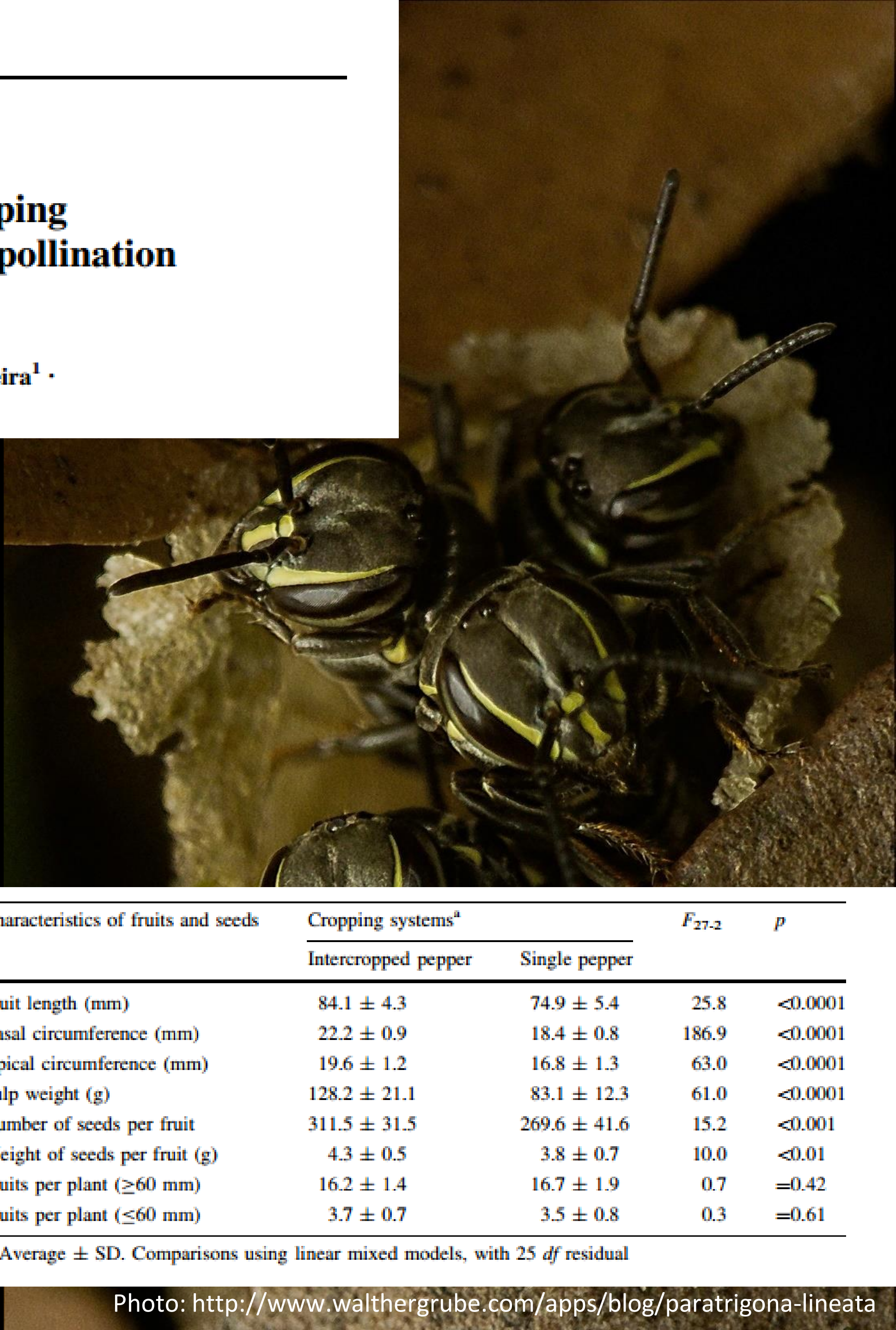


Photo: http://www.walthergrube.com/apps/blog/paratrigona-lineata

50 YEARS WITH IMPACT
Journal of Applied Ecology
1913 British Ecological Society 2013 CELEBRATING 100 YEARS

Journal of Applied Ecology 2014 doi: 10.1111/1365-2664.12257

Flower plantings increase wild bee abundance and the pollination services provided to a pollination-dependent crop

Brett R. Blaauw* and Rufus Isaacs

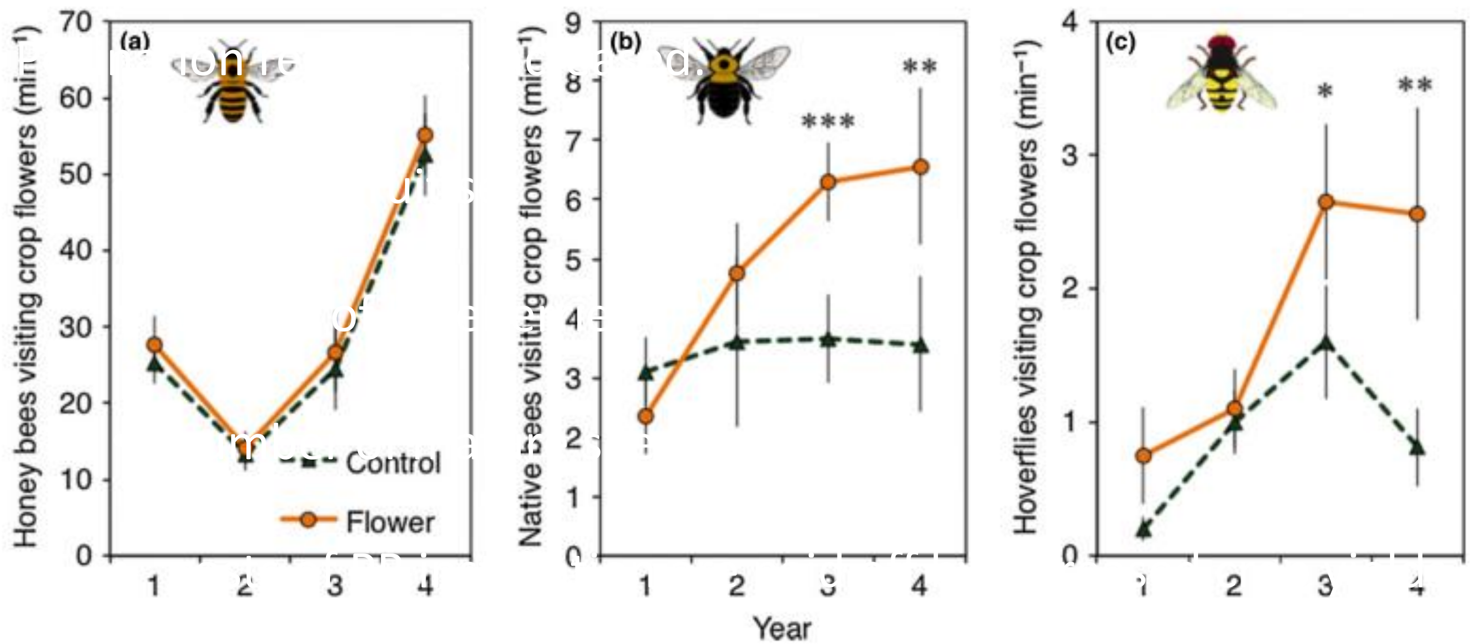


Fig. 1. Mean ± SE abundance of (a) honeybees, (b) wild bees and (c) hoverflies observed visiting blueberry flowers during 15 min observational samples. Asterisks indicate levels of significance (*$P < 0{\cdot}05$, **$P < 0{\cdot}01$, ***$P < 0{\cdot}001$) for difference between control and flower treatments.

Agricultural and Forest Entomology (2015), **17**, 302–308 DOI: 10.1111/afe.12108

Can floral field margins improve pollination and seed production in coriander *Coriandrum sativum* L. (Apiaceae)?

Jelena Barbir, Francisco R. Badenes-Pérez, César Fernández-Quintanilla and José Dorado

Institute of Agricultural Sciences, CSIC, Serrano 115b, 28006 Madrid, Spain

- Floral field margins increased:
  - pol
  - cor rmination)
  - INCREASED CORIANDER PRODUCTION BY 220%!

Table 5 Estimated marginal mean ± S lant and percentage of SW per plant of coriander under control, monospeci

Measured parameters	Mixed
Seed set/umbel (%)**	29.15 ± 0.46a
SW/seed (mg)**	13.3 ± 0.6a
SW/plant (g)*	2.45 ± 0.20a
SW/plant (%)*	255.21a

*Significant differences between the tre 0.001; different lowercase letters in a row indicate that there are significant d

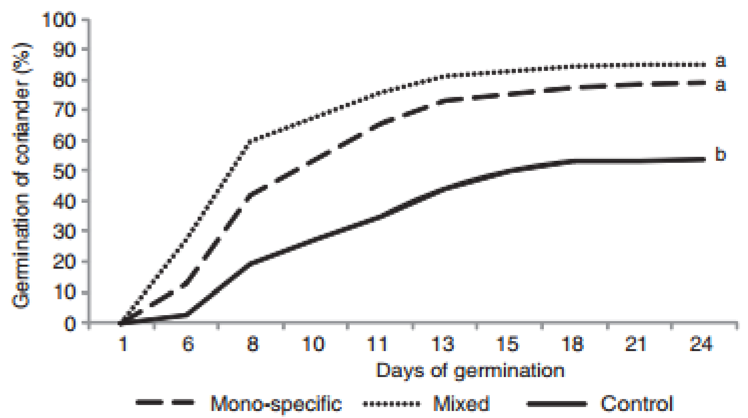


Figure 1 Germination rate of coriander seeds produced in the vicinity of monospecific margins, mixed margins and without margins (control). Means with the same letter are not significantly different at $P \leq 0.05$ as determined by a Bonferroni post-hoc test.

Can PRs be effective tools to increase wild bee abundance and diversity? **Absolutely Yes!!**

What can PRs do for your crop? **Increase pollination from wild bees, crop quality, and yield!**

Photo credit: Dr. Richard Pywell, Copyright, Centre for Ecology & Hydrology

Part III: Examples from Maine

Journal of Economic Entomology, 2017, 1–14
doi: 10.1093/jee/tow285
Research article

OXFORD

Apiculture & Social Insects

Pollination Reservoirs in Lowbush Blueberry (Ericales: Ericaceae)

E. M. Venturini,[1,2] F. A. Drummond,[1,3] A. K. Hoshide,[4] A. C. Dibble,[1] and L. B. Stack[3,5]

[1]School of Biology and Ecology, University of Maine, 5722 Deering Hall, Orono, ME 04469 (Eric.Venturini@maine.edu; FDrummond@maine.edu; ADibble2@gmail.com), [2]Corresponding author, e-mail: Eric.Venturini@maine.edu, [3]University of Maine Cooperative Extension, 495 College Ave., Orono, ME 04469 (Lois.Stack@maine.edu), [4]School of Economics, University of Maine, 206 Winslow Hall, Orono, ME 04469 (Aaron_Hoshide@umit.maine.edu), and [5]School of Food and Agriculture, University of Maine, 5722 Deering Hall, Orono, ME 04469

Subject Editor: Robert Danka

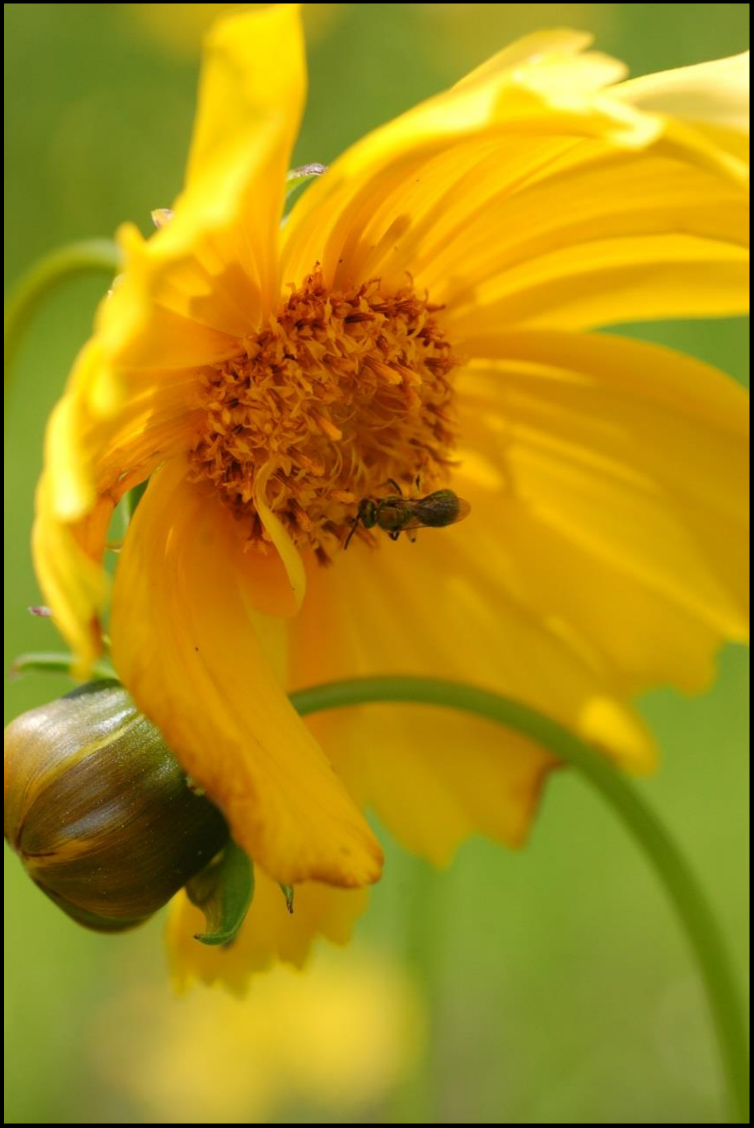
Received 22 July 2016; Editorial decision 12 November 2016

PRs in Maine lowbush blueberry (Venturini et al. 2017b)

PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Visitation Sampling:

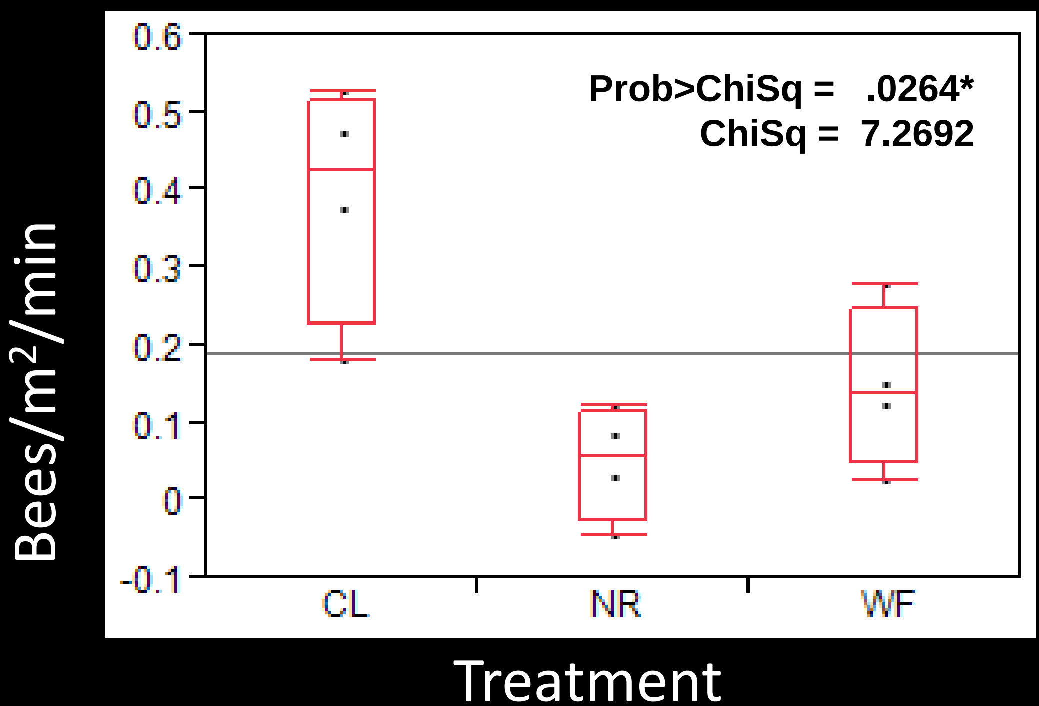
- Visited each site every 2 – 3 weeks from June to September
- 3 dominant flowers per treatment
- 3, I min., 1 m^2 observations per flower
- 27, 1 min observations per site visit



PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Which treatment is most utilized?

Bumblebees

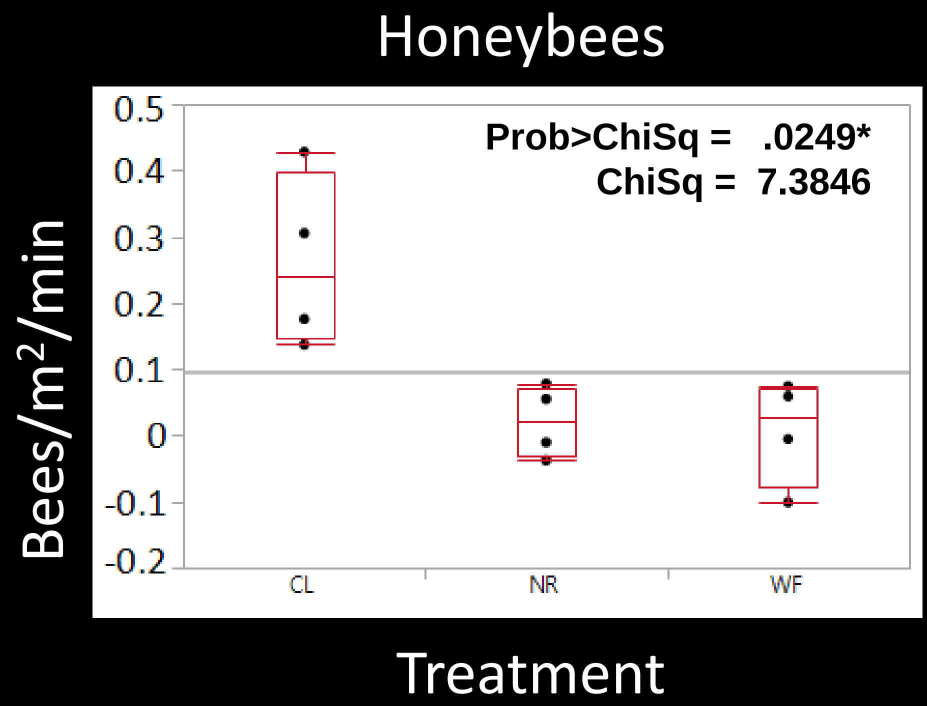


Nonparametric Wilcoxon Each Pair Comparisons:

Comparison	P-Value
WF vs. NR	.3123
WF vs. CL	.0606
NR vs. CL	.0304*

PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Which treatment is most utilized?



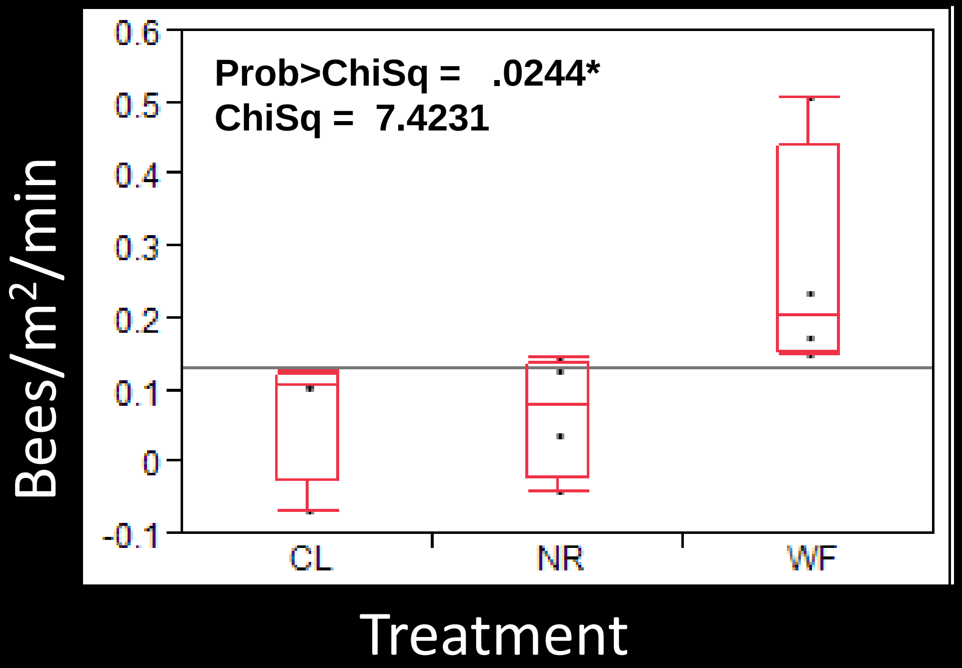
Nonparametric Wilcoxon Each Pair Comparisons:

Comparison	P-Value
WF vs. NR	1.000
WF vs. CL	.0304*
NR vs. CL	.0304*

PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Which treatment is most utilized?

Solitary Bees



Nonparametric Wilcoxon Each Pair Comparisons:

Comparison	P-Value
WF vs. NR	.0304*
WF vs. CL	.0304*
NR vs. CL	.8852

PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Which treatment is most utilized?

Major Findings:

- Solitary bees utilized the wildflower mix
- Social bees (honeybees and bumblebees) utilized the clover mix

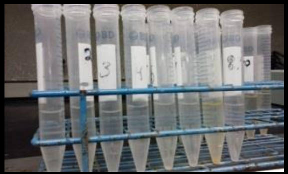
PRs in Maine lowbush blueberry (Venturini et al. 2017b)

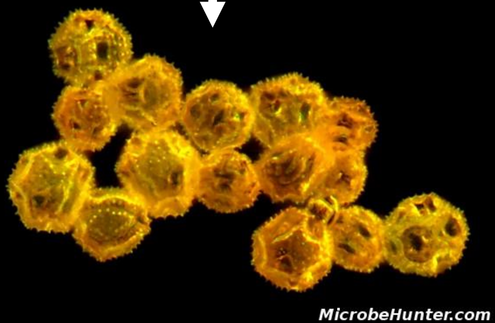
Do bumblebees utilize bee pasture?

What proportion of bumblebee diet is comprised of bee pasture pollen?

Methods:

- 4 tmt sites, 3 ctl sites
- 15 pollen carrying workers collected, 2 times/year/site
- 240 bees/year for 2 years
- Pollen processed using acetolysis, mounted on slides, and identified to taxa groups
- 40x microscopy
- ≥ 100 grains ID'd per sample



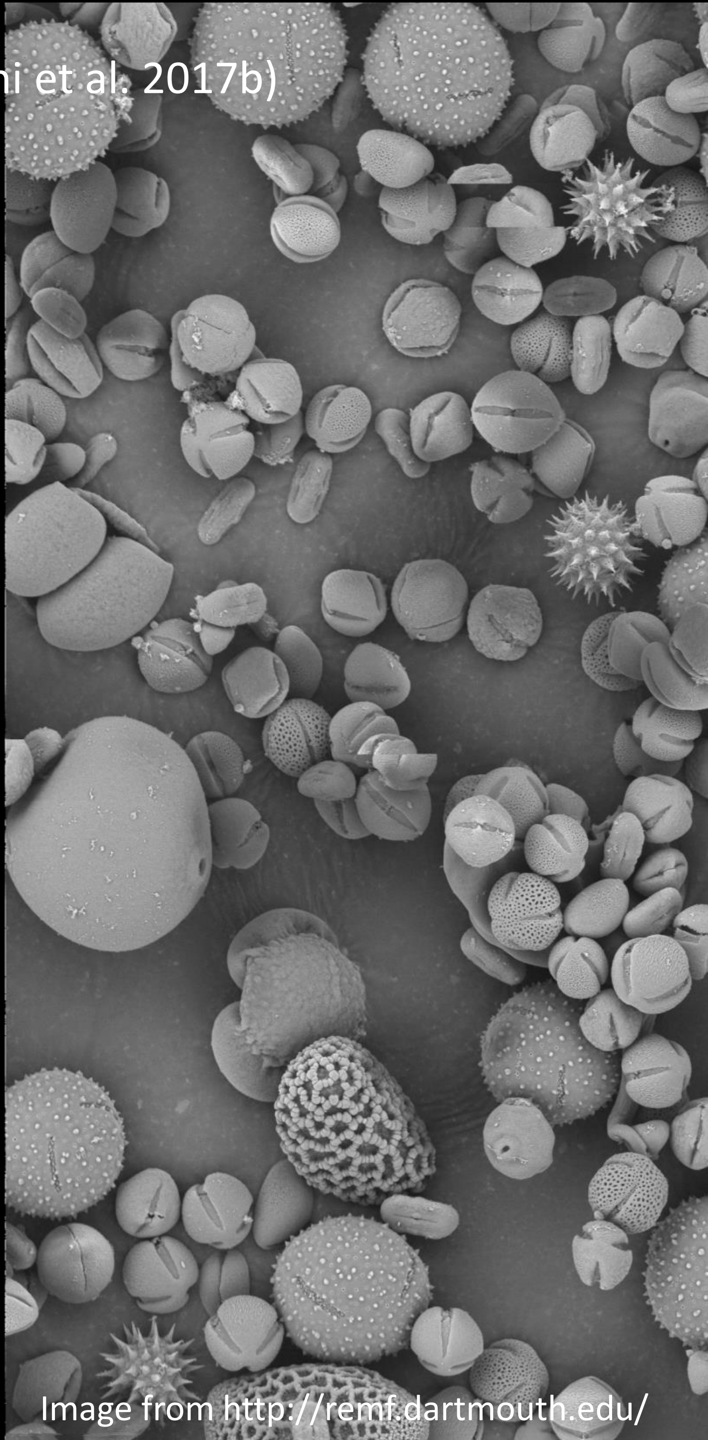


PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Do bumblebees utilize bee pasture?

What proportion of bumblebee diet is comprised of bee pasture pollen?

Level	Student's T-test[1]	N	Percent PR pollen	Effect Test (Prob > F)
Treatment, Early, 2013	A	38	49%	<.0001
Treatment, Late, 2013	B	46	26%	
Treatment, Late, 2012	B	37	20%	
Treatment, Early, 2012	C	32	5%	
Control, Late, 2013	C	46	5%	
Control, Late, 2012	C	20	5%	
Control, Early, 2013	C	40	0.01%	
Control, Early, 2012	C	37	0.007%	



PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Do bumblebees utilize bee pasture?

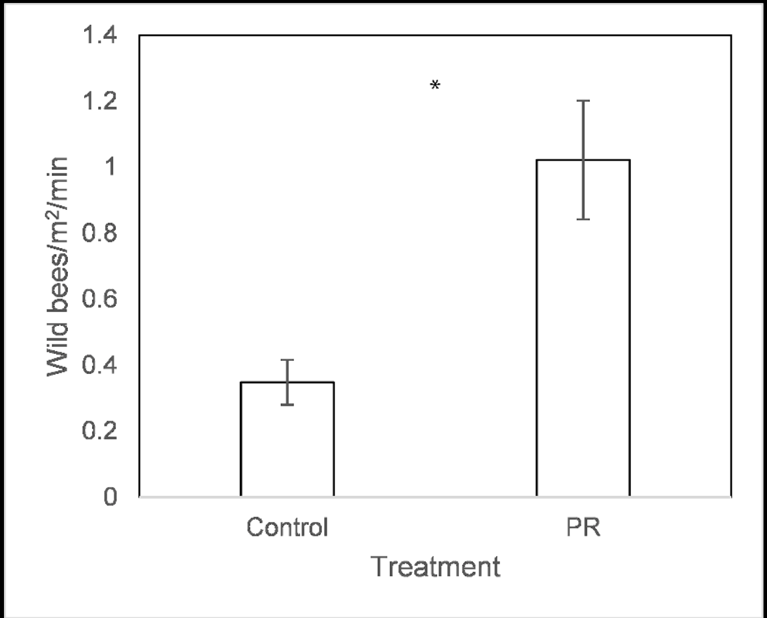
Major finding:

- Small PRs can provide over 1/3 of bumblebee dietary pollen

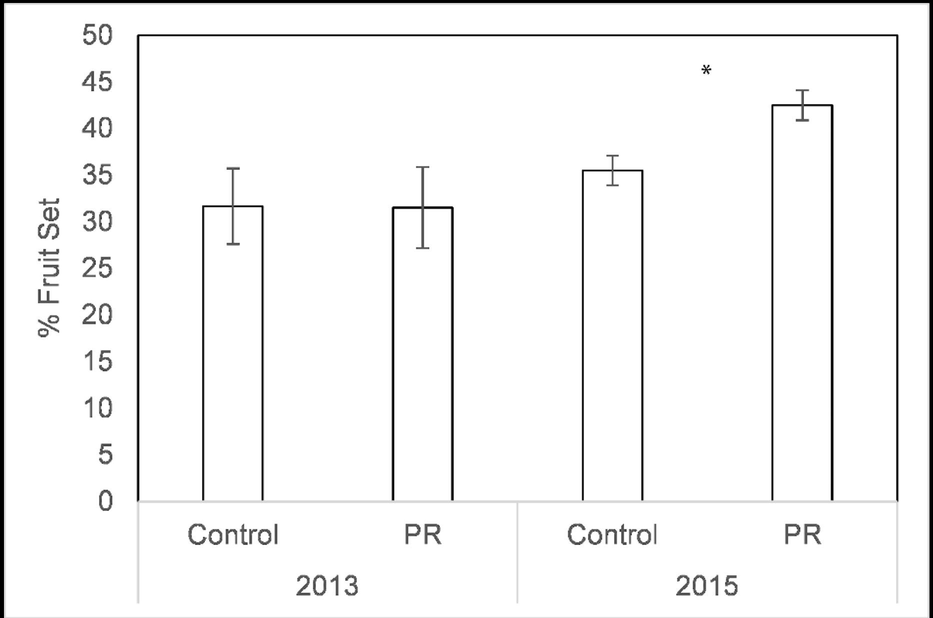
PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Effect on the crop?

Visitation by wild bees to crop, 4 years after planting PR



Percent fruit set in PR fields versus control fields 2, and 4 years after planting PR



Part IV: Taking advantage of wild bees for enhanced crop pollination

Cut-flower production adjacent to pollinator-dependent crops

Image from www.johnnyseeds.com

Grow a succession of flowering cash crops

Apple → Blueberry → Cane Fruit → Tomato → Cucurbit → Sunflower

www.willardfarms.com

www.floradequebec.com

www.40acrewoods.com

www.eXtension.org

www.123rf.com

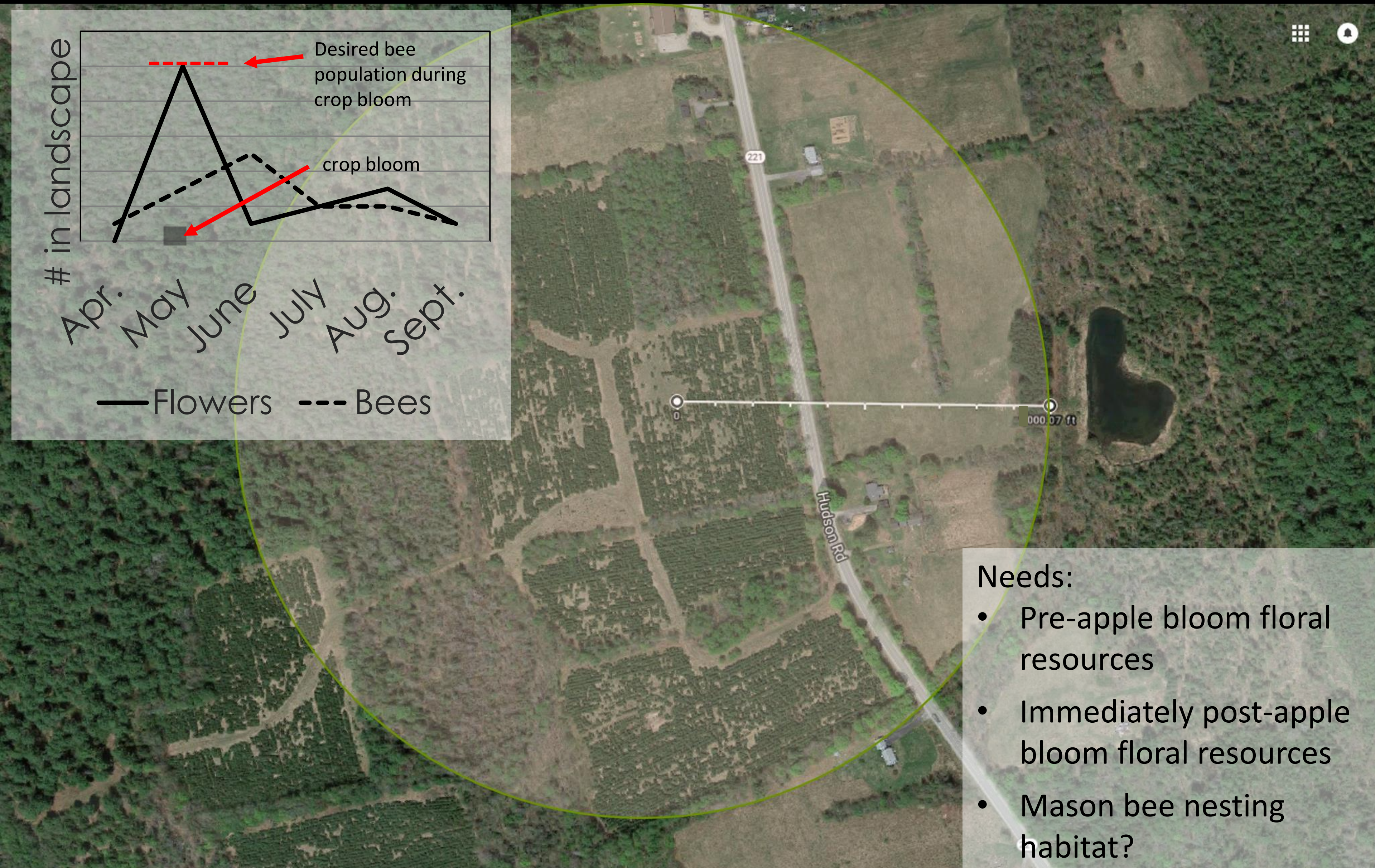
Plant flowering cover crops

Image from www.extension.oregonstate.edu

Eliminate or minimize the use of pesticides – especially during crop bloom

Consider the landscape context

Apple orchard

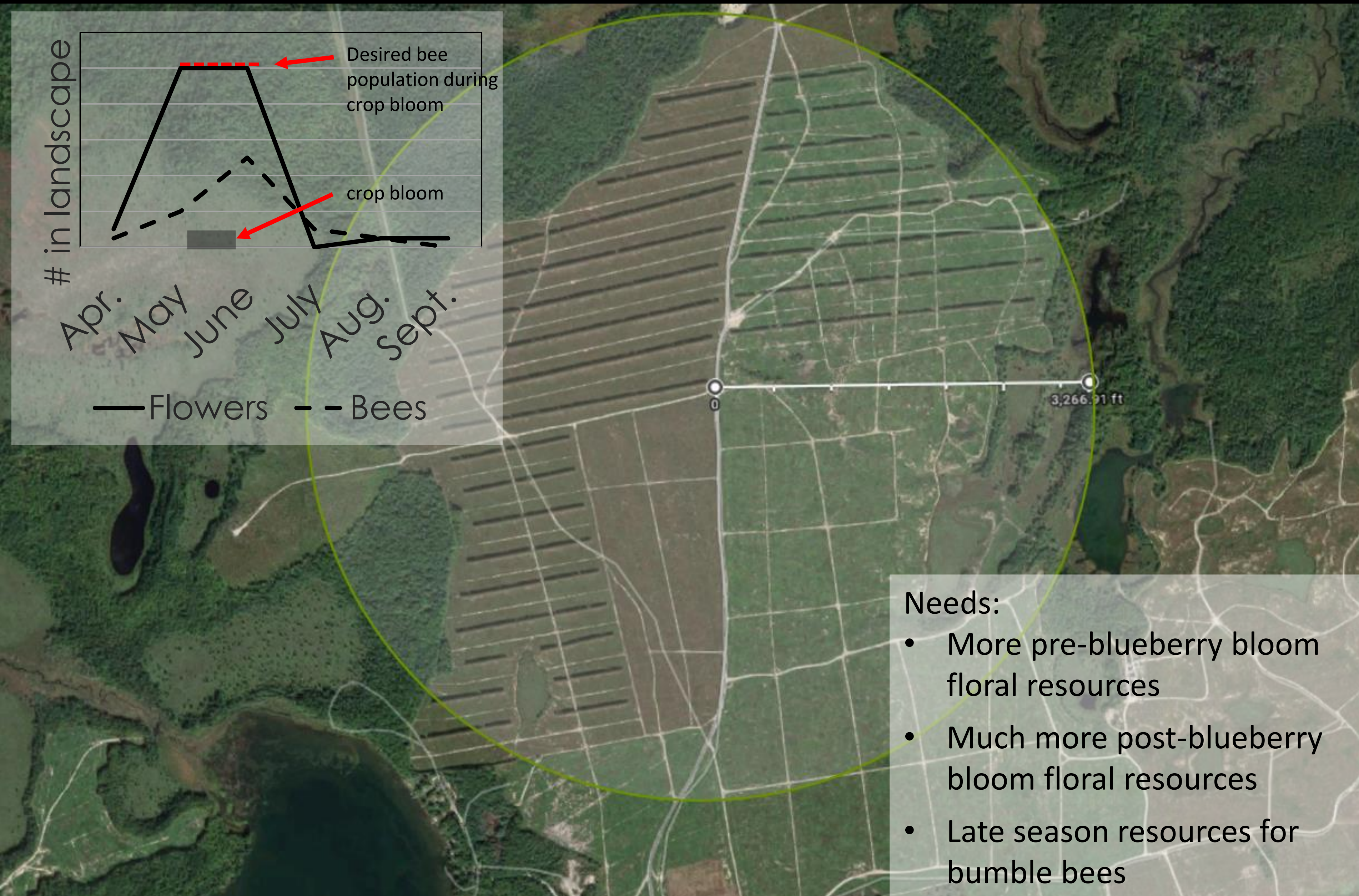


Needs:

- Pre-apple bloom floral resources
- Immediately post-apple bloom floral resources
- Mason bee nesting habitat?

3. Consider the landscape context

Lowbush Blueberry



Needs:

- More pre-blueberry bloom floral resources
- Much more post-blueberry bloom floral resources
- Late season resources for bumble bees

Part V: Installing a pollination reservoir

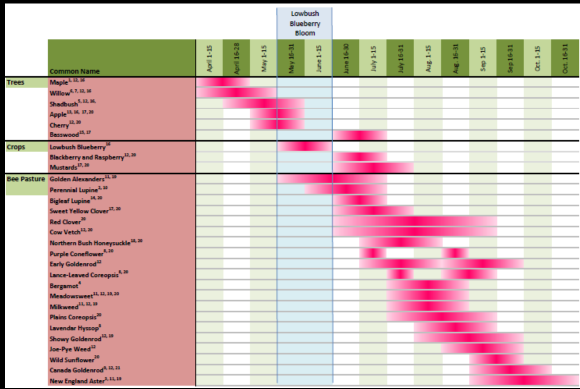
1. **Survey the Site**
    a. Flowers
    b. Pollinators
    c. Phenology

Photo: Eric Gallandt

2. **Control Weeds**
    a. Kill standing vegetation
    b. Decrease # of weed seeds in soil

Photo: Frank Drummond

3. **Site Prep**
    a. pH tests
    b. Liming
    c. Finely textured seed bed



4. Select Flower Mix

a. When do they bloom?

b. Who do they attract?

c. Other filters


Lowbush Blueberry Bloom
Common Name
April 1-15
April 16-28
May 1-15
May 16-31
June 1-15
June 16-30
July 1-15
July 16-31
Aug. 1-15
Aug. 16-31
Sep 1-15
Sep 16-31
Oct. 1-15
Oct. 16-31
Trees
Maple[1, 12, 16]
Willow[6, 7, 12, 16]
Shadbush[5, 12, 16,]
Apple[13, 16, 17, 20]
Cherry[12, 20]
Basswood[15, 17]
Crops
Lowbush Blueberry[16]
Blackberry and Raspberry[12, 20]
Mustards[17, 20]
Bee Pasture
Golden Alexanders[11, 19]
Perennial Lupine[2, 10]
Bigleaf Lupine[14, 20]
Sweet Yellow Clover[17, 20]
Red Clover[20]
Cow Vetch[12, 20]
Northern Bush Honeysuckle[18, 20]
Purple Coneflower[8, 20]
Early Goldenrod[12]
Lance-Leaved Coreopsis[8, 20]
Bergamot[4]
Meadowsweet[11, 12, 19, 20]
Milkweed[11, 12, 19]
Plains Coreopsis[20]
Lavendar Hyssop[8]
Showy Goldenrod[12, 19]
Joe-Pye Weed[12]
Wild Sunflower[20]
Canada Goldenrod[9, 12, 21]
New England Aster[3, 11, 19]

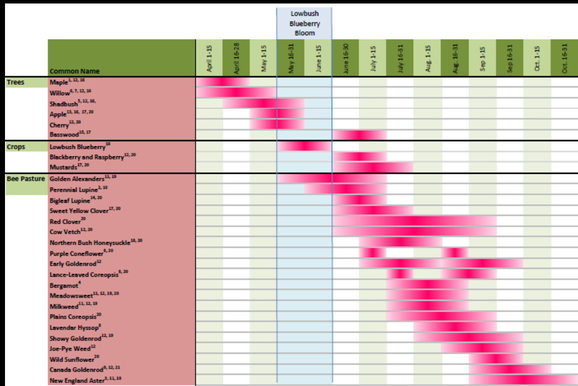



Photo: Eric Venturini


www.nelsonfamilyfarm.com

4. **Select Flower Mix**
    a. When do they bloom?
    b. Who do they attract?
    c. Other filters

5. **Plant**
    a. Smooth seedbed
    b. Bulk seeds with sand/vermiculite
    c. Compact soil
    d. Water during early establishment

6. **Maintenance**
    a. Mow and remove debris first year (unless annual flowers)
    b. Mow in fall, 1/3 per year

THANK YOU!!!!

Dr. Frank Drummond, Dr. Aaron Hoshide, Dr. Lois Berg Stack, Dr. Alison Dibble, Sam Droege, Judy Collins, Paul Allen, Dr. Eric Asare, Dr. Anne Averill, Jacob Bailey, Dr. Kalyn Bickerman, Holly Bixby and Tod Cheney, Dr. Brett Blaauw, Haley Boddington, Jeff Brann, Dr. Sara Bushmann, Joe Cannon, Shannon Chapin, Peter Collin, Danner and Dewey Curtis, Billy Desisto, Brianne Du Clos, Dell Emerson, Nathan Frederick, Dr. Eric Gallandt, Dr. Sam Hanes, Bruce Hoskins, Dr. Rufus Isaacs, Steve Javorek, Audrey Maddox, Connor McCormic, Marge McCullough, Dr. Julia McGuire, Chris McManus, Jeff Norment, Andrea Nurse, Nick Peterson, David and Ellen Simmons, Dr. John Skinner, Josh Stubbs, Paul Sweetland, Dr. Corianne Tatariw, Doug VanHorn, Glenn and Marian Venturini, Sarah Watts, Sadie Wight, Diane Wilson, Wesley Woods, Everyone else that I've missed!

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Ecology and Environmental Sciences
Program, Applewood Seed Company,
Umaine Graduate Student Government,
and the School of Biology and Ecology
at the University of Maine

Agapostemon virescens **-** Photo Credit Sam Droege, USGS Bee Inventory and Monitoring Lab

Questions?

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PRs in Maine lowbush blueberry (Venturini et al. 2017b)

Common Name	Species	Habit	No. live seeds/ sq foot	No. live seeds per acre
Wildflower Treatment				
Plains Coreopsis	*Coreopsis tinctoria*	*Annual*	9.55	416,000
Indian Blanket	*Gaillardia pulchella*	*Annual*	7.66	333,600
Sunflower	*Helianthus annuus*	*Annual*	2.75	120,000
Lavender Hyssop	*Agastache foeniculum*	*Perennial*	5.29	230,400
Lance-Lvd. Coreoopsis	*Coreopsis lanceolata*	*Perennial*	5.79	252,000
Canada Tick Trefoil	*Desmodium canadense*	*Perennial*	1.82	79,200
Purple Coneflower	*Echinacea purpurea*	*Perennial*	4.69	204,400
Common Boneset	*Eupatorium perfoliatum*	*Perennial*	3.53	153,600
Bee Balm	*Monarda fistulosa*	*Perennial*	4.01	174,720
New-England Aster	*Symphyotrichum novae-angliae*	*Perennial*	4.52	196,800
		Total Wildflower →	**49.60**	**2,160,720**
Clover Treatment			**lbs/acre**	**$/lb**
Crimson Clover	*Trifolium incarnatum*	*Annual*	7.00	7.95
Medium Red Clover	*Trifolium pratense*	*Perennial (short-lived)*	5.00	9.50
Sweet Yellow Clover	*Melilotus officinalis*	*Biennial*	6.00	8.20
		Total Clover →	**18.00**	**25.65**