Agroforestry: A Perfect Pollinator Partnership


Washington Agroforestry Workshop
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Pollination Economics

All Crop Pollinators

- $18-27 billion contribution of honey bee pollination to U.S. crops (Vaughan adaptation of Morse and Calderone 2000, Klein et al 2006)

Oregon Crop	2017 Value ($ millions)
Pears	$176.4
Blueberries	$147.6
Sweet cherries	$70.2
Apples	$38.6
Blackberries	$31.1
Raspberries	$6.0

Native Bees

- $2.4 billion to California crops alone (Chaplin-Kramer 2011)
- $3.0 billion to U.S. crops (Losey and Vaughan 2006)

Morse and Calderone. 2000. The value of honey bees as pollinators of U.S. crops in 2000. *Bee Culture* 128:1-15
Chaplin-Kramer, et al. 2011. Value of Wildand Habitat for Supplying Pollination Services to Californian Agriculture. *Rangelands* 33(3):33-41
Losey and Vaughan. 2006. The economic value of ecological services provided by insects. *BioScience* 56:311–323.

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Beyond Food

- Over 75% of flowering plants in temperate regions require animal pollination *Ollerton et al. 2011*

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The Buzz about Pollinators?

- 30% of food production relies on insect pollination *Klein et al. 2007*
- Most of our vitamins and minerals are from insect-pollinated plants

Insect Pollination Of Cultivated Crop Plants
S. E. McGregor USDA 1976

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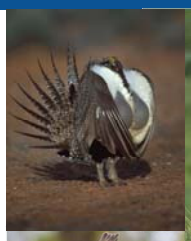
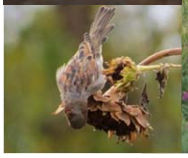
Beyond Food

Pollinators and wildlife

- Pollinators and insects are critical food source for 89% of birds, and many other wildlife.
- Seeds and fruit provide other critical food sources for wildlife


Losey and Vaughan. 2006. Econ value of insects. Bioscience. 56(4):311-323

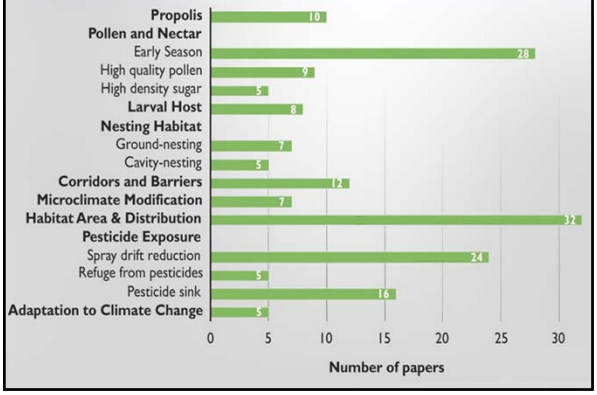
Photos: USDA-NRCS/Ron Nichols (ul); NPS/Karen Ward (r); Xerces Society/Matthew Shepherd (ll)

Pollinator Species

Bees & Wasps | Flies | Butterflies & Moths

Beetles | Bats | Hummingbirds

Propolis, Pollen and Nesting Habitat



Threats

- Habitat loss, degradation, & fragmentation
- Pesticide exposure
- Non-native species & diseases
- Climate change

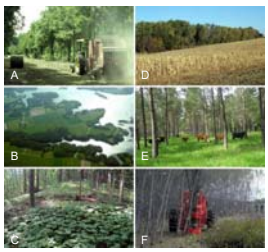
Enhancing Pollinator Habitat

1. Providing foraging resources & nesting or egg-laying sites

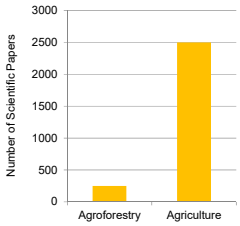
2. Enhancing site & landscape connectivity

3. Reducing pesticide exposure

Scientific Assessment



A. Alley Cropping
B. Riparian Forest Buffers
C. Forest Farming
D. Windbreaks
E. Silvopasture
F. Additional Applications



\+ Pollinators

Foraging Habitat

- Quality pollen/nectar
- Hi-density of resources
- Diversity of resources
- Range of bloom times
- Larval resources

Quality Pollen & Nectar

Species	Common Name	Nectar	Pollen
Acer spp.	Maples	0.600	0.600
Amelanchier spp.	Serviceberry	0.500	0.400
Prunus spp.	Cherry	0.750	0.750
Quercus spp.	Oak	0.000	0.700
Rubus spp.	Rubus	0.700	0.600
Salix spp.	Willow	0.800	0.900
Sambucus spp.	Elderberry	0.300	0.600
Baptisia spp.	Wild Indigo	1.000	0.500
Solidago spp.	Goldenrod	0.900	0.800
Trifolium spp.	Clover	0.750	0.750

0=no pollen/nectar source
1=major pollen/nectar source

Adapted from Loose et al. 2005
*Based on honeybee data

Larval Resources

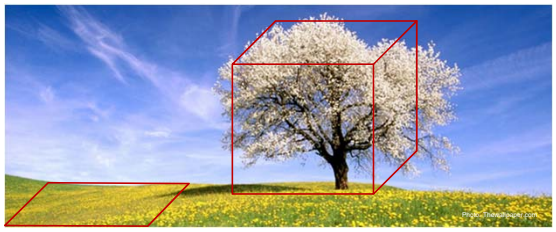
Common Name	Plant Genus	# of butterflies & moths supported
Oaks	*Quercus*	543
Cherry, plum	*Prunus*	456
Willow	*Salix*	455
Birch	*Betula*	411
Poplar	*Populus*	367
Crabapple	*Malus*	305
Maple	*Acer*	297
Blueberry	*Vaccinium*	294
Hickory	*Carya*	235

Tallamy and Shropshire 2009

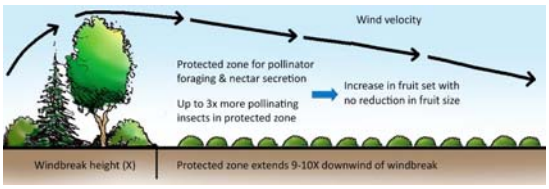
Hi-Density of Resources

Species	Flowers/m²	Nectar productivity kg/ha cover/year
Salix cinerea	334,178	3612
Crataegus monogyna	19,003	584
Aster tripoium	9,565	169
Epilobium montanium	560	51

Baude et al. 2016



Microclimate Modification



Smith and Lewis 1972, Pinzauti 1986, Pasek 1988

- Populations in overwintered hives up to 52% higher when protected by windbreaks. *Merrill 1923*

Range of Bloom Times

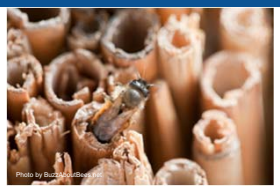
Common Name	Scientific Name	March	April	May	June	July	August	Sept
Vine maple	*Acer circinatum*							
Willows	*Salix* spp.							
Oregon grape	*Mahonia aquifolium*							
Currants	*Ribes* spp.							
Pacific dogwood	*Cornus nuttallii*							
Snowbrush ceanothus	*Ceanothus velutinus*							
Salmonberry	*Rubus spectabilis*							
Manzanita	*Arctostaphylos* spp.							
Snowberry	*Symphoricarpos albus*							
Nootka rose	*Rosa nutkana*							
Pacific ninebark	*Physocarpus capitatus*							
Blue elderberry	*Sambucus nigra* ssp. *cerulea*							
Ocean spray	*Holodiscus discolor*							
Rose spiraea	*Spiraea douglasii*							

Other Foraged Resources

- Bees also collect resins and oils from trees and other plants.
- Honey bees use resins to make propolis which has antimicrobial properties
- Poplar trees (*Populus* spp.) are a common source for these resins.
- Other tree species include pine (*Pinus* spp.), birch (*Betula* spp.), elm (*Ulmus* spp.), alder (*Alnus* spp.), beech (*Fagus* spp.), and horse-chestnut (*Aesculus* spp.)

Tunnel-nesting

- 30% of native bee species build their nests inside hollow tunnels.
- Use plants with soft pithy centers:
  - Elderberry
  - Boxelder
  - Rubus spp.
  - Dogwood
  - Sumac
- Use pruning to expose the pithy interior of the stems
- Piles of cut-out invasive Himalayan Blackberry stems
- Retain dead or dying trees and branches whenever practical



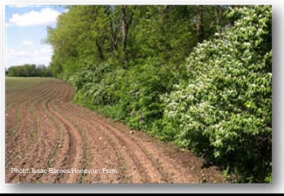
Connectivity - Foraging Distances

Bee Size	Foraging Distance (m)	Bee Group	Example of Crops Pollinated
	50-300	Dark sweat bees, blue-green sweat bees	Melon, tomato, pepper
	130-700	Mason, sweat, squash bees	Raspberries, blackberries, tomato, pepper, squash, peach, pear
	500 -1100	Plasterer, mining, alkali bees	Blueberry, apple, strawberry, alfalfa
	1500-2500	Bumble bees	Blueberry, cranberry, squash, watermelon, cucumber, tomatoes, clover

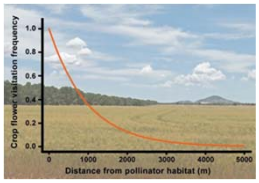
Zurbuchen et al. 2010
USDA 2015

Ground-nesting

- 70% solitary ground nesting bees.
- Undisturbed area necessary for ground nesting species.
- May be found in turf, more often on bare, exposed ground and south-facing slopes
- Sandy to loam soils preferred



Site & Landscape Connectivity



- Pollinator visits to crops declines to 50% of its maximum at ~600 m from semi-natural habitat. *Ricketts et al. 2008*

Bumble bees

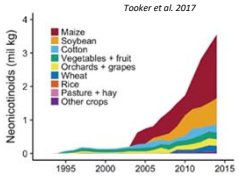
- About species of social bumble bee in the U.S.
- Nest in small cavities, such as abandoned rodent burrows.
- Bumble bee nest densities twice as high in linear woody habitats.

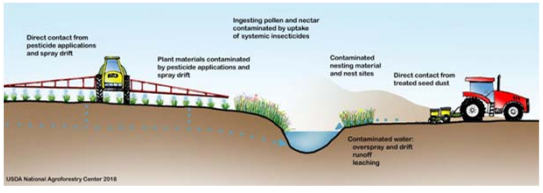
Osborne et al. 2008

Pesticide Exposure

- Woody plantings can reduce spray drift by up to 80-90%. *Ucar and Hall 2001*
- 40 to 100% reduction of pesticides in run-off using agroforestry systems. *Pavlidis and Tsihrintzis 2017*

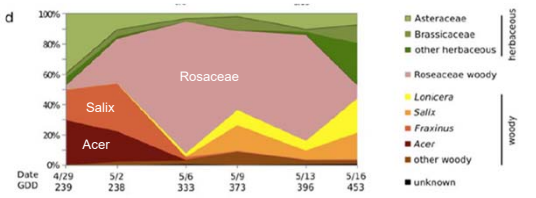
Tooker et al. 2017





Pesticide Sink?

- High concentrations of neonicotinoids in early-flowering tree and shrub pollen.



Ohio bee-collected pollen

Corn Dust Research Consortium 2015

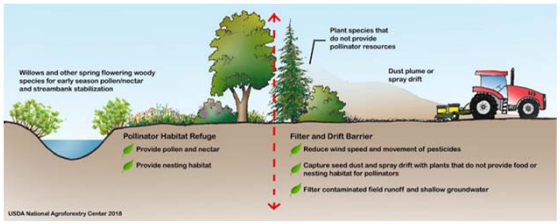
Marketable Products

Common Name	Wood	Fruit	Botanical	Biomass	Decorative Floral	Handicraft
Maples	•					•
Willows				•	•	•
Serviceberry		•				
Salal		•				•
Bearberry			•			
Black chokeberry		•	•			
Elderberry		•	•			

- Willow stems for the floral industry: $8 - $17 net income per plant (2018 US$)

https://nfs.unl.edu/documents/SpecialtyForest/growersguideweb2007.pdf

Reducing Pesticide Exposure

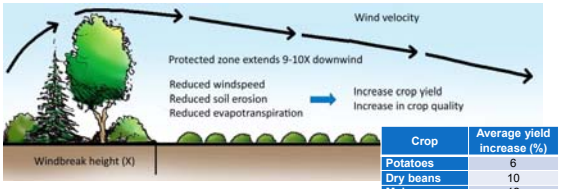


Diversification & Risk Management

Energy Conservation

- 10 – 30% energy savings with a shelterbelt *DeWalle & Heisler 1988*

Other Agroforestry Benefits



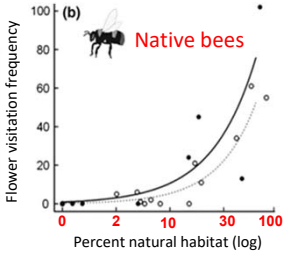
Crop	Average yield increase (%)
Potatoes	6
Dry beans	10
Maize	12
Tomatoes	16
Grass hay	20
Winter wheat	23
Barley	25
Raspberry	40
Snap beans	40
Strawberry	56

Benefits to horticultural crops

- Reduced soil abrasion
- Reduced desiccation of canes
- Earlier ripening
- May increase sugar content

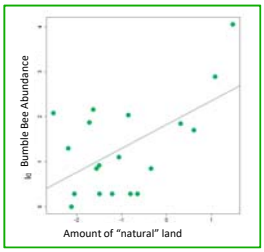
Value of Habitat

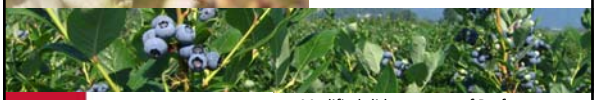
Spatial Extent



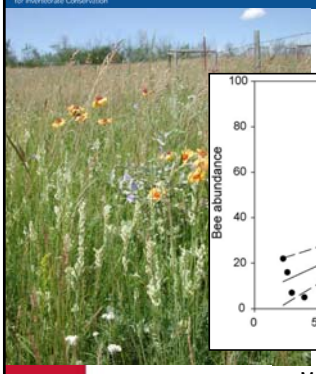
- Full pollination for watermelon when 30% of the land within 1.2 km of a field is in pollinator habitat. *Kremen et al. 2004*
- A higher proportion of semi-natural habitats (i.e., 17% vs 2%) decreased the negative effects of warmer temperatures on native bee richness and abundance in ag lands. *Papanikolaou et al. 2017*

More natural land around highbush blueberry fields → more wild bumblebees

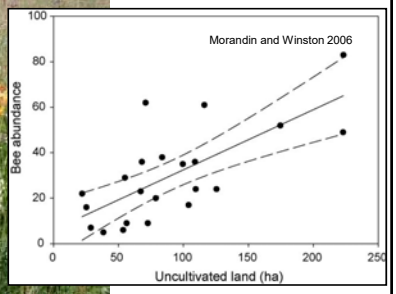




Modified slide courtesy of Professor Elizabeth Elle, Simon Fraser University



More natural land nearby means more bees in Canola



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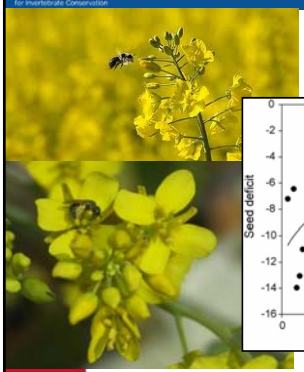
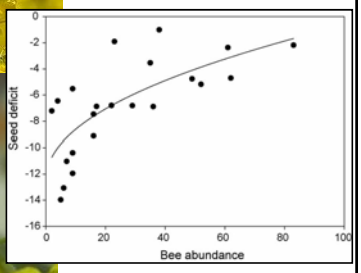
Agroforestry Practices and Pollinators



More bees → better pollination



Modified slide courtesy of Professor Elizabeth Elle, Simon Fraser University

Hedgerows:

Poll benefits: Can be designed to include species that provide forage and nest sites for pollinators

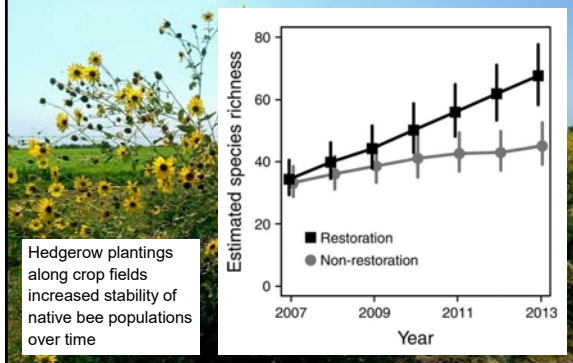
Hedgerows:

Other benefits:

- Improve crop microclimate
- Help retain moisture
- Reduce abrasion from blown soil
- Support other beneficial insects that fight pests
- Eliminate weeds
- Buffers between urban and agricultural lands
- Beautification

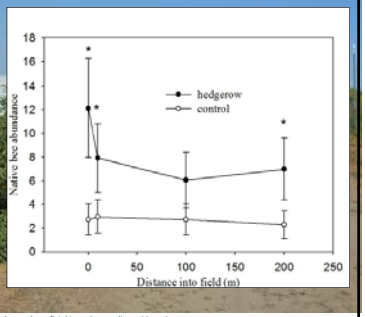
Photo: Katharina Ullmann

Hedgerow plantings along crop fields increased stability of native bee populations over time



M'Gonigle, Ponisio, Cutler, and Kremen, 2015

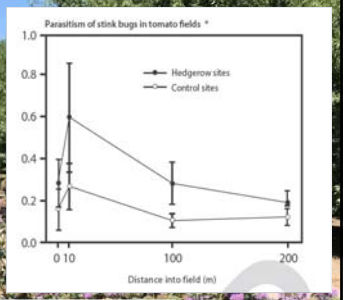
More Bees travel into crops adjacent to hedgerows



Morandin, L., R. Long, and C. Kremen. 2014. Hedgerows enhance beneficial insects on adjacent tomato fields in an intensive agricultural landscape. Agriculture, Ecosystems, and Environment. 189: 164-170.

Native Plant Hedgerows Enhance Pest Control

- More stink bug eggs parasitized by wasps in fields with nearby native plant hedgerows



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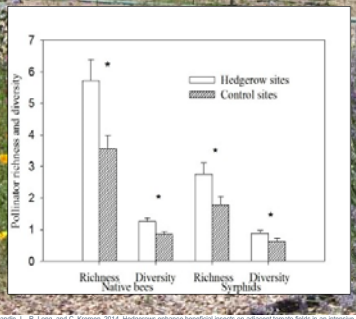
Greater pollinator abundance and diversity on farms with hedgerows



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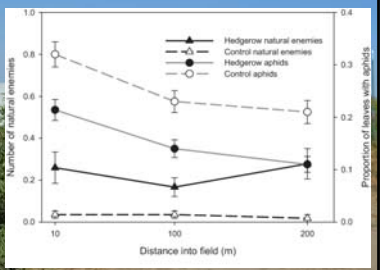
Native Plant Hedgerows Enhance Pest Control



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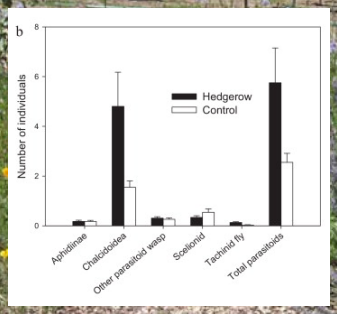
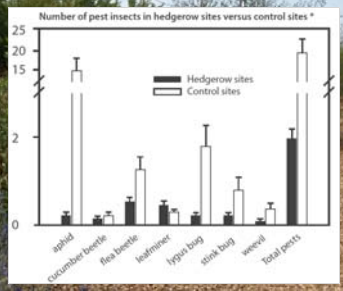
Greater abundance and diversity of beneficial insects on farms with hedgerows



Native plant hedgerows versus weedy field edges

Fewer pests (except leafminers) at the hedgerow sites



Hedgerows:

Other design considerations:

- Tree height and number of rows
- Proximity to crops: balance protection from pesticide drift and foraging distance of bees
- Can choose edible species or species that help feed wildlife
- Addition of perennial wildflowers adds pollinator benefits before trees and shrubs mature


Windbreaks:
Can be designed to include species that provide forage and nest sites for pollinators
Photo: Jessa Kay-Cruz (Xerces Society)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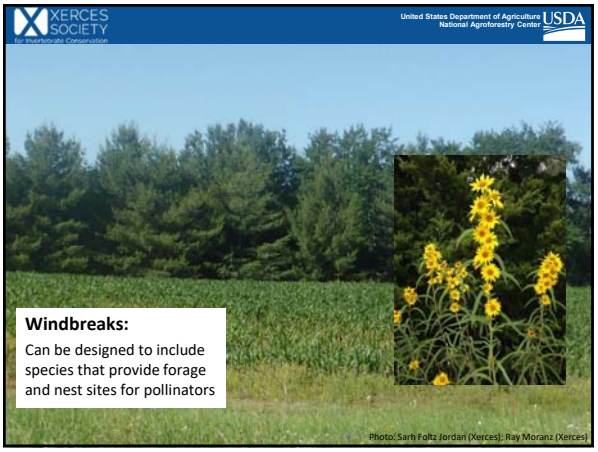
Windbreaks:
Can be designed to include species that provide forage and nest sites for pollinators
Photo: Sarh Foltz Jordan (Xerces); Ray Moranz (Xerces)


Windbreaks:
Can be designed to help prevent or capture drifting pesticides
Key design considerations:
• Small needled conifers that don't drop lower branches (e.g. spruce, juniper, cypress, arborvitae, fir, etc.)
• ~ 60% density, in at least two rows
LEARN HOW YOU CAN USE AGROFORESTRY TO HELP POLLINATORS
AGROFORESTRY NOTES
Ucar and Hall. 2001. Windbreaks as a pesticide drift mitigation strategy: a review. Pest Mgmt Science. 57:663-675.
Photo: Sarah Foltz Jordan / Xerces Society


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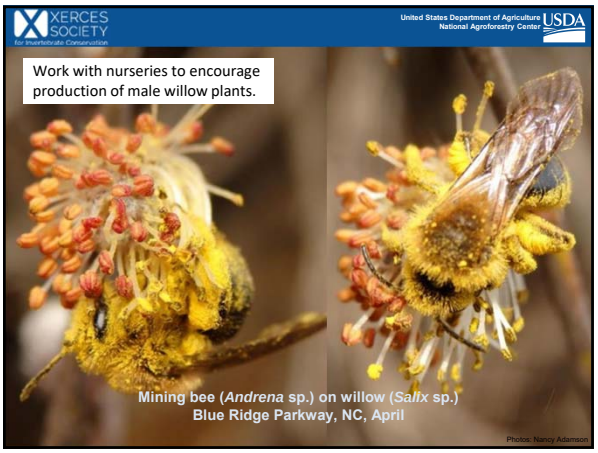
Photos: Kelly Gill/Xerces Society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Work with nurseries to encourage production of male willow plants.
Mining bee (Andrena sp.) on willow (Salix sp.)
Blue Ridge Parkway, NC, April
Photos: Nancy Adamson


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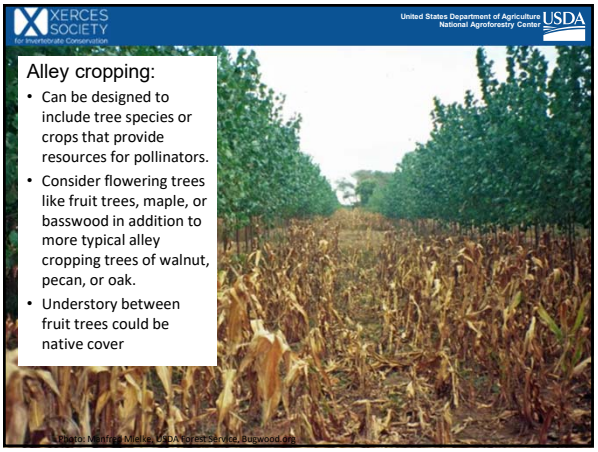
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Alley cropping:
• Can be designed to include tree species or crops that provide resources for pollinators.
• Consider flowering trees like fruit trees, maple, or basswood in addition to more typical alley cropping trees of walnut, pecan, or oak.
• Understory between fruit trees could be native cover
Photo: Manfred Mielke, USDA Forest Service, Bugwood.org


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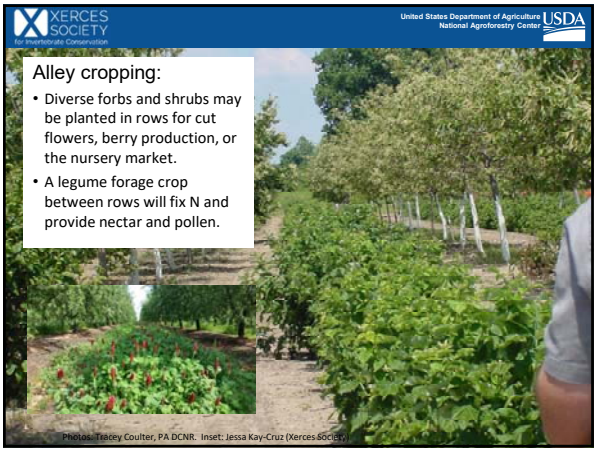
Riparian forest buffers:
Can easily be designed to include trees, shrubs, and wildflowers for pollinators.
Photo: U.S. Department of Agriculture, Sockeye salmon by Wilson Hui (creative commons)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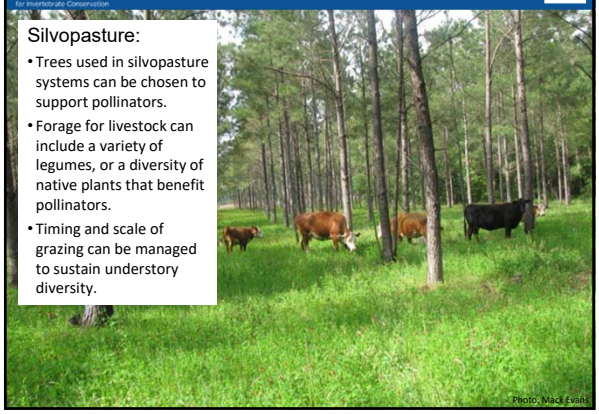
Alley cropping:
• Diverse forbs and shrubs may be planted in rows for cut flowers, berry production, or the nursery market.
• A legume forage crop between rows will fix N and provide nectar and pollen.
Photos: Tracey Coulter, PA DCNR. Inset: Jessa Kay-Cruz (Xerces Society)

Silvopasture:

- Trees used in silvopasture systems can be chosen to support pollinators.
- Forage for livestock can include a variety of legumes, or a diversity of native plants that benefit pollinators.
- Timing and scale of grazing can be managed to sustain understory diversity.



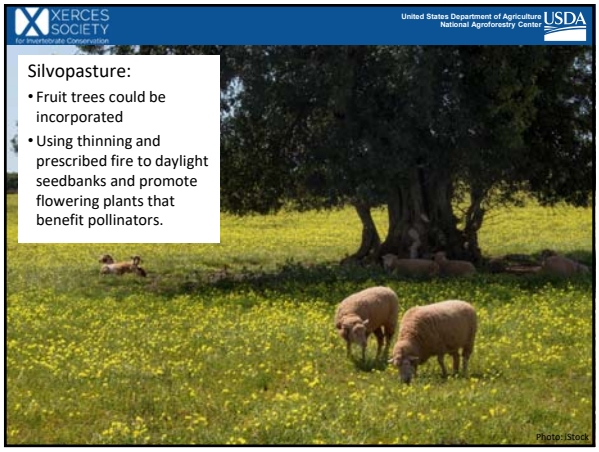
Forest farming:

Many valuable overstory and timber trees:

- Big-leaf maple (*Acer* spp)
- Tulip tree (*Lirodendron*)
- Horse chestnut (*Aesculus*)
- Basswood (*Tilia* spp)
- Oaks (*Quercus*)
- And more…

Silvopasture:

- Fruit trees could be incorporated
- Using thinning and prescribed fire to daylight seedbanks and promote flowering plants that benefit pollinators.



The USDA Natural Resources Conservation Service

- Technical Assistance
- Financial Support for Conservation

Find out more at: www.nrcs.usda.gov

http://plants.usda.gov/pollinators/NRCSdocuments.html

United States Department of Agriculture Natural Resources Conservation Service

Forest farming:

High value medicinal plants, such as ginseng, black cohosh, and goldenseal, benefit pollinators.

https://xerces.org

http://xerces.org/pollinator-resource-center/

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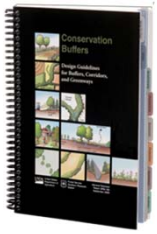
United States Department of Agriculture Natural Resources Conservation Service NRCS

Where to go…
- Efotg (search "Pollinator")
- https://plants.usda.gov/pollinators/NRCSdocuments.html

Extra Slides



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www.fs.usda.gov/nac/index.shtml

More natural land around highbush blueberry fields → less pollination "deficit"

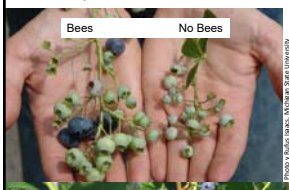
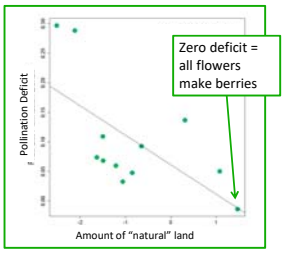


Photo: Julius Isaacs, Michigan State University



SFU SIMON FRASER UNIVERSITY ENGAGING THE WORLD

Modified slide courtesy of Professor Elizabeth Elle, Simon Fraser University

Questions?

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Native Plant Hedgerows Enhance Pest Control

- Study comparing stink bug parasitism in tomato fields adjacent to hedgerows to tomato fields without habitat.
- Parasitism rate 3x as high in fields adjacent to hedgerows

Photos: Jessa Kay Cruz, Don Loarie (flickr CC2.0), David Cappaert (Bugwood.org), Thelma Heidel-Baker, Xerces Society

Morandin LA, Long RF, Kremen C 2014. Hedgerows enhance beneficial insects on adjacent tomato fields in an intensive agricultural landscape. Agric Ecosyst Environ

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Bottlebrush Buckeye

Maple

Willows

Buttonbush

Photos: Nancy Lee Adamson

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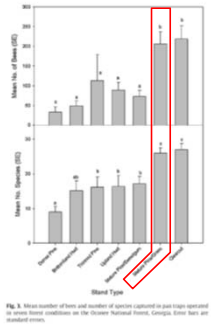
What about silvopasture?

Image by Rich Straight



Hanula et al. 2015. Have changing forests conditions contributed to pollinator decline in the Southeastern United States? Forest Ecology and Management 348 (2015) 142–152.