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Guidelines for cover crop mixtures:

1. **Weeds**: Have 1-2 species that provide fast ground-cover in the fall, then add species to achieve other goals
2. **Insects**: To support beneficial insects for pollination or biological control, manage mixtures to include flowers
3. **Nitrogen**: Combine a well-adapted legume with a low seeding rate of a winterhardy grass or brassica
4. **Overall**: Aim for balanced biomass from all species in the mix to benefit from a range of functions

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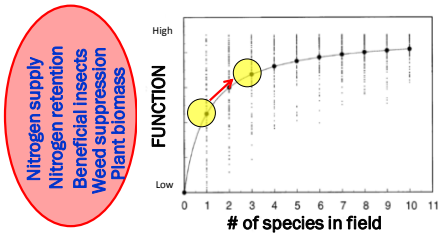
Farmer use of mixtures aligns with ecological theory



Adapted from Hooper et al. 2005

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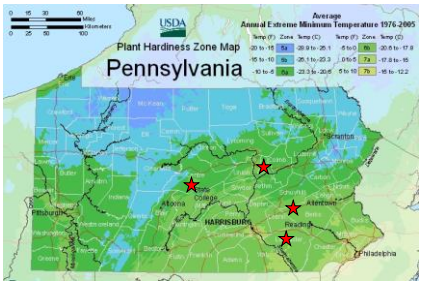
Winter Cover Crop Mixtures in Pennsylvania



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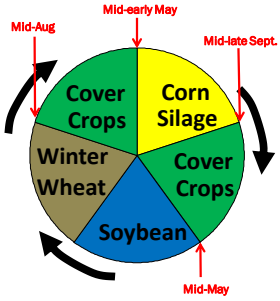
Cover Crop Mixtures in a Corn-Soy-Wheat Rotation for Organic Feed and Forage



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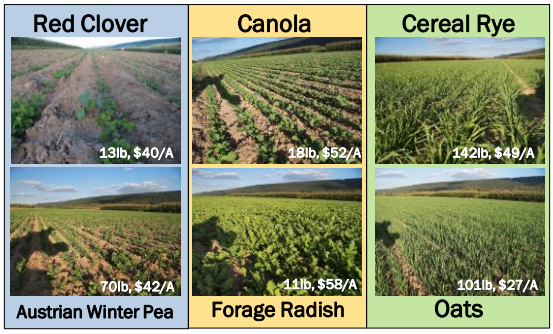
An example with six cover crop species



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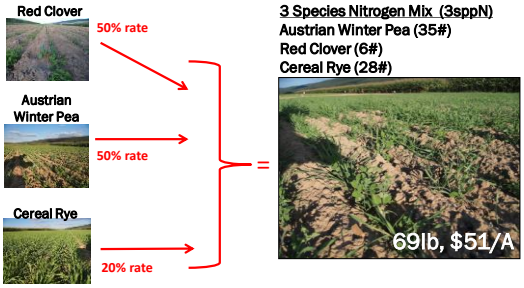
3-Species Nitrogen Mix = 3sppN

Goal: Supply and retain N



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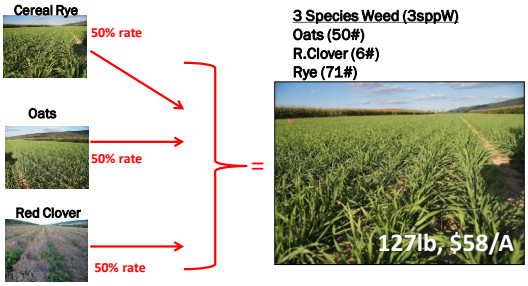
3-Species Weed Mix = 3sppW

Goal: Suppress weeds and supply and retain N



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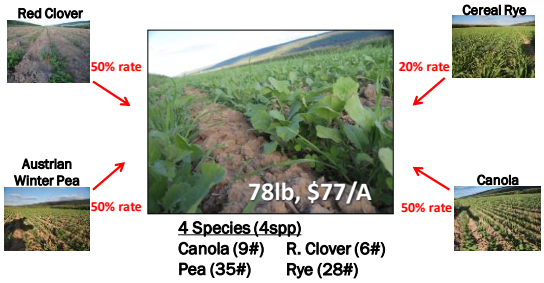
4-Species Mix = 4spp

Goal: Support pollinators & beneficial insects, suppress weeds and manage N



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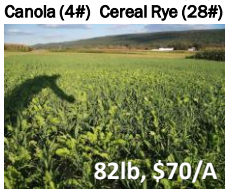
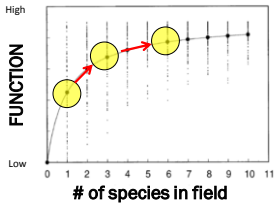
6-Species Mix = 6spp

Goal: The "Insurance" Mix

6-Species Mix (6spp)
Radish (4#) A.Winter Pea (18#)
Oat (25#) Red Clover (3#)
Canola (4#) Cereal Rye (28#)





Adapted from Hooper et al. 2005

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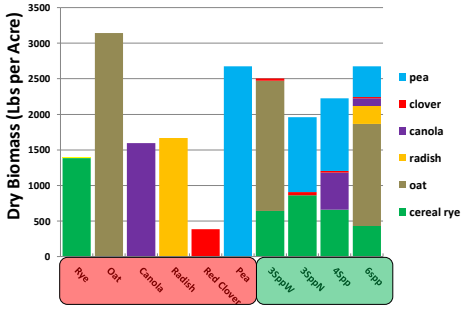
Fall Cover Crop Biomass

Poor red clover establishment in cover crop mixtures



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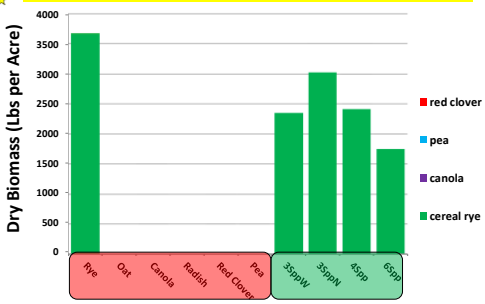
Spring Cover Crop Biomass

If planted after corn, then spring biomass is nearly 100% rye



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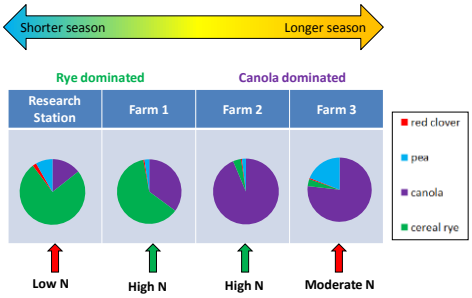
The Same "4 Species Mix" Varies by Farm



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Can mixtures achieve multiple goals on the farm?

1. **Weed suppression and management**
2. **Beneficial insects**
3. **Nitrogen management**

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Weed Management with Cover Crop Mixtures

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Weed Management Goals:

- Keep weeds from setting seed
- Grow cover crops, not weeds
  - Get the benefits you paid for
- Bonus: Draw down the weed seedbank

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Weed Management Questions:

- Which cover crops work best?
- Do mixtures help?
- *How* do cover crops suppress weeds?

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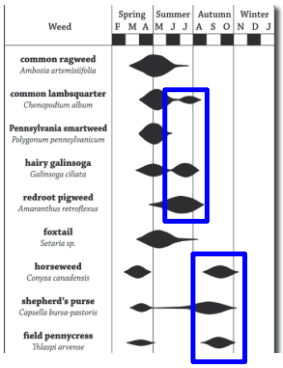

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Weed Take-Homes:

- Many cover crop treatments can be effective
  - Watch out for slow-growing legumes on their own
  - Start from a weed-suppressive base, build out
- Winter-killed cover crops can suppress weeds through the spring
- Rapid fall growth is key
  - Focus on getting a good stand
- Manage tillage timing to draw down weed seedbank

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Cover Crop Mixtures and their Influences on Beneficial Insects

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Beneficial Insects

- Provide valuable ecosystem services on farm.
  - Pollinate crops
  - Suppress pest insects
- Pollinators provide approximately $29 billion in pollination each year.
- Natural enemies provide estimated $4.6 billion in pest suppression service each year.

http://blogs.discovermagazine.com/d-brief/files/2013/03/honeybee-flower1.jpg

Photo: Jermaine Hinds

http://www.freshplaza.it/imagery/201307/17/aphidius1.jpg

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Insects and Cover Crops

- Plants represent a valuable resource to beneficial insects.
  - Food
    - Nectar, Pollen, Alt. Prey
  - Shelter
    - Egg laying sites, ground-dwellers
- Cover crops may support insects when insect prey numbers are low.
- Can we use cover crop mixtures to support beneficial insects?

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Insects Have Preferences, Too!

- Insects exhibit preferences for specific floral resources
- Different insects may appear depending on plant characteristics:
  - Flower:
    - Shape
    - Size
    - Color
    - Smell
- More diverse mixtures may support a more diverse group of beneficial insects

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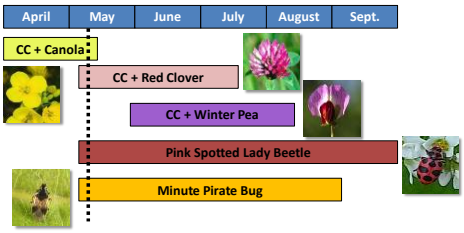
Need to consider cover crop termination and crop establishment if a goal is to provision beneficial insects



In rotations where cover crop mixtures must be terminated before flowering, are there alternative ways to use them to promote beneficial insects?

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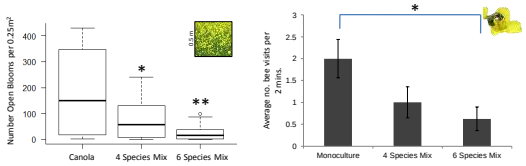
Conservation of Bees for Pollination Services

A diverse group of wild bees visit canola plants in cover crop mixtures:

- More frequent visits in the monoculture plots where floral density was highest



Slide Credit: Katie Ellis

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Can Mixes Be Tailored to Attract Specific Natural Enemies?

Buckwheat	Cowpea	Buckwheat-Cowpea Mixture
•Nectar/pollen for beneficial insects	•Early extrafloral nectaries for beneficial insects	•Floral nectar/pollen AND •Extrafloral nectar for beneficial insects

Would a biculture of buckwheat and cowpea provide combined benefits from both plant species? In progress, stay tuned……

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Insect Take-Homes:

Flower presence and flower density may be more important than cover crop diversity

- Compatibility with farm goals and crop:
  - Timing
    - Establishment, flowering, termination
  - Alternative
    - Insectary strips
- Mixture design:
  - Diversity of flower types
  - Be aware of potential crop pests in your system and if cover crop species will support them

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Nitrogen Management with Cover Crop Mixtures

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Nitrogen Management with Cover Crop Mixtures

Goals

- Prevent Nitrate Leaching
  "N retention"
- Supply N to the next cash crop

Behavior of Mixtures is Affected by Species Characteristics

- Grasses, Brassicas, Legumes
- Winterhardy vs. Winterkilled

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Species Characteristics: Nitrogen Acquisition

- **Grasses and brassicas only acquire N from the soil**
- **Legumes can acquire N from the atmosphere through N fixation**

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Species Characteristics: Growth Period

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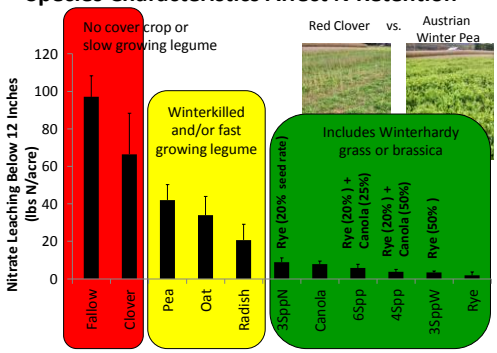
Species Characteristics Affect N Retention



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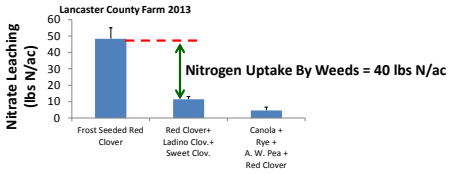
On-Farm Results

Frost seeded red clover allows significant nitrate leaching



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Nitrogen Supply: N is released from cover crop residues by microbial decomposition

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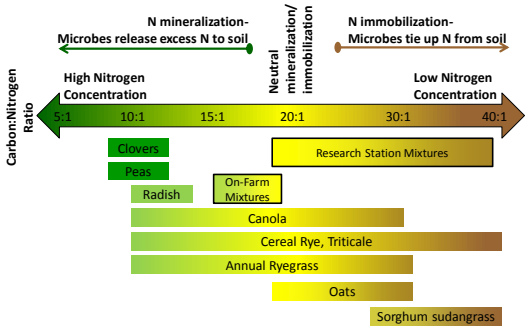
C:N ratio of cover crop residues regulates N supply vs. N tie up



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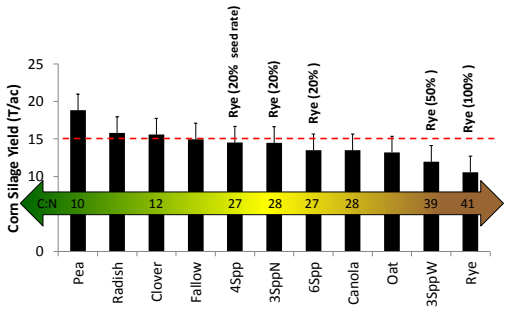
Corn Yield Declined with Increasing C:N Ratio of Cover Crop



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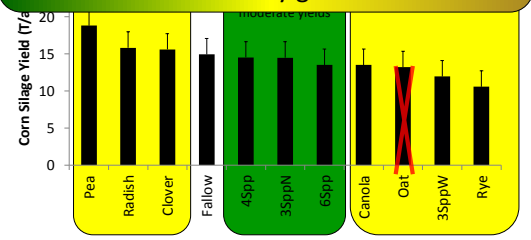
Nitrogen Management with Cover Crop Mixtures Rule of Thumb

To balance N retention and supply, combine a well-adapted legume with a low seeding rate of a winterhardy grass or brassica



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Can mixtures achieve multiple goals?

Yes – but make a plan

Guidelines:

1. **Weeds**: Have 1-2 species that provide fast ground-cover in the fall, then add species to achieve other goals
2. **Insects**: To support beneficial insects for pollination or biological control, manage mixtures to include flowers
3. **Nitrogen**: Combine a well-adapted legume with a low seeding rate of a winterhardy grass or brassica
4. **Overall**: Aim for balanced biomass from all species in the mix to benefit from a range of functions

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Making the most of cover crop mixtures

Identify the functions you want from the cover crop mixture

- Build organic matter
- Nitrogen fixation
- Nitrogen retention
- Weed suppression
- Beneficial insects
- Fall and/or spring forage production

Identify the planting window

- Late summer
- Early fall
- Late fall

Fine-tune for an even mixture on your farm

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Thank you!

Organic Research and Extension Initiative (OREI)

USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

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