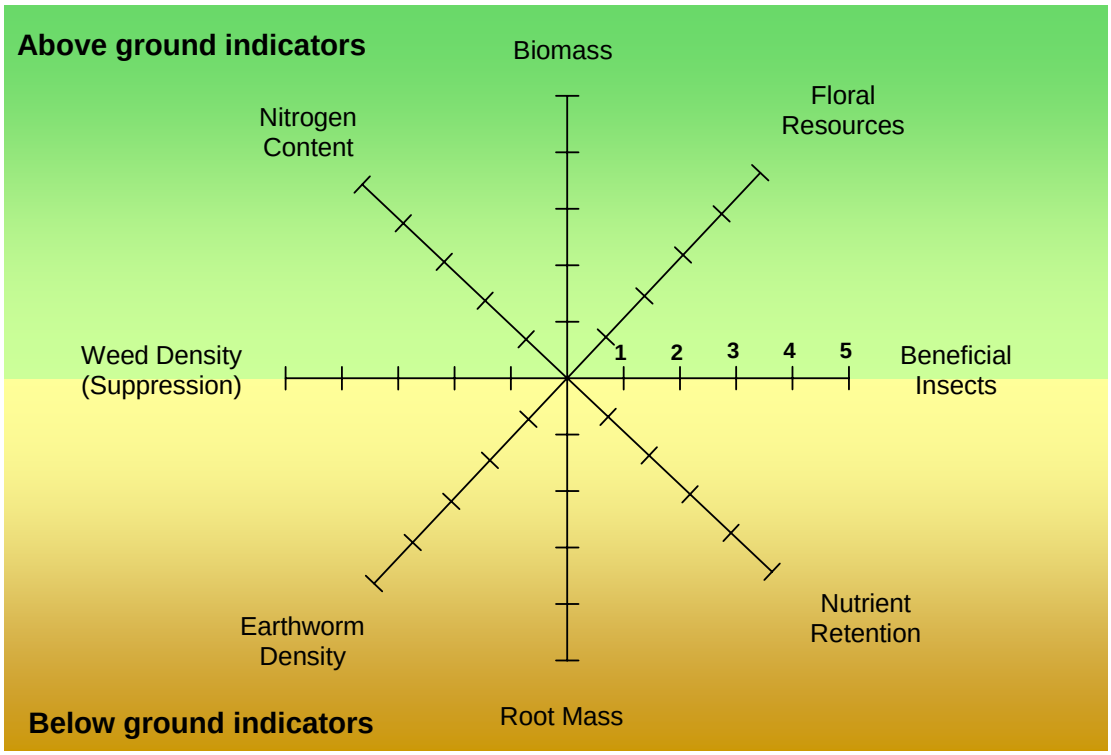
Evaluating Ecosystem Services from Cover Crops



Cover Crop:_____

Date: _____

Table 1. Value ranges for indicators used in spider plot evaluation

	Ranks				
Indicators	**1**	**2**	**3**	**4**	**5**
Beneficial Insect Diversity (# of different groups)	≤ 1	2 – 3	4 – 5	6 – 7	≥ 8
Floral Resources (% floral cover)	1 – 19	20 – 39	40 – 59	60 – 79	80 – 100
Weed Density (# / 2.69 ft^2)	≥ 80	60 – 79	40 – 59	20 – 39	≤ 19
Biomass (lbs/acre)	≤ 5,999	6,000 – 7,999	8,000– 9,999	10,000 – 11,999	≥ 12,000
Nitrogen Content (lbs/ acre)	≤ 29	30 – 59	60 – 89	90 – 119	≥ 120
Root Mass (lbs)	≤ 0.03	0.04 – 0.07	0.08 – 0.11	0.12 – 0.15	≥ 0.16
Earthworm Density (# / 2.69 ft^2)	0	1 – 3	4 – 6	7 – 9	≥ 10
Nutrient Retention (C:N of plant residue)	10 – 19	20 – 29	30 – 39	40 – 49	≥ 50

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Purpose

Cover crops provide multiple services for farming systems. They can be used to suppress weed populations, add organic matter to the soil, revitalize a compacted soil, prevent leaching, reduce soil erosion, break up pest cycles, and provide resources for beneficial insects. However, typically cover crops do not provide all of these services to an equal extent. Thus, there are trade-offs when choosing between different cover crops. How then can we select cover crops to meet the needs of our particular circumstances (i.e. soil conditions, topography, and climate)?

The goal of this activity is to learn how to use a decision-making tool (a spider plot) to compare the potential benefits and limitations of different cover crops. The indicators presented here relate to particular ecosystem services important to the sustainability of farming systems. For example, the abundance of bees found in a cover crop tells us something about the pollination services that may be enhanced in an adjacent orchard or field. Similarly, the number of weeds found in the understory of the cover crop is related to the ability of the cover crop to suppress weeds. While the indicators presented here encompass major services rendered by cover crops, they are not exhaustive and can be substituted with other indicators that may better relate to the circumstances of your farm or your particular production goals.

What you will need

1 Plastic bowl
1 Quadrat
1 Pair of shears
1 Shovel
1 Calculator
1 Paper bag
1 Pencil

What you will do

Each team of researchers will evaluate the ecosystem services gained from one of five cover crops (rye/hairy vetch, wheat, pea/triticale, mustard, or buckwheat). The instructions below will help you collect data regarding each indicator of a particular ecosystem service. Each indicator has a corresponding axis on the spider plot on the front page of this hand-out where you can record your data. After your team has plotted the values for each indicator on the spider plot, connect the dots. Look at the shape of the resulting spider "web" – is it symmetric? How does your cover crop compare to the other cover crops (we'll do this last part as group!).

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Indicators

A. Beneficial Insect Diversity

Cover crops provide habitat (food and refuge) for beneficial insects and spiders.
To assess the potential to enhance pollination and biological control services, follow these steps:

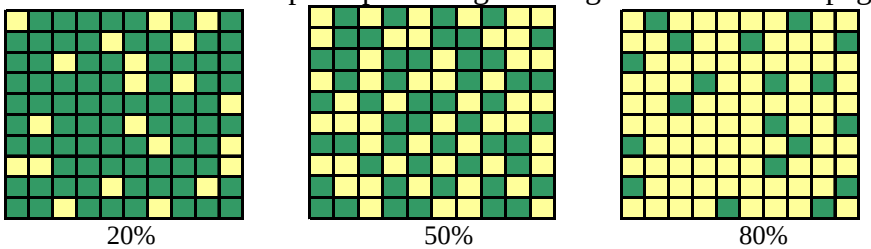
1. Stand by the edge of the cover crop plot and spend 2 min observing any pollinators or natural enemies visiting flowers or walking on vegetation.
2. Inspect a pitfall trap in the center of the plot (indicated by a colored flag) for any soil dwelling arthropods. You can use the plastic bowl to dump out and inspect the contents.
3. Use the table below to record your observations and then plot the data on the spider plot.

Beneficial Insects and Spiders	**1 = present 0 = absent**
Bees	
Wasp parasitoids	
Syrphid flies	
Lady beetles	
Soldier beetles	
Minute pirate bugs	
Lacewings	
Spiders	
Harvestmen	
Ground beetles	
Rove beetles	
Total # of Groups =	

B. Floral Resources

To evaluate the availability of floral resources to attract insect pollinators and natural enemies, follow these steps:

1. Place your quadrat over a representative area of your cover crop and estimate the proportion of the cover crop canopy in flower. Refer to the diagram below.
2. Record the data on the spider plot using the ranges in the table on page 1.



20% 50% 80%

Increasing percentage of flowers (yellow) in a plant canopy (green)

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C. Weed Density

Cover crops can suppress weeds by creating a dense canopy that limits light for weed germination and growth, competing with weeds for nutrients and water, or altering the chemistry of the soil (e.g. through allelopathy) making it less suitable for weed growth.

To estimate the density of weeds in the cover crop, follow these steps:

1. Place a ¼ m^2 (2.69 ft^2) quadrat in a representative area of the cover crop.
2. Count the number of weeds in the quadrat. It is easiest if you pick them out of the plot.
3. Record the data on the spider plot using the ranges in the table on page 1.

D. Biomass

A dense cover crop canopy has several advantages. First, it shades out weeds growing in the understory and reduces germination rates of weed seeds in the seed bank. Second, the above ground plant material is an indicator of the potential contribution of organic matter to the soil. Organic matter fuels the diversity of soil organisms that cycle nutrients and build soil structure.

To estimate the amount of plant material that will be turned into the soil, follow these steps:

1. Using shears, clip the cover crops to their base.
2. Put the plant material in the labeled paper bag.
3. Weigh your bag on the scale.
4. Calculate the yield of the cover crop (lbs/acre) following these steps:

   A. Weight of cover crop = _____ lbs

   B. Dry weight factor for crop (table below) = _____

   C. Multiply weight by the dry weight factor = _____ lbs

   D. Divide by 2.69 = _____ lbs/ ft^2

   E. Multiply by 43,560 ft^2/A = _____ lbs of biomass/A

5. Record the value from line E above on the spider plot using the ranges in the table on page 1.

Cover crop	Dry weight factor
Rye/hairy vetch	0.25
Wheat	0.25
Pea/triticale	0.20
Mustard	0.15
Buckwheat	0.15

$$\text{Yield (lbs/A)} = \frac{\text{Dry weight of cover crop (lbs)}}{2.69\ ft^2 \text{ sampled}} \times 43{,}560\ ft^2/A$$

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E. Nitrogen Content of Biomass

A major service of cover crops is their ability to replenish soils with nutrients necessary for the following crop's development. Leguminous crops (peas, vetch, clover, alfalfa, etc.) fix nitrogen from the atmosphere with the aid of soil bacteria (rhizobia) that live inside their root nodules. Because legumes are able to fix their own nitrogen, their plant tissue is higher in nitrogen content than other cover crops. Legumes also decompose quickly in the soil, making them suitable cover crops prior to heavy feeders like corn or tomatoes.

To estimate the amount of nitrogen going into the soil from your cover crop, follow these steps:

1. Multiply the biomass weight (**Line E from previous section**) by the percentage of nitrogen in your cover crop (refer to the table below).

   _____ lbs /A x _____% N/100 = _____ lbs of N /acre
   (Biomass)

Cover crops	Pre Flowering % N	Post Flowering % N
Rye/hairy vetch	3	2
Wheat	2.5	1.5
Pea/triticale	4	3
Mustard	3	2
Buckwheat	3	2

Source: Sarrantonio, M. 1994. *Northeast Cover Crop Handbook*. Emmaus, PA: Rodale Institute

2. Record the data on the spider plot using the ranges in the table on page 1.

F. Root Mass

Deep, fibrous root systems stabilize and improve soil structure, while crops with deep tap roots help break up compacted soil and access nutrients and water deep in the soil profile. As roots develop and are fed upon by soil organisms, they contribute to the organic matter accumulation in the soil. Generally, the more root development, the greater the improvement in soil structure.

To estimate root development in your cover crop, follow these steps:

1. Weigh the pre-collected root mass of your cover crop (located on reference table).
2. Record the data on the spider plot using the ranges in the table.

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G. Earthworm Density

Earthworm density is an indicator of overall soil quality. Soils rich with earthworms tend to have high organic matter content, high porosity (due to earthworm tunneling), and good moisture retention.

To estimate the number of earthworms living in the soil under your cover crop, follow these steps:

1. Using a garden shovel, dig up a shovel full of soil within the quadrat.
2. Break up the soil with your hands to look for earthworms.
3. Count the earthworms and record the data on the spider plot using the ranges in the table.
4. *Please replace the soil in the hole when you are done.*

H. Nutrient Retention

When cover crops are turned in as green manure, soil microorganisms begin decomposing the organic matter. If the crop residues are rich in carbon relative to nitrogen (C:N ratios of 30 or higher), soil microbes will tie up plant-available nitrogen in the soil. It will also take a longer time for microbes to decompose crop residue high in carbon (e.g. grass) than residue high in nitrogen, such as a legume. Consequently the nutrients tied up in that crop residue are made less available to the following crop, but are also less vulnerable to leaching. A slower decomposition rate of the cover crop also leads to greater accumulation of organic matter in the soil over time.

To estimate the ability of your cover crop to retain nutrients in the system, follow these steps:

1. Use the C:N ratios of the cover crop listed in the table below.
2. Record the value on the spider plot using the ranges in the table on page 1.

Cover crop residue	C:N
Rye/hairy vetch	30*
Wheat	80
Pea/triticale	20*
Mustard	18
Buckwheat	18

* Estimates based on mixture of grass (high C:N) and legume (low C:N) and current vegetative state

Source: Brady, N. C. and Weil, R. R. (2002) "Chapter 12: Soil Organic Matter." *The Nature and Properties of Soils (13th ed).* Upper Saddle River, NJ: Prentice Hall

Congratulations! You have assessed the multi-functionality of your cover crop!