**Small Farms Biodiversity Toolkit**

**In partial fulfillment of the requirements for the degree of**

**MASTER of SCIENCE**

**in**

**SUSTAINABLE FOOD SYSTEMS**

**by**

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# DEDICATION

To all who give their love and energy to growing food. May this work inspire curiosity and gratitude as you collaborate with the living world.

ACKNOWLEDGMENTS

Gratitude overflows to so many who traveled the long journey of this project with me. To all my Green Mountain College and Prescott College MSFS professors: Thank you for fostering my passion for a robust food system, elevating my writing skills, opening my mind to new ways of living and new life forms, all with a generous helping of humanity, humility and encouragement. To my Capstone Advisors: Dr. Wendy Sue Harper, who opened my eyes to the exquisite, invisible world of soil microbes and plant roots. Thank you for encouraging me to write something I could use on our farm and for reminding me that we will *always* be learning more about the magnificent world that sustains us. Somehow, the prospect of endless learning is comforting. And to Dr. Barbara Gemmill-Herren, who introduced me to the beautifully intricate world of pollinators. Your passion for these threatened, gorgeous insects on whom we rely is contagious. You've made me an advocate.

This Toolkit is grounded in the research of scientists who have worked for decades to understand and promote an ecological agriculture that sustains all people. Their literature complements generations of indigenous people's intimate knowledge and care for the land. I owe a tremendous debt of gratitude especially to the following people and institutions who make agroecological research accessible and practicable: Fred Magdoff and Harold Van Es, whose work I continually reference; the Xerces Society; ATTRA; SARE; Marion County Soil and Water Conservation District; FAO; Savanna Institute; Green Lands Blue Waters; Indiana Native Plant Society; NRCS; Purdue Extension; USDA; OARDC.

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# ABBREVIATIONS

ATTRA: Appropriate Technology Transfer for Rural America (National Sustainable Agriculture Information Service)

FAO: Food and Agriculture Organization of the United Nations

MCS&WCD: Marion County Soil and Water Conservation District

NCAT: National Center for Appropriate Technology

OARDC: Ohio Agricultural Research and Development Center

SARE: Sustainable Agriculture Research and Education

# INTRODUCTION

When I began farming on a small urban acreage in Indianapolis, I was in the middle of Sustainable Food Systems Masters coursework that was opening my mind to new possibilities in agriculture. I was learning that soil microbes help feed plants and protect crops from disease and pests. A suite of insects would not only pollinate our crops, but others would prey on crop pests. Small livestock such as chickens could provide fertility, eat weeds and invasive species, and diversify our business. Collaborating with the ecology that sustains human life on earth could help us create a productive and resilient farm. This is farming with biodiversity, a path to environmental, economic and social sustainability.

Years of coursework, on-farm experimentation based on research-supported principles, and a collection of vetted resources have provided the foundation on which we are now building our farm. The resources that have inspired me and given me detailed practices for our farm are compiled in this publication to make them easily accessible for others. The Small Farms Biodiversity Toolkit is a compilation of core principles and practices for promoting on-farm biodiversity, something I wish I had all in one place when we began this journey. Although biodiversity is complex, the Toolkit focuses on three main research-based principles for supporting it on the farm: building soil health, creating landscapes to attract pollinators and other beneficial insects, and including small livestock for an integrated, biodiverse farm. A proactive approach replaces a reactive one when collaborating with nature's synergistic processes. Toolkit practices, therefore, promote a regenerative farm system that feeds and protects itself. Resulting ecological health keeps a farm resilient and profitable through stresses and disturbance.

If you are already prioritizing principles introduced in the Toolkit, kudos! You are supporting nature's ability to provide nutrient cycling, pest and disease regulation, and

pollination. This Toolkit may inspire further steps to promote and prioritize biodiversity throughout your farm, with documentation of supportive practices and resources. Opportunities for collaboration with Nature's complex web of vitality are exciting and extensive, so consider these practices a springboard from which you launch to create a productive, biodiverse farm.

Please take the survey at the end of the Toolkit to share what you are already implementing and what kind of support you would need to adopt more practices promoting on-farm biodiversity. Thank you!

CHAPTER I

# Promoting Soil Biodiversity

## Principles of a biodiverse soil

A diverse soil microbe community is crucial on the farm. It feeds plants, protects them from pests and diseases, and creates organic matter. To promote and support soil biodiversity on the farm, organic matter is key, as it supports fungi, bacteria and plant roots. Soil biodiversity is also connected to and supported by plant biodiversity because of the soil-root connection in the root zone, or rhizosphere. Below are practices to incorporate organic matter and diverse plantings for a biodiverse soil on your farm.

## Practices to build organic matter

1. **Diverse organic matter additions** are critical: animal manures, compost, cover crops tilled or not tilled in. An annual addition of organic matter is recommended by researchers because it improves all soil properties, including fertility, water holding capacity, aggregation, and aeration without causing excess nutrient enrichment.

2. **Planting crops with fibrous root systems** builds soil organic matter. This requires careful planning, with rotations that include vegetables (such as forage radish, carrots, other root vegetables) and grasses (such as alfalfa, sorghum sudangrass, oats, winter wheat, barley). See the Resource List at the end of the Toolkit for a link to *Crop Rotation on Organic Farms: a Planning Manual,* a free online SARE Outreach publication. Non-crop plants (grasses and wildflowers) with large root systems can also be incorporated into strips within and adjacent to the growing field. Further, using "living walkways" maintains a continuous, active root system between growing beds, contributing to greater biodiversity in the soil surrounding and connected to crop beds. When designed to be mower-width, living walkways can be maintained with weekly mowing and edging while feeding crops. See the Resource List at the end of the Toolkit for the link to a video made possible in part by Southern SARE about living pathways. It addresses the benefits and challenges of this practice.

3. **Low disturbance** is critical to protecting organic matter. Reducing or eliminating tillage protects living fungal networks in the soil that feed and protect plants.

4. **Reducing the use of fungicides and insecticides** is critical, as these substances reduce beneficial soil bacteria and fungi.

5. **On-farm composting** turns crop residue, manure, leaves, grass clippings, and

fruit and vegetable waste into a rich organic matter amendment. Rynk's *On-Farm Composting Handbook* outlines various composting systems so you can choose one to suit your farm. A link to the pdf can be found in the Resource List.

**Practices to increase plant diversity within the season or over time to support soil biodiversity**:

1. **Crop diversity in a bed within one growing season:** For example**,** July-harvested garlic can be followed by a cash crop such as snap beans, beets, cabbage, collard greens, carrots, radishes or spinach.

2. **Cover crops** are an effective way to incorporate plant diversity that serves a diverse soil microbe community. Begin with crops that are easy to manage and require minimal equipment. For example, oats planted in the fall will die over winter, and their residue is easy to plant into. See the "Farmer to Farmer" section below to read about how we used cover crops in our first year. Also, see the Resource List at the end of the Toolkit for a link to *Managing Cover Crops Profitably*, a free online SARE Outreach publication.
   Examples of cover crops and their soil benefits[1]:
   Sorghum-sudangrass (SSG): subsoil aerator, nematode and disease fighter, root mass increases when chopped, increasing soil organic matter.
   Cowpeas: N fixing, stimulate/attract specific soil microbes.
   Oats: prevent erosion, scavenge excess nutrients, add biomass to increase organic matter.
   Annual rye: prevents erosion, dense root system improves water infiltration and builds soil organic matter, scavenges nutrients.
   Buckwheat: root system loosens topsoil and promotes soil biological activity.
   Red clover: N source, extensive root system builds soil organic matter, taproot aerates soil.
   Pearl millet: cover crop diversity promotes soil microbe diversity
   Barley: prevents erosion, scavenges excess nutrients, dense root system improves water infiltration and builds soil organic matter, biomass adds organic matter that feeds soil microbes.
   Sunflower: cover crop diversity promotes soil microbe diversity
   Winter wheat: prevents erosion, scavenges excess nutrients, root system loosens topsoil and promotes soil biological activity, biomass provides organic matter to feed soil microbes.
   Crimson clover: N fixer, prevents erosion, root system loosens topsoil and promotes soil biological activity.

Daikon radish: alleviates compaction, aerates soil, as taproots decompose, they provide organic matter, feed soil microbes, and increase water infiltration.

3. **Perennial crops:** Perennial crop systems enable plant roots to persist in the soil, continuing to feed soil organisms. Perennial root systems also contribute significantly to organic matter accumulation, supporting soil life.[2] Some examples of perennial crops for small farms in Indiana: trees (chestnut, hazelnut, elderberry, serviceberry), berries (brambles), aronia, asparagus, ramps, rhubarb, horseradish, Jerusalem artichoke.

4. **Crop rotations**: In an ecologically-based system, crop rotations increase soil quality[3] and manage pests[4]. Grasses and legumes restore soil organic matter, nutrients and aggregation depleted by cash crops.[5] Expert farmers implement long-term strategies of improving soil health while feeding their next crop, staying flexible to keep the farm profitable.[6] See the Resource List at the end of the Toolkit for a link to *Crop Rotation on Organic Farms: a Planning Manual,* a free online SARE Outreach publication.

5. **Temporary grasslands**: Grassland species increase earthworm abundance and richness, as well as living fungal networks that increase nutrient and water uptake[7]. Cover crop grass species such as oats, annual rye, buckwheat, millet and barley can be used for this purpose.

**How to begin? Here, we classify the above practices, from the simplest to the most complex changes to your farm system.**

**Small shifts**
Diverse organic matter additions
Low disturbance
Crop diversity in a bed/season
Reducing use of fungicides and insecticides

**Next steps**
Planting crops with large root systems
On-farm composting
Cover crops
Crop rotations

**Long term transformation**

Perennial crops

Temporary grasslands

**Considerations and concerns**

1. **Timing** and location of organic matter additions can be important, depending on the type. Timing of cover crop mowing to disrupt weeds in the understory can also be important.
2. **Soil testing** annually is recommended.
3. **Consult and connect** with supportive resources to ensure success with long-term transformation practices.

**Support**

Contact your County Soil and Water Conservation District for technical support.

**Climate Connection:** Because soil microbes help create organic matter, they promote both infiltration during flooding and water holding capacity in the midst of drought. When climate change causes rainfall changes, a biodiverse soil can keep farms productive.

**Our First Steps**

In our farm's first year, we did the following to promote a biodiverse soil microbe community:

**Summer (fallow year)**

Planted cover crop mix in whole field to begin soil improvement: sorghum-sudangrass (SSG) + cowpeas

Sorghum-sudangrass and cowpeas/ Photo by MaryEllen Pitts

**What we noticed**: These cover crops grew well without watering after they germinated. Earthworm abundance increased and soil texture improved. Note: if using a paper pot transplanter in spring, we do not recommend SSG as a fall cover crop, as its residue is very fibrous.

**Spring**

Used walk-behind tractor to flail-mow winter-killed cover crops. It chopped them and left the pulverized biomass on the field.

Soil benefits: adds organic matter to the soil, feeds soil microbes

Planted trees as part of hedgerow on west and south sides of lot.

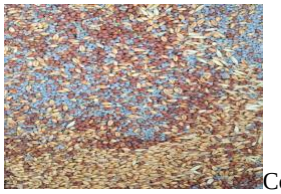

Photo by MaryEllen Pitts

Soil benefits: canopy trees restore soil biological activity, cedars prevent erosion
Important: newly planted trees need weekly watering in spring, summer and fall for their first two years.

Planted cover crop mix in fallowing field: oats (20%), annual rye (20%), buckwheat (16%), red clover (8%), millet (8%), cowpeas (8%), barley (8%) and sunflower (12%).
**What we noticed**: Because of its quick germination and rapid establishment, buckwheat dominated this cover crop mix by shading out other species. The other species grew, but less robustly. Only a few sunflowers germinated. Decreasing the percentage of buckwheat in the seed mix could promote more even species growth.

**Fall**

Planted cover crop mix in entire field: 25% each winter wheat, oats, crimson clover, daikon radish.


Cover crop seed mix/ Photo by MaryEllen Pitts

**What we noticed:** Oats came up first and winter wheat last. The clover did not have time to flower. These cover crops kept growing until the end of December and provided weed control and good soil cover to prevent erosion. Frost killed the radish leaves first.

Raked leaves off the lawn and used for in-field composting over the winter.

 Photo by MaryEllen Pitts

Soil benefits: increases organic matter, feeds soil microbes

**What we noticed**: We began by piling leaves on the south edge of the field and then had to move them onto the field as a second step. Next year, we will directly apply them to the field during the raking phase for efficiency. If harvesting is not finished in an area, leaves can be applied to adjacent areas and then raked onto beds as they are ready. Shredding will help leaves break down faster and prevent a matting effect. The following spring, we noticed areas where leaves had been applied had improved soil aggregation.

**Spring, Year 2**

Spring cover crops: oats (44%), rye (12%), berseem clover (7%) and buckwheat (37%)

 Cover crop seed mix/ Photo by MaryEllen Pitts

**Spring and Summer**

Sheet mulching to create new beds. I followed guidelines provided in the document at this link. Key steps included thoroughly watering the site initially (or sheet mulching after rain) *and after each layer of materials*; broadforking; applying a thin N layer; laying down cardboard as a weed barrier, making sure to overlap the edges; adding another thin N-rich layer; adding a thick layer of straw; adding a couple of inches of compost; and topping it with a thin layer of weed-seed-free straw. Some beds were seeded within weeks, and those created at the end of the growing season remained fallow this season.

 Sheet mulch layers  Chicken bedding

Photos by MaryEllen Pitts

Materials used in various combinations, as available: recycled cardboard; on-farm grass clippings; on-farm chicken bedding (straw from run and pine shavings from coop) with manure mixed in; rabbit manure from rabbit farm; composted horse manure from horse farm; straw (purchased); purchased compost; contents from kitchen compost tumbler; crop and weed residue (weeds in low layer); food waste from school; produce waste from local, small grocery store.

**What we noticed**: This method of creating beds did not disturb the soil, as the rotary plow does. These beds had significantly fewer weeds, and crops grew well in all but a portion of one of them. Green beans failed in a portion of one of these beds, but the problem may have been the seeds or an insect pest. Crops in the rest of that bed flourished.

## CHAPTER II

### Promoting Pollinators and Beneficial Insects through Landscape Biodiversity


Map of our farm

**Principles of a biodiverse farm landscape for promoting pollinators and beneficial insects**

A biodiverse farm landscape provides an ecological environment where crops are pollinated and productive, and pest and disease pressure are kept below a level of economic significance. Such a landscape mimics nature by providing biological diversity across field and landscape spaces, through species choices and placement, and increasing diversity over time. Spatial biodiversity is accomplished with multiple levels of habitat for pollinators and natural enemies. Genetic biodiversity includes polycultures for food system stability, redundancy, and ecological stability.

Temporal biodiversity provides flowering and fruiting provision for pollinators throughout the growing season and for natural enemies when prey is absent. A variety of pollinator forage resources are essential to support crucial native and wild pollinators. Species suited for Indiana farms are listed in the online Purdue Extension and MCS&WCD publications in Resource List.

Complex agricultural landscapes can be created by a re-visioning of farms, and studies are showing that overall, small field sizes promote on-farm biodiversity.[8] While dedicating land to biodiversity means less space for cash crops, biodiversity contributes to the ecological balance vital to productive, sustainable agriculture by increasing the flowering habitat, extending bloom time, and providing refuge for beneficial insects and pollinators. Incorporating native vegetation on 20% of agricultural land provides abundant pollination, sufficient pest suppression by natural enemies, increased water infiltration, and soil retention, enhancing crop productivity.[9]

**Practices**

**Diverse plantings in various locations** on the farm accomplish these goals and are described below.

1. **Hedgerows** provide spatial, genetic, and temporal biodiversity and consist of specifically-selected trees, shrubs and grasses that support pollination, pest control and soil health. They provide floral resources and nesting habitat for pollinators and refuge from pesticides. These woody plants and grasses also provide winter shelter and habitat for beneficial birds and insects, promoting natural predator presence in time for crop pests. Birds attracted to hedgerows are essentially berry and insect-eating species, rather than crop-eating pests. Wild Farm Alliance is an organization that provides guidance on farming in harmony with wildlife. See the Resource List for a link to their website. Selecting perennial plant species minimizes soil disturbance, protecting ground-dwelling beneficial insects and soil health. Research has shown that when smallholder growers provide these resources for pollinators, crop productivity increases by as much as 24%.[10] **Examples of Indiana species include**: red maple (*Acer rubrum*), serviceberry (*Amelanchier arborea*), black chokeberry (*Aronia melanocarpa*), big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). Some species can provide additional farm income. See Resource List for online publications with species lists, benefits and considerations.

2. **Woodlots** are segments of woods or forest that can produce sap, wild edibles, herbal medicine materials, or wood for fuel or building. They provide spatial, genetic and temporal biodiversity, also providing food and protection for migrating birds and contributing to soil health. **Examples of Indiana woodlot species**: tulip tree (*Liriodendron tulipifera*), shagbark hickory (*Carya ovata*), sugar maple (*Acer saccharum*), gray dogwood (*Cornus racemosa*), hazelnut (*Corylus avellana*). Some species can provide additional farm income. See Resource List for online publications

with species lists and benefits.

3. **Wildflowers**: Research has found that both perennial and annual wildflowers provide biodiversity in the landscape and over time on farms. **Perennial** wildflowers planted in strips adjacent to vegetable crops increase pollinator presence, reduce disease and pests, and increase both water availability and soil organic carbon.[11] They provide overwintering habitat for beneficial insects, promoting natural predator presence in time for crop pests. Farmers can use these strips on field edges for beneficial habitat, so as not to remove land from production. **Annual** flowering strips grown adjacent to vegetable crops provide natural enemies with shelter, pollen, nectar and alternative prey when pests are not present. Hoverflies and parasitoids especially benefit from these resources. Designing a wildflower habitat with floral resources throughout the growing season is critical. **Plant species commonly used** are sweet alyssum, coriander, phacelia and buckwheat.[12] Studies show that plants with small flowers are accessible to more beneficials, because large mouth parts are not needed to access these flowers.[13] Additionally, single blooms are more accessible than double blooms (usually hybrids). Because different plants attract different functional groups of insects, plant species selection is important. See the Resource List at the end of the Toolkit for online publications from ATTRA, Marion County Soil & Water Conservation District, and Purdue Extension to match crops, pests, beneficial insects and plants to attract the beneficials and pollinators your farm needs.

4. **Perennial grasslands:** Spatial and temporal biodiversity on small farms is greatly increased by incorporating perennial grasses and sedges into the landscape. These plants do not typically provide food for pollinators, but they can be larval food hosts for certain pollinators.[14] Grasses and sedges can be used in field border or in-field perennial wildflower strips or beetle banks. Beetle banks, habitats for pest- and weed seed-eating beetles are described in detail below. **Examples of Indiana perennial grass species include**: big bluestem (*Adropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), and prairie dropseed (*Sporobolus heterolepis)*. See links to MCS&WCD, Purdue Extension and USDA online publications (in Resource List) for more species, benefits, and to check for invasiveness.

5. **Cover crops**: Cover crops provide on-farm biodiversity. They provide moisture, physical spaces and food for beneficial insects.[15] Studies have shown that higher biomass cover crops (such as winter wheat, oats, annual rye) likely provide a more complex habitat, attracting a greater abundance and diversity of beneficial insects than lower biomass species (such as crimson clover) or no cover.[16] If possible, farmers should plant seeds into cover crop residue so that predators are present when the primary crop begins to grow. Leaving strips of residue can provide enough habitat for beneficial insects to

remain and feed off pests. Cover crops can also be selected to attract specific beneficial insects[17]. **For example, to attract Braconid wasps (predator of cabbageworm, aphids, caterpillars, others):** plant hairy vetch, buckwheat, or cowpea. See *ATTRA Farmscaping for Biological Control* (in Resource List) for more examples.

Cover crops also provide flowering habitats for pollinators and thus support crop production. They can be used as an understory to attract pollinating wild bees in crop systems. A mix of cover crops species is needed to provide nectar and pollen for beneficial insects throughout the growing season. **Focusing on forbs such as** clover, buckwheat, phacelia, vetch and mustards/brassicas helps accomplish this goal. Incorporating natives is also key. Allowing as much bloom as possible before termination is critical, as is incorporating with the least amount of soil disturbance. Termination options minimizing ecological harm include roller crimping and flail mowing. *Managing Cover Crops Profitably*, a SARE publication linked in the Resource List, provides termination guidance for each cover crop discussed. Leaving cover crops undisturbed provides refuge for beneficials to recolonize cover or cash crops and protects the soil.[18]

Examples of cover crops and their benefits to pollinators and beneficial organisms:

Oat benefits: residue provides cover for beneficial insects
Rye benefits: residue provides cover for beneficial insects
Buckwheat benefits: attracts beneficial insects including hover flies, predatory wasps, minute pirate bugs, insidious flower bugs, tachinid flies, and lady beetles
Red clover benefits: attracts pollinators and beneficial insects including weed seed eating beetles
Pearl millet benefits: attracts songbirds
Cowpeas benefits: crop diversity; provides EFNs, supplemental food for beneficial insects including many wasp species, honey bees, lady beetles, ants and soft-winged flower beetles
Barley benefits: residue provides cover for beneficial insects; studies show it can reduce incidence of leafhoppers, aphids, armyworms, root-knot nematodes
Sunflower benefits: supports big-eyed bugs, honey bees, green lynx spiders, ants, lady beetles, predatory stink bugs, and assassin bugs.[19]

6. **Extrafloral nectaries (EFNs)**: Some plants have extrafloral nectaries, nectar-producing glands separate from flowers. Scientists hypothesize that EFNs attract insects that defend plants from pests. The glands provide a food source in addition to or in the absence of blooms. This nutritional diversity creates a more stable food supply for beneficial insects. **Indiana plant species with EFNs include cowpea, partridge pea and elderberry**.

 Partridge pea (*Chamaecrista fasciculata*)  Cowpea (*Vigna unguiculata*)
Photos by MaryEllen Pitts

**Additional management strategies**

1. **Tolerating damage below economic threshold:** An important example is the native leaf-cutter bee (*Megachile*), a critical pollinator of vegetables, fruits and flowers.[20] This solitary bee cuts small round holes from the leaves of many plants to create cells in its nest. The damage is only aesthetic, and the crop production benefit from the leaf-cutter bee outweighs the hole-punch look it leaves behind.

2. **Crop rotations**: In-field crop diversity prevents pest build-up. See online publication *Crop Rotation on Organic Farms: A Planning Manual* in the Resource List.

3. **Protect ground-nesting bees (especially if growing squash)**: These wild bees are important crop pollinators and also enhance honey bee pollination services, so protecting them is vital.[21] Their nests can be located in various locations on the farm. Walking around and identifying them will help you manage for these ground nesters. Avoiding deep tillage, minimizing flooding, avoiding hot, frequent fires and minimizing intense livestock grazing is recommended.[22] Researchers continue to study these vital ecological partners; to learn more, see FAO online publication *Toward Sustainable Crop Pollination Services* in Resource List.

4. **Biocontrol to Reduce Pesticide Use:** Increasing biodiversity increases natural enemies in an ecosystem, promoting self-regulation in agricultural systems.[23] Habitat manipulation through food and shelter supports predators and parasitoids that plants "call" by emitting volatile compounds when threatened by pests. Studies have shown that predators' biological control increased yields slightly and enabled farmers to reduce pesticide use, thereby reducing labor and resulting in a small increase in economic performance. Reducing or eliminating pesticide application also improves food safety and environmental quality on and off farms.

   **Biocontrol practices include:**

   a. **Beetle banks:** Originated in the UK, beetle banks are elevated berm strips within a crop field planted with permanent native prairie grass. Combining with perennial wildflower strips, as described above, is possible. Beetle banks provide

daytime and overwintering cover habitat for pest and weed seed-eating beetles. Ground beetles forage at night and hide in the soil or litter in the daytime. They eat caterpillars, root maggots, snails, slugs and weed seeds. Xerces Society recommends Midwest beetle banks planted with Little bluestem (*Schizachyrium scoparium*), Big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and Switchgrass (*Panicum virgatum*). On a small farm, the width is about the same as a vegetable bed. On larger farms, prairie strips are more extensive. Researchers have implemented variations on crop field perimeters with success. An Indiana study showed that red clover (*Trifolium pratense L.*) strips attracted weed seed-eating carabid beetles and facilitated seed predation for the entire growing season.[24] Knowledge of crop pest, predator and habitat required for specific crop biocontrol are required. ATTRA and Xerces Society (linked in Resource List) provide research-based biocontrol information for farmers.

b. **Cover between rows** for beneficials: Cover crop residue and dry or living mulches between crop rows have been shown to lower pest pressure and harbor greater populations of beneficial insects than those with bare rows in between.[25] This method provides habitat for natural enemies to provide pest biocontrol to crops. Mulch also attracts alternative prey for predators in early spring before the crop attracts the pest that the beneficial will prey on during the growing season.

c. **Specific relationships between insects and plants.** Exploring the complex world of insects and plants is a worthwhile lifelong pursuit, especially for farmers. Insects are usually small and require careful observation to see them carry out critical pollination, parasitisation, and predation work on the farm. For example, *Scoliid* wasps are parasitoids that lay eggs on white grubs (June and Japanese beetle larvae). These eggs feed on the larvae and prevent June and Japanese beetles from becoming crop pests.[26] Planting goldenrod (*Solidago*) and mountain mint (*Pycnanthemum*) will attract *Scoliid* wasps in the landscape.[27]

   See online publications, *ATTRA Farmscaping to Enhance Biological Control* and MCS&WCD's *Native Plantings for Beneficial Insects and Pollinators* in the Resource list for more pest, predator and habitat plant relationships.

5. **Insecticides:** Reducing insecticides is critical to improve food safety and environmental health. It is also crucial to maintaining balance in the ecological food web. For example, if crop pests are wiped out by insecticides, generalist predators will eat pollinators, creating a problematic situation. Further, pests repopulate a crop faster than predators, so if chemical insecticides kill both, when pests return, predators' arrival will be delayed,

and crops will be more vulnerable to herbivory.

**<u>If applying pesticides, use these guidelines from Xerces:</u>**

a. Even these **organic- approved pesticides can be dangerous** for bees and other beneficial insects: Pyrethrins, Spinosad, *Beauvaria bassiana*.
b. **Apply these at night and not to blooms**: Insecticidal soap, horticultural oils, Neem.
c. **Safer pest management options:** Bt, insect repellants (garlic or citrus oils), Kaolin clay barriers, pheromone traps, mating disruptors. Additional guidance is available in the Xerces online publication, *How to Reduce Bee Poisoning from Pesticides* and SARE's online *Resource Guide for Organic Insect and Disease Management*. Links provided in Resource List.

**How to begin? Here, we classify the above practices, from the simplest to the most complex changes to your farm system.**

**Small Shifts**

Wildflowers planted adjacent to or within crop bed
Tolerating damage below economic threshold
Protect ground-nesting bees
Cover between rows for beneficials
Reduce pesticide use and use Xerces and SARE guidelines

**Next Steps**

Cover crops
Incorporating plants with extrafloral nectaries (EFNs)
Crop rotations
Learn some specific relationships between insects and plants

**Long term transformation**

Beetle bank installation
Hedgerows
Woodlots
Perennial grasslands

**Considerations**

1. **Sometimes a predator provides multiple services:**
   For example, wildflower strips can attract hoverflies, which reduce aphids and pollinate certain crops.

2. **On-farm biodiversity can create income diversity:** Farmers are finding ways to use cover crops to feed pollinators and diversify a farm's income stream. Studies have shown that camelina (*Camelina sativa* L.) has multiple functions and benefits. It feeds pollinators, improves soil health, and the seed is pressed for oil, with the resulting cake fed to animals.[28]

**Financial and Technical Support:** Grants are available for supporting on-farm biodiversity. In Indiana, the Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP) helps growers implement practices that promote production and environmental quality simultaneously. Financial and technical assistance is available to help farmers implement conservation practices, including improving pollinator habitat. Plans typically include incorporating three plants that bloom in spring, three in summer and three in fall, for pollinator forage. A link to more information is provided on the Resources List.

**Example of Indiana small farm landscaping for pollinators and beneficial insects:**
See the link below for a collaboration between Marion County Soil and Water Conservation District and Indy Urban Acres that demonstrates native plantings installed on a small farm to attract pollinators and beneficial insects, as well as to provide other ecosystem services.
https://marionswcd.org/native-plant-agriculture/

**Climate connection:** Climate change threatens plant and pollinator timing. A diversely-planted landscape attracts a diversity of pollinators, crucial for food production.

**Our First Steps:**
In our farm's first year, we did the following to promote a biodiverse landscape.

**Summer (fallow year)**

Planted cover crop mix in whole field: sorghum sudangrass (SSG) + cowpeas
Benefits: The residue left on the field over winter provided cover for beneficial insects to populate crop beds for the next growing season.
What we noticed: An abundance of spiders (generalist predators) populated the field for the entire next growing season.

**Spring**

Planted over 60 mostly native trees and shrubs on south and west borders of our lot (all within 200 feet of the crop field).
Benefits:

Tulip poplar (*Liriodendron tulipifera*): support bees and tiger swallowtail butterflies
Native Oaks (*Quercus*): provide food for caterpillars, the backbone of a stable food web that includes songbirds and birds of prey that keep pest populations in

check
Serviceberry (*Amelanchier arborea*): support bee, beetle and fly pollinators; serve as striped hairstreak host
Redbud (*Cercis canadensis*): magnet for pollinating bees, beetles, butterflies, moths, flies, and wasps
Elderberry (*Sambucus canadensis*): bird habitat, crop diversity, have EFNs (supplemental food source for beneficial insects)
Witch hazel (*Hamamelis virginiana*): bird habitat, larval habitat for multiple moth species
Nannyberry (*Viburnum lentago*): larval host for Spring Azure (Celestrina "ladon" butterfly
Hazelnut (*Corylus Americana*): nesting habitat for songbirds, crop diversity, larval habitat for multiple moth and butterfly species
What we noticed: The trees and shrubs are very young; our main focus the first season was watering them regularly. We will monitor them for pollinators and beneficial organisms.

Planted cover crop mix in fallowing field: oats (20%), annual rye (20%), buckwheat (16%), red clover (8%), millet (8%), cowpeas (8%), barley (8%) and sunflower (12%).
What we noticed: These cover crops filled the non-cropped portion of our quarter acre by June, and birds, a variety of bees, butterflies and other pollinators visited, making the field hum with activity. On the ground, spiders (generalist predators) were plentiful. We found a tomato hornworm covered with eggs laid by a parasitoid wasp. The wasp larvae feed on the caterpillar, killing it and saving the tomato plant. Hundreds of praying mantises lived in our field. Although they sometimes eat beneficials, they also eat a variety of pests, including aphids and grasshoppers.

Direct-seeded a 30" x 75' beneficial bed with the annual flowering herbs of Cosmos, Phacelia, Dill, Parsley, and Cilantro. This bed was adjacent to a crop bed.
Cosmos benefits: attracts spiders (generalist predators), and Lacewing, Neuroptera family (predator of aphids, caterpillars, mites)
Phacelia benefits: attracts Tachinid flies (predator of cabbage looper, Japanese beetle, squash bug, green stink bug)
Dill benefits: attracts Braconid wasps (predators of cabbageworm, aphids, caterpillars, others), Tachinid flies (predator of cabbage looper, Japanese beetle, squash bug, green stink bug), spiders (generalist predators), Lacewing, Neuroptera family (predator of aphids, caterpillars, mites), ladybugs (predators of aphids, spider mites, soft scales), Parasitic wasps.

Parsley benefits: attracts Braconid wasps (predators of cabbageworm, aphids, caterpillars, others), Tachinid flies (predator of cabbage looper, Japanese beetle, squash bug, green stink bug).
Cilantro benefits: attracts Tachinid flies (predator of cabbage looper, Japanese beetle, squash bug, green stink bug), Lacewing, Neuroptera family (predator of aphids, caterpillars, mites), ladybugs (predators of aphids, spider mites, soft scales), hoverflies (pollinator)
What we noticed: This bed was visited by a variety of pollinators, as well as ladybugs. A more impactful location of this bed would be adjacent to crops most affected by aphids, so they would have benefitted from beneficial insects that prey on aphids.


Lacewing on pea vines/Photo by MaryEllen Pitts

In-field crop biodiversity experimentation: planted radishes around zucchini mounds, direct seeded onions into established beet beds, direct seeded carrots into established onion beds, and planted alyssum and red clover seed beneath tomatoes.

Radish/zucchini combination benefits: Studies list radishes as one of several companion plants that repel squash bugs, although systemic, mechanical and physical strategies are the most effective deterrents.[29] Efficient use of space since radishes were harvested before zucchini plants filled space.
Interplanted root vegetable bed benefits: lower weed pressure, improved soil texture, crop succession increases farm productivity.
Alyssum benefits: attracts Tachinid flies (predator of cabbage looper, Japanese beetle, squash bug, green stink bug).
Red clover benefits: Nitrogen fixer, attracts pollinators, weed suppressor.
What we noticed: Radishes around zucchini mounds likely repelled squash bugs and aphids, as we saw no evidence of these pests. They also used space efficiently, since they were harvested before zucchini plants filled out their space. We observed lower weed pressure and improved soil texture in the interplanted root vegetable beds. Carrots seeded into onion beds also grew longer than those in a monocrop bed. The alyssum and red clover did not germinate well enough the first season to determine if they protect tomatoes. In the second season, this protective function worked.

**Fall**

Planted cover crop mix in entire field: 25% each winter wheat, oats, crimson clover, daikon radish.

Benefits to beneficials: residue provides cover for ground beetles, allowing for repopulation in the field early in the growing season.

What we noticed: The oats and winter wheat did not go to seed. Winter wheat did not fully winter-kill, but as a result, I was able to feed some to the chickens as a fresh green food during the winter. We will mow the wheat or rotate the chickens in a mobile enclosure this spring to eat the remaining wheat before planting. Mowing is said to be effective if the wheat has not gone to seed.[30]

In the **second season**, we did the following to promote a biodiverse landscape:

**Spring/Summer**

Seeded lettuce and carrots in garlic bed.

Benefit goal: crop diversity within a bed; maximize bed production.

What we noticed: These companions did not work. The lettuce and carrots got dug up during the garlic harvest. A possible garlic companion is green onions seeded to be ready for harvest with garlic. Timing is critical. Another option is to sow carrots, beets, spinach, or a brassica after the garlic harvest, as these can be harvested in the fall.

Garlic bed interplanted with lettuce and carrots/ Photo by MaryEllen Pitts

Planted cosmos in the jalapeño bed.

Benefit: Attract a wide variety of pollinators: bees and wasps, butterflies, hummingbirds and other birds.

What we noticed: The cosmos attracted all of the pollinators listed above. They also leaned into/blocked aisles, and overshadowed the jalapeño plants. The jalapeños were still productive and healthy; they were just hard to reach. We had to prune back ⅔ of Cosmos in July/August. Cosmos need their own bed or to be grown on a field edge.

 Cosmos in jalapeño bed/ Photo by MaryEllen Pitts

Planted alyssum in tomato and tomatillo beds.

Benefit: Attract wasp predators of tomato hornworm.

What we noticed: Alyssum grew at the base of the tomato and tomatillo plants and did not interfere with plant growth. We noticed wasp eggs on a tomato hornworm on a tomato plant but no pest damage. The tomato and tomatillo plants were free of disease and pest damage, as well as productive all season.

 Tomato hornworm covered with braconid wasp eggs

Planted zinnias at the head of the tomato bed.

Benefit: Attract multiple pollinators.

What we noticed: Many bees, butterflies, and hummingbirds visited.

 Zinnias/Photo by MaryEllen Pitts

Planted a bed of annual herbs and flowers.

Benefit: Attract pollinators and beneficial insects to adjacent crop beds.

What we noticed: Weed competition was strong because we were away at a crucial weeding time. Some centaurea, partridge pea, zinnia, dill, cilantro, and phacelia survived after subsequent weeding and were visited by butterflies and bees.

Planted a beetle bank (30” x 80’): native grasses down the center of the crop field.

*Schizachyrium scoparium, Panicum virgatum, Sporobolus heterolepis and Carex pensylvanica*

Benefit: Provide habitat for pest- and weed seed- eating beetles.

What we noticed: The native grasses grew throughout the summer. We did not witness beetle activity this season due to their nocturnal nature but will continue monitoring for reduction in weeds and pests.

 Beetle bank in June, 2022  Beetle bank in October, 2022

Photos by MaryEllen Pitts

Planted a strip of sunflowers on the north side of the ⅛ acre fallow field.

Benefit: Attract various bee species, lacewings, big-eyed bugs, ladybird beetles, parasitoids.

What we noticed: Various bees, assassin bugs, and goldfinches visited the sunflowers.

 Sunflowers/ Photo by MaryEllen Pitts

Planted nasturtiums in various crop beds.

Benefit: Attract pollinators, lure pests away from crops.

What we noticed: Various bees and assassin bugs visited the nasturtiums.

 Assassin bug on nasturtium / Photo by MaryEllen Pitts

Planted red clover in pollinator strip adjacent to crop field.

Benefit: Nitrogen fixer, attracts pollinators, weed suppressor.

What we noticed: Swallowtails, bees, moths, wasps visited throughout the summer; monarchs visited in late summer.

Planted spring cover crops (buckwheat, oats, barley, rye, red clover, cowpeas) in fallow ⅛ acre east of beetle bank.

Benefit: Provide food for various pollinators throughout the summer and habitat for beneficial insects.

What we noticed: This fallow field was visited by many pollinators, especially when the buckwheat was blooming. We observed many crickets, spiders, and grasshoppers but saw no crop damage from grasshoppers.


Spring-planted cover crops in summer/ Photo by MaryEllen Pitts

Allowed fallow east ¼ acre cover crops from fall seeding to fill in that space in the spring. (Crimson clover, red clover, winter wheat and barley)

Benefit: Provide food for various pollinators throughout the summer and habitat for beneficial insects.

What we noticed: Many dragonflies visited this field daily from June through August.


Crimson clover, May, 2022/Photo by MaryEllen Pitts

Interplanted parsley with peppers, other herbs, and nasturtium.

Benefit: Parsley attracts butterflies and predatory wasps.

What we noticed: Caterpillars for the Black swallowtail butterfly took up residence at the beginning of October. We stopped harvesting the foliage and are leaving these plants in the growing bed until the caterpillars complete metamorphosis in April.


Black Swallowtail (*Papilio polyxenes*)/ Photo by MaryEllen Pitts

CHAPTER III

# Incorporating Small Livestock for an Integrated, Biodiverse Farm

*The challenge with this chapter is balancing very small steps to introduce crop farmers to livestock with a vision for long-term system change. Farm acreage size impacts possibilities, too. Yet Purdue natural resources professor Linda Prokopy is among researchers calling for Midwest farms to incorporate land diversification, small grains, and forage crops into rotations.*

## Principles of Integrated Systems

Farming systems that include livestock mimic natural systems, where organisms meet each others' needs to create ecological balance. Increased soil fertility and decreased waste are commonly known benefits of livestock integration, but research has revealed more. Degraded land is restored by manure and hooves/feet scratching the soil. Animals can clear invasive plants and prepare land for cropping. Small livestock grazing crop stubble removes certain crop pests' habitat and larvae. Although weed management can be touted as a benefit, research has found it to vary with animal species and timing. In agroforestry systems, fallen fruit and nuts in orchards can be food for small livestock. Cover crops in crop systems can be "terminated" by foraging animals, reducing tillage. Livestock can also diversify and increase farm income with meat, eggs, milk and fiber products. Incorporating livestock helps achieve a closed-loop system, where necessary farm resources are produced within the farm, increasing self-sufficiency. Making the farm system whole in this way reduces costs, increases income, and improves landscape ecology.

## Overcoming hesitancy

Because of specialization, farms integrating crops and small livestock are less common today than fifty years ago. Knowledge and skills to manage daily practicalities of an integrated system are not as widespread and can seem daunting to a farmer focused on either crops or livestock. Added complexity can be a barrier to integration, as it presents practical concerns. Manure management is a critical issue. Handling, storage and food safety are serious matters, as are environmental considerations of leaching and ammonia volatilization. Using appropriate ratios of bedding to manure for composting is vital yet achievable. Choosing livestock species to incorporate into a farm system without disrupting a profitable enterprise, however, may feel risky. Choosing animals suited for a farm's purpose is crucial. For example, managing livestock to prevent damage to orchards and vineyards can be challenging. While the benefits of livestock are significant, knowledge and experience gaps must be bridged. Educational and technical support systems and farmer collaboration is greatly needed. Supportive policy and infrastructure must also be developed. Research and a measured approach are therefore recommended when considering integration. Below are real-life examples and farmer and research-based recommendations for temporary and less-temporary livestock integration on micro and macro scales.

**Practices**

**Small Shifts**

1. Visit a farm with livestock to familiarize yourself with different species and learn from another farmer.

2. If in an apprentice stage, volunteer on livestock farms. Full time crop farmers can collaborate with a neighboring livestock farmer to learn management, financial, infrastructure and marketing demands before making a large commitment.

3. If growing crops, begin with very small livestock to provide fertility and/or diversify farm income.

   Examples

   - Laying hens provide soil fertility and add eggs to a farm enterprise. (See "Our First Steps" below for how we have incorporated hens on our farm.)
   - Ducks can provide pest control, fertility and eggs to a small farm enterprise.* *Certified organic farmers must document when animals are rotated out of a field to ensure they have a minimum of 120 days prior to harvest when the edible portion of the crop has soil contact and 90 days to harvest for all other food crops. See "Considerations and Concerns" below for crop examples.

**Key moves summary**: Research housing, fencing, feeding and care; talk with farmers who have the type of livestock you are considering.

**Next Steps**

1. Temporary use of *other farmers' livestock* (Grazing Services):

   Find goats, sheep and cattle for land clearing or grazing crop residue or cover crops on the **Midwest Grazing Exchange** website: https://www.midwestgrazingexchange.com.

   This Michigan State University presentation describes how collaborating crop farmers and small ruminant farmers both benefit from **annual forage crops (Brassicas, radish, oats) being introduced into crop rotations**. Results: soil restoration, improved cash crop productivity, and animal health. https://www.midwestcovercrops.org/wp-content/uploads/2017/03/2017MCCC-Forage-Ehrhardt.pdf

   Examples of crop farmers partnering with researchers to incorporate livestock on a temporary basis:

   - This video shows a research project involving a small flock of 30 sheep grazing

on farmers' fields and large grassy areas. Aside from the researcher's fencing and labor to move them around, the pasture was free. https://www.youtube.com/watch?v=UX4HOZOZYJg

- SARE-funded example: A 2011 project on a Hawaiian homestead farm successfully integrated goats with a crop farm enterprise to save on land clearing costs. Twelve goats cleared grass, brush and woody plants from a one-acre site to be planted with fruits and vegetables. Farmer-researchers rotated the goats through paddocks over the course of 54 days as they grazed vegetation. Avoiding the costs of hiring a tractor service saved $2,250 - $2,500 in land preparation costs and fossil fuel pollution. Growers waited 120 days in keeping with food safety standards, prepared beds to plant, and successfully grew fruits and vegetables for market.[31]

2. Introduce livestock into a specialty crop system to remove crop residue, disturb weeds and pests, and add fertility.

   Leon Stangl of Yourganic Farm in Montana uses multiple species throughout the year. Cattle, hogs and sheep remove crop residue and provide minimal tillage in preparation for crop planting, increasing soil health. His sheep graze on squash vine residue in one field and are removed more than 120 days before harvest of the next crop, carrots. Grazing provides minimal tillage, which in turn reduces weed pressure. Stangl also overwinters 10-15 cattle in a brassica field, providing a round bale feeder for them, moving it every 3-4 days. This strategy sheet composts the field, and he removes the cattle 6 months before vegetable harvest (well within the FSMA 120-day rule). Sheet composting creates a habitat for beneficial beetles, who forage on crop pests and weeds seeds. An ATTRA video shows his system: https://www.youtube.com/watch?v=e_2Z99jfK04

   See **Resource List** for links to

   - an AgEmerge podcast discussing the complexities and benefits of livestock integration
   - Soul Fire Farm's guide to raising chickens
   - an NCAT/ATTRA publication on Small Scale Livestock Production
   - "How to Get Started with Sheep" blog post from Cornell University Small Farms Program

   **Key moves summary**: Research housing, fencing, feeding and care; talk with farmers who have the type of livestock you are considering.

## Long-term transformation

1. Consider transitioning parts of the farm to perennial systems. Although this can be a major shift for annual crop farmers, research reveals significant ecological, climate, social and economic benefits of perennial agroecosystems.
   **Agroforestry** incorporates trees and shrubs with crops or livestock to provide ecological and economic benefits. Livestock can be trained to graze on forage grown in alleys of high-value timber stands.
   a. SARE's fact sheet series is an informative introduction to agroforestry: https://northcentral.sare.org/resources/agroforestry-fact-sheet-series/
   b. This publication describes a variety of research-based, creative combinations, one of which may suit your farm system. Diversified farm profiles are included. https://www.sare.org/publications/diversifying-cropping-systems/agroforestry/
   c. The Savanna Institute, in Wisconsin, promotes Midwest agroforestry for "ecological resilience, climate stability, economic prosperity and vibrant communities." It provides resources and programs for getting started, including farm finance planning with agroforestry. https://www.savannainstitute.org/ https://www.savannainstitute.org/planting-tree-crops/

2. Designing territorial landscape for livestock integration *among* farms
   This long-term opportunity is a widespread and permanent development of #1 under "Next Steps." Specialized farms remain specialized but collaborate for mutual benefit. Supportive organizations are needed to facilitate collaborations, infrastructure, and policy to create robust regional systems. *Although more complex, this approach may be easier to achieve because it requires less change within individual farm systems.*

   Benefits:

   a. Crop farmers do not have to manage livestock.
   b. Livestock grazing amplifies a cover crop rotation's benefits to a crop farm.
   c. Livestock farmers have access to increased acres and diversity of forage.
   d. Grassland rotations are more easily facilitated with a greater pool of farms.
   e. Increased numbers of participating livestock farmers facilitates growing local enterprises to rebuild rural communities, i.e., regional slaughterhouses or mobile units, selling meat direct to consumers and restaurants, value-added product creation.

Example: **"Match Made in Heaven: Livestock + Crops":** Currently, SARE grant-supported participatory research (farmers + researchers) is underway to support integrating /re-integrating crops and livestock. This work provides an opportunity for farmers to reduce risk, share cost, further knowledge and expand capacities and connections. Green Lands Blue Waters is conducting a 3-year, 6 state (including Indiana) project to identify opportunities and barriers to integrating / re-integrating crops and livestock, and seeks to identify strategies to capture the multifaceted benefits of integrated farming systems. See the Resource List for links to their website and survey.

**Considerations and concerns**

1. Critical food safety considerations and regulations
   Timing is key when it comes to livestock presence in crop fields.
   Requirement: USDA requires raw, uncomposted livestock manure to be incorporated into the soil of food crops:
   - a minimum of 120 days prior to harvest when the edible portion of the crop has soil contact (i.e. leafy greens, squash, melon, peas and others that may get soil splashed onto them from rain or irrigation); and
   - a minimum of 90 days prior to harvest of all other food crops (tree fruit, sweet corn, etc.).

   Therefore: livestock need to be removed from crop fields and vineyards 90-120 days prior to harvest.

   Solutions:
   - Include an annual grass/ legume mix rotation in your crop rotation. Let livestock graze on it and provide manure for the successive crop.[32] Is this feasible on your farm?
   - Let livestock graze on crop residue at the end of the growing season and after fall/winter cover crops such as a winter grain undersown with a legume have winter-killed.

2. Cost effective infrastructure such as fencing, shelter and water are critical components to successful integrated livestock systems. Providing infrastructure plus predator protection efficiently and at a reasonable cost is challenging, especially while avoiding soil compaction, crop damage, and pathogen contamination. Labor for livestock care can also be costly and year-round, causing farmer work-life balance to be reduced. Finally, matching livestock products with local or regional processing availability and market needs is critical to a sustainable integrated livestock and crop farm business.[33]

3. Be open to learning new skills or expanding exposure to new agricultural avenues such as meat processing. There might be a market needing service, such as Halal meat for a local Muslim population.

**Support:** Livestock re-integration is a recent development in Indiana, thus supportive infrastructure is yet to be fully formed. For updates on developments, consult the following organizations:

Green Lands Blue Waters: Match Made in Heaven: Livestock & Crops project (See Resource List)

Hoosier Young Farmer Coalition https://www.hoosieryfc.org/

Purdue Extension Diversified Farming and Food Systems: Beginning Farmer Program Connects farmers to resources, programs, projects with partnering agencies and farm events. https://extension.purdue.edu/anr/_teams/dffs/beginning_farmer/index.html

SARE: Offers competitive grants to fund research and education projects advancing sustainable agriculture. Read about funded projects and/or apply for a grant to fund a project on your farm.

**Climate Connection**

Increased soil aggregation from livestock activity leads to improved water infiltration and water holding capacity. Forage crops and perennial systems increase carbon sequestration.

**Our First Steps**

In our farm's first year, we did the following to integrate small livestock onto the farm:

Fall 2021

Incorporated chickens into farm

Chickens/ Photo by MaryEllen Pitts

Soil benefits: Composted chicken manure increases soil fertility, organic matter content, biological activity, and disease suppression.[34]

Spring/Summer 2022

Keeping layers provided on-farm soil-building materials, diversified income, and reduced waste

Soil benefits: Chicken bedding materials (straw + manure and pine shavings +

manure) used in sheet mulching method bed creation.
What we noticed: The straw we bought for the chicken run got repurposed, saving money.
Income diversity: We added eggs to our weekly farm sale offerings.
What we noticed: Although the income from selling eggs from seven chickens did not fully pay for their monthly feed, the fertility they added to crop beds replaced purchased amendments. We will continue to analyze costs and benefits.
Waste reduction: Chickens eat vegetable and meat scraps, as well as dandelion leaves, and unmarketable crop materials.
What we noticed: They ate leaves from cover crop daikon radishes, bolted lettuce stalks/leaves, unmarketable tomatoes, and spent snap pea vines.

Collaboration with local livestock farmers led to mutual benefits (fertility for our farm, manure removal for theirs)
Low cost or free fertility sources
Purchased horse manure from urban horse farm for low price
Picked up free rabbit manure from rural rabbit farm
Critical considerations: timing of application, composting manure, excessive phosphate buildup in soil interfering with other nutrient uptake in crop plants, weed seeds. See link to USDA Organic Tipsheet: Manure in Organic Production Systems in Resource List at end of Toolkit.

# CONCLUSION

A biodiverse farm is founded on relationships. This Toolkit illustrates a system in which the grower is not the sole driver of farm health, productivity, and resilience; soil microbes, plants, insects, animals and other farmers are collaborators. While the chapters provide three areas of focus, the principles they discuss are interwoven, as evidenced by practices that appear in multiple chapters. Nature, then, is not mechanistic. Instead, synergies create effects that are greater than the sum of their causes. Your farm is a complex natural system. Incorporating the research-based practices in this Toolkit and observing the results will reveal intricate relationships that promote persistence, stability, and resilience. Attention to the interactions among these supportive organisms will reveal next steps in the flourishing of your farm.

This Toolkit has aimed to reveal the power of ecological systems that underpin life on the farm and invite growers to collaborate with organisms that support them. The practices discussed may be familiar or new, but they are all research-based. If you can do nothing else, plant cover crops for the multiple benefits they provide. My hope is that farmers will implement many practices in the Toolkit, building regenerative farm systems that feed and protect themselves. These healthy farms will remain resilient and profitable through stresses and disturbance.

My research includes learning what practices farmers are already implementing and asking what support is needed to collaboratively increase agricultural biodiversity. If you are a farmer or gardener, I'd like to hear from you. What biodiversity-supporting practices are you already implementing? What might you be willing to try? Please take about five minutes to fill out a short survey at the following link https://forms.gle/9w3xQS3AWiWieWaR9. Just copy and paste the link into your browser. As a farmer or gardener, your responses will help inform how to support on-farm biodiversity in Indiana and the Midwest. This research is being shared across

multiple sustainable agriculture- supporting platforms in order to collect hundreds of responses from small farmers in the Midwest. Aside from your time, there are no costs for taking part in the survey and no monetary compensation for participating. Responses will be confidential. When you click into the survey, you are giving consent to participating in this study. You may withdraw consent at any time by leaving the survey incomplete. Any questions or concerns about the survey can be addressed to MaryEllen Pitts at maryellen.pitts@student.prescott.edu.

**Resource List**

## Chapter I: Promoting Soil Biodiversity

Books

*Building Soils for Better Crops: Sustainable Soil Management*, by Fred Magdoff and Harold Van Es. Download a free PDF or order a print copy: https://www.sare.org/news/updated-building-soils-for-better-crops-focuses-on-soil-health-fundamentals/

*Crop Rotation on Organic Farms: a Planning Manual*, Charles L. Mohler & Sue Ellen Johnson, eds. Download a free PDF or order a print copy: https://www.sare.org/resources/crop-rotation-on-organic-farms/

*Managing Cover Crops Profitably*, SARE Outreach publication. Download a free PDF or order a print copy: https://www.sare.org/resources/managing-cover-crops-profitably-3rd-edition/

Rynk, R. (1992). *On-Farm Composting Handbook*. Ithaca, NY: NRAES-54 https://ecommons.cornell.edu/handle/1813/67142

Webpage

USDA. (n.d.). Soil Building- Manures & Composts. https://www.ams.usda.gov/grades-standards/soil-building-manures-composts

Videos

*The Downsides of my Living Pathways.*
https://www.youtube.com/watch?v=T9MTA8zlMu4
Published on May 1, 2022
This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2020-38640-31521 through the Southern Sustainable Agriculture Research and Education program under project number LS21-348. USDA is an equal opportunity employer and service provider." The goal with this grant is to provide context and technical detail for the four principles of soil health.

## Chapter II: Promoting Pollinators and Beneficial Insects through Landscape Biodiversity

Online resources

Adam, S. (2022). Blue Winged Wasp, Scolia Dubia, is a Real Asset! PennState Extension. https://extension.psu.edu/blue-winged-wasp-scolia-dubia-is-a-real-asset

ATTRA

*Farmscaping to Enhance Biological Control*

How to increase and manage biodiversity on a farm to favor beneficial organisms, especially insects.
https://attra.ncat.org/product/farmscaping-to-enhance-biological-control/

Bedford Audubon
*Native Plants for Habitat Gardening*
https://bedfordaudubon.org/habitat-gardening/plants-for-habitat-gardening/

California Audubon Society
*Hedgerows turn farm edges into bird habitat.*
Addresses concerns about hedgerows attracting pest birds.
https://ca.audubon.org/conservation/hedgerows-turn-farm-edges-bird-habitat

*Crop Rotation on Organic Farms: a Planning Manual*, Charles L. Mohler & Sue Ellen Johnson, eds. Download a free PDF or order a print copy:
https://www.sare.org/resources/crop-rotation-on-organic-farms/

FAO. 2020. *Towards sustainable crop pollination services – Measures at field, farm and landscape scales.* Rome. https://doi.org/10.4060/ca8965en

Indiana Native Plant Society
*Landscaping with Plants Native to Indiana*
This site provides valuable information about using native grasses and wildflowers in the landscape.
https://indiananativeplants.org/wp-content/uploads/2020/02/LandscapingPlants020820.pdf

Marion County Soil and Water Conservation District.
*Native Plantings for Beneficial Insects & Pollinators*.
This site provides valuable information about native plants and their benefits to farm ecology.
https://marionswcd.org/wp-content/uploads/marionswcd-native-plantings-for-beneficial-insects-and-pollinators.pdf

Collaboration between Marion County Soil and Water Conservation District and Indy Urban Acres. https://marionswcd.org/native-plant-agriculture/

Natural Resource Conservation Service
*Conservation Practice Standard: Hedgerow Planting, Code 422*
This publication addresses hedgerow planting, providing Indiana hedgerow plant species,

considerations and concerns.
https://www.in.gov/isda/files/422_Hedgerow_Planting1.pdf

Ohio Agricultural Research and Development Center

*Identifying and Enhancing Natural Enemies in Vegetable Crops*
https://www.youtube.com/watch?v=r1EYCevAgnY
Published on Nov 7, 2011; 25:03
A thirty minute video about how to identify and enhance natural enemies. The video also includes strategies for habitat management.

Purdue Extension

*Protecting Pollinators: Best Management Practices for Indiana Pollinator Habitat*.
How to establish and conserve effective pollinator habitats
https://extension.entm.purdue.edu/publications/POL-5/POL-5.html

*Recommended Indiana-native Plants for Attracting Pollinators*
Companion to *Protecting Pollinators: Best Management Practices for Indiana Pollinator Habitat*. Detailed table supporting plant selection for pollinator habitats.
https://extension.entm.purdue.edu/publications/POL-6/POL-6.html

*Indiana's Urban Woodlots*
The values and benefits of urban woodlots, and how a landowner can create a plan to preserve and manage theirs.
https://extension.purdue.edu/extmedia/fnr/fnr-489-w.pdf

SARE

*Resource Guide for Organic Insect and Disease Management*.
https://northeast.sare.org/resources/resource-guide-for-organic-insect-and-disease-management/

*Managing Cover Crops Profitably*. Download a free PDF or order a print copy:
https://www.sare.org/resources/managing-cover-crops-profitably-3rd-edition/

Savanna Institute

Provides extensive resources and programs to support perennial agriculture in the Midwest. https://www.savannainstitute.org

USDA

Environmental Quality Incentives Program- Indiana. (EQIP) Provides financial and technical assistance to agricultural producers and non-industrial forest managers to

conserve natural resources while strengthening their operations.
https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives/indiana/environmental-quality-incentives

PLANTS Database provides standardized information about plant attributes, including invasiveness.
https://plants.usda.gov/home

USDA NRCS East National Technology Support Center (2013). Farming for Beneficial Insects: Pollinators, Predators and Parasitoids.
https://www.youtube.com/watch?v=lxXb0NFc-v0

Wild Farm Alliance

Nonprofit organization promoting "healthy, viable agriculture that helps to protect and restore wild nature."
https://www.wildfarmalliance.org

The Xerces Society

Nonprofit organization devoted to protecting "the natural world through the conservation of invertebrates and their habitats."
*On-Farm Habitat for Beneficials Provides Multiple Benefits*
https://www.xerces.org/blog/on-farm-habitat-for-beneficial-insects-provides-multiple-benefits
*Organic Site Preparation for Wildflower Establishment*
https://xerces.org/publications/guidelines/organic-site-preparation-for-wildflower-establishment
*Organic Site Preparation Methods: Comparative Overview*
https://www.xerces.org/sites/default/files/2018-05/18-002_01_XercesSoc_Organic-Site-Prep-Methods-Overview_web4pg.pdf
*Farming for Pollinators*
https://xerces.org/sites/default/files/2018-05/08-006_01_XercesSoc_Farming-for-Pollinators-brochure.pdf
*How to Reduce Bee Poisoning from Pesticides*
https://xerces.org/publications/scientific-reports/how-to-reduce-bee-poisoning-from-pesticides
*Conservation Biological Control*
https://www.xerces.org/pesticides/ecological-pest-management/conservation-biological-control

Videos

OARDC

Identifying and Enhancing Natural Enemies in Vegetable Crops
https://www.youtube.com/watch?v=r1EYCevAgnY
Published on Nov 7, 2011; 25:03
A thirty-minute video about how to identify and enhance natural enemies. The video also includes strategies for habitat management.

SARE Outreach

Sowing Biodiversity: Cover Crops for Bees, Beneficial Insects and Pest Management - Eric Lee-Mader https://www.youtube.com/watch?v=77oJkzg2RrY
Published on Mar 1, 2018; 40:23
Highlights of this session include: (1) Introduction and overview of the latest science and practice of pollinator and beneficial insect conservation using cover crop practices; (2) Conservation threats to pollinators and real world case studies of natural pest suppression by beneficial insects through the use of cover crops; (3) Experimental new cover crop species; (4) Management of cover crops to mitigate beneficial insect harm (such as pesticide risk reduction, termination practices); (5) Results from a three-year study in western and east-central Illinois that evaluated the effects of several fall-planted cover crops on disease development in following soybean crops.

USDA NRCS East National Technology Support Center

Farming for Beneficial Insects: Pollinators, Predators and Parasitoids
https://www.youtube.com/watch?v=lxXb0NFc-v0
Published on Dec 4, 2013; 1:05:07
Presented by Nancy Lee Adamson, Ph.D., Pollinator Conservation Specialist, USDA NRCS East National Technology Support Center, Greensboro, NC, and The Xerces Society. Learn how to support beneficial insects (pollinators and natural enemies of crop pests) on farms. Pollinators and other beneficial insects help ensure healthy crop harvests. Participate in this webinar to learn how to support pollinators and natural enemies of crop pests (predators and parasitoids) by providing diverse habitat and protection from pesticides. This webinar highlights research showing how diverse habitat adjacent to cropland supports improved pollination and reduces pest pressure.

**Chapter III: Incorporating Small Livestock for an Integrated, Biodiverse Farm**

Online resources

AgEmerge Podcast 2020

Episode 035: Livestock Integration with Bottens Family Farm Livestock Team: Farmer podcast discussing complexities and benefits of livestock integration.

https://soundcloud.com/agemerge/agemerge-2020-livestock-integration-with-bottens-family-farm-livestock-team

Aquino, C. (2011). Integrating Existing Crop and Livestock Enterprises on a Native Hawaiian Homestead Farm. SARE. https://projects.sare.org/project-reports/fw09-004/

Coffey, L. & Mumma, T. (2014). Integrating Livestock and Crops: Improving Soil, Solving Problems, Increasing Income. ATTRA Sustainable Agriculture. https://attra.ncat.org/wp-content/uploads/2019/05/integrating_livestock.pdf?

Cornell University Small Farms Program

"How to Get Started with Sheep" blog post by Ulf Kintzel, owner/operator of White Clover Sheep Farm.
https://smallfarms.cornell.edu/2010/07/how-to-get-started-with-sheep/

Green Lands Blue Waters

"Match Made in Heaven: Livestock + Crops." This 3-year, 6 state (including Indiana) project aims to identify opportunities and barriers to integrating / re-integrating crops and livestock, and seeks to identify strategies to capture the multifaceted benefits of integrated farming systems. Learn more here: https://greenlandsbluewaters.org/match-made-in-heaven-livestock-crops/
Take their survey here:
https://uwmadison.co1.qualtrics.com/jfe/form/SV_6RInPZ8my9ryqbA

Kersbergen, R. (n.d.). *Integrating Livestock with Crop Production Yields Benefits for Both.* Midwest Organic Sustainable Education Service. https://mosesorganic.org/farming/farming-topics/livestock/integrating-livestock-with-crop-production/

Michigan State University

"Use of Annual Forages in Pasture Rotations and as Cover Crops to Benefit Small Ruminant Farming Systems," presentation by Richard Ehrhardt, Small Ruminant Specialist.
https://www.midwestcovercrops.org/wp-content/uploads/2017/03/2017MCCC-Forage-Ehrhardt.pdf

Midwest Grazing Exchange

Find goats, sheep and cattle for clearing or grazing crop residue or cover crops.
https://www.midwestgrazingexchange.com/

Montana State University Research

Three-year research project: Impacts of Integrating Livestock into Cropping Systems on Soil Health and Crop Production.
https://agresearch.montana.edu/warc/research_current/integrated-livestock/production_systems.html

NCAT/ATTRA

Small Scale Livestock Production: This publication discusses the benefits and challenges of raising small livestock on a small farm. Species considerations, fencing and markets, local climate, finding a mentor, building networks and regulations are all covered.
https://attra.ncat.org/publication/small-scale-livestock-production/

Saenz, E. (2020). Researchers: Midwest's Agri-food System Must Transform to Survive. *Indiana Environmental Reporter*.
https://www.indianaenvironmentalreporter.org/posts/researchers-midwests-agri-food-system-must-transform-to-survive

SARE

Agroforestry publications
https://northcentral.sare.org/resources/agroforestry-fact-sheet-series/
https://www.sare.org/publications/diversifying-cropping-systems/agroforestry/

Savanna Institute

Provides extensive resources and programs to support agroforestry in the Midwest.
https://www.savannainstitute.org
https://www.savannainstitute.org/planting-tree-crops/

Soul Fire Farm

*Soul Fire Farm: Raising Chickens at Soul Fire Farm*. A guide to how they raise meat chickens and laying hens. https://www.soulfirefarm.org/resources/

USDA. (2015). Organic Tipsheet: Manure in Organic Production Systems.
https://www.ams.usda.gov/sites/default/files/media/Manure%20in%20Organic%20Production%20Systems_FINAL.pdf

WARC. (2021). Integrated Livestock in Fruit and Vegetable Production.
https://agresearch.montana.edu/warc/research_current/integrated-livestock/index.html#summary

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