



Integrating Livestock and Crops: Improving Soil, Solving Problems, Increasing Income

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Traditional farms relied on livestock to maintain soil fertility and to use plant material that would otherwise have been wasted. Modern agriculture has tended to favor specialization, leading to large crop farms with no livestock. Incorporating livestock into a crop farm (grain, vegetable, or orchard) can benefit the soil organic matter and fertility, diversify the product base, provide new sources of income and farm resilience, and help with weed and pest control. Chemical, fuel, and fertilizer expenditures can be minimized and a new dimension added to the farm. This publication will outline some of the benefits and challenges of integrating livestock into a farm and will offer tips and resources to ease the transition. Case studies are included.



Multispecies grazing is a great way to diversify product lines and get the best use of forages. Photo: Ken Coffey, University of Arkansas

Introduction

Generations of farmers and ranchers have used livestock to graze areas that were not cropped, to browse woodlands and to clean up cropped areas and use vegetable and orchard waste. Animals controlled weeds and brush and recycled plant material, in turn providing manure to enrich the land, as well as meat, milk, fiber and skins, and even draft power. Livestock were an additional enterprise and gave farmers the flexibility to sell crops or livestock or both

at favorable times. A failed crop could still be grazed, and so livestock provided “insurance” in a time when crop insurance did not exist.

In recent years, economics and farm policy have tended to favor systems that separate animals from cropland. Farmers have increasingly specialized and have depended on mechanical equipment, pesticides, and commercial fertilizers to control weeds and maintain fertility. As costs of these inputs have risen and problems have become more apparent with these specialized systems, it

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appears that many producers could benefit from bringing livestock back to their farms. In addition to the benefits identified by our grandfathers (and their grandfathers), recent research has shown that livestock can:

- Increase soil organic matter, which increases water-holding capacity
- Improve soil fertility, adding nitrogen, phosphorus, potassium, and many micro-nutrients essential for plant growth
- Increase soil life and biodiversity, which improves soil functioning
- Reduce pest problems, including wheat saw fly and alfalfa weevil, by grazing during dormant season to remove pest habitat
- Remove weeds in fallow ground to not only reduce weed problems but also conserve soil moisture
- Reduce waste on the farm by grazing residue, consuming spoiled vegetables and fruits, or grazing damaged crops. This salvaging function enables income from crops even in a difficult year when crops are unsalable.
- In orchards, animals consuming dropped fruits can greatly reduce pest problems, including plum curculio.
- Grazing buffer zones, lanes between tree rows, and riparian edges can help maintain the landscape while making these areas productive parts of the farm.
- Enable income during rotations that might otherwise be strictly cover crops; turn cover crops into another cash crop by grazing, improving soil, and breaking pest cycles, while still producing a salable product
- “Close the loop” of farm cycles, making a more self-sufficient unit
- Produce other products for diversified income streams, better cash flow, less risk, and greater consumer interest
- Add animate life to the farm, increasing interest for the farm family and for visitors

Using croplands (their own or those of neighbors) also has many benefits for livestock producers, primarily reduced feed costs. During a drought



Grazing buffer zones, lanes between tree rows, and riparian edges can help maintain the landscape while making these areas productive parts of the farm.
Photo: Joan Burke, USDA, ARS

Related ATTRA Publications

www.attra.ncat.org

An Illustrated Guide to Growing Safe Produce on Your Farm

Grazing Contracts for Livestock

No-Till Case Study, Brown's Ranch: Improving Soil Health Improves the Bottom Line

No-Till Case Study, Richter Farm: Cover Crop Cocktails in a Forage-Based System

Paddock Design, Fencing, and Water Systems for Controlled Grazing

Ruminant Nutrition for Graziers

Small-Scale Livestock Production

Tips for Marketing Sheep and Goat Products

year, such as those many have suffered in recent years, exploring alternative feed options for livestock can make the difference between profit and having to sell out. The synergy of connecting crops and livestock can also apply to connecting crop and livestock producers: each component is stronger by being associated with the other.

Soil Improvement

The foundation of agriculture is the soil, and increasing interest in ways to build and manage healthy soils is a positive sign for the future of agriculture. A recent Natural Resources Conservation Service (NRCS) publication, *Healthy, Productive Soils Checklist for Growers*, lists four basic principles to improving soil health (NRCS, no date):

- Keep the soil covered as much as possible.
- Disturb the soil as little as possible.
- Keep plants growing throughout the year to feed the soil.
- Diversify as much as possible using crop rotation and cover crops.

As the NRCS points out, following these principles will not only improve soil health but also reduce input costs, protect against drought, and increase production. These practices are beneficial for a number of reasons, including the following:

- Keeping soil covered helps prevent erosion.
- Low disturbance preserves soil structure and increases soil organic matter, which makes for a better growing environment.

- Keeping plants growing throughout the year will keep soil covered and harvest sunlight continuously, providing more organic matter and nitrogen (if legumes are included) for the soil. This also makes a good environment for soil microbes.
- Diversified crop systems help break pest cycles, reducing problems from nematodes and soil-borne diseases and providing food for diverse soil life. They also help break weed cycles without using herbicides.
- Livestock manure increases microbes, adds organic matter, and helps with weed control. Weeds are a forage asset, not just a crop problem.

A combination of cover crops and livestock can accomplish all these goals on farms, whether the farm includes field crops, vegetables, or orchards. Livestock are important in maximizing benefits because they turn cover crops and crop residue into dollars while further improving the soil by depositing manure. They also offer a means of terminating cover crops. In June 2013, three USDA agencies—NRCS, Risk Management Agency, and Farm Service Agency—issued Cover Crop Termination Guidelines for Non-Irrigated Cropland, stating that “cover crops may be grazed as long as the planned amount of biomass is available at the time of termination. Cover crops that winterkill may be grazed to a level that meets their conservation purpose” (NRCS, 2013). Research conducted in Illinois has shown that yields are higher and soil organic matter is improved when

a corn cropping system includes both cover crops and grazing, as opposed to continuous corn or corn and a cover crop (Maughan et al., 2009).

Topsoil is conserved when land is in grass or in a rotation that maintains cover. For example, at the University of Missouri-Columbia’s Sanborn Field, there have been 100 years of research comparing systems of cropping and soil management. Topsoil at the end of that 100 years averaged 20 centimeters under continuous corn, 31 centimeters under a six-year rotation of corn-oat-wheat-red clover-timothy-timothy, and 44 centimeters under continuous timothy (Franzluebbers, 2007). These long-term studies also resulted in the following important findings:

- Shorter rotations generally provide greater economic returns but longer rotations help in maintaining soil productivity.
- Where erosion has decreased topsoil depth, reduced water-holding capacity is the most limiting factor, and additions of nutrients have limited value in restoring soil productivity.
- Cropping systems with legume or grass pastures and/or addition of barnyard manure or N fertilizer proved necessary to maintain soil organic matter. After 100 years, soil organic matter averaged 1.0% in continuous corn plots without manure or fertilizer, 2.3% with annual application of barnyard manure, and 1.9% with N-P-K fertilizer (Reeves, 1997).



Turnips and other cover crops keep the soil protected and provide great nutritious feed to livestock. Photo: Ken Coffey, University of Arkansas

Other long-term studies show compelling evidence of the value both of crop rotation and of using manures and/or N-P-K fertilizer. In various environments and crops, the importance of maintaining the soil quality becomes clearer with time. Yields may be maintained for a while without properly caring for the soil, but if soil organic matter is not preserved, soon the productivity drops as well. In one study in Oregon, wheat stubble was burned with no decline in yields for the first 20 or 30 years. In the 10 years following, however, soil organic matter and yields both dropped in that system. The only systems that held or improved soil organic matter were those that used manure (Reeves, 1997).

Preserving topsoil and soil organic matter maximizes water-use efficiency. This is because soil organic matter absorbs water, improving water-holding capacity and infiltration rate. Therefore, when a good rain comes, more of it is absorbed

into the soil rather than running off and causing erosion. This water is then available for crops. Soil organic matter helps soil tilth, meaning that roots more easily penetrate the ground. And soil microorganisms increase as organic matter increases, further improving the health of the soil and the crops grown on it. Over time, building and retaining soil organic matter and keeping cover on the ground will make a big difference in the health of the land and in the ability of the soil to grow crops. While all these benefits accrue from growing cover crops or incorporating grass into a rotation, adding livestock also contributes the fertility boost of manure to further build soil organic matter and soil microorganisms. The cover crops or grass rotations incorporated in a cropping system to benefit the land and future crops can also provide high-quality grazing for livestock.

See ATTRA's case study series on no-till farming and other helpful information on building

Table 1: Nutrients in Livestock Manure at Time of Land Application

| Type of livestock | SOLID MANURE lbs/ton | | | | LIQUID MANURE PIT lbs/1,000 gals | | | | LAGOON lbs/1,000 gals | | | |
|-------------------|-------------------------|-----------------|-------------------------------|------------------|-------------------------------------|-----------------|-------------------------------|------------------|--------------------------|-----------------|-------------------------------|------------------|
| | Total N | NH ₄ | P ₂ O ₅ | K ₂ O | Total N | NH ₄ | P ₂ O ₅ | K ₂ O | Total N | NH ₄ | P ₂ O ₅ | K ₂ O |
| Farrow | 9.0 | 3.5 | 6.0 | 4.0 | 15.0 | 7.5 | 12.0 | 11.0 | 3.0 | 2.8 | 1.5 | 1.5 |
| Nursery | 13.3 | 5.0 | 8.0 | 4.0 | 25.0 | 14.0 | 19.0 | 22.0 | 4.0 | 3.5 | 3.0 | 3.0 |
| Grow-Fin | 16.0 | 6.0 | 9.0 | 5.0 | 32.8 | 19.0 | 26.4 | 25.4 | 5.0 | 4.5 | 3.0 | 4.0 |
| Breed-Gest | 9.0 | 5.0 | 7.0 | 5.0 | 25.0 | 12.0 | 25.0 | 24.0 | 3.5 | 3.2 | 3.5 | 4.0 |
| Dairy Cow | 9.0 | 2.2 | 3.5 | 6.5 | 31.0 | 6.5 | 15.0 | 19.0 | 4.2 | 2.3 | 1.7 | 3.0 |
| Dairy Heifer | 9.6 | 2.0 | 3.8 | 6.8 | 32.0 | 6.0 | 14.0 | 28.0 | 4.2 | 2.1 | 2.0 | 3.0 |
| Dairy Calf | 9.6 | 2.0 | 3.0 | 5.0 | 27.0 | 5.0 | 14.0 | 24.0 | 3.0 | 2.0 | 1.0 | 2.5 |
| Veal Calf | 9.0 | 5.0 | 3.5 | 6.0 | 26.5 | 21.0 | 22.0 | 40.0 | 3.0 | 2.5 | 1.0 | 3.0 |
| Beef Cows | 7.0 | 3.0 | 4.0 | 7.0 | 20.0 | 7.0 | 16.0 | 24.0 | 4.0 | 2.0 | 3.0 | 4.0 |
| Feeder Calves | 8.8 | 3.1 | 4.50 | 8.3 | 27.0 | 8.0 | 18.0 | 24.0 | 4.0 | 2.2 | 3.0 | 3.5 |
| Fattening Cattle | 11.0 | 4.1 | 7.0 | 10.5 | 29.0 | 8.0 | 18.0 | 26.0 | 5.0 | 2.7 | 4.0 | 5.0 |
| Broilers | 50.0 | 8.0 | 40.00 | 30.0 | 63.0 | 13.0 | 40.0 | 29.0 | 8.5 | 5.0 | 4.3 | 3.5 |
| Pullets | 48.0 | 9.0 | 35.0 | 27.0 | 60.0 | 12.0 | 35.0 | 30.0 | 8.5 | 4.5 | 4.0 | 3.5 |
| Layers | 38.0 | 18.0 | 35.0 | 22.0 | 60.0 | 13.0 | 45.0 | 28.0 | 7.0 | 5.5 | 4.0 | 3.5 |
| Tom Turkeys | 38.0 | 8.0 | 30.0 | 22.0 | 60.0 | 20.0 | 50.0 | 29.4 | 8.0 | 6.0 | 4.0 | 4.5 |
| Hen Turkeys | 36.0 | 8.0 | 27.0 | 20.0 | 53.0 | 16.0 | 50.0 | 32.1 | 8.0 | 6.0 | 4.0 | 4.0 |
| Ducks | 20.0 | 5.0 | 18.0 | 11.0 | 22.0 | 5.0 | 15.0 | 8.0 | 5.0 | 3.5 | 3.0 | 2.5 |
| Lamb | 18.0 | 5.0 | 11.0 | 26.0 | ---- | ---- | ---- | ---- | ---- | --- | --- | --- |
| Ewe | 14.0 | 5.0 | 9.0 | 25.0 | ---- | ---- | ---- | ---- | ---- | --- | --- | --- |
| Horse | 14.0 | 4.0 | 4.0 | 14.0 | ---- | ---- | ---- | ---- | ---- | --- | --- | --- |

*Estimates as removed from storage at time of land application based on numerous samples collected in Indiana; dilution water and bedding additions can change nutrient values dramatically.

Source: Sutton et al., 1994

healthy soil at <https://attra.ncat.org/soils.html>. In addition, *Building Soils for Better Crops: Sustainable Soil Management* (see Further Resources) is an excellent book that provides practical help and information about improving soils. Great information about using cover crops can be found at www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition, where you can download the book *Managing Cover Crops Profitably* and access SARE reports of research done across the United States on this important topic.

Benefits of cover crops

- Reduce erosion
- Improve soil tilth
- Increase water-infiltration rates
- Break weed cycles
- Break disease cycles
- Capture nitrogen not used in the previous crop
- Provide nitrogen for the next crop (if legumes are used for the cover crop)
- Provide grazing for ruminant livestock

Source: Gardner and Faulkner, no date

Benefits of Livestock

Livestock deposit manure while grazing, and the benefits of manure on cropland have been known for thousands of years. Research has verified and quantified the impacts of manure. For example, Douglas Edmeades reviewed long-term comparisons of manure and fertilizer and showed that both have very large effects on soil productivity as shown by crop yields. Also, adding manure to soils was shown in these studies to increase organic matter and soil microorganisms; increase phosphorus, potassium, calcium, and magnesium in topsoils; and increase nitrate nitrogen, calcium, and magnesium in subsoils. Manured soils also were shown to be more porous and have lower bulk density (a measure of compaction) and higher aggregate stability than fertilized soils (Edmeades, 2003). At the levels used in these studies, there was no significant difference in crop yields between fertilized and manured soils. However, as prices of fertilizer rise, economics

may favor the use of manure, particularly if that manure is applied directly by the animals as they are grazing in a controlled way. The free Manure Valuator app from the University of Arkansas can help calculate the nutrient and monetary value of field-applied manure. Even if economics do not favor using manure, however, it does afford long-term health benefits to the soil, as discussed earlier.

Solving Problems

Grazing livestock not only improve soil by depositing manure and by stimulating plant growth through the action of grazing, but they also help solve weed, pest, and disease problems. For example:

- Sheep grazing alfalfa in the dormant season remove habitat and larvae of the alfalfa weevil (Hatfield et al., 2011).
- Sheep grazing wheat stubble remove habitat and larvae of the wheat sawfly (Hatfield et al., 2011).
- Sheep grazing alfalfa can reduce weeds in a new seeding (Bell and Guerrero, 1997).
- Animals grazing fallen apples remove plum curculio (Grieshop et al., 2010).
- Incorporating cover crops or sod (such as bahagrass) and then harvesting by grazing breaks disease cycles for peanut, cotton, and other crops, increasing yields in following years (Hill, 2002). (See also Conference Proceedings in the Further Resources section.)
- Animals strip-grazing crop residue can bring it down fairly precisely to a level that is easily incorporated into the ground, yet is still protecting the soil from erosion.
- Cattle, sheep, or hogs can be used to harvest a grain crop that failed or to glean after combining is done, reducing volunteers in subsequent crops.
- Livestock can clean up garden residue and use over-ripe vegetables and fruits, reducing waste on the farm.
- Using bahagrass (for livestock forage) as part of a rotation reduced peanut nematodes and increased peanut yields in following years by nearly 30% compared with continuous peanut (Hill, 2002).

Animals serve all these functions while improving the soil, producing a product (meat, milk, or fiber), and eliminating the cost of herbicides or fuel. Other weed-control alternatives, such as fire or mowing, are more costly and do not improve soil.

Finding More Information

Research on the management and benefits of livestock grazing is ongoing. Many research projects receive funding from Sustainable Agriculture Research and Education (SARE), and the results of these projects are added to an online database as the projects are completed. Visit the “Search Projects” section of www.sare.org and use search terms such as “grazing cover crops” and “livestock integration” to find current information from research projects across the United States. Don’t miss the Cover Crop Topic Room at www.sare.org/Learning-Center/Topic-Rooms/Cover-Crops.

Increasing Income

Livestock can offer a farm both services and products. Services include soil improvement and pest management, accomplished by breaking disease and weed cycles, as well as by actually removing some pests. Services such as these contribute to improved crop yields in future years. Livestock can also be used to “clean up” an area, clearing brush and weeds so that the land can be put to more productive use. Money saved is money earned,

too, and by saving fuel, fertilizer, herbicides, and pesticides, animals benefit the bottom line.

Livestock can provide a farm with additional products to sell, which can improve cash flow; offset the cost of planting cover crops; and reduce risk by diversifying income streams. Ruminant animals can produce meat, milk, or fiber using the forages on the farm, while hogs can be very useful in using waste vegetables, fruit, and grain stubble or failed crops to grow to market weight. Poultry can produce meat or eggs. For examples of how livestock can be marketed to add to farm revenue, see ATTRA’s series of publications titled *Tips for Marketing Sheep and Goat Products*. In addition to generating direct revenue, livestock can help increase a farm’s customer base. For farms that encourage visitors, adding livestock adds a lot of interest and liveliness. Customers often appreciate the opportunity to watch and interact with livestock, and well-managed livestock of any species will add sound and motion and beauty to the landscape. Baby livestock in particular draw customers to a farm.

An important advantage of livestock is the marketing flexibility. If forages are not available, it is possible to sell livestock at a lighter weight or younger age. Herd size can be managed according to forage availability. When plenty of forage is present, farmers can raise livestock to market weight and sell at market, or (if processing is available) harvest the animal and sell it as meat.

Livestock can help solve weed problems and add income to the farm. Noxious weeds such as leafy spurge can be controlled by grazing with sheep or goats. Photo: Dave Scott, NCAT



Increasing Farm Resilience to Climate Change

A 2012 USDA report on the effects of climate change on agriculture asserts that, “Given the projected effects of climate change, some U.S. agricultural systems will have to undergo more transformative changes to remain productive and profitable” (Walthall et al., 2012).

Adaptation measures such as...diversifying crop rotations, integrating livestock with crop production systems, improving soil quality, minimizing off-farm flow of nutrients and pesticides, and other practices typically associated with sustainable agriculture are actions that may increase the capacity of the agricultural system to minimize the effects of climate change on productivity. For example...production practices that enhance the ability of healthy soils to regulate water resource dynamics at the farm and watershed scales will be particularly critical for the maintenance of crop and livestock productivity under conditions of variable and extreme weather events. (Walthall et al., 2012)

Adding livestock to your farming operation might be an effective way to hedge against weather extremes, while also improving and protecting soil health and increasing profitability.

Beaverdam Farms, Mississippi: The Pinion Family

In 2012, Dustin Pinion and his partner Ali Fratesi raised pastured poultry, hogs, and rabbits, as well as tomatoes and other vegetables.

The Pinion family (Dustin's parents) began with hydroponic tomatoes 12 years ago. Dustin became interested in livestock as a way to diversify income sources. “If we got sprayed by a neighbor, we lost the crop for the year. We'd have a couple of good years, then a bad year; I was tired of the insecurity. So I was thinking about other options and decided to go work on other farms to learn about livestock because I had a strictly vegetable background. It surprised me, after getting some experience in livestock, to find out how much I enjoyed livestock. I'd rather raise livestock than vegetables; I love the personalities, and they are building soil, capturing carbon...you do a lot with livestock.”

Dustin's biggest challenge has been the initial lack of knowledge. His internships at two different farms (in Colorado and Virginia) filled that gap and also gave him experience with several marketing options, including CSA and buying clubs, as well as on-farm sales. Dustin balanced the internship training with his own training on the home farm. “I left college for the summer and built a few pens, did a couple of batches of broilers, then left for Colorado for eight or nine months and worked on that farm. I came back from Colorado and did a couple more batches of my own birds before I left for Virginia (Polyface Farm) for six months. It taught me a lot. I learned that I like the CSA model: you get to know families, people who appreciate what you do. The buying club has advantages, too. Knowing how to market your product is key.”

As for advice for others, Dustin emphatically advises, “Start small, and build your customer base. Start with no debt. Team up with another farmer if you can; for instance, if you are raising vegetables or crops, you might team up with a livestock farmer and let the livestock graze and fertilize, while you provide a customer base for selling livestock products. It's a lot easier to sell two or three products to an existing customer than to find three new customers.”

Increased profitability and green, green grass are among the benefits realized at Beaverdam Farms. Because the tomatoes are grown hydroponically, the benefits of the manure are not realized for that part of the farm. However, they have added a hoop house, and this will allow them to winter rabbits and chickens inside the hoop house, and then grow vegetables during the growing season. Because of that green grass provided by the pastured poultry, Dustin has an opportunity to add herbivores (cattle, sheep, or goats) to turn that grass into meat or milk. And his existing customer base provided a ready market for the livestock products.



Hogs can be very useful in using waste vegetables, fruit, and grain stubble or failed crops to grow to market weight. Photo: Linda Coffey, NCAT

Considerations

While the benefits of adding livestock are substantial, some farmers are reluctant to take this step. In contrast to the diversified farms of earlier years, today's farms may not be equipped to handle livestock. You may have some of the following questions and concerns:

- I don't know how to raise livestock.
- What livestock species (and breeds) will work best on my farm?
- What will it cost to get started with livestock?
- Should I purchase my own livestock or contract grazing services?
- How much labor will be needed to take care of the livestock?
- Should I get involved in breeding livestock (a year-round commitment) or purchase young stock seasonally?
- How will I feed stock outside the forage season?
- What sort of infrastructure (fencing, watering, handling system, and shelter) is needed?
- How do I make sure my animals can't damage my crops?
- Will my crop insurance allow terminating a cover crop by grazing?
- What management systems will use manure most effectively?
- What equipment will I need to collect, compost, and distribute manure on the fields?
- When should I apply manure to my cropland?
- Will grazing livestock compact the soil?
- How will I market the products of the livestock?
- Is there processing available so I can sell meat?

None of these concerns is insurmountable and help is available. See Further Resources at the end

of this publication, as well as the list of related ATTRA publications on page 2 that will be especially helpful. *Small-Scale Livestock Production* offers a good introduction for those who are new to livestock enterprises. Experience with livestock and with the fencing and facilities needed for a particular species of livestock is best gained on someone else's farm: be alert to opportunities in your region for workshops and farm tours that allow you to see firsthand how livestock are being used and handled on other farms similar to yours.

Controlling where the livestock range is necessary to prevent them from damaging crops. Particularly for those raising high-value vegetable or fruit crops, having a fence that can be trusted to contain the animals is a key component of making a livestock enterprise feasible. Electric fencing is a cost-effective way to accomplish this. To learn more, see the 2005 NRCS publication *Electric Fencing for Serious Graziers* (see Further Resources). In addition, the ATTRA publication *Paddock Design, Fencing, and Water Systems for Controlled Grazing* offers useful ideas about fencing.

It may be wise to start with a simple livestock enterprise and add to it later as your interest and experience grows. Buying your own stockers or contracting out someone else's stocker cattle or sheep allows you to focus your livestock education on the essentials and reduces your learning curve. You can concentrate on discovering how to reliably fence out your animals from areas of the farm that you do not want them in, such as high-value market garden crops. This in itself takes time to learn and usually includes some trial and error. For example, we have learned that to be very sure that animals are never in areas that are off limits, the best temporary fencing is two electric fences with a buffer zone between them. Animals usually get the idea that electricity hurts and the buffer zone allows time for that revelation to sink in.

Similarly, knowing how to build a flexible stock-watering system that is easily adapted to your farm's needs and constraints takes some knowledge and experience. The placement of water has a direct influence on forage utilization and on the ease of grazing multiple paddocks. In many cases, it is a critical limiting factor in the adoption of grazing techniques that allow for increased soil health, which include shorter grazing periods, more directed trampling of the grazed crop, and greater residue management.

Incorporating stocker livestock into your grazing plan eliminates the additional liabilities associated with breeding stock. Breeding stock most often require facilities for seasonal shelter and manure storage, especially in the northern tier. In the absence of artificial insemination, they must be bred by bulls, rams, or bucks, which constitute a safety concern for inexperienced livestock handlers. Additional knowledge in feeding, birthing, and animal health is also required. These prerequisites can easily overwhelm a farmer whose primary interest and source of income is in crop production. There are easier ways to accomplish your goal of improving soil health and fertility than through year-round ownership and care of livestock. Keep it simple and allow yourself time to acquire the skills of livestock care and handling.

Furthermore, if you decide that that you are not yet ready to manage any livestock yourself, consider contracting for livestock services. There are targeted grazing businesses that contract to control noxious weeds, graze alfalfa to reduce alfalfa weevil, reduce weed and wheat sawfly problems, and manage kudzu and other problematic plants. See *Targeted Grazing* for details on using animals in farming systems, orchards, woodlands, and to control specific weeds (Launchbaugh, 2006). Chapters address working with a contract provider, managing the livestock yourself, and starting a business of contract grazing. One way to find a provider in your area is to look at Livestock for Landscapes' Provider Directory at www.livestockforlandscapes.com; read the section about goats and fire control to find the directory, arranged alphabetically by state. The Montana Sheep Institute (www.sheepinstitute.montana.edu/) is a great source for information, as is TEAM Leafy Spurge (www.team.ars.usda.gov/). It is wise, when contracting for any services, to ask for references and to have plans in writing. See the ATTRA publication *Grazing Contracts for Livestock* for more information on contracting grazing.

If livestock are already being raised in your area, cooperating with existing livestock producers may be an excellent solution for both of you. The producers gain good grazing for their animals, which saves them money, while you gain the grazing and fertilizing services for the time the animals are on your land. The owners can maintain responsibility for the animals and the crop grower can focus on normal tasks. An example of this is described in *Sustainable Vegetable Production from Start-Up*



to Market (Grubinger, 1999), where a grower in Vermont arranged to crop 10 acres of vegetables each year, seeding down one-third of the land to alfalfa every three or four years to be used by a neighboring sheep farmer for intensive grazing. A similar area that was mature alfalfa (grazed and fertilized by sheep for three years) was then turned under and planted to vegetables. In this way, the farm kept renewing the soil and breaking soil-borne disease cycles. Of course, this type of arrangement requires good, cooperative neighbors and a strong desire on both sides to create a win-win situation, where both benefit.

Using sheep to clean up an area before planting is a time-honored method. Modern electronet fencing makes controlling the animals much easier.
Photo: Dave Scott, NCAT

Concerns

Soil compaction is a valid concern. Where livestock are allowed to remain on land during wet periods, there may be significant compaction, which would reduce water infiltration and make tillage more difficult. However, research conducted in North Dakota to examine water infiltration rates showed that livestock grazing cropland in the winter did not affect infiltration rate at three, six, or nine years after establishment of an integrated crop-livestock system. The researchers credited freeze-thaw cycles and

Herbicides and Grazing Alert

Be aware that if you use herbicides while growing a crop, you must comply with the grazing and forage-harvesting restrictions of those particular herbicides. The restrictions on some herbicides also affect the following crop, even if it is a cover crop. Information about this issue can be found at www.mccc.msu.edu/states/Wisconsin/2014_Factsheet_HerbicideRotationRestrictions.pdf.

no-till management for creating resistance to change in soil properties, although they warned that others should be cautious in applying these results in other regions or management systems (Liebig et al., 2011). A study in Illinois found that integrating cattle on corn cropland resulted in increased yield compared with continuous corn (Tracy and Zhang, no date). The researchers in this study speculated that the conventional tillage they used in their system may have alleviated some compaction. They

also reported significant increases in soil carbon within five years of conversion from corn-soybean rotation, suggesting that integrating cattle with grain crops can build soil organic matter rapidly. Other research (reviewed by Roger Gates) found some evidence of soil compaction with grazing but no clear impact on future yields (Gates, 2003). To ensure no detrimental effects of animals, managers can think of ways to balance traffic across the field, if possible, and remove animals while residue is still sufficient to protect the soil from erosion.

Another concern may be how to provide proper nutrition to livestock that are grazing crop residues or weeds. Good management guidelines for



Having manure available to compost and then spread on land will greatly assist soil-building, ensuring future productivity. Photo: Dave Scott, NCAT

beef cattle are found in *Grazing Crop Residues with Beef Cattle* (Rasby et al., 2008). The ATTRA publication *Ruminant Nutrition for Graziers* will help in understanding nutritional needs for cattle, sheep, or goats at various stages of production.

Vineyards and orchards have successfully incorporated animals (see the case study Chaffin Family Orchards, California). A major concern for orchardists is that livestock not damage the trees. Poultry are often the best livestock for orchards for that reason, although sheep can be used if trees are protected and if managers will inspect daily to be sure animals are not eating bark. Mineral deficiencies may trigger bark-eating; in any

Using Manure as Fertilizer on Food Crops: Food Safety Considerations

The USDA National Organic Program (NOP) soil fertility and crop nutrient management practice standard specifies that if raw (not composted) manure is used on crops intended for human consumption, the manure must be incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles or not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles (Code of Federal Regulations, section 205.203). In 2013, the U.S. Food and Drug Administration issued a Proposed Rule for Produce Safety under the Food Safety Modernization Act. This Proposed Rule requires a nine-month interval between application and harvest if an untreated biological soil amendment—such as manure—has a chance of coming into contact with covered produce after application (NSAC, 2013). Produce growers and other food crop producers who choose to integrate livestock into their operations will need to take appropriate measures to ensure food safety.

“Integrating Livestock Production into a Vegetable Cropping System: Pros and Cons, Do’s and Don’ts” by Rick Kersbergen, is an excellent, concise article that includes links to food safety information. For details, see Further Resources. In addition, the ATTRA publication *An Illustrated Guide to Growing Safe Produce on Your Farm* discusses ways farmers can reduce produce contamination risk, which creates a safer food system and increases consumer confidence in their own products and farm at the same time.

Chris Kerston manages the Chaffin Family Orchards on the north-east side of the Sacramento Valley. The farm raises olives, citrus and other fruits, sheep, goats, cattle, and pastured poultry. This farm has been in the stewardship of the Chaffin family for three generations and is managed with the future in mind. The farm is operated using permaculture techniques and wildlife-friendly practices, and farm produce is marketed at farmers markets, to natural food stores, through a CSA, at the farm store, and online. A video tour and lots of photos are available on the farm website at www.chaffinfamilyorchards.com/.

The land was a sheep farm in the 1800s and later became an orchard. When Del Chaffin started managing the orchards, he added cattle and then sheep.

ATTRA talked with Chris Kerston about integrating livestock with orchards. Kerston explained:

"Olive trees are very hardy, so grazing in the groves makes perfect sense. The ruminants keep the vegetation down and turn it into meat that can be harvested and sold and manure that acts as fertilizer to the grass and trees.

During the last 10 years, the table olive market has been extremely volatile. One year the crop was only worth about 10% of what would have been average market value in years prior. While the market has recovered some, it's never really come all the way back to its former strength. The migration of the fruit fly, in addition to cheap international imports of olives, has put tremendous pressure on the domestic olive industry. The devaluation of our main crop here forced us to further diversify. During this transition we've added goats, chickens, and switched from meat sheep to fiber sheep. So the sheep and cows provide us with the mowing [of] the orchards, the chickens debug and fertilize, and the goats handle invasive weeds. And we've also done some small trials with hogs, waterfowl, and turkeys in the orchards and we're now working on scaling up those operations.

The animals solve quite a few problems for us. Firstly, they diversify our income. So on an acre that used to solely give us one type of orchard crop, we're now able to harvest both an orchard crop and multiple animal crops, while increasing fertility in the soil, and harvest multiple times per year, extending cash flow. We also drastically diminish our needs for inputs such as tractor work, soil amendments, and spray applications. Our fuel consumption is down tremendously from what it was a decade ago, and we're watching the orchards get healthier and healthier each year.

The stone fruit and citrus orchards are more sensitive to grazing/animal impact than the olive orchards are, so in those orchards we only utilize the poultry and sheep. However, the olive orchards are tough enough to handle all of the animal species that we've tried thus far."

Kerston went on to describe some of the challenges Chaffin Orchards experienced in the process of integrating livestock: "One of the biggest challenges of raising animals in an orchard is keeping them in some sort of fenced paddock. You can't really

build permanent fences because this would negatively impact the orchard farming and harvest tasks. So we use solar-charged polynet electric fences. The solar chargers keep the fences hot, which keeps livestock in and predators out (we also employ the use of guardian dogs). We buy our fencing from places like Live Wire Products www.livewireproducts.com/ and Premier Fencing www.premier1supplies.com/. The fences are completely portable so we're able to set them up wherever we need and move them to new areas when we need to do orchard farming work. On average we move the livestock about once per week.

Another challenge we face is keeping costs down. Granted, we do replace quite a few depreciable inputs by using the animals, but moving them all the time can be quite labor-intensive. We have to balance that out with the services they're providing. However, it's part of our mission to keep people employed, which we believe helps strengthen our local economy and works like an investment in our future.

Another challenge is deciding whether we make decisions based on what's best for the animals or best for the orchard crops. We usually let the livestock dictate the pace and then shore up any challenges in the orchards with more traditional farming methods.

Yes, the livestock have proven to be profitable. Some more than others. Maybe the biggest challenge [with] livestock is finding legal, affordable, competent butchering services available within a reasonable distance. The butchering cost per pound is drastically higher on sheep and goats than it is on beef. That's one of the reasons we switched to the wool sheep."

ATTRA asked Kerston if he had any tips for others thinking about integrating livestock into their operations. He responded:

"For beginners, I would start with a small quantity of small animals. Poultry is a good place to start. They're a manageable size and fairly easy to care for. Rabbits are also good for similar reasons. Both are also legal for home butchering in most states. As more experience is gained, one could move on to a small flock of sheep or goats.

Start small and get quality livestock and equipment. Keep livestock nutrition up with supplemental minerals; this will help fertilize your orchards at the same time. And maintain your equipment well to prevent animal breakouts. Putting collared bells on some of your animals will help you better locate them if they escape. If you're having trouble with predators, definitely get guardian dogs. You can also bait the electric fences with peanut butter. Most mammals can't resist the smell of peanut butter and when they lick it they will get shocked on their tongue and learn to respect the fence regardless of how tasty the animals inside it look.

As a farm diversifies, it definitely grows the customer base and increases the spending of your existing customers. You become more convenient to your customers as you become less specialized and more of one-stop-shopping."

case, once sheep begin to nibble on the bark, they should be removed from the area. Goats are not recommended in orchards because they have a strong liking for woody plants and are agile and smart.

Many of the logistics of incorporating livestock are covered in the ATTRA publication *Small-Scale Livestock Production*. Following are some suggestions to keep in mind if you are considering integrating livestock with your crops.

Tips for adding livestock to your farm

- Start small, giving yourself time to learn and adapt without much risk.
- Visit other farms and ask questions. Take pictures of facilities.
- Find local, experienced help: a mentor is invaluable.
- Locate a veterinarian and visit with your vet about preventative practices.
- Investigate the possibility of hiring animals, or contracting to graze them, rather than owning them yourself.
- Learn about portable electric fencing to cut costs and build flexibility into your system.
- Graze market animals, rather than breeding stock.
- Combine smaller ruminants (sheep or goats) with a market garden operation, for less soil compaction and more complete forage cleanup.
- Choose cattle for larger crop acreages to save on fencing requirements.

Conclusion

Integrating livestock with crops offers farmers opportunities to improve soil health and enter new, diversified markets that can reduce risks and increase farm resilience to weather extremes. Before adding livestock to an operation, however, it's important to understand the financial, infrastructure, and marketing demands involved in producing animals. Contracting grazing services might be a good way to begin integrating livestock with a cropping operation.

References

Bell, Carl E. and Juan N. Guerrero. 1997. Sheep grazing effectively controls weeds in seedling alfalfa. *California Agriculture*. Vol. 51 (2): 19–23. March–April. <http://ucanr.org/repository/cao/landingpage.cfm?article=ca.v051n02p19&fulltext=yes>



Having livestock available increases farm appeal. Photo: Tracy Mumma, NCAT

Edmeades, Douglas C. 2003. The long-term effects of manures and fertilizers on soil productivity and quality: a review. *Nutrient Cycling in Agroecosystems*. Vol. 66: 165–180.

Franzluebbers, Alan J. 2007. Soil physical aspects of integrated crop-livestock systems. USDA/ARS Watkinsville, Georgia. PowerPoint presentation. www.fao.org/fileadmin/templates/agphome/scpi/cgwg/2007_Aug_-_Soil_physical_aspects_of_integrated_crop-livestock_systems_-_Int_Symp_ICLS_-_Curitiba_Brazil.pdf

Gardner, J.C. and D.B Faulkner. No date. Use of cover crops with integrated crop-livestock production systems. *Integrated Crop-Livestock Systems*. p. 185–198. www.swcs.org/documents/filelibrary/CCCW11crop_livestock_AAB12051E71FC.pdf

Gates, Roger N. 2003. Integration of perennial forages and grazing in sod based crop rotations. In: *Proceedings of Sod Based Cropping Systems Conference*. North Florida Research and Education Center. University of Florida. February 20–21. p. 7–14.

Grieshop, Matt, Mark Whalon, David Epstein, John Wise, and Larry Gut. 2010. Organic management of plum curculio. *Integrated Pest Management News*. Michigan State University.

Grubinger, Vernon. 1999. Sustainable Vegetable Production from Start-Up to Market. NRAES-104. Plant and Life Sciences Publishing, Ithaca, NY.

Hatfield, Patrick, Hayes Goosey, Andrew Lenssen, and Sue Blodgett. 2011. Sheep Grazing to Manage Crop Residues, Insects and Weeds in Northern Plains Grain and Alfalfa Systems. Agricultural Innovations Fact Sheet. Sustainable Agriculture Research & Education. www.sare.org/publications/factsheet/pdf/11AGI2011.pdf

Hill, Gary M., et al. 2002. Crop/livestock Integration: Restoring a Traditional Paradigm in Contemporary Agricultural Research, Outreach and Practice. SARE Project LS01-123. <http://mysare.sare.org/mySARE/ProjectReport.aspx?do=viewProj&pn=LS01-123>

Launchbaugh, Karen (ed.). 2006. Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement. American Sheep Industry Association. www.webpages.uidaho.edu/rx-grazing/handbook.htm

Liebig, Mark A., Don L. Tanaka, Scott L. Kronberg, Eric J. Scholljegerdes, and Jim F. Karn. 2011. Soil hydrology attributes of an integrated crop-livestock agroecosystem: Increased adaptation through resistance to soil change. Applied and Environmental Soil Science. Vol. 10. Article ID 464827.

Maughan, Matthew W., Joao Paulo C. Flores, Ibanor Anglinoni, German Bollero, Fabian G. Fernandez, and Benjamin F. Tracy. 2009. Soil quality and corn yield under crop-livestock integration in Illinois. Agronomy Journal. Vol. 101, Issue 6. p. 1503–1510.

Maughan, Matthew W., German A. Bollero, and Benjamin F. Tracy. No date. Integrated crop-livestock system: effect on soil compaction, microbial biomass, and grain yield. PowerPoint presentation. http://my.extension.uiuc.edu/documents/1846092304090409/DSD2007_Tracy.pdf

NRCS. No date. Healthy, Productive Soil Checklist for Growers. USDA. www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/

NRCS. 2013. NRCS Cover Crop Termination Guidelines: Non-Irrigated Cropland. USDA. www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1167871.pdf

National Sustainable Agriculture Coalition (NSAC). 2013. The Food Safety Modernization Act: Manure and Compost. <http://sustainableagriculture.net/fsma/learn-about-the-issues/manure-and-compost/>

Rasby, Rick J., Galen E. Erickson, Terry J. Klopfenstein, and Darrell R. Mark. 2008. Grazing Crop Residues with Beef Cattle. University of Nebraska-Lincoln Extension. EC278.

Reeves, D. W. 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil & Tillage Research. Volume 43: 131-167. <http://naldc.nal.usda.gov/download/10593/PDF>.

Tracy, Benjamin F. and Yan Zhang. No date. Soil compaction, corn yield response and soil nutrient pool dynamics within an integrated crop-livestock system in Illinois <http://my.extension.uiuc.edu/documents/1144092307090709/Compaction%20paper-Crop%20Sci%20Final.pdf>

Walthall, C.L., et al. 2012. Climate Change and Agriculture in the United States: Effects and Adaptation. USDA Technical Bulletin 1935. Washington, DC. www.usda.gov/oc/climate_change/effects_2012/effects_agriculture.htm

Further Resources

Books

Building Soils for Better Crops: Sustainable Soil Management, Third Edition. 2009. By Fred Magdoff and Harold Van Es. Sustainable Agriculture Research and Education (SARE) Program. Handbook Series Book 10. www.sare.org/Learning-Center/Books

This book offers a comprehensive, interesting, readable, and practical look at soil and how to manage it to increase organic matter and fertility, resulting in healthier plants and more productive land. Farm case studies, photos, illustrations, graphs, and tables break up the chapters, and historical quotes add to the interest.

Managing Cover Crops Profitably, Third Edition. 2012. Edited by Andy Clark. Sustainable Agriculture Research and Education (SARE) Program. Handbook Series Book 9. www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition

This book explores how and why cover crops work and provides all the information needed to build cover crops into any farming operation. It offers specific information on using grains, brassicas, legumes, grasses, and mustards, and enables producers to make good decisions about the cover crops and rotations that will work best for them.

Targeted Grazing Handbook. 2006. Edited by Karen Launchbaugh. American Sheep Industry Association. www.webpages.uidaho.edu/rx-grazing/handbook.htm

Chapter 14 includes great examples of incorporating targeted grazing into farming systems.

Articles

Best Management Practices: Land Application of Animal Manure. Johnson, Jay, and Don Eckert. No date. The Ohio State University Extension. AGF-208-95.
<http://ohioline.osu.edu/agf-fact/0208.html>

Concise publication giving guidelines to properly apply manure to land while protecting the environment. Many tables showing nutrient content of various manures, nitrogen content of manures, availability of residual nitrogen in subsequent years, and more.

Electric Fencing for Serious Graziers. By USDA Natural Resources Conservation Service. 2005. www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_010636.pdf

This 34-page document is colorful, readable, and very practical. Many illustrations and drawings help the reader understand the fundamentals of using electric fence. Local NRCS offices may have this in print.

Environmental Benefits of Manure Application. By Rick Koelsch and Ron Wiederhold. 2012. eXtension.
www.extension.org/pages/14879/environmental-benefits-of-manure-application#.U6hsunagqVE

A very short article with links to more information. Manure that is applied correctly has many benefits to the environment, as explained here.

Grazing Crop Residues with Beef Cattle. By Rick J. Rasby, Galen E. Erickson, Terry J. Klopfenstein, and Darrell R. Mark. 2008. University of Nebraska-Lincoln Extension. EC278.

This article details the use of crop residues with respect to beef cattle nutrition and includes helpful guidelines on supplementing cattle once residues become too low-quality. Provides good management guidelines, a budget, and tips on figuring rental rates.

Integrating Livestock Production into a Vegetable Cropping System: Pros and cons, dos and don'ts. By Rick Kersbergen. No date. University of Maine Cooperative Extension.
www.newenglandvfc.org/pdf_proceedings/integrating_Livestock.pdf

The benefits and challenges of using livestock or manure from livestock operations on a vegetable farm are spelled out here concisely. There are also links to information regarding food safety and the use of manures on vegetable operations, and the Good Agricultural Practices audit and certification process.

Perspectives in Grazing. By Janet Bradbury et al. 2003. North Dakota Private Grazing Lands Coalition.

This publication features 10 ranches in North Dakota and describes the practices used by the ranchers to improve the ecological condition of the land and the economic condition of the family. Benefits, advice from the ranchers, beautiful color photos, and graphics.

Sheep Grazing Effectively Controls Weeds in Seedling Alfalfa. By Carl E. Bell and Juan N. Guerrero. 1997. California Agriculture. Vol. 51 (2): 19–23. March-April.
<http://ucanr.org/repository/cao/landingpage.cfm?article=ca.v051n02p19&fulltext=yes>

A three-year experiment compared sheep grazing to herbicides for weed control in seedling alfalfa in the Imperial Valley. Yields for the first season were highest with the grazed treatment and the untreated control because of the contribution of weeds to the hay. There was no difference in the alfalfa forage yield and density among any of the treatments. Lambs preferred weeds to the alfalfa, and the nutritional value of the weeds was usually comparable to that of the alfalfa.

PowerPoint Presentation

Integrated Crop-livestock System: Effect on Soil Compaction, Microbial Biomass, and Grain Yield. By Matthew W. Maughan, German A. Bollero, and Benjamin F. Tracy. No date. PowerPoint presentation. http://my.extension.uiuc.edu/documents/1846092304090409/DSD2007_Tracy.pdf

In Illinois, a traditional corn-soybean farm was converted into an integrated crop-livestock research farm. This presentation (22 slides) shows graphs of the results. Soil was compacted on the fields grazed by cattle, but corn yields were better when compared to continuous corn. Technical presentation.

Webinars

Integrating Livestock into a Cropping System for Sustainability and Soil Health. 2013. USDA NRCS East and West National Technology Support Centers.

Jay Fuhrer and Mike and Becky Small present a practical discussion of how the Smalls use a combination of cover crops and improved grazing management to meet their goals on their North Dakota Angus ranch. One hour long. Archived at www.forestrywebinars.net/webinars/integrating-livestock-into-a-cropping-system.

Integrating Livestock into Dryland Organic Crop Rotations. 2013. eOrganic.

Jonathon Wachter, Lynne Carpenter-Boggs, and Kate Painter present an overview of practices and a discussion of research to show positive and negative aspects of integrating livestock into rotations. 72 minutes.

Archived at www.youtube.com/watch?v=FO7BAOCpoKE.

Cover Crops for Drought Sites. 2012. University of Missouri Extension.

Charles Ellis and Rich Hoormann explain some results from several years of experiments on farms in Missouri, including least risk and expense cover crops, practical information to improve success, and cover crops that offer opportunities for grazing or hay in the fall as well as for grazing in winter or spring. 1 hour, 43 minutes. Archived at www.sare.org/Learning-Center/Multimedia/North-Central-SARE-Multimedia/SARE-Cover-Crops-Webinars.

Re-Integrating Livestock Manure and Cover Crops to Build Soil Health. 2014. American Society of Agronomy.

Tim Harrigan, Michigan State University, and Kent Solburg, producer of grassfed livestock, present research, practical experience, and tips during this webinar, part of a four-part series. One hour long. Available at: www.certifiedcropadviser.org/videos/play/certified/education/cover-crops-combining-livestock.flv

Conference Proceedings

National Conference on Cover Crops and Soil Health: Harvesting the Potential. 2014.

This SARE-sponsored conference included a session titled “Grazing Cover Crops and Benefits for Livestock Operations.” Access information from this conference, including video of sessions and 10 short videos of innovative farmers who outline their experiences with cover crops, at www.sare.org/Events/National-Conference-on-Cover-Crops-and-Soil-Health.

Sod Based Cropping Systems Conference, North Florida 2003. North Florida Research and Education Center. University of Florida.

Topics include use of bahiagrass, cattle, peanuts, cotton, corn, tomatoes, soil quality, economics, and more. See articles and presentations at http://nfrec.ifas.ufl.edu/programs/sod_rotation_conf.shtml.

Topic Room

SARE has a large collection of conference proceedings, an extensive and very readable book, 10 short videos of farmers outlining their cover crop practices, research reports, and many links to further information. See this wealth of information at www.sare.org/Learning-Center/Topic-Rooms/Cover-Crops.

Notes

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Solving Problems, Increasing Income
By Linda Coffey, NCAT Agriculture Specialist and Tracy
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