

Chapter 7 Increasing Physical Infrastructure

Is your soil quality increasing? Is your on-farm storage capacity increasing? Is your irrigation capacity increasing? Are you gradually accumulating more processing equipment?

Introduction

In an ecologically resilient system, physical infrastructure should both be increasing and responsive to meet demands over time as operations expand or change. Though let us be clear that an ecologically resilient system doesn't mature overnight, it ebbs and flows depending on the *stage* of growth. You may be just starting out, well into your professional agricultural career, or somewhere in between. Each stage must take a stage appropriate approach to physical infrastructure, whether that's creating a well-developed tool and equipment inventory, or the freedom to choose what that inventory will look like.

Always remember: all your physical infrastructure is filtered through and effected by you. A particular piece of physical infrastructure for one person is a burden for another. A processing facility, irrigation reservoir, ax, computer or draft horse can be a valuable tool if you know how to use and maintain it, but just costly and useless if you do not. Increasing resilience requires first understanding, maintaining and improving your most important asset: yourself.

Psychological researchers, independent of ecological resilience research, have generated many useful insights on how to improve your personal resilience. They have studied it under a variety of terms including psychological resilience, emotional resilience, resourcefulness, grit, and mental toughness.

The foundation of all personal resilience is adaptability. We are all susceptible to the opposite: locking into particular states. For instance, we can become locked into depression, a quite stable condition, impervious to all attempts to change it. On a more subtle level, the mind has a tendency to lock into one of several alternative interpretations of reality. Optical illusions are well-known examples. In the adjacent image, seeing a young woman or older lady simultaneously is virtually impossible. Instead, we snap to one of several interpretations. Unfortunately this happens not just in interpretation of pictures, but in more much more complex theories and world views. Scientists are often faced with this problem in their work. They have a tendency to unconsciously select and magnify phenomena that fall into harmony with the theory while unconsciously neglecting and ignoring contradictory phenomena. The same mechanism may play a role in ideology of all kinds, from political to religious beliefs.



Locking into a particular mode, from which it may be difficult to break free, serves a valuable purpose when faced with a predator or enemy where your options are limited to fight or flight. Whichever you choose, you should go for it completely. Don't fight half-heartedly or flee slowly. Hormonal (adrenocortical) stress response leads to a positive feedback mechanism which escalates fight or flight

behavior and offers a better chance of survival than hesitating between different modes of action.²¹⁹ Resilience outside fight or flight situations is enhanced by the ability to resist being locked into any standard mode of reaction.

Emmy Werner was one of the first psychologists to use the term resilience. She studied a cohort of children from Kauai, Hawaii. Kauai was quite poor and many of the children in the study grew up with alcoholic or mentally ill parents. Many of the parents were also out of work. Werner noted that of the children who grew up in these very bad situations, two-thirds exhibited destructive behaviors in their later teen years, such as chronic unemployment, substance abuse, and teenage pregnancies. However one-third of these youngsters did not exhibit destructive behaviors. Werner called the latter group 'resilient'. In contrast to their peers, these resilient children were bright, outgoing, had positive self-concepts; had close bonds with an emotionally stable parent; and received support from their peers.²²⁰

Personal resilience has been intensively studied in children. Numerous studies have shown that some practices that parents utilized help promote resilience within families. These include frequent displays of warmth, affection, emotional support; reasonable expectations for children combined with straightforward, not overly harsh discipline; family routines and celebrations; and the maintenance of common values regarding money and leisure.²²¹ The primary factor conditioning personal resilience is having positive relationships inside or outside one's family. These positive relationships include traits such as mutual, reciprocal support and caring.

Positive emotions and resilience are highly related. Maintaining positive emotions while facing adversity promotes flexibility in thinking and problem solving. Positive emotions serve an important function in their ability to help an individual recover from stressful experiences and encounters. It also facilitates adaptive coping, builds enduring social resources, and increases personal well-being.²²²

Grit is the aspect of personal resilience which refers to the perseverance and passion for long term goals. People with high levels of grit work persistently towards challenges and maintain effort and interest over years despite negative feedback, adversity, plateaus in progress, or failure. High grit people view accomplishments as a marathon rather than an immediate goal.²²³

10 Ways to Build Resilience A summary of the research on achieving personal resilience is provided by the American Psychological Association as "10 Ways to Build Resilience":

1. **Make connections.** Good relationships with close family members, friends or others are important. Accepting help and support from those who care about you and will listen to you strengthens resilience. Some people find that being active in civic groups, faith-based organizations, or other local groups provides social support and can help with reclaiming hope. Assisting others in their time of need also can benefit the helper.

²¹⁹ Scheffer, M., F. Westley and W. Brock. 2003. Slow response of societies to new problems, causes and costs. *Ecosystems* 6:493–502.

²²⁰ Eerner, E., & Smith, R. S., 1992. *Overcoming the odds: high risk children from birth to adulthood*. Ithaca, NY: Cornell University Press.

²²¹ Cauce, Ana Mari; Stewart, Angela; Rodriguez, Melanie D.; Cochran, Bryan; Ginzler, Joshua, 2003. *Overcoming the Odds? Adolescent Development in the Context of Urban Poverty*, pp. 343–391 in Suniya S. Luthar (ed.), *Resilience and Vulnerability: Adaptation in the Context of Childhood Adversities*. Cambridge: Cambridge University Press, ISBN 0521001617.

²²² Tugade, M.M, Fredrickson, B.L. Resilient individuals use positive emotions to bounce back from negative emotional experiences. *Journal of Personality and Social Psychology*. 2004; 86:320–333.

²²³ Duckworth, A.L.; Peterson, C.; Matthews, M.D.; Kelly, D.R., 2007. Grit: perseverance and passion for long-term goals. *J Pers Soc Psychol* 92: 1107–1101. doi:10.1037/0022-3514.92.6.1087.

2. **Avoid seeing crises as insurmountable problems.** You can't change the fact that highly stressful events happen, but you can change how you interpret and respond to these events. Try looking beyond the present to how future circumstances may be a little better. Note any subtle ways in which you might already feel somewhat better as you deal with difficult situations.
3. **Accept that change is a part of living.** Certain goals may no longer be attainable as a result of adverse situations. Accepting circumstances that cannot be changed can help you focus on circumstances that you can alter.
4. **Move toward your goals.** Develop some realistic goals. Do something regularly — even if it seems like a small accomplishment — that enables you to move toward your goals. Instead of focusing on tasks that seem unachievable, ask yourself, "What's one thing I know I can accomplish today that helps me move in the direction I want to go?"
5. **Take decisive actions,** rather than detaching completely from problems and stresses and wishing they would just go away. Act on adverse situations as much as you can.
6. **Look for opportunities for self-discovery.** People often learn something about themselves and may find that they have grown in some respect as a result of their struggle with loss. Many people who have experienced tragedies and hardship have reported better relationships, greater sense of strength even while feeling vulnerable, increased sense of self-worth, a more developed spirituality and heightened appreciation for life.
7. **Nurture a positive view of yourself.** Developing confidence in your ability to solve problems and trusting your instincts helps build resilience.
8. **Keep things in perspective.** Even when facing very painful events, try to consider the stressful situation in a broader context and keep a long-term perspective. Avoid blowing the event out of proportion.
9. **Maintain a hopeful outlook.** An optimistic outlook enables you to expect that good things will happen in your life. Try visualizing what you want, rather than worrying about what you fear.
10. **Take care of yourself.** Pay attention to your own needs and feelings. Engage in activities that you enjoy and find relaxing. Exercise regularly. Taking care of yourself helps to keep your mind and body primed to deal with situations that require resilience.²²⁴

By enhancing your personal resilience you become more empowered and capable of accumulating all manner of physical infrastructure. By fostering this kind of adaptability you are able to see opportunities you didn't see before, and opportunities which didn't exist earlier. By leveraging your imagination and willingness to remain flexible depending on what you discover to be your best options, you are more empowered to reach out to your community for precise and directed assistance. No enterprise, whether a farm, an empire or a thriving business has ever been created in isolation by one person. The stereotypical image of the independent farmer, doing all the work on their land is flat *wrong*. A resilient farmer probably organized the crop plan and management scheme but they still called upon their community to pull in the crops at harvest.

Developing a strategy for increasing physical infrastructure. To help you strategize your approach and determine some of your first steps in building your physical infrastructure, it is helpful to know what stage of development your system is in. In Chapter 1 we covered the **adaptive cycle** that governs ecological systems and stimulates growth and renewal. The cycle urges us to be dynamic and strategize our systems so we can thrive from where we are, leveraging our current condition. There are four stages

²²⁴ <http://www.apa.org/helpcenter/road-resilience.aspx>

within this cycle and in order to determine how to build your physical infrastructure, we must consider which of those four stages you're currently in. To better build your physical infrastructure, consider to following question(s) and suggestions as you assess your own stage of development:

What stage of the adaptive cycle is my system in?

K Phase (Conservation) - Are you inheriting an old farm with lots of equipment, land and tools? Are you entering into a working agreement with others who have accumulated equipment, land and tools?

If you're in this phase, you may be burdened by your physical infrastructure and would benefit more from selling some and reorganizing with the infusion of cash. Or, you have the opportunity to organize your farm plan around your existing physical infrastructure.

The biggest rule of thumb for those in the K phase is not to be limited by existing physical infrastructure. If you inherit a dairy farm but only have experience and interest in vegetables, consider selling your equipment and investing in appropriate tools for that instead. Similarly, if you inherit 1000 acres but only plan to develop 500, the existing equipment may be larger than you need. There can be long learning curves to operating a new business, do you have the time and resources to make the required mistakes?

Ω Phase (Omega, or, Release) – Are you starting from the figurative “square one”? Do you consider yourself a kind of “army of one”? Are you pretty confident that the only physical infrastructure you have is, perhaps, this book?

If you're in the Omega phase, don't fret! The world is your oyster and you're free to choose your path to development. There are many paths to building physical infrastructure in the form of loans, grants, donations, cooperative purchasing and so on.

The biggest rule of thumb for this phase is to be imaginative. If you think there is only one way to accumulate physical infrastructure, you're simply wrong. You will benefit greatly from the chapter in this book on Modular Connectivity and Local Organizing as guides to building your network and subsequently your resources and opportunities.

α Phase (Reorganization) - Are you established in your community with lots of valuable, though diverse, connections? Have you developed a few ideas or plans for new enterprises but haven't chosen which to pursue yet? Do you have access to a variety of valuable, though largely unrelated, tools and opportunities?

If you find yourself in this phase, your biggest obstacle and opportunity is to narrow your options. To develop thriving systems we encourage you to build in complementary diversity, but at this stage it will benefit you most to choose what you're most passionate about and most prepared for.

It is easy to say “I can do it all! I have all these great connections and opportunities!”. This approach, though noble and theoretically possible, can lead to burn out and slow development of your ideal business model. When we narrow our options down to one, or just a few, we increase the amount of time and energy we can direct towards developing those plans.

The biggest rule of thumb for this phase is to choose passion and feasibility over idealism and grandiosity. As exciting as it may be to build an empire, it begins with a single structure, built with great intention.

r Phase (Growth) – Do you have your business plan developed? Is that plan being shared with financial advisors or members of your community? Have you received either financial or community support for your plan? Are you seeing the first stages of growth in your business?

If you are in this phase it is important to be specific about your investments, taking adequate time for research and inquiry about the best tools for your current capacity. This is a vital stage where your investments can be well suited, or a burden. Whether you're taking out loans, receiving grant money, channeling donations from your community or however you're making your investments it is up to you to make your choices scale appropriate at this stage.

The biggest rule of thumb for this phase is to research, research, and research! And remember, if you make an investment and you find that it is not suited to your scale, you can likely re-sell your equipment and reinvest.

The key here is that every stage of the adaptive cycle has obstacles and opportunities directly linked to them. Depending on what stage you're in will influence how relevant certain parts of this chapter are to you. Similarly, as you develop your business refer back to this chapter for guidance on how to develop and manage your physical infrastructure.

Now that you've placed yourself in the adaptive cycle, let's begin exploring what physical infrastructure are first by understand the difference between **Material** and **Immaterial Physical infrastructure**

Material Physical infrastructure maintains a certain degree of monetary and trade value given their practical uses. This physical infrastructure can be traded, sold and bought depending on the needs of the land manager. These physical infrastructure also need upkeep and maintenance, backups and technical know-how to be of the greatest value.

It is through careful selection of and the accumulation of knowledge and tools to repair these items that we garner the greatest yield from them over time. Without a doubt, material physical infrastructure are the things that stand to increase your production with ever greater efficiency.

Immaterial infrastructure: These are often most apparent in your community in the form of agricultural organizations, specific knowledge bases like tax law and business consulting and training opportunities to heighten your skills. Though often intangible, this infrastructure is crucial in the maintenance, growth and overall success of your farm. By working with experts within your community, gaining more knowledge and skillsets and networking with organizations you can launch your business with greater success and greater speed than could ever be accomplished on your own. These are discussed in more detail in our chapter on modular connectivity.

Material Physical infrastructure: Emphasizing quality, ensuring longevity, weighing benefits and limitations

If you already have land, or know where you'll be developing your business, consider what you already have and how to optimize those physical infrastructure. If you're just starting and planning your venture, think about how you can optimize your investments and build systems specifically to maintain them. Maintenance is crucial to the resilience of your system. If your equipment is always breaking down due

to carelessness and you're regularly spending money on replacement parts or costly visits to your mechanic you're limiting your capacity to respond to other issues that will inevitably arise.

In your operation dealing with maintenance of physical infrastructure may take the form of a dedicated savings account and maintenance schedule, both of which require your attention and consistent contribution. Consider how much you can invest per month, or per sale towards maintenance of your equipment and find quality companies to do the work that you can't do yourself. Fact: Some things ARE better left to professionals.

Further in the chapter we will take a closer look at maintenance strategies for different types of equipment and help you determine what work you can and can't do on your own.

We have separated material physical infrastructure into categories to help you reference the material as well as to help you organize your own physical infrastructure. Whether you have many or none of these things, consider what items would benefit you in attaining the goals of your business.

Land Physical infrastructure:

Encompasses the ecological system that you're interacting with including microorganisms, fungi, earthworms, perennial plants, animals and all living organisms.

Water Physical infrastructure: We will consider water catchment and purification, improving water retention in your soil, improving groundwater supply and harnessing your local water sources such as lakes, streams, and ponds.

Structural Physical infrastructure: Including barns, alternate outbuildings, and land topography.

An example of how maintenance of material physical infrastructure contributes to the success, or failure of water security in rural Africa. Resilient food systems depend on the key physical infrastructure of resilient water supply systems. In poor rural areas of Africa donor agencies and NGOs have spent hundreds of millions of dollars digging wells that become useless because they are not maintained or fixed when they break down. As a result, 150,000 water supply points are not functioning across rural Africa. Only one third of water points built by NGOs in Senegal's Kaolack region are working and 58% of water points in northern Ghana are in disrepair (for details, see <http://pubs.iied.org/pdfs/17055IIED.pdf>).

The charity members feel good about leaving a fine physical infrastructure of a pump and a deep well for a rural community who had no water. However, unless they also invested in developing local capacity to maintain the pump they have not increased the resilience of the community.

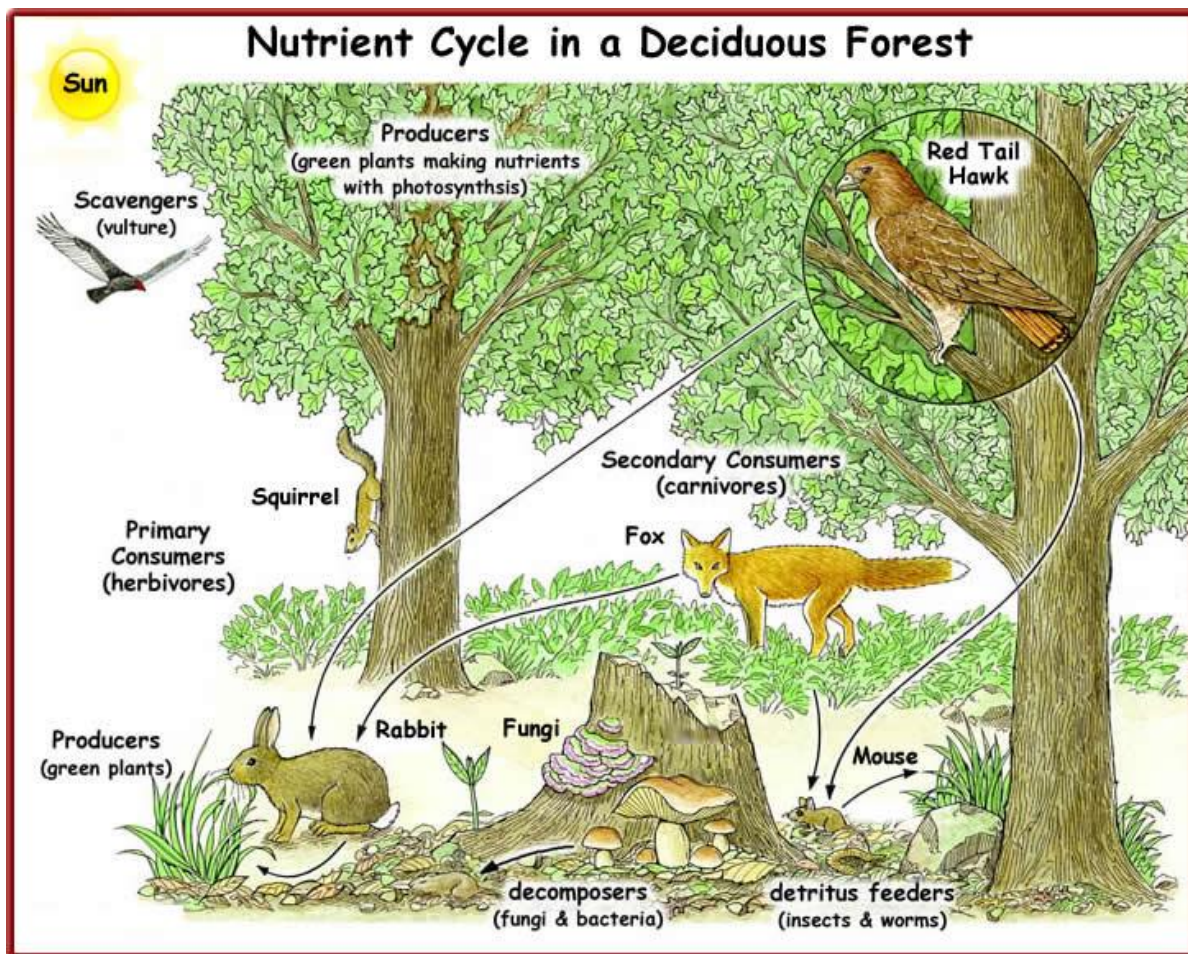
Where NGOs train local people in well and pump maintenance and the local community pays modest water fees which go to the well maintenance person, water supply systems are much more likely to be maintained.

In Lubango, Angola, a small town water utility maintains handpumps in surrounding villages for a fee. The company has maintained handpumps in the rural and peri-urban areas surrounding the town since 1990. Each family pays US\$0.40 per month to the pump caretaker, half of which was for the caretaker's salary and the rest to the company. The estimated annual revenue per handpump was \$240 versus annual costs of \$150 for salary, spare parts, unforeseen repairs, and future investment (for details see <http://www.ircwash.org/sites/default/files/Beers-2001-Leasing.pdf>). A number of other system designs have also worked. Their commonality is rewarding local maintenance with income from water usage.

Machine and Tool Physical infrastructure: Including thoughts on tractor sizing and scale, maintaining integrity of your tools, and good rules for maintenance.

Land

How can you improve your land's abilities and vitality? The fields and furrows that make up your land are filled to the brim with communities of organisms, large and small, that have been building soils and developing the plant and animal diversity all around us. Due to genetic adaptation generation after generation, through changing ecosystems and climates, species have developed beneficial relationships and unique qualities that are key to growing your soil infrastructure. These organisms ought to be your first choice as co-workers in developing vital and resilient soils!



Whether you intend to farm the land yourself or lease it out to others, consider the benefits of a vital and robust ecological system. Heightened water retention of soils leads to drought resistance. Greater plant and animal diversity can help to lower overall management demands as the flora and fauna naturally manage their own populations and pests. Soil erosion is better managed as plant roots and

mycorrhizal root systems with incredible tensile strength per square inch literally hold soil together. Avoid degradation of resource by, for example, decreasing pollutants from accidental or intentional pesticide use by filtering irrigation water before it reaches the water table.

By managing your land physical infrastructure you stand to increase your yields, lower your costs and increase overall ecosystem health. This overall health is chiefly obtained by increasing soil organic matter which even contributes to the sequestering of carbon from the atmosphere and the health of the planet!

If you're not sure about your soils, use the following test to evaluate soils of land you have or may want to acquire. This is a seven dimension soil test you can do to rank the quality of any soil. The only tool you need for this test is a shovel. Just turn over a shovel full of soil about 8 inches deep. Observe the soil you turn over and adjacent ground for these seven indicators.

| | Poor soil quality | Good soil quality |
|------------------|---|---|
| Soil workability | Waxiness, water puddling, slow drying after rain, cloddy, compacted | Workable under wide range of moisture levels, flaky and crumbly |
| Compaction | Hardpan at less than 8 in. | No or deep hardpan |
| Cracking | Wide cracks (2-3 in.) | No cracks |
| Topsoil depth | 2-3 inches | 12 inches and up |
| Texture | High clay or high sand | Clay loam, silt loam |
| Color | Gray or light colored | Brownish black |
| Roots | No roots in top 6 inches | Many roots extended below tillage layer, many feeder roots |

To better understand the state of your soils, send in your samples for soil test that include trace minerals and ideally an analysis of microbial life present in the soil. It is imperative to be able to build your soils for nutrient density and therefor nutrient delivery to your plants, and the items produced.

When choosing a laboratory you want to make sure that it covers all the items you intend to measure and whether or not they are prepared to give you any recommendations for soil amendment.

Here are some sample questions that will help guide you in asking the right questions to yield the answers you're looking for:

1. What analysis does your laboratory offer?
2. What does it cost?
3. How long will it take to get my results?
 - a. This can be important depending on when you're planning to plant your crops as applied fertilizer will need time to integrate into the soil.
4. Do you participate in the North American Laboratory Proficiency Program? If so, how has your performance been?
 - a. Though you may have resistance to asking the question, it is worth your time to do it. The program sets standards for testing and quality assurance aiding in consistency and

quality products. Depending on where the recommendation comes from for a laboratory that doesn't participate, don't let this be a deal breaker.

Soil testing can give useful data, but don't take it for gospel and don't blindly follow the advice of any laboratory. The best test of soil quality are the response of plants. As you get to know how plants grow on a particular plot, you will be able to deduce what the soil needs.

If you are working with a limited budget, do what you can and make your amendments balanced. Instead of forgoing or partially spreading the most expensive, take your recommendations and reduce them equally. If you put too much of one and not enough of another you can burn your plants and ruin your crop yields.

To distribute your recommended fertilizers, first evenly distribute them into compost that you can spread over your fields. This helps to hold the nutrients and minerals in the soil as the humus that comprises compost, made of microorganisms and mycelia, attract and bond to the positively and negatively charged fertilizers.

For some micro nutrients, such as copper or boron, consider diluting those items in water and spraying them evenly over your field.

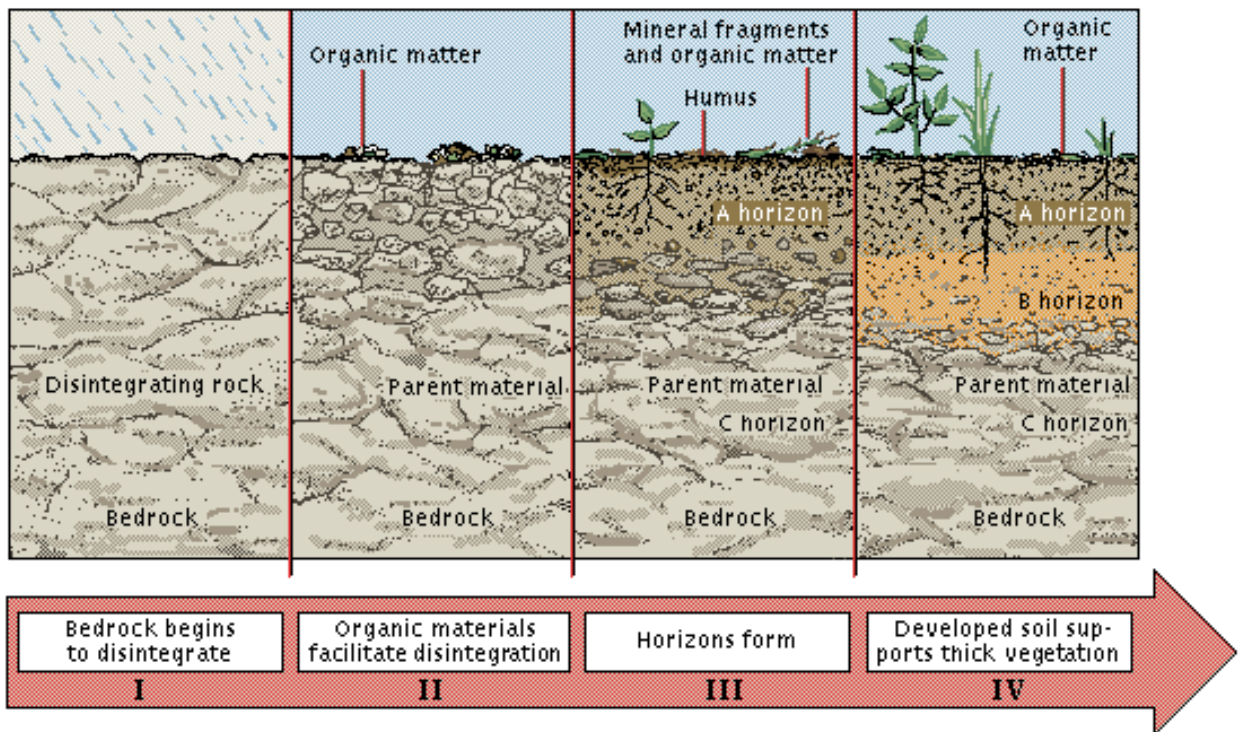
By remineralizing your soil, crops will have greater pest resistance, longer shelf life due to lower moisture retention and for edible crops they will attain a more complex flavor that reflects the heightened nutrients and trace minerals in your soil. This is better for profits, as well as for the health of those who consume your products. Over the past 60 years our fruits and vegetables have delivered less and less nutrient to consumers resulting in higher health care costs and the necessity to eat more fruits and vegetables to receive the same health benefits!

Soil health, though vitally important to your crops and the health of our world and families, is but one aspect of your land assets. Does your land contain forests? Wild animals? Waterways? All these things begin to increase your land assets and provide you with resources to pull from that can be maintained and renewed by working with and managing those ecosystems.

Carbon sequestration, soil organic matter and carbon markets.

The quality of your soil which makes it most resilient—the levels of carbon (or organic matter) stored or sequestered in the soil—only occurs when carbon dioxide is taken out of the air. No soils start out with much organic matter. This is because soil parent materials come from rock. Little organic matter survives the temperatures, pressures, and other disturbances which turn rock into soil parent material. Once a parent material comes to rest and plants begin to grow, by photosynthesis of carbon dioxide, organic matter starts to accumulate.

The two major natural variables which affect how much organic matter accumulates in a soil are temperature and moisture. Temperature affects organic matter accumulation in two ways. First, plants



tend to grow faster and produce more total mass as temperatures increase. Everybody's mental image of a tropical rain forest involves lush, thick vegetation. Secondly, however, and usually overcoming the first point is that, as temperatures increase, microbial activity, including the activity of decomposing microorganisms, also increases. Given your mental picture of a tropical rain forest, you might be surprised to find relatively little organic matter persisting in the soils of the forest floor. Microbial activity is just too intense to allow organic matter to accumulate.

Moisture is more straightforward in its effect on soil organic matter. As rainfall increases, total plant production of organic matter increases, and so soil organic matter increases.. In the continental United States, east of the Rocky Mountains, the general trend is that soil organic matter content increases from west to east (low rainfall to high rainfall) and from south to north (high temperatures to low temperatures).

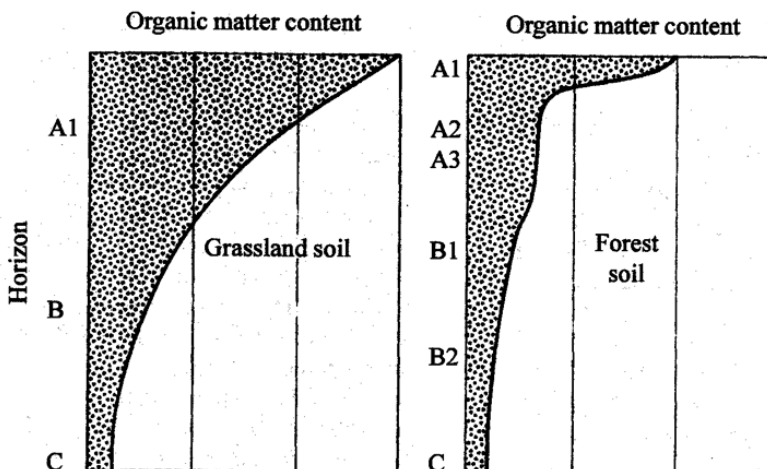
There are many factors which modify these trends. When water accumulates to a degree that the soil is flooded for long periods of the year, as in swamps or bogs, the excess water produces a shortage of oxygen which the decomposing bacteria need for their work. As a consequence, organic matter builds up regardless of the temperature, until the swamp is drained by natural or human causes. These locations are the source of peat available in garden stores.

Humans have been changing soil organic matter long before modern agriculture began. American Indians and other aboriginals set fires to decrease forests and increase grasslands for the animals they hunted. These huge herds eating, manuring, trampling manure into the soil and then rotating to new pastures led to prairie soils as high as 6% organic matter. Then came the plow. Tillage opens up more of

the soil to oxygen and increases microorganism breakdown of organic matter, at least temporarily. Within just a few years, organic matter content of a tilled soil can decrease to half of what it was in its previous prairie state. Managing a cropped soil with less disturbance, by reducing tillage or using perennial crops, will allow the organic matter content to rise. Returning the land to pasture and recreating large herds of rotationally grazing animals can bring it back to or above the level of a native grassland.

It may surprise you to learn that forest nearly always has less soil organic material than grasslands in a similar climactic zone. As the following graphic shows, grassland soil profiles contain about twice as much organic matter more uniformly distributed through the profile than forest soils under similar environmental conditions. Of course the forest also has carbon fixed as part of its roots and trunks.

Worldwide about 1500 Gigatons (Gt) of carbon are stored in the soil, while Earth's plants store about 560 Gt, with wood in trees being the largest faction. The atmosphere holds about 750 Gt of carbon, mostly as carbon dioxide.



Increasing organic matter in soils by developing grasslands and then developing forests on the grasslands gradually through silvopasture (grazing livestock under trees, see Working with Nature chapter) sequesters the most carbon of any agricultural system.

Increasing organic matter in your soil makes your soil asset more valuable. Some are trying to help farmers get paid for sequestering that carbon. Sequestering carbon in the soil has the potential to offset all the carbon being released by industries as carbon dioxide. Carbon markets have developed so that those sequestering carbon can be paid by those producing it. The most well-known are the cap and trade systems. In these, a cap is placed on emissions and companies given permits to produce only a set amount which decreases yearly. If they don't meet the requirement, they must buy permits (called carbon financial instruments or CFIs in the US).²²⁵ If approved, farmers can be issued CFIs for sequestering carbon and industries may buy them. The program depends on a huge non-locally controlled infrastructure to operate, so making the case for its resilience is difficult. However, if you're interested in resilience, we're sure you've heard about carbon markets and now you know what they are.

This section is meant to impress upon you the value of your land, and particularly your soil assets while providing methods for measuring the condition of your soil and land assets. We encourage you to

²²⁵ https://www.theice.com/publicdocs/ccx/CCX_Offset_Registry_Program_Manual.pdf

explore the following chapter on Working with Nature to take a closer look at how to build your soils and your ecosystem with a summary of practices and additional resources.

Some Observations and Considerations on Acreage and Ownership

Many people have defined opinions on what constitutes valuable acreage and what it means to own land. We encourage you to explore those two ideals and ask yourself: What do I consider valuable and what does ownership mean to me?

Depending on your situation, different arrangements will suit you more than others. Perhaps you're most interested in purchasing large tracts of land and either farming the whole acreage or leasing out a percentage. Perhaps you're more transient and would prefer to cooperatively farm a piece of land you don't own. Perhaps you are interested in a long term land transfer from aging farmers.

Each of these options has its critics and supporters, decide on your own what's best for *you*. Weigh the expenses, limitations, opportunities and conditions of each before you decide on anything.

On Land Transfer: Good agricultural land is a basic asset for healthy food production. A resilient agriculture and food system insures that farmland is saved and maintained. Collapsing systems let farmland become degraded or convert it to other uses. Many extremely rural states are experiencing losses of farmland as shown in the table. Some of them have programs to counter this trend. The first farmland preservation program was enacted in Suffolk County, Long Island, NY in 1974. In the 40 years since, 18 states²²⁶ and scores of counties and cities have begun programs. The links below²²⁷ will help you how you can help in farmland preservation. We hope you contribute to resilience on a larger scale by becoming active in such efforts in your area.

| The top 10 states losing farmland between 2007 and 2012: |
|--|
| 1. Kentucky, 6.7 percent |
| 2. Alaska 5.4 percent |
| 3. Georgia 5.2 percent |
| 4. Mississippi 4.6 percent |
| 5. Wisconsin 4.1 percent |
| 6. Minnesota 3.2 percent |
| 7. Montana 2.65 percent |
| 8. Missouri 2.61 percent |
| 9. Louisiana 2.57 percent |
| 10. New Jersey 2.5 percent |
| Source: 2012 Census of Agriculture |

Simply preserving farmland is not sufficient to make this asset available to farmers. More resilient systems will ensure that farmland is transferred to new farmers who will maintain and enhance the land. The age of farmers in the US (averaging close to 60 years old), the lack of interest of many of their children in farming, and the extremely high value of farmland has made land transfer to new farmers crucial to resilient systems.

If you are searching for land, have land you'd like to make available or are interested in assisting in land transfer in other ways, become familiar with the many innovative strategies for land transfer.²²⁸

²²⁶ DE, MD, PA, VT, NY, NJ, CA, MA, CT, RI, VA, WV, OH, MI, NC, ME, NM & WI.

²²⁷ <http://ageconsearch.umn.edu/bitstream/19102/1/co98co01.pdf>;
<http://www.farmlandpreservationreport.com/>; <http://www.farmland.org/actioncenter/no-farms-no-food/7-ways-to-save-farmland.asp>; http://www.farmlandinfo.org/sites/default/files/fp_toolbox_02-2008_1.pdf

²²⁸ <http://farmlink.cascadeharvest.org/sites/default/files/u15/Farmland%20Changing%20Hands.pdf> and <http://www.youngfarmers.org/reports/conservation2.0.pdf>

One commonality among successful land transfers is a strong and positive relationship between the owner and the new farmer. Whether the transfer is between relatives or friends, good will, a shared mission, or common faith in a solid business plan, these are the foundations for successful land transfer. Below we highlight two of the innumerable examples of innovative land transfer to illustrate the breadth of systems which can contribute to this aspect of resilience:

One couple in Washington State didn't want their farm to become yet another residential development but didn't have children who wanted to farm. They gave a former intern the opportunity to farm their land. They retained rights to live on the land and carried the note on the property themselves. The former intern is making monthly payments which pay for the former owners' retirement.

Cuyahoga Valley National Park (CVNP) in Ohio leases public land to new farmers. The farmer is competitively awarded a long-term lease of a proposed site only after powerfully articulating his or her plan to manage and farm that site through the entire term of the lease. These farms are expected to be managed with only sustainable farming practices and the farmers are required to positively interact with CVNP visitors. To date there are 10 farms with two more to be leased in 2015. A farmers market helps facilitate their success. The farms range in size from 5-60 acres and include production of eggs, vegetables, intensive grazing and integrated crop-livestock operations. Farming practices are monitored for sustainability. Leases are granted for 60 years.

We've seen dozens of successful transfers of land to new farmers. They all begin with networking by new farmers and retiring farmers, feature the development of mutual respect, progress through good lawyers and end up with results which meet the goals of both sides.

The asset of land is not unattainable. Older people all across the country have land they would like to pass on to a younger farmer. They just need to meet the right young farmer.

Water Infrastructure

Every farmer knows what an asset water is to successful production. The common factor in all living organisms, water is perhaps our greatest asset and is often abused, overlooked, or used in excess. In agriculture there are many approaches to maintaining water quantity and quality through harvesting methods, capture, and soil composition. One farmer we spoke with in Tennessee²²⁹ doesn't irrigate his fields at all. His crops, surrounded by forest, and primarily on Tennessee mountain tops have such diversity of microorganisms and density of organic matter that he simply doesn't need to irrigate. True, during the driest part of the summer his yields may be lower than his irrigating neighbors but his infrastructure costs and demands on the water table are remarkably lower. Similarly, a farmer in

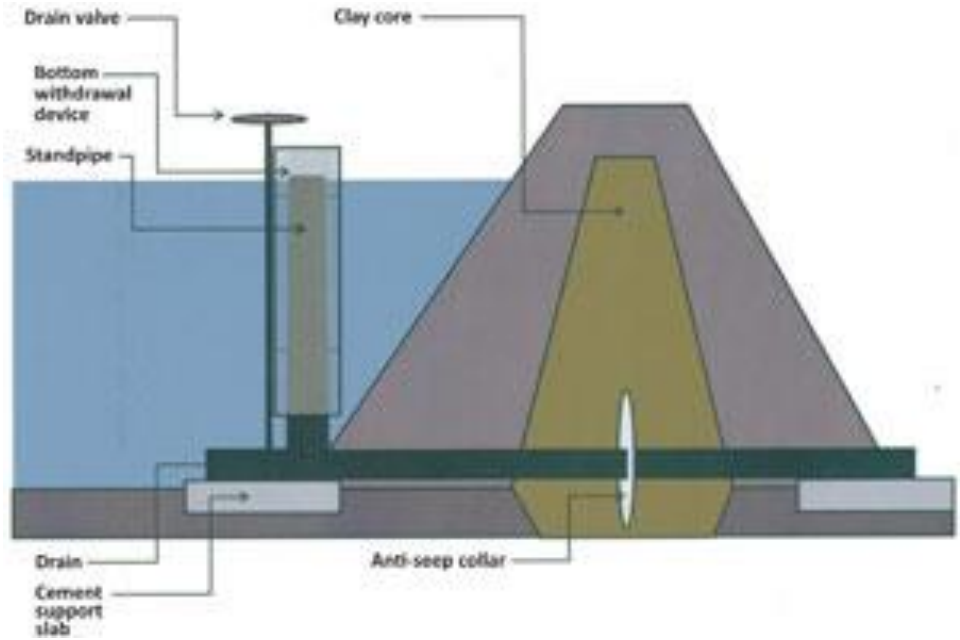
²²⁹ Jeff Poppen, AKA, The Barefoot Farmer : <http://barefootfarmer.org/>

Texas²³⁰ relies solely on water catchment to operate a dry gardening CSA, devising methods for both capturing, holding and distributing efficiently.

Lets first look at a few ways you can increase the **quantity** of that invaluable asset: *Water*.

Water Catchment Systems.

Coming in a variety of forms, water catchment can be as simple or complex as you're willing to make it. For some it may be most practical to dig a pond, serving both as a mini ecosystem and a large pool of water with its own nutrient cycles that feed your plants. For others the construction or installation of a water cistern for rainwater catchment may be most economical.



Pond Construction: If you're considering constructing a pond, look at your land and consider your existing soil structure. If your soil is mostly sandy, or loam, with will be challenging to simply dig a pond that will hold water effectively and you may be forced to line the pond with costly rubber liner. Though effective it is an additional cost to consider. There are vendors²³¹ that can help you determine pricing help you with pond pumps and other equipment you'll need to maintain moving water in the pond.

If, rather, your soil is more clay the odds are good that your pond will successfully hold water in a short time. Whether it's red or gray clay as excavators dig your pond they should compact the clay before they're done, helping to seal up any holes that may remain. For a few days after you will likely see bubbles form as air pockets below fill with water.

Overflow will need to be accounted for in the instance of heavy rains and storms. Some use overflow pumps depicted in Fig. 1, or constructing a gravel or concrete overflow depicted in Fig. 2.



²³⁰ Tim Miller of Millberg Farms, <http://www.texasyoungfarmers.org/tim-miller-teaches-dry-gardening-all-around-excellence/>

²³¹ Pond Accessories Vendor: <http://www.conservationtechnology.com/pond.html>

If you opt for an overflow pump over a more passive gravel or cement overflow a combination drain and overflow pipe, as well as an emergency spillway, are necessary for good management. It is very important that you place the drainpipe on the pond bottom so you can completely drain the pond.

Controlling the water level is important for weed control and fisheries management. A drain is necessary *Figure 10 Gravel Overflow*

to manage the pond efficiently. The overflow pipe is the outlet for normal water flow through the pond. The emergency spillway is an area lower than the top of the dam on one side of the dam to safely release excessive runoff from heavy rainfall.

Determine pond size by your needs and desires. Bigger is not always better. Small ponds (1 to 3 acres) provide enjoyable fishing if you follow good planning and management guidelines. Larger ponds and lakes are more suited to water supply for irrigation, and they are less susceptible to water level changes. For surface runoff ponds, use the area of land that flows into the pond to determine the pond's size. In general, 5 to 10 acres of drainage area is required for each surface acre of pond water.

For more information on pond building reach out to your local extension agent or contact local excavators. The capabilities of your land for holding water can be tricky to determine, this is a prime

To determine your storage capacity for rain water catchment use this simple equation:

$$\text{Collectable rainwater (gallons)} = 0.5 \times \text{rainfall (inches)} \times \text{area (square feet)}$$

time to get expert input.

Rainwater Catchment: Whether you use a cisterns, terracing or the increase of soil organic matter as a method for rainwater catchment, each has its strengths and weaknesses. Cistern use is mostly seen in urban areas with expansive rooftops and high grey water needs from city dwellers. Around the world aid organizations have been working to harvest rainwater for landscaping, grey water and emergency drinking water. On small to mid-scale agriculture rainwater can play a role for animals and plants alike, depending on how much roof space you have for catchment.

Different approaches have been taken to water cisterns, from pre-formed plastic containers to the construction of cement cisterns they can be simple or complex, large or small depending on your needs and desires. This tactic has been used in arid regions of the world for thousands of years and many of those cisterns are still in use today.

Brad Lancaster²³² suggests 8 principles for successful rainwater harvesting. He suggests that it takes the inclusion of *all* 8 principles to develop a successful and long lasting system that will generate the kind of results you're looking for.

1. Begin with long and thoughtful observation.

Use all your senses to see where the water flows and how. What is working, what is not? Build on what works.

²³² Brad Lancaster, author of the book "Harvesting Rainwater for Drylands and Beyond"
<http://www.harvestingrainwater.com/>

2. Start at the top (highpoint) of your watershed and work your way down.

Water travels downhill, so collect water at your high points for more immediate infiltration and easy gravity-fed distribution. Start at the top where there is less volume and velocity of water.

3. Start small and simple.

Work at the human scale so you can build and repair everything. Many small strategies are far more effective than one big one when you are trying to infiltrate water into the soil.

4. Slow, spread, and infiltrate the flow of water.

Rather than having water run erosively off the land's surface, encourage it to stick around, "walk" around, and infiltrate into the soil. Slow it, spread it, sink it.

5. Always plan an overflow route, and manage that overflow as a resource.

Always have an overflow route for the water in times of extra heavy rains, and where possible, use the overflow as a resource.

6. Maximize living and organic groundcover.

Create a living sponge so the harvested water is used to create more resources, while the soil's ability to infiltrate and hold water steadily improves.

7. Maximize beneficial relationships and efficiency by "stacking functions."

Get your water harvesting strategies to do more than hold water. Berms can double as high-and-dry raised paths. Plantings can be placed to cool buildings in summer. Vegetation can be selected to provide food.

8. Continually reassess your system: the "feedback loop."

Observe how your work affects the site, beginning again with the first principle. Make any needed changes, using the principles to guide you.

Though the use of rainwater catchment in cisterns for large scale agriculture hasn't received much research or development, it stands to reason that there is room for development of ideas. Whether it waters your livestock or your hyacinths, cistern use has its place in effective water use.

Others still may be more interested in terraforming their land to reflect many permaculture designs that integrate berms and swales that passively catch, and hold water over time. This approach is a great passive way to maintain moisture in design schemes that are low management and are of an organic shape, not confined to rows. This is a great option if you're land is on a consistent slope where you can restructure the land to hold rainwater before it washes away. Though potentially resource intensive, cultures have been employing this model for thousands of years similar to what we see in figure 3 below.



Figure 11 Swale style terracing in China

These systems, though appropriate for some, aren't applicable to most large scale farmers who rely on irrigation technology. Fortunately, there are methods of optimizing those systems as well through sensors, low flow and a mindful approach you can reduce your consumption dramatically. Let's investigate further:

Optimization through Irrigation. Depending on your operation, budget and personal preference certain systems will work better for you than others. As a rule though irrigation should be one of the last considerations you make in terms of developing a water conservation program for your land. Through cover cropping, integration of organic matter and a reduction in tilling all lead to higher rates of water retention. As you develop vitally rich soils the demands for irrigation will reduce. As a farmer from Colorado says, "We're not farming for the best yields this year, we're farming for the best yields 30 years from now". This long term approach requires some sacrifice in use of space and yield volume in the beginning as cover crops need a full season to mature before tilling into the ground. The long term return on using these practices is unprecedented though, mimicking nature's own systems of growth and decay, building soil organic matter season after season, year after year.

Take time to refer to the Working with Nature chapter for some suggestions and resources on cover cropping and further suggestions on generating more organic matter in your soil.

Once you've developed the initial stages of your water conservation plan, it's time to consider appropriate irrigation options for your fields.

Flood Irrigation: If you are using this system, or planning to use it, we would first advise you to use something else. Though cheap and easy to operate, flood irrigation can mean losing up to *half* of the water pumped into fields. Either by evaporation or run off, the waste incurred by this method is significantly greater than other approaches.

If you do decide to use floor irrigation, whether bound by expense or upper management, there are ways to mitigate the losses. 1) Ensure that your fields are level. Even a small hill or mound can mean significant losses and inefficiencies. 2) Surge Flooding is a method of releasing less water, more frequently. This will reduce runoff and more saturation in your fields. 3) Capturing and re-using runoff by channeling the excess run off into ponds or holding tanks to be pumped back into your irrigation system.

One more way to limit soil evaporation loss is to wet less of the soil surface. For fields with slopes less than 1 percent, irrigating every other furrow is a viable option. This effectively cuts surface evaporation losses by nearly 50 percent without sacrificing crop production. Irrigating every other furrow also will reduce the amount of water lost to deep percolation and surface runoff.



Figure 12 Drip Tape

Drip Irrigation: Though it can be labor intensive to lay on, or bury into, the ground it is a highly effective in reducing evaporation. As water is released directly to the ground at a low flow water is absorbed almost immediately. Also whether the line is laid below or above the ground water is delivered in closer proximity to the roots themselves offering a more immediate delivery.

Spray Irrigation: Either in the form of a center pivot system or a ground level sprinkler system, this method though less efficient than drip irrigation is still more efficient than flood irrigation. Additionally, this is often a onetime investment of equipment and often a well. There are costs for maintenance over time, but it will require less overall input than drip irrigation demands.



Figure 13 Spray Irrigation

Proper management of sprinkler irrigation systems can also greatly reduce losses. An irrigation system that is managed to keep the soil saturated at all times will experience some deep percolation losses. This is because the system does not apply water at 100 percent uniformity. Some areas will receive more water than others due to sprinkler pressure differences caused by soil elevation differences. Pressure regulators or flow control nozzles help insure that water delivered to the soil surface is as uniform as possible. Other portions of the field could be affected when wind distorts the water application pattern. Such distortion can be reduced by avoiding operation when winds exceed 10 mph.



Figure 14 Low Energy Spray

Low Energy Spray Irrigation: In traditional spray irrigation much water is lost to the wind or evaporation. Better spray Irrigation is a combination of drip irrigation and spray irrigation by gently spraying from hanging pipes. In addition to water savings, you will notice an energy savings as well since this system requires far less water pressure to push water through the nozzle. Moreover as pressure is reduced, droplet size increases, reducing the amount of evaporation and wind drift as each droplet weighs more and requires more energy to evaporate than a fine mist.

Increasing Overall Efficiency: This can be accomplished by either your management and careful eye, or a small investment in sensors around your property. Through the use of moisture sensors throughout your fields you can more effectively and efficiently irrigate your fields without over, or under watering your crops.

How to Measure Irrigation Efficiency: There are two main ways to evaluate water loss during irrigation: 1) take detailed field measurements; and 2) visually estimate losses. In some cases it may be necessary to combine these methods to develop an accurate estimate of where losses occur and how significant they are to the system's application efficiency. For example, to estimate water losses during irrigation, measure the flow rate of water entering the system with a flow meter. Visually estimate how much of the water is lost to runoff. This amount, however, will not account for other potential losses.

Natural Bodies of Water: Their Uses and Maintenance in Agriculture, If your property is bordered by or contains streams or rivers you have a great asset in developing both thriving and self-managed ecosystems. This can lend itself to greater yields due to increases in native pollinators, less rodent and small critter populations and even opportunities for mushroom cultivation along the shady, cool and moist banks.

Caring for this particular asset is a relatively simple task, mostly entailing the construction of buffer zones and creature habitats. As with almost every aspect of your system this can be as simple as a line of trees to absorb excess water and break down inorganic matter, to a thriving ecosystem of trees, wildflowers, mushroom filtration networks²³³ and more. In *Working with Nature* we look at Riparian Forest Buffers²³⁴ as a prime option for management of natural water ways.

It's important to remember that we are always effecting whatever is downstream. That could be your neighbor's well, a unique and vital cave system, certified organic farms that risk losing their certification if too many pesticides are found in their soil or in their water. If we don't work to preserve our waterways we run the risk of permanently poisoning our groundwater and therefore our drinking water. What will we do then if there is no clean, pure water?

One of the best ways to mitigate damages to your water table is to create natural filters in the form of mycelium networks, sand filters or biochar barriers that waste and overflow water has to pass through before entering waterways.

Natural Filters: An Overview. First, let us consider mushrooms, or fungi, as a filter. With upwards of 8 miles of mycelium in a square inch of soil, they make for incredible filters! Places in waterways or at drain sites, these mushrooms can process your waste similarly to a micron filter. You want to choose the right variety for the right purpose though and here are a few to get your gears turning about projects and applications.



Figure 15 Blewit Mushrooms

Blewit: This variety's mycelium is low in tensile strength and would be a poor choice for places where you'll get a high volume of drainage all at once. The Blewit is an excellent bacterial filter though, excreting antibacterial solution on contact with e-coli and a number of other pollutants.

This could be used as a stage in water filtration for rain water reserves or in areas where water will be running at a steady, relatively slow pace.

²³³ A selection of journals and publications on mycoremediation:

<http://mushroommountain.com/bioremediation/journals.asp>

²³⁴ Reference material for constructing your own Riparian Forest Buffer:

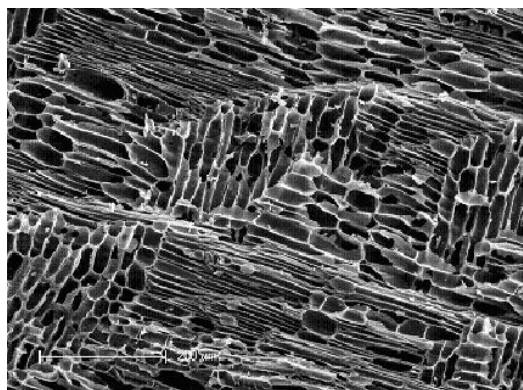
<http://nac.unl.edu/riparianforestbuffers.htm>

Pearl Oyster: This mushroom has gained a lot of interest over the past few decades for its incredible ability to break down petrochemicals. It has been used with great success in converting used oil back to organic matter than can be composted. The image in Fig. 8 is a pile of used engine oil and straw inoculated by Paul Stamets with White Oyster mushrooms. It was part of a study by the Washington State DOT²³⁵ between competing bioremediation techniques. In 4 weeks the material which began as a pile “blackened with oil and reeked of aromatic hydrocarbons” matured into the image in Fig. 8. A few weeks later, grasses were growing on the pile and eventually it was a thriving ecosystem compared to the alternate models in the study.



Figure 16 White Oyster - Mycoremediation Project

On your farm the White Oyster can be used at drainage sites, particularly where petrochemicals are used. By filling canvas sacks with inoculated medium and stacking them along your drainage route the chemicals in your water have to pass through the filter, allowing the oyster mushrooms to digest and convert many pesticides and chemicals back to organic matter that’s safe for the water table, creeks and streams.



Biochar: An incredible network of micro pores, biochar is an incredible filter. A bit of char has limited external surface area, but this is tiny compared to char’s vast inner surfaces. The walls of all the inner chambers are many times greater than outer surfaces. The added internal capacity of char is estimated between a few thousand, to maybe a million, times more than external surface. So, a little char goes a long ways!

Charcoal has abundant positively and negatively charged sites that give it tremendous capacity to pull molecules out of solution, and hold onto atoms on—and even in—the char. Charcoal’s high adsorption²³⁶ is what makes it an ideal media for water filtration. In water purification, ions in solution are considered “pollutants.” But in soil, the important ions are “nutrients.” Biochar is a sponge that also soaks up and holds ions of elements and biomolecules.

These are but a few examples of different substances you can use to filter your waste water without the use of high cost filtration systems or containment.

²³⁵ Paul Stamets on Mycoremediation trials with White Oyster
<http://www.yesmagazine.org/issues/our-planet-our-selves/mushroom-power>

²³⁶ “Adsorption” is a technical term electric attraction between atoms and molecules. Biochar’s “absorption” of water operates largely by capillary action from differential pressures. But “adsorption” occurs due to electric charges that cause atoms and molecules to be attracted, form clusters and align in groups.

Summary: Water is an invaluable and limited asset that we must care for with attention to detail and diligence. Let's say you re-mineralize your soil, generate loads of organic matter and cover crop your entire acreage but have a depleted or toxic water table, what then? It's up to each land holder, and community member to find solutions that fit their system. We can always make our systems more efficient and less hazardous while working with nature and on a relatively small budget. If you find the improvements you want to make to be more costly than you can manage, consider reaching out to your community or organizations such as the NRCS (National Resource Conservation Service) for financial assistance.

Remember, we're not just planning for crops this year, we're planning for crops 30 years from now.

Buildings

Consider either your existing property, or that ideal property that you're dreaming about. Are there old barns? Sheds? Existing fencing? If so, what condition are those structures in? How does their condition effect the overall resilience of those assets and therefor your system as a whole?

The biggest rule for your buildings is: Quality, quality and quality. It all starts there, simple as that. Perhaps you have an old barn on your property that 100 years ago was a fantastic asset serving multiple functions. Maybe it even appears to be structurally sound. Consider though, are you using that space? Is it *actually* structurally sound? Would you be better off selling the wood to one of many companies that reclaim aged barn wood for art and other purposes? Would be better off investing into a new space that serves the needs and functions of your growing business, like a clean room for mushroom cultivation, or a milking area for dairy cattle. Sometimes retrofitting and renovation is a viable option and sometimes it's not.

Barns and Sheds: There are many styles, and designs for these structures, all of which have their benefits and shortcomings. We will look at a few of the most common, and a few uncommon styles and approaches that people have taken from new construction, to upcycled materials, to earthen materials like straw bale and cob. We hope to give you some insight into what will be best for your operation and your budget.

Metal vs Wood Frame Construction

These are the most common materials used today in barn and shed construction. We will consider **Builder Accessibility, Cost, Durability/Efficiency** and **Restoration Capacity**

Steel Frame Construction- The Pro's and Con's:

Builder Accessibility: For the individual that wants to build and design their own structure, this is often not a suitable option. Usually designs require certain expertise with the equipment for construction. All building companies will work with you to design your end product, but be aware that the further you stray from standard construction will increase your price. So unless you're willing to purchase the installation materials, learn to design with metal and train others to help you construct your custom fabrication building, you're best to leaving it to the experts.

Cost: Be prepared for the higher cost of building with this material. Though building time is shorter and will require lower labor costs, the materials and design process will cost more than wood construction.

The frame and joists are relatively cheap but combined with the price of fasteners and equipment required for installation, the comparison can be startling to wood construction. On the other hand, with proper maintenance and if you're in a good climate that reduces rust, metal construction can last significantly longer than wooden buildings.

Durability/Efficiency: Metal's worst enemy is moisture which can cause rust. Many in the builder community will tell you that standard design will reduce the likelihood of this occurring, but Mother Nature can be crafty and resourceful. This is also the case with wood, but metal is harder to replace in many instances. Though, given some humidity control metal can last a significant length of time.

It has also been noted that the joints and inner folds of steel framing can be susceptible to mold as it can wick moisture and has a high capacity for heat transfer.

In terms of efficiency, metal framing transfers heat and cold significantly faster than wood and can pose problems for maintaining warmth over the winter. On the other hand, there are many excellent insulators that are used in steel construction that balance its capacity for leaking heat. The point here is that if you build a metal structure it is worth the investment to insulate, Without it, the building will draw heat and cool much faster than its uninsulated wooden counterpart.

Metal has also been exalted for its pest resistance. Since no carpenter ant or fungus is capable of digesting metal, it is excellent in areas that are notorious for pest or fungal corrosion issues.

Restoration Capacity: Low. Since these buildings require a particular expertise your ability to repair or add onto these buildings is minimal. Unless you acquire the tools specific for the job and a quality outlet for replacement materials it is unlikely that you will be able to repair these buildings with the same quality they were constructed with.

Overall: Higher cost initial cost, maintenance demands dependent on climate (the dryer the better), reliance on construction company, great pest resistance, insulation as a necessity and has a potential for a longer life given proper design and installation. It is suggested that unless you are comfortable fabricating metal or you are in an area that has an abundance of experts and materials, that wood construction may be a more resilient option for you.

Wood Construction- The Pro's and Con's

Builder Accessibility: Given the easily accessible nature of both new and used lumber the accessibility is naturally greater. Humanity has used this product for 1000's of years in construction with remarkable success. With wooden structures there is a heightened ability to replace certain parts of the building in case of weathering or failing supports. Unlike metal construction there is no special equipment needed for manipulating material apart from standard carpentry tools. So even if the building is constructed by a builder you are automatically more capable of replacing or refinishing sections of the structure long after the builder has finished their work.

Cost: Determined by you. For instance, if you purchase pressure treated versus untreated lumber your cost will naturally be higher, but over the long term you should consider it an investment. Bear in mind with pressure treated lumber (produced after 2003) that producers are no longer using the arsenic based treatment of the past. Though better for the builder and the environment, the new chemicals

break down metal fasteners and screws at a much faster rate. Experts suggest the use of coated nails and screws as a *minimum*.

Cost for construction may be marginally lower than that of steel buildings but assembly time will be greater. With that in mind cost for labor will be greater and the time it takes to erect your new building will be marginally greater.

It is also true that many resourceful builders have sourced their small, and large, buildings at little to no cost, save for time and labor. By sourcing waste products from construction or pallet disposal you stand to erect your building in record time with significant savings which you could direct other places!

Durability/Efficiency: As with steel construction this is largely effected by site conditions and how well you insulate bare wood from moisture and the elements. Assuming you lay a concrete foundation or at least elevate your posts (particularly untreated lumber) off of the ground this will greatly reduce damage from moisture or pests like termites or carpenter ants.

Exposed wood in construction must be periodically retreated by brushing on sealants, sanding or a variety of other methods. Retreatment of wood used in ground contact must be treated with an application of pastes and wrapping with preservative impregnate bandages.

Around the world there are wooden construction buildings that have been standing for 100's of years still in use. These buildings use specifically hardwoods (Chestnut, Oak or Juniper) that have natural decay resistance and high density. They also feature insulation as a vapor barrier, whether it is a chemical compound such as a polymer or in the case of ancient buildings the cumulative layers of lye or other natural coatings re-applied annually or semi-annually.

Restoration Capacity: High. This construction has been around so long that tools are ample, designs are aplenty, and there are always local builders who can help you replace, repair or add onto your wooden structures.

Overall: In terms of overall resiliency wooden structures are considered a more resilient structure based on a few elements. The ability to locally source lumber is much higher than sourcing steel beams, studs, or fasteners. There is an abundance of easily accessible information on wood construction and there are always local builders who are well versed in wooden fabrication. Even in lieu of new lumber, or even nails and screw, you can often source all your materials used.

If you are considering using reclaimed materials: Some will suggest that using reclaimed materials is better for one of a multitude of reasons spanning from economic benefits or simply a more "authentic" appeal. If, for whatever reasons, you are considering using reclaimed material consider this first:

Do I know where to source the items I need? Moreover, do I know what items I need?

Often, it seems interesting and perhaps fun to go to auctions or salvage yards to source your materials. This tactic can be both challenging and time consuming. If you need materials quickly, but still want them to be reclaimed, consider using a company who specializes in it. Some examples are Habitat for Humanity, ecobusinesslinks.com, or planetreuse.com to source you materials.

If you're specifically wanting an old barn, or perhaps you're looking to sell an existing archaic structure, check out <http://www.oldbarnwoodsite.com/> to browse existing listings, or list your own!

The benefits of reclaiming, or upcycling, your materials can absolutely outweigh the shortcomings if you're willing to either wait till you find the right items, or if you're willing to work with someone who already does.

Roofing Materials

Installing a roof can be both challenging and rewarding requiring the installer to know some basic carpentry, take safety precautions and know the basics of roof designs. You'll need to be able to either hire someone to install your roof, or calculate the square footage and angles yourself and install them on your own time.

As a rule, always work when the weather is going to be good for a few days, buy more than you need in case of mistakes, and buy the best quality that you can afford, buying the style that is appropriate for your project. To ensure this, talk with local builders or to the clerks at your local hardware store to ask their advice. Between metal and shingles roofs there is a vast array of materials that are suited to particular applications. Also consider what tools you will need including extension ladders or scaffolding that can be rented or purchased beforehand.

The most common comparison on the market is between **sheet metal** and **asphalt shingle** roofing. Granted, you could use shake²³⁷, tile or even a green roof on your buildings but we have restricted our comparison to these two materials as they are likely to be the most accessible, economical and are commonly used materials in barn and shed construction. As in frame construction, we will consider **Builder Accessibility, Cost, Durability/Efficiency and Restoration Capacity**

Metal: The Pro's and Con's (*This review is taking into consideration ONLY corrugated steel roofing as in Fig. 9.*)

Builder Accessibility: Manipulating the material will be the most challenging as you will need a saw(s) that can cut the material as well as gloves to handle the jagged edged.

Moreover, if you're working with an existing building it is *possible* to simply cover older roofing material like shingles or shake but you need to make sure you know what can and cannot be covered. If there are swells in the roof it can cause buckling and unstable supports can cause substantial issues later. Most roofers would suggest that you lay an underlayment, often an insulating felt, accompanied by battens that separate the metal roof from the actual structure. This helps to promote airflow between the two to reduce or eliminate moisture issues while also allowing accumulated heat to rise up and exit at the roofs peak.

Overall, you can certainly lay this roof yourself, though you'll need to make sure you have some extra hands to help considering the large pieces of jagged metal and the fact that you're on a roof. That's just not a job you should do by yourself.

Cost: You can expect to pay an average of 1/3 more for your metal roof over asphalt shingles. Some report a comparable price, others end up paying double, though it is rare to hear of someone pay less

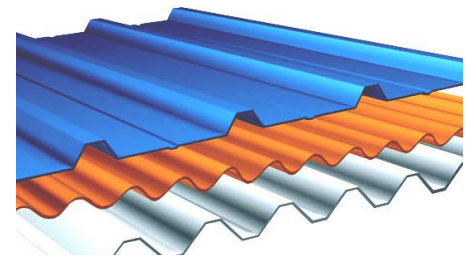


Figure 17 Corrugated Steel Roofing

²³⁷ Shake: A roof constructed of finely cut pieces of wood, most commonly cedar for its insect and UV repellent properties, staggered together in an overlapping format. Often chosen for its damage resistance in hail and heavy storms.

than asphalt roofing. It can be safely assumed that your metal roof will outlast an asphalt roof by decades more and with little or no maintenance costs.

In addition, you may end up saving money as many insurance companies prefer metal roofing with reductions of up to 10% off your monthly policy. With less risk of damage from wind, fire or caving from excessive snow or ice, comes lower residual cost.

Bear in mind that prices are also based on many factors, including but not limited to the following: local availability, labor costs if the work is contracted out, old roof removal and whatever unforeseen issues that may arise as you get into an old structure.

Durability/Efficiency: Metal roofing is quite high on both accounts. The material itself boasts low to zero deterioration by the sun, naturally fireproof, responds well to high winds, and has a great capacity for heat reflectivity. Metal roofing can be remarkably durable and efficient given the appropriate amount of care during installation.

Bottom line, the long term life of your roof is often directly tied to the knowledge of the roofer who installs it. An inexperienced roofer can easily make mistakes with this material, especially around piping and vents that require quality seals to avoid leaks.

Moreover, ensuring a quality structure to build on is vital. This includes the trusses or supports themselves, being sure that if you do construct directly over an old shingle roof that you provide quality underlayment and battens to separate the metal from your roof. You want air flow below the metal, rising from the seams of the gutters up through the apex of your roof.

Restoration Capacity: As a restoration project, it is certainly possible with these initial questions to gauge your roofs capacity for repair.

1) *What is the environment?* If you live in an agricultural area your roof may have a coating of pesticide residue that will need to be removed. If you live near an airport you will need to consider accumulated jet fuel covering your roof. Take time to think about what airborne chemicals might be deposited on your roof and what it will take to remove them before applying your new roof coating. This includes paint that will require some abrasions

2) *Is your roof structurally sound?* Are the panels so rusted that they have lost their integrity? It needs to be taken into consideration as workers with up to 100 lbs of equipment will be walking along the surface, cleaning and applying new surface coating.

Once you've answered those questions and are clear on what removal will be necessary and whether your roof will bear the weight of restoration crews it's time to remove whatever layers of paint, chemical deposits, or debris that might exist on your roof.

We would also suggest that when refinishing your roof that you re-seal and finish it with a reflective paint. These are significantly cheaper than replacing the roof, but do carry a cost. Look into what available products and price out what's appropriate for you. If you're on a paper thin budget, consider at minimum a white, or grey paint instead of a darker shade.

Asphalt Shingles: The Pro's and Con's

Builder Accessibility: Shingles are retailed in bundles called squares. To determine how many squares you'll need to buy, measure the square footage of the roof. The dividend of the square footage by 100 equals the number of shingles required. Always buy extra material just in case.

Cost: Though significantly lower upfront costs, it is worth realizing that shingle roofing is a continual investment in the form of replacement shingles from wind damage or hail. It will be worth your money to buy extra as you inevitably will need to replace parts and sections as time passes.



Durability/Efficiency: Too often a roof will boast its 30, 40, or 50 year life span only to be torn off in high winds or pummeled in the wake of a hail storm well before its life expectancy date. Though sheet metal roofing isn't impervious to these weather hazards, they are notoriously more resistant.

Moreover the environmental toll of asphalt shingling can be great as much of the asphalt is far from biodegradable and it limits your ability to catch water off of its broad surface.

Finally, if you choose asphalt shingles do aim for a lighter color of tan or light green as the dark, often black, surfaces of these roofs absorb incredible amounts of heat increasing your cooling bill in the summer time.

Restoration Capacity: Unless you are subject to extreme weather that tears off huge parts of your roof or you're looking to renovate a particularly aged roof, restoration is particularly easy as shingles can be removed one at a time as problems occur. It is advised to be aware of your roof, inspecting it after particularly large storms or in case of limbs that fall on the roof that may either tear or puncture shingles.

A note on Wood Roofing: Depending on your skillset, available materials, time and/or budget shake roofing can be an option. Many people suggest that it is the best roofing material, particularly cedar shake for its anti-fungal and insect resistant nature. Properly installed, wooden roofing can last for a considerable amount of, from 20-40 years given your climate and the quality of materials.

There is *shake* and *shingle* roofing, the only real difference being the general consistency of the product. Shake notoriously is more wavy, of a varying size and generally adds a more aloof, rustic appearance. Whereas the shingle roofing is cut to a more precise measurement and will consistently lay flat, unlike shake which is subject to weather due to the inconsistencies and wavy nature.

Closing thoughts on alternative building (e.g. cob, earthen, geodesic, etc.)

Depending on your building codes, willingness to experiment, and available materials alternative materials can be an engaging, exciting and creative outlet for the enthused builder! If you've never dealt with the materials you're planning to use, it will be worth your time to consult an expert, hire someone with experience to help you, or attend one of numerous workshops around the country.

Truly though, this building style can generate beautiful, rewarding and substantially efficient buildings that, with minimal upkeep, can last for upwards of centuries!

Consult your local building codes, hire or enlist an architect or structural engineer to help you design the frame and consider hosting a workshop to share the experience with others. The topic is simply too large to expand on in one chapter, though in terms of resilient structures earthen buildings are among the greatest as notoriously materials can be sourced either on site, or hyper locally. Moreover repair is usual minimal given enough foresight during construction and the maintenance, though regular, is not difficult.

Machines and Equipment

The size of your operation, intentions for the future and available funding will inevitably be the biggest contributor to your end purchases. The future outlook that you've taken through the length of this chapter will prevail into the machine and equipment that you purchase; the fun part is that unlike structural assets or natural water assets, you stand to be able to exchange what you purchase at the start for something more appropriate in the future! We stress with all our suggestions the need for purchasing of equipment and materials that retain their value through the years, depending on your care of course.

So how do you purchase for now while planning for the future?

Getting to know other farmers and their equipment

For many this means getting by with what they have until determining exactly what is needed for their scale of production. You can do better though by reaching out to similar operations to find out what they're using, how they made their work easier and mistakes they made along the way. It is through conservative innovation that we can make better choices over the long run, learning from the mistakes and successes of others.

The internet is an incredible source of information and networking, opening the door to discovering new ideas and other professionals. Through forums, discussion groups, informational videos, interviews and archives like USDA's recent upload²³⁸ of informational .PDF's covering a myriad of topics on farming from the turn of the last century to modern day discoveries, you can acquire the information necessary to make wise investments.

Maintenance, maintenance, maintenance....

Though this may seem obvious, it's worth mentioning the value of being knowledgeable about your equipment and machines. The efficiency and longevity of your machinery really depends on your ability to know when the oil needs changed, what the engine should or should not sound like, whether the tires are low, etc. The list goes on, suffice to say that if you endeavor to maintain the value of your assets you have to maintain the machinery and equipment itself.

What classes could you take on small engine repair at a regional community college? Do you know anyone in the community who maintains their own equipment that could help you know what to look

²³⁸ Organic Roots is an electronic collection of historic documents published before 1942 – a time before synthetic chemicals became widely used :. <http://organicroots.nal.usda.gov/orc/home.xhtml>
Agricultural Research Service (ARS) free search engine tool for USDA and peer reviewed agriculture-related research publications. Their digital collection features 40,000 full-text articles from the USDA as well as 300,000 citations : <http://www.nal.usda.gov/>

for? In the worst case scenario when something comes up that's outside of your experience, who can you call that will reliably work on your tractor or small engine?

These are important questions that ought to be considered in any large purchase that you make. Maintenance relies on your willingness to know your equipment and take time to repair and service it as well as the accumulation of the tools to do the job right.

In modern farming the demand for yield is higher than ever and to produce that yield it will more times than not require the use of large equipment. Most certainly the use of tools beyond a shovel and a pair of gardening gloves, so, how do you intend to manage those assets that you'll inevitably accumulate? The answer revolves around knowledge, diligence and being attuned to your equipment, always keeping an ear for ticks, grinding and low power output from your engines.

Bottom line: To harness the asset of community, you yourself must interact fluidly with it, giving as well as receiving.

Self-assessment of the building assets factor of resilience. If you've read this chapter, we're sure you can generate numerous questions to assess the strength of this factor on your farm. They should be similar to the following:

1. Is your soil quality increasing?
 - a. ↑Organic matter, ↓erosion
2. Is your on-farm storage capacity increasing?
 - a. grain bins, coolers
3. Is your irrigation capacity increasing?
 - a. reservoirs, equipment
4. Are you gradually accumulating more processing equipment?
 - a. grain dryers,
 - b. vegetable graders
 - c. grain mills
 - d. packaging lines

Secondary database analysis of increasing physical infrastructure quality. Based on one single appropriate variable available at a county-level (change in farm machinery value from 2007 to 2012 according to the USDA Agricultural Census, we made the estimates of strength of this factor in all Southern states. See Appendix for details on method.

Table 7 shows state by state comparison of the only available county-level measure of increasing physical infrastructure (ISI).

As the adjacent box shows, this measure differentiates little between the states. Louisiana does stand out with a much higher percentage of counties in the highest quartile compared to any other state.

The ranking of Tennessee, Kentucky, Virginia and South Carolina in the lowest tier is also noteworthy, since their overall SRI scores are much nearer the top. Of the top ranked states on overall SRI, only North Carolina and Florida ranked highly on this measure of ISI.

| States ranked by % of counties in highest quartile on increase in farm machinery value (Infrastructure) | | | |
|---|-------------|----------------|------|
| Infra structure | Overall SRI | State | % |
| 1 | 6 | Louisiana | 45.2 |
| 2 | 2 | North Carolina | 33.0 |
| 3 | 5 | Florida | 32.8 |
| 4 | 11 | Texas | 28.7 |
| 5 | 13 | Mississippi | 26.8 |
| 6 | 9 | Georgia | 23.3 |
| 7 | 8 | Arkansas | 22.7 |
| 8 | 10 | Oklahoma | 22.1 |
| 9 | 1 | Virginia | 21.4 |
| 10 | 12 | Alabama | 20.9 |
| 11 | 4 | South Carolina | 19.6 |
| 12 | 3 | Kentucky | 16.7 |
| 13 | 7 | Tennessee | 12.6 |

Summary

One of the most important aspects that defines physical infrastructure or an asset is its ability to maintain value into the future. In ecosystems, which we aim to mimic in our designs, assets are built year by year in the form of trees, soil and biological activity all holding onto nutrients and moisture. Trees and soil composition don't arrive all at once and neither should all your assets. It is through the slow, progressive and persistent accumulation of truly valuable assets that we become more resilient.

As the best speaker we've ever heard on farm equipment said: "bootstrap it as long as you can so that you can find out what you really need instead of buying a lot of things you *think* you need."

What will remain truly valuable to you in the future? What investments (like tractors or processing machines) will hold their market value in the event you need to sell your equipment and scale up? Similarly, if you decide to build a structure on your property, say a barn or utility shed, bear in mind that you may sell that property in the future to move onto something bigger. Design not only for the now, design for the future and for those that come after you. It is our ability to plan for the future, building structures that last, that we move towards securing the kind of lasting systems that resilience demands.

Though this topic is covered in depth in the locally self-organized and modular connectivity chapters, we should note here that community is invaluable infrastructure, whether it's your local community of friends and neighbors who share equipment and labor, a regional network of marketing contacts or a national community of practitioners from whom you get inspiration and ideas. It's important to realize too that your community also contains *you*. How can you become an asset to your community? What can you contribute in return? Communities are made up of people with feelings, schedules, limitations and opinions, to increase the value of this asset, we must be sensitive and generous while not hesitating to ask for help in return.