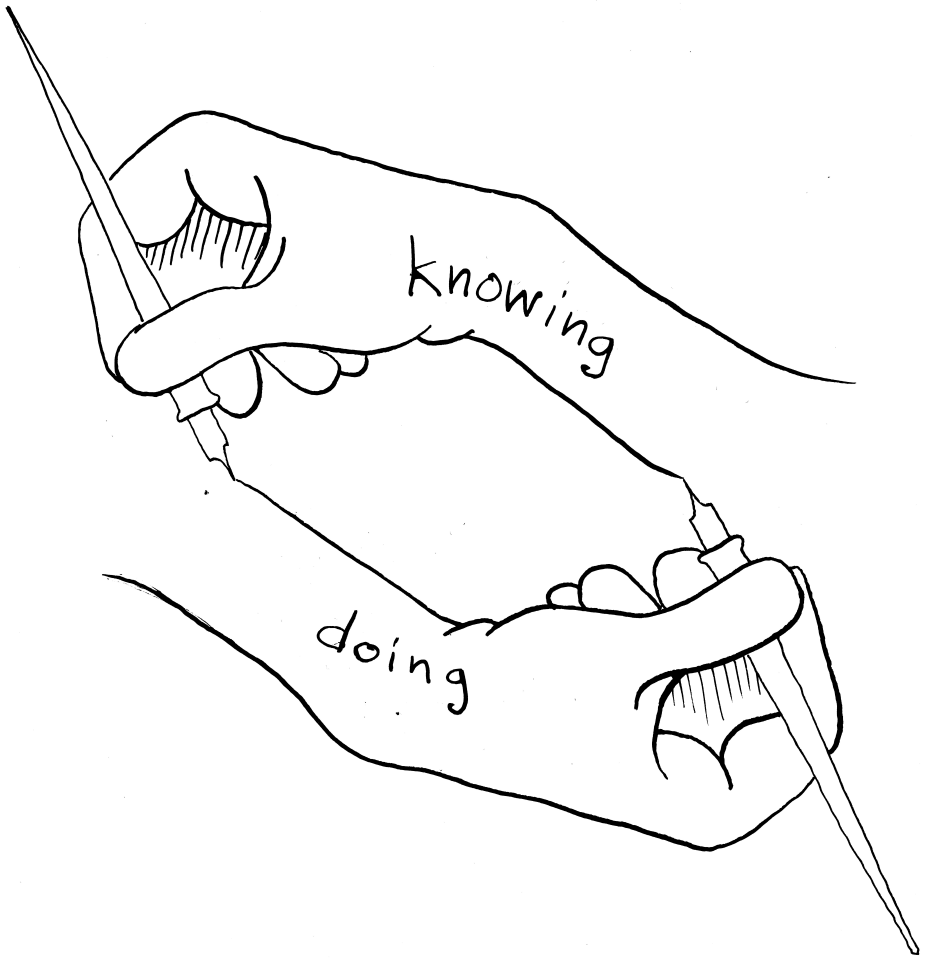
Atlas of Biological Work

growing a shared intelligence
a shared politics and economics
on soil health and watershed function
. . . and maybe more . . .



Peter Donovan
Soil Carbon Coalition
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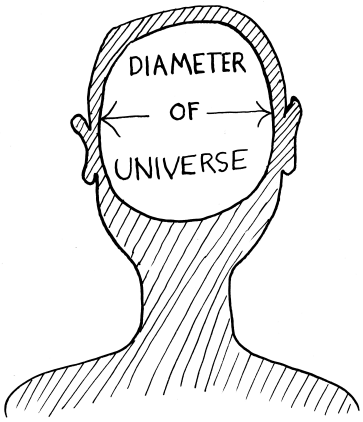
IMAGINE that we could begin to grasp how the carbon cycle—the circle of life and the most powerful planetary force—functions on our farms, our watersheds, our land. How is this circle of life working for me, my family, my community? Are we holding on to the rain that falls, capturing solar energy with plants, and letting microbes convert some of it into spongy, water-holding soil?

Imagine that people living and working in a watershed could participate in growing a shared, evidence-based intelligence on basic function and trends, and broaden their sense of possibility, opportunity, and responsibility? What might this mean for easing conflicts and creating the kind of outcomes that everyone needs?



This booklet aims at helping you recognize the opportunity of working **with** the circle of life, and share this recognition and opportunity with your neighbors, your area, your region. Specialized expert knowledge is not required! In fact, it may become a barrier to learning in complex situations with many feedbacks and many unknowns, such as the circle of life. The purpose of this booklet is not to load you with specialized knowledge, but to expand the range and quality of your ignorance—and your imagination.

Good questions help. What follows is some background to help you ask good questions, share them and repeat them, involve other people, and connect with evidence and to measurable outcomes in soil function.

LIFE, powered by a tiny fraction of incoming sunlight, is the most powerful and creative planetary force. Our planet's atmosphere, its soils, its blue, white, and green colors viewed from space, even the composition of its crust and oceans, are the products of eons of life's complex chemical wizardry. This work of life powers carbon cycling, as well as the cycling of nitrogen and other elements. It modifies and slows the vastly greater power of water cycling at all scales. We are riding an enormous, incredibly complex, fractal eddying flow of sunlight energy used in many ways by interrelated communities of self-motivated living organisms whose metabolisms, behaviors, and relationships are increasingly influenced by our own.

This work and power of life and sunlight connects earth, water, soil, plants, fungi, animals, atmosphere, and human economies and societies into a continuum. But we break this continuum or flow of energy into separate parts by our attempts at understanding and classifying it. Our increasing human influence has changed not only the water-holding capacity of soils, but the routings and timings of these enormous flows of energy—on which our economies and societies depend, but which are usually outside our economics and politics: for us, *energy* is what we can capture, turn into work, and power our industry, transport, and homes. For us, nature or the environment is resources or things to either exploit or conserve.

Frames

Many of us have been taught about photosynthesis in school. But the basic facts, discovered hundreds of years ago—that the dry material of a tree or plant comes mainly from the air, for example, not the soil—are often denied, forgotten, or simply misplaced because they don't fit the frames or contexts by which we recognize and organize our beliefs, judgments, categories, and decisions.

Here are two of the most common frames.

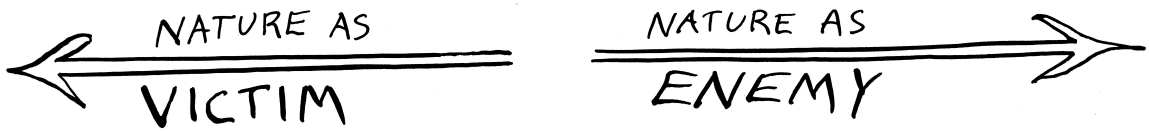
1. Nature is an *ENEMY*

One of the oldest frames, this is the belief, paradigm, or orientation of nature as our dominion, using technology and organizing our society to conquer nature, and to protect ourselves from famines, diseases, pests, and disasters. Most of us owe our lives to this protection and dominion, from the most primitive hut and plow to most of modern technology. We continue to seek technical solutions to every problem and threat.

2. Nature is a *VICTIM*

The environmental movement arose as many people realized that our technology, our conquest of nature—pollution, removing forests, extinctions of species—had damaged or destroyed aspects of nature that we valued. Our technology may even spell the end of nature (wild

things). Many of us have deep personal experience of these losses. We seek to limit and restrain ourselves and our technology, and find a more sustainable way to live.

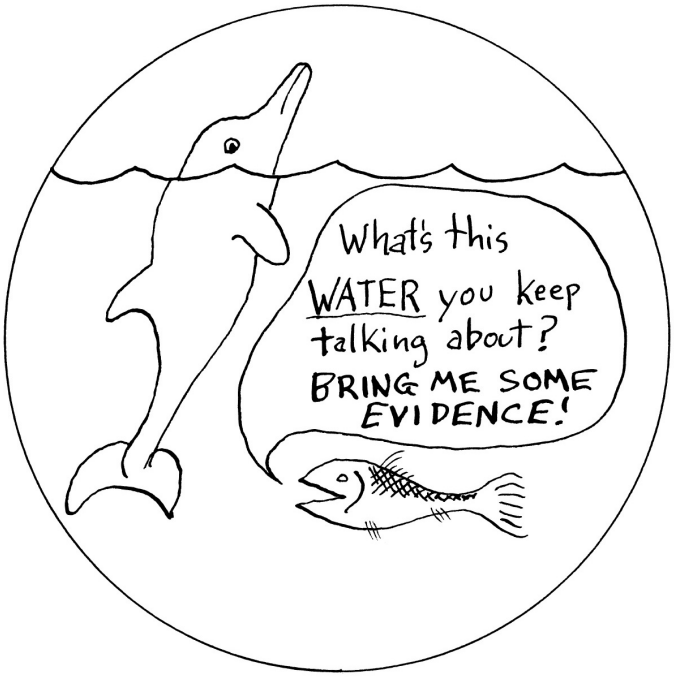


Though we often regard these frames or orientations as opposed, **they share many characteristics.** They both:

- ☐ problem-solve, manage *against* what we don't want
- ☐ rely on expert decision-making and leadership, often with rule-based systems
- ☐ categorize and label species as good or bad: cows or wolves, native or non-native
- ☐ categorize and label practices or tools as good or bad: concentrated animal feeding operations, conservation easements
- ☐ regard nature as resources or things (to either exploit or save)
- ☐ regard humans as somehow separate from nature

Both these frames—"nature as enemy" and "nature as victim"—are based on evidence and personal experience. Wherever you stand along this spectrum, there is loyalty to beliefs and behaviors. There are enormous vested interests and sunk costs: agricultural chemical companies for example on one hand, environmental organizations

and committed movements on the other, and even long-running governmental and civil efforts at somehow balancing the two (which often compromise and combine the worst features of both sides or positions). These various vested interests now fund most science and research. It's where the money and jobs are.

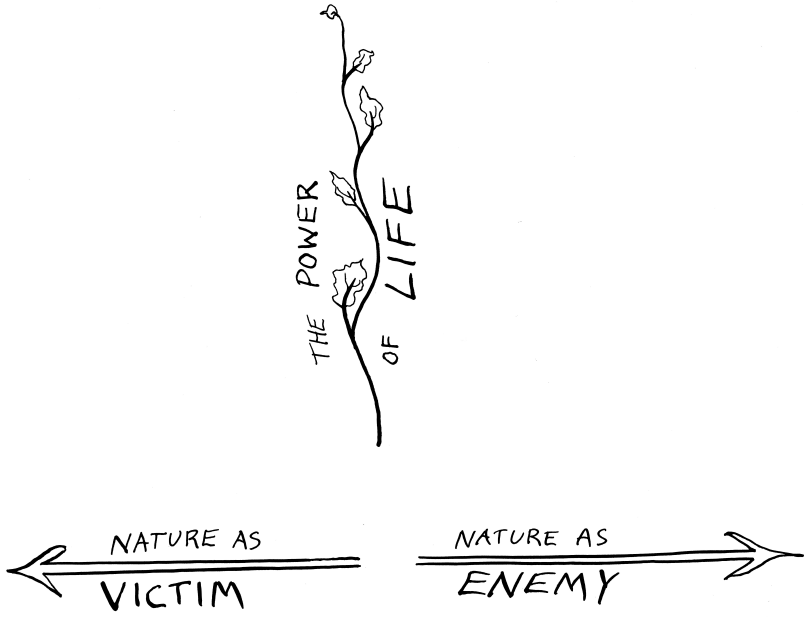


We recognize and judge things according to their position on this polarized spectrum. This turns most issues into wedges that divide people along the spectrum. How do you feel about atmospheric carbon dioxide? livestock or grazing? nitrogen fertilizer? If you're like most people, your feelings about these matters reflect your identity and loyalty to one or more positions on the polarizing spectrum, which can become the **context for your judgment and decision making.** This context, in which protecting economic sectors and protecting the environment are locked in an expensive and perpetual conflict, results in a zero-sum or finite game in which our choices and opportunities for improving our lives are limited or merely predatory.

A different frame or context is possible, practical, and available:

3. Life is the most powerful planetary force

Humans are part of nature. This is not a compromise or combination of "nature as enemy" and "nature as victim," but something different. Nature is not just species, resources, substances, or things but **processes, flows of energy, that do an enormous amount of work**. We influence that work and depend on it.



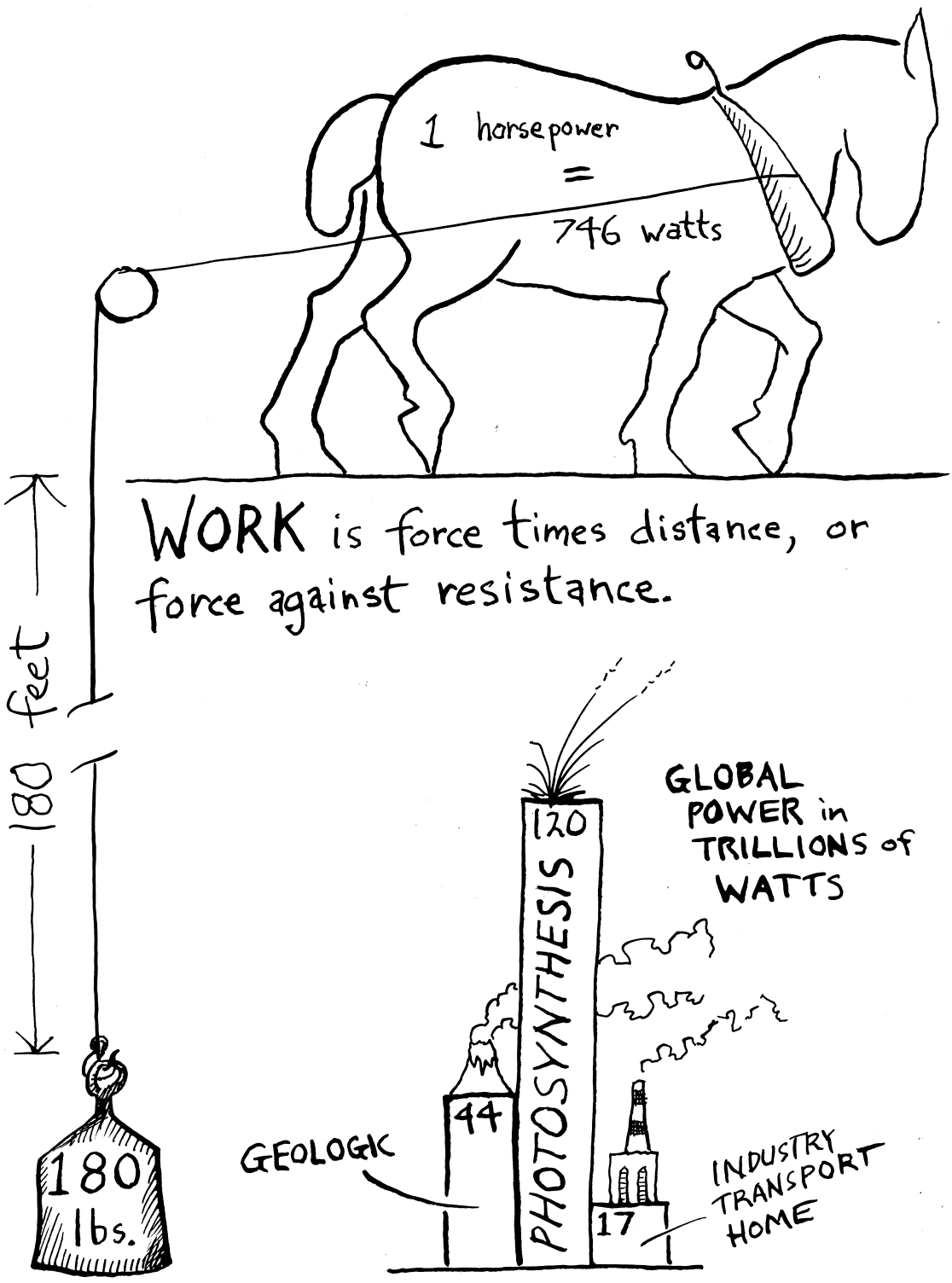
Through human history, we have unintentionally and inadvertently worked against the circle of life, resulting in land degradation, desertification, failing watersheds, and failing civilizations.

If we can learn to manage complex communities of self-motivated organisms, to ally and align ourselves with that work, we have huge opportunities to slow down the water cycle (the main factor in climate and in sea-level

	To manage parts:	**To manage wholes:**
energy	energy means sources of industrial, transport, and home energy	energy includes the power of photosynthesis, which has huge leverage over the vastly greater power of the water cycle
water	focus on control of water in ditches, pipes, wells, and behind dams	soil moisture, groundwater, river flow, soil cover, soil structure, and atmospheric water vapor are all related, even locally: how we manage the soil surface
climate	focus on atmospheric carbon dioxide and methane	focus also on soil sponge because it influences the water cycle: plants manage water, and in managing water they manage heat

rise), improve human health and nutrition, boost farm profits and quality of life, and save taxpayers and governments some of the enormous sums they are laying out for infrastructure repair, disaster relief, water purification, healthcare, social programs, and insurance.

But this opportunity isn't often recognized by the vested interests, leadership, or expertise of either side of the left/right polarized spectrum. It doesn't fit rule-based systems very well. The opportunity may remain camouflaged by our focus on competing problems and competing solutions, by our focus on things, substances such as carbon or nitrogen, or species. Experts can become gatekeepers, guarding the problem definitions that match their expertise.



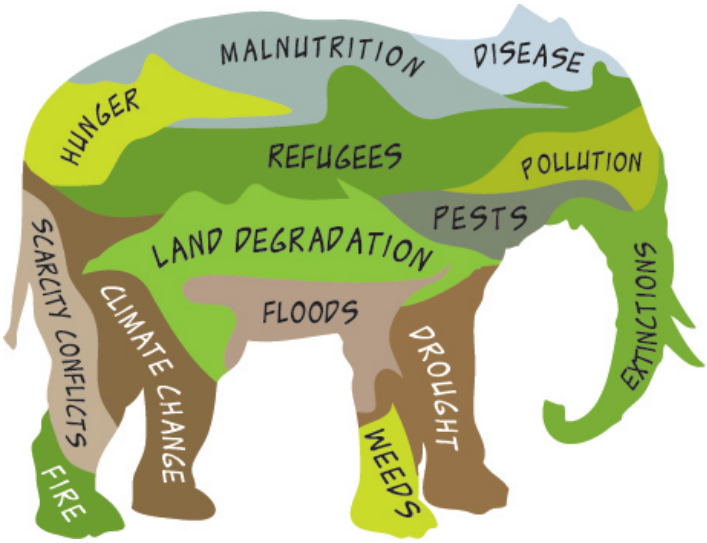
Any kind of physical or chemical change involves ***work****.* ***Power*** *is work per unit of time. James Watt found that a brewery horse could raise 180 pounds, 180 feet (=32,400 foot-pounds) in one minute. This became a horsepower—about 746 watts.* ***What planetary power could be the strongest ally of change?***

Energy, change, and work

When a problem can't be solved, enlarge it.

Dwight D. Eisenhower

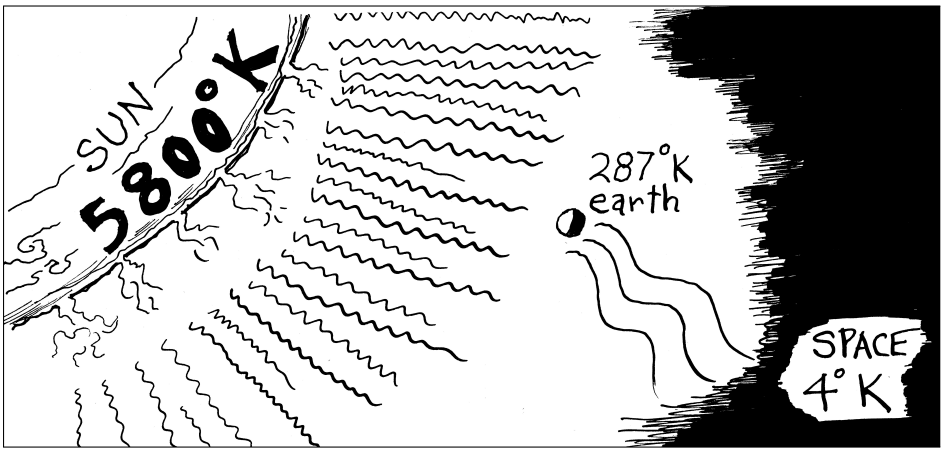
We need big changes—in the health of our soils and watersheds, in the composition and dynamics of the atmosphere. Change, such as moving a mountain, requires a huge amount of energy—the capacity to do work. We can feel energy and measure it—but only by the work it does over time, by the changes it creates, by its results. Energy drives the circle of life, and it relates all living things with each other and with earth, water, air, and fire into a continuum or whole.



So energy is more verb (action) than noun (thing). Energy includes heat, radiant energy such as light or radio waves or x-rays, objects that are moving or have the potential to move, and the energy of chemical bonds forming or breaking, as with fire or oxidation. On earth the primary sources of energy are 1) Solar radiation, well over 99.9 percent. 2) Residual heat from the formation of the earth, plus some radioactive decay, maintains the plastic flow of magma which moves the continental plates and drives earthquakes and volcanoes. Compared

to solar energy, at the earth's surface this geologic power is almost negligible—but continents and landforms influence the flow of solar energy in many ways. 3) The movement of ocean tides, which respond to the motions and gravity of sun and moon.

Radiant energy turns into heat, heat into motion, and vice versa. Radiant energy evaporates water (water cycling) or becomes chemical bonds (photosynthesis), chemical bonds turn into motion or electricity, and always eventually into heat that radiates out into space, each transformation influencing another in multiple overlapping feedbacks, and with considerable local variations.



We're in the middle of an enormous flow of solar energy. The surface of the sun is about 5800° Kelvin (degrees Celsius above absolute zero) although its interior temperatures must be in the millions. Earth averages about 13–14° C above the freezing point of water. Sooner or later earth re-radiates nearly all the gazillions of watts it receives from the sun as longwave or infrared radiation into cold, dark space.

What makes the world happen?
Seven generations of sunlight

Energy, the verb, varies widely with time, location, and human decisions. Global averages here are approximate for all seasons, day and night, all latitudes. As the average human has approximately one ovary and one testicle, it is worth keeping in mind that averages may be rare or brief.

We live, work, and play in the midst of inconceivably large flows of matter and solar energy. And we *are* flows of matter and energy, like a flame, a river, like eddies or curlicues in these larger turbulent flows. At the base of all of our resource or environmental concerns is some form of solar energy.

What follows is a global context for some stages of solar energy, and an invitation to questions: how is the solar energy your land or area receives being used or divided up? What might be some ways to influence that, and how might we get feedback to test our strategies or beliefs?

1. Atmospheric absorption and reflection

An average of about 340 watts per square meter of the earth's surface, or about 1,850 horsepower per acre, reaches the top of our atmosphere.

About a third of this radiation does no work, but is merely reflected back into space by clouds, snow and ice, aerosols, dust particles, and other reflective surfaces. Some is absorbed in the atmosphere by various gases that are mostly transparent to visible light but absorb some wavelengths, and re-radiate it in all directions as heat (commonly known as greenhouse gases). These

include water vapor, carbon dioxide, methane, nitrous oxide, and a few others. Reflection, atmospheric absorption, and re-radiation from these atmospheric gases result in an average of about 240 watts per square meter reaching the surfaces of the earth: ocean, rock, soil, a blade of grass, your cheek. If all this could be converted to mechanical power, it would be about 1,300 horsepower per acre. James Watt's brewery horses would be shoulder to shoulder.

2. Absorbed as heat

About two-thirds of what reaches the earth's surface, averaging about 160 watts per square meter or 870 horsepower per acre, is absorbed as heat, much of it by dark oceans. Because the earth is round, varied, and spins on a tilted axis relative to the sun, heat absorption is uneven. This drives gazillions of horsepower worth of ocean currents and winds, and moves equatorial heat toward higher latitudes.

3. Water cycle

The other third of what reaches the surface, averaging about 80 watts per square meter or 435 horsepower per acre, evaporates water from seas, soils, and plant tissues, and drives water cycling. As water moves from the solid or liquid phase to a vapor, it absorbs and stores an immense amount of energy in the form of latent heat. It becomes lighter than air, moves and rises, and releases this heat on condensation or freezing. If it falls on land,

it can move back to the sea in rivers, groundwater, or ice. Water cycling spreads heat from the equator toward the poles.

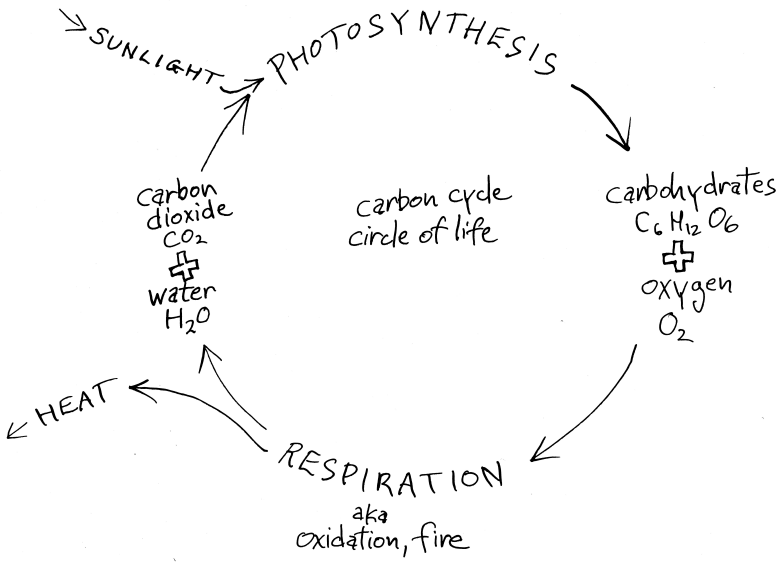
Water that falls on the land can either evaporate or be transpired through a plant, it can run off into a river, or it can infiltrate and eventually become groundwater. The same raindrop can at various times do all three, in different orders. What happens to the rain that falls on your land, your watershed?

Keep in mind that water, when it is held by surface tension in the soil sponge as soil moisture, is a huge and important reservoir of sunlight energy.

4. Photosynthesis

Plants eat light. Though photosynthesis uses only a pinhole's worth of the sunlight that reaches earth's surface (about .25 watts per square meter, or about 1 horsepower per acre for a global average), it does creative chemistry that over time transforms the flows of matter and energy on earth. Creative chemistry requires high-quality energy, not just warmth, to sever chemical bonds and assemble new ones. Reactants must be concentrated and often catalyzed, which requires a container such as the membranes of the chloroplasts and cell walls where the reactions take place. It happens quietly and gradually in the growth of a lichen, leaf, or diatom. It's happening almost everywhere on earth, in millions of different kinds of organisms. Unlike diesel engines or volcanic eruptions, photosynthesis occurs at ordinary temperatures

and pressures, in microbes and parts of cells that are too small to see.



For living organisms, this carbon cycle or circle of life couples growth and decay, love and death, production and consumption, engine and fuel, order and freedom, actuality and possibility. For the planet as a whole, it creates and maintains a radical chemical disequilibrium or potential, like a charged battery, exemplified by our atmosphere with abundant oxygen and low carbon dioxide, that we have traditionally viewed as the nonliving environment of life. The creative power of this chemical potential is immense.

This complex circle of life, solar-powered through photosynthesis, does about 8 times more work globally than all our industry, transport, and home power. It does almost 3 times the work of the geologic forces that move the continental plates and trigger earthquakes and volcanic eruptions.

5. Respiration, behavior, knowing

> Life is the most powerful geologic force.
>
> Vladimir Vernadsky

Much of the chemical energy produced by photosynthesis, and stored in chemical bonds of organic carbon compounds, is respired (oxidized) in the mitochondria, the energy transducers of living cells. A fair amount is burned in immense and numerous fires that occur on every continent except Antarctica. Some is stored or buried in some longer-lasting forms such as wood, peat, soil carbon, fossil fuel deposits, or marine sediments, which can then become rock such as limestone or chalk, and are cycled by the much slower geologic carbon cycle.

Behavior is a general term for what self-motivated living organisms *do* with the energy released in respiration, which is turned into proteins, heat, activity, motion. Another general term is cognition or knowhow. Much of this is biochemical, such as enzymes working on their target molecules, bacteria moving along a chemical gradient, plants initiating flowering in response to changing day length, or when you become adrenalized by sudden fear or transformed by love. Part of this behavior is the building of the photosynthetic molecules and structures themselves, so immediately we see that there are profound circularities in the organization of living beings—they literally make themselves, using energy and materials from their surrounds. A cell membrane is able to distinguish between different elements or ions, and regulate

passage accordingly. This is knowing or cognition, but it is not necessarily conscious in our usual sense, or even necessarily associated with a nervous system or brain.

Every action, every expenditure of energy, every development by living organisms is a manifestation of knowing. As an embryo, you *knew* how to develop five fingers on each hand. This wasn't theoretical knowledge. You probably weren't aware of the exact steps you took to do this. And yet you can pass this knowing, or knowhow, to your kids.

Knowing or cognition is a powerful coupling of an organism to its surrounds, but it is not a mechanical system, or a one-way interaction. The error of regarding subject and object as distinct is difficult to escape, for it is slyly embedded in our language, our beliefs, and most of our science.

The behavior or cognition of living organisms also leads to diversification, because every living being is interacting with its surrounds, which include changing populations of other living beings. Behaviors vary from many causes, and these variations may be conserved or further diversified in future generations, or the organism may become extinct—as have most of the world's multicellular life forms.

6. Consciousness

Knowing *that* we know is a faculty of humans and quite likely some other mammals and even birds. It is a tiny fraction of total respiration, but with grand and far-

reaching influence. This is a sense or perception of a self, being a witness to one's mental processes and states. One strong indicator is language, which enables us (and perhaps commits us) to talk to ourselves as well as to each other. We reflect on our experience and form our beliefs, what we think we know, using language, telling stories.

Once language-using humans formed intelligent nests, we were able to modify our environment with purpose and anticipation. Our beliefs (powered by respiration and therefore photosynthesis), the stories we tell ourselves and others, both create culture, economies, and politics, and are formed by these. Complex feedback loops abound. Stress, fear, envy, gratitude, loyalty, obedience, rebellion, greed, the belief that a gallon of gasoline is worth $4.09—these are all paths of solar energy flow, and we influence them with varying degrees of intention and awareness.

7. Self-awareness

> Humankind is nature becoming self-conscious.
>
> Elisée Reclus, *L'Homme et la Terre* (1905)

A tiny and intermittent manifestation of carbon cycling, behavior, and consciousness is knowing *how* we know, *how* we make decisions, the extent and character of our ignorance, and some awareness of our beliefs, paradigms, and assumptions. Our beliefs and assumptions are often not visible to us until they fail, and sometimes not even then. When we do "see" how it is we

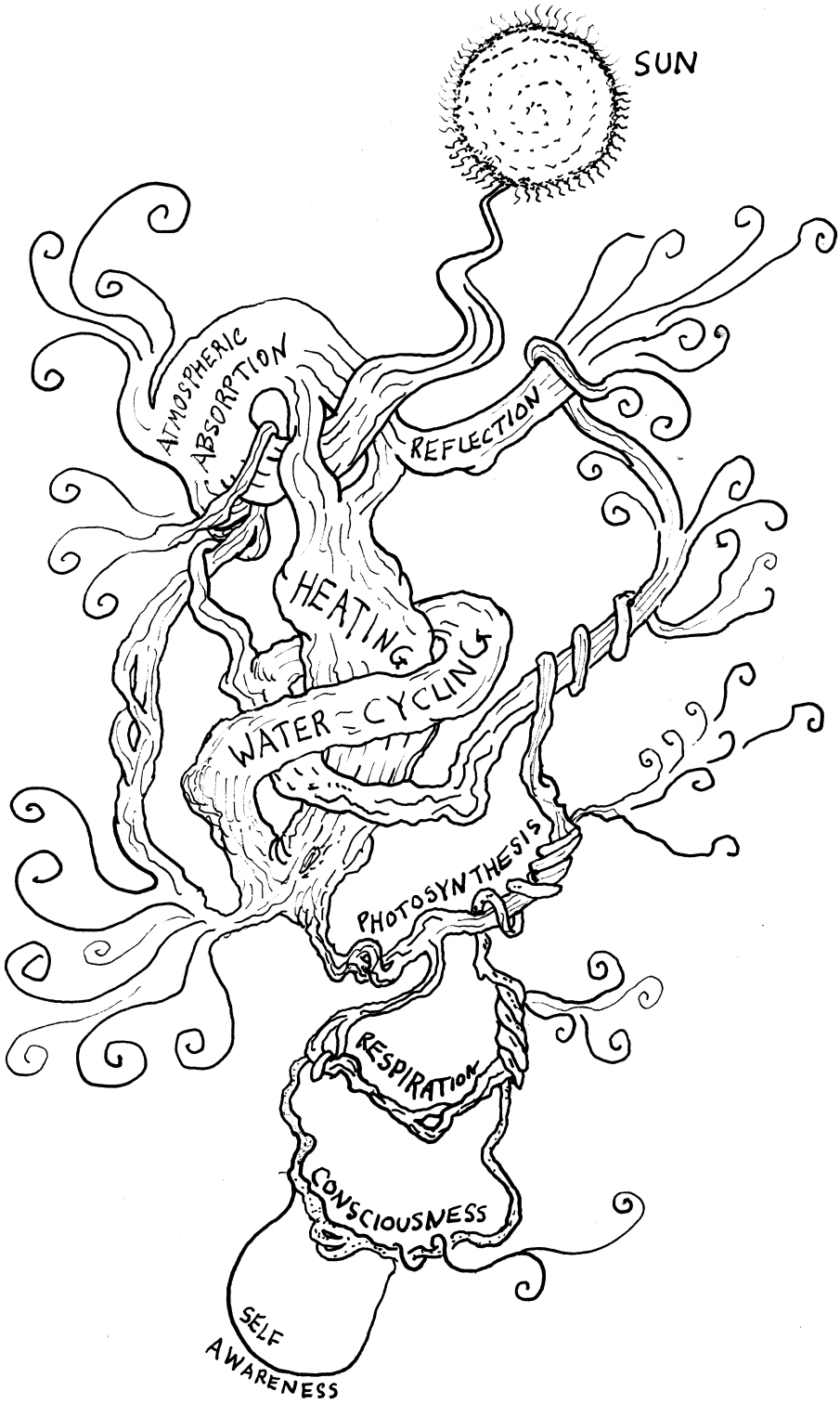
see, when we recognize our hidden beliefs, it opens the way for creation, innovation, transcendence, and self-transformation.

> If you want to make small changes, change how you do things.
> If you want to make big changes, change how you see things.
>
> Don Campbell, Saskatchewan rancher

Local, human-scale feedbacks connect knowing and doing

In our interactions with our surrounds, what we perceive is often categorized as resources or things: objects, minerals, organisms or species of plants or animals, habitats, land, or sets or collections of these. In solving a problem or moving toward an objective or goal, we ask ourselves: **1. What resources or things should we use, buy, sell, conserve, eradicate, save, sequester, or restore, and how fast?** Most of the decisions we make are answers to this question: shopping, business decisions, planting a crop, choosing the way home, avoiding a pedestrian, pulling a weed, preparing a meal, cleaning the kitchen.

As mentioned, our answers often have far-reaching, often unintended negative consequences on the flows of solar energy. When people plowed up the southern plains in the 1920s to plant wheat, solar energy was diverted from evapotranspiration and long-season photosynthesis of prairie grasses and forbs, and from the protection, growth, and maintenance of soil structure, to



The flow of solar energy through earth is truly complex: multiple overlapping circular feedbacks that are more actions *than* things, *verbs more than nouns. How can we work* with *such a complex, mysterious tangle? How can we steer it toward what we need, test our beliefs against the results we're getting, and evaluate our efforts?*

the heating and drying of bare soil and the degradation of soil structure and aggregation. Devastating wind erosion further degraded soil structure, and destroyed the human economies and communities that depended on its stability.

Here's a question that we can add, especially for complex situations such as land management: **2. How can we enable, influence, steer, or partition the flows of solar energy toward what we need and want?**

The smaller uses of solar energy (for example, human consciousness and beliefs) have, over time, produced changes in the larger uses of solar energy, even changing the reflectivity of our planet. A small force can change or steer a larger force because we're in moving flows of energy, **not** a static equilibrium. To create the results we want in the way our complex ecosystems, economies, and societies function, takes appropriate feedback.

Scientific agencies often issue warnings, for example reporting on status and changes of atmospheric carbon dioxide or methane and global temperature averages and extremes. Many people hope that these kinds of warnings will result in more people changing their beliefs and behaviors—changing lightbulbs, reducing fossil fuel emissions, and carbon "sequestration" strategies. And those who believe in and pursue these strategies may hope or intend that it will make a difference in global atmospheric carbon dioxide or temperature.

It's not that these warnings or hopes are not based on evidence, on good science or research. But the feedback

loops here are stretched thin because they skip over the intermediate influences and flows of energy: water cycling, photosynthesis, and the behavior, diversity, and abundance of respiring, self-motivated living organisms. Without appropriate feedback, our beliefs that we are doing the right thing remain untested. Deceiving ourselves is easy, and without human-scale, local feedback this kind of framing becomes a wedge issue that divides people and encourages gridlock. We become powerless over the issue, and blame the other side.

We can do better by paying lots of attention to the middle generations: water cycling, photosynthesis, carbon cycling on human-relevant time scales such as years or decades, on the crucial linkages and influences that connect them, and on benefits and improvements relevant and important to our neighborhoods and regions. Soil, and the soil surface, is the hub or center of gravity of these functions.

Orienting ourselves

Soil is often regarded as the dance floor or stage upon which the real activity occurs: plants, animals, vehicles, buildings, our civilization. But in fact there are enormous flows of matter and energy through soil that we seldom notice: water, carbon and sugars moving into soils—all the activity of the rooting zone—and water, carbon dioxide, and other transparent gases moving out.

The flows of carbon compounds, energy, and water in

and out of the soil surface include the formation and also the degradation of soil aggregates—the tiny clumps of sand, silt, and clay held together by the cements, glues, and fibers produced by the soil foodweb, and fed by plant photosynthesis. This results in a fantastic micro-architecture that holds water, air, and provides a variety of niches, food, and habitats for important soil organisms such as bacteria, fungi, nematodes, and worms, most of them beneficial to agriculture. This micro-architecture of soil aggregates is the fundamental infrastructure of our human civilization. Without it, water and wind carry the soil away, floods will take out the rest of our infrastructure, and droughts will finish off our economy.

Technology can't build soil aggregates, but technology such as tillage or some chemical applications can destroy them faster than the soil foodweb can rebuild them. This is a complex situation. In complex situations we learn through feedback, by outcomes in physical reality.

Practices—such as no-till, cover crops, rotational grazing—are tough to define with any accuracy. Everyone's situation is different, and everyone does things at least a little bit differently, with different timing. A few wise USDA people in North Dakota came up with some principles that can be implemented in a variety of creative ways depending on your situation, your resources, and your resource concerns:

Soil health principles

keep soil covered with dead or living plant material
living roots for as long as possible
diversity of plants
minimize tillage
integrate livestock

"Integrate livestock" is sometimes left off, but nature does not try to grow food without animals. And this means more than just having livestock in the system, but using livestock at the right time and place for the soils, plants, animals, and people that share the habitat. A good and flexible planning procedure will accommodate all of this.

The soil health principles are enabling conditions for the formation of soil aggregates from solar energy. Similarly, observation and listening—to the land, people, animals—is an enabling condition for learning. Being in the right position is an enabling condition for low-stress livestock handling, for letting your animals do what you need them to do.

Some good questions

> Do civilizations fall when the soil fails to produce, or does a soil fail only when the people living on it no longer know how to manage their civilization?
>
> Charles E. Kellogg, USDA soil survey chief in 1930s

Most people have an innate capacity to connect with the circle of life, with a context larger than their im-

To manage parts:	To manage wholes:
A few accredited experts and specialists have the power and resources to ask, frame, interpret, forecast, regulate, and collect data. Diversity of opinion becomes a liability.	Ask, how does the whole system function? What works for all, in the long run? Diversity of opinion can become a creative asset.
Ask, what are the mechanisms of the parts?	Engage more people in asking and answering whole-system questions, based on observations, real data, variability over space and time, and creativity.
Manage **against** problems (or symptoms) with rule-based systems.	Manage **for** what we need and want. Ask, what are the enabling conditions for these?

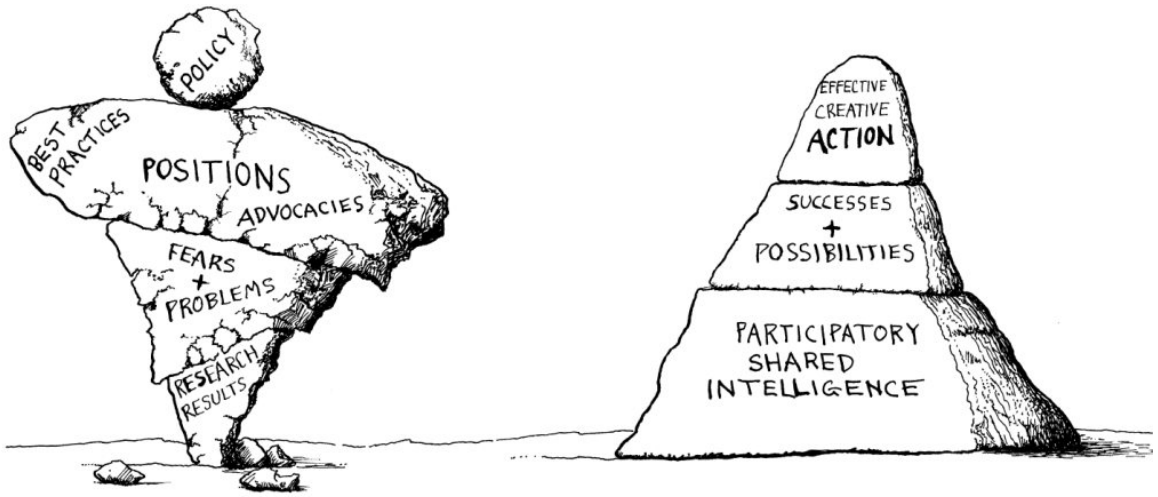
mediate issues. But often the paths to connection are camouflaged or hidden, and we're accustomed to usual answers or getting lost in the details. Where fear, habits, and urgency rule, we default to accepted answers, to managing parts.

Good questions help us escape the polarizing, left/right spectrum, and opt out of inappropriate frames and dysfunctional categorizations. Good questions orient us around wholes, around what we don't know, and perhaps need to know.

Monitoring energy flow through animals, plants, and soil connects us to physical reality in a particular time and place, which can often challenge the stories we tell ourselves, or test our beliefs.

And it may challenge our fears, often based on experience, of data being used against us. But data can also

common questions	**better questions**
Am I doing the right thing?	What results am I getting?
Is this species or practice good or bad?	What work does it do, and how does it function in the larger system?
How do I kill this weed? How do I get rid of this person?	What conditions can I begin to create so that this weed or person is no longer a problem?
Are we doing sustainable or regenerative practices?	Is our soil covered, do we have living roots for all of the growing season, and diversity of plants and animals?
What best management practices are commonly associated with accomplishing *X*, and which appeal to me?	What conditions will enable *X* to occur? What position do I need to be in, what behavior do I need, for *X* to begin to occur?
What's my soil type? Is it good or bad?	How long does it take successive inches of water to infiltrate?
How can we incentivize landowners to sequester carbon?	How can we **hire** land managers to grow the soil sponge, based on results that are important for our watershed and community?
How can we make this [leaky, ineffective] system more efficient? or more benign?	How can this system become effective for what we need?



be creative feedback, like a dipstick in an engine, to help you create the results you need and want. This all takes courage and leadership.

Questions about soil cover, diversity, production per unit of input, food and forage analysis, soil samples and analyses can be answered with repeatable measurements and observations so we can track progress. If these measurements and observations are open (as they are on the free web app `atlasbiowork.com`) they can also be an instance of leadership, of a growing and shared intelligence on the circle of life.

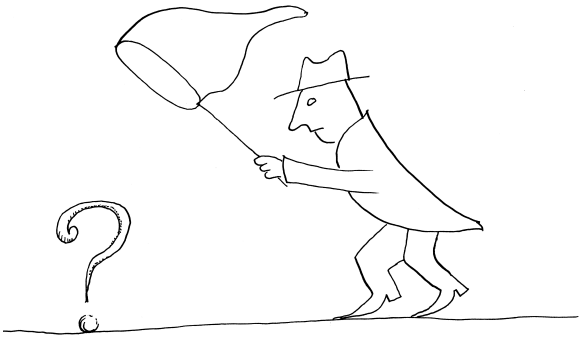
Orienting ourselves around the power of life

1. **Ask good questions** about soil health and watershed function, with some quantitative measurements of physical realities and outcomes, and about systems, about managing wholes, about our own beliefs and behaviors

2. **Engage more people in asking and answering these questions.** This means connecting a local area's **stakeholders and assets**—people with their imagination and creativity, along with programs, resources, data, and ways of interacting with data—in ways that allow them to participate in and contribute to a shared intelligence on the circle of life, and highlight their stake in the outcomes. Building community around the power of the circle of life is more inclusive and creative than the left/right

spectrum (page 2), which tends toward letting experts address the symptoms, wedge issues, and rule-based systems that hamper creativity and flexibility in complex situations.

This is to orient people around the work of the biosphere, the circle of life, and the opportunities of working **with** the most powerful geologic force. Many places have many assets for this orientation, but they may not be connected enough, or people may not realize how they can be connected. Can a county road department, or a local hospital, become an asset to a soil health movement? Can old crop yield data or stream gauge data become an asset? You bet.



Good questions include observations and measurements that can evaluate projects and programs on actual results and physical outcomes, more than talking points or the application of practices such as acres protected or acres treated. This gives **accountability**, and offers the potential of closing the gap between **agency** (the power that, for example, a farmer or land manager has to make decisions that affect soil health and watershed function) and the **intention** to enhance these. The potential is where agency and intention overlap, and this overlap can be expanded.

How can I get started in my area?

a. hands-on, participatory Land Listener workshops to orient people around the circle of life, how the soil carbon sponge is the hub, as well as both cause and effect of water cycling and carbon cycling, and introducing some citizen-science projects (for example, `soilcarboncoalition.org/land-listeners-project`)

b. ask questions: How is solar energy being used here? What's happening to rainfall here? What are wind and rain doing to bare soil? How does soil structure modify flooding and drought? What's the evidence that soil health principles are in effect on my land, or in my neighborhood?

c. Identifying resources, and champions who can connect with other local assets, stakeholders, and resources:

    soil and water districts
    watershed groups, conservancies, land trusts
    federal, state, local agencies
    water, sewer, road departments and utilities
    food system, landscapers, healthcare sector
    banking and finance
    local governments, newspapers
    schools, community and 4-year colleges

d. gatherings, large and small, that allow people to acknowledge the problems and challenges, and also

affirm the opportunities—with a format that allows everyone to contribute creatively, to find new ground

e. data hackathons with data and GIS people to grow **citizen-usable maps and map layers** on local soil health and watershed function, including both small-sample observations and large-area measurements via satellite imagery and hydrology

f. identification of people and resources, as well as a strategy and blueprint, for continuing the project, sharing skills for connecting assets and framing questions, growing the shared intelligence, incorporating new technology, and networking with other areas

g. a residency where a facilitator and data person can help with all of the above, and can introduce length of green season from satellite data, production per unit of input such as stock days per acre per inch of rain, or bushels of corn per acre per pound of N, water infiltration, and other practical, repeatable, and relevant feedback for growing soil health and watershed function.

Contact us at `managingwholes.com@gmail.com` or `info@soilcarboncoalition.org` if this is something you'd like to explore.

Feedback: guidance of a system based on its *actual* performance rather than its *expected* performance.

Links and resources

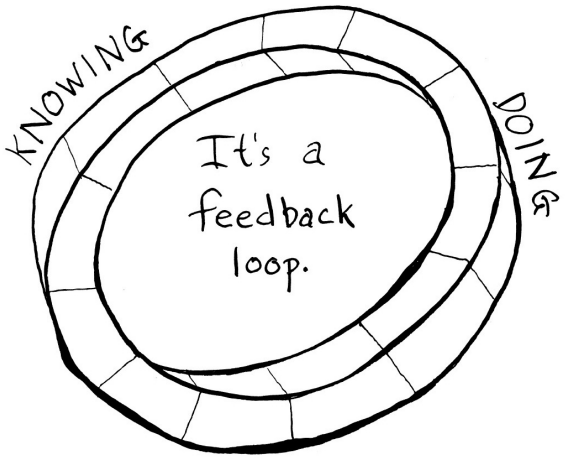
`soilcarboncoalition.org/learn` includes many hands-on, inquiry-based learning resources for schools, communities, adults about soil health, watershed function, and a guide to simple monitoring. **NEW:** citizen-science projects for youth and adults.

`soilcarboncoalition.org/downloads` Free downloads in printable pdf form, including this and other booklets. `big-force.pdf` is a short booklet that includes an example of working out livestock production (stock days per acre, or pounds gain per acre) per inch of rainfall. If you can increase this over time, and that is an excellent indicator of soil function and health, and many farmers and ranchers keep these kinds of records.

`soilcarboncoalition.org/atlas` for other links and updates, also including downloadable copies of this booklet.

`managingwholes.com` for a library of articles on managing wholes, low-stress livestock handling, consensus building, and forestry

The circle of life—carbon and water cycling—is the most powerful geologic force. This circle and force is not a random series of unrelated events or problems to be solved just with best practices or policies. It is a complex mystery that we live within. How we recognize it influences our beliefs and actions, which in turn influence the circle of life.



This booklet is for you if you want to:

- ☐ broaden, deepen, and diversify the constituency for growing the soil sponge
- ☐ spread better questions, offer opportunities for citizen science and participatory learning and sharing
- ☐ help evaluate efforts toward enhancing landscape function, whether your own or those of others
- ☐ help grow awareness of the invisible flows of solar energy, and share data with interactive maps
- ☐ advocate, without accusation and blame, for soil health and watershed function