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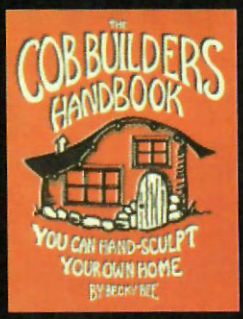

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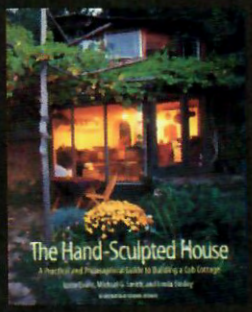

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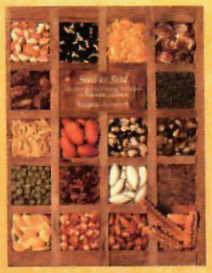

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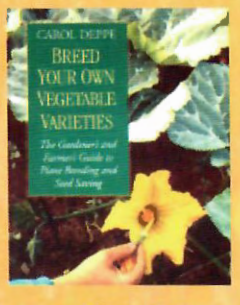

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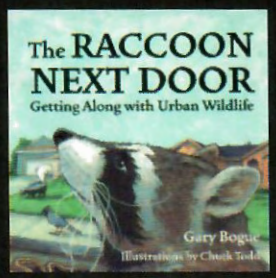

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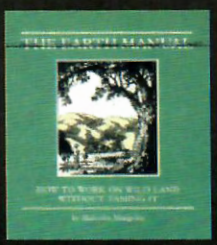

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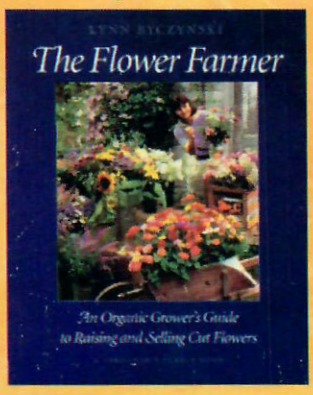

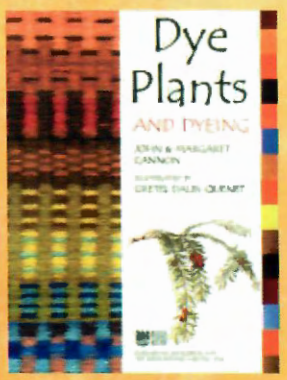

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Permaculture is a holistic system of DESIGN, based on direct observation of nature, learning from traditional knowledge, and the findings of modern science. Embodying a philosophy of positive action and grassroots education, Permaculture aims to restructure society by returning control of resources for living: food, water, shelter, and the means of livelihood, to ordinary people in their communities, as the only antidote to centralized power. For 25 years Pc has combined top-down thinking with bottom-up action to make a world of difference in over 60 countries. We are everywhere.

Editor's Edge

Handyman of the Unseen

Scott Horton, Editor

A FEW YEARS AGO, Trathen Heckman asked me to help facilitate a strategic planning process for his organization, Daily Acts, because of my communications and marketing background. The mission of Daily Acts is to help people find ways to create positive impacts on the environment and culture that are meaningful, manageable, and comfortable for them. The Daily Actors are talking about little things that can be done on a consistent basis which, together, can have tremendous effects, like switching to recycled household paper products and biodegradable soaps, and bicycling or taking public transportation to work. If we all did a few little things that conserved resources and minimized waste, perhaps—the Daily Actors think—we could pull our culture back from the brink of ecological and social collapse just enough to save ourselves. It's a great concept, especially when you consider that many of us pull back in fear when bombarded by dire predictions about the environment; the news media's "If it bleeds it leads" predisposition doesn't help. Don't misunderstand: I think we're in urgent trouble, but we need to present a balance of solutions-oriented messages along with the gloom-and-doom if we want people to respond, not just freeze in the headlights of oncoming crises like so many startled deer.

. . . we must make a fundamental cultural shift from the idea of ownership to one of relationship.

Daily Acts is a non-profit with limited financial resources, but Trathen generously offered to pay me what they could afford while suggesting I consider bartering in some other way to mutual benefit. I told him I'd be happy with just a fancy title. So he named me Daily Acts' "Handyman of the Unseen." It's in my resume now, and one of the best job titles I've ever had.

As permaculturists, I think we're all handymen and women of the unseen. We have a responsibility to observe and work with the unseen kin-doms that, more than we may realize, form the invisible but essential foundation of our stock and trade.

Satish Kumar—visionary activist, teacher, author, and Friday *chef de cuisine* at England's Schumacher College—talks about how we must make a fundamental cultural shift from the idea of ownership to one of relationship. Only then can we truly serve the ethics of permaculture. For more details on the subject, particularly as it relates to poverty as a direct result of concentrated ownership of land rather than conscious relationship with it, Satish's editorial, "From Ownership to Relationship," in the March/April issue of *Resurgence* is an excellent read.

The articles in this issue make visible, in myriad ways, relationships that are perhaps out of sight, but which as designers we can never afford to let out of mind. How much fruit could our forest gardens and orchards produce without the largely unnoticed work of pollinators? Is it even possible for forests to grow without fungi? Dare we think the damage that modern agricultural practices and lifestyles wreak on the ocean floor is any less severe because hidden under the swells?

It's time we start noticing and then working to repair, restore, and create mutual benefit for these un-seen relationships that surround us. Let's pick up our tools and get down to vital and rewarding work as handymen and women of the unseen. Δ

Publisher's Note

We thank our readers and friends for their support during our recent move from North Carolina to Indiana. The Activist office has been re-established in newly remodeled quarters with more space than before and better facilities. Other aspects of our lives are still being reconstructed however: the garden, the home, friendships and daily habits, so we ask for your understanding in the coming months as we continue to settle in.

We discovered belatedly that the new zip code printed in our last issue was in error by one digit; also the old Black Mountain return address on our #60 cover refused to disappear, so we have labored to make sure that all appearances of our address information in this issue are correct. May the devas of the print world look with favor on our efforts! By such daily acts we transform the world and ourselves. —Peter Bane

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The Art of Site Assessment:

Using Naturalist Observation as a Design Tool

Amanda Malachesky

DEVELOPING AWARENESS OF THE LANDSCAPE for the purpose of design requires us to step into the home territories of our non-human neighbors. When we egin this process, we are at first intruders, and our presence esults in ripples of effect. In orking with permaculture, ur ultimate goal is to ıtegrate our needs with the ırrounding ecological rocesses, so that we can ork in harmony with our llow creatures. But if we ish to understand such rocesses and account for ıem, we need first and remost to be able to erceive their presence.

How do we develop ıis awareness?

It is no easy task, for we re unaccustomed to non-uman ways of knowing. irds and other wild animals re typically wary of the ıovements of humans, and ıese creatures, of relatively nall size, leave slight and mewhat invisible impacts on the land. Plants, trees, and forests re stationary and difficult to comprehend in any one moment: ıeir secrets unfold through time. In order to find what we are ooking for, we need to see with a different kind of vision, hear y a different kind of listening, and use our senses in ways to hich we are likely unaccustomed. With a little practice and a lot f patience, however, a new and rich perception can emerge from ersistent observation, giving increasingly complex feedback out what is going on beneath our feet. Such familiarity with lace is essential to creating appropriate design.

Tracking skills can help identify often unseen residents and neighbors like raccoons.

Daily practice

When my husband and I bought a three-acre piece of land in orthern California, I had already lived in the area for more than ree years. Through my work with a local restoration group, I as familiar with the environmental issues that our local atershed faces, and the general local ecology. And while this ackground information was useful, it didn't prepare me for the depth of what I was soon to discover in one small area.

On this piece of land, I wanted to honor the permaculture site assessment process as deeply as possible, partly to see where it would lead, and partly because of personal ethics, which include the importance of thoughtful planning. I began visiting the land regularly, using awareness exercises as a design tool to learn about who lived here, what they were doing, and to understand their lives. I continue this practice today.

To begin my daily journey of observation, I step outside my front door into sunshine and onto solid earth. I stand tall, take a few deep breaths, and center my mind. Then, when I feel sufficiently calm, I begin to offer thanks to all the inhabitants and energies of this great green earth: the earth, the waters, the plants, the animals, the trees, the birds, the sun, the moon, the stars, the weather and clouds, winds, human communities, and future generations. This practice is a Mohawk Nation tradition called the Thanksgiving Address, taught to me by the Wilderness Awareness School, shared with them by the Tree of Peace Society (see resources at end of article). After I have completed my thanksgiving, I head out to explore, walking slowly with soft eyes, feet, and ears. This practice has become an integral part of my study of permaculture and my practice of "thoughtful and protracted observation."

The first time I tried my hand at the Thanksgiving Address, I wasn't sure what results I would get. I felt a little awkward, offering words to the unseen, hiding in space or time. Yet I was unprepared for the dramatic result. Within moments of the first utterance in my mind of "I give thanks for the earth beneath my feet," a winter flock of dark-eyed juncos landed 15 feet from me and began to feed, happily and noisily chattering to one another, as they flitted and hopped and scratched at the winter earth.

In my ongoing training as a naturalist, I have learned that when feeding, animals and birds are relaxed. A distressed or

frightened creature won't be comfortable enough to feed, and will likely be on the run or on the wing, placing distance between itself and the perceived threat. These birds didn't perceive my presence a threat at the moment I gave thanks, so they commenced to feed. Softening our body language in this way can bring the previously unseen into stark focus, allowing greater perception of events and phenomena.

Birds can be especially useful for taking the pulse of your surroundings, because they are sensitive to malintent, will react to predatory behavior, and are readily available for study anywhere. They make noise when they are upset, allowing us the opportunity to investigate the source of a disturbance. Learning about their habitat requirements can also teach us about deeper ecological information.

One of the first birds I heard at our place was the winter wren, a small, feisty bird who lives close to the ground. It is usually one of the first birds to investigate me when I visit the forest, bravely scolding my presence from just out of reach. It lives in shaded, moist riparian areas. Knowing that it has these requirements and that it lives in the area throughout the year tells me that those conditions are met year-round. Of course, I can see that there is a creek running through my land, but the presence of a bird who needs dark, wet places leads me to ask who else might be able to live there: might there be salamanders? Toads? Frogs? Willows? Alders? What types of insects would be there? Who eats those? And so on.

The answers to these types of questions unfold through the course of my daily visitations. Eventually, I will be in the right place at the right time to view new plants or animals. It has been useful for me to keep a record of my sightings, which includes the date and weather. Sometimes, reviewing my journal can reveal an "a-ha," something I didn't think of before, or it can remind me of approximately when the hawks nest, or when it's common to see toads. These events constitute the design data, which provide a basic sense of what we are looking at.

Long-term lessons

Mammals prove to be more elusive and difficult to see. After living here for over two years, I have only actually seen four species of mammals: mule deer, river otter, western gray squirrel, and the chickaree, by my own tracking abilities. I've seen several others by accident, while driving on my road at night, or by startling them when I ventured outside unexpectedly. However, I've been able to compile quite an impressive list of mammals by learning to observe signs of their presence: tracks, trails, scat, dens, marks on trees, food caches, or others. The long-term, broad-based information I glean from my observations is like the mammals: scarce, uncertain, and rare.

After visiting for more than two years, I still find new animal trails. Perhaps they move location in response to changing conditions, or maybe my eyes continue to adjust to the "dark." Just the other day, I was visiting my sit spot, a place I try to go to every day, and noticed a deer trail leading up to it from our creek. I have been to this place hundreds of times, and just hadn't looked in the right way yet.

This illustrates the importance of long-term observation, continuously revisiting places we think we know. When we think we've already seen it all, our awareness and our brains shut down; we can actually stop seeing what is truly there. This world around us is constantly changing. Things we take for granted may actually not be permanent, but how would we know if we stopped paying attention?

We often create more questions than we answer . . .

Trying to see mammals and some birds, or even evidence of them, can be a very humbling experience. They are masters of camouflage, and more and more, I think that they always know where I am, while I don't know where they are. Increasingly, I believe that they only allow us to see them when they are ready to reveal themselves. Maybe we need to condition ourselves to a certain level of respect before we are worthy of their sight. We need to work for the common respect before they will welcome us and allow us the benefit of their lessons and secrets.

For years, I have listened to the springtime song of the hermit thrush, in the distance in the forest. It is an ethereal, flute-like song, drifting lazily through the early morning light, or the late afternoon sunshine. About three years ago, I tried for several weeks to catch a glimpse of the hermit thrush, without success. It is a secretive bird. One early afternoon this past spring, I was napping in the sun on my porch, and opened my eyes to see a hermit thrush perched nearby. In my excitement, I tried to be still so as not to startle it, and received the gift of watching it feed for several minutes before it got nervous and returned to the cover of the forest. Throughout the next two weeks, I encountered hermit thrushes every day while traveling to and from my sit spot. What accounts for this difference of experience? My own state of mind? The time of year? Neither or both? This is the irony of the practice: we often create more questions than we answer, leading ever closer to something we can never see, but can only sense.

Design solutions

The search for the hidden and elusive aspects of the land's residents is a metaphor for seeking the earthly understanding of your local ecological processes for use in design. In my experience, my awareness of it unfolds when I am ready to see it, and not a moment sooner. One approach to site assessment is to make lists of the organisms and site conditions, and maybe maps

show where they are, but these are only part of the important icture for permaculture designers. While awareness exercises an give a context and toolset for observing nature, the difficult ork of synthesizing that data into useful information is the ecessary next step, and takes time. It requires the difficult work f trying to answer "why" questions: Why do deer sleep in the racken fern, but not right by the creek? Why do I only see the otted towhee in the brush by the house? Why does wild iris ow at the edge of the forest? What conditions are being met to low these things to happen? What do these things highlight out what is important for design? Do they ow warm or cold spots, moist or dry areas, ighly productive and diverse habitats that ould remain undisturbed, places that could se a little support or restoration? We will kely have a difficult time of finding efinitive answers, but we can get to the earby vicinity, which can yield valuable formation to guide our design ideas.

Awareness practice is a very qualitative xperience. I want to be careful not to iscount quantitative aspects as well, and ave dabbled in some of these methods, such s collecting rainfall data, collecting inimum/maximum temperature data, and nalyzing soils. There is an important place in ssessment for these types of information, nd they can give us a deeper perspective on he answers we seek. However, I believe that we are seeking to connect our livelihoods ith the current dwellers in our habitats, we lso need a subjective experience of our non-uman neighbors and the conditions that they ve with and why, to inform our designs.

The process continuum

This practice is an ongoing one for me and a key element in my permaculture practice. will never be "finished." With this formation, I will create designs to the best f my abilities and then continue observing eir effects and the level of integration with e landscape they achieve. Based on that edback, I will make new designs. In this ay, observation and assessment become ols of adaptation, sustaining a connection ith the non-human residents and energy ows on site. As I write, the spotted towhee is alling, and I am curious why, so I will enture out into the spring rain to find out. Δ

ESOURCES: For more information about e Thanksgiving Address or training in these ethods of practice, see the following:

* Tree of Peace Society: www.treeofpeacesociety.info/index.html
* Wilderness Awareness School and the Kamana Naturalist Training Program: www.wildernessawareness.org

Amanda Malechesky is a permaculture designer living in Northern California. She is currently beginning the assessment process on a new, 50-acre piece of land near the village of Petrolia. She holds a MA in Ecological Design from Prescott College.

Fungi, like this turkeytail, can reveal physical and chemical processes in organic matter and soils.

Cooperating with the Garden

The Purpose of Weeding is *Not* to Eliminate

Brigitte Norland

SPRING ARRIVES, and with it the emergence of millions of exuberant new seedlings and shoots. The gardener taps into the dynamic of the season by sowing and planting but faces the dilemma of weeding to ensure the survival of the new plants. One possibility is not to weed, ever, and to enjoy the Earth's re-clothing in the microcosm of the garden (and to be constantly surprised at what is waiting to establish itself). But, for most of us, discerning action has to be taken to ensure that food, flowers, and foliage flourish.

Bare earth is never bare for long and a sprinkling of cotyledons (the first 'leaves' of a germinated seed) appear within a few days of spring warmth. That is the time to stroke the earth with a hoe or rake: just enough to disturb the surface of the soil and uproot the first tiny germinations. Let them grow on and it will be necessary to hoe more deeply, relying on the power of the sun to dry off the young plants on the soil surface. Leave it longer, as I usually do, and a basket or barrow will be needed to carry away the enveloping mounds of foliage, flower, and seed!

Weeding is one of my greatest pleasures: it tells me about the condition of my soil, handling the plants that self-seed in our garden brings me great delight in their diversity of form, and I also learn from them what to grow there myself.

Weeds are storytellers of soil and microclimate

Identifying the species that emerge on the bare ground gives an indication of the health of your soil and what will flourish as well as what could be done to improve things. Carpets of chickweed indicate a nitrogen-rich area, as do nettles. Spurge *(Euphorbia spp)*, groundsel *(Senecio vulgaris)*, fat hen *(Chenopodium album)*, and speedwell *(Veronica spp)* will make do with poorer soils. Feeding the soil makes them easier to weed out as they develop into bigger plants before seeding. Sow-thistle *(Sonchus spp)* has accompanied humans on all their migrations, appearing everywhere land has been cultivated, and like groundsel, it flowers at any time of the year. It evades the slice of the hoe and breaks when you pull it, but along with docks and cleavers it indicates a good soil, capable of growing anything.

All these plants support insect life and indicate the folly of the desire for control; the purpose of weeding is not to eliminate, but to enter into a spirit of co-operation. Plant roots secrete as well as absorb and create a lively interchange within the soil. Above-ground diversity creates a community of insect life where predator and prey coexist in a self-maintaining web, in which we participate and observe.

Over the years it has become easier for me to weed without battling, to savour the experience, knowing each weed brings something unique out of the earth to enrich the compost heap. Naturally, there is always more weeding to be done, grounding me in a sense of the infinite.

Our garden is old; it has been cultivated for centuries and carries a store of weeds associated with human usage, from the spurges, chickweeds *(Stellaria media)*, speedwells, and buttercups *(Ranunculus spp)* in the vegetable garden to the deep tap-rooted hogweeds *(Amaranthus spp)* and the mats of ground elder in parts of the ornamental garden, now returning to woodland. In between, couch grass *(Agropyron repens)*, marestail *(Hippuris vulgaris)*, and bindweed crown a host of other colonisers whose presence is less than welcome.

Often considered a weed, dock (Rumex spp) *readily grows in disturbed and poor soils, is a dynamic accumulator of soil nutrients, builds soil structure, and is edible. (Photos: Keith Johnson)*

Weeding from the ground up is reserved for the vegetable garden; everywhere else, cutting, pulling, and mulching suffice. Hogweed and thistles *(Cirsium spp)* give up when each flowering stalk is cut; docks can be restrained though not eliminated with the same treatment; marestail is deeply compromised when pulled a couple of times in its growing season; and couch is easily controlled with forking out when the soil is reasonably dry. This can even be in the winter, in a dry, cold spell, which is also the best time to unearth the fat, white rhizomes of the greater bindweed. The smaller bindweeds need persistent pulling.

Ground elder is the one weed whose ascendancy is uncompromising, and so it is better mowed. Since our garden is large I no longer attempt to cultivate its areas of colonisation—there is plenty of ground to begin again somewhere else. In other places the tree and shrub canopy has become more dense and the ground elder mat has become thinner and less obvious. There are plants that co-exist with ground elder: a patch of trilliums is slowly spreading under the ground elder whose flower spikes I pull each spring. Elsewhere it continues to grow through the

vinter and one leaf may betray the presence of roots over several square feet.

If you need the ground where ground elder is rampant, eliminate light and water by covering it with black plastic sheet. After a growing season the plant is severely weakened and you can then dig the dry soil carefully, taking everything out bit by bit, watching for the tiniest piece to re-emerge. Time and persistence will always effect a result.

Weeding is one of my greatest pleasures: it tells me about the condition of my soil. . .

In contrast to my feelings about ground elder I think of nettles *(Urtica dioica)* as a gardener's friend. True, they hurt to handle, and an old clump can be tough to dig out, but where nettles grow the ground is in good heart. In spring their first shoots make a delicious soup, in summer their cut wands add heat to the compost heap, and their beautiful golden roots, while extensive, are not immortal as with other perennial weeds. Like so many of our indigenous plants they are a host to insect life and have a medicinal action.

Dandelions *(Taraxacum officinale)* are another magnificent phenomenon, their detoxifying tap-roots drawing up nutrients from the subsoil, their edible leaves and beautiful rich yellow flowers a joy for April. Bittercress, fat hen, sorrel *(Rumex acetocella),* and chickweed make a late spring salad, and there are many other edible weeds I have not yet tried.

Since the garden is old, it has some very well-established inhabitants easing out of their original places as well as emerging from the seed bank of the soil; lemon balm *(Melissa officinalis)* and Michaelmas daisies *(Aster spp)* fall within this group. By the beginning of June my best friend in the garden is a small well-sharpened hook, curtailing the flowering and seeding of annual weeds but also renewing clumps of lemon balm to give a fresh growth of scented leaves. The Michaelmas daisies are prone to mildew and sow themselves everywhere, eventually reverting to a rather grey flower. I keep an eye out for the dull clumps and pull; their roots are superficial.

Plots with personality

The garden has an identity of its own, and the concept of weeding becomes the spirit of serendipity; the joy of responding to the life of another being. Without intentional intervention on my part, it generates patches of foxgloves *(Digitalis spp),* mulleins *(Verbascum spp),* poppies *(Papaver spp),* evening primrose *(Oenethera biennis),* white herb Robert, and marigolds *(Tagetes spp).* Since we have introduced them, Himalayan balsam, ox-eye daisies, Scotch thistles, purslane, and hypericum all seed to exuberant effect. Less prolific are hollyhocks *(Alcea rosea)* and sages of various types.

When last year's onion patch became this year's pumpkin patch, some lupin seedlings were spared and grew too big to move, and a hollyhock developed a ten-foot spire, encircled by a dozen spikes of clear rosy pink. It is hard to negate such optimism in their own survival by transplanting potentillas, feverfew, clary sage and even buddleia and rue from the vegetable garden to the flowering border. Whilst seedling recognition becomes compulsive, sparing errant self-seeders brings much joy. Δ

Bindweed (Convulvulus arvensis)

Brigitte Norland lives and gardens in Devon, England. This article originally appeared in the March/April 2006 issue of Resurgence *magazine (www.resurgence.org) and is reprinted here with permission.*

Terra Incognita Revealed

Mysteries of the Soil Food Web

Bart Anderson

We know more about the movement of celestial bodies than about the soil underfoot."

—Leonardo da Vinci

"Any sufficiently advanced technology is indistinguishable from magic."

—Arthur C. Clarke

"MAGIC" IS HOW HUMANS have customarily described the soil's natural cycles of decay and growth. Without scientific understanding, our ancestors relied on observation and tradition to grow crops.

Modern science has been little better at understanding the soil. Unable to comprehend the natural cycles of fertility, but determined to achieve control, industrial agriculture bypasses biology with synthetic fertilizers and pesticides. Despite the outward successes of modern agriculture, its heavy-handed approach brings with it pollution, soil degradation, and other ills.

In contrast, organic methods like permaculture emphasize working with natural cycles. Many insights and successful practices have emerged, yet a widely accepted and rigorous scientific model is still lacking. The research of Alan Smith showing the linkage between tillage and soil infertility (1) has been too little known—along with the vital role of anaerobic bacteria in mobilizing nutrients at root microsites. And though permaculture teachers rightly base the practice of soil mulching on this science, a more complete picture of soil biology has remained elusive.

Recently, however, soil ecology has developed to the point where we can open the lid on the black box of underground processes. As a consequence of new discoveries, it is no longer just compost-lovers who are excited about soil. The respected journal *Science* devoted an issue to "Soils: the Final Frontier" (June 11, 2004), saying: "In many ways the ground beneath our feet is as alien as a distant planet. The processes occurring in the top few centimenters of Earth's surface are the basis of all life on dry land but the opacity of soil has severely limited our understanding of how it functions... However, perspectives are beginning to change... Interest in soil is booming, spurred in part by technical advances of the past decade."

We can now begin to understand how micro-organisms maintain the structure and fertility of the soil. Symbiotic relationships between plants and micro-organisms are not the exception but the rule, a rule that modern agriculture ignores at its peril.

Waiting for Dr. Ingham

It's a chilly winter day at the San Mateo Garden Center in Northern California. Several dozen of us are drinking tea and coffee, waiting to hear soil microbiologist Dr. Elaine Ingham talk on the soil food web. We're drawn by the promise that by understanding soil ecology, we can grow healthier plants without relying on pesticides and synthetic fertilizers. In the long run, we're told, it will be cheaper and easier.

It is no longer just compost-lovers who are excited about soil.

Actually most of us don't have to be convinced—we're a cross-section of greenies from the San Francisco Peninsula: landscape designers, horticulture teachers, nursery owners, master gardeners, master composters, and permaculture activists. We know Ingham's reputation and are here to listen to the master.

At last Dr. Ingham steps to the front and we're off. For the next two days we are inundated with dense, high-intensity information that's very different from the usual. It's like having your head unscrewed.

She's the kind of professor you wish you'd had in college. She loves her subject and invites you to share it with her.

Much of the talk around organics is vague—but not with Dr. Ingham at the helm. Ask a question or raise an objection, and she'll come back with a detailed response, complete with references in the scientific literature. As we say in the master gardeners program: "science-based gardening advice."

Ingham has been researching soil microbiology for over 25 years, having received her PhD in 1981. She taught at Oregon State University (Corvallis) from 1986 to 2001. She left academia to devote herself to Soil Foodweb, Inc., the consulting and testing service she started in 1996. She has published over 50 articles in

refereed journals.

Years spent peering through a microscope have given her a perspective that is best described as different. As one aside, she remarked that humans, if viewed from outer space, would bear a remarkable resemblance to rod-shaped bacteria. As with many good biologists, she has an affection and respect for the organisms she studies.

She also has a gift for apt metaphor that makes technical concepts come alive:

- Pests and diseases are "garbage collectors" which take away stressed plants growing in the wrong habitats.
- When adding water to compost, follow the "Goldilocks Principle" (not too little, not too much—just the right amount).

After several days of lectures, I had taken over 100 pages of notes and was in danger of getting lost in the details. How to summarize Ingham's message? Here's an overview:

Life on earth is sustained by a complex underground ecological system—the soil food web.

Through ignorance, we've disrupted this food web, in particular with ill-advised farming and gardening methods.

We can return the food web to health by restoring the soil biology.

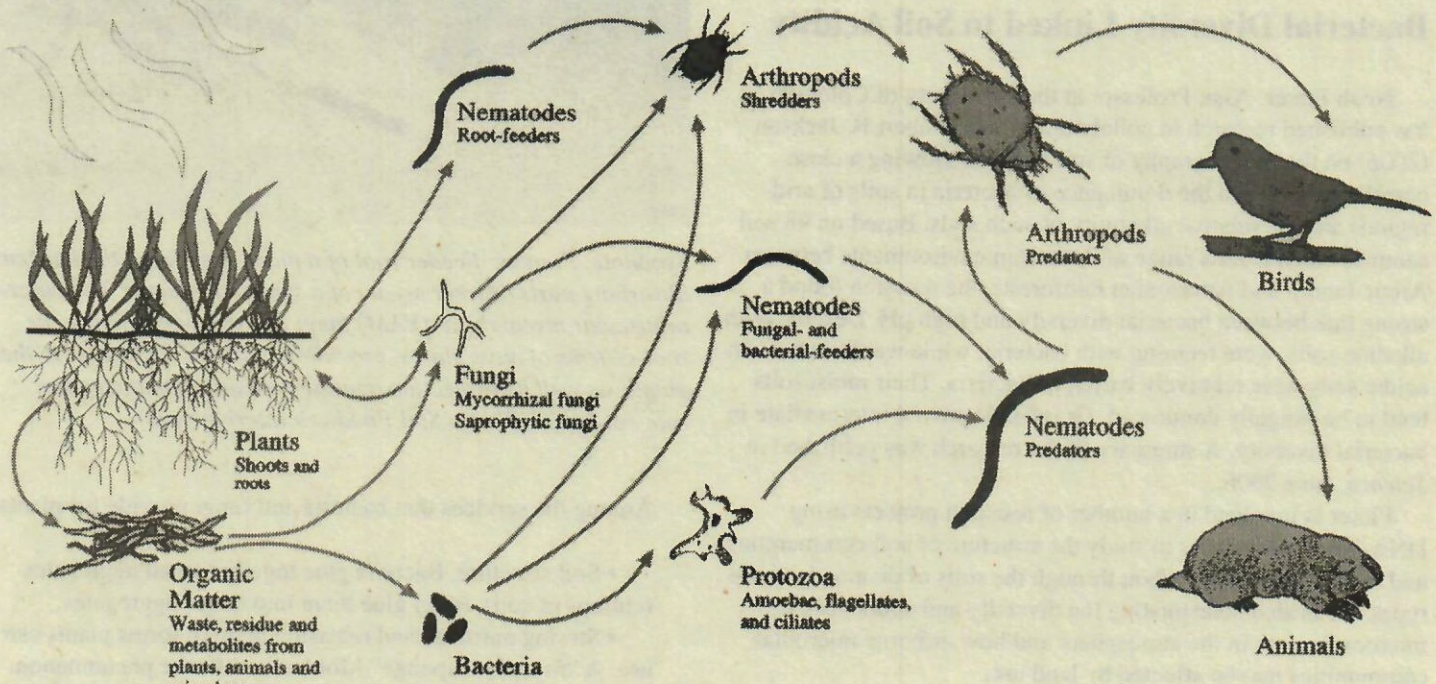
The picture of the soil food web that Ingham presents seems to be widely accepted. Rarely, however, are the ideas synthesized into a coherent whole. No wonder. The concepts come from many different fields—microbiology, ecology, soil science, and agronomy. Specialists absorbed in their own fields often find it difficult to see the big picture.

Beyond the big picture, Ingham does differ from other scientists. She has a higher level of passion than one expects in academia. Also, some of her specific methods and recommendations are unconventional. For example, she and her associates developed methods of assessing soil health by making direct counts of organisms under a microscope. Among the public, she is probably best known for advocating the use of aerobic compost tea.

The rest of this article gives highlights from Ingham's presentations, then discusses the implications of her vision. To learn more, see the list of resources at the end of this article. Especially recommended is the *Soil Biology Primer*, which Ingham co-authored.

Soil food web

Learning about the soil food web is like entering an alternate reality. We see the results of the microbial world in processes of decomposition, in foods (wine and cheese, for example), and in diseases. However the microbial world operates with huge numbers and at a scale that is disturbingly alien. One handful of good garden soil can contain more organisms than the number of human beings who have ever lived: one trillion bacteria (10^{12}), 10,000 protozoa, 10,000 nematodes and 25 km of fungi, according to Young and Crawford in *Science* magazine. As far as alien-ness, let's not even talk about bacterial sex!



I had known the numbers were high and thought that the picture was hopelessly complex. What I learned, though, is that the organisms in the soil belong to a manageable number of functional groups. These can be studied and we can make generalizations about them. Ingham's colleague, Andrew Moldenke, says: "All soils everywhere comprise the same basic critter groups. What's different about a desert, the tundra, a rainforest, or a cornfield are numbers (relative densities of critters)."

The concept that ties the different groups together is the soil food web.

Energy and nutrients are passed as one group of organisms feeds on another. At the bottom level of the food web is the decaying organic matter in the soil that ultimately came from plants. Roots are a source of nourishment for some organisms. Feeding on the organic matter are bacteria, fungi, root-feeding nematodes (microscopic round worms), and other organisms. Feeding on them are the first-level predators such as protozoa (one-celled organisms like amoebae), some species of nematodes, and arthropods ("bugs" with jointed legs like mites and insects). Above them are higher level predators such as those pictured on page 11. Even in this highly simplified diagram, you can see the multiple interconnections characteristic of a food web.

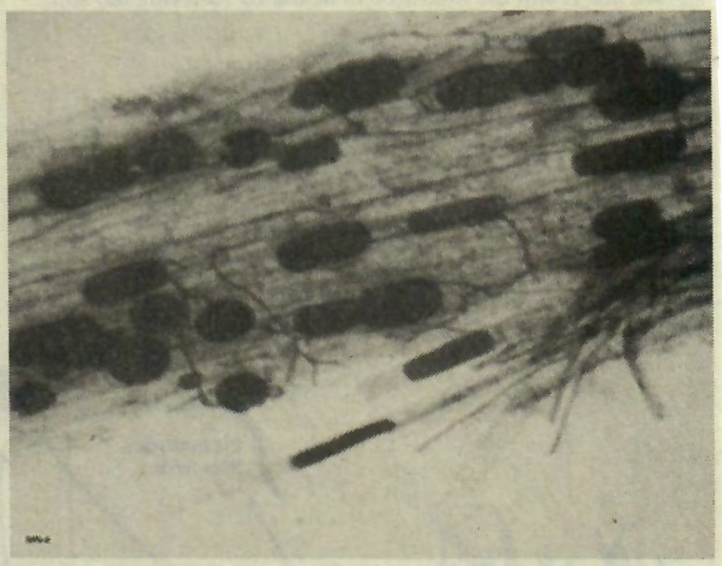
Decomposers and mutualists

The stars of the underground are bacteria and fungi. Bacteria are small bundles of protein containing a high portion of nitrogen. They're "like power plants," according to Andrew Moldenke. If the nutrients they need are "at the precise site of the bacterium, then bacterial metabolic rate is unequaled. But everything has to be present, just like the coal and oil at a power plant."

In contrast, Moldenke describes fungi as being "like railroad systems. They are immensely long systems of threadlike hyphae that can mobilize carbon from one region, nitrogen from another region..."

Before learning about soil ecology, I had thought that bacteria and fungi were bit players. Some caused plant diseases, I knew, but the rest seemed innocuous and uninteresting. Several things Ingham said made me realize how wrong I was.

- Bacteria and fungi evolved one billion years before plants, according to Ingham. Since plants developed in a world already inhabited by bacteria and fungi, doesn't it make sense that they would evolve to take advantage of those micro-organisms?
- About 80% of plants have fungi associated with their roots (mycorrhizal fungi). That figure is from *Science*. Others say more. Something about the plant-fungal relationship must be extremely important for it to be so widespread.
- Plants can release through their roots as much as 20% of their photosynthetic production. (Figure from *Science*; Ingham quotes higher numbers. Why would plants make this substantial investment, unless they were getting something vital from the bacteria and fungi attracted by these foods?



Symbiotic Fungus: Feeder root of a plant containing the nutrient-absorbing parts (darker areas) of a symbiotic fungus. Vesicular-arbuscular mycorrhizal (VAM) fungi like this one colonize the root systems of most plants, providing nutrients and water to the plants, as well as protection against parasitic nematodes and root-rot fungi. (Photo: Soil Foodweb International)

Among the services that bacteria and fungi provide for plants:

- Soil structure. Bacteria glue together small aggregates (clumps of soil); fungi glue them into larger aggregates.
- Storing nutrients and releasing them in forms plants can use. A "microbial sponge" Moldenke calls the phenomenon. One way micro-organisms do this is by incorporating nitrogen

Bacterial Diversity Linked to Soil Acidity

Noah Fierer, Asst. Professor at the University of Colorado, has published research in collaboration with Robert B. Jackson (2006) on the biogeography of soil bacteria showing a close correlation between the dominance of bacteria in soils of arid regions and the relative alkalinity of such soils. Based on 98 soil samples taken from a range of American environments between Arctic tundra and Amazonian rainforests, the research found a strong link between bacterial diversity and high pH. Deserts, with alkaline soils, were teeming with bacteria, while wet forests, with acidic soils were relatively barren of bacteria. Their moist soils tend to be fungally dominated. Grasslands proved intermediate in bacterial diversity. A summary of the research was published in *Science,* June 2006.

Fierer is involved in a number of research projects using DNA-based techniques to study the structure of soil communities and the movement of carbon through the soils of diverse land use types. He is also investigating the diversity and abundance of microorganisms in the atmosphere and how airborne microbial communities maybe affected by land use.

http://www.colorado.edu/eeb/EEBprojects/FiererLab/

and other nutrients in their own bodies—a much less leach-prone form than if the nutrients were in their inorganic forms.

• Protecting plants against diseases and pests. Beneficial bacteria and fungi out-compete pathogens and occupy potential sites of infection on the plant.

One of the most intriguing portion of the soil is the "rhizosphere"—the soil around the plant roots. It's a zone of intense activity, with bacteria and fungi attracted by the sugars, carbohydrates, and proteins exuded by plant roots.

Ingham uses striking images to describe the process. Noting that the exudates contain the same basic ingredients as used for baking [sugar, carbohydrates (flour) and protein (eggs)], she calls them "cakes and cookies." No wonder they're attractive.

The bacteria and fungi attracted to the roots are "the white knights fighting off the bad guys."

Moldenke describes fungi as being "like railroad systems. . . ."

Fungal vs. bacterial soils

Moving back from the microscopic view, the distinction between fungi and bacteria has practical consequences for farmers and gardeners. Different plant communities have different ratios of fungi to bacteria.

Bacteria dominate soils in early successional communities such as bare earth, weeds patches, and vegetable gardens. For flowers and most row crops, fungi and bacteria are in equal balance. Soils of late succession communities such as shrubs and trees are dominated by fungi.

Knowing the optimum bacteria/fungal ratio for the crop you're raising, you can employ different practices to encourage one or the other. Tilling or digging, for example, favors bacteria over fungi. (Most farmland is bacteria-dominated.) Ingham suggests applying compost that is right for the plants you are growing, such as fungal-dominated compost around fruit trees (very fungal around conifers) and bacterial for grass. To build soil, she says, encourage fungi.

Predators, engineers, taxicabs, and shredders

Larger organisms play a variety of roles in the soil food web. Many are predators who keep prey populations in balance. Some of the large organisms, especially earthworms, are "engineers," improving the architecture of the soil by creating air passages and hallways with their burrowing.

Micro-arthropods are "taxi cabs" for the less mobile smaller organisms such as bacteria, helping them spread throughout the soil and onto leaf surfaces. In this way, they bring bacteria to where the nutrients are.

Andrew Moldenke points out that some arthropods shred dead plant parts, so that their nutrients become accessible to bacteria.

Restoring the soil food web

Unfortunately, scientific knowledge of the soil food web has only arisen in recent decades. We haven't appreciated what the soil food web can do for us, and Ingham says that many of our common practices degrade it:

- Compacting the soil.
- Tilling, turning and digging
- Pollution
- Pesticides
- Synthetic fertilizers

The degraded food web invites disease, pests, and nutrient problems. In a vicious cycle, we attack the problems with chemical solutions which further degrade the food web.

The solution, according to Dr. Ingham, is to restore and enhance the soil biology. In her words:

"Over the last 50-60 years, the attitude has been to get rid of the bad guys through pesticides, not understanding that if you destroy the bad guys, you also get rid of the good guys. When we nuke soils and destroy life, what comes back are the bad guys.

"Put your workforce back into place. They don't need holidays. Just make sure they're in your soil and feed them. ... Our job is to make sure there is a diversity of micro-organisms, so plants can choose which organisms they need."

Monitoring the soil life

The first step in restoring the soil biology is being able to diagnose it. Since we can't look at the soil food web directly, we must rely on indirect methods. Some have suggested nematodes and springtails as indicators of soil health.

As a scientist, Ingham advocates a "direct count" method, in which individual organisms in a sample are counted under a microscope. Following a protocol, a trained technician counts the number of different classes of organisms (bacteria, fungi, and protozoa, for example). The result is a report on the organisms estimated to be in the sample. The numbers indicate possible problems in the soil. For example, a high number of ciliates (a group of protozoa) suggests anaerobic conditions that are harmful to plant life.

Other researchers have used plate counts. A soil sample is placed in a growth medium like agar, typically in a Petri dish. The number of bacterial or fungal colonies that grow from a soil sample are then counted.

Ingham maintains that this method grossly underestimates the number and variety of soil organisms. She says that the method was designed to detect and grow human disease organisms such

as *E. coli.* In contrast, soil organisms need different conditions than the laboratory setting and growth media can provide. Only about .01 percent of soil organisms can be detected with traditional plate counts, she estimates.

Compost

Restoring soil biology requires a source of micro-organisms, and compost is ideal for that purpose. The compost should have a huge species diversity. Not just bacteria but fungi, protozoa, nematodes, and microarthropods, as well as organic matter for them to feed on. The compost should be made locally, so that its soil biology is similar to the soil on which it is applied.

To people already involved with compost, Ingham's discussion on compost-making should be familiar, if more rigorous than the usual. Most of her information comes from an Austrian family, the Luebkes, who developed the Controlled Microbial Composting (CMC) method. CMC is a thermal (hot) method, which involves frequent turning and close monitoring.

Fungal Strands in Compost: Not all the life in the soil food web is microscopic. Some fungi can be seen with the naked eye, as can earthworms and arthropods (such as insects, spiders, and centipedes). (Photo: Soil Foodweb International)

You can control the fungi-to-bacteria ratio of the compost by the raw materials you start with, and by your methods. Frequent turning, for example favors bacteria, since every time you turn a compost pile you "slice and dice" the fungal hyphae.

One thing you learn quickly about compost from Ingham: Aerobic GOOD! Anaerobic BAD!

Anaerobic bacteria—those that thrive at low levels of oxygen—are on her list of "bad guys." Some are pathogens. The foul-smelling compounds produced under anaerobic conditions are bad for plants. Bad compost has foul odors like:

- rotten eggs (hydrogen sulfide)
- sour milk (butyric acid)
- decaying flesh (putrescine acid)
- vomit (valeric acid)
- ammonia
- vinegar (acetic acid)

Just reading the list of smells is motivation enough to keep a pile from going anaerobic.

In addition to thermal compost, Ingham's presentation covers static (cold) compost and worm compost, which she recommends highly.

Compost Tea

A keystone of Dr. Ingham's approach is compost tea (CT), made by soaking compost in water. It's a convenient way to apply organisms that have grown in compost. The effect is similar to using solid compost, but it's easier to transport, and it's the only way to apply compost organisms to leaves (foliar application).

One disadvantage is that compost teas lacks the solid organic matter contained in regular compost. Without this food for the micro-organisms, the effects of CT do not last as long (five months of biology vs. five years with compost, says Ingham).

Compost teas are not a recent invention. Ingham says they have been used in traditional agriculture since before the Roman Empire. With the chemical era, compost tea was dropped, probably because the results were variable.

Many different kinds of compost tea exist, including leachates, manure teas, anaerobic teas, and passive aerobic teas. What Ingham studies and recommends is one particular variety: actively aerated compost tea (AACT). Conditions are kept aerobic by agitating the liquid or with a bubbler.

Actively aerated teas brewed from good compost make for results that can be duplicated, she says. Traditional teas, made without aeration, have variable results. And if compost tea goes anaerobic, you've lost most of the aerobic micro-organisms. On the other hand, she said she was interested in studying anaerobic teas and their possible benefits.

Machines for brewing compost tea in various sizes are available from manufacturers. *"Caveat emptor,"* (Buyer beware) Ingham says. She encourages people to read reviews and ask for data from the manufacturers. You can also make your own brewing apparatus. Ingham wrote an article explaining how to brew CT for *Kitchen Gardener* magazine.

Some of the hints proferred by Ingham for good tea:

- Good compost
- Good (potable) water without chlorine or chloramine
- A good brewing machine, easy to clean
- Appropriate temperatures
- Appropriate food for desired organisms
- Brewing times variable (about 24 hours)
- Prompt application

To encourage bacteria, add bacterial foods like sugars. For more fungi, add fungal foods like humic acid, corn meal, oatmeal, and fish hydrates.

Brewing Compost Tea: Permaculturist Alane Weber in the middle of a compost tea brew cycle. She's checking the smell ("Very important!" she says) and the flow in and around the mesh bags holding the compost. The brewer is a 100-gallon model from KIS, and is located at Lyngso Garden Materials, Redwood City, California. (Photo: Rick Weber / Botanical Art)

One question that puzzled me was how micro-organisms stay on plant leaves after a foliar application of compost tea. Dr. Ingham replied that bacteria quickly make slimey glue to stick to surfaces," so they aren't washed away.

Perspective on the Soil Food Web

Is compost tea the answer?

The part of Ingham's approach that has aroused the most enthusiasm has been compost tea. It promises all the benefits a healthy food web can bring—resistance to pests and disease, better yields, more vigorous plant growth, etc. Many compost tea users seem to be happy with the results.

On the other hand, skeptics point to the paucity of scientific validation and are dubious of claims that compost tea is a cure-all. Some are suspicious of the commercialization of the process.

Dr. Ingham wisely points out the limitations of compost tea: "Compost tea is not a 'silver bullet' for the problems in your yard. Other practices, such as organic fertilizing, soil amending, mulching, etc., are also important to build and sustain a healthy garden. The soil, environmental, and prior chemical conditions of your yard all play a role in its overall health."

So far, most of the evidence for the effectiveness of compost tea is anecdotal, she says. She doesn't have replicated scientific studies, adding that such studies require money and resources. However, she does point to scientific studies which confirm the underlying concepts of the food web.

Determining the effects of compost tea may be complicated by the many variables in the process:

- Many preparations have been called compost tea, and the brewing process has many variables. Dr. Ingham has provided details on what she means by compost tea.
- The biology (micro-organisms) in the compost tea is wildly variable. Adding sugars or fungal food will change the fungi:bacteria ratio. If compost is non-local, the resulting tea may not contain organisms adapted to the environment.
- Nature of the plant problem and the environment. For example, soils with few micro-organisms would seem to respond more dramatically to compost tea than those soils with a thriving food web.

A second difficulty is that the effects of compost tea are probably indirect rather than direct. For example, a pesticide or antibiotic tends to have a direct action on the target, perhaps by disrupting a key biological process. In contrast, a compost tea might provide resistance to disease by adding organisms that would occupy potential infection sites.

It seems rather early in the study of compost tea to make categorical pronouncements. We should remember that many organic methods that are now accepted, such as compost and non-chemical pest controls, were derided when first introduced.

With our new understandings of soil ecology, the opportunities for investigation are wide open—not only for compost tea, but for other organic and traditional practices.

Chemical and environmental models

The soil food web gives a firmer scientific foundation for the ecological view of agriculture. The table below highlights the differences between the conventional or chemical model and the ecological model.

Conventional/chemical	**Ecological**
A mechanical model:	Natural cycles:
• Inputs: fertilizers, pesticides	• Nutrient recycling
• Outputs: crops	• Natural checks and balances
• Problems: pests, diseases	• Pests seen as symptoms of underlying problems
• Side effects: pollution, wastes	• Waste from one process is food for another
• Simple systems (e.g. monocultures)	• Complex systems (biodiversity)

Many ecological ideas have been incorporated into conventional gardening and agriculture. For example Integrated Pest Management (IPM) has become part of many Ag Extension programs. (see the the IPM website and the manual *Pests of the Garden and Small Farm* from University of California).

One can imagine a combination of the two models, in which environmental thinking prevailed but chemical solutions might be used on a temporary basis for particular problems. Dr. Ingham, while fiercely opposed to the overuse of chemicals, admits that in a few cases they may be necessary as a first step in restoring some farmlands.

A shift to a more ecological agriculture may happen sooner than we think.

End of the chemical era?

A shift to a more ecological agriculture may happen sooner than we think. And the reasons may be economic and political rather than environmental.

Modern agriculture developed during the 20th century, a period of cheap energy. Oil and natural gas have been abundant, and our current food system uses both freely. Estimates are that it takes ten or more calories of fossil fuels to grow one calorie of food. Food writer Michael Pollan says that the American diet with its emphasis on corn and corn products is really an oil diet:

"Corn is the SUV of plants. Growing it the way we do requires it to guzzle fuel in the form of fertilizer, about a quarter to a third of a gallon of petroleum for each bushel." (Interview from the UC Berkeley News Service)

The basis of modern agriculture is nitrogen fertilizer manufactured by the energy-intensive Haber process. Since its invention in the early 1900s, the Haber process has helped avert famines as world population rose from two billion to 6.6 billion. Making this fertilizer requires 1% of the world's energy supply, estimates *Science* magazine. (Natural gas is the usual feedstock for fertilizers; petroleum is the feedstock for many pesticides.)

Arguments aside about its successes and shortcomings, modern agriculture needs cheap fuels. Without them, it is in trouble.

Are we facing energy shortages? An increasing number of people think so. The followers of Peak Oil believe we will soon reach the peak of oil production, after which supplies will shrink and prices will go up and up. David Holmgren and others in permaculture are talking about "energy descent"—preparing for a low-energy future. Even members of the U.S. elite are worried about disruptions to the oil supply; their number includes ex-Fed Director Alan Greenspan and ex-CIA heads James Schlesinger and James Woolsey.

Supply distruptions can happen whether or not oil production has reached its peak. When the Soviet Union disintegrated in 1989, Cuba lost its source of cheap oil and other imports required to maintain its conventional, chemical-based agriculture. It got through the crisis by turning to organic methods and restructuring its large-scale farms. (See article in *Permaculture Activist* #59).

In an era in which oil, natural gas, and energy in general will probably become more and more expensive, it would seem prudent to develop an agriculture that is not so dependent on them. Soils, plants, microbes and water are everywhere. The processes of ecological agriculture may be tricky (for example, the turning and monitoring of compost), but they are do-able, and they don't require imports from far-off countries.

What to do?

Assuming the scientists are right and the soil ecology picture is correct, what next?

As a start, let's make soil ecology a part of the culture. If people don't know about the soil food web, they won't value it. Are there any visionaries who can see this as a subject for science fiction or children's books? It will take imagination, since ciliates and springtails don't have the cuddle factor of baby mammals. The BBC aired an example of what is possible, in their wild radio segment "Soil Safari" available on the Web.

Some good basic texts would be helpful. The subject cries out for photos, figures, and diagrams to make the concepts vivid. The *Soil Biology Primer* is a good example of what can be done. Generalizations should be linked to supporting studies, so we can sort out myth from science.

A knowledge of micro-organisms and the environment will be increasingly important in public debates. Although this article has only discussed gardening and agriculture, soil ecology plays a part in global warming (healthy soil sequesters more carbon), in trawling and disturbance of the ocean floor, in invasive organisms, and in restoration ecology. A few popular science books on soil ecology have been published (see List of Resources), but more are needed.

As I researched this article, I kept hoping to see more work by agricultural extension researchers. They have the resources to do the research and education we need. We can hope they'll adopt soil ecology, as they previously took up Integrated Pest Mgmt.

For permaculturists and organic gardeners, the news about soil ecology should be gratifying. Many of our practices have a scientific basis and are good for the soil food web. The way is now open for more research and experimentation.

Learning more

An article, a set of CDs or even a weekend seminar can do no more than scratch the surface of soil ecology. However, excellent resources are available online and in print.

A good place to start is the *Soil Biology Primer*, an inexpensive ($15) 48-page booklet with clear explanations and vivid photographs. Elaine Ingham is one of the co-authors. You can read the book online, but the printed version is much easier to follow (and the pictures are better!).

Dr. Ingham makes much information available free on the website of her organization, Soil Foodweb, Inc.: http://www.soilfoodweb.com/. A good entry point is "The Soil Foodweb Approach." The website also has details on CDs, classes, and other services.

A knowledge of micro-organisms and the environment will be increasingly important in public debates.

Most gardening books don't cover soil ecology well. Either they skip over it completely, or speak in vague mystical terms. Exceptions include chapters in the permaculture-oriented *Edible Forest Gardens* by Dave Jacke with Eric Toensmeier; and *Gaia's Garden* by Toby Hemenway.

A book to look for is *Teaming with Microbes: A Gardener's Guide to the Soil Food Web* by Jeff Lowenfels, due out August 15, 2006.

Two popular science books give background on soil microbiology and the environment: *Under Ground: How Creatures of Mud and Dirt Shape Our World* by Yvonne Baskin and *Tales From the Underground: A Natural History of Subterranean Life* by David W. Wolfe.

To get deeper into the science, see "Soils: the Final Frontier" a special issue of *Science* magazine (June 11, 2004). More science references are available from Elaine Ingham's website (SFI: Recent academic and popular information sources). Several scientific journals and textbooks are devoted to soil ecology. For an extensive list of links, see the Web version of this article.

Soil food web in brief

To Review—

- **Soil food web—basis for life on the land.**
  - o Breaks down dead plants and animals; recycles nutrients.
  - o Numbers and varieties of organisms are staggering.
  - o Reproduction rates are high (especially bacteria), and populations tend to boom and bust with different levels of oxygen, nutrients, heat, pH, and water.
  - o Complex ecological relationships.

- **Soil food web is composed of several classes of organisms.**
  - o Plants—roots and organic matter from plants.
  - o Bacteria and fungi—many varieties and functions. Most are decomposers, while many others are mutualists.
  - o Other members of the food web—protozoa, nematodes, arthropods, earthworms, and higher predators.
  - o Predators eat other organisms and make nutrients available.

- **Soil food web is important for plant growth**:
  - o Builds soil structure.
  - o Stores nutrients and releases them in forms plants can use.
  - o Protects plants against diseases and pests.
  - o Can tie up salts and harmful chemicals.
  - o Provides resilience and adaptation to changing conditions.

- **Some bacteria and fungi form mutualistic associations with plant roots. Both plants and micro-organisms benefit.**
  - o Plant roots exude proteins, sugars, and carbohydrates ("cakes and cookies") which attract beneficial micro-organisms.
  - o Nitrogen-fixing bacteria inhabit the roots of legumes.
  - o About 80% of world's plants have symbiotic relationships with fungi (mycorrhizae).

- **Ratio of bacteria to fungi is different for different plant communities.**
  - o Bacteria-dominated in early succession communities (bare earth, weeds, vegetables).
  - o Fungal-dominated in late succession communities (shrubs, trees, old growth).
  - o Equal balance of bacteria and fungi for most row crops and garden flowers.
  - o Bacteria/fungal ratio can be changed to favor different kinds of plants.

- **Soil food web is degraded in disturbed land.**
  - o Enemies of the soil food web: compaction, tilling (turning), pollution, pesticides, synthetic fertilizers.
  - o Degraded food web invites pests, disease and nutrient problems.
  - o Chemical solutions aggravate the problem.
  - o Need to restore and enhance the soil biology.

- **Monitoring soil biology.**
  - o Ingham advocates a "direct count" method, in which individual organisms in a sample are counted under a microscope.
  - o The result is a report on the numbers/biomass of different classes of organisms estimated to be in the sample.
  - o These numbers give indication about the health or problems with the soil. For example, a high number of ciliates (a group of protozoa) indicates anaerobic conditions.
  - o Many problems can be solved or alleviated by applying compost or compost tea, according to Dr. Ingham.

• **Compost**

o Aerobic good, anaerobic bad. It should not stink (stink=anaerobic).

o Three methods discussed: thermal (hot), worm, and static (backyard).

o The balance between fungi and bacteria can be controlled by different feedstocks and methods.

o Monitoring compost quality is important-all composts are not created equal.

• **Compost tea is a convenient way to apply compost.**

o Actively aerated compost tea (AACT) is what Ingham studies and recommends.

o Other compost teas and liquid amendments exist (some anaerobic).

o Process

+ Good compost.

+ Good (potable) water without chlorine or chloramine.

+ Good brewing machine, easy to clean. Ask manufacturer for data.

+ Appropriate temperatures

+ Appropriate food for desired organisms

+ Brewing times variable (about 24 hours)

+ Prompt application.

Δ

Resources

• *Soil Biology Primer* by Elaine R. Ingham, Andrew R. Moldenke and Clive A. Edwards. Soil and Water Conservation Society (in cooperation with the USDA-NRCS). 2000.

Print version available through SWCS or Earth Fortification.

Online Version available.

• Soil Foodweb Inc. website: http://www.soilfoodweb.com/

• *Teaming with Microbes: A Gardener's Guide to the Soil Food Web* by Jeff Lowenfels. Timber Press. Publishing date: August 15, 2006.

• *Edible Forest Gardens* by Dave Jacke; with Eric Toensmeier. Chelsea Green. 2005. Monumental two-volume work. Chapter 5 in volume 1 covers "Structures of the Underground Economy" and describes Elaine Ingham's soil food web concepts (pages 216-234).

• *Gaia's Garden: A Guide to Home-Scale Permaculture* by Toby Hemenway. Chapter 4 is devoted to "Bringing the Soil to Life."

• *Under Ground: How Creatures of Mud and Dirt Shape Our World* by Yvonne Baskin. Island Press. 2005.

• *Tales From the Underground: A Natural History of Subterranean Life* by David W. Wolfe. Perseus Publishing. 2001.

• "Soils: the Final Frontier"—special issue of *Science* magazine (June 11, 2004).

Many online resources are listed in the web version of this document. Available at *http://energybulletin.net.*

Bart Anderson has been a reporter, high school teacher and technical writer. He now gardens and writes on sustainability and energy issues. He is co-editor of Energy Bulletin (http://energybulletin.net). Bart has no connection with any business or group involved in compost tea.

Can Mushrooms Save the Planet?

Mycelium as Nature's Internet

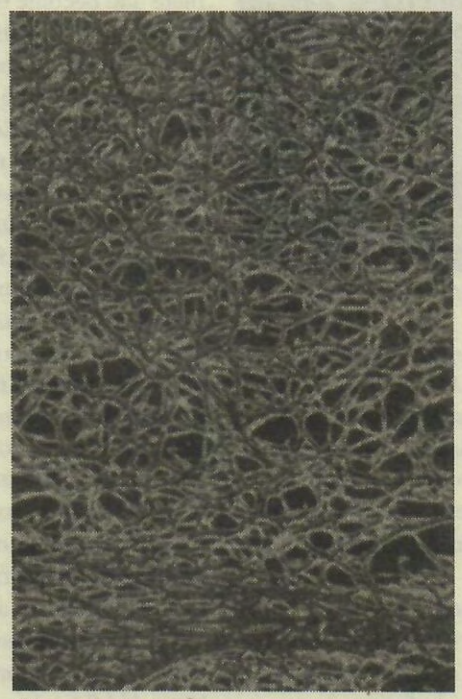
Paul Stamets

I BELIEVE THAT MYCELIUM is the neurological network of nature. Interlacing mosaics of mycelium infuse habitats with information-sharing membranes. These membranes are aware, react to change, and collectively have the long-term health of the host environment in mind. The mycelium stays in constant molecular communication with its environment, devising diverse enzymatic and chemical responses to complex challenges. These networks not only survive, but sometimes expand to thousands of acres in size, achieving the greatest mass of any individual organism on this planet. That mycelia can spread enormous cellular mats across thousands of acres is a testimonial to a successful and versatile evolutionary strategy.

Animals are more closely related to fungi than to any other kingdom

The history of fungal networks

Animals are more closely related to fungi than to any other kingdom. More than 465 million years ago we shared a common ancestry. Fungi evolved a means of externally digesting food by secreting acids and enzymes into their immediate environs and then absorbing nutrients using netlike cell chains. Many fungi partnered with plants, which largely lacked these digestive juices. Mycologists believe that this alliance allowed plants to inhabit land around 400 million years ago. Many millions of years later, one evolutionary branch of fungi led to the development of animals. The branch of fungi leading to animals evolved to capture nutrients by surrounding their food with cellular sacs, essentially primitive stomachs. As species emerged from aquatic habitats, organisms adapted means to prevent moisture loss. In terrestrial creatures, skin composed of many layers of cells emerged as a barrier against infection. Taking a different evolutionary path, the mycelium retained its netlike form of interweaving chains of cells and went underground, forming a vast food web upon which life flourished.



The mycelial network is a membrane of inteweaving, continuously branching cell chains, only one cell wall thick.

About 250 million years ago, at the boundary of the Permian and Triassic periods, a catastrophe wiped out 90 percent of the Earth's species when, according to some scientists, a meteorite struck. Tidal waves, lava flows, hot gases, and winds of more than a thousand miles per hour scourged the planet. The Earth darkened under a dust cloud of airborne debris, causing massive extinctions of plants and animals. Fungi inherited the Earth, surging to recycle the postcataclysmic debris fields. The era of dinosaurs began and then ended 185 million years later when another meteorite hit, causing a second massive extinction. Once again, fungi surged and many symbiotically partnered with plants for survival. The classic cap and stem mushrooms, so common today, are the descendants of varieties that predated this second catastrophic event. (The oldest known mushroom—encased in amber and collected in New Jersey—dates from Cretaceous time, 92 to 94 million years ago. Mushrooms evolved their basic forms well before the most distant mammal ancestors of humans.) Mycelium steers the course of ecosystems by favoring successions of species. Ultimately, mycelium prepares its immediate environment for its benefit by growing ecosystems that fuel its food chains.

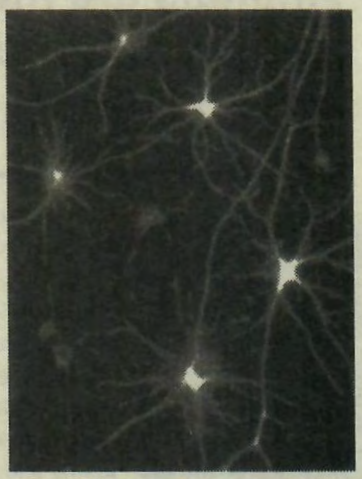
Ecotheorist James Lovelock, together with Lynn Margulis, came up with the Gaia hypothesis, which postulated that the planet's biosphere intelligently piloted its course to sustain and breed new life. I see mycelium as the living network that manifests the natural intelligence imagined by Gaia theorists. The mycelium is an exposed sentient membrane, aware and responsive to changes in its environment. As hikers, deer, or insects walk across these sensitive filamentous nets, they leave impressions, and mycelia sense and respond to these movements. A complex and resourceful structure for sharing information, mycelium can adapt and evolve through the ever-changing forces of nature. I

especially feel that this is true upon entering a forest after a rainfall when, I believe, interlacing mycelial membranes awaken. These sensitive mycelial membranes act as a collective fungal consciousness. As mycelia's metabolisms surge, they emit attractants, imparting sweet fragrances to the forest and connecting ecosystems and their species with scent trails. Like a matrix, a biomolecular superhighway, the mycelium is in constant dialogue with its environment, reacting to and

. . .fungi can be intelligent and may have potential as our allies. . .

governing the flow of essential nutrients cycling through the food chain.

I believe that the mycelium operates at a level of complexity that exceeds the computational powers of our most advanced supercomputers. I see the mycelium as the Earth's natural Internet, a consciousness with which we might be able to communicate. Through cross-species interfacing, we may one day exchange information with these sentient cellular networks. Because these externalized neurological nets sense any impression upon them, from footsteps to falling tree branches, they could relay enormous amounts of data regarding the movements of all organisms through the landscape. A new bioneering science could be born, dedicated to programming myconeurological networks to monitor and respond to threats to environments. Mycelial webs could be used as information platforms for mycoengineered ecosystems.



Neural networks in the brain

The idea that a cellular organism can demonstrate intelligence might seem radical if not for work by researchers like Toshuyiki Nakagaki (2000). He placed a maze over a petri dish filled with the nutrient agar and introduced nutritious oat flakes at an entrance and exit. He then inoculated the entrance with a culture of the slime mold *Physarum polycephalum* under sterile conditions. As it grew through the maze it consistently chose the shortest route to the oat flakes at the end, rejecting dead ends and empty exits, demonstrating a form of intelligence, according to Nakagami and his fellow researchers. If this is true, then the neural nets of microbes and mycelia may be deeply intelligent.

A few recent studies support this novel perspective that fungi can be intelligent and may have potential as our allies, perhaps being programmed to collect environmental data, as suggested above, or to communicate with silicon chips in a computer interface. Envisioning fungi as nanoconductors in mycocomputers, Gorman (2003) and his fellow researchers at Northwestern University have manipulated mycelia of *Aspergillus niger* to organize gold into its DNA, in effect creating mycelial conductors of electrical potentials. NASA reports that microbiologists at the University of Tennessee, led by Gary Sayler, have developed a rugged biological computer chip housing bacteria that glow upon sensing pollutants, from heavy metals to PCBs (Miller 2004). Such innovations hint at new microbiotechnologies on the near horizon. Working together, fungal networks and environmentally responsive bacteria could provide us with data about pH, detect nutrients and toxic waste, and even measure biological populations.

Fungi in outer space?

Fungi may not be unique to Earth. Scientists theorize that life is spread throughout the cosmos, and that it is likely to exist wherever water is found in a liquid state. Recently, scientists detected a distant planet 5,600 light-years away, which formed 13 billion years ago, old enough that life could have evolved there and become extinct several times over (Savage et al. 2003). (It took 4 billion years for life to evolve on Earth.) Thus far 120 planets outside our solar system have been discovered, and more are being discovered every few months. Astrobiologists believe that the precursors of DNA, prenucleic acids, are forming throughout the cosmos as an inevitable consequence of matter as it organizes, and I have little doubt that we will eventually survey planets for mycological communities. The fact that NASA has established the Astrobiology Institute and that Cambridge University Press has established *The International Journal for Astrobiology* is strong support for the theory that life springs from matter and is likely widely distributed throughout the galaxies. I predict an Interplanetary Journal of Astromycology will emerge as fungi are discovered on other planets. It is possible that proto-germplasm could travel throughout the galactic expanses riding upon comets or carried by stellar winds. This form of interstellar protobiological migration, known as panspermia, does not sound as farfetched today as it did when first proposed by Sir Fred Doyle and Chandra Wickramasinghe in the early 1970s. NASA considered the possibility of using fungi for interplanetary colonization. Now that we have landed rovers on Mars, NASA takes seriously the unknown consequences that our microbes will have on seeding other planets. Spores recognize no borders.

Table 1. Branched Intertwined Soil Fungi

The mycelial archetype

Nature tends to build upon its successes. The mycelial archetype can be seen throughout the universe: in the patterns of hurricanes, dark matter, and the Internet. The similarity in form to mycelium may not be merely a coincidence. Biological systems are influenced by the laws of physics, and it may be

Wherever a catastrophe creates a field of debris–whether from downed trees or an oil spill—many fungi respond with waves of mycelium.

that mycelium exploits the natural momentum of matter, just like salmon take advantage of the tides. The architecture of mycelium resemble patterns predicted in string theory, and astrophysicists theorize that the most energy-conserving forms in the universe will be organized as threads of matter/energy.

The arrangement of these strings resembles the architecture of mycelium. When the Internet was designed, its weblike structure maximized the pooling of data and computational power while minimizing critical points upon which the system is dependent. I believe that the structure of the Internet is simply an archetypal form, the inevitable consequence of a previously proven evolutionary model, which is also seen in the human brain; diagrams of computer networks bear resemblance to both mycelium and neurological arrays in the mammalian brain. Our understanding of information networks in their many forms will lead to a quantum leap in human computational power.

Mycelium in the web of life

As an evolutionary strategy, mycelial architecture is amazing: one cell wall thick, in direct contact with myriad hostile organisms, and yet so pervasive that a single cubic inch of topsoil contains enough fungal cells to stretch more than 8 miles if placed end to end. I calculate that every footstep I take impacts more than 300 miles of mycelium. These fungal fabrics run through the top few inches of virtually all landmasses that support life, sharing the soil with legions of other organisms. If you were a tiny organism in a forest soil, you would be enmeshed in a carnival of activity, with mycelium constantly moving through subterranean landscapes like cellular waves, through dancing bacteria and swimming protozoa with nematodes racing like whales through a microcosmic sea of life.

Year-round, fungi decompose and recycle plant debris, filter microbes and sediments from runoff, and restore soil. In the end, life-sustaining soil is created from debris, particularly dead wood. We are now entering a time when mycofilters of select mushroom species can be constructed to destroy toxic waste and prevent disease, such as infection from coliform or staph bacteria and protozoa and plagues caused by disease-carrying organisms. In the near future, we can orchestrate selected mushroom species to manage species successions. While

mycelium nourishes plants, mushrooms themselves are nourishment for worms, insects, mammals, bacteria, and other, parasitic fungi. I believe that the occurrence and decomposition of a mushroom pre-determines the nature and composition of downstream populations in its habitat niche.

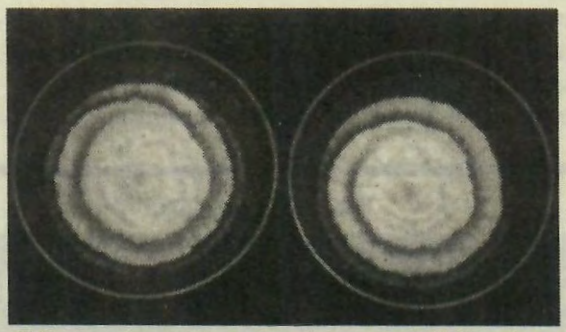
We have now learned that we must tread softly on the web of life, or else it will unravel beneath us.

Wherever a catastrophe creates a field of debris—whether from downed trees or an oil spill—many fungi respond with waves of mycelium. This adaptive ability reflects the deep-rooted ancestry and diversity of fungi—resulting in the evolution of a whole kingdom populated with between one and two million species. Fungi outnumber plants at a ratio of at least six to one. About ten percent of fungi are what we call mushrooms (Hawksworth 2001), and only about ten percent of the mushroom species have been identified, meaning that our taxonomic knowledge of mushrooms is exceeded by our ignorance by at least one order of magnitude. The surprising diversity of fungi speaks to the complexity needed for a healthy environment. What has been become increasingly clear to mycologists is that protecting the health of the environment is directly related to our understanding of the roles of its complex fungal populations. Our bodies and our environs are habitats with immune systems; fungi are a common bridge between the two.

All habitats depend directly on these fungal allies, without which the life-support system of the Earth would soon collapse. Mycelial networks hold soils together and aerate them. Fungal enzymes, acids, and antibiotics dramatically affect the condition and structure of soils. In the wake of catastrophes, fungal diversity helps restore devastated habitats. Evolutionary trends generally lead to increased biodiversity. However, due to human activities we are losing many species before we can even identify them. In effect, as we lose species, we are experiencing devolution—turning back the clock on biodiversity, which is a slippery slope toward massive ecological collapse. The interconnectedness of life is an obvious truth that we ignore at our peril.

In the 1960s, the concept of "better living through chemistry" became the ideal as plastics, alloys, pesticides, fungicides, and petrochemicals were born in the laboratory. When these synthetics were released into nature, they often had a dramatic and initially desirable effect on their targets. However, events in the past few decades have shown that many of these inventions were in fact bitter fruits of science, levying a heavy toll on the biosphere. We have now learned that we must tread softly on the web of life, or else it will unravel beneath us.Toxic fungicides like methyl bromide, once touted, not only harm targeted species but also nontargeted organisms and their food chains and threaten the ozone layer. Toxic insecticides often confer a temporary solution until tolerance is achieved. When the natural benefits of fungi have been repressed, the perceived need for artificial fertilizers increases, creating a cycle of chemical dependence, ultimately eroding sustainability. However, we can create mycologically sustainable environments by introducing plant-partnering fungi (mycorrhizal and endophytic) in combination with mulching with saprophytic mushroom mycelia. The results of these fungal activities include healthy soil, biodynamic communities, and endless cycles of renewal. With every cycle, soil depth increases and the capacity for biodiversity is enhanced.

Living in harmony with our natural environment is key to our health as individuals and as a species. We are a reflection of the environment that has given us birth. Wantonly destroying our life-support ecosystems is tantamount to suicide. Enlisting fungi as allies, we can offset the environmental damage inflicted by humans by accelerating organic decomposition of the massive fields of debris we create—through everything from clear-cutting forests to constructing cities. Our relatively sudden rise as a destructive species is stressing the fungal recycling systems of nature. The cascade of toxins and debris generated by humans destabilizes nutrient return cycles, causing crop failure, global warming, climate change and, in a worst-case scenario, quickening the pace towards eco-catastrophes of our own making. As ecological disrupters, humans challenge the immune systems of our environment beyond their limits. The rule of nature is that when a species exceeds the carrying capacity of its host environment, its food chains collapse and diseases emerge to devastate the population of the threatening organism. I believe we can come into balance with nature using mycelium to regulate the flow of nutrients. The age of mycological medicine is upon us. Now is the time to ensure the future of our planet and our species by partnering, or running, with mycelium. Δ



Cultures of yet-to-be-named California Psilocybe *mushroom spiral outward like galaxies. Growth rates increase with time.*

Paul Stamets, founder of Fungi Perfecti (www.fungi.com), has been a dedicated mycologist for more than 30 years. He was the 1998 recipient of the Collective Heritage Institute's Bioneers Award, and has written five books about mushroom cultivation, the most recent of which, Mycelium Running, *is the source of this excerpt, reproduced with permission.*

Using Fungi in the Permaculture Garden

Making Your Own Mycorrhizal Inoculum

from Sunseed Desert Technology

THIS IS A SIMPLE AND EFFECTIVE METHOD of inoculating your plants with beneficial fungi. You can make your own from local soil. The soil that you make will be rich in beneficial fungi. The "inoculum" takes about an hour or less to set up and is very simple to maintain.

Background and benefits

What are mycorrhizae? Mycorrhizal fungi are a group of soil fungi that infect the roots of most plants. The fungi is neither pest nor parasite as it supplies the plant with nutrients like phosphorus, copper, and zinc, as well as increasing water availability. The plant supports the fungus with carbon in the form of sugars released through the roots. This symbiotic relationship does not affect the plants adversely, as they produce excess carbon. In fact, lack of water and nutrients is more often the limiting factor to plants' growth and establishment. Mycorrhizal fungi are found in most environments, although their importance is greater in more extreme environments, where nutrients and water may be limiting. There are very few plants that do not form mycorrhizal associations at all, although most can grow without it. In plants that have been infected by mycorrhizal fungi, the fungus is actually the chief method of nutrient uptake, not the roots.

There are several types of mycorrhizae. The type that we are interested in are by far the most common and are called arbuscular mycorrhiza (AM). This type of mycorrhiza is invisible to the naked eye but forms a fine mesh through the soil. They enter the cells of the roots where they form branched arbuscles within these cells. This is where the exchange of nutrients and carbon occurs.

How do you know if a plant species can be a host to this type of fungus? The vast majority of plants do grow with AM. This includes the majority of domestic and wild plants. However some species do not form this association, these include pines, firs, spruce, and oaks. It would be impossible to list all the species and their mycorrhizal associations, so if you are in any doubt contact us; we can confirm if the species will benefit from the inoculation method.

Results that you can expect

The most notable improvement should be an increase in survival rate. It has been shown that mycorrhizal plants cope better with stresses such as drought and disease than non-mycorrhizal plants. Depending on your conditions and the species that you are using, you may also notice an increase in growth. This is due to the plant accessing more phosphorus from the soil (this varies from just a few percentage points to double the normal growth). There are other benefits that mycorrhiza can bring to the soil. Its fine structure helps stabilize the soil structure, slowing both sheet and subsurface erosion. Under the soil, invisible from above, a network of fungal hyphae will start to spread from your plant, gradually colonizing other plants and in effect starting to rebuild a healthy ecosystem. This underground structure is the key part of restoring the ecosystem. The plants then act as fertility islands, with increased organic matter, better soil nutrient levels, and increased nutrient cycling.

. . . the fungus is actually the chief method of nutrient uptake, not the roots.

The results so far have been very positive, showing faster growth and better survival in the most arid areas of Spain and Tanzania where we have been trying this method. However, we are still at the trial stage and we want to know how it works in different locations, climates, soil types, and with a variety of species.

If you are interested in producing inoculum for your own use or running some trials, we recommend the following methods and step-by-step guide to setting up your own experiment using a mixed mycorrhizal inoculum made from your own soil. This also instructs you on how to set up your own trial with different target species, be it trees or crops, seeds, seedlings, or established plants.

Method

Mycorrhizal inoculum can be produced either in pots or in a "trap-trough" made from a plastic liner in a depression dug into the earth. The method is virtually the same for both.

If you decide to undertake such a trial, we'd like to hear your results. The first step would be to fill out a trial proposal form. Once completed, this will give us vital information about the conditions in which your trial will be carried out, including climate and soil type, and the species that you will be attempting

to grow in the trap pot. It will also enable us to make sure the proposed trial is viable. Once your trial is established we would like you to keep us informed of its progress. We are happy to provide information and support on the following:

1. Where to collect your starter soil
2. How to set up a trap-trough to make your own inoculum
3. How to maintain your trap-trough
4. How to harvest the inoculum
5. How to use the inoculum
6. How to set up a trial
7. How to record the progress of your inoculated and uninoculated plants

Before you start you will need:

- an area to dig a trench or set up some pots
- plastic sacks or other waterproof sheeting (for trap-trough)
- or plastic pots (5 liters or larger)
- spade or other digging implement
- seeds
- water

Step 1: Collecting your starter soil

Materials needed: spade, and sacks or wheelbarrow to move soil.

Around 80% of vegetation forms mycorrhizal associations. The infected plant roots and the spores and hyphae of the beneficial fungi are in the soil and can colonize new plants. You can be pretty sure of getting a good starter soil from any undisturbed area containing native vegetation including most grown trees, woody shrubs, and perennial grasses.

The best place to collect your starter soil is from under local native vegetation that is growing well in an area that has not recently been cultivated. It is good if you can collect some of the soil from under the same species as that on which you plan to use the mycorrhizal inoculum (i.e. your tree, shrub, or crop species).

Clear away about a half-meter square (approx. 19" x 19") of the vegetation underneath your target plant. Dig down to a depth of about 25cm (about 10") collecting the soil and as many fine roots as possible. It is better, but not essential, to collect from under several different trees and shrubs. With stony soil it is best to sieve it to get rid of large stones.

Step 2: Multiplying the mycorrhiza

To multiply the mycorrhiza from your starter soil we use a "trap-pot" or "trap-trough." This method grows mycorrhiza-dependent annuals in the collected soil. These plants, often called "bait plants," will become inoculated with the mycorrhizal fungus causing the fungal population to multiply. Often two bait plant species are grown together to enhance growth of different mycorrhizal species. One of these will be a species of Gramineae (grasses) or *Allium*, and the second will be a species of legume. Examples of these species are shown in the table below. Combining corn and beans, for example, is a good choice as they grow well together. It depends, however, on what you know to grow well in your area and on what you have available.

Select Species 1	Select Species 2
Gramineae or *Allium* spp	Fabaceae spp (legumes)
Maize/Leeks	Alfalfa
Millet/Onions	Beans
Sorghum	Clover
Wheat	Peas
Oats	Lentils

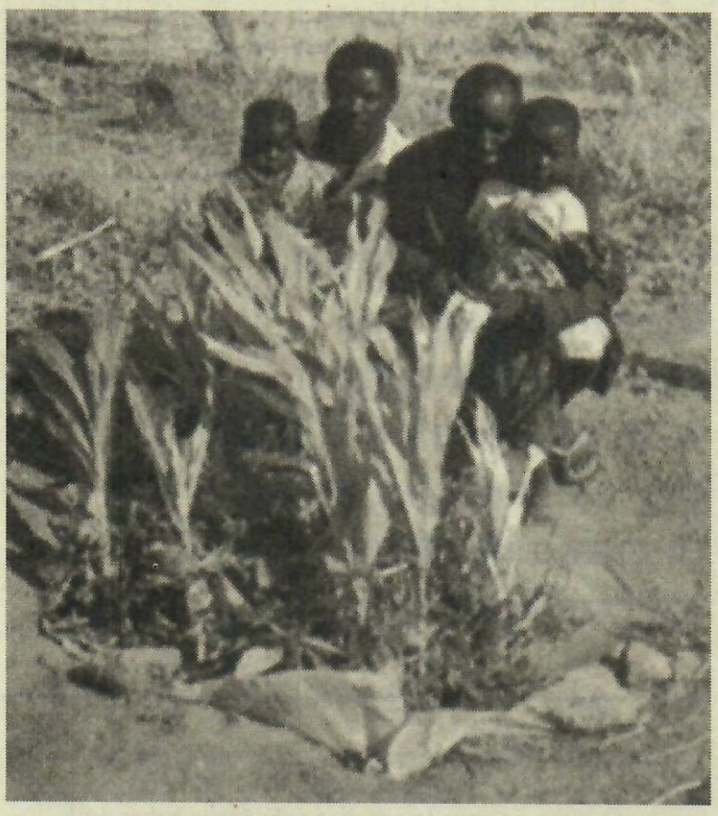
Materials needed: spade, plastic sacks/pots (5 liters or larger), seeds of your two selected species, water.

Trap pots (above) and a trap trough (below).

The best place is in a site that will not be needed for at least three months and where you can keep an eye on it. It will need regular watering, adequate light, and protection from herbivores.

Take your starter soil to the site you have chosen and then fill one or several plastic pots or basins (depending on how much inoculum you need). Alternatively, a trench can be dug into the ground and lined with the plastic sacks or other material

available. This is what we call a "trap-trough." The pit should be dug about 100cm (approx. 39 inches) x 50cm (about 19 inches) to a depth of 50cm and then lined with the plastic sacks. Plastic sheeting, bin liners, or sugar sacks will serve. Perforate the plastic to allow for drainage. Make sure that the plastic covers the whole basin with overlap between the sheets. Place stones on the overlaps and fill the trough with soil. Soak the seeds of your two chosen species overnight. Plant them closer than normal, alternating the species.



A successful trap-trough.

Note: The soil that you dig out of the trench can be used to fill holes where you extracted soil from under the local vegetation.

How much inoculum do you want to make? This depends on what size container you will be planting in, but estimate about 1/6 of each pot to be filled with the inoculum. If using on crops see 'inoculating crops' below.

Step 3: Maintaining your trap-pots or trough

Once you have set up your trap-pot or trough you can more or less forget about it. Just keep it regularly watered. In this time the roots of the bait plants will be developing and forming the association with the mycorrhiza.

Depending on the season you might need to shade it or protect it from frost. If growing trap-pots then they can be moved into a more sheltered area.

Step 4: Three months later...

Ten days before you are ready to use the inoculum, the bait plants should be cut at the base of their stem and watering should be stopped. This kills the plant, and tricks the fungus into producing reproductive spores. Then, after the ten days, the inoculum is prepared by pulling up the roots of the bait plants which should be chopped into roughly 1 cm pieces (1/2") and then mixed back into the soil from the trap-pot or trough. This mixture of roots and soil is the inoculum.

Step 5: Using the inoculum

The inoculum can be used on a wide range of different trees, shrubs, crops, and garden plants. In all cases the plants should be given the same care as normal. A small amount of compost will complement the addition of mycorrhiza but no artificial fertilizers or herbicides should be added.

There are a few things to consider if setting up a trial. (See section below).

Inoculating trees, growing them from seed

Materials needed: inoculum, seeds, growing tubes or plant pots, soil, compost.

Two thirds of the pot or growing tube should be filled with normal soil, with a little compost mixed in, if available. Then add a layer of inoculum and finally another layer of normal soil into which the seed is sown. The inoculum layer need only be a couple of centimeters deep (1"). This means that when the roots grow down the tube they will come into contact with the fungus, and quickly become infected. The trees are then cared for as usual, and planted out at the same time as normal, to coincide with the growing season. The trees that have been infected with the fungus should be much better equipped to cope with shortages in rainfall, and will also improve the mycorrhizal potential of the surrounding soil.

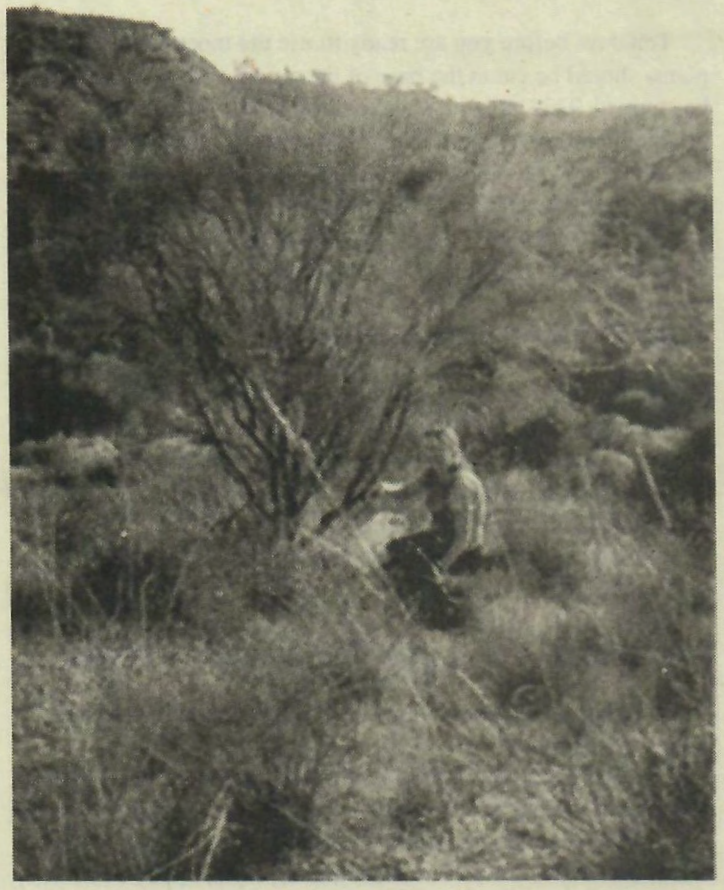
Inoculating pre-grown trees

Materials needed: inoculum, trees, spade.

Dig the hole where you will plant your tree and throw in a spade-full of the inoculum. Place the sapling in the hole and sprinkle a little more of the inoculum around the edges as you fill it in. If you are adding compost then dig the hole slightly deeper, add the compost, cover over with normal soil and then add the spade-full of inoculum.

Inoculating crops

Put a pinch of inoculum into any hole that you are about to plant into. Or mix a couple of handfuls of the inoculum with seeds that you are about to sow and plant as usual. If transplanting, first soak the root ball in water and then dip it in the inoculum. The root ball will then have a coating of inoculum.



Collecting starter soil from under a retama *shrub.*

Plant as normal.

When you have used as much of the inoculum as you need, the trap-pot or trough can be topped up again with more starter soil, re-planted with bait plants and the cycle repeated. This ensures that there is a ready supply of inoculum all through the year.

Setting Up a Trial: Things to consider

Setting up your site

Labeling your plants. Keep a careful note of where each plant was planted and what treatment if any it was given. It is useful to give each plant a number.

Label each plant in a way that will not be destroyed by the elements. You are unlikely to remember which plants are where months later. We usually label the plants either mycorrhizal (M) or non-mycorrhizal (NM)

Layout of M and NM plants

Do not plant too close together. Spacing them will reduce the chance of the fungi spreading to non-inoculated plants. It is preferable but not essential that the treated and non-treated plants are laid out randomly. This reduces environmental factors that might affect the results. One way of doing this is a randomised block design, alternating sections of plantings of treated and non-treated plants, keeping careful note and charting which is which.

Designing the trial

It is worth spending some time considering where and when you want to set up the trial. How much space you have as well as the amount of care that you can give the plants. The trap-pot or trough needs to be set up three months in advance of your scheduled planting in order for the mycorrhizal population to mature fully.

It has been shown that mycorrhizal plants cope better with stresses such as dry conditions and disease than non-mycorrhizal plants.

For whatever planting you are doing try incorporating the mycorrhizal method. But if you have a blank area and would like to set up a more rigorous test of the method then below are a couple of examples of how you might lay out a trial. The first is non-random. This has the advantage of giving a direct and easy-to-see comparison. However, with this layout external factors might well influence your results. For example, factors such as wind direction, shade, and soil variability could induce better growth in one side regardless of the treatment. Using a randomised block design is a fairly simple way of reducing the risk of these factors influencing your results. An example of a randomised block design is shown below.

If you have the time and resources to set up a trial we will give you all the support we can. Please contact us and let us know what you have in mind.

How to record the progress of your inoculated and non-inoculated plants

To help you record data we have produced data sheets on our website for measuring both survival and height. At first sight this spreadsheet may look overly complicated but don't panic! There are full instructions for filling out all the information. Along with

the data sheets we have also included a sample data sheet of measurements from trials in Tanzania. The data shown in these examples are not real data, but should give a good idea of how we would like your data to be presented. If you have any problems at all then contact us and we can help.

Finished mycorrhizal inoculum.

You will need to keep a regular check on the plants you are growing. In particular there are two key measurements that we would like to receive information on: "survival" and "height."

Survival is simply a matter of recording the number of inoculated and control plants surviving. This is less time-consuming than taking height measurements.

We would only expect height measurements to be taken if you are growing small numbers of plants, or if you feel you have sufficient time and labor. The system for measuring the plants needs to be consistent, using the same unit of measurement (preferably millimeters), the same instrument and if at all possible, by the same person.

The frequency of measurements is up to you, the more regular the better. Here, we measure height and survival in the nursery every two weeks, and decrease that to once a month after the plants have been planted in the field. It is recommended that the measurements be taken with an interval of not more than a month.

In addition to measurements, we would encourage additional comments on the data pages, to record information relevant to specific plants (e.g. eaten by insects, broken by children, etc.) and any other information about the trial and external factors in general (e.g. bad rains, widespread diseases, etc.). This will all be useful information for us.

We appreciate all the information that you send to us. Our aim is to try this method in as many situations as is possible. We would not publish your results without prior permission first, and you would be acknowledged in the publication. All completed trial proposal forms and data sheets should be sent to the Mycorrhizal Research Coordinator. Please contact us with any queries or problems with entering data on the sheets provided or if you have any problems or suggestions on how to improve this site or how to make it more accessible. Δ

For more information or assitance setting up, administering and reporting a trial, visit www.sunseed.org.uk.

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Extracting the Essential

Bees: The Sweetest of Community Builders

Minna Jain

HERE, IN THE HIGH DESERT temperate climate of northern New Mexico, the water is limited, soils are alkaline, and our growing season is full of hardships, such as strong, drying winds and extreme temperature swings. Spring frosts make stone fruit production unpredictable from year to year and growing vegetables is sustainable only on a very small scale, prompting local permaculturists to contract with other species more adept at creating abundance in this climate.

Bees are an embodiment of the permaculture principle of concentrating limited resources; they forage large territories and extract sweet essence from the desert. The arid environment often feels barren and thirsty, but it is punctuated by unexpected moments of exquisite beauty, pockets of saturated color, and fierce, delicate life. Like the rich, clay-red light of dusk, or a penstemmon in bloom, bees concentrate the essence of our landscape, sharing their vibrancy and their subtly woven world with us as we eat the fruits of their pollination, tend their hives, and harvest their miraculous hive products.

Productive communities: bees and beekeepers embody permaculture principles.

For these reasons, we decided to welcome bees to EcoVersity, a Santa Fe based sustainability learning center. Our two original hives quickly grew into a bee village, and a seven-month-long beekeeping certificate program, taught by Les Crowder. The goal of the program is to give vocational skills for right livelihood to local bee stewards, as well as to protect bees and introduce this important pollinator to the permacultural consciousness of the bioregion.

Getting present: a reeducation

When I first met Les Crowder, I was compelled by his stillness and the confident, humble way he speaks and teaches. A beekeeper for thirty years, Les shares heartfelt stories of beekeeping, revealing a life-long love of these insects and making their world come alive in unexpected and inspiring ways. Hands in his pockets, white beard and red hair catching shadows cast by the elms in our bee class room, Les teaches us, day by day, the permaculture of bees.

We light a smoker, don our bee veils, and open a hive. I've never been so close to so many bees, and I notice right away that all the qualities I appreciate about Les: his quiet calm, his humble grounded presence, his awareness of the sun and wind, day lengths and blooming times, his thoughtful, thorough attention to detail, his understanding of local economy and industrial agriculture, all seem to stem from the heightened focus and sensitivity he brings to working with the bees. I listen as Les speaks softly to each bee in Spanish, coaxing them aside, waiting until every worker has safely moved out of harm's way before replacing a comb and moving on to a new one. I notice how he moves so slowly, minding every finger placement, even where he is stepping. The bees seem not only tolerant of his presence, but soothed by it. The sense of presence and calm is contagious and, within the hour, I begin to understand the differences in pitch and intensity of the bees' humming as their moods shift. I start to notice the different smells of the hive, and the endless array of worker-bee activities. I lose a great deal of my fear, and gain a fair amount of respect for these fierce, beautiful creatures.

The message Les shares is that by honoring the bees and their natural processes, we gain the most from them. By disrupting those processes, as modern agriculture does in order to increase profit and yield, we invite disease and risk the eradication of bee populations. This is an essential ingredient in permaculture: designing systems and ways of interaction that support the

natural rhythms and patterns of the elements of those systems, and also positively inform our ways of thinking and acting as individuals and in community.

Paying attention: connecting zones

Les points out that keeping bees inherently increases our connection with the land, the seasons, local economy and food production, and with the larger webs of relationships within our human and non-human communities. He has written, "Honeybees continue to weave threads that connect us to the sun, the soil, the seasons, our fellow humans, our food, insecticides, the local bears, and life in this amazing, at times difficult, at times glorious universe."

The sense of presence and calm is contagious. . .

If we pay attention to our bees' foraging zone, a circle of between six to twenty-four miles in diameter, we can discover what blooms in our area, when it blooms, and the distinct sorts of pollen and honey that the bees produce. An attentive beekeeper knows who is gardening and farming in the area, who is planting cover crops that also serve as bee forage, and what sorts of old fruit trees and wildflowers are tenaciously splitting sidewalks and haunting abandoned gardens in public and private spaces. In this way, the sphere of our attention extends up to 12 miles in every direction, bringing into focus the growing, humming, living, designed, and natural systems of our community.

Listening to Les tell stories of capturing swarms from neighborhood trees, educating children in classrooms with glass hives and trading honey for space to keep his bee yard, it is clear to me that keeping bees builds community. The possibility of over the fence relationships with neighbors who may want honey, wax, propolis, or simply pollination, gives us good reasons to get to know the people around us.

Additionally, beekeepers pay attention to local materials that are miticidal, such as juniper bark. Burned in a smoker, it eliminates the need for harsh chemicals, and connects our beekeeping process even more soundly to resources and solutions that come from our immediate surroundings.

Patterns in time: rhythm and connection

Working with the bees means being aware of the subtle nuances of the day and the larger patterns they fit into. Bees are most docile when many of the bees are out on their bee-errands: foraging, scouting, and pollinating. If it is very cold or very hot out, windy, or if a storm is brewing, more bees will be at home in the hive and feeling defensive.

In our region, from mid-February until the summer solstice we can divide hives to increase their numbers. This encourages honey production and discourages swarming. It is possible to establish new hives from caught swarms, "divides" or purchased "packages." This is also a good time to move hives out of inconvenient locations such as tree trunks and walls, and to raise queens. After the solstice until mid-September, we harvest honey and other hive products and enjoy! Between mid-September and mid-February (the dearth season), the hives must take care of themselves, and as beekeepers, there's not very much we can do with or for them. For Les and other beekeepers, taking the cue from our bees, this is the time for us to slow down, spend time with the family, mind our homes, tell stories and stay warm. The bee's daily and seasonal rhythms define the pace and the conduct of the beekeeper, keeping us necessarily slow, mindful of large patterns and small details, and connected to the pulse of our community.

Building and using simple top-bar hives minimizes energy inputs, maximizes yields, and provides comfort and protection for bees.

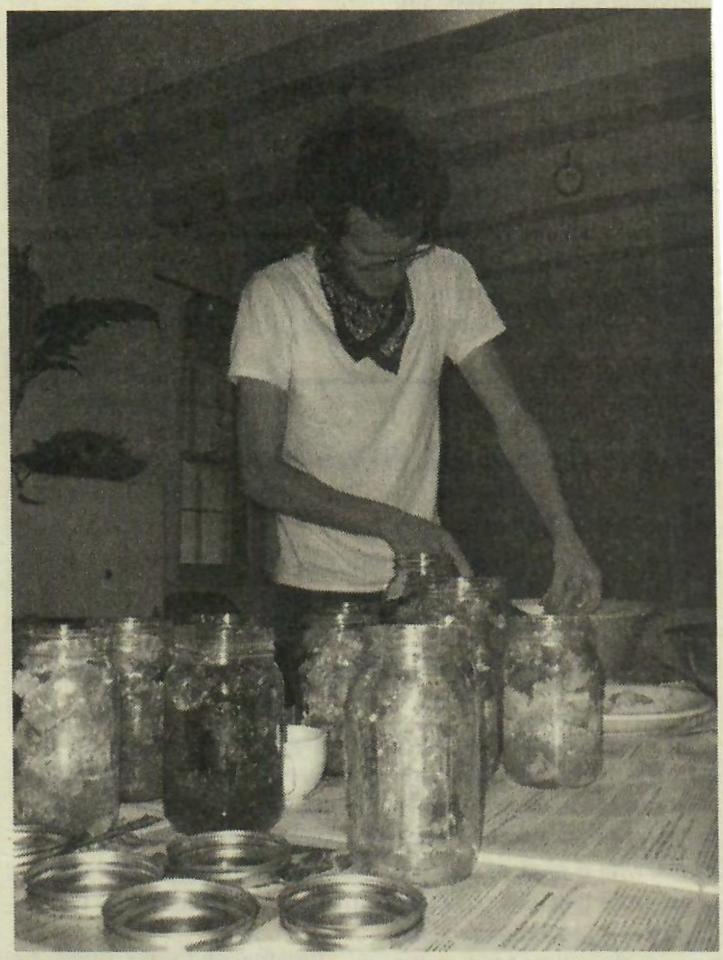
Less work, more abundance: a simple hive is a happy hive

We work with eight top bar hives set in a semi-circle on the southern edge of our campus, which we lovingly call the Bee Village. They surround a small, bright circle of native flowers and other bee forage, and back up against the outdoor bee class room with a mulch floor and simple shade structure. One weekend a month our beekeeping class gathers there with veils and smokers, white button-down shirts and hive tools, listening as Les shares his wisdom and participating as he walks us through the beehives and all their subtle workings.

The design of the hive has a direct impact on the amount of resources used, such as time, materials, and money that must be spent to establish and maintain it. The hive design also impacts the incidence of disease and mites, and therefore the need for chemicals and antibiotics. Work creates work, and the best designs are often the most simple and elegant ones, the ones that allow the natural rhythms and patterns of systems to do the work for us. Hive design is one of the most essential ways in which we can honor the natural processes of the bees and work in partnership with them. For these reasons, EcoVersity uses top bar hives rather than the more conventional Langstroth hives.

The design of the hive has a direct impact on the amount of resources used. . .

A top bar hive is essentially a long cradle-like box, shaped like the bottom half of a hexagon, mimicking the angles of the hexagons honey bees build their wax comb out of. The box is about 44 inches long and the top is covered with wooden bars that are uniformly 1 and 3/8 inches wide and 20 inches long. The bees build a comb on each one of these top bars. One can make an entire hive out of one 10" x 16' board, or by simply scavenging for scrap wood (being careful not to use treated wood that may off-gas harmful chemicals into the hive). Les even uses rain barrels cut in half and other recycled materials. The hives are very durable, quite cheap to put together, and require far less specialized equipment for storage, harvesting honey and wax, gathering pollen, replacing brood comb, etc. For example, when harvesting honey, the top bar beekeeper simply cuts the whole comb from a top bar and places the comb in a bucket. The comb is then cut up to sell as comb-honey, or crushed and left to filter through a sieve, separating the wax from the honey and allowing the honey to retain as much pollen and other highly nutritive properties as possible. This also induces the hive to create more comb in order to produce more honey and therefore any fat soluble toxins they may have absorbed from their environments will be diluted in the on-going wax production.



Natural preservative properties and nutrients make honey ideal for packaging and storing with minimal or no processing, as Sam Stevenson demonstrates.

With Langstroth hives, honey is extracted from the comb centrifugally, and the empty comb is put back into the hive for the bees to refill. This requires specialized equipment, and also keeps the bees from producing the wax combs themselves. Top bar hive design takes into consideration the long term health and natural preferences of the bees. Because of this, top bar beekeepers are able to avoid many of the problems chemicals and antibiotics are used to "solve."

Because comb is not harvested in gathering honey from a Langstroth hive, the comb needs to be stored over the winter when the bees are focusing on keeping their brood alive, and not producing honey. This storage requires chemicals to ward off wax-moths that want to eat the empty comb. In a top bar hive, the bees are always present to weed out the wax-moths before they become problematic, and there is no extra comb to store because it has all been harvested. In fact, in nature, hives abandon very old black brood comb and let the wax moths eat it, partnering with them to clear space for new, clean comb.

When the bee larva hatches from a cell in a brood comb, the

cocoon-lined cell is cleaned, coated with anti-microbial propolis, and reused. Over time, cocoons and defecation build up in the cell, darkening the comb and making each cell smaller and smaller. Sub-layers inevitably harbor bacteria and fungi. These are the combs the bees naturally abandon to the wax moths. With top bar hives this elimination process is quite simple, simulating the natural culling process of the bees. Old brood comb is easy to access and harvest for compost. But in Langstroth hives, the frame and foundation of the brood comb is costly in money and labor, they are not culled as often as they ought to be, and antibiotics are used to battle the fungi and bacteria.

. . .it's difficult to imagine designing a permaculture food forest, backyard, or homestead without them.

Langstroth hive foundation sheets are machine made to a pre-determined cell size. The bees build combs onto these machined sheets of beeswax or plastic, which are fit into wooden frames. This cell size is larger than what the bees would naturally choose, so that the brood combs can be reused for a longer duration before they become too restricted.

Left to their own devices, bees tend to build a variety of cell sizes in their brood comb, larger cells for honey and pollen storage, and smaller cells where they will lay eggs and raise brood. They can then shift where the queen lays eggs, favoring the larger cells to raise larger workers whose fat bodies may survive a cold winter with greater ease. Smaller cells grant some disease and mite resistance to the bees raised in them. In top bar hives the bees have the freedom to build their comb as they see fit, responding to the seasons and to the threat of mites and disease, and eliminating much of the need for our intervention as beekeepers.

Full Circle

Bees are so beneficial to ecosystems in general, that it's difficult to imagine designing a permaculture food forest, backyard, or homestead without them. Bees essentially feed themselves and—through pollination—feed us, other creatures, and the soil. Their honey is delicious, anti-bacterial, full of enzymes, minerals, and complex sugars, and is the best burn ointment yet discovered. Propolis can be used for infections, sore throats, care of gums and teeth and the treatment of ulcers. Beeswax is ideal for candles, salve, and lip balm. Bee venom can stimulate the auto-immune system, and ease arthritis.

If we keep and study our bees with respect and a sense of wonder, taking the lessons they teach us about presence, slowing down, and noticing the threads that weave our communities to heart, we may be able to create health and hope in our roots and blossoms, peaches and zucchinis, and in the people they feed! Δ

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For more information about beekeeping at Ecoversity, visit www.ecoversity.org.

Minna Jain has been organizing around sustainability and social change for eight years, focusing on working with young people in underserved communities throughout the United States. She is a recent graduate of EcoVersity's Earth Based Vocations program, and a participant in the Beekeeping Certificate Course. Her greatest passion is telling stories.

Les Crowder has taught beekeeping classes for 17 years. He makes a livelihood of beekeeping with about 100 hives in central New Mexico. He works with honey, beeswax, propolis, bee pollen, and royal jelly.

Les Crowder and company relocate a hive (below).

Cover Crops as Bee Forage in the Desert Southwest

Lynda Prim

MANY COVER CROPS that are planted specifically for their soil-enriching qualities can double as bee forage.

Legume cover crops, which are important sources of nectar and pollen for bees, are also excellent for protecting areas of the soil between plantings, building soil fertility, and as living mulches in permanent beds.

Combinations of cover crop plants are useful for creating biodiversity. When considering whether to plant cover crops, remember that in addition to providing forage for bees, these plants can also provide habitat for beneficial insects and soil organisms. To enhance all of these functions, interplant wildflowers and annual herbs.

You can plant a cover crop anywhere you need it as the next crop in rotation with vegetable, flower, or herb crops. However, it is not worth the trouble to grow a cover crop if it will be growing less than six to eight weeks. If you are planning a cover crop for bee forage, you have to let the cover crop go through the flowering phase.

Examples of cover crops for bee forage

Perennial Legumes:
Strawberry Clover (*Trifolium fragiferum*): drought and alkaline tolerant; a good choice for paths between beds.

New Zealand White Clover (*Trifolium repens*): tolerant of shade, heat, and alkalinity.

Sainfoin (*Onobrychis viciaefolia*): a hay and grazing plant; source of the very finest honey; long-lived, deep-rooted. Renumex is a variety specifically developed for the desert Southwest.

Purple Prairie Clover (*Petalostemum purpureum*): very drought tolerant, long-term permanent cover crop; native to the desert Southwest; provides habitat for Trichogramma wasps.

Annual Legumes:
Red Kenland Clover (*Trifolium pratense*), good forage and habitat; blossoms are medicinal and edible; cold-tolerant; adaptable to many soils.

. . .these plants can also provide habitat for beneficial insects and soil organisms.

Hykon Rose Clover (*Trifolium hirtum*): thrives in poor soils with moderate irrigation or rainfall; good forage and habitat.

Vetch (*Vicia spp.*): excellent nectar source for beneficials and pollinators; does well in high desert climates; good honey plant.

Other plants:
Field Peas (*Pisum sativum*, var. "Austrian Winter" and "Maple"); Fava Beans (*Vicia fava*, var. "Bell"), Buckwheat Δ

Lynda Prim developed a passion for the land and growing food from her Syrian grandparents as a child. She came to New Mexico in 1977 to do fieldwork in cultural anthropology, and studied ethnobotany and traditional agriculture at the Pot Creek Site and Taos Pueblo. That work led her to the High Desert Research farm where she became farm manager. She is co-founder of The Farm Connection and the NM Farming and Gardening Expo with 12 years experience as an organic certification inspector. Lynda has a small farm in Dixon, NM, works as a consultant for organic growers, and is designing Urban Permaculture Programs for EcoVersity.

Unseen Forces and the Subconscious Mind

Earth Energies Inform Design

Lee Barnes

MANY UNSEEN, BUT NOT UNNOTICED, "subtle energies" shape our inner and outer landscapes. The flow and flux of both natural and man-made electromagnetic energy fields permeates our atmosphere, subconsciously affecting all life. These energies manifest themselves in the cycles of day and night; in the atmosphere's electrical fluctuations due to lightning; through seasonal changes in day length and light levels; by rhythmic tides that mirror the moon's gravitational field; and as energy changes felt during distinct occultations of the sun and moon alignments—these combine to produce the subtle pulse of the planet.

Awareness of these energies is important to permaculture design, especially affecting the placement of structures. Careful site observation and attention to "internal feelings" will give clues to both natural energies flows and man-made energies, revealing preferred sites for buildings, places to avoid, and the location of "special places" within the landscape.

The awareness of these energies is important to permaculture design, especially in the placement of structures.

These energies have flows and can be sensed as patterns across the landscape; they can be uniquely felt and carefully delineated. Distinct energy field changes can be detected within inches. This information can be used to better understand and work with, not against, the unseen energy flows unique to each place.

Every major world culture has its traditional versions of the sorcier, dowser, diviner, shaman, quester, medicine man, or medicine woman who could sense or otherwise attain unseen information or knowledge. Today everywhere there are sensitive individuals capable of forms of "applied intuition"—a skill that may be termed "biolocation"—the ability to locate the edges of weak electromagnetic fields using the human body's bio-electrical field, also known as the "aura." Biolocators have learned to sense the unique energies associated with flowing underground water, to "feel" weaknesses in human and animal biofields, or to somehow resonate and tune-in to the unique frequencies of unseen but sensed objects.

Traditional cultures were aware of subtle earth energies and their effects on mood and health. Histories mention "spirit lines," "song lines," "ley lines," "dragon lines," and lines of "chi" flow.

High energy or "power sites" were recognized and visited for short periods of time. But homes were built on electromagnetically neutral or safe ground. It has been suggested that these neutral locations feel comfortable to humans and their animals because they harbor no disturbing magnetic fields, thus animal and plants remain free of stress and are better able to maintain good health and vitality.

The human animal shares many relations with the unseen kin-doms.

Our bioelectric bodies are capable of sensing distressful thermal, electromagnetic (EM), and radiation fields. Modern terms to label these apparently electromagnetic energies include "dowseable energies," "geopathic energy" (earth-pathic), and Geopathic Stress Zone (GSZ) for unseen energies that are generally considered to be stressing or unhealthy for particular organisms. Some biolocators prefer to use the label "uncomfortable energies" for any sort of energy that is felt as internal discomfort or stress, such as from close exposure to flowing piped or underground water; electromagnetic fields around objects, and other, yet-to-be-identified, "Dowseable Energy Lines." (DELs).

We live in an interacting symphony of radiation that intersects and resonates with compound forces. Places of unusual energy were found and used as sacred spaces and places of power—sacred altars, springs, and holy wells, sacred caves and groves, earthen mounds, and stone circles. It is important to understand that these "high energy" sites were used for ceremony and personal energy stimulation—their fields appear to be too strong for healthy long-term exposure by humans. Occupancy for short periods delivered small doses of these potent energies, perhaps akin to homeopathic medicine, or as triggers for the glandular or immune systems. Science generally observes that long exposure to very weak EM or radiation sources results in similar cellular damage to that from a short exposure to high levels of radiation.

Traditional knowledge of "uncomfortable" energies has been widely ignored in modern architecture and landscape design and placement. Design with natural energy flows should ensure a better relationship with the land. Every site design should include an analysis of all unseen energies that can affect the health of animals, plants, and beneficial microbes.

The human animal shares many relations with the unseen kin-doms, and this can be seen in the impact of subtle earth energies. Electromagnetic energies have been shown under lab conditions to affect the growth and health of bacteria, seed germination, and cell membrane transport of calcium, hormones, and possibly vitamin B_{12}. Certain bacteria grow in alignment with magnetic fields. Magnetic orientation has long been suspected as a guiding factor in bird and sea mammal migrations. Most humans can detect very weak magnetic fields, commonly 1/100th the power of earth's ambient magnetic fields, or enough to move a needle on a simple compass—a good biolocator can detect a magnetic field 1/1000th the strength of the background magnetism.

Biolocators are able to sense weak electromagnetic fields by literally tapping into their unconscious awareness, and using simple tools or body feelings to identify changes in local fields. The ability to detect magnetic fields is believed to be associated with minute metallic particles located in the hypothalamus and other organs. Biolocators are recognized world-wide for their abilities to find flowing underground water, but they can also sense subtle energies associated with dug ditches, buried electrical lines, geologic faults, edges of underground ore bodies and rock strata, and surface location of caves and tunnels. Experienced biolocators can easily detect magnetic north or major EM field shift around electric power lines.

Infants will try to avoid certain dowseable GSZ and will crawl out of these fields. Animals will seek or avoid these subtle energies depending on their species energy affinities. Dogs, horses, and sheep avoid energy fields that humans feel as uncomfortable and are considered indicators of neutral energy. Other animals such as bees and cats apparently prefer stronger EM fields that other animals avoid. Beehives placed along DEL's are observed to produce higher honey yields and to enjoy better resistance to parasites.

Dogs, horses, and sheep avoid energy fields that humans feel as uncomfortable . . .

Geopathic energies have been studied for over 70 years in Germany and Russia. Observations of unusually high local cancer rates have been coupled with dowsers' detection of flowing underground water below bedrooms and geopathic stress zones traced through dwellings. Kathy Bucher in her classic book, *Earth Radiation* (1989), summarized thousands of health cases where individuals sleeping over certain energy zones that influenced sleeplessness, also experienced decreased immune system function, and correlated with unusual tumors and cancers in the body regions specifically exposed to the geopathic energy. David Cowan has republished his book, *Safe As Houses?*, as a free Internet download (http://www.leyman.demon.co.uk/Book,_Safe_As_Houses.html). This is a wonderful introduction to earth energies. His on-line book *Ley Lines, Geopathic Stress,...Dowsing, Poltergeists, and Electrostress* (http://www.leyman.demon.co.uk/index.html) is a great review of earth

energies and electromagnetic stress on brain awareness, observations of poltergeists, and other unusual visual phenomena.

A new consciousness is emerging about the body's own biofield, suggesting that organisms from bacteria and amoeba to more complex animals, try to maintain a certain energy balance or homeostasis, and that this can be disturbed by external energy fields that weaken biological functions.

There are two ways to detect these uncomfortable energies: either through analysis by trained, sensitized individuals (biolocators) or by bioassay of test animals. In certain early European cultures, cattle would be grazed for a season on a field where a building was to be built. When these animals were slaughtered, their tissues and organs would be examined for quality and for irregular growths and tumors. If few or no tumors were found, the site was deemed safe, but if many tumors were discovered, the site was avoided for permanent building. Obviously, this strategy is a precursor to modern lab testing and bioassay.

Geopathic dowsers can quickly survey a house and precisely detect DELs and areas or zones of subtle energy that cause them stress. I recommend that a dowser be brought onto a site prior to building placement for a subtle energy audit. In many cases, the building foundations can be adjusted by a few feet to avoid these flows or placed so that energy flows are along and within the length of a wall rather than through a sleeping space. A casual inspection would include looking for flowing underground water, and any "dowseable energy lines" that pass through a structure. Experienced dowsers can estimate the "Safe Time" for exposure to these energy fields based on 1) the individual's sensitivity and ability to repair from the EM stress, 2) the relative strength and distance from the energy source, and 3) time under stress (in minutes or hours.) The dowser searches for the maximum time a person can spend exposed to the energies prior to severe damage and from these data can estimate a maximum daily exposure.

These subtle energies have been recognized in various forms by ancient cultures, and are now studied as the new science of bioelectromagnetics (www.bioelectromagnetics.org/) by international organizations, such as the International Society for the Study of Subtle Energies and Energy Medicine (www.issseem).

Biolocation is a natural intuitive ability that can be relatively easily re-learned, and should be individually exercised to better understand subconscious states of awareness when reviewing properties. By becoming more aware of the one's internal feelings while on a site, we can design healthy interactions with the subtle energies of place.
Δ

Lee Barnes received his Ph.D. in Environmental Horticulture from the University of Florida. Working from his home in western North Carolina, he practices water well dowsing and geopathic energy location for homes and landscapes. He can be reached at lbarnes2@earthlink.net. Additional references and articles can be found at http://WNCdowsers.org/.

ZERI Principles and Methods—
Design for the Five Kingdoms

Kris Holstrom and Tom Riesing

REMEMBER THE EXCITEMENT, the feeling of overwhelming possibilities arising from your first permaculture design course, or your first exposure to the powerful ideas of permaculture? Finding an approach that brought together disciplines and ideas that had been careening around in our brains was incredibly powerful, both frightening and empowering. Since those days the practice of permaculture ideas and ideals has been a daily part of our lives. In the spring of 2005 a similar experience unfolded with our introduction to the concepts of Zero Emissions Research and Initiatives (ZERI).

While the ZERI and permaculture trainings were for us equally empowering, we imagine that a combination of the two, the way they fit hand-in-glove, dovetailing ideas and actions into a coherent path for the future, could be very exciting.

A brief history of ZERI follows the path of Gunter Pauli. He graduated in Economics from Loyola University in Belgium and obtained his masters in business administration from INSEAD (the premier European business school) in France. Under his leadership in 1992, Ecover developed the first biodegradable detergent using palm oil. The new Ecover factory built in Belgium was a marvel of the time, incorporating a grass roof for heating and cooling with solar and wind-powered water treatment systems. The company also addressed the social and cultural health of its employees, offering bicycles to all, bonuses for carpooling, and frequent company activities and events.

In a nutshell, ZERI is systems design for sustainability.

As Gunter delved more deeply into the concept of sustainability he realized that creating a product that cleaned up one part of the world, Europe, while devastating another part, the tropical rainforest (source of the palm oil), was not a sustainable model. After much soul searching, he decided to leave Ecover in 1994 to found ZERI, a non-profit organization. ZERI is devoted to practical approaches to meeting humanity's needs for water, food, energy, jobs, shelter and more—in an environmentally sustainable manner—by

applying science and technology and involving government, business, and academia. In a nutshell, ZERI is systems design for sustainability.

This article is an exploration of the five ZERI design principles—what ZERI calls "Nature's Design Principles" derived from the five kingdoms of nature (bacteria, algae, animals, fungi, and plants)—and the five-step ZERI Business Methodology used to evaluate and plan potential businesses or projects.

Since it is much easier to grasp design principles in the context of a real-life example, we will describe two case studies to understand what ZERI brings to the table and to give readers a brief overview of how permaculture and ZERI can be used in concert.

Colombian coffee growers

In the 1990s, Colombian coffee growers experienced a real decline in their standard of living even while earning a premium over coffees from other countries. It occurred because there was a glut of coffee on the global market. The decline in living standards led the coffee growers to try many other means to raise their incomes: Some switched to growing organic coffee. Some razed their coffee plantations to grow beef, but the land would only support two cattle per hectare (1 hectare = 2.47 acres.)

The plight of Colombian coffee growers coincided with the early years of ZERI and attracted the attention of Gunter and his network of scientists and practitioners. A major factor in the lowered standard of living was that the coffee growers were operating from the old core-business model—coffee was the one and only product. Of the total biomass of a coffee plant, only 4% ends up in the beans—the final product. How could one expect to make money when 96% of what Nature produces is wasted? So, each year as the coffee bushes are trimmed, that waste represents an opportunity to add value to the enterprise—a value above and beyond the value of the core product.

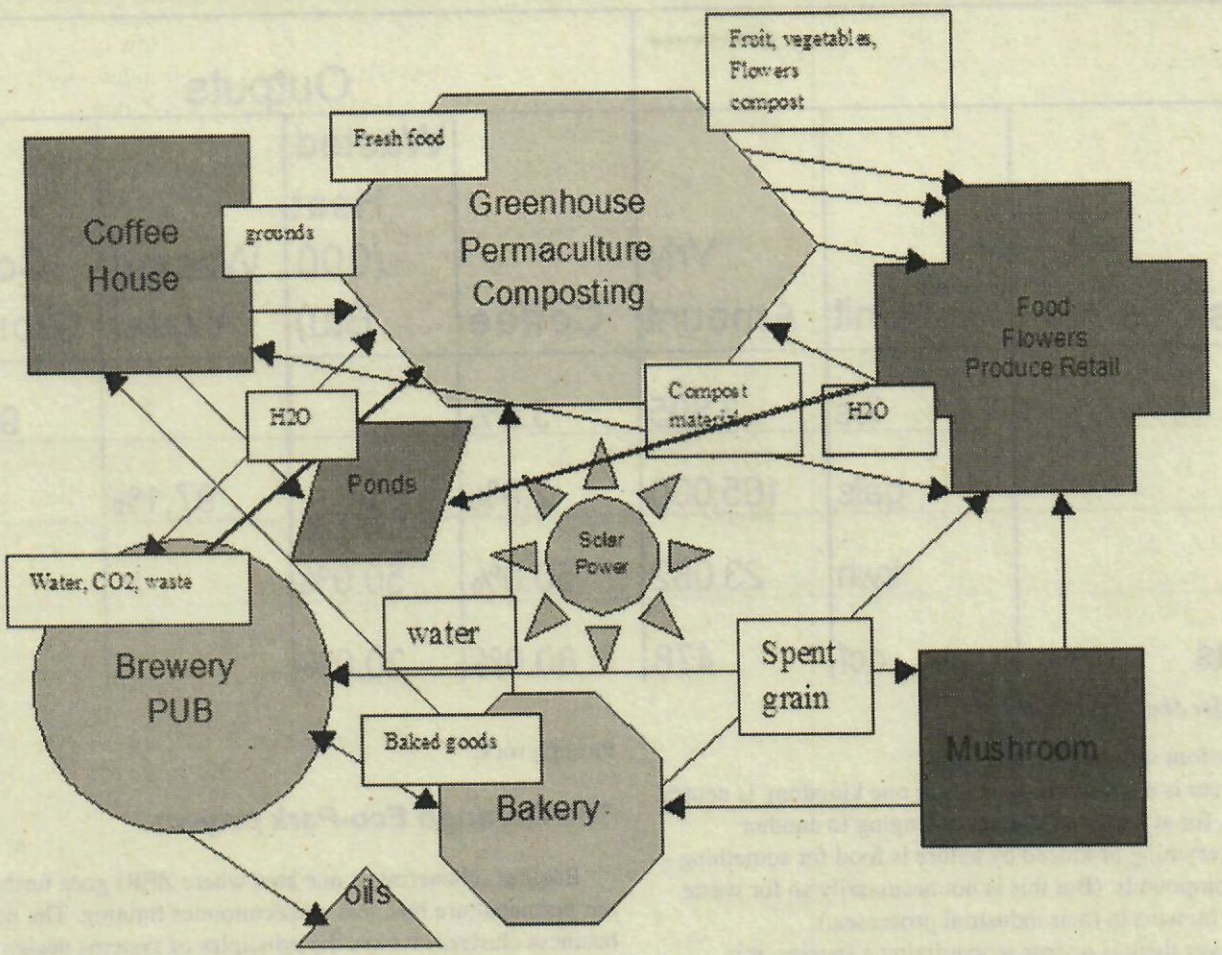
To enhance the income from coffee, two parts of the system were changed. First bananas were over planted to create a higher quality, shade-grown coffee. Organic growing techniques were adopted, so herbs were planted to attract beneficial insects for pest control. This gave the growers the ability to charge more for their coffee and resulted in two additional products—dried bananas and dried herbs—and increased the diversity of their system in the plant kingdom.

The first major concept that ZERI brings is an awareness of the five kingdoms of nature, after Lynn Margulis' book, *Five Kingdoms*. From the five kingdoms, ZERI derived "Nature's Five Design Principles," the first of which states that "Whatever is waste for one species in one kingdom is food for another species in another kingdom." What kingdom is particularly adept at feeding off of the waste from trees? Fungi. Feeding the slash from the annual trimming of the coffee plants to fungi—in particular *Pleurotus ostreatus* or oyster mushrooms—creates a high-value product which can be sold both locally and globally. Moreover, once the mycelium (the thin white strands of fungi that are the major "body" of fungi) have grown through the slash, they convert it from a mostly indigestible material to a highly nutritious animal feed from which both cows and pigs can thrive.

This introduces the animal kingdom. People eat the fruit of the mushrooms, and cows and pigs eat the enriched mushroom substrate once the mushrooms are harvested. The manure from

Table 1. Brewery Input/Output

Outputs		Beer	Waste Heat	Waste Water	Spent Grain	CO2	Yeast	Trub	Cleaning Chem-icals
Inputs									
Water	864 gallons	12.5%		81.6%	5.6%			0.3%	
Malted Barley	192 pounds	5.0%			95.0%				
Hops	9 pounds	5.0%						95.0%	
Yeast	3 pounds	trace					1000.0%		
Honey	10 pounds	100.0%							
Fruit	100 pounds	90.0%						10.0%	
CO2 (percentage of co2 created)		10.0%				90.0%			
Cleaning Chemicals	7 gallons	0.0%							100.0%
Electricity	115 kWh	0.0%	100.0%						
Natural Gas (heat/steam)	1.75 CCF	0.0%	100.0%						



Durango Ecopark

Figure 1. Schematic Connèction–Durango Eco-Park

the animals could be used as compost, but it has more value if it is used to feed anaerobic bacteria in a bio-digester. Enter the bacteria kingdom. The bio-digester produces methane, natural gas. This is burned to produce steam to pasteurize the slash from the coffee plants before it is inoculated with the mushroom spawn. Thus the bio-digester and the anaerobic bacteria which make it work together eliminate the need to buy gas for the pasteurization process. Meat from the cows and pigs is another value-added product for the coffee grower to sell locally. Finally, sludge from the bio-digester flows into a series of ponds in which algae grow; they purify the water and are eaten by fish—yet another local value-added product.

Colombian ZERI coffee plantations now offer a multi-product package consisting not only of coffee, but also dried oyster mushrooms, dried herbs, and dried bananas. The ZERI coffee plantation is now the low-cost producer and virtually immune to competition from multi-national corporations. Previously they had been buffeted by the vagaries of international coffee markets. Today, so much value is generated from the by-products of the process, that the price they receive for coffee is not so important. Product diversity assures a steady income in good coffee-growing years and bad.

This Colombian example makes use of a valuable tool created through the ZERI network and which is specifically the work of George Chan—"Integrated Farming and Waste Management System" (IF-WMS) (1). The ultimate goal of zero waste is the driving force behind these systems. Waste is always a resource in nature—and we must mimic her time-tested ways.

Nature's design principles

In the Colombian coffee growers example, we were primarily focused on the first of Nature's Design Principles (2):

1. Whatever is waste for one species in one kingdom, is food for another species in another kingdom. A corollary is that if one species is fed its own waste, it will degenerate. We see this today as mad cow disease. (And see #3 below.)

We saw that the slash from the coffee plants was the perfect food for oyster mushrooms, and that the resulting enriched substrate provided a nutritionally balanced feed for cows and pigs. Their waste in turn fed the anaerobic bacteria in a bio-digester (producing methane) and the resulting sludge became food for algae—so all five kingdoms were needed to recycle all of the nutrients from the coffee tree slash.

			Outputs			
Inputs	Unit	Yrly Amount	Coffee	Wasted Heat (000 Btu)	Wasted Water	Coffee Grounds
Coffee	lbs	3,895	5.0%			95.0%
Water	gals	165,000	2.9%		97.1%	
Elec	kwh	23,082	50.0%	50.0%		
Nat'l Gas	ccf	478	80.0%	20.0%		

Table 2. Coffee Shop Input/Output.

The other four design principles are:

2. Whatever is a toxin for a species in one kingdom, is neutral or a nutrient, for at least one species belonging to another kingdom. Everything produced by nature is food for something—even toxic compounds. (But this is not necessarily so for waste produced by humans in their industrial processes.)

3. Whenever there is a virus jeopardizing a species, it is harmless for species in at least 3 other kingdoms. Passing infected material (waste) through the other kingdoms provides a way of eliminating the infection. The opposite of this is what has created diseases like mad-cow—feeding animal waste to the same species of animal.

4. The more diverse and local, the more efficient and resilient. The epitome of this is the thousands of seed banks once maintained by individual farmers. They stored seeds that were developed over centuries as those best suited to produce in their locality. This treasure has largely been lost—deliberately undermined by multi-national seed/bio-engineering companies. Their loss puts humanity at risk.

5. Whenever species of all five kingdoms interact, the system will integrate and separate all matter at ambient temperature and pressure. This is an incredible capability. We are very good at putting things together—aseptic or "tetra" packaging, CDs, etc., but generally don't think of how the end product can be broken down for reuse or recycling. During our ZERI training we saw a video of an aseptic package (Like a juice container which consists of a layer of cardboard, a layer of aluminum foil and a layer of plastic all glued together) being "disassembled" by a solution containing members of all five kingdoms. The material was put in the solution, and it immediately began to come apart. Lichens (a symbiotic pairing of algae and fungi) were one of the main ingredients in this "bioliquid." They can extend very narrow filaments only two microns wide up to a mile or two a day through rock.

The Durango Eco-Park project

Business clustering is one area where ZERI goes further than our permaculture business and economics training. The notion of business clusters invokes the principles of systems design for strategic business planning.

One of the homework assignments in our ZERI training was to complete a business plan for a proposed business or process using the five-step ZERI business methodology, including the business cluster concept. The five steps of this process are (3):

1. Assemble total throughput models using input-output tables.
2. Search these tables for potential value-added products or cost-savings.
3. Model business clusters to exploit the system's elements.
4. Identify breakthrough technologies.
5. Identify or design industrial policies to support the business.

The concept behind the Durango Eco-Park project was to combine a set of businesses into one symbiotic system—each business generates a waste that is an input required by another—in a single location to facilitate those exchanges. This, of course, parallels the permaculture principle, "Integrate rather than segregate," placing elements in proximity for beneficial function.

There were five 'core' businesses included in this project:

- Brew Pub
- Bakery
- Coffee Shop
- Mushroom Grower
- Greenhouse and Nursery

The analysis begins with input-output tables. Number-crunching of the cost-accounting realm include making a list of the amounts of all the material inputs to each production process. (See Table 1. Brewery Input/Output.) The numbers are then normalized so that 100 is the starting amount for each input. Inputs are shown in rows and outputs are shown in columns. Each column shows the percentage of each input that winds up in that product or waste. A normal business analysis would only show a single column for the output, in this case beer. But in the ZERI analysis, we deliberately include the product wastes.

From the brew pub there are several "emissions" (See table 1): waste heat, waste water, spent grain, CO_2, yeast, trub (a sticky sweet/bitter residue that is left at the bottom of the kettle after the wort is removed), and cleaning chemicals. Waste heat would be shared with the coffee shop and the bakery. The waste water would go to the greenhouse and nursery. The spent grain would become a substrate on which to grow mushrooms, and some of it would be be used in bread. Piped into the greenhouse, CO_2 would increase the growth of the plants. The brewing process yields almost ten times as much yeast as one begins with. The extra yeast would be used in the bakery both to make bread and to make dog biscuits, in which it is a major nutritional component. In our plans, there were two possible uses for the trub: for crackers where the bitterness from the hops is desirable, and as a possible base for a pep-bar.

This analysis begins to give us a feeling for how the input/output tables can be used. The "waste" outputs are all potential means of adding value—either by generating new revenues or by reducing or eliminating costs. Figure 1 is a schematic diagram showing some of the connections from this business to others in the park.

Table 2 contains the input-output analysis for the Coffee Shop. It shows that 50% of the electric usage results in waste heat. There is also a lot of waste water and, of course, coffee grounds. Once again the waste heat is shared with the brewery and the bakery, and the waste water goes to the greenhouse and nursery. The coffee grounds can be used both to grow oyster mushrooms and also for vermiculture, as food for worms. The worms can be sold and the worm castings either packaged as a rich compost or used in the greenhouse and nursery in place of purchased fertilizer.

Table 3 shows the inputs and outputs for the bakery. The major waste from the bakery is heat—which in this table hasn't been quantified. One of the ways of using some of this heat is to dry the dog biscuits. They don't require baking—they only need to be dried, and this can be done in the heat rising above the ovens.

Finally, Table 4 shows what ZERI calls the output-input table. Here each of the wastes from the input-output tables is shown as an input row. Each use of one of those wastes as a new product or as an input (to reduce costs) is shown as a new column. New revenues are generated from the greenhouse/nursery and from mushroom cultivation. One of the cost-saving opportunities in the mushroom cultivation process is the possibility of inoculating the coffee grounds and spent grain after they leave the coffee shop and brewery without having to reheat them. Since heating the substrate is a significant cost of mushroom cultivation, this is a major advantage to be realized.

Table 3. Bakery Input/Output.

Output ⟹	Bread (loaves)	Bagels (dozens)	Pastries (dozens)	Crackers	Dog Biscuits	Dog Treats	Waste Heat[1]
Inputs							
Flour	200.0	12.5	12.5		25		
Water ($25/month)	150.0	6.5	7.5		0		
Yeast	2.05	0.04	0.10		0.05		
Salt	1.56	0.20	0.08		0.5		
Sugar	0.00	0.51	0.75		0		
Fat	0.00	0.00	0.75		0		
Flour from spent grain[2]	50.0				0		
Trub (from brewery)				7	0		
Dog Biscuits					15.5		
Dog Treats						12.5	
Electricity[6]							
Natural Gas (heat/steam)							

	Value-Added					
	Vegetables, Greenhouse	Mush-rooms	Dog Bakery	Human Bakery	Beer	Cleaning Chemicals
Unused Outputs						
Waste Heat (Gas)		100/60	100/20		100/20	
Waste Heat (Elec)		100/60	100/20		100/20	
Grey Water	100/50	100/50				
Waste Water	100/95					100/5
Coffee Grounds	100/5	100/95				
Spent Grain		100/90		100/10		
CO2	100/90				100/10	
Yeast	100/25		100/50	100/16	100/9	
Trub				100/100		

Table 4. Value added from combined wastes.

Lessons to be learned

Start with local resources and allow them to co-evolve with Nature. The days of cheap oil are ending and relocalization will be key. We will no longer be able to move resources around with impunity. The major import to and export from local economies will be knowledge. Co-evolving with Nature would slow our impatient and often destructive tendency to rush products and ideas through without understanding long-term implications and effects.

Provide a local solution to a global crisis. Our global crises were built one local problem at a time. We can dismantle crises in the same way, though the urgency is clear. Use waste as "food" to produce more income; generate more jobs to sustain local communities, and eliminate pollution.

Don't ask how to get more out of nature, ask how you can make the most out of what Nature provides. Diversify products and income streams. What a contrast to the prevailing business model of downsizing! Contemporary business dogma says : Consolidate, become less local, eliminate jobs, eliminate competition—all to create monetary wealth for a few. Upsizing through ZERI design is win-win-win: more jobs, more income for many, no pollution—which in turn improves health, improves job productivity, and increases sustainability through diverse and interconnected businesses. Let us learn from a master in systems design and mimic nature's time-tested techniques.

Use all the kingdoms of nature. While not always possible when looking at specific business clusters, this goal should always be kept in mind. Incorporating all five kingdoms increases the stability and resilience of the system. Thinking "outside the box" in this way provides a stimulating challenge.

The whole is greater than the sum of the parts. Clusters of businesses are diverse, robust, and profitable. Why settle for one thing done well when a smorgasbord of opportunity is before you? If a sumptious meal was presented, would you just eat cake?

While one person or one entity may prefer to concentrate on creating the perfect cake, the meal must be planned—as a system. The ZERI feast leaves no waste behind and feeds our bodies, our minds and our imaginations.

ZERI and permaculture can dovetail to create a powerful synergy for our times. We need to become more savvy in the methods and madness of the business world. As individuals we must continue to evolve our personal paths, incorporating permaculture in our homes and lives. As workers and business owners we need to consider a zone beyond "wilderness"—the zone of commercial business. It is vital for us as designers and as world citizens to understand the interactions, connections, and patterns outlined in permaculture and by the ZERI processes noted above. By combining the insights of Permaculture and ZERI we can create the resilient, productive, imaginative systems we need to thrive in an ever-changing, lightning-paced world. Δ

Tom Riesing, a former investment banker, and his partner Christie Berven, operate Oakhaven Permaculture Center at 8,700' near Durango, Colorado. Both trained in Permaculture Design at Central Rocky Mountain Permaculture Institute (CRMPI) and in Permaculture Teaching at Earthaven Ecovillage. Kris Holstrom, who also trained at CRMPI, consults and runs nearby Tomten Farm, a solar-powered permaculture demonstration at 9,000'.

Notes

1. See http://groups.yahoo.com/group/if-wms/
2. http://zeri.org/index.cfm?id=designprinciples
3. Pauli, Gunter, *Upsizing: The Road to Zero Emissions, More Jobs, More Income and No Pollution*, Greenleaf Publishing, 1998, p. 114.

Flows of Energy in Social-Scapes

Time to Rekindle Local Currencies

Susan Witt

THOSE OF US LIVING in the Southern Berkshires realize how lucky we are to have the complex of locally owned stores and restaurants that help shape our community. Main Street hums with activity. Consumers know that Great Barrington shops are unique to the Berkshires; a welcome change from the monoculture look and standardized products of franchises. Visitors are surprised by the originality; regulars are proud and loyal patrons. The owners and clerks and chefs and waitpersons are our neighbors and friends. We sit on school boards together, gather at town meetings, and stroll past each other on the River Walk. Our youth prefer to spend free time on Main Street rather than at the mall. They experience and contribute to the vibrancy of our "downtown."

. . .keeping dollars local supports the cultural, environmental, and social fabric. . .

Part of what has led to this successful local entrepreneurship is an informed citizenry that understands that keeping dollars local supports the cultural, environmental, and social fabric of the Berkshires. They ask for locally grown food at restaurants; they make weekly visits to the farmers' market as a household ritual; and they hire local professionals before distant impersonal firms. Another factor in the success of our local businesses is the plethora of still locally owned and managed banks in the Berkshires. With all of the changes in regulation and the consolidation in the banking industry, a handful of local banks remain in our region, an important resource for the health of our Berkshire economy.

One of those quintessential local bankers, Eugene Hannon, died at the end of April 2004. He was an active member of the Southern Berkshire Chamber of Commerce, a member of the Great Barrington Rotary Club, an advocate for affordable mortgages for first-time homebuyers, and a champion of lending opportunities for the growing Hispanic population. I have my own favorite memories of Gene relative to the development of a local currency for the Southern Berkshires.

In 1989 Frank Tortorelli, the owner of the popular Great Barrington Deli, turned to Gene for a bank loan to renovate a new site for his restaurant. Bank regulations were getting tighter. Frank's figures didn't compute, and Gene had to turn him down. Frank then came to the SHARE loan collateralization program that I managed at the time and asked for help. We told him that he didn't need our group of local investors because he already had a strong customer base and he should turn to them for a loan through pre-sales. What emerged were "Deli Dollars." Frank sold each Deli Dollar Note for $8, redeemable for $10 worth of Zonker Harris and other colorfully named sandwiches once the new space was open. He raised $5,000 in 30 days, repayable not in hard-to-come-by federal dollars but in product. The Deli Dollars were dated over a year's time so they would not all come due the first month of operation and so cause a cash-flow problem. Frank had structured his own loan repayment schedule.

Gene Hannon was one of the first to buy a set of Deli Dollars. A loan for Frank's Deli wasn't bankable under current national standards, but this local banker knew that Frank's community credentials were excellent. Frank would be there to make the sandwich when the note was redeemed.

Berkshire Farm Preserve Notes followed, jointly issued by two farm stands, Taft Farms and the Corn Crib. A head of cabbage replaced the head of George Washington. The logo read "In Farms We Trust" rather than "In God We Trust." We had created a "Berkshire Farm Preserve Note" rather than a "Federal Reserve Note." And we all had fun doing so.

In May of 1991 the Deli Dollar was front page news in *The Washington Post* with a story of "Yankee Ingenuity." ABC, CBS, NBC, CNN, and Tokyo TV all traveled to the Berkshires for prime-time stories on these Berkshire currencies. Gene had to tell and retell on camera why he couldn't make the loan but would support the Deli by

purchasing Deli Dollars. In the process he became a spokesperson for our small local businesses.

In the summer of 1992, seventy Main Street businesses got together through the Main Street Action program of the Chamber of Commerce to issue BerkShares. During a six-week period BerkShares were given away to customers shopping in the participating stores at the rate of one BerkShare for every ten dollars of purchase. Every store signed the back of each BerkShare before it was issued so that we could track the source. Then, during a three-day period in the middle of September the BerkShares could be redeemed at any of the participating stores. We attempted to have a standard redemption policy, but the stores had differing needs. Most stores accepted BerkShares as payment for 20% to 50% of the cost of any item. The Snap Shop on Railroad Street understood that we were introducing a local currency that would benefit the whole community and therefore permitted 100% redemption. Some lucky folks collected enough BerkShares to purchase that long-dreamed-of new camera.

Celebrating local support

There was a spirit of festivity on Main Street and in the larger community. Second-home owners called their year-round neighbors to say, "I can't make it up for BerkShares weekend, so please go to my kitchen, and on the shelf over the sink, you will find a stack of BerkShares. Get something nice for your kids."

Over 75,000 BerkShares went into circulation, representing three-quarters of a million dollars in trade. Twenty-eight thousand were used in a three-day redemption period—remarkable return on a give-away item.

With that success in place, the BerkShare committee of the Chamber called a meeting of banks to discuss issuing BerkShares at the holiday period. A similar program was implemented in several prairie communities on the Canadian border. In November, these prairie banks launch a 0% interest loan program for holiday shopping. The loans are made in a local currency to ensure that the purchasing remains local. The local money cannot be spent at chain stores or for catalogue or Internet shopping. The banks and merchants thereby create a local economic tool to encourage support of small regional businesses. Local merchants redeem the notes at the participating banks at 97 cents on the dollar, thus sharing the cost of the program with the bank.

At the meeting, it was Gene Hannon who said, "Why are we putting time and energy into another short-term issue? Why don't we just work for a year-round local currency?" I remember asking him how he thought such a program would work. He suggested a 10% discount note. Consumers would purchase BerkShares at participating banks for 90 cents each. Participating merchants and producers would accept BerkShares at a dollar equivalent in payment for goods and services. As long as the BerkShares stayed in circulation—for change, for partial payment of salaries, and for purchase of goods—they would keep full dollar value; however, when merchants accumulated too many in their cash registers, they could redeem the notes at their banks for 90 cents on the BerkShare.

Purchasing BerkShares would be a citizen's way of voting for local businesses and keeping money local. Non-profits might purchase a $10,000 block of BerkShares for $9,000 and then sell them to their members at full value as a way of fundraising and as a way of showing that a healthy local business economy is deeply connected to a healthy arts, environmental, educational, and social services community.

"Why are we putting time and energy into another short-term issue? . . ."

Gene Hannon's challenge to introduce a year-round local currency has remained tucked in a drawer since that meeting, but the E. F. Schumacher Society is pulling it out and dusting it off in the face of the powerful impact of the global economy on all local economies. The Society has undertaken a campaign to raise first-year funding for such a program. Much work is ahead. It will mean reconvening the business and banking sectors for their input and advice as to how to shape such a program. It will require the cooperation of concerned consumers.

In order to bring as many resources as possible together around the history, theory, and practice of issuing local currencies, the E. F. Schumacher Society organized an international conference at Bard College in Annandale-on-Hudson, New York, titled "Local Currencies in the Twenty-First Century" in June 2004. Bernard Lietaer, Margrit Kennedy, Edgar Cahn, Paul Glover, Richard Douthwaite, Thomas Greco, Michael Linton, Mary-Beth Raddon, Michael Shuman, and other leaders in the local currency movement spoke. Honored guest Pete Seeger closed the event on Sunday with a Local Food Fest and Concert. Read more about the conference at www.localcurrency.org.

Gene knew about the conference. I had hoped he would be well enough to attend, but he knew it would be otherwise. He was a champion of the strong, diverse local businesses that are at the heart of our Berkshire community. He would have been pleased to see folks gathered together to create new economic tools that will further support those businesses. Δ

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Dead Zones Increasing at the Edge of the Sea

Janet Larsen

AS SUMMER COMES TO THE GULF of Mexico, it brings with it each year a giant "dead zone" devoid of fish and other aquatic life. Expanding over the past several decades, this area now can span up to 21,000 square kilometers, which is larger than the state of New Jersey. A similar situation is found on a smaller scale in the Chesapeake Bay, where since the 1970s a large lifeless zone has become a yearly phenomenon, sometimes shrouding 40 percent of the bay.

Worldwide, there are some 146 dead zones; areas of water that are too low in dissolved oxygen to sustain life. Since the 1960s, the number of dead zones has doubled each decade. Many are seasonal, but some of the low-oxygen areas persist year-round.

Coastal Dead Zones Around the World Source: http://www.unep.org/geo/yearbook GEO Yearbook 2003 (Nairobi: 2004), compiled from Boesch 2002, Caddy 2000, Diaz et al. (in press), Green and Short 2003, Rabalais 2002.

Complex causes

What is killing fish and other living organisms in these coastal areas? A complex chain of events is to blame, but it often starts with farmers trying to grow more food for the world's burgeoning population. Fertilizers provide nutrients for crops to grow, but when they are flushed into rivers and seas they fertilize microscopic plant life as well. In the presence of excessive concentrations of nitrogen and phosphorus, phytoplankton and algae can proliferate into massive blooms. When the phytoplankton die, they fall to the seafloor and are digested by microorganisms. This process removes oxygen from the bottom water and creates low-oxygen, or hypoxic, zones.

Most sea life cannot survive in low-oxygen conditions. Fish and other creatures that can swim away abandon dead zones. But they are still not entirely safe; by relocating they may become vulnerable to predators and face other stresses. Other aquatic life, like shellfish, that cannot migrate in time suffocate in low-oxygen waters.

Dead zones range in size from small sections of coastal bays and estuaries to large areas of seabed spanning some 70,000 square kilometers. Most occur in temperate waters, concentrated off the east coast of the United States and in the seas of Europe. Others have appeared off the coasts of China, Japan, Brazil, Australia, and New Zealand.

The world's largest dead zone is found in the Baltic Sea, where a combination of agricultural runoff, deposition of nitrogen from burning fossil fuels, and human waste discharge has overfertilized the sea. Similar problems have created hypoxic areas in the northern Adriatic Sea, the Yellow Sea, and the Gulf of Thailand. Offshore fish farming is another growing source of nutrient buildup in some coastal waters.

30% of Zones are in US

Forty-three of the world's known dead zones occur in U.S. coastal waters. The one in the Gulf of Mexico, now the world's second largest, disrupts a highly productive fishery that provides some 18 percent of the U.S. annual catch. Gulf shrimpers and fishers have had to move outside of the hypoxic area to find fish and shrimp. Landings of brown shrimp, the most economically important seafood product from the Gulf, have fallen from the record high in 1990, with the lowest catches corresponding to the highly hypoxic years.

Excess nutrients from fertilizer runoff transported by the Mississippi River are thought to be the primary cause of the Gulf

of Mexico's dead zone. Each year some 1.6 million tons of nitrogen now enter the Gulf from the Mississippi basin, more than triple the average flux measured between 1955 and 1970. The Mississippi River drains 41 percent of the U.S. landmass, yet most of the nitrogen originates in fertilizer used in the productive Corn Belt.

Worldwide, annual fertilizer use has climbed to 145 million tons, a tenfold rise over the last half-century. This coincides with the increase in the number of dead zones around the globe. And not only has more usable nitrogen been added to the environment each year, but nature's capacity to filter nutrients has been reduced as wetlands are drained and as areas along riverbanks are developed. Over the last century, the world has lost half its wetlands.

In the United States, some of the key farming states like Ohio, Indiana, Illinois, and Iowa have drained 80% of their wetlands. Louisiana, Mississippi, Arkansas, and Tennessee have lost over half of theirs. This lets even more of the excess fertilizer farmers apply flow down the Mississippi River to the gulf.

What is killing fish and other living organisms in these coastal areas?

There is no one way to cure hypoxia, as the mix of contributing factors varies among locations. But the keys are to reduce nutrient pollution and to restore ecosystem functions. Fortunately, there are a few successes to point to. The Kattegat Strait between Denmark and Sweden had been plagued with hypoxic conditions, plankton blooms, and fish kills since the 1970s. In 1986, the Norway lobster fishery collapsed, leading the Danish government to draw up an action plan. Since then, phosphorus levels in the water have been reduced by 80 percent, primarily by cutting emissions from wastewater treatment plants and industry. This, combined with the reestablishment of coastal wetlands and reductions of fertilizer use by farmers, has limited plankton growth and raised dissolved oxygen levels.

The effects of reducing pollution

The dead zone on the northwestern shelf of the Black Sea peaked at 20,000 square kilometers in the 1980s. Largely because of the collapse of centralized economies in the region, phosphorus applications were cut by 60 percent and nitrogen use was halved in the Danube River watershed and fell similarly in other Black Sea river basins. As a result, the dead zone shrank. In 1996 it was absent for the first time in 23 years. Although farmers sharply reduced fertilizer use, crop yields did not suffer proportionately, suggesting they had been using too much fertilizer before.

While phosphorus appears to have been the main culprit in the Black Sea, nitrogen from atmospheric sources—namely, emissions from fossil fuel burning—seems to be the primary cause of the dead zones in the North and Baltic seas. Curbing fuel use through efficiency improvements, conservation, and a move toward renewable energy can diminish this cause of the problem.

Worldwide, annual fertilizer use has climbed to 145 million tons, a tenfold rise over the last half-century.

For the Gulf of Mexico, curbing nitrogen runoff from farms could shrink the dead zone. Applying fertilizer to match crop needs more precisely would allow more nutrients to be taken up by plants instead of being washed out to sea. Preventing erosion through conservation tillage and changing crop rotations, along with wetland restoration and preservation, could also play a part.

Innovative programs such as the American Farmland Trust's Nutrient Best Management Practices Endorsement can reduce the common practice of using too much fertilizer. Farmers who follow recommendations for fertilizer application and cut their use are guaranteed financial coverage for potential shortfalls in crop yields. They save money on fertilizer purchases and are insured against losses. Under test programs in the United States, fertilizer use has dropped by a quarter.

With carefully set goals and management, it is possible for some dead zones to shrink in as little as a year. For other hypoxic areas (especially in the Baltic, a largely enclosed sea with slower nutrient turnover), improvement may take longer, pointing to the need for early action. For while dead zones shrink or grow depending on nutrient input and climatic conditions, the resulting fish dieoffs are not so easily reversed. Δ

On the Edges

Between Ice and Ocean

Albert Bates

IN JARED DIAMOND'S *COLLAPSE: How Societies Choose to Fail or Succeed*, there is an oft-quoted tale of the early Greenland settlers. For whatever religious or cultural reasons, they simply refused to adapt their European customs of food, habitation and land use to either the traditions of the well-adjusted and resourceful native populations or the necessities brought about by sudden climate change. Instead, they went extinct.

Ironically, the early Greenlanders went extinct because they could not tame their land to match their ways of living. They died and the ice prevailed. Today, it is the ice that is dying and the humans who are seeming to prevail. I say "seeming," because the ice is not really going very far. It is becoming ocean. We might beat some ice. We won't beat the ocean.

There is an unseen edge at the phase change that freshwater goes through on millennial timescales. Until now that edge hasn't been particularly important to humans because it was invisible, and because its change was so, well, glacial. Both of those attributes are disappearing and our science is only just coming to grips with what that means. For the one billion humans and the many more wild creatures who inhabit coastal plains and ocean shorelines, the importance of far-away ice, it seems, will be very significant indeed.

As the world's water locked in glacial ice is released at an increasing rate, the edges of continents change, literally shaping the frontiers of the future.

The key to Eurpoean climate

The Greenland ice sheet is two miles thick and about the expanse of Mexico. Deep in its core are memories of snowfalls a quarter million years ago, including the ice record of 20 sudden climate changes in the past 110,000 years. To say that Greenland holds the key to the climate of Europe is not an understatement. The freshwater resource entombed in Greenland's snows, if loosed into the North Atlantic, could slow the deep ocean conveyor that regulates weather for much of the world.

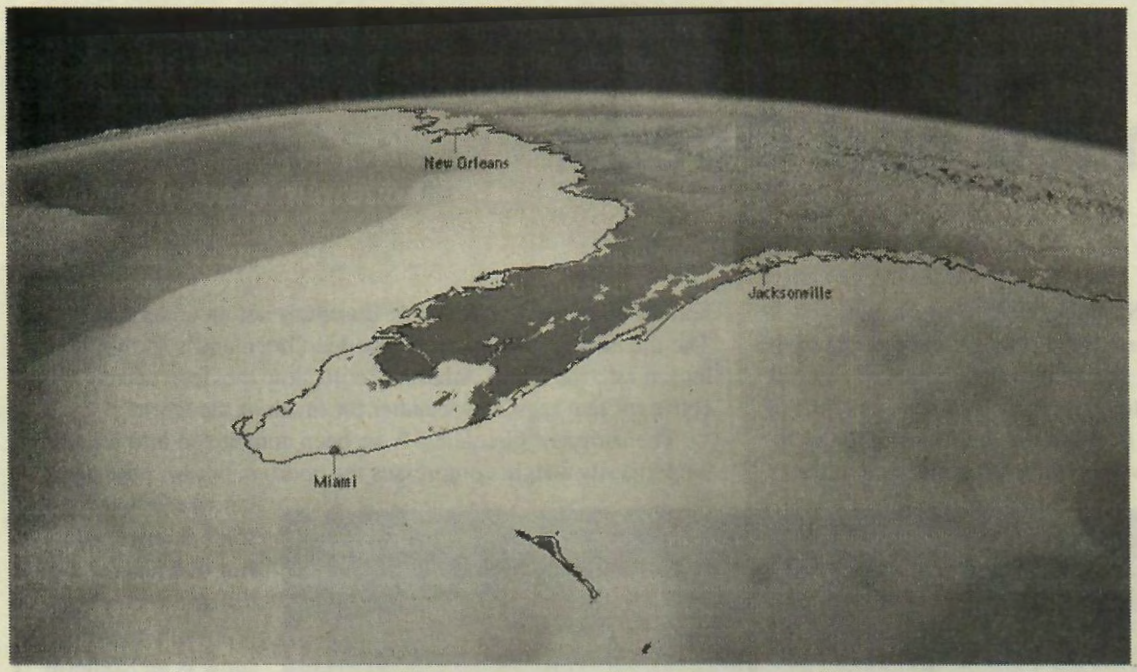
The snows of Greenland have been compacted into ice so thick that its weight compresses the bedrock below, pushing it below sea level in some interior valleys. But that weight is now lifting.

Around the rim of snow is an isotherm that marks the zone where summer and winter have historically tussled: the thaw-mark scientists call the equilibrium line. What had been a narrow band in the 1970s is now at its broadest since recordkeeping began.

Satellite gravity measurements from 130 miles up in space show Greenland is melting. In 2005 it lost 52 cubic miles of ice to the ocean, triple the average 10 years ago. December is a time when Greenland usually adds ice, but last year, about the same time as the record 15th hurricane of the season was forming in the mid-Atlantic, Greenland's ice was melting.

If you have ever sat quietly on a winter day and watched snow and ice melt, then many of these patterns will be familiar. It gets wetter on the surface, and that wetness makes it shine but is also more transparent, meaning the sun's rays penetrate deeper. As accumulations thaw, they crack apart, and those cracks become conduits for meltwater. Below the surface, sometimes seen, often unseen, the water is making and enlarging channels for itself, pulled by gravity and pushed by the pressure of the ice behind. Air bubbles flow in this water like tiny sledgehammers, smashing new channels and enlarging older ones.

At summer tent camps in Greenland's interior, ice-penetrating radar is mapping a maze of drainage crevices, tunnels and cracks



Perhaps Florida's visitor industry will be better served in the future by water parks than by magic kingdoms.

below the surface that are completely invisible to the human eye. The process is not invisible to our senses of hearing and touch, though. As Greenland's 12 glaciers thaw and their sweat dribbles into the sea, the bedrock sighs and stretches like someone arousing from a gentle sleep. Unburdened, it tries to stand up straight again. We mere humans feel and hear this as Richter 5 earthquakes. In 2005 the total number of ice-quakes in Greenland was three times the average ten years earlier, with five times more in summer than in winter.

Half a world away, in the Antarctic, warm oceans are melting the offshore ice shelves that form a barrier between the continental ice sheets and seawater. A few decades ago the shelves extended 5,200 square miles further than they do today. As these shelves melt, the land sheets discharge more icebergs and then, diminished in depth and eroded by their own water underneath, they too melt faster. Meltwater that started as trickles in the hot sun forms broad unseen rivers that move the great sheets oceanward.

In the past, deep underground, these rivers could encounter such thick coastal shelves that they would refreeze, slowing the loss of ice. When the Larson B ice sheet broke apart and slid off West Antarctica in 2002, it added a block of ice the size of Rhode Island to the Pacific Ocean. It also unplugged many hidden dams in the meltwater rivers extending up under the West Antarctic Ice Sheet. Since the Larsen collapse, it has become clear that the West Antarctic has a snowball's chance in Hell of holding its shape.

Doubling iceberg migration

The volume of icebergs leaving West Antarctica's coasts doubled between 1995 and 2005 and is expected to double again by 2015, to 100 cubic miles per year. Greenland's ice mass is diminishing at nearly twice that rate.

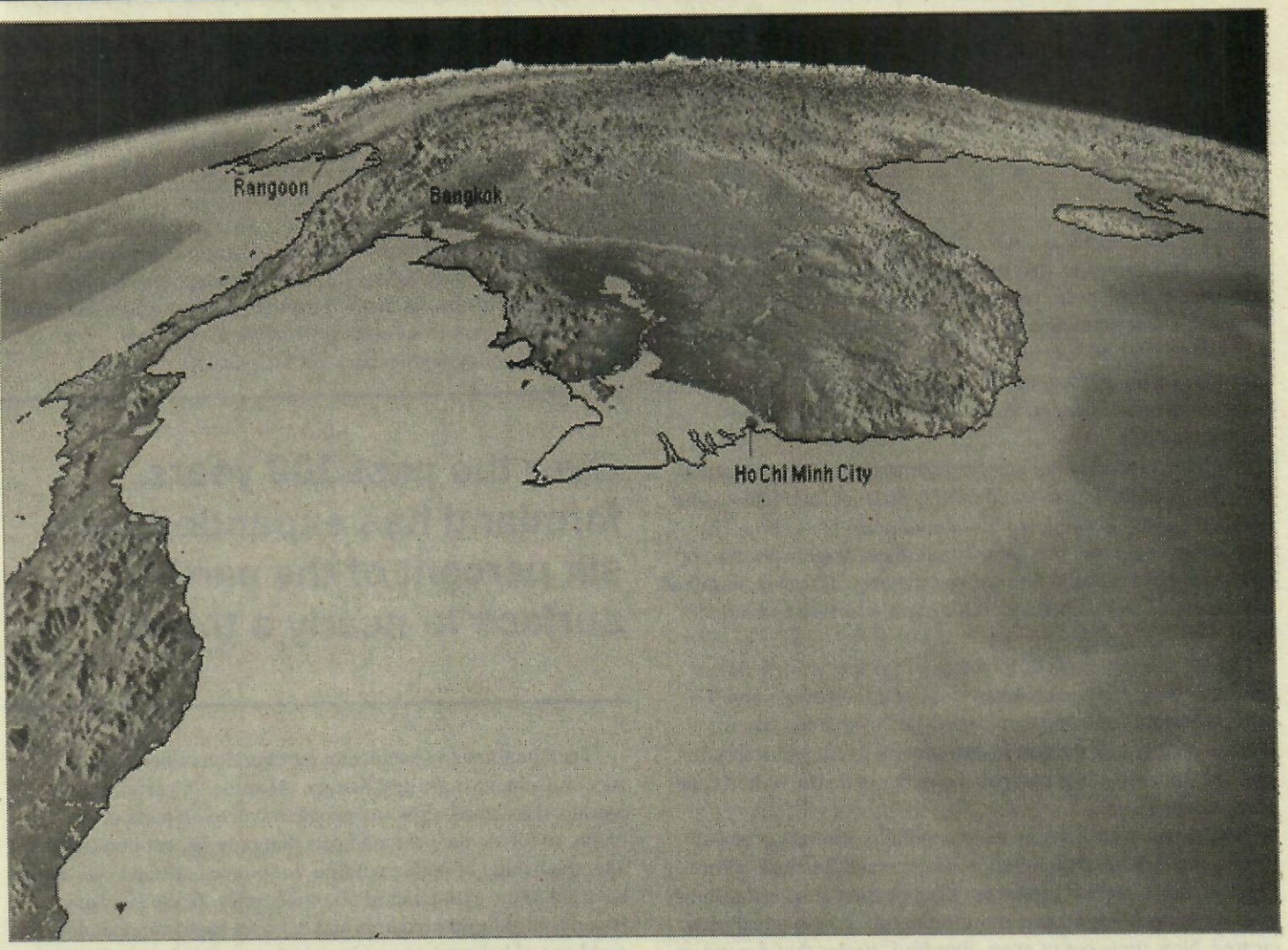
If either Greenland's glaciers or the West Antarctic Ice Sheet were to slide away completely, global seas would rise by 15 to 20 feet, re-sculpting coastlines worldwide. While worst-case estimates for sea level rise from august bodies such as the Intergovernmental Panel on Climate Change have suggested such increases might take a century, the meltwater roller skates under the West Antarctic sheet and the earthquakes caused by the unweighting of the Greenland land mass could precipitate giant masses of ice sliding into the ocean in the short span of a single summer.

The crash of gargantuan icebergs into the ocean on that scale could unleash a torrent of tsunamis traveling the earth at jet-aircraft speed. When the waves finally subsided, the oceans will not have receded. Sea level could remain elevated for 20,000 years. Perhaps longer. If the East Antarctic Ice Sheet were to melt as well, seas would rise as much as 200 feet.

Deep in its core are memories of snowfalls a quarter million years ago. . .

If I were a town planner in Rotterdam, Tokyo, Cancun, Bangkok, New York, or Miami I would not be working on waterfront parks and recreation. I would be thinking about very large and long dikes about now. Or maybe about moving low-lying populations to higher ground.

The kinship between ocean and ice is very old and very essential. It is yet another means by which Mother Nature sequestered carbon to soothe our fevered planet when it drifted too close to the sun. Ice at the poles reflects sunlight into space and that also keeps us cool. The effect of ice-chilled saltwater in



Fighting for control of the Mekong Delta takes on a whole new meaning.

propelling our deep ocean conveyors is well known. What is less well-known is what happens when it is no longer there. It seems quite likely we, or our children, are about to find out. Δ

Illustrations from William Haxby, Lamont-Doherty Earth Observatory, for Nova: Warnings from the Ice (PBS: 2000). http://www.pbs.org/wgbh/nova/warnings/waterworld/

Albert Bates has been director of the Global Village Institute for Appropriate Technology since 1984 and of the Ecovillage Training Center at The Farm community in Summertown, Tennessee, since 1994. He is the author of several books on energy, environment, and history, including Climate in Crisis: The Greenhouse Effect and What You Can Do *(1990). His new book,* The Post-Petroleum Survival Guide and Cookbook: Recipes for Changing Times, *will be out in September from New Society Publications.*

Empty Skies: World's Birds at Risk

Janet Larsen

EVEN BEFORE CANARIES WERE BROUGHT into coal mines to alert miners to the presence of poisonous gas, birds were giving us early warning calls signaling the earth's deteriorating environmental health. Worldwide, some 1,212 of 9,775 bird species—one out of every eight—is threatened with extinction. Destruction and degradation of habitat is the number one danger, threatening 87 percent of these vulnerable birds.

As an ever-expanding human population has altered natural places around the globe—wetlands, grasslands, and forests-bird numbers have fallen. Global bird populations have shrunk by upto 25 percent since pre-agricultural times, largely because of conversion of habitat to farms. Over the past 300 years, farmland has expanded from 6 percent of the earth's surface to nearly a third.

Today three quarters of threatened bird species depend on forests as their principal habitat; each year, however, some 13 million hectares of forests are destroyed, an area the size of Greece. Nearly half the forests lost are relatively undisturbed primary forests that are home to a number of sensitive birds and other creatures.

The sharpest declines in avian populations in recent years have come in Asia, particularly in Borneo and Sumatra, where lowland moist tropical forests are disappearing at an astonishing rate. By 2000, some 40 percent of Indonesia's forests had been cleared. Now three out of every four bird species that depend on Sumatra's lowland forest are on the verge of extinction. In addition to the loss of forests due to logging for lumber, the increasing demand for palm oil—recently touted as a biofuel—has raised pressure to convert natural forests to palm plantations. Without a rapid reversal of deforestation trends, all the lowland forest could be lost within a decade. Overall, some 118 of Indonesia's bird species, including several endemic parrots and cockatoos, are threatened with extinction—the highest number of any country.

Close behind in numbers is Brazil, where 115 bird species are threatened. Both the Amazonian rainforest and the savannah-like *cerrado* are being cleared for ranches and farms, most recently for large-scale soybean production for feed, food, and fuel. In addition, Brazil's Atlantic rainforest has shrunk by 90 percent, squeezed by growing cities and farms. This fragmented forest is home to some 950 kinds of birds, 55 of which are endemic and threatened.

Since the year 1500, 150 species of birds are believed to have disappeared entirely. Some 50 of these extinctions were the result of overhunting. Hunting brought about the demise of North America's passenger pigeon, once the most numerous bird on earth, within a human lifetime. Direct exploitation, including hunting for food and capture for the pet trade, is the second greatest danger after habitat loss, affecting nearly a third of threatened bird species today. Fifty-two of the world's 388 parrot species are at risk from overexploitation. (See data at www.earthpolicy.org/Updates/2005/Update50_data.htm.)

Over the past 300 years, farmland has expanded from six percent of the earth's surface to nearly a third.

The intentional or accidental introduction of non-native species is the next greatest danger, affecting 28 percent of the world's threatened birds. As people travel to all parts of the globe, so too do the pests and pets that prey on, out-compete, or alter the habitat of native wildlife. Introduced rats and cats alone have led to the extinction of 50 bird species. In the Hawaiian Islands, introduced predators and diseases have compounded problems of habitat loss and knocked out more than half of the 100-plus endemic bird groups. Possums, rats, and other mammals brought into New Zealand in the past 200 years have ravaged the once abundant diversity of large birds that had evolved over 80 million years with no natural predators.

Pollution poses an additional risk, affecting 12 percent of the threatened bird species. In India, Gyps vulture populations have plummeted by 95 percent in less than a decade, many poisoned by medicine used to treat the livestock they feed upon. Populations of common Western European farmland birds dropped by 57 percent between 1980 and 2003, with much of the decline attributed to the intensification of agriculture. In addition to direct poisoning from fertilizer and pesticide applications, runoff of chemicals contaminates the wetlands upon which migrating waterfowl rely. Persistent organic pollutants, such as DDT residues, dioxins, and polychlorinated biphenyls, accumulate in the food chain, and can lead to deformities, reproductive failure, and disease in birds.

Climate change is a relatively new threat to birds and other wildlife. Worldwide, a third of plant and animal species could become extinct by 2050 as a result of climate change. Over the last three decades, global temperatures have risen by 0.6°C (1°F), bringing changes to the migration, breeding, and habitat ranges of

some birds. For example, as spring has come earlier in the Netherlands, so too has the emergence of the caterpillars that great tit birds need to feed to their nestlings. Unfortunately, the birds' egg-laying date has not shifted, putting the hatching of the chicks out of sync with their food supply.

Birds that spend all or part of their lives at the earth's poles are particularly vulnerable to rising temperatures. Migratory waterbirds in the Arctic will lose out as warming alters this vulnerable ecosystem. In the Southern Hemisphere, where 10 of the world's 17 penguin species already are threatened, conditions will not improve as global temperatures increase by a projected 1.4-5.8°C (2.5-10.4°F) during this century.

In addition to these looming threats, seven percent of threatened bird species are at risk from incidental mortality. A rapid decline in seabird populations over the last 15 years corresponds with the growth in commercial longline fisheries. Each year these operations kill some 300,000 seabirds that are tempted by bait and then ensnared. All 21 species of albatross are now threatened or near-threatened because of run-ins with the fishing industry. Birds also fall prey to industrial development, which endangers more than half of the threatened birds in eight Latin American and Caribbean countries. In Europe, Central Asia, and Africa, electrocution on power lines has caused the mass mortality of raptors. And hundreds of millions of birds in the United States die each year from collision with windows, the number one cause of U.S. avian mortality.

If birds disappear, so do the economically valuable services they provide. Birds pollinate flowers, disperse seeds, and help to eliminate rodents, insects, weed seeds, and other pests. Scavenger species recycle nutrients and clean up dead and decaying animals that might otherwise be sources of disease.

Preventing the decline and extinction of additional bird populations depends largely on protecting the world's remaining wild spaces and preserving the health of our natural and altered ecosystems. For species that are critically endangered, more-intensive management may be needed if population numbers are to return to a viable level. This may include captive breeding and re-introduction, and the active removal of invasive predators to the extent possible. To prevent the spread of avian disease, more stringent biosecurity is needed to limit contact between infected domestic flocks and wild birds. Diverting birds away from artificial structures—buildings, towers, and turbines—and siting new construction outside of migratory paths also could prevent avian fatalities.

Reports this past spring that the ivory-billed woodpecker, long thought to be extinct, is still with us thrilled birdwatchers and others, but this sort of second chance seldom occurs in nature. Even with continued habitat protection, once wildlife populations drop dramatically, a rebound is far from guaranteed. And without stabilizing climate and human numbers, putting fences around all the parks in the world will not be enough to protect threatened species. Δ

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- Birds and Buidlings. http://www.birdsandbuildings.org
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- Convention on the Conservation of Migratory Species of Wild Animals. http://www.cms.int
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From the Regions

Founder of Brazil's First Permaculture Institute Begins Anew

Marsha Hanzi

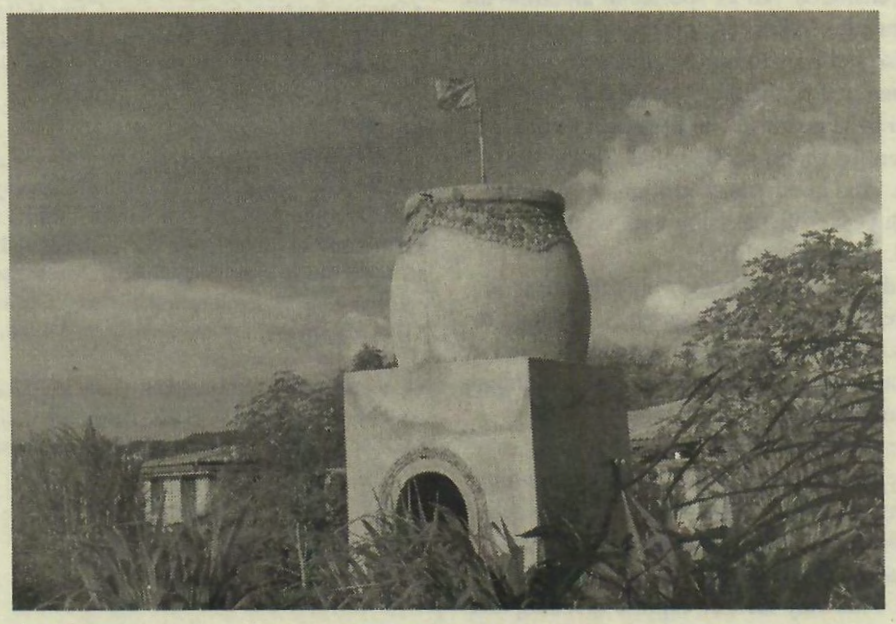
WHEN I WAS SEVEN, IN FLORIDA, someone told me of street kids in Brazil living in cardboard boxes. This so revolted my young heart that I demanded that my parents adopt one of these kids, finally forgiving them when I too, became a mother and realized how hard it is to raise children.

Fate would have it that 25 years later I would find myself living in Sao Paulo, Brazil's gigantic metropolis of 15 million people, one third of whom live in slums. Kids-in-boxes became a daily, unforgettable experience.

It soon became clear that the problem was not the kids, but their parents' circumstances: rural refugees, uprooted, penniless, unable to support their children under the harshness of the new urban life. The only way to help these kids was to prevent rural exodus by improving rural conditions.

Thus, changing Brazil's agricultural model became the center of my professional life for the next thirty years, first through organic agriculture, as I had learned in Europe, then through agroforests and permaculture. Our Bahian Permaculture Institute was the first in Brazil, founded in 1992.

Today I can sincerely say we are well underway towards that goal: the Institute's "Dryland Polyculture Project" which I created and implemented with my talented young colleagues, is working with 700 farm families and is scheduled to go to 1,000 before the end of 2006. More than 600 people, mostly young idealistic agronomy students, have gone through our permaculture design courses and have gone on to do splendid work. And we are not alone: there are many other professionals and institutes working along similar lines.



An elegantly designed cistern sits atop a welcoming gateway, emblematic of Marsha Hanzi's transformation of Brazilian drylands.

Freed somehow of that childhood commitment, my daughters grown and gone, my 30-year marriage winding down, I decided, at the age of 56, to start over again, this time in pursuit of another lifelong dream: to transform a really degraded piece of land into a Garden of Eden. I had already done that on an urban lot, but now I wanted more. The rainforest region was too "easy" for my Aries soul, so I chose the drylands, whose open spaces, luminosity, and strong, rich culture have always attracted me. I confess a touch of arrogance as well: I love to do things people say "can't be done." Of course I often fail, but sometimes there is success. I believe that, after three years of intense work, this is going to be one.

It took me a year of searching to fall in love with and buy 23 acres of pure white beach sand in a lovely valley. Only later would I perceive that, in spite of its terrible soils, the land holds a powerful energy vortex, which is usually felt by visitors , and must have been the cause of my attraction.

That land was once the bed of a prehistoric river, proven by layers of sand, clay, and river stones we found while digging the well. A terrible situation for annual crops but wonderful for trees, once they get their roots three meters down into the first clay layer.

The land had been plowed for watermelons. It was completely bare, no weeds, nothing except two gigantic cashew *(Anacardium occidentale)* trees (which we call "Grandfather" and "Grandmother"), ten local palms with wonderful edible nuts, and a bit of scrub along a dry creek bed.

That was the beginning of "Mariz–Epicenter for Culture and

groecology." The original intention was marked by four points:

1. To produce food for five to six people in a semi-wild groforest system;
2. To learn to live interdimensionally, with no separation etween the sacred and the profane, moving in organic, not linear me, developing intuition and the capacity to channel nformation directly from the system;
3. To create a healing space—for the planet, this land, its nhabitants, and all those who would pass through it;
4. To be good neighbors, contributing in whatever way would e useful.

Where do you begin when you have nothing? My long years f permaculture practice and the Perelandra techniques, which I have used for years (see www.perelandra-ltd.com) gave an excellent starting point, and the land taught me the rest. Little by little we got into an ongoing dialogue with our drylands, which deepens with the years.

Where do you begin when you have nothing?

Brazilian dryland agroforests

Characteristics of the Brazilian dryland agroforest, based on Ernst Goetsch's successional agroforestry system are basic elements for structuring the field, creating soil, and furnishing dry season ground cover. Bromeliads (aloe vera, which is native), agaves (sisal, a fiber plant), and cactuses (opuntia, edible and a good animal fodder) are planted every meter. Castor bean *(Ricinus communis)* and pigeon pea *(Cajanas cajan),* as well as four types of local shrubs, all mulch plants and soil improvers, occupy the middle story. Cashews are planted every three meters, to be thinned later to twelve-meter intervals. As the cashew supports enormous biodiversity (see article "Slow Cashews" at www.marsha.com.br) this dense planting gives Marsha the opportunity to select the best producers.

Trees in this region bring their canopy down to the ground, creating their own cool microclimate. Therefore, it is not possible to work in various stories, as one would in the rainforest. A few trees—coffee, some types of bananas, custard apple *(Annona squamosa)*—grow in this dense shade, but the other trees are planted around the perimeter of the cashews, which can grow to be immense. ("Grandfather's" crown diameter measured 25m/82'!)

The local palm, *"licori,"* has a wonderful edible nut which furnishes milk (similar to coconut milk) and oil, and is highly appreciated boiled green. It will be planted in the entire area.

There are some twenty fruits native or adapted to this region, as well as a number of noble wood trees. All are being interplanted among the cashews, depending on availability of planting material. Several legume trees, leucaena and gliricidia among them are planted for nitrogen fixation; others such as moringa and *quipe* for their products.

Strips of polycultures are also planted to increase biomass production and biodiversity. These include some twenty elements, from radishes to long-term trees. Especially successful elements have been jack beans *(Canavalia ensiformis),* cowpeas *(Vigna sinensis),* sorghum (with fabulous resprouting capacity even in drought) and sesame, with tree cotton *(Gossypium arboreum),* moringa, and custard apples. Sunflowers are highly appreciated, but often eaten down by caterpillars.

It took three years to begin to see the results. The first year, even cactus and sisal died! Even now, the vegetation in the areas where we have not yet intervened is barely over one foot high. In contrast, the areas which have been mulched, planted into polycultures, and treated with micro-organisms, show vibrant health and are beginning to take off. We took three years to get to where we would have gotten in just one year in the rainforest region.

Romanticism can be expensive. Repairing severely degraded land in the drylands is wonderful, but it takes time, labor, imported materials when you have none locally, transport, and infrastructure, all of which demand a constant flow of money. Fortunately, my former husband financed these first years for me, and has supported me completely in this new endeavor.

Today we are basically "there." We have a small house for me, a large visitor house, a common kitchen, a living room, and bathroom area. Our cistern capacity is 40,000 liters; we should double that yet this year. The well, which I located by dowsing, has never failed us, even in the driest months, although the water is of poor quality, heavy in carbonates. Even so, it is the best water in the area, compared to the neighbor's salty wells. The land has been completely planted in cashews and other agroforest elements, and the neighbors are beginning to notice! Local invitations for courses, field days, and lectures are coming in.

Walls are of cheap local brick, with a minimum of cement. The visitor house was built with a clay-lime mortar. The bricks are left bare, to reduce maintenance. Local formats were used, but improved with trellises and the use of the Golden Mean.

Comfort is achieved through careful placement by aspect, the use of high ceilings, and judicious plantings. The temperature difference from sun to shade is 8°C/14°F—huge! Within three years the entire area should be shaded by trees.

Water is from cisterns for the plants and for drinking, and from the well for washing. We store drinking water in a pot-shaped cistern (inspired by Viktor Schauberger) with a capacity of 7,000 liters. A similar cistern will be built at the new visitor house. The well water is distributed by gravity to the whole area from a beautiful pot on a pedestal, capacity 3,000 liters. All used water is recycled to plants. Sinks and showers go directly to trees or banana circles, and toilets go to underground brick boxes filled with coconut husks, accessed by trees planted around the perimeter. Marsha's house uses a sawdust toilet, with urine recycled directly to her garden.

There are two frond-roofed hen houses, ample and

comfortable. Their bedding material is removed from time to time to fertilize the system. A new rabbit house has been built, and is still under experimentation. The "house cow" has a small rotational system planted in cane grass and polycultures (sorghum, cowpeas, mustard, etc.), and a pasture area on the second plot of land. There are two small guard dogs who keep Marsha company at night, and several cats who have spontaneously taken up residence.

Comfort is achieved through careful placement by aspect . . .

In the meantime I bought 28 more acres nearby with much better soils and a small pond, where we can do serious annual cropping, but we have barely found time to scratch the surface, and I will probably rent it out to neighbors next year.

What has been the hardest part of this experience? Well, actually it has nothing to do with the project itself. I get tired much quicker than I used to, which is frustrating when there is so much to be done, and I am sometimes lonely, especially at night. The work itself, though demanding, has been profoundly rewarding, in spite of the severely hot climate, and it doesn't seem "hard." On the contrary, one feels great after a day of physical labor!

At this point I must raise my hat to the neighbors, especially my wonderful team who work alongside me every day, who received this unexpected "parachute drop" with open arms, supporting me, curious, doubting but hopeful—after all, my solutions may be their solutions, too.

Plans for the future? To make this place beautiful—it is still "raw"—with color, ceramics, flowers. And to go on to the next project—a Sudbury school (see www.sudval.org). After all, a big new project is the best preventive to getting old! Δ

Marsha Hanzi is the founder of the Instituto de Permacultura da Bahia, which she coordinated until 2001. She holds a Diploma in Permaculture teaching (1994), and has done courses with Max Lindegger and Lea Harrison, Bill Mollison and Scott Pittman, Ianto Evans and Alenjandra Caballero, and, more recently, Penny Livingston-Stark and Starhawk. She has worked with energy techniques for the last thirty years. For information about Marsha's work and teaching, see details on www.marsha.com.br, and for the Bahian Permaculture Institute, see www.permacultura-bahia.org.br.

This article is one in a series about Brazilian permaculturists, projects, and sites that will appear in the *Permaculture Activist* in advance of the 8th International Permaculture Convergence (IPC8) to be held in Brazil in May 2007, Details in the column to the right.

International Permaculture Convergence in May 2007

Recognizing that the equatorial and subtropical rainforests of Brazil hold many lessons and opportunities for permaculturists worldwide, the Eighth International Permaculture Conference (IPC8) has been slated for May 2007 in Sao Paulo, Brazil. The biennial event is held on a different continent each convening, and past locations have included Australia, the United States, New Zealand, Nepal, Scandinavia, and most recently, Croatia in 2005. For information about the 2007 IPC-8, visit www.ipc8.org.

Hosting the event for 2007 will be Permacultura America Latina (PAL). The Brazilian Permaculture Network, comprising four organizations, will handle the Brazilian and on-site coordination of the event.

The theme of the 2007 event will be "Greening Our Economy with the Principles of Permaculture." Workshops, lectures, field trips, and case studies will highlight the public policies needed to encourage sustainable economies at the local, state and national levels through local currencies, cooperatives, micro-financing, global environmental marketing, ecological restoration, economic democracy, certification, green accounting, and related themes.

The IPC program has traditionally consisted of four components: Conference, Convergence, Visit, and Permaculture Certification Course. The Conference will be a three-and-a-half day event in Sao Paolo. The Convergence is a private four-day gathering of permaculture design certificate holders for the purpose of setting continental and global agendas, making connections and sharing experiences. Convergence working committees will be organized into major climate groupings and special attention paid to green technology, genetic resources, trade, and urban self-reliance.The Visit will provide opportunities for international participants to visit Brazilian permaculture programs around the country including central and southern Brazil and the Amazon. Details of the permaculture design course will be annouced. Δ

Rochester, New York Folk Art Guild Embraces Permaculture

Mark House

"TO WORK CONCENTRATEDLY and to do something that speaks truly to another man is a miracle." These words spoken by Rochester Folk Art Guild founder Louise March have guided the work and mission of the Guild over its long 49-year history. Founded in 1957 in Rochester, NY the guild grew for ten years until the move was made in 1967 to the 350-acre East Hill Farm in Middlesex, NY situated in the Canandaigua Lake watershed and larger Finger Lakes bioregion. East Hill Farm has remained the Guild's home for the past 39 years and during that time Guild members built workshops for all the major crafts and other buildings to support the life of the community. The craft traditions currently practiced at the Guild are pottery, woodworking, boat building and restoration, graphic arts, and textiles. Our blacksmithing and glassblowing shops are not currently active.

An equally important ingredient to the life of the community and mission of the Guild has been farming and learning to live more sustainably on the land. A long tradition of land stewardship exists at East Hill Farm, and the farm has benefited from a diversity of ideas and human energy over the years. The community has developed and cared for extensive gardens, orchards, and vineyards and followed organic methods that emphasized sensitivity to the earth and the processes that support life. Over the 39 years at East Hill Farm many people have come and gone, ideas and enthusiasm have ebbed and flowed, but the core mission of the guild as a community for conscious work in the crafts, on the land, and in practical life has remained.

A couple of years ago the Guild membership began an extensive re-visioning process. Supported by its strong foundation in the crafts tradition and through wisdom gained from decades of work and struggle as a shared intentional community, the need for new ideas, energies, and direction was recognized. A particular focus during the re-visioning process was the farm. The Guild has long recognized that the extensive infrastructure of the farm has increasingly become underused as people have moved away and not been replaced. The recognition that East Hill Farm has much of relevance to offer in addition to its infrastructure, long history of commitment to the land, and community, made the adoption of permaculture principles and techniques as a long-range mission relatively straightforward.

Permaculture literature often points to the observation that small, mature communities with an orientation toward self-sufficiency as a general practice and philosophy seem to embrace permaculture design without much difficulty. An added benefit, accrued through years of experience, is the understanding that good design, like worthwhile community, takes years of nurturing, commitment, and concentration, and the knowledge that the two aims cannot really be separated.

Intentional, purpose-driven communities often operate on the periphery of mainstream society but this fact can either be viewed as a blessing or a curse. Many communities eventually succumb to the pressure exerted by outside influences and history bears this out; few are able to maintain a core sense of purpose over the long haul. One of the opportunities recognized by the Guild membership when it adopted permaculture principles and affirmed the essential importance of long range, future-oriented design models, was its own lack of long-term vision (whether due to economic circumstance or insufficient organization) and the commitment required to create a good design. The reorientation should begin to meet this need.

It is the aim of the Rochester Folk Art Guild to carry this understanding and knowledge gained into the future and to incorporate permaculture principles, established craft traditions, and community life into a design center that encourages work towards wholeness within the individual and the larger community.

For more information about the Guild including Apprenticeship/Internship programs, write to the Guild Secretary at 1445 Upper Hill Rd., Middlesex, NY 14507, call 585-554-3539, or e-mail the farm at rfag@frontiernet.net Δ

Mark House is the East Hill Farm development coordinator and organic farmer. He received his permaculture design certificate through the Finger Lakes Permaculture Institute in Ithaca, NY, and plans to continue work toward a teaching credential.

Reviews

Accessing the Forest Internet

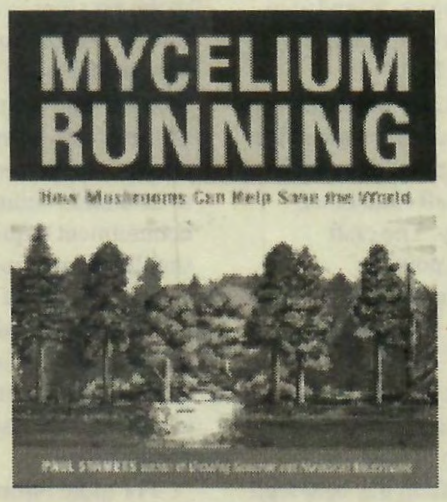
Review by Scott Horton

PAUL STAMETS
Mycelium Running:
How Mushrooms Can Help Save the World
Ten Speed Press. Berkeley, CA. 2005.
339 pp. paper. $35

Paul Stamets has established himself as a kind of Johnny Appleseed of the mushroom world, spreading information and practical fungus advice and lore as well as billions and billions of actual spores of edible, medicinal, and otherwise useful mushrooms around North America and the world. His *Growing Gourmet and Medicinal Mushrooms* is the standard against which all other writing on the subject has come to be measured, and he has cultivated ever-widening circles of interest in fungi among permaculturists, gardeners, farmers, chemists, wild mushroomers, and, intriguingly, U.S. government agencies.

As important, fascinating, and influential as his past writings have been, his latest book, *Mycelium Running: How Mushrooms Can Help Save the World*, attains a level of eloquent accessibility and user-friendliness not before reached by Stamets or, to my knowledge, any other mycologist. When we discuss mycoremediation and edible mushroom cultivation and applications in design courses, it engenders some of the greatest interest among participants. What often follows is a quick drop off the continental shelf of enthusiasm into the cold and murky depths of seemingly impenetrable scientific detail. Do we have to have clean labs and calculate and monitor moisture levels and temperatures of growth media to achieve success in growing mushrooms? Does anything more complicated than growing shiitakes or oyster mushrooms require a graduate degree just to provide food for the dinner table? *Mycelium Running* offers a resounding "Not any more" to these and other mystical manifestations of mushrooming.

This book breaks down the complicated chemistry, physics, and biology of fungus into small, easy-to-understand bits which awaken in the reader a hunger for more. For instance, Stamets does an artful job of explaining the dense matting of information about fungi by using comparisons like the structure of the



Internet to describe vast communication networks fungi form in forest ecologies. Subsequent discussions of mushroom sex, lifecycles, and habitats make the inarguable case that life on earth would simply not exist without fungi. Clearly, any attempts to repair human damage to ecosystems and the environ-ment will be enormously enhanced by using fungus to help do the job.

Following 50 pages of the story of mushrooms abundantly illustrated with color photos and artwork (as is the entire book) Stamets moves along to four chapters chronicling his work in the areas of mycofiltration, mycoforestry, mycoremediation, and mycopesticides. This is not just theoretical stuff, but pages packed with actual studies. They are backed by scientific rigor and fueled by a passion and creativity that sets Stamets apart not only a scientist of the first order but as an artist as well. Stamets names names of household and garden pests, heavy metals, and pathogens, and the mushrooms that mitigate them. There are often sci-fi-like detours into stories, e.g. the fungus in Costa Rica that infects ants and somehow compels them to climb to the tops of emergent trees, where they lock mandibles into leaves and die, ensuring maximum dispersal of the mushroom's spores throug the rainforest. Another story tells how the author's teenage daughter awakened him early one morning to show him a swarm o carpenter ants devouring fungus grown on rice that he had put out hoping they would eat it and spread lethal spores to the nest. You'll have to read the book to find out the ending—it's worthy of H.P. Lovecraft.

In the third and final section of the book, Stamets provides an enormous amount of information that generously

. . .life on earth would simply not exist without fungi.

details and demystifies how to inoculate and successfully grow edible and medicinal mushrooms simply and without all the autoclaves, walk-in refrigerators, and other equipment. Amounting to two-thirds of the book, this is where the juice is, and it will clearly be an indispensable resource for permaculturists, gardeners, farmers, and those who like to eat and use mushrooms. Nearly a hundred pages are devoted to detailed descriptions of more than two dozen species of mushrooms, their ranges, habitats, methods of cultivation, nutritional and medicinal properties, cooking tips, and other information. At the beginning of this section, Stamets wisely and humbly acknowledges that the study of mushrooms and their uses is an ever-expanding work in progress, and he welcomes readers to submit information to his website.

An essential glossary, a bibliography, and a list of resources reveal further depths readers may wish to plumb.

While first glance at the subtitle, *How Mushrooms Can Help Save the World*, might invite skepticism, Stamets delivers tight and tantalizing evidence to bears out his claim, and inspires a desire to run with the mycelium to that hoped-for result. Δ

Scott Horton is Editor of the Permaculture Activist *and lives in the San Jacinto Mountains of southern California.*

Politics
Beyond Red and Blue
Review by Peter Bane

JEREMY RIFKIN
The European Dream:
How Europe's vision of the future is quietly eclipsing the American Dream
Jeremy P. Tarcher/Penguin. New York. 2004. 434 pp. cloth. $25.95.

Jeremy Rifkin's 1991 book *Biosphere Politics* marked him as the pre-eminent social theorist—in the transatlantic Anglophone world—of the green meme, a visionary cultural tide moving through human societies for the past century and a half that is carrying the impulse for greater inclusion in community to the center of the political arena. Movements for participatory democracy, for the liberation of women, ethnic communities, and oppressed minorities, for the rights of nature, as well as therapeutic efforts to reanimate the soul, all have their impetus in this deep welling up of change within the human species. It is at root a reaction to and a repudiation of materialism and the mechanistic world view that grew out of Reformation theology and Enlightenment science.

In *The European Dream*, Rifkin contrasts the emerging vision of the European Community, what he calls the first post-modern, non-territorial governance structure, with the much better known American Dream, which he asserts is now in decline and out of step with the currents of human evolution. The American Dream is about independence based on material success. It rests on twin pillars: the Reformation theological assumptions that each person is responsible for his own spiritual fate and that constant work is the obligation of the elect of God, and the Enlightenment belief in endless material progress—the perfection of man and society.

Europe, having emerged from a century of destruction and colossal evil, is rightly leery of utopian visions. The peoples of "old Europe" are consciously forging a future based on inclusion, submerging old nationalisms into a continental fabric of participatory values. In the European context bioregionalism, which there has a thousand years of continuous history to sustain it, is taking on new power as Europe's regions, Catalonia, Scotland, Slovenia, and dozens more, are slipping out from under the hegemony of national governments, forming their own political, economic, and cultural ties with other parts of the continent. There is a real excitement to the diffusion of political power that is happening through conscious development of network relationships in and beyond Europe. The European Union's crown of stars symbolizes the glory of this new vision, which is taking shape across a hundred realms of society, economy, and technology. Political networks, computer networks, business networks, and cultural networks are making flexible strength out of diversity. They are changing people's vision of security and prosperity. No longer is independence a source of strength. In a networked world, participation is everything.

...ecological agriculture and energy-conscious design make financial sense and can be "sold" within the paradigm of material progress, efficiency, and self-reliance...

With technology shrinking time and space, and limits to resources demanding reconstruction of the acquisitive urge in human beings, inclusion is arguably the potent political idea of our time. The only way to increase satisfaction in a crowded world is to increase meaning in human life, thus, the many efforts to resacralize nature go hand in hand with greater access to the political process for previously marginalized groups.

Though its design approach emphasizes synthesis, an even more powerful meme than inclusion, permaculture rises and falls with the success of the green meme. To the extent that green values color the political ground of a society it will be open to the concepts of embedding humans harmoniously in nature, the fundamental condition toward which permaculture is aimed. Of course ecological agriculture and energy-conscious design make financial sense and can be "sold" within the paradigm of material progress, efficiency, and self-reliance, where many modern Americans find their cultural comfort zone, but as many of us have seen, this path is strewn with obstacles and setbacks as the competing interests of a brawling, get-ahead society continuously frustrate whole systems thinking.

Europe is no paradise, nor should the reader imagine that Rifkin, raised, educated, and employed in the US, is unappreciative of this society's positive qualities. Nor is he blind to Europe's shortcomings—its relative military incompetence, aging population, and rising tide of resistance to immigration from the Middle East and Africa. It is just his familiarity with both sides of the Atlantic that enables him to contrast the two dramatically different value systems embodied in their respective cultures.

Indeed, with last summer's rejection of the European constitution by French and Dutch voters, and winter rioting in France, the European Dream would appear to be at a crossroads. It is not, however, likely to go away or disintegrate. Along with the strong authoritarian measures that the French government imposed in response to street violence last autumn have come generous programs to open economic doors to include immigrant youth in the commonwealth. The European Dream has been developing at the hands of Europe's leaders for two generations. A majority of Europe's population have been raised on its values. The European Dream is neither whimsical nor a quixotic experiment. It is creating a new kind of human being. Despite bonds of common history and postwar alliance, Europeans and Americans today are in very different states of mind.

States of mind have consequences too. Memes play out in material form. The US,

once (and in the minds of most Americans still) the preeminent leader of the world, is sliding toward mediocrity in the measures of human health, education, and welfare. Dynamic job growth in the US has not alleviated poverty. Indeed, degradation in pay rates has exacerabated income inequality, homelessness, and hunger. The dollar, despite being propped up by the U.S. military's wars for oil, has slid precipitously against the upstart euro since the latter's introduction in 1999. Even in realms of technology, Europe and European companies are edging out their American rivals. In cell phone coverage, in airplane sales, and a host of fields Americans think they invented, Europe leads.

Paying more attention to developments across the sea could stimulate positive social change in this country.

Rifkin is a good writer, but he's writing about values and their impact on society; this isn't a fast read. I found myself plodding a bit through the first half of the book wherein he reviews the origins of the American Dream. The second half, in which he explores the unfolding of the new European vision, held my interest more closely. But then I am impatient with the American Dream in life. A middle-aged, middle-class Boomer, I was born into the green meme. My coming of age was not in the back of a Chevy on the backroads of America, but on the back of a bus filled with teenagers travelling through Europe. Like millions in the rest of the world I am frustrated with the naive mix of religiosity and materialism that passes for political dialogue in the US. When will we grow up and get over the fetishistic notion that we have a mission to save the world for free markets or Jesus?

Rifkin comes to no conclusions about the outcome of history, nor can we expect US society to turn itself inside out overnight, but substantial segments of the US population already subscribe to the values of the European Dream. Paying more attention to developments across the sea could stimulate positive social change in this country.

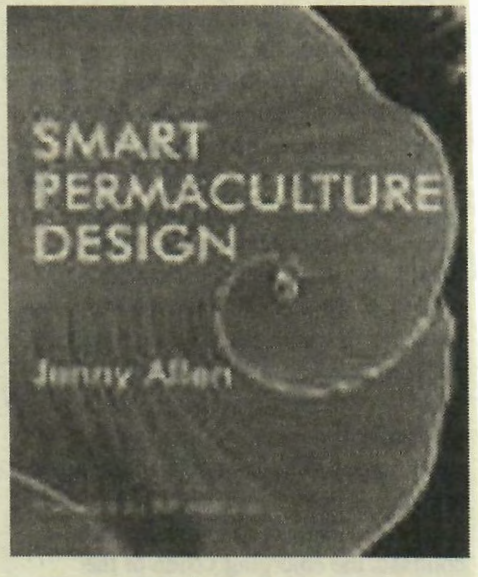
Permaculture designers would be well advised to study the *European Dream*. It presents a mature, sophisticated, and evolving approach to inclusive politics and shows what may be possible with the flowering of the green meme, a creative vision forestalled in the States or at best patchwork and submerged in a sea of modernist orange materialism and traditional blue authoritarianism that sloshes over the plain of mass consciousness.

If we can harness the (red) energy of assertion with a positive adherence to the righteous (blue) authority of nature and a competent (orange) application of technology and enterprise within the participatory (green) realm of communities, we shall truly exhibit spiral wizardry and be worthy of emerging into the next stage of human evolution, where synthesis and integration will accelerate our communion with all that is. Δ

The First Organic, Fair Trade Coffee Table Book?

Review by Scott Horton

JENNY ALLEN
Smart Permaculture Design
New Holland Publishers,
248 pp. paper. color illustrations.



One of the perennial and pressing questions among permaculturists is, "How can we take permaculture to a broader public, maybe even go 'mainstream'?" For me, the answer is not to be found in filling design courses to bursting, doctrinal hair-splitting, estimating the number of mycologists that can dance atop a compost pile, or haranguing the public that the environmental end is nigh if we don't adopt permaculture as a universal design science now. Instead, the answer is in beauty and legibility. If we are able to create permaculture sites and projects that attract and engage with their beauty and function while clearly communicating strategic and integral harmony with the natural world, we will attract more and more people to our ethics and principles. Then we have an opportunity to educate, inform, and transform.

Veteran Australian permaculturist Jenny Allen's *Smart Permaculture Design* goes far to carry the message through beautifully photographed and written documentation of her site, its design, history and present. Max O. Lindegger has been quoted as saying that whenever permaculture designers achieve at least three functions for every element in a design, a fourth and vital function results: beauty. Judging by the evidence lavishly presented by Allen, nothing could ring more true as embodied in her site.

This book is magnetic. During a winter series of houseguests it was on my table and each and every one picked it up and spent time with it—two sat with it for awhile, quoted aloud from it and shared photos of interest. *Smart Permaculture Design* inspires reflection, discussion, and vision about the possible. By its elegant, full-color splendor and captivating writing alone, the hook is baited and set, and Allen is well on the way to reeling in new permaculture enthusiasts while dazzling even the most seasoned designer. Beyond the limits of a permaculture audience, this

book should find its way onto the shelves of every gardener who ever aspired to create abundance, beauty, and peace while engendering a deeper relationship with nature.

Much more than soft-core sustainability, though, the book takes the reader on a gentle, beautiful, scented, and flavorful garden walk through the tenets and possibilities of permaculture. You might read the book or just look at the photos and not realize you are strolling through a thorough outline of much of the

Allen is well on the way to reeling in new permaculture enthusiasts

permaculture design curriculum. This is not surprising given Allen's impressive record as a teacher and designer on several continents. Although the writing is atmospheric and perfumed with adjectives and descriptions that are sometimes over the top, the book is amply accessible with compelling chapters that present the principles, reading the landscape, integrated pest management, climate and micro-climate, water and earthworks, design plan staging and budgeting, and other topics. The author takes time out to give practical tips, design ideas, culinary advice, and suggestions for engaging children in permaculture. It may seem pedestrian and mundane as a list of contents but the material, facts, and concepts are consistently presented with abundant illustrations and examples that elevate the content to a high level of visual passion that borders on propaganda; and this is a good thing.

One shortcoming of the book, at least for readers outside of Australia, may be the emphasis on plant species that are exotic elsewhere. Chocolate pudding fruit, lemonade fruit, feijoa, peanut butter tree, Davidson's plum, warrigal greens, and other edible species sound delicious and useful but I wonder how viable they are in other climates, the author's information on cultivating them notwithstanding. Allen tells stories about learning and acquiring some of these plants from locals and indigenous people, so I suspect her point is, in part, to instruct readers to go out, observe, forage, learn about, and acquire species appropriate to their own bioregions. She cautions not to be seduced by "interesting" plants at nurseries or to succumb to slick marketing strategies designed to dupe gardeners. But the 23 pages she invests in glorifying unusual species tempts readers outside her area to just the kind of failure by desire she warns against. A bit of bioregional translation and the metaphoric grains of salt incorporated in the design process—make choices informed by thoughtful observation, start small, and learn from mistakes—will be helpful on the part of non-Aussie readers that want to make practical use of Allen's list.

This is an excellent design reference volume, adjunct to the more technical, plodding , and methodical books on the subject. Allen's depth of experience, enthusiasm, and accessible style make it a great hammock read as well. Whether taking in a section or a photo at a time or a cover-to-cover study, readers will find it beautiful, rewarding, and inspirational. Δ

Up, Down, and All Around

Review by Peter Bane

TYLER VOLK
Gaia's Body:
Toward a Physiology of Earth

MIT. Press, Cambridge, Mass. 2003. 269 pp + xx. paper. illustrated. $22.

Much of what matters to life on this planet is unseen and was unknowable until the earth sciences of recent decades applied high technology to look deeply into the oceans and beneath the earth's crust. Our forays into near space and the outer atmosphere have also contributed. This book lifts the lid on stupendous discoveries. In other words my friends, we are not in Kansas anymore. Your grandmother did not know this. The emerging field of Gaian studies (after the work of Lovelock and Margulis), or biogeochemistry in a simpler construction, is entering into realms of knowledge previously accessed by humans only through mythic awareness of the dream world.

Tyler Volk, an Associate Professor of Biology at New York University and author of *Metapatterns: Across Space, Time, and Mind,* has done a creditable job both of defining the superorganism Gaia, and of sketching its main chemical flows and energy exchanges. As a scientist, Volk is asking, and attempting to answer the questions: What are the main energy pathways and materials cycles within the biosphere? How much energy is coming in from the sun, where is it going, what is it doing, and how much of it is captured by life? How are the key elements of life: carbon, nitrogen, hydrogen, oxygen, phosphorus, potassium, calcium, and dozens of others supplied, held, circulated? What processes regulate these cycles? The answers he offers provide at best a prelimary picture of a vastly complex system that enables humans to sing opera, make love, and write book reviews, among its uncountable yields. Despite what cannot yet be known, the emerging picture is fascinating.

Identifying Gaia closely with the reach of living organisms on, within, or above the Earth's surface, Volk zeros in on the concept of material fluxes—specifically the flow of elemental chemicals within the biosphere—to define the boundaries of Gaia as those limits across which material flow is very small. Even more so with Gaia than in our animal bodies, internal circulation of elements is greater than exchange beyond the skin. Annually, very little material that cycles through living bodies leaves the envelope of the Gaian atmosphere to space, perhaps even less disappears beneath the crust into the molten regions of Vulcan, the planet's superheated interior.

He amplifies this concept by exploring the cycling ratios of key life elements: carbon, nitrogen, phosphorus, i.e. the ratio of material used within the Gaian system to that amount which leaves or enters it across the system boundary. For example, photosynthesizing plants and other organisms use about 100 billion tons of carbon a year to supply energy for life. (Despite the preponderance of ocean,

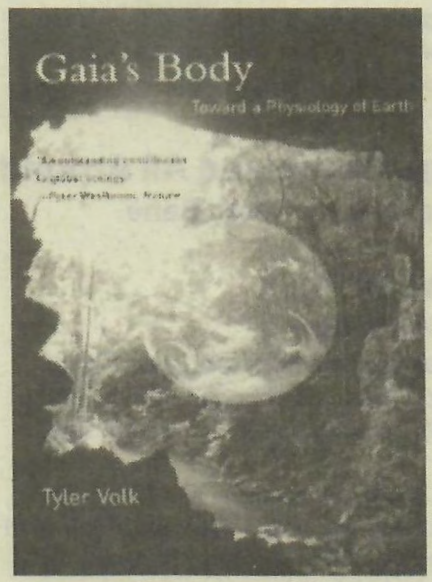
terrestrial plants do about 60% of this photosynthesis.) During the same interval, about a half-billion tons leave Gaia through deposition as carbonates on the ocean floor. Therefore, the cycling ratio for carbon is 200:1. On average, a carbon atom does 200 transactions before leaving the system. If our money worked so well in local economies, we'd all be fabulously wealthy! Nitrogen is even more tightly cycled—used between 500 and 1300 times before slipping away. Minerals from the crust are in more abundant supply relative to demand, but even there life has pitched the circulation up to near feverish levels in some cases. Phosphorus stands out as a nutrient in critical need: life has found ways to cycle each atom 46 times before relinquishing it to marine deposition.

By these measures, Volk helps bring Gaia's physiology into focus. He also gives us new ways to think about the "organs" of the planetary system. Neither continents or biomes meet his conceptual test, rather disparate and widely separated groups of organisms prove to be linked by function within Gaia.

Consider nitrogen.

A weird bacterium that forms worm-like colonies in the shallow waters of the eastern Pacific, *Thioplaca*, plays an important but not fully understood role in the cycling of nitrogen. Unnamed organisms living in the hypoxic or low-oxygen black muck of the continental shelf off the Chilean coast have evolved means to strip oxygen from sulfate ions (SO_4), and they do it in great quantities. Sulfate ions, abundant in all seawater, provide the oxygen these organisms need for metabolism, as they feast on a great rain of detritus from the rich fisheries near the surface to produce carbon dioxide and hydrogen sulfide. Here *Thioplaca* enters the picture. The hydrogen sulfide—to humans a toxic and foul-smelling gas—carries embedded energy that could drive the life processes of yet other organisms; only nitrate is needed to enable the necessary reactions. But nitrates in the water are out of reach of organisms submerged in the bottom muck. *Thioplaca* have organized themselves into long, spaghetti-like strands to bridge the critical inches between energy rich sulfides and the nitrates that can unlock them. The result: denitrification, or the release of nitrogen gas back to the atmosphere.

Why does all this matter? We learn that *Thioplaca*, like anaerobic bacteria in soil the world over, help release nitrogen. They're part of a guild of denitrifiers linked in a global dance with nitrogen-fixing actinomycetes and rhizobia at the roots of legumes which work furiously to split nitrogen atoms and make them available to plants. This great tennis match



keeps the Nitrogen ball in play almost continuously: only one serve in a thousand goes off the court. The atmosphere's immense, but still limited reservoir of nitrogen is fundamentally conserved for the benefit of living organisms.

But there's more to Gaia than chemistry. Stuff moves. Along the way to the continental shelf of South America, we learn about the cold currents upwelling there and off of Africa which provide the lion's share of global fish production—about half. Thus the importance of obscure bacteria; there's a huge amount of "waste" to be converted and recycled in those coastal waters.

Gaia reaches from the ocean sediments up to the thin vacuum of space, and Volk takes us on a tour of atmospheric and oceanic circulation en route to a better understanding of our home. We learn that equatorial air currents, rising and spreading out to 30° north and south latitudes—the so-called Hadley cells which drive the tradewinds of the tropical latitudes—descend bone dry at the outer limits of their circulation to contribute to the maintenance of the earth's great deserts. As students of nuclear testing have learned, the northern and southern halves of the Gaian atmosphere mix only slowly, in large measure because of the severity of the convergence zone at the planetary middle. The chief vector that stirs the two pools of air is the Indian monsoon, which pulls moist air inland toward the Tibetan plateau and the interior of Asia with such immense force that it draws from far into the southern Indian Ocean across this nearly inviolable frontier. Mother India, it seems, is the diaphragm of Gaia, enabling a mixing of the atmosphere south to north about once a year.

Other annual rhythms of the atmosphere hold great consequence for us as well. Measurements at Mauna Loa's atmospheric laboratories reveal the

This book lifts the lid on stupendous discoveries. In other words my friends, we are not in Kansas anymore.

breathing of Gaia. When northern summer brings a surge in photosynthesis, carbon dioxide levels in the atmosphere drop (because the land mass, and thus the volume of plants capturing sunlight and carbon, is much greater in the northern hemisphere than in the southern). Northern winter brings a surge in CO_2 levels. But—and this is the key point—each year the maximum and minimum levels rise. This is the measure of human impact. Volk estimates that techno-respiration (fossil fuel-driven combustion) amplifies the impact of humans at least five times. Our species breathes with the force of 30 billion bodies, only 20% of them respiring within the Gaian limits. The annual fluctuation of CO_2 is about 7 parts per million from winter to summer. Each year the fossil carbon we burn adds 2 ppm to the total as we ratchet up from

bout 380 (280 ppm was the pre-industrial evel) towards 400 and an unknown future.

Extra carbon dioxide in the atmosphere s increasing total photosynthesis and espiration, complementary processes, but lso leading to higher temperatures at orthern latitudes, more rainfall, and onsequently wilder fluctuations of limate with potentially devastating results or human settlement.

This is the science of policy debates, he chemistry of consequence. We would lo well to learn it, soon. *Gaia's Body* is an lluring cartoon drawing of the larger ody to which we all belong, and as such leserves a broad readership.

The author draws on personal stories to ring the vastness of his subject home to is readers. We eavesdrop on the pub talk f geoscientists, hear his grumpiness about the silly rituals of sailors crossing the equator, and dip into vignettes from his childhood in New York and his sojourn in the dry mountains of New Mexico. Volk the author seems an outsized personality (a prefatory photo shows him boldly stepping off a waterfall ledge with a big grin on his face, much as the Fool in the tarot deck steps off a cliff)—an attribute I don't expect to find in a scientist—he's a character whom I suspect one either likes or dislikes, with little in between. His style meanders across the page from obscure (read it several times to follow the train of thought) to bald, from erudite to absurd, the contrasts being more unnerving than either pole alone might be. As if to drag the minutiae of global chemistry onto the big stage of history by the hair, he writes with a verve that seems pitched to the attention span of teenagers reared on television. "Yeah, Gaia!," we read after a summary of the wonders of homeostasis. I don't need wacky American boosterism to stand in awe of the miracle of planetary life, but perhaps others do. And I wanted more data, less dilation.

Like a travelogue illustrated with amateur snapshots— 'Here we are at the boundary of sulfate reduction.' 'And that's me in front of the Equatorial convergence. I'm the one in the yellow waders…' Volk serves up a homely but enticing picture of a mysterious world just emerging from obscurity.

Ignore the silliness; read the book. It takes us giddily into the territory of a new, scarcely imagined science. More elegant guides will undoubtedly appear; this book is important for being one of the first. Δ

A Final Thought

The Acceleration of Evolution

Albert Bates

FOR FOUR MILLION YEARS, humans evolved by the slow process of experimental changes in genetic coding, a process which typically took thousands of generations to accomplish each successful alteration. Over all those millions of years, nature remained relatively constant in its patterns and cycles. Evolving human biology relied on Earth's constancy to fashion the best possible machinery to perform the tasks of daily survival. We evolved to fit our habitat.

Now, in the past few hundred years, by our success in manipulating our surroundings, we have changed the course of nature more dramatically than it has changed in the previous four million years. There is now a large and growing mismatch between our biological inheritance and our environment.

Our physiology, including our mental capacity, will not evolve in time to help us cope with our changed environment. The human mind is designed to respond well to immediate stimuli, because the evolutionary background was relatively constant. It evolved to efficiently manage the needs of individuals, families, and small groups, because until only a few thousand years ago, that's how we lived. It evolved to remember dangerous or beneficial sights, sounds, and smells, because that is how we discovered food and avoided peril.

. . . a day-to-day outlook is inadequate, because the effects of present actions are only felt over decades and centuries.

Carbon dioxide doesn't have an odor or sound, and it's invisible. Those things we may do to improve the lot of our families and friends—like burying our garbage—may unknowingly impair the well-being of larger societies and future peoples. To cope with climate change, a day-to-day outlook is inadequate, because the effects of present actions are only felt over decades and centuries. Somehow, we can't respond to a squiggly line on a chart they way we might have to a bear at the door of the cave.

We are at the most important turning point since the Agricultural Revolution pushed us onto the population escalator. We may or may not survive. If we are to have a chance, we have to *consciously evolve*, not physiologically, but spiritually, into a new relationship with nature. Δ

EVENTS

Advanced Permaculture Design
Mexico

Dates: November 11-20
Location: Huamantla, in highland Mexico, 2 hours east of Mexico City.
Description: This course is an intensive design process for Permaculture Design Course graduates. Participants will work on designing portions of the restoration of the 16th century Hacienda Santa Barbara in rural Mexico to become an eco-inn, permaculture center, and elementary school for the neighboring area. The restoration process is funded and has begun, but there is much design work that needs to be completed, presenting an opportunity for participants to gain in-depth design experience on the "ground floor" of a real-time, multi-faceted permaculture design. There will be two all-day field trips to neighboring historic, permaculture, and natural building sites.
Instructors: Scott Horton, Capra JfNeva and guests.
Cost: $1,050 includes lodging, meals, field trips, and all course materials.
Contact: Scott Horton
San Jacinto Mountains
Permaculture Institute
P.O. Box 1762
Idyllwild, CA 92549
951-659-5362
LaSemillaBesada@hotmail.com

Intl. Permaculture Convergence (IPC 8)
Brazil

Dates: May 2007
Location: Sao Paulo, Brazil
Description:"Greening our Economy with the Principles of Permaculture." Workshops, lectures, field trips, and case studies will highlight public policy changes needed to encourage sustainable economies at the local, state, and national level. Focus on local currencies, cooperatives, micro-financing, global environmental markets, ecological restoration, carbon credits, fair trade, economic democracy, certification, green accounting, and other related themes.
Instructors: Speakers will be from all over the world—from Grameen to favela coops to barefoot economists, to prominent green thinkers, to US millionaires ecologically transforming their corporations, to successful credit banks.
Contact: www.ipc8.org
ipc8@lists.riseup.net

Learning Spanish in Community
Argentina

Dates: December 1-13
Location: Gaia Ecovillage, Navarro, Buenos Aires, Argentina
Description: This immersion Spanish course offers a unique opportunity to learn and practice Spanish while experiencing life in a pioneer eco-village in South America. This course is suitable for absolute beginners as well as people with a high intermediate mastery of the Spanish language.
Cost: $600 includes tuition, course materials, lodging and meals. 50% deposit to confirm. Application form required.
Contact: Argentine Permaculture Institute - Asociación GAIA
+54-2272-492072
Fx+54-11-47522197
www.gaia.org.ar
gaia@gaia.org.ar

Learning and Exploring Sustainable Life Principles
Argentina

Dates: September 1-10
January 15-24, 2007
Location: Gaia Ecovillage, Navarro, Buenos Aires, Argentina
Description: This course is for students looking for practical skills in sustainability that college can not offer. Opportunities to see and participate in permaculture living systems in different development stages, and be involved in the work.
Contact: Asociación GAIA
see above

Permaculture Design Course
Spain

Dates: November 9-21
Location: Spain
Description: This design course is both theoretical and practical and will be taught through lectures, audio-visuals, group interchange, deep observation, and practice. Students will participate in a profound design analysis of the components of a sustainable society in the post oil era, which is beginning now. Participants will acquire knowledge and basic skills for designing and using sustainable systems that are in harmony with natural world.
Instructors: Gustavo Ramirez & Silvia Balado (from Instituto Argentino de Permacultura) and Stefano Soldati (from Centro di Permacultura La Boa, Italia), and local guest teachers.
Contact: www.casadereposo.com
Asociación GAIA (above)

5th Annual
Permaculture Design Course
Bahamas

Dates: January 4-19, 2007
Location: Cape Eleuthera, Bahamas
Description: Our 100-hour Certificated Permaculture Design Course is an opportunity to learn and experience permaculture at the Island School, an institution committed to a sustainabilty and place-based curriculum. Participants will experience the beauty and challenge of our site as well as be part of the design process as the Island School continues to evolve.
Instructors: Chris Shanks, Sarah Gardner, Jack Kenworthy, and local Bahamians.
Cost: $1995
Contact: Chris Shanks
ch_shanks@hotmail.com
www.islandschool.org
www.permaculturenow.com

4th Annual
Permaculture Design Course
Central America

Dates: February 1-18, 2007
Location: Project Bona Fide, Isla Ometepe, Nicaragua
Description: Join our fully bilingual, simultaneously translated, 100-hour Certificated Permaculture Design Course. Project Bona Fide is a non-profit dedicated to the communities of the Maderas volcano region through workshops, seed banks, multi-use trees for agro-forestry, regenerative food production systems, natural building, off the grid living, and appropriate technologies such as: ferro-cement, drip irrigation, on-site metal working, bamboo technologies, and innovative water pumping/storage solutions. Participants will be living and learning in a rural setting where most folk are subsistence farmers. This course will be taught through the language of the land, the culture of the place, and its living systems.
Instructors: Chris Shanks, Michael Judd, Reed Aubin, Jenny Pell, Joanna Mae Souers, and Andrea Calfuquir.
Cost: $1500. $400 deposit by 12/1. $100 discount by 11/1. College credit available.
Contact: Chris Shanks
ch_shanks@hotmail.com
www.silentdust.com/bonafide
www.permaculturenow.com

Free Event and Calendar Listings
Email your info to:
pcaeditor@earthlink.net

ermaculture Design Course
lawaii

Dates: December 2-16
Location: Puna District, Big Island
Instructors: Douglas Bullock, Lonnie amble, Sean Canetta, Brian Robbins, and ther local guests.
Contact: Diana Krystofiac
641-472-7033
kryst@natel.net
www.internproject.com
www.permaculturenow.com

ark Design Workshop
outhern California

Dates: August 12-13 and 19-20, September 2-4
Location: Los Angeles Eco-Village, Los Angeles, CA
Description: Participants in the three-weekend intensive workshop will design aspects of a 60,000 square-foot public park in Wilshire Center/Koreatown near downtown Los Angeles on one of the cities' busiest and most visible transportation corridors. Participants will learn in-depth mapping and scale drawing, water collection and management, native and useful plants for sustainable public spaces, community and stakeholder processes. The majority of the workshop time will be devoted to actual designing with sessions of instruction on various aspects of creating sustainable, integral permaculture designs. Final workshop designs will be considered by the park's planning team to make the project permacultural. Pre-requisite for participation is completion of a permaculture design course.
Instructors: Scott Horton, Dr. Bill Roley and guests.
Cost: $550 includes materials and lunches. Pre-regististration and $100 deposit required.
Contact: CRSP, 117 Bimini Pl. #221
Los Angeles CA 90004
Lois Arkin: crsp@igc.org
213-728-1254
Scott Horton:
lasemillabesada@hotmail.com

Permaculture First Responder Design Course
Northern California

Dates: August 18-27
October 13-15
Location: Carmel Valley, Big Sur, CA
Description: Come gather the necessary tools for responding in times of natural disasters and technological shifts using Permaculture principles, ethics and practices. This 96-hour course will certify participants in Permaculture design, CPR, and First Aid. Students will develop skills to respond as communities undergo stress and extremes due to changes in the environment. These include eco-base camp design, organic gardening, soil building, water catchment, natural building, eco-forestry, mycorestoration, group facilitation and conflict resolution, appropriate technologies, herbal remedies, wilderness awareness, emergency response, and much more!.
Instructors: Benjamin Fahrer, Kat Steele, Erik Ohlsen, Starhawk, Brock Dolman, Trathen Heckman, and Wilderness Medical Institute Instructors
Cost: $1125-$1550 includes organic meals and camping.
Contact: The RITES project
707-360-7060
www.urbanpermacultureguild.org/pfr

Earth Activist Training
Northern California

Dates: January 7-21, 2007
Location: Northern California
Description: EAT combines a full permaculture certification course with earth-based spirituality and practical political know-how. Learn Magic 101, Nature Awareness, Solutions (urban gardens, organic farming, natural building, bioremediation, greywater systems, ecoforestry, soil-building, watershed restoration), Consensus Process, Planning for Big Changes, Creating Ritual, Movement Building, Renewal of Hope, Breaking the Spell (of fear, rage, grief, frustration).
Instructors: Starhawk & Erik Ohlsen
Cost: $1100-$1600 sliding scale, work-trade and loans available.
Contact: mer@starhawk.org
www.earthactivisttraining.org

Permaculture Teacher Training
Northwest USA

Dates: September 20-25
Location: Oregon TBA
Description: Empower yourself to advocate sustainable living and design! In this dynamic, interactive, and fun course learn teaching techniques to communicate whole systems education and Permaculture principles. Jude and Tom create innovative experiences that address varied adult learning styles that use your unique strengths and talents. Lecture, discussions, module building, and group presentations provide the essential learning experiences for this course.
Instructors: Jude Hobbs and Tom Ward.
Cost: $625-$675 (sliding scale) including materials, camping, and meals.
Contact: Jude Hobbs
541-342-1160
hobbsj@efn.org
www.cascadiapermaculture.com

Permaculture Design Course
Sonoma County, California

Dates: September 16-29
Location: Occidental, CA
Description: This is a two-week certificate course in land-use design based on the sustainable living philosophy of permaculture. Topics to be covered include permaculture theory, food diversity, soil enrichment, water use, erosion control, natural building, organic gardening, forest farming.
Instructors: Brock Dolman and Penny Livingston.
Cost: $1350 including lodging and meals. $1250 with two-weeks advance reg.
Contact: Occidental Arts &Ecology
15290 Coleman Valley Rd.
Occidental, CA 95465
707-874-1557 x.201
707-874-1558
oaec@oaec.org
www.oaec.org

Permaculture Design Course
Western Canada

Dates: August 14-25
Location: Abbotsford, BC, Canada
Description: This is the basic two-week permaculture design course. It presents a good balance between theory & hands-on projects. The course will also include slide shows, lectures, discussions, field trips & design exercises.
Instructors: Gregoire Lamoureux & guests. **Cost:** CAN$740.
Contact: Grant Watson
604-872-4060
grant@nowbc.ca
www.alternatives.com/vpn

Interntional Strawbale Conference
Central Canada

Dates: September 24-October 1
Location: Lakefield, ON
Description: The International Straw Bale Building Conference is a bi-annual gathering of a world-wide community of straw bale building practitioners, advocates, and enthusiasts. These gatherings offer a chance to share information and techniques to promote the better design and construction of straw bale buildings. Past conferences have been held in California, Nebraska, Australia and Denmark. The Ontario Straw Bale Building Coalition is excited to bring the conference to Canada for the first time and build on the successes of earlier gatherings. The schedule is packed with presentations by international authors and builders from straw bale and natural building communities worldwide. The panel discussions and hands-on sessions will offer an incredible variety of topics for owners and builders addressing the latest materials and techniques, as well as how to incorporate other technologies with straw bale. Take part in the first ever Straw Bale Olympics! A vendor's tent will feature the latest books from natural building publishers, services by natural builders, and materials from suppliers.
Contact: www.strawbalebuilding.ca/isbbc.shtml

Permaculture Design Course
Southwest US

Dates: September 30-October 1
Location: Phoenix, AX
Description: 72 hour design course with an emphasis on drylands permaculture.
Instructors: Phoenix Permaculture Guild
Cost: $600 before 8/15, $650 after.
Contact: Phoenix Permaculture Guild
Don Titmus
fdpc@4dirs.com
www.permaculture.net/phxguild/

Permaculture Design Course
Southwest, US

Dates: September 30-November 18
Alternate Weekends
Location: Phoenix, AX
Instructors: Phoenix Permaculture Guild
Cost: $600 before 8/15, $650 after.
Contact: Phoenix Permaculture Guild
Don Titmus
fdpc@4dirs.com
www.permaculture.net/phxguild/

Permaculture Design Course
Southwest USA

Dates: August 4 -18
March 30-April 13, 2007
June 29-July 13, 2007
August 3-August 17, 2007
Location: Santa Fe, NM
Description: 72-hour intensive taught by Scott Pittman and Joel Glanzberg, with emphasis on systemic thinking, pattern literacy, dryland strategies, food forestry, community practices, and invisible structure. This course is recommended for people from all biomes. Offered at EcoVersity's earth-based community demonstration site, this course spans from theoretical to practical sustainability.
Instructors: Scott Pittman
Cost: $1200 includes indoor lodging and meals. $100 non-refundable deposit due upon registration.
Contact: EcoVersity
2639 Agua Fria Street
Santa Fe, NM 87505
505-424-9797
www.ecoversity.org
info@ecoversity.org

Certificate Program in Earth-based Vocations
New Mexico

Dates: August 4-October 13
March 29-June 8, 2007
August 2-October 12, 2007
Location: Santa Fe, New Mexico
Description: The integrated curriculum of this 10-week certificate program builds on a permaculture base into the fields of Natural Building, Sustainable Land & Garden, Alternative Energies and Land Arts and Community Activism. Learning takes place in the classroom and in the field, with real-life projects and installations. Graduates learn skills for living on the land, and working with earth-based enterprises. This 'hands-on" program is recommended for people interested in finding alternative vocational skills and in gaining practical experience to pioneer a meaningful livelihood.
Contact: EcoVersity
505-424-9797 extn. 10
www.ecoversity.org
info@ecoversity.org

Earth Activist Training
Ozarks

Dates: August 26-September 9
Location: Diana's Grove, Missouri
Description: Our world is in trouble. Join EAT in planting the seeds of change. Starhawk and friends teach Earth Activist Training: a unique two-week intensive of culture-shifting skills: Practical permaculture principles and techniques, Deep Earth-based spirituality, Effective activism, Connection with nature. Whether you're a beginner contemplating the mess, or a veteran lifeboat-builder on Earthship Titanic, you'll find new core tools at Earth Activist Training. Learn how to transform the world and yourself.
Cost: $1100-$1600 sliding scale, work-trade and loans available.
Instructors: Starhawk & Charles Williams
Contact: mer@starhawk.org
www.earthactivisttraining.org

Send Event and Calendar Listings to:

pcaeditor@earthlink.net

Next Issue: #62,

The Art of Permaculture

Deadline: September 1st

editor@permacultureactivist.net

Advanced Design Course
Colorado Rocky Mountains

Dates: August 21-25
Location: Basalt, CO
Description: Provides a professional orientation to permaculture design work for graduates of the 72-hour course. Participants will deepen their land analysis, learn to read and interpret maps, and learn how to design earthworks and manage equipment for bioengineering. We will examine typical design challenges and responses across a range of landscape scales and types of projects, emphasizing core principles and pattern language literacy. The course will prepare designers to select and focus their work strategically, adopt appropriate tools, and market their skills.
Instructors: Peter Bane, Andrew Goodheart Brown, and guests.
Cost: $450 includes meals and camping.
Contact: Central Rocky Mountain Permaculture Institute
POB 631, Basalt, CO 81621
970-927-4158
www.crmpi.org
jerome@crmpi.org

Permaculture Teacher Training
Colorado Rocky Mountains

Dates: August 28-September 1
Location: Basalt, CO
Description: Teaching is a vocation but the skills needed to do it well can be developed. This course covers teaching skills, curriculum, and course management and design. Participants will learn methods for assessing groups and managing classrom situations, as well as how adults learn and how information can be effectively conveyed, both dynamically and through the written and spoken words. We will recapitulate and analyze the 72-hr design curriculum with an eye to how it can be structured and how shorter formats can be drawn from it, as well as learn how to organize and present workshops and events. The course will offer opportunities for practice, self-observation, and feedback.
Instructors: Peter Bane, Andrew Goodheart Brown, and guests.
Cost: $450 includes meals and camping.
Contact: Central Rocky Mountain Pc Institute (see left column)
www.crmpi.org

Permaculture Design Workshop
Northern Illinois

Dates: October 21-28
Location: Stelle, IL
Description: 7-Day Course. Includes Pre-Webinar Classes.
Instructors: Mark Shepard & Wayne Weiseman
Contact: 815-256-2204
www.CenterForSustainableCommunity.org

Natural Building Courses
Middle Tennessee

Natural Building Immersion: September 15-22
Hot Tubs: August 17-20
Cordwood: September 26-28
Location: Summertown, TN
Description: Introduction to building with straw, cob, wood, and other natural materials. Wattle and daub, adobe, earthbags, earthships, traditional Mexican styles, timber frame, domes and arches, earthen floors, earth plasters and alis, passive solar, foundations and drainage, living roofs and pole frame.
Instructors: Architect Howard Switzer and builders Katey Culver, Albert Bates, Matthew English.
Cost: $300 for weekend, $700 for full-week program, meals and lodging included
Contact: Ecovillage Training Center
The Farm, www.thefarm.org

Permaculture Design Course
Upstate New York

Dates: 5 wknds August-December
5 wknds February-June '07
Location: Hancock, NY
Description: This world-recognized course provides an introduction to permaculture. Students are invited to bring details of their own sites or potential sites and explore site-specific permaculture solutions in hands-on workshops. The course serves as foundation for further study.
Instructors: Geoff Lawton, Andrew Jones, Andrew Leslie Phillips, Claudia Joseph, Ethan Roland, and guests.
Cost: $200 per week-end unit.
Contact: 917-771-9382
greenman124@yahoo.com
www.hancockpermaculture.org

Permaculture Weekend Course
Central New England

Dates: Every other weekend
September 23-24 through
December 2-3
Location: Earthlands, Petersham, MA and Sirius Community, Shutesbury, MA
Description: This series is for adult learners with work responsibilities. Take any day or weekend as a stand-alone workshop or take them all and receive a full design course and certificate. Each day offers in-depth learning about specific aspects of permaculture and embodies the design principles and processes in both its structure and its content. We'll use participatory exercises, observation, sketch problems, design projects, and other techniques to co-create a practical and multifaceted experience of ecological culture design and a new view of human nature.
Instructors: Dave Jacke, Jono Neiger, and friends.
Cost: $125-135 per day; $230-350 per weekend; $1,220-1,600 full course. Work trade available.
Contact: Jono Neiger, 413-367-2304
jononeiger@earthlink.net
Dave Jacke, 603-357-8899
dave@edibleforestgardens.com
www.edibleforestgardens.com/events.html

11th Annual
Permaculture Design Course
On-line

Dates: November 5
Location: On-line
Description: Our 11th annual, six-month long course includes reports, weekly reading assignments, and participation in questions and discussion via email. The heart of the course is The Permaculture Design Course CD-ROM, which includes more than 300 files including several "posts" of course notes and readings for each of the 21 course modules, numerous papers and pamphlets, at least one sample of a full permaculture design, sample standard designs, databases, and other resource materials including a full-length book. The course CD, now in enlarged and improved Version 3, is also available in a self-study edition and an economy edition that includes only the weekly posts and course tools, but not any of the additional reading materials. Purchasers of the full self-study edition may monitor the course at no tuition charge.
Instructors: Dan Hemenway, Cynthia Hemenway, and Willem Smuts.
Cost: $1200
Contact: Barking Frogs Permaculture Center
barkingfrogspc.tripod.com/frames.html
BarkingFrogsPC@aol.com

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II, 2 May '86 IPC-2 & Pc Courses
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II, 4 Nov. '86 Fukuoka, Keyline, Genetic Cons'vn, City Farms, Oceanic PC
III, 1 Feb. '87 Networking, Natural Farming, D-Q Univ., Children's PC
III, 2 May '87 PC Restoration of Wild Lands, Design for Sacramento Farm
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III, 4 Nov. '87 **Trees for Life**
IV, 1 Feb. '88 **Marketing PC Products,** Bamboo, Home Wastewater Treatment
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V, 2 May '89 **Plant Guilds,** Roof Gardens, Small Livestock
V, 3 Aug. '89 Rainforest Conservation in Ecuador, Gaia, Weed Gardens
V, 4 Nov. '89 PC Def's, Water Conservation, Small Dams, Ponds, Keyline
VI, 1 Feb. '90 **Household Greywater** Systems, Soil Imprinting
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VI,4 Nov. '90 **Urban Permaculture:** Ecocity Conf., Soil Detox, Suburbs & Pc.
#23 May '91 **Politics of Diversity:** Greenhouse Market Gdn; PC in Nepal.
#24 Oct. '91 **Creativity in Design:** Examples; **Index Issues #1-23**;
#25 Dec. '91 **Design for Community:** CSAs, Restoring Forest; Garden Ecol.
#26* May '92 **Soil:** Our Past, Our Future: Fertility, Worms, Cover Crops
#27* Aug '92 **Integrating Pc:** Deconstructing Utopia, Grassroots Organizing, Garden Polyculture, Pattern Learning, Living Fences
#28* Feb. '93 **Structures:** Comn'ty Dsgn, LETS, Industry, Strawbale/Timber-frame Bldgs.
#29/30*July '93 **Networks:** Special Media Rvw, Rural Reconstr'n, Leaf Conc., Comn'ty Food Initiatives, Pc in Palestine, Do-Nothing Educ., *Feng Shui,* Pc Acad.
#31* May '94 **Forest Gdng:** Energy & Pc, Mushrm Cultvn, Robt.Hart's F.G., Spp for N. Cal., Alders, Agroforestry in Belize & China, Honeylocust, N-fixers.
#32 April '95 **Animals & Aquaculture:** Animal Polyculture, Small-scale Cattle, Goat Dairy, Keyline, Feral Chickens, Bee Plants, Constructed Wetlands
#33 Dec. '95 **Cities & Their Regions:** Green Cities, LA Eco-Village, MAGIC Gardens, CoHousing, Micro-Enterprise Lending, Suburban Conversion.
#34 June '96 **Useful Plants:** Bamboo Polyculture, Medicinals, Pest Control, Root Crops, Oaks, R. Hart's For. Gdn, Russian Plants, Regl. Plants, Sources
#35 Nov. '96 **Village Design:** Pattern Language, Consensus Democracy, Conflict, Historic & New Villages, Planning for Tribe, Vill. Economics
#36 Mar. '97 **Climate & Microclimate:** Climate Change,Windbreaks, Low-Tech Sun Locator, Drylands, Cool Slopes, Straw-Clay Bldg, Round Beehive, Water Catch.
#37 Sept. '97 **Tools & Appropriate Technology:** Dowsing, Workbikes, New Energy, Scythes, Japanese Saws, Nursery, Ferrocement, Greywater, A-frame & Bunyip Levels, Ram Pump, Solar Toilet, Log Yoke, Cookstoves…
#38* Feb. '98 **Economic Transformation:** Speculative Economy, No Middle Class Worker-Owned Coops, WWOOF, No Money!, Global Warming, What Profits?, Holistic Financial Planning, Land Use, Adopt-A-Hive
#39 July '98 **Knowledge, Pattern & Design:** Pc: A Way of Seeing, Sand Dunes, Native Conservation., Language Worldview & Gender, Patterning as Process, Land-Use Planning, Teaching Pc, Vietnam, Holmgren on Pc
#40 Dec. '98 **New Forestry:** Regl. Devlpmt., Horselogging, Menominee Reserv'n, Forest Investing, Restoration, Old Growth, Homestead Tenure, Forest Soils, Forest Farming, Woody Agric., Rainforests, Windbreaks, Coppice
#41* May. '99 **Natural Building:** Oregon Cob, Cordwood, Bamboo, Thatch, Ethics, High Winds, Origins of Conflict, Greenhouses, Ponds, Adobe, Road-Building, MicroHydro, Bldgs. That Live, Under $20K Houses, Dreams
#42 Dec. '99 **Self-Reliance & Community Cooperation:** Co-Intelligence & Self-Orgn., Archetype Design, Sovereignty, Samoa, Mondragon, Natural Housing, Comm. Gdns., Zone Zero, Solar Electric Tractor, Beekeeping
#43 June '00 **Food & Fiber:** Hunger, Ferments, Seasons Salads, Heirlooms, Fencing, Self-Fertile Gdns, Rice Revolution, Cold-climate Food, Edible Insects, Chilies, Food Origins, Garlic, Ethnobotany, Wild Food, Bamboo, Hemp
#44 Nov. '00 **Earthworks & Energy:** Spreader Drain, Horse Swales, Earth Dams, Machinery, Carpet-lined Ponds, Constr. Wetlands, Biogas, Windmills…
#45 Mar. '01 **Medicine & Health:** World & Self, Healthy Home, Designing Care, Ayurveda, Agents of Decay, Comm. Health Centres, Women Trad. Med 4th World Apothecary, Healing Weeds, Medicinal Crops, Hawaiian Bot'ls.
#46 July '01 **Good Work & Right Livelihood:** Pc Golf Course, Downsize Cost of Living, New Forest Economy, Energy Currency, Buddhist Mkting., End Wage Slavery, What's Surplus?, Urban Community, Enterprise Facil'n.
#47 June '02 **Watersheds:** Water as Commodity, Basins of Relations, Beavers Watershed Development, Skywater Center, Urban Stormwater Gabions, Conservation Investments, Peat Bogs, Rabbits.
#48 Sept. '02 **Making Changes:** Co-Intelligent Activism, Webs of Power, Urban Food, How to Change, Teaching for Change, Global Transformation, City Repair, Escaping the Job Trap, Argentine Recovery, Costa Rica Pc
#49 Dec. '02 **Where is Permaculture?** Land-Rent Reform; 10 N. American sites plus Cuban Agric.; Beauty+Sustainability in NZ; Cacti/Succulent Plants; Animal Self-Medication; Challenge to Pc Movement
#50 May '03 **Ecosystems:** Holmgren on Pc Mvmt; E. Hazelip & Synrg. Agric. Chestnuts/Pigeons; Oak Savannas; Root Crop Polycultrs.; Alders Fungal Ecosys.; Humans & Wildn; Indoor Ecos.; Humid Tropics.
#51 Jan '04 **Traditional Knowledge & Regeneration:** Bates on Cataclysm& Collective Memory; Shepard's Wisdom of the Genome; Waru Waru; Biosculpture; Inuit Medicine; Fermented Stimulants.
#52 May '04 **Aquaculture:** Ecological Aquaculture; Fish for Health; Dowsing; Designing Ponds; Greywater Biotreatment; N. Amer. Polyculture; Managing for Native Species; Integrated Village Fisheries; Vietnam.
#53 Aug. '04 **Education:** Life-long Learning; Edge-ucation; The Albany Free School; Indigenous Education & Ecology; Ecocentric Pedagogy; School Gdn and Dances; Ecology of Learning; Brain Gym.
#54 Nov. '04 **Fire & Catastrophe:** Designing Beyond Disaster; Opportunity; Rise of Globalization; Invasion Biology; Street Orchards as Security; Community Food Security; Water Rising; Disrupted Climates.
#55 Feb. '05 **Learning from Our Mistakes:** Petroleum Dependence;Village Design; Aust. Hard-Won Lessons; Read the @!#*!@ Manual; Trial&Error; Experiments in Forestry; Owner-Builder; Ten Mistaken Ideas in Pc.
#56 May '05 **Tree Crops, Tree Guilds:** History of Pine Nuts; Tree Vegetables; Acorns; Restoring American Chestnut; Honeylocust as Silvopasture; Broadscale Agroforestry; Bamboo; Wondrous Willow; Social Forestry.
#57 Aug. '05 **20th Anniversary Issue:** Challenges; Remembrance; Pc in USA; Hawaii Retrospective; Pc Changes; Permatecture; Pc's Soft Edge; PINC; Gaia University; Oil Depletion; IPC-7; Retrofitting Suburbs.
#58 Nov. '05 **Urban Permaculture:** Urban/Rural Futures; City Zones & Sectors; Growing Food; Detroit Visionaries; Rebuilding New Orleans & Everytown; Transformation of a Military Base; Workers Co-op; Energy Descent.
#59 Feb. '06 **Peak Oil:** Peak Oil & Pc; Ecological Collapse & Trauma Theory; Thom Hartmann; Pathways for Energy Descent; How Cuba Survived; Oil & Food; Biofuels; Cultivating Algae for Fuel; Relocalize.
#60 May '06 **Land Use Past & Present:** Sust. Ag an Oxymoron?; Negev's Bedouin; Eastern Woodlands Agroforestry; Pc Heals in India; Arcosanti Land Planning; Pop. Growth/Land Hunger; Mexican Reforest; Rocky Mtns.

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The Permaculture Activist

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except for the following: Vol. I,1 -VI, 2 & 32-36 - $5.00 each,
* #26 - 31, #38, #40, #41 - $7.50 each

CALENDAR

ugust 4-18. Santa Fe, NM. Permaculture esign Course. Ecoversity. 505-424-9797 x10. ww.ecoversity.org, info@ecoversity.org.

ugust 4-October 13. Santa Fe, NM. ertificate Program in Earth-based ocations. EcoVersity. 505-424-9797 x.10. ww.ecoversity.org, info@ecoversity.org.

ugust 6-18. Basalt, CO. Permaculture esign Course. Central Rocky Mountain ermaculture Institute. PO Box 631, Basalt, O 8162. 970-927-4158. www.crmpi.org, erome@crmpi.org.

ugust 7-13. Winnipeg, MB CANADA. lerbology Week-long. St. Norbert Arts entre. 204-269-9272. snac@snac.mb.ca, ww.snac.mb.ca.

ugust 7-19. Sandy Lake, PA. Permaculture esign Course. Three Sisters Farm. 24-376-2797. defrey@bioshelter.com, ww.bioshelter.com.

ugust 11-13 Summertown, TN. Bamboo ultivation and Construction. Ecovillage raining Center, The Farm. 931-964-4474. covillage@thefarm.org, www.thefarm.org.

ugust 11-25. Ithaca, NY. Permaculture esign Course. Finger Lakes Permaculture nstitute. PO Box 54, Ithaca, NY 14851. 07-227-0316. www.flpci.org, lpcipermaculture@yahoo.com.

ugust 12-13 & 19-20, September 2-4. os Angeles, CA. Park Design Workshop. RSP, 117 Bimini Pl. #221, Los Angeles CA 0004. Lois Arkin, crsp@igc.org, 213-728-254. Scott, lasemillabesada@hotmail.com.

ugust 14-25. Abbotsford, BC CANADA. ermaculture Design Course. Grant Watson. 04-872-4060. grant@nowbc.ca, ww.alternatives.com/vpn.

ugust 17-20. Summertown, TN. Hot Tub atural Building. Ecovillage Training Center, he Farm. 931-964-4474. covillage@thefarm.org, www.thefarm.org.

August 18-20. Flagstaff, AZ. Walkabout Course. Ancient Pathways. 928-774-7522. www.apathways.com, www.southwestsemester.com.

August 18-27. Big Sur, CA. Permaculture First Responder Design Course. The RITES Project. 707-360-7060, www.urbanpermaculturegulld.org/pfr.

August 19-20. Basalt, CO. CRMPI Reunion. Central Rocky Mountain Permaculture Institute. 970-927-4158. www.crmpi.org, jerome@crmpi.org.

August 21-25. Basalt, CO. Advanced Permaculture Design Course. Central Rocky Mountain Permaculture Institute. 970-927-4158. www.crmpi.org, jerome@crmpi.org.

August 26-September 9. Diana's Grove, MO. Earth Activist Training. mer@starhawk.org. www.earthactivisttraining.org.

August 26-27. Santa Fe, NM. Beekeeping Certificate Program. EcoVersity. 505-424-9797. www.ecoversity.org, info@ecoversity.org.

August 27-October 28. Flagstaff, AZ. Ancient Pathways, Southwest Semester. Ancient Pathways. 928-774-7522. info@apathways.com, www.southwestsemester.com.

August 28-September 1. Basalt, CO. Permaculture Teacher Training. Central Rocky Mountain Permaculture Institute. 970-927-4158. www.crmpi.org, jerome@crmpi.org.

August-December (5 weekends). Hancock, NY. Permaculture Design Course. 917-771-9382. greenman124@yahoo.com, www.hancockpermaculture.org.

September 4-October 6. Summertown, TN. Ecovillage Apprenticeships. Ecovillage Training Center, The Farm. 931-964-4474. ecovillage@thefarm.org, www.thefarm.org.

September 9-10. Santa Fe, NM. Beekeeping Certificate Program. EcoVersity. 505-424-9797. www.ecoversity.org, info@ecoversity.org.

September 15-22. Summertown, TN. Natural Building Immersion. Ecovillage Training Center, The Farm. 931-964-4474. ecovillage@thefarm.org, www.thefarm.org.

September 16-29. Occidental, CA. Permaculture Design Course. Occidental Arts and Ecology Center, 15290 Coleman Valley Road, Occidental, CA 95465. 707-874-1557 x.201, 707-874-1558. oaec@oaec.org.

September 20-25. Oregon. Permaculture Teacher Training. Jude Hobbs. 541-342-1160. hobbsj@efn.org, www.cascadiapermaculture.com.

September 22-24. Flat Rock, NC. 2nd Annual Southeast Women's Herbal Conference. Red Moon Herbs. 828-669-1310. www.redmoonherb.com, conference@redmoonherbs.com.

September 23-October 7. Hot Springs, MT. Permaculture Design Course. ana_starr@yahoo.com.

September 23-24 thru December 2-3 (Every other weekend) Western MA. Permaculture Weekend Series Course. Jono Neiger, 413-367-2304, jononeiger@earthlink.net. Dave Jacke, dave@edibleforestgardens.com, 603-357-8899. www.edibleforestgardens.com/events.html.

September 24-October 1. ONTARIO. Interntional Strawbale Conference. www.strawbalebuilding.ca/isbbc.shtml.

September 26-28. Summertown, TN. Cordwood Natural Building. Ecovillage Training Center, The Farm. 931-964-4474. ecovillage@thefarm.org, www.thefarm.org.

September 27-October 28. Flagstaff, AZ. 9-Week Southwest Semester Program. Ancient Pathways. 928-774-7522. www.apathways.com, www.southwestsemester.com.

September 30-October 1. Phoenix, AZ. Permaculture Design Course. Phoenix Permaculture Guild. Don Titmus. fdpc@4dirs.com, www.permaculture.net/phxguild/.

October 2-27. Dexter, OR. Ecovillage & Permaculture Certificate Program. Lost Valley Educational Ctr. 541-937-3351 x112. events@lostvalley.org, www.lostvalley.org.

October 13-15. Big Sur, CA. Permaculture First Responder Design Course. The RITES project. 707-360-7060, www.urbanpermaculturegulld.org/pfr.

October 21-28. Stelle, IL. Permaculture Design Workshop. 815-256-2204. www.CenterForSustainableCommunity.org.

November 5. On-line. 11th Annual Permaculture Design Course. Barking Frogs Permaculture Center. BarkingFrogsPC@aol.com. barkingfrogspc.tripod.com/frames.html.

November 10-12. nr. Tustin, MI. Raising Vegetables and Civic Values: CSA in the 21st Century. Second Biennial Conference for Community Supported Agriculture. CSA-MI, 3480 Potter Rd, Bear Lake, MI 49614. 231-889-3216, toll free 877-526-1441. csafarm@jackpine.net, www.csafarms.org.

November 11-20 . MEXICO. Advanced Permaculture Design. Scott Horton, San Jacinto Mountains Permaculture Institute. P.O. Box 1762, Idyllwild, CA 92549. 951-659-5362. LaSemillaBesada@hotmail.com.

November. THAILAND. Permaculture Design Certificate and Cultural Immersion. EcoLogical Solutions. info@ecologicalsolutions.com.au, www.ecologicalsolutions.com.au.

December 2-16. Big Island, HI. Permaculture Design Course. Diana Krystofiac. 641-472-7033. kryst@natel.net, www.internproject.com.

January 4-19, 2007. BAHAMAS. Permaculture Design Course. Chris Shanks, ch_shanks@hotmail.com, www.islandschool.org, www.permaculturenow.com.

January 7-21, 2007, CA. Earth Activist Training with Starhawk. mer@starhawk.org, www.earthactivisttraining.org.

January 24-27, 2007. Pacific Grove, CA. Ecological Farming Conference. Eco-Farm Association. 406 Main St., Watsonville, CA 95076. 831-763-2111. www.eco-farm.org.

February 1-18, 2007. NICARAGUA. Permaculture Design Course. Chris Shanks, ch_shanks@hotmail.com, www.silentdust.com/bonafide, www.permaculturenow.com.

February-June, 2007(5 weekends). Hancock, NY. Permaculture Design Course. 917-771-9382. greenman124@yahoo.com, www.hancockpermaculture.org.

May 2007. BRAZIL. International Permaculture Convergence (IPC 8). www.ipc8.org, ipc8@lists.riseup.net.

Gaia University Courses
USA, Germany

Gaia University announces its first MSc and Graduate Diploma programs beginning in the Spring, Summer, and Fall of 2006. Gaia University founders, Andy Langford and Liora Adler as well as other selected faculty will teach these first Masters level programs.

1. MSc degrees and Graduate Diplomas in **Integrative EcoSocial Design** with specializations available in Permaculture, Ecovillage Design, Life Transitions, Social Communication, Appropriate Technology and other areas of sustainable/regenerative design. Credit for PDC certificates and diplomas as well as prior experience. **USA- September 26-October 10, 2006.**

2. **Open Topic** MSc and Graduate Diploma in any field of world change and regeneration. **USA: June 4-11 or Sept 29-October 6, 2006 and Germany: August 28-Sept. 3, 2006.**

3. MSc and Graduate Diploma program for **Regional Development of Gaia U. worldwide. USA: May 11-20 or October 23-Nov.1, 2006 and Germany: August 18-27, 2006.**

4. **Affiliation opportunities** for course and workshop providers in the fields of permaculture, ecovillage design, holistic health, peace studies, and other world change curricula.

Affiliate your learning centers with Gaia University to enable your participants and teachers to earn credits toward current or future accredited degree programs with Gaia U. There is no fee for affiliation.

Application forms and further information are available online at www.gaiauniversity.org

NETWORKS

Santa Fe Leads in Biofuels

In November of 2004, the nation's first triple biofuels dispenser opened in Santa Fe to allow drivers to choose three brands of biofuels:

•E10 unleaded (10% ethanol/90% gasoline) which can be used in any gasoline vehicle.

•Ethanol E85 (85% ethanol/15% gasoline) intended for use by Flex-Fuel vehicles

•B20 Biodiesel (20% biodiesel/80% petroleum diesel) which can be used in any diesel engine.

Use of these fuels in the appropriate vehicle requires no modifications to the vehicle and does not void the manufacturer's warranty.

The biodiesel offered at the Sante Fe station is called Blue Sun Premium Biodiesel, made from virgin soy oil. Blue Sun also includes additives that enhance cold-weather performance, increase mileage and power, and provide 400% better lubricity than standard petroleum diesel.

Ethanol and biodiesel are oxygenates, meaning they contain oxygen which improves the combustion process, thus producing more power per horsepower while reducing harmful emissions. In the three months after the opening of the biofuels station, analysts estimate that drivers have prevented 90 tons of fossil CO_2 from entering the atmosphere. Use of biofuels can improve air quality and reduce CO_2 emissions by 78% for biodiesel and 68% for ethanol.

Overall, US drivers have by January 2005 logged more than two trillon miles on ethanol blends. Over a six-month period (11/03 to 4/04) Ethanol comprised 5.7% of the gasoline sold in California and 10% of the gasoline sold in Albuquerque. —>

The Santa Fe station is a project of Renewable Energy Partners, a non-profit founded in 1998 and located in Santa Fe. Their mission is to promote the use of utility-scale renewable energy for electrical generation and to further the use of renewable transportation fuels. Their website is www.renewableenergypartnes.org.

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Contact

Wanted: 1. Contact with my fellow gardeners in Zone 9, Florida, USA. 2. Experienced designer for assistance in laying out a 6 acre plot. rosalind.baker@gmail.com.

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