

Principles of Ecological Design

Integrating Technology, Economics, and Ecology

Art Ludwig

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Printing tips

The layout has been optimized for printing on 8.5 x 11 or A4 paper with minimum waste. To save more resources, you can read this on screen, or use the print options in Adobe Acrobat Reader to print only the odd pages, then print the even pages on the back.

To save ink, you can specify from Adobe Acrobat that colors be printed in black, and consider not printing the covers which have lots of image coverage.

This is part one of an expanded and revised web edition of the book "Living with Nature," originally published in 1989. Check oasisdesign.net for the other parts, which are scheduled for later release.

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Principles of ecological design

Transcend market culture

The main obstacles to living with nature are cultural, not technical or economic.

It is widely believed that while other peoples are moved by raw emotion or quirky religions, everything we do in Western culture is governed by economics and scientific reason.

However, a close look reveals that we do things not because they make social or economic sense, but simply because our society has been led to believe in them. The culture—the gut-level idea of the right way to live—is a force which shapes desires and constrains the mainstream of society. In the West it determines, for example, what is thought to be “economically viable” at least as much as economics does.

What then determines the culture? Much of the American way of life has been designed by market forces. Globalization is now spreading this way of life to every corner of the earth.

Free-market enthusiasts claim that no system is more effective for filling human needs. This is probably true. But a way of life designed with the goal of living best would be very different than one designed to maximize profit.

Whether made from filling basic needs, exaggerated needs, or fabricated needs, a dollar is a dollar. Once basic needs were fully commercialized, growth moved inexorably on to exaggerating and fabricating needs. This is no help for living well.

Every facet of life which can be reshaped to be more profitable is subject to cultural engineering by marketeers. “Information asymmetries” are exploited to this end. Few individual consumers are as informed about something as a company which lives from pushing it.

An example: Infant formula is a type of food which qualifies as a basic need in a handful of special circumstances, such as the case of an ill or missing mother. However, once a company is tooled up to make and market formula, the temptation is to expand from the tiny legitimate market into the much vaster territory occupied by breastfeeding. There isn't a way to make serious money off breastfeeding. Formula makers are able to out-spend and out-market volunteer breastfeeding advocates. They are willing to use diabolical tactics such as providing enough free formula at birth to ensure that new mother's breasts dry up. Despite the compelling advantages of breastfeeding (see sidebar), 75% of American babies a few months old are already on formula.

Nuzzle your warm mother's breast in the family bed, or lay alone in a crib by the TV with a bottle of genetically engineered formula?

If markets really just gave us what we want, as market fundamentalists say, I doubt so many of us would have had to settle for the latter.

Why Breast is Best

Breastfeeding offers compelling advantages for babies:

- ❖ Raises the child's IQ by an average of 10 points
- ❖ Makes almost every organ function better
- ❖ Reduces the risk of diabetes
- ❖ Jump starts the immune system
- ❖ Better jaw alignment
- ❖ Less chance of needing braces as adults
- ❖ Leaner physique as adults
- ❖ Superior nutrition: breastmilk provides hundreds of nutrients that are not found in formula



Mothers who breastfeed experience many benefits:

- ❖ More intimacy
- ❖ Faster postpartum recovery
- ❖ Easier return to normal weight
- ❖ Reduced risk of breast, uterine, and ovarian cancers
- ❖ Less chance of hip fractures and osteoporosis
- ❖ A smart investment: doctors estimate that an increase in frequency and duration of breastfeeding could save \$29 billion a year in medical costs in the United States alone.¹

Formula is just one of the more egregious examples of the failure of the market to optimize our quality of life. A complete catalog of these failures would extend to virtually every facet of life in America, from deodorant (a need fabricated in the 1950's from shame advertised by Proctor and Gamble) to the space-based missile defence shield (a multi-billion dollar payoff to defense contractor/campaign donors which no reputable scientist considers capable of functioning effectively).

This book explains nothing less than how to redesign our way of life from the ground up, optimized for long-term quality, not short-term profitability.

Is there hope for accomplishing this? In the case of you individually, absolutely. You can change your priorities and live better with less. For the whole culture, the prospects are dimmer. Still, in the case of breastfeeding, the truth is winning out: Despite over a billion dollars a year in revenue to fund disinformation, 300% more American mothers are breastfeeding now than thirty years ago.¹

The shouldering of the human herd tends to keep those in the mainstream going the same direction, whether they want to or not.

Shifting your direction involves first transcending the culture so you're capable of forming your own goals, then moving out of the middle of the herd so it is physically possible to take a different path.

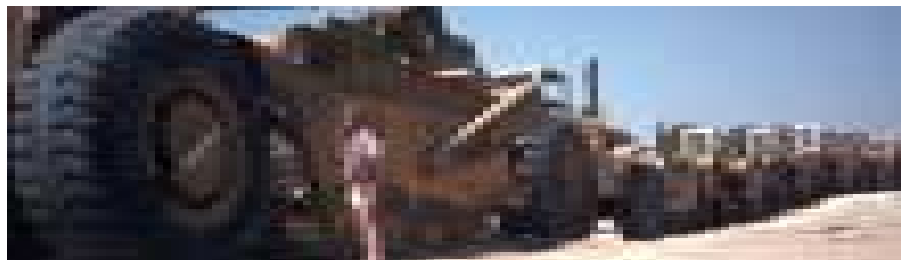
To shift a society's direction, the force field of the culture must change. The score boards by which success and desirability are measured have profound impact on the behavior of individuals and societies (see next page).

"How much do you make?" is a widely accepted standard measure of success. However, the degree to which you "**want what you have**"² is arguably a more real measure of success, security, and happiness. Additionally, as a goal, wanting what you have encourages more soul-nourishing behavior. Corporate engineered consumer culture and it's measures of success are at their root a deceptive rip-off.

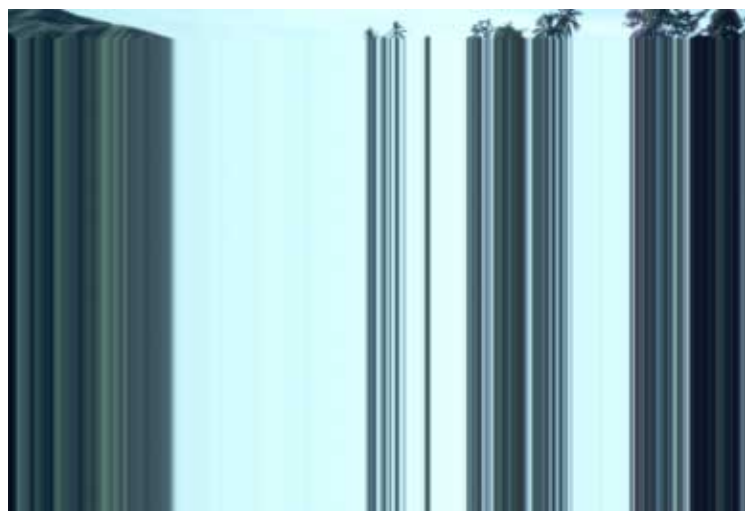
A wealthy American woman who does volunteer aid work in a village in Guatemala told me she can only stand to be there for two weeks at a time because the Indians are "too damn happy." That people living a dozen per dirt floored shack can find the happiness which eludes her "just becomes too confronting."

The holes in our hearts cannot be filled with stuff. They can only be filled with the love of ourselves and others.

A mile-long line of graders at work on a new LA freeway.



Los Angeles devotes more land and money to transport than almost any place on earth. Is this an objective decision? Hardly. While India has the Sacred Cow, Los Angeles has the Sacred Car. Car devotees are blind or resigned to extreme social and ecological costs.



Fijians, more than any other culture I've visited, were unimpressed with Hollywood culture. They were so content with their lives that British colonizers were forced to import laborers from India to work their fields. Fijians could not see the point. (Unfortunately, I've heard that the powerful new force field of television is now sowing discontent).

ALTERNATIVES TO THE CONVENTIONAL SCOREBOARD FOR SUCCESS

*These are ideas to spur your own creations.
If you're happy with your life, make up a scoreboard by which it is successful.*

Conventional	Alternative(s)
<p>How much do you make? Downside: Selling your soul is too easy of a way to increase income.</p>	<p>Want what you have Upside: Really wanting what you already have provides true security and happiness (<i>he is wealthiest who wants least</i>); more freedom (there are many more options for making \$10,000 a year than \$100,000); longer, more frequent vacations; a clean conscience, etc.</p> <p>How long can you live from how little work? Upside: Having to work less. Note that the fewer hours you work, often the more you can charge for them (supply and demand). Also, if you work less, your total income is less, tax rate lower, and you take home more per hour.</p>
<p>Quantity and appearance of stuff Downside: You serve your possessions rather than the other way around.</p>	<p>Quality and function of stuff Upside: Tools which serve well.</p> <p>Stuff doesn't matter Upside: Step on the road to nirvana.</p>
<p>You are what you drive Downside: What good is a prestige car if your body is an atrophied wreck?</p>	<p>You are what you eat Upside: Encourages eating better food; fresh, local, and organic. A good investment, as health is true wealth.</p>
<p>Complain-brag about how busy you are Downside: Endorses compulsive busyness and consequent shortage of time for things that matter.</p>	<p>Explain that "you are as busy as you want to be" Upside: Encourages empowerment to discern what is worth spending time on.</p>
<p>How do you look? Downside: Eating disorders, complications from cosmetic surgery, superficiality, hazard of empty relationships ("Implants, meet Viagra...").</p>	<p>Healthy is sexy Upside: Being natural, comfortable, and healthy.</p> <p>Appearances don't matter Upside: Another step on the road to nirvana.</p>
<p>What do you do? Downside: Temptation to assume a impressive-sounding label (doctor, lawyer) which may not suit your nature.</p>	<p>What kind of person are you? How do you serve? Upside: Helps focus on optimizing the use of unique, individual qualities, finding a livelihood which suits these, and benefiting society and nature with ones' productive energy.</p>
<p>What are you worth? Downside: Encourages pathological focus on accumulating money.</p>	<p>What do the people who know you best think of you? Upside: Love and admiration from people who know you is more gratifying than most anything.</p> <p>Do your dream Upside: Achieve your highest potential.</p> <p>Do you enjoy what you do? Do you believe in it? Upside: You may find something you enjoy and believe in doing, a rare luxury.</p> <p>What do you know? Upside: Mastery of life and work skills provides deep level satisfaction.</p>

Individuals can entice others out of the herd by example of living better. With visibility, timing, charisma, and good luck, the direction of the whole culture can be shifted by getting out in front and capturing the collective imagination.

Changing laws helps, as laws in overdeveloped countries tend to discourage living with nature. But this alone is not sufficient. It is ultimately the culture that we can and must change in order to live in balance with nature. Without transcending corporate consumer culture within your own being, any attempt to live ecologically won't go far.

Alternative success does not preclude conventional success. If you understand money and the principles of natural economics, you'll be successful by conventional measures unless you actively avoid it.

For example, if you focus on doing your dream rather than whatever profession is generally lucrative, you may wind up in a niche so unique that people are willing to pay quite a lot for what only you can do well.

Also, focusing on saving will over the years result in accumulation of real wealth. Here's the math: the average American earns \$30,000 a year, but their savings rate is currently negative (!). Lets be generous and say it's 1%. That's \$300 a year. Suppose you work dramatically less, earn \$16,000 a year, but save 25%. That's \$4000 a year. Suppose you each work from age 18 to 65 and invest at 6% interest. The average saver will retire into poverty with \$60,000 in savings. You'd retire with over a million.

Why might one want to avoid success by conventional measures?

Earning a lot of money is fundamentally hostile to living with nature. How? Well, most natural living alternatives take more time than their conventional counterparts. The more money you make per hour, the less alternative living seems like a good deal.

If time is money, my wife and I are forgoing about \$250 a week in income by spending extra time laundering and line drying cloth diapers. If we earned minimum wage, we'd only be missing out on \$45, at which point we'd be closer to saving money compared to the cost of disposable diapers.

Of course, there is little to stop us from spending our time living how we want, and if we really did earn minimum wage, maybe we wouldn't have time to launder diapers even if it were "cheaper."

In general, however, *voluntary* poverty creates a safety net which precludes the worst excesses of modern life—by simply not having the money to fund wasteful ways of doing things, even if you are temporarily blinded into wanting them. Having money, on the other hand, means foregoing excess is *only* a matter of will.

Does the chance that you might end up as rich as "them" contradict my suggestion that you embrace these alternative goals for success? No—they are still light-years ahead of the conventional goals, in terms of soul-satisfaction, and what that satisfaction costs the earth and its residents. Any riches which result are likely to arrive slowly and gently. By that time, you'll hopefully be so used to living simply that you will be psychologically unable to live wastefully.

On the other hand, if you are an individual who can totally renounce this kind of striving, that's better yet. Don't focus on the *quantity and appearance of things* or on the *quality and function of things*. Simply forgo obsession with things entirely. I've seen one or two people successfully do this in the United States, more in other contexts. I believe this is the highest path.

Follow nature's example

A natural solution is a resolution of the system of forces at a place which maintains that part of the world in balance. It gives equal weight to the needs of the part and the needs of the whole.³

Healthy ecosystems are valuable reminders of what natural solutions are like, and should be woven into the built landscape. Regular exposure to wilderness helps maintain perspective and inspiration.

Many popular patterns of living do not maintain balance in their part of the world. Reductionist thinking prevents the needs of the whole from being given adequate consideration. Also, people who think they are outside the natural system tip the balance so more resources flow toward their economic



Art Ludwig Sr.

There is much more on these themes in the article Natural Economics and Right Livelihood—see inside back cover.

A riparian finger of wilderness passes through a town in Ticino, Switzerland. Such wilderness fingers provide wild-life corridors, water purification, noise reduction, flood protection, and spiritual sustenance for residents.

interests. (It is said, for example, that water in the western United States flows uphill—towards money.)⁴

Natural areas woven into the built fabric provide noise reduction, flood control, water and air purification, and wildlife habitat more effectively and economically than their engineered counterparts. A healthy built area features a continuous web of natural corridors, so any part can be reached from any other without leaving a relatively wild area, and threads of nature have to be crossed to get from one part of a city to another, or even from one structure to another.

Natural systems are always in dynamic balance with the whole. They serve to keep us connected, reminding us what is natural. Regular visits to more pristine wilderness deepens and broadens this connection, and anchors our souls against currents of cultural madness.

Nature has heavily influenced this book. About a third of the work was done in the wilderness. Most of the rest, in nature-focused homes and workspaces.

*Wisdom begins
in wonder.*
—Socrates



Water system design inspiration from nature. A wilderness watershed is floored in dirt, muck, bugs, worms, and feces. Yet the bottom drain for this whole valley runs pure, drinking quality water. Beneficial bacteria in soil break everything down into water soluble plant nutrients, plant roots extract the nutrients, and purified water percolates down to the groundwater and the river. Root filaments extract the small amount of nutrients in the river itself, keeping algae from growing.

Listen to Trees

“My grandfather he live in the jungle, in the Congo, man, where the equator go through Africa! There be thousands and thousands of really big trees, and each tree it have a name. He don’ know the days of the week, but he know the name of every tree. My grandfather he tell me, ‘You listen to the trees, you watch the trees. The trees they dance, the trees they sing, sometimes the trees they cry. You learn all you need to know from the trees.’ All my music is inspired by the trees, the animals, the birds.” —Elo

Intervene as little as possible

Ecological designs operate as much as possible like ecosystems. By restraining the scale and intensity of human activities, the likelihood of disturbing the ecological balance is reduced.

Our planet’s natural systems have been fine-tuned over five billion years. As we learn more about the unforeseen ways in which we have tipped this intricate balance, it seems wisest to live within the existing natural framework to the greatest extent possible.

Artificial and natural systems cannot be disentangled. Nature cannot be preserved pristine under glass while sustaining ourselves “elsewhere” with artificial systems. Rather, we must integrate our life support systems with natural systems, with sensitivity, elegance, and restraint. Nature must be



The same system, slightly domesticated, purifies the water from a kitchen sink in Costa Rica.

kept pristine with us smack in the middle of it!

For example, for medium density housing, on-site biological wastewater treatment and reuse achieves higher purification levels with lower cost, energy, and materials use than sending the wastewater to a centralized treatment plant.

Maximum intervention for water supply.

This reverse osmosis plant in Santa Barbara is the largest in the western hemisphere. It can produce fresh water from the ocean for \$5000 an acre foot (half of that for electricity) compared to \$30 an acre foot for water naturally extracted from the ocean by sun and wind and collected as rain in the wilderness behind Santa Barbara.



Greywater-irrigated landscape (above) and sewage treatment plant (below). A greywater system⁵ treats and reuses on site most of the wastewater from this house.

Otherwise, it would be pumped through this treatment plant, chlorinated, and dumped in the ocean. If everyone in the service area of this plant treated as much water on site as practical, the plant could be a lot smaller and less expensive, and more effective.



Natural Harmony

Shhh. Listen!

Our voices and walking cease, leaving big empty space.

We look around in wonder, up to the tops of the big trees. Our feet shifting over the duff seem intolerably loud. We sit quiet, close our eyes in mute agreement.

Invisible bugs drone bagpipe-like all around us. Steady for minutes at a time, it suddenly stops for a few beats, then resumes. Bees buzz by intermittently. Soft, growing loud, then fading. A woodpecker's staccato drum riff sounds out nearby. One beat before he stops, another down canyon starts. One beat before that one stops, another still further starts. There's apparently another one we can't hear, then the nearest one lets loose his riff again. A beetle clicks time: short, sharp like musical claves. Is he the one keeping the whole symphony on the beat? Bird song dances gloriously, melodiously over the top of the percussion. A canyon wren warbles down the scale. In the distance an eagle calls out—our skin tingles.

The shaman of this canyon explained how the birds talk in song to one another in call and response, and how he learned to talk with them. He sat for weeks listening, ears straining all up and down the canyon, listening for voices in their large circle. Then he gradually spoke up, employing a whole medicine bag of whistles and flutes. The morning wind carried down the songs from up canyon, and the afternoon updraft carried up the songs from way down, by the ocean. In this way, using the wind as a telegraph, they would sing their heart songs to each other all up and down the valley.

Under the ocean there is singing too. Whales on their way from Mexico to Alaska sing a swimming song which can be heard for hundreds of miles. Each group has its own variation, and each variation evolves from one year to the next.

Light plays inside my eyelids. Opening them, I see wind waves stir water waves which scatter light waves from the surface of the pool into a dancing tracery of light and shadow among the ferns on the overhanging rocks.

One aspect of the web of life is eating each other. Another, making music together: finding and refining our part in this incredible, ever-unfolding, multimedia symphony. So subtle a quiet voice drowns most of it out, we spend most of our lives in dissonance with this unnoticed music.

But for the moment we're tuned in—swaying, humming, chanting, breathing, hearts beating in natural harmony...



Context is everything

The context must be known in order to determine if a design is "good" or not.

There are no universal solutions. There are approaches and patterns that can be applied to generate the optimum solution in a variety of contexts.

Ecological design is so context-sensitive that one piece of new information about a critical variable can change the direction of the design completely.

Context is king in ecological design. In all cases, the greatest efficiency—and performance as well—is achieved when the power of the tool is well-matched to the task at hand. Overkill is one of the saddest sources of waste in our society. Elimination of overkill does not mean sacrifice. The resources saved by using simple tools for easy tasks can be applied toward more difficult tasks. Using transportation as an example, walking would be used when adequate, bicycles for distances too long to walk, buses, trains and carpooling for distances too long to bike or in bad weather, planes for speed or great distances. Getting superfluous cars off the road would enable the necessary ones to get around without being choked by traffic. Moving through the world under our own power eases a whole host of environmental and health problems as well.



Buses and bikes in Copenhagen. Northern European countries recognize the social and environmental benefits of bicycling, walking, and public transport. These options are encouraged. This is perhaps the most important single factor which enables Europeans to enjoy a standard of living comparable to Americans with about half the resource use.



Using transport bicycles such as this 1950 Schwinn cruiser instead of a car saved me enough money in nine years to pay for three years of overseas travel by bike, boat, and plane. It carries a comfortable payload of 80 lbs in lockable, waterproof panniers.

COST COMPARISON: CAR TRANSPORTATION VS MULTIMODAL MIX

	Miles/day	Cost (\$/day)	Time (min/day)
Car only*	41	\$20.00	70
Gym membership or increased medical expense**		\$1.60	20
Total	41	\$21.60	90
Walking	0.25	\$0.00	5
Biking	5	\$0.30	30
Public transport	1	\$1.00	6
Plane, car rental, cabs	5	\$1.00	0
Demand reduction***		\$5.00	30
Total	11.25	\$7.30	71
Difference	29.75	\$14.30	19
Ten year difference	108,588	\$52,195	68620
	miles	dollars	minutes

*The average American spends 70 minutes a day to drive 15,000 miles a year, at a cost of \$0.50 a mile.

**Deaths from car-enabled sloth and consequent disease are several times the 43,000 deaths a year from car wrecks. These, in turn, are nearly ten times the rate of American combat deaths during the Vietnam war.

***There may be a cost associated with choosing housing, work, school, and shopping which are closer together.

By using a mix of transport modes instead of driving as much as average, my wife and I have saved about \$180,000 in our 20 year driving lives—about what it cost to pay off our house.⁶

Cleverly matching the power of the tool to the task at hand is cheaper, healthier, lower impact, and more enjoyable—yet ultimately more powerful than any single solution.

Uniform solutions appeal to centralized bureaucracies. However, implementation of a single solution across the board, without regard to context, generates a host of new problems. For example, water-seal toilets are the single solution promoted for feces disposal everywhere from boats, to mobile homes, to planes, to skyscrapers, to farms, from deserts to jungles. A context-sensitive approach generates a variety of solutions which are better adapted to each of these vastly different situations.

Please bear context sensitivity in mind while reading on. Those readers who are used to uniform solutions will be quick to point out situations where, for example, a composting toilet is unsuitable. *None of the solutions proposed here are applicable across the board, nor is it suggested that any of the technologies criticized here should be eliminated completely. What is suggested is that the range of solutions be matched to their contexts using common sense.*

Appropriate Technology

“Not all solar collectors are appropriate and not all methane digesters are useful or even necessary. The important factor is always the context in which a tool or technique is used—scale, source, location, and need.” —Rain

“Appropriate for what? Appropriate for whom? No technology is value free. Some technologies are appropriate for conditions of growth, vast resources, and small populations. Others are appropriate for conditions of stability, plentiful labor, and scarce resources. Some technologies increase the wealth of a few while impoverishing the many. Others tend to equalize wealth and power. Some technologies degrade and destroy the people using them, while others give the opportunity for the growth of skills, confidence and abilities...Appropriate technology reminds us that before we choose our tools and techniques we must choose our dreams and values, for some technologies serve them, while others make them unattainable.”

— Tom Bender (tombender.org)



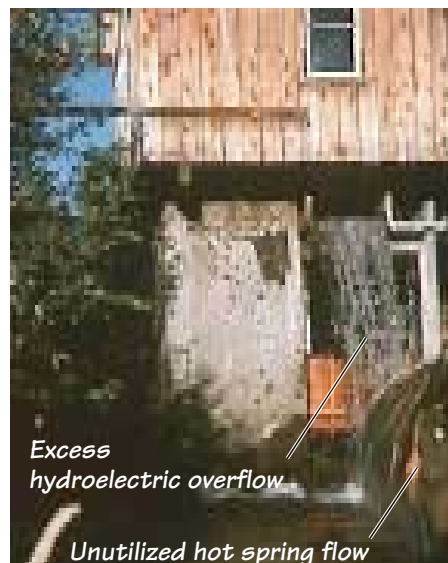
Photographer unknown

In the Yucatán Peninsula of Mexico there are no above-ground rivers and no soil. The entire peninsula is limestone Swiss-cheesed with an intricate network of underground watercourses ranging in size from mere capillaries to twenty foot-diameter rivers that people scuba through for miles. Where the roof of an underground river collapses, the result is a beautiful window into this amazing underground world. Normally the soil purifies surface water before it becomes groundwater. Not so here. The land is so young there is no soil. The underground rivers connect directly to the surface through countless holes of all sizes in the naked bedrock. The freshwater mains, storm drains, and sewers are not only connected, they are the same pipe network! Above-ground composting toilets and carefully designed greywater systems are the best hope of maintaining water quality in the face of increasing population density. Standard solutions such as septic tanks have led to well intakes clogged with toilet paper and destruction of coral reefs.

Breitenbush Hot Springs in Oregon is a mind-bending design context. There is a super abundance of particular kinds of water and energy, while others are in short supply. The Breitenbush river, thousands of gallons per second of fresh water, runs through the middle of the property. However, it cannot supply the community by gravity, and is unsuited for drinking without treatment. A large turbine in the powerhouse (right) generates hydroelectric power on a “use it or lose it” basis. It always runs and any unused power is lost.

The ground water under the entire property is nearly boiling water. It is pumped all over the property through 2" copper mains.

Things which would be appalling in most contexts are appropriate here. There are single leaks in the flume which are greater than the water consumption of entire desert communities. Unoccupied sheds are toasty warm all winter from geothermally heated radiators, saving the ecological impact of insulation.



Moderate and efficient resource use

Natural designs encourage awareness and moderation in the use of energy and other resources.

Consider energy. Fossil fuels and electricity have severed the connection between energy source and consumer. One thin pair of wires can invisibly, silently channel an unbelievable amount of energy without creating a ripple of awareness. This has enabled our relationship with energy to skew way out of scale.

To put our energy use in a human, comprehensible perspective, try measuring it in units of *energy slaves* (es). If you shackled a very fit slave to an exercycle, they could generate about 75 watts of power, twelve hours a day. This is about what a bike rider expends cruising on flat land. To make the math easier, we'll round it up generously to 100 watts = 1 es. This is a level of energy expenditure which an average American might be able to keep up for thirty minutes before collapsing. Now look around for energy slaves at work. This is what energy slaves are doing for me right now:

1.50	es for my computer
0.25	es for my music
0.25	es for the compact florescent office light which I forgot to turn off when it got light this morning.
<hr/>	
2.0	es total

Not too bad; only two energy slaves catering for me at the moment.

Someone just came into the office to make a photocopy; ten more energy slaves. The little electric heater by my feet (I wasn't going to tell you about this) just cycled on—fifteen more energy slaves. If the well pump which serves our community is going, that's another 30 energy slaves.

It racks up fast. A blow dryer—fifteen energy slaves. An electric water heater: thirty or more.

This is nothing compared to the toil out on the street: Our little Honda Civic—750 energy slaves. A Ford Expedition SUV—1700 energy slaves. Arranged on bikes four abreast (a bit wider than a standard ten foot road lane) and squeezed so there was just a few feet between the front wheel of one and the rear wheel of the next, the Ford Expedition would require a regiment of energy slaves nearly a mile long. When you consider the shadow army of energy slaves that precedes each car, our roads are crowded indeed.

All told, the average American has over 26 energy slaves pedaling twelve hour shifts for them three hundred and sixty five days a year.⁷ This seems rather a lot. Imagine feeding and housing 7.8 billion energy slaves to serve the United States alone.

If we had to maintain the books in current balance, the cost would be more apparent. The only way we are able to do what we are doing is by burning up three hundred million years of fossilized effort from past energy slaves, with an estimated hundred years or so to go before it is gone (I've heard it said that in the US, denial is our most abundant renewable resource).

A great deal of energy and ingenuity has gone into hiding the supply and waste systems we use. Effective action follows awareness. Hiding certain things has caused an "unknowing," and our morals have developed without critical knowledge. Those who gain from increased consumption have gained tremendously. All others, especially future generations, have lost.

Natural designs strive for moderation and awareness in the employment of energy slaves as well in the use of other resources.



By permission CA state water authority

A pump station sends water 3000 feet over a mountain pass. At full capacity, it uses 2,460,000 energy slaves of power.

If the entire population of the city of Los Angeles did nothing but pedal hard and sleep, they would generate this much energy.

By importing water from up to 600 miles away, Los Angeles removed its growth-limiting factor. It's population has increased by a factor of 1000 in 150 years.

During the drought of the 1990's, at the point when the state water project agricultural deliveries were slashed 90%, LA was conserving 5%.

Limits—Running out of water, electricity, gas, whatever, at some point, are a key ecological design feature which hones awareness and keeps consumption from growing out of reasonable bounds.

Not too little, not too much: just enough

Deficiency is stunting, excess is toxic and unbalancing. In most cases the optimal growth arises from *just enough* resources. This is true across a wide spectrum, from nutrition, to emotional needs, to national economies.

For example, the world's poorest people suffer malnutrition, while many of the richest suffer from obesity and heart disease. The healthiest people have adequate but not excessive food intake.

While green consumption is surely a slower path to ecological annihilation, I am concerned about its promotion as a cure. Consuming *less* would be a far more effective step. In ecological design, you're best off to:

Choose the most inherently simple solution, then implement it as well as possible.

Market economies favor the exact opposite: marketers seek out and push the fundamentally most expensive solutions, with the option of shoddy execution or financing if you want to save money up front. This yields the maximum profit and use of resources.

Housing in Southern California is a dramatic example. The shade of an oak tree offers adequate shelter for half the year. A tent, teepee, or yurt could provide adequate shelter year round (and greater earthquake safety) for a substantial fraction of the population, especially those who cannot afford half-million dollar houses.

Instead, developer profits and the property tax base are propped up by mandating complicated construction. Though the rules succeed in mandating high cost, they fail to insure quality. Flimsier and flimsier houses are built like stage-sets for a one-act play: the sale. In Santa Barbara, 40,000 square foot mansions are approved routinely, while living in a yurt is illegal. It seems unconstitutional that it is against the law to live lightly on the earth.



When we weren't living in a cabin, our family has lived happily in tents or shacks for three of the last ten years.

Empower and require individual thought and action

Because natural solutions are context sensitive, it is up to the people facing a situation to figure out what to do about it and how. Natural solutions are generally less idiot-proof than current common practice. They both demand and reward user interaction.

Systems should be designed with moderate capacity. It's okay, even desirable, for users to bump against capacity limits now and then.

Ecological design places ultimate responsibility for implementing sensible solutions with local people who have knowledge of local conditions. Also, many of the systems themselves require independent thought from users on an ongoing basis.

More than any other feature, it is the interaction of the user with the design that enables ecological design to be so much more efficient.

For example, recycling requires more thought and action from people than if they put any solid they don't want in the trash, and any liquid they're done with down the drain. At least some user separation is key to tap the substantial economic and ecological advantages of recycling materials.

Many of the cycles in natural living environments are of such small scale that they can be maintained by a single individual.

The short feedback loops in natural living environments both suggest and reward ecological living. The reward is usually in the form of better performance, lower cost, and ever-increasing awareness. Compounded over the years, the savings and awareness facilitate a significantly better quality of life.

In contrast, the promotion of high consumption depends on perpetuating dissatisfaction. Buying into consumerism is certainly costly, generally dulls awareness, and yields little long-term fulfillment.

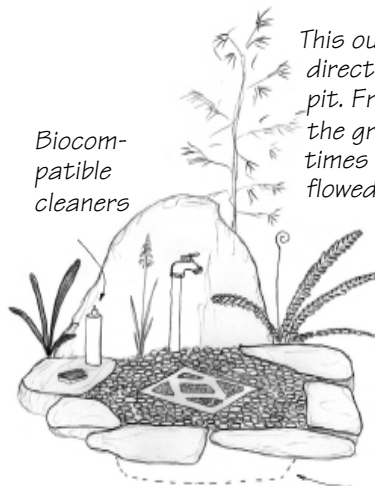
A ubiquitous but unspoken assumption in mainstream design is that the capacity of the system must almost never limit the user. This maximizes profits from sale and use of the system, and ensures that users will learn no conservative habits from the system.

Systems of moderate capacity tend to be cheaper and simpler to build, and to use less resources. What's more, bumping into the limits of system capacity system provides useful feedback, which raises awareness and promotes good habits.

A system which occasionally leaves a user without hot water or electricity can be provocative when consumers are conditioned to believe they should have everything they want, when they want it. Is it worth four times the cost, complexity, and resource use to have hot water 99% of the time instead of 90%? At a minimum, the capacity/performance standard of any system should be openly debated.

While bicycling through communist Eastern Europe before the fall of the Berlin wall, people remarked to me many times that "Americans have all that freedom and don't use it." Though we are subject to annoying external pressures, we are comparatively free to determine our own patterns of thinking, production, and consumption.

Many crises are brought about by the summation of our individual actions. Together, we are capable of making a mess of the whole planet. Paradoxically, most individuals feel powerless to influence things for the better. In practice, however, individuals who make an effort to be part of the solution rather than the problem have a disproportionate positive effect. If, for example, just one person on the block starts riding a bike or carpooling, suddenly all have this option illuminated—like being the first to dance at a party.



This outdoor kitchen sink drains directly to a shallow, rock-filled pit. From the pit, water filters into the ground. Two of the first three times I used it, the water overflowed the pit. I then moderated my water use and it never overflowed again in ten years of daily use.

Small capacity pit for storing waste water surges before infiltration (about 5 gal or 20 L).



This valve switches between solar panel-direct and solar-preheated hot water. The timer switch controls the power to the backup heater. Active user involvement enables the hardware to be ex-

ceptionally cheap and simple for its high performance. It provides 95% of the hot water from solar alone year round in this Southern California installation. The limited water supply rewards paying attention to the weather and conserving as needed. The reward is large ongoing cost savings and the satisfaction of long, hot, guilt-free showers on freezing cold, clear days.



Fuzzy logic irrigation controller. A few \$30 tensiometers to read soil moisture, plus a \$12 mechanical automatic sprinkler shut off, plus using your brain to decide when to turn it on and for how long, yields a drip irrigation controller which in many ways outperforms electronic controllers costing \$500 or more.

Green Living Inspiration List

Life direction

- ❖ Do your dream; consciously manifest your life the way you want it to be.
- ❖ Seek fulfillment in relationships with family, friends, and nature, rather than solace in consumerism
- ❖ Want what you have
- ❖ Believe in yourself
- ❖ Question authority
- ❖ Seek balance between body, mind, spirit

Community & relationships

- ❖ Create community wherever you are
- ❖ Stay home
- ❖ Cooperate and share with your neighbors
- ❖ Enjoy celebrations & rituals
- ❖ Listen

Parenting

- ❖ Have fewer children & give them more
- ❖ Birth your children at home
- ❖ Natural parenting—breastfeeding, attachment parenting, reusable diapers, etc.
- ❖ Provide your children freedom & responsibility
- ❖ School your own children

Livelihood & thrift

- ❖ Practice right livelihood
- ❖ Use alternative measures of success
- ❖ Save money
- ❖ Avoid buying things on credit
- ❖ Make things yourself, cut your family's own hair, etc.
- ❖ Buy things used
- ❖ Choose quality and durability
- ❖ Avoid disposable products
- ❖ Do without toxic products
- ❖ Save water
- ❖ Save energy
- ❖ Reduce, reuse, recycle

Food & health

- ❖ Eat local and/or organic food
- ❖ Grow your own food
- ❖ Compost your organic waste
- ❖ Stay active and healthy
- ❖ Banish television & video from the house
- ❖ Use alternative health care when appropriate; massage, acupuncture, etc.

Transportation

- ❖ Drive less or not at all
- ❖ Walk or ride a bicycle
- ❖ Carpool or use public transport

Recreation & hobbies

- ❖ Enjoy music, dance, art
- ❖ Enjoy natural recreation; sunsets, camping...
- ❖ Sleep outside
- ❖ Learn from traveling slow and deep...make the effort to learn the language

Activism

- ❖ Engage in activism, vote, write letters, sign petitions
- ❖ Support local industry and initiative
- ❖ Support green and alternative business
- ❖ Invest ethically
- ❖ Help achieve population control, slowing of genetic erosion, indigenous people's rights, equitable resource distribution, peace, campaign finance reform, local self-determination & self reliance, sustainable development, etc.

Practice cooperative anarchy

Cooperative anarchy is the order of ecosystems and the social order of people who are thinking and acting independently in their own enlightened self-interest.

In cooperative anarchy, each individual gravitates toward the tasks they care about and do best. Individual uniqueness is cherished and ensures that a wide range of functions is attended to. In cooperative anarchy, the people doing a task decide how to do it, people's level of skill determines their level of autonomy, and their performance determines their compensation. Each person illuminates a part of the truth for the group's understanding. Group decisions are by consensus.⁸ Ideas which make the most sense get the most attention.

Rainbow gatherings are a spectacular demonstration of cooperative anarchy. Free food, water systems, sanitation, etc. are organized for up to 20,000 campers.



A circle of Pomaro Indian women in Maruata meet frequently to discuss the running of their businesses, palapa accommodations on the beach for travelers. Among other things, they divvy up large groups of visitors fairly so no one gets too much business or too little.



Make true progress

True progress actually solves problems. Most of what is commonly called "progress" is the relocation of problems out of sight in space or time.

It is wiser to add new ways alongside the old, rather than completely and immediately supplant them. By the time the problems of a new technology are recognized, reinstating old methods where they were superior is often not feasible: traditional knowledge has been lost, and/or the resources which the traditional approach requires have been appropriated for other uses.

We're losing what we had (e.g., biodiversity, native people's empirical knowledge and wisdom, and easily extractable natural resources) at a rate that exceeds the astounding rate we are "progressing." For example, hunger has been relocated out of developed countries, partly into the third world, but mostly forward in time. It is not obvious what we will eat in a future clouded by the loss of aquifers and topsoil.

We appear rich, but most of our "income" is from the liquidation of age-old assets. True progress is less spectacular—it's hard to compete with the effect of squandering five billion years worth of natural capital in a few hundred years—but it is real.

Our era is marked by tragic, wholesale loss of irreplaceable wisdom. Oral tradition and apprenticeship forms chains of knowledge which stretch back, unbroken through countless generations. However, there remains an unprecedented opportunity for true progress at this time. There is a phenomenal body of new knowledge and capabilities crying out for integration with the traditional wisdom which is left.

*Wisdom is dead.
Long live
information.*
—Mason Cooley



A family with solar cooker in background. A through-the-wall solar oven installed in a house in Mexico and insulated haybox⁹ for retaining heat once a pot is heated (not shown) complements the older technique: cooking with firewood.

True progress comes in incremental steps towards an optimum balance between the many different design factors in a given context. Natural living environments are important both as habitat for the preservation of ancient wisdom, and as a crucible for the integration of modern science and technology with ancient wisdom.

Preserving our Legacy of Ancient Wisdom

Some tribal peoples lived well for thousands of years without damaging local ecosystems. Our ancestors created complex, even spectacular civilizations in a variety of climates and ecosystems without the benefit of modern materials. These are not trivial achievements. We'd be ill-advised to junk this incalculably valuable informational heritage.

How could we back up what's left of this priceless legacy, which took billions of patient people-years to develop?

First, we can support efforts to maintain tribal cultures intact and in place where they still exist. Second, in places which are overrun entirely by colonizers, perhaps the old ways could be kept alive in modern recreations similar to the "Stone Age Villages" in Europe.¹⁰ Several different sites and groups would be desirable for each bioregion. For example, a group of at least a hundred people on 100 acres could live in European self-sufficiency, with gardening, animal husbandry, food preserving, aborigiculture, knitting, dying, weaving, sewing, leather work, ceramics, glassblowing, smith work, boat making, stonemasonry, carpentry, herbal medicine, midwifery, etc. A group of at least fifty on 1000 acres surrounded by national forest could safeguard traditional hunter-gatherer knowledge; gathering, processing, and storing wild foods, fishing, hunting, cooking, crafting, traditional medicine, story telling, weather watching, and constructing traditional dwellings. A third group could be chartered to synthesize the best elements of the European, Tribal, Modern, or any other lifestyle into a blend optimized for the bioregion. Ideally the lifestyle of this group would come to be adopted by the balance of the population.

Exemplary Progress: Italian Stoves

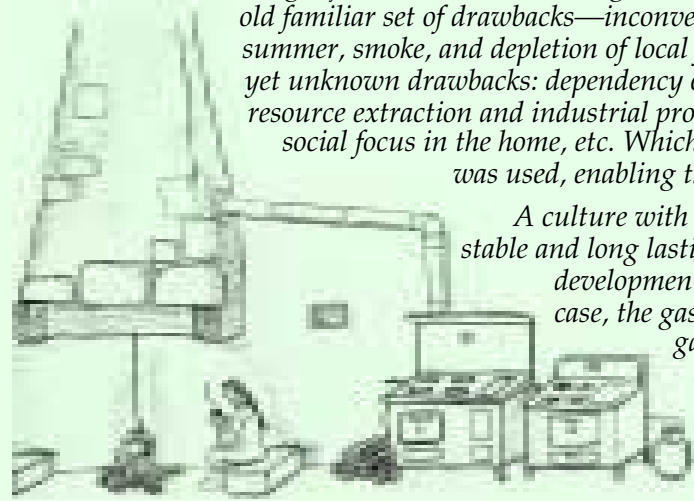
In Italy the camino (fireplace) has been used for heat and cooking for a long time. They are versatile: they help dry food and clothes, and provide warmth and light on long winter nights. They are aesthetically beautiful and can be fabricated and repaired by the users with on-site materials. They can easily last a century between repairs.

Cast iron wood stoves are efficient for cooking, but cannot be fabricated or repaired locally and do not provide light or social focus. When they became widely available, many Italians simply knocked a hole in the chimney of the camino and installed the wood stove next to it. In this way they enjoy the advantages of both. Gas stoves offer still higher cooking efficiency but have no other uses. In many cases, they too were added, next to the wood stoves.

I first witnessed this lineup of three generations of cooking technology at a cafe in the center of the ancient Roman town of Forli. It was winter, and only the camino and the wood stove were in use at the time, because of their desirable feature of warming the room while cooking the food.

This exemplifies an almost unheard-of degree of common sense in handling technological progress. Far from being rejected, the new technologies were embraced, but only for what they were good for. The old familiar set of drawbacks—inconvenience of gathering wood, undesirable heat in the summer, smoke, and depletion of local forest resources—were not merely traded for new, as yet unknown drawbacks: dependency on strangers, environmental consequences of large scale resource extraction and industrial production, depletion of nonrenewable fuel, loss of winter social focus in the home, etc. Whichever technology best fit the requirements of the moment was used, enabling the enjoyment of the advantages of all three.

A culture with a balanced relationship to technology will be more stable and long lasting in the face of change, whether in the form of rapid development of new technologies or economic decline. In the latter case, the gas stove might be scrapped after the first summer without gas, the wood stove after several decades when it had burned through beyond repair, and the little cafe would continue unperturbed, making good food for people and turning a profit using the camino, just as it did for the first thousand years.



Enjoy true comfort

Adaptive discomfort produces healthy people who are more comfortable in all situations. Adaptation to a rich variety of environments with diverse adaptive pressures is true comfort.

Adaptive pressures include temperature, humidity, insects, microorganisms, sunlight, varied terrain, elevation, physical activities, and social environments. Except in the most sheltered inner nest, the character of natural living environments varies substantially with the weather and time of day, resulting in an appropriate, baseline level of adaptive pressure.

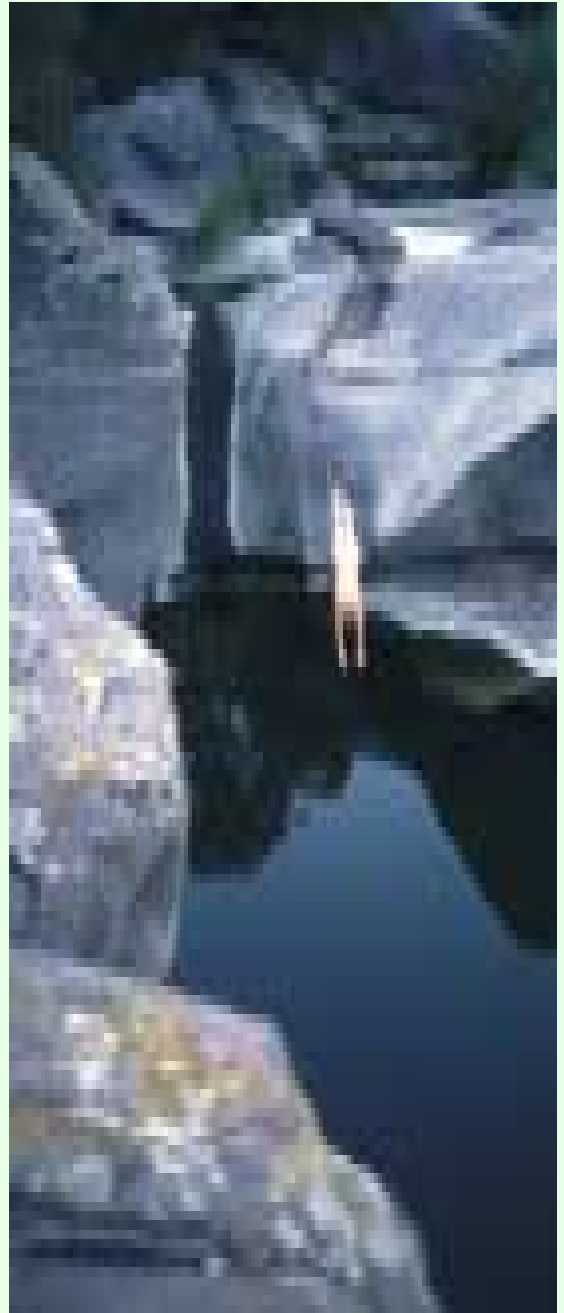
Elimination of adaptive pressures, as in a seventy degree, sixty percent relative humidity armchair, results in real short term comfort. Indulged in excess, however, it leads to severely restricted physical capabilities, and eventually discomfort and degenerative disease. The more someone is (gently) pushed, their comfortable limits widen to accommodate more and more interesting environments and activities.

The whole body changes in response to its environment. Head out into the wilderness and your skin browns and thickens, reaction to bug bites and poison oak lessens, your stomach shrinks, your feet toughen, your thyroid cranks the thermostat up or down to maintain comfort, and you can see better in the dark. At high elevation, your lung capillarity and red blood cell count increase. Nerves in your cerebellum connect more intricately to perform all the calculations needed to keep your balance on rough terrain, your heart becomes slower and stronger.

Ecological design strikes a balance between short term comfort and long term comfort from a strong, adaptable, and adapted body. Shelter doesn't have to be so elaborate—and even the armchair feels better.

Creek running

Birds call and the creek calls and my feet answer: Slowly at first, they scratch the earth's back, then the muscles behind dig in. Soon wind caresses my skin, whistles in my ears. I watch fascinated as rocks slip by below, my flight smooth over the rough creek bed, faster and faster, breathing bigger and bigger...finally a great gulp as feet push off the last rock into the air then slipping otter into the water, turning rolling eyes open in green room below emerging lots of pool still on me water falling great sheets washing new rocks below faster again heart beating pounding laughing wild free to be me ho! Great spirit I contain all I contain nothing but dancing speeding foot on to that next rock!



Please check oasisdesign.net for more articles in the Ecological Design series

References

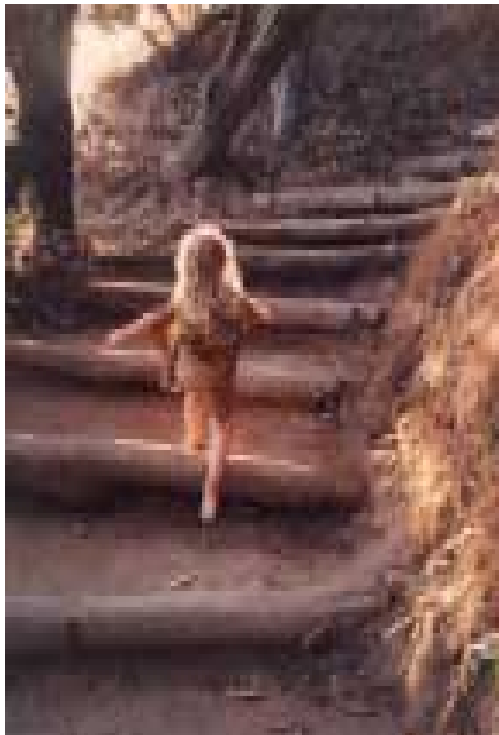
Check oasisdesign.net for updated references to this book.

¹ Inspired by a sidebar from an article by Hannah Miller in the *Santa Barbara Independent* (independent.com), July 18th, 2002. Other figures are from breastfeeding.com.

Astute readers will have noted that each \$1 in formula sales costs society \$25 in increased lifetime medical expenses. As the revenue from formula is immediate and concentrated, while the costs are long delayed and diffuse, the invisible hand of the market is incapable of keeping formula confined to its rightful, economical place. Worse, what should be costs to the formula industry are income for the medical industry. Dependent on income from formula overuse, smoking, car crashes, etc. for a substantial portion of their livelihood, the health care industry has perverse economic incentives which keep them focused on cure rather than on prevention.

If we had single payer health care, the “owners” (the public) would have their economic and health interests both pulling in the same direction. Counter-marketing and lawsuits against formula makers, tobacco companies, etc. would be more likely, and the market for formula would be likely to shrink closer to its optimal size.

Infant formula is just one of many examples of the market failing to allocate resources optimally, the way its proponents say it's supposed to. The costs of cleaning up mining and industrial wastes often exceed the total sales of the company that left them. Logging roads cost taxpayers more than the value of the timber cut, cars get massive subsidies, tobacco costs society hundreds of times what it gains tobacco companies. If the market *did* allocate resources economically, our whole economy would be revolutionized.



² *How to Want What You Have: Discovering the Magic and Grandeur of Ordinary Existence.* Timothy Ray Miller. 1996.

³ *The Timeless Way of Building.* Christopher Alexander. 1979. Oxford University Press, New York.

⁴ *Cadillac Desert.* Marc Reisner. 1986. Penguin Books, New York.

⁵ *Create an Oasis with Greywater.* Art Ludwig. 2002. Oasis Design, Santa Barbara.

⁶ True cost of cars: oasisdesign.net/transport/carcost.htm

⁷ overpopulation.com/energy_consumption_north_america.html

⁸ Consensus resources:

Getting to Yes

Introduction to Consensus. Beatrice Briggs.

Also available in Spanish. From International Institute for Facilitation and Consensus (iifac.org) and Fellowship for Intentional Communities (ic.org).

On conflict and Consensus: A Handbook on Formal Consensus Decision Making. C.T. Butler, consensus.net.

⁹ Aprovecho Institute, efn.org/~apro information about efficient woodstoves and straw boxes.

¹⁰ The Stone Age Village of Kussow, Germany is an example of a site where traditional wisdom is preserved: all-in-all.com/english/boltenhagen/kussow.htm

Future articles in the Ecological Design series:

Natural Economics and Right Livelihood

Understanding time and money, how to negotiate the hazards of our economic jungle, how to save money, measures of real wealth, how to live better with less, how to buy land, how to find and follow your calling.

Design for Community

Make community where you are, community structures that work, resources for consensus and conflict resolution.

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“Every truth passes through three stages before it is recognized. In the first it is ridiculed, in the second it is opposed, in the third it is regarded as self-evident.”
— Arthur Schopenhauer (1788-1860)

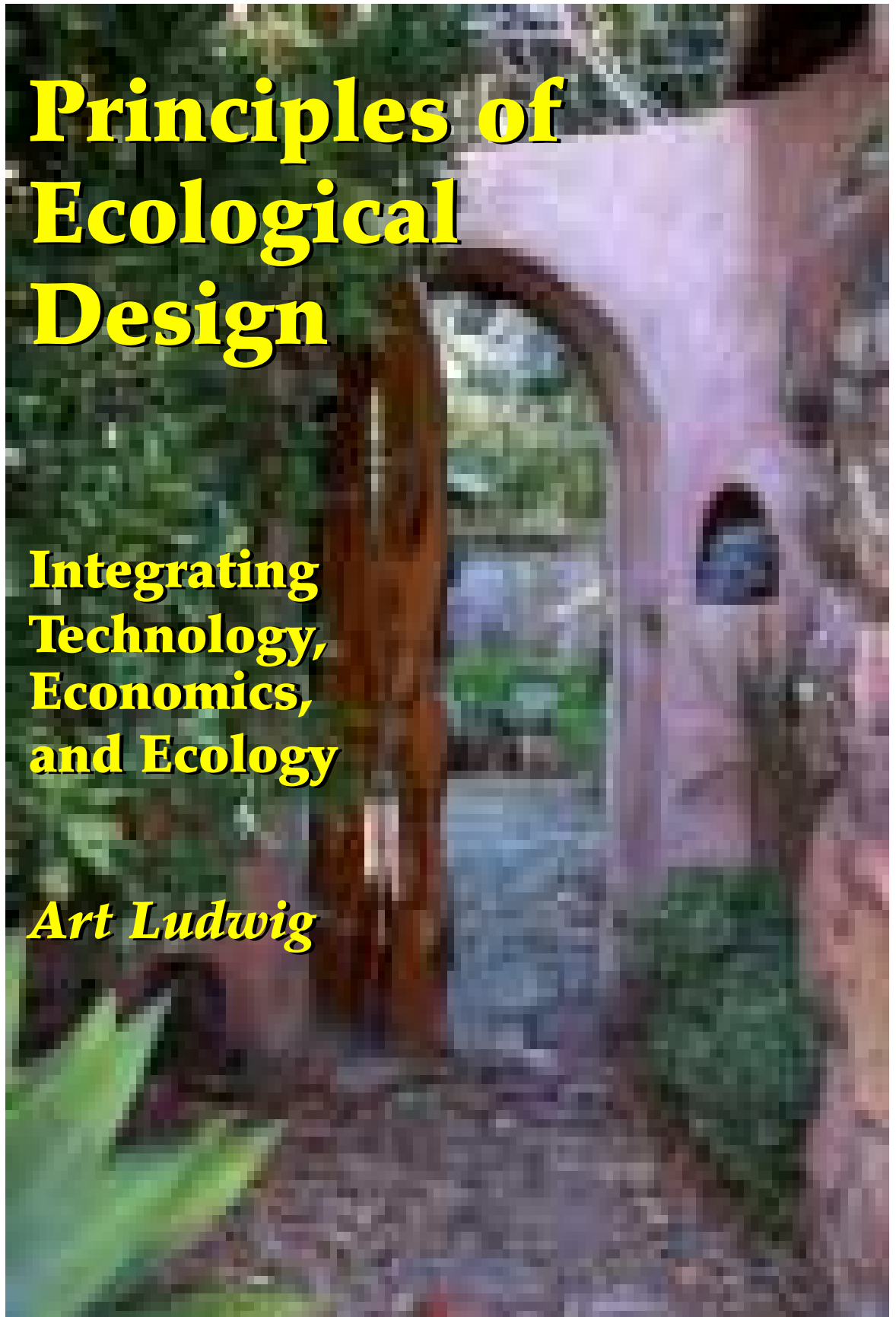
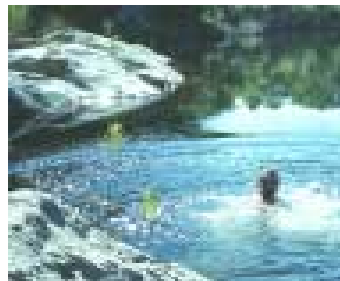
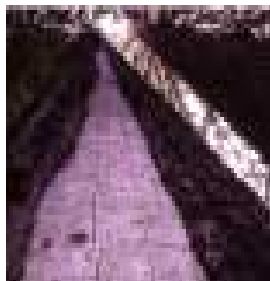


Why not make things of balance and beauty, even if they be but ephemeral?

Principles of Ecological Design

Integrating Technology, Economics, and Ecology

Art Ludwig

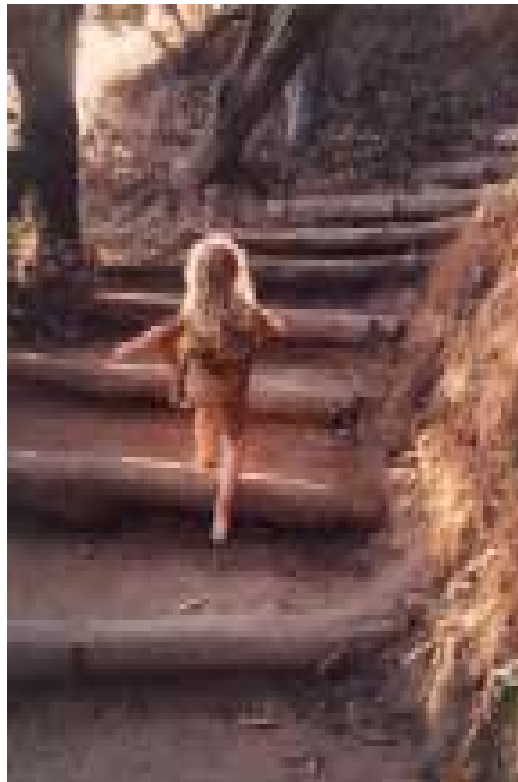


Principles of Ecological Design gives insight, inspiration, and guidance for a radical redesign of our way of life.

Designs which integrate technology, economics, and ecology enable us to disengage from corporate consumer culture, and create a more fulfilling lifestyle.

Includes:

- Follow nature's example
- Transcend market culture
- Alternatives to the conventional scoreboard for success
- Intervene as little as possible
- Context is everything
- Appropriate technology
- Moderate and efficient resource use
- Individual thought and action
- Green living inspiration
- Cooperative anarchy
- True progress
- True comfort
- Preserving our legacy of ancient wisdom



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—*Sim Van der Ryn, author of Ecological Design*

"The best written, most concise, eloquent instruction manual for lifestyle transformation. If you're uneasy about your effect on the planet yet don't know what to do, here is your guidebook."

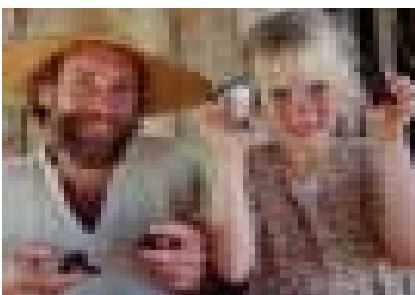
—*Ianto Evans, co-author, The Hand-Sculpted House, Cob Cottage Company co-founder*

"This concise little booklet is densely packed with information immensely helpful for a life close with nature...I couldn't put it down."

—*Bob Wilson, Wild Bounty, Mount Shasta, California*

"The books you wrote on greywater were very informative & straight-up, but it didn't reveal at all how radical you are..."

—*The guerrilla greywater grrls, Oakland, California*



Art Ludwig's day job has been ecological system design for 25 years. He is the author of *Create an Oasis with Greywater* and other ecological design how-to books and articles.

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