Industrial Ecology • Why Public Radio Isn't • Kill More Trees
Clowns Up The Amazon • Guns?

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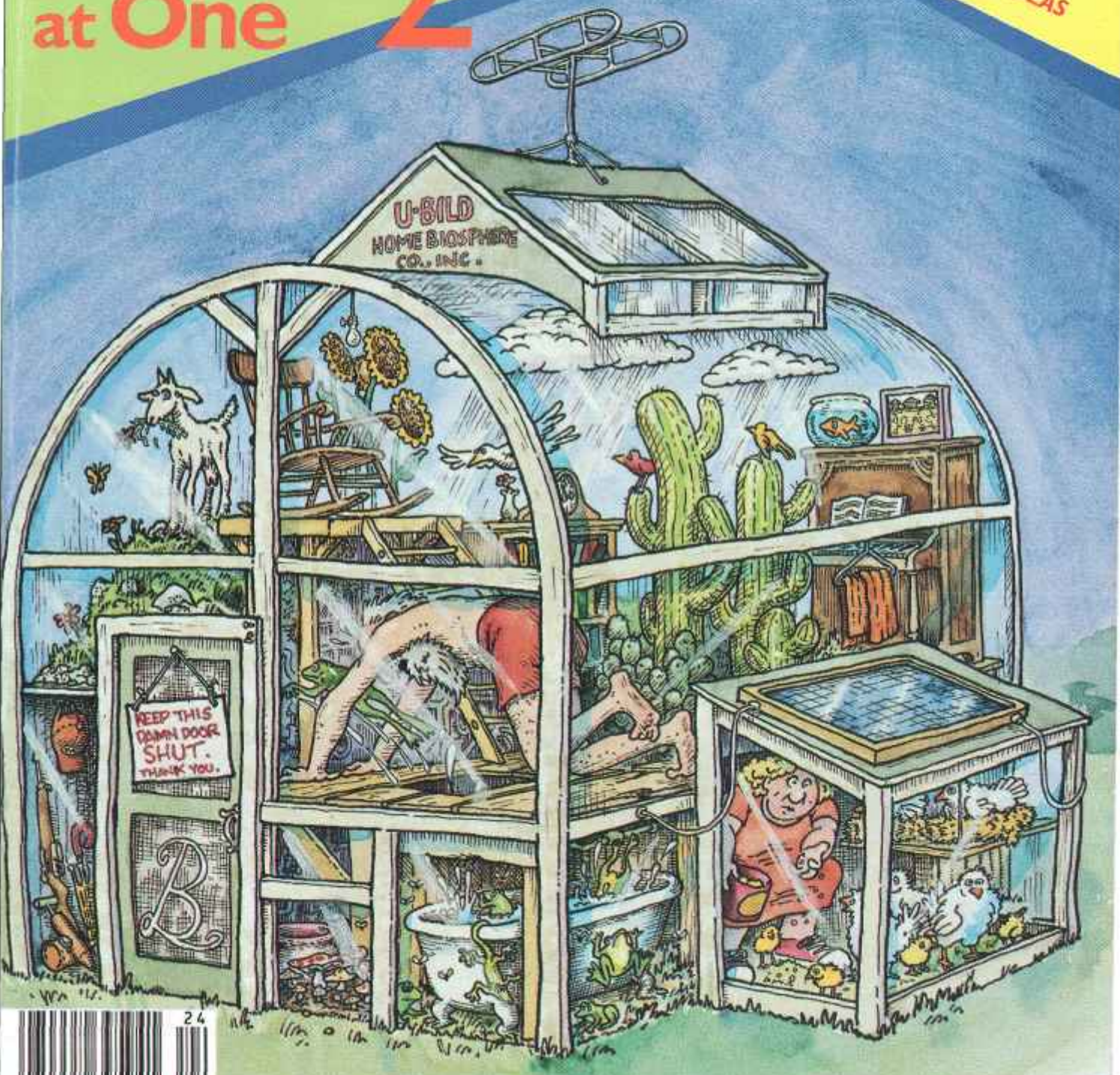
WHOLE EARTH REVIEW

ACCESS TO TOOLS & IDEAS

Biosphere 2 at One



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STORIES OF

Why can't Johnny read? get an answer at last. According to psychologist Renee Fuller, most anyone can learn to read — even a person with an IQ of 20. Dr. Fuller's astonishingly effective methods are almost certainly not the way you were taught — there's no alphabet recitation or complicated phonetics to obfuscate, humiliate and confuse. Instead, her "Ball-Stick-Bird" technique encourages reading for context and concept from the very beginning, taking advantage of the way the human brain is "wired" to acquire, store, recall and utilize information.
THE ASSAYER'S SCALE begins on page 118.

Gun control! Yow! Should we even bring this up? Yup: remember that this magazine will take on most any topic. So: is gun control desirable or not? Is it even possible? The many sides of this controversy have become so entrenched and politicized that "debate" is euphemistic and any attempt at resolution seems doomed to die in a grim fusillade of howls, sneers, and threats. Agendas remain hidden. People seem to have forgotten the underlying issues, but we haven't — see **Firearms: No Right Is An Island** (p. 40).

Philip A. Rutter

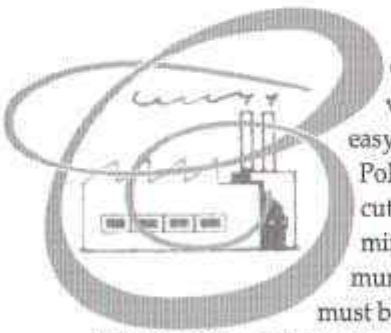
Find out how to play God, and why, in* KILL MORE TREES; AS FAST AS POSSIBLE *(p. 110). It sounds bad, but the results are better trees and more intelligent land use. Did you think we were advocating a sequoia clearcut!

Cesare Scarsovino

Clowning their way to health and happiness, a daring traveling carnival is doing a great job of teaching health care and self-respect to illiterate inhabitants of Brazil's rainforests. ***Clowns Up The River*** *is a story of love, hubris, and occasional terror. The show starts on page 26.*

Gonna Have A Good Time (p. 66) and **Mississippi Plates** (p. 72) give a nostalgic or informative look (depending on your age) at how things went while young white middle-class kids were learning to think about race issues in the fifties and sixties.

A GUEST EDITOR usually has a thematic idea for an entire issue and the time to develop it. I was out of town when my mandate was bestowed, returning just in time to sit down at the editor's desk. On the desk was a pile of articles and reviews, mostly written by or brought in by our outrageously eclectic staff and close friends. It's not quite "inmates taking over the asylum" as threatened in the last issue, but the crew as a whole has been more involved than usual in the editorial and production process. Here goes . . .



CORPORATE villainy is so easy to attack: Polluting! Clear-cutting and strip mining! Dolphin murder! They must be stopped! But all of us — even the most extreme environmental champions — use the products of the corporations we decry. We don't want (most) corporations destroyed, we want them to be good environmental citizens. But they don't know how.

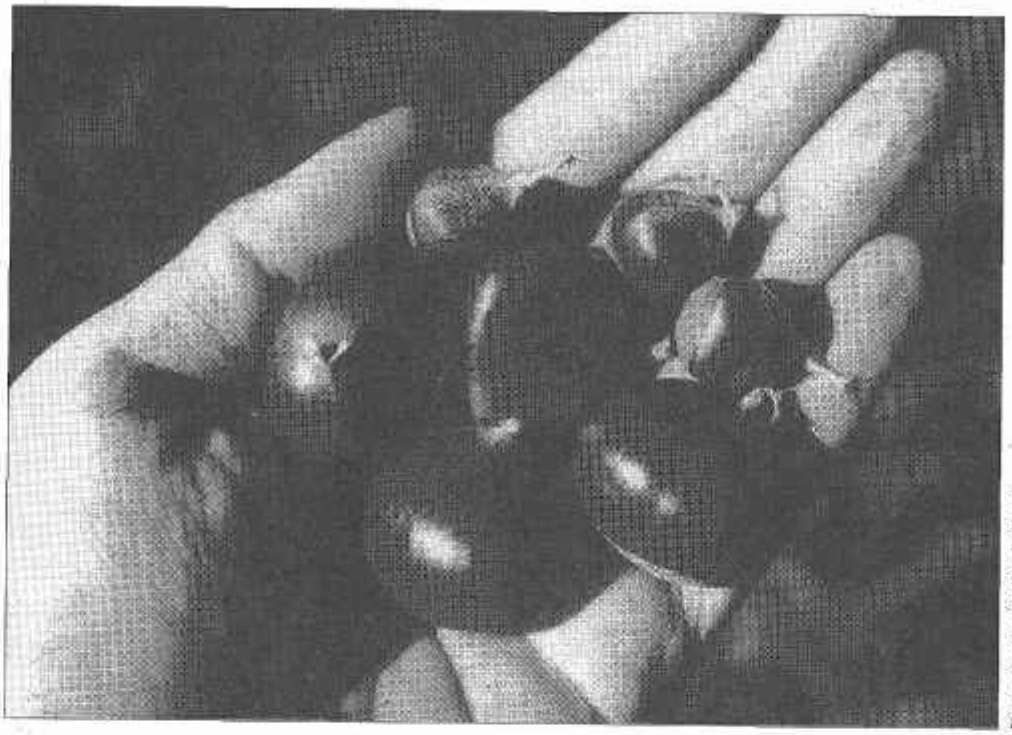
Experience shows that corporate malfeasance rarely derives from malignant intent; it's more often caused by a lack of familiarity with ecological concepts and their long-range importance. A business education usually doesn't include biology. The problem *must* be ignorance, or corporations would already be cleaner and more energy- and resource-efficient. Enlightened (or coerced) companies often find increased profits from pollution prevention (it's always cheaper than cleanup) they once stoutly resisted. Long-ignored energy efficiency turns out to be a moneymaker as well as to reduce ecological degradation.

INDUSTRIAL ECOLOGY (p. 4) is the best basic guide to improving corporate environmental attitude and performance I've seen. It's written in a language that business folks will accept; it helps environmental workers understand business realities; it should engender cooperation. I'll bet the concept and the term take hold strongly and soon.

Abigail Allig

The Biospherians have been getting some hostile media coverage during their first year sequestered in a glassed-in world. Highhanded attempts to control Bio2 news have encouraged accusations of cheating, commercialism, and poor science.

Kevin Kelly wrote an early Biosphere II report as the cover story for *WER* #67 (p. 2). Two years later, in contrast to other reporters, he finds good science, some unexpected phenomena, and a few shenanigans. It's more than ever a Grand Experiment. **Biosphere 2 at One** starts on page 90.



Photos and charts by Philip A. Rutter

Kill More Trees; As Fast As Possible

BY PHILIP A. RUTTER

The Rutters have been friends of mine since the sixties. They stayed with the biology that I wandered away from, and have been doing one thing very well. Here's a report from their Badgersett Research Farm, a grand family project just coming into the public eye. They've received grants for demonstration plantings of hazelnut windbreaks in Michigan and for hand-harvestable hazels and chestnuts in Hubei, one of the most sophisticated agricultural provinces in China; their chestnuts are among the trees in Biosphere II. —Hank Roberts

IMAGINE THE FIELDS of the Cornbelt in July — one organism basically — corn, plus a few bacteria and a nematode or two. A few others use the fields for food — crows, deer, coon — but nothing lives there. It is an unquestioned and unexamined absolute of policymakers: the best lands are reserved for agriculture. Period. We certainly aren't going to change that policy; one cannot suggest that "crop lands" be diverted for any uses or needs other than food production.

What we need is a way to make food production "planet-friendly." Woody agriculture may be a start.

The ultimate limit to any agricultural system is how much sun can be captured. Woody plants capture more sun, and are more efficient, than annual crops in temperate climates. Woody crops' actual measured efficiency is over three times more carbon fixed per field per year than that of a single crop of corn.

Current agricultural practices have been inherited almost intact from our ancestors, whose mobility led them to favor grasses (rye, oats, wheat, corn) that could be carried and replanted wherever a tribe found itself in the springtime. With this reliable source of staple crops assured, horticultural research has concentrated on developing trees as sources of perishable fruits.

We at Badgersett Farm feel that a basic change in philosophy is necessary, moving away from the searching of natural forests for interesting trees, and turning to intensive breeding with the specific intent of altering wild trees, which basically have no reason to produce large, regular crops for human use, into genuinely domesticated plants.

(Opposite) The genetic diversity of chestnuts offers many variations. From these, commercial varieties suitable for different agricultural systems can be selected and bred.

I have no desire to be categorized as a missionary of anything, except maybe logic. If one of the crop systems we are proposing makes economic sense, then farmers should try it.

We want to develop woody perennial plants for tree crops with commercial potential, initially as luxury crops and eventually as staples. We also intend to have demonstration plantings of working commercial cropping procedures at Badgersett. We have begun to make real the potential of such species to become producers of staples, and we are ready to go head-to-head against corn and soybeans as commercial field crops in the market.

Our intention is to conduct "real-world" research, which means that in all respects, the crop systems must have an honest chance of being useful on a large scale, without requiring the world to change its religion, politics, socioeconomic structure, or eating habits. Feed them first (or save their soil first), then maybe they can listen and see. I have no desire to be categorized as a missionary of anything, except maybe logic. If one of the crop systems we are proposing makes economic sense, then farmers should try it. Not otherwise.

The primary reason for seeking such production of staples is our desire to provide viable alternatives to the current agricultural practices, which require extensive tilling of the soil. Tilling soil kills not only macroorganisms, but hugely simplifies the soil microbiota. Imagine the fields of the Cornbelt in July; now imagine the same fields a vast, permanent thicket, habitat (as our hazel bushes are now) for myriad organisms: salamanders, tree frogs, warblers, bluebirds, weasels, jumping mice, shrews, mushrooms, wildflowers, spiders, beetles, snakes, millipedes — absolutely everything.

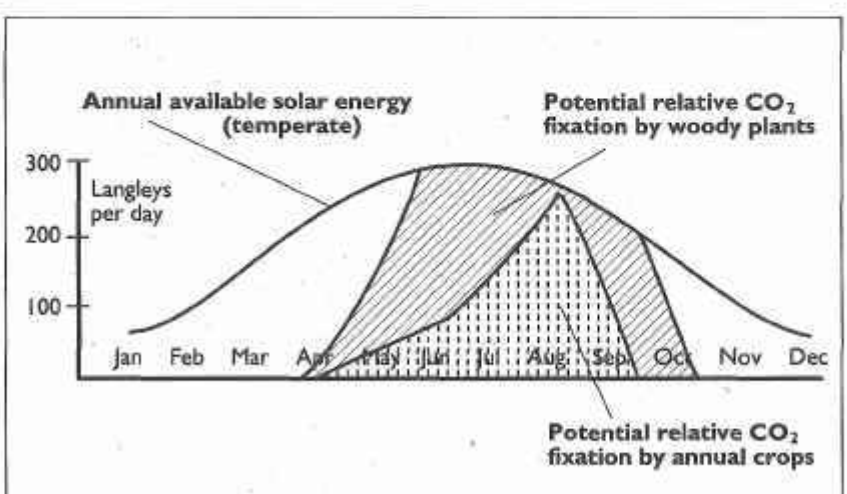
We need to emphasize that the more advanced possibilities are not present realities; although we have demonstrated the potential, the large-scale commercial infrastructure is not yet worked out. If you want to plant 200 acres of machine-harvestable hazelnuts, you can't do it yet, although we hope you'll be able to in five or six years. If you want to plant one to ten acres of pick-your-own bush hazels or chestnuts, that you can do right now.

The real hope for improving the environment rests with the ability to make these crops available to the large-scale machine-oriented growers (in the First World countries); they are the ones using the large tracts of farmland that stay bare through the winters.

Badgersett Research Farm

Badgersett is a 160-acre Minnesota family farm with ninety acres of conventional corn and alfalfa contour strips, five acres of Christmas trees, and ten acres of experimental nut plantings.

Badgersett is my wife Mary's and my farm. We have lived on and managed it for seventeen years. Row crops are handled by a renter; all tree crops have been planted and developed by us. The nuts are hybrid hazels and hybrid chestnuts, first planted in 1980 at extremely high density. Extensive data collection began in 1985. The farm is intended to function as a private, independent, horticultural research station, with several specific goals in mind, both long-range and



During peak sun, annual crops have at best only half their photosynthetic surface deployed. Corn is "knee high by the 4th of July" — a week past peak. Woody plants, with rapid early leaf deployment, multiple leaf layers, and longer growing season, can capture significantly more solar energy than traditional annual crops. Deep roots allow them to continue CO_2 capture even during moderate dry spells. This means more — potentially much more — CO_2 fixed.

One thing is quite clear: "intuitive" ideas about how to breed are very often proven incorrect.

immediate. While we expect that the hazels may become economically productive more quickly than the chestnuts, the chestnuts have a greater long-range potential because of their basic biology; they seem to have a unique physiology, and their unusual characteristics seem to lend themselves to the possibility of domestication.

Many farmers are eager to find alternatives to corn and soybeans, and would prefer crops that are not so hard on the soil, but economically realistic options are currently rather limited. It is our hope to gradually introduce people to the more unusual crops and ideas here through the sale of the standard crops of Christmas trees and cider. We have an orchard coming on, which consists solely of cider apples, and we eventually will have hazels and chestnuts for sale as byproducts of the initial start-up plantings. Our scenario has folks coming to get their tree and cider; we will then hand out samples of roasted chestnuts (there is little tradition for them here), and perhaps cookies made with hazelnuts. With luck, folks will find the food attractive, and buy some to take home. If we can show our farmer customers that we are making money at this, they will quickly begin to consider planting chestnuts or hazels themselves. The international market is well established for both.

We recognize that this is a very ambitious goal. In such a situation, it is best to find out what others have accomplished and to build on past labors.

Where we live in Minnesota, hazels were in fact one of the dominant plants before the arrival of agriculture; they are a natural choice to investigate for crop potential. Carl Weschcke, who had a planting of many kinds of trees at River Falls, Wisconsin, left behind him not only the trees (now neglected) but also a book outlining his experiences and opinions. His conclusion was that hybrid hazels and chestnuts might be the most promising trees for this region, and we started with those trees. We still agree, after having delved into the possibilities further.

The science of genetics, and the understanding of how best to select and breed for complex traits and combinations of traits, have progressed mightily in the past few decades. One thing is quite clear: "intuitive" ideas about how to breed are very often proven incorrect. If we are to hope for real progress in our goal of domestication, we have to use the best tools available. Serious science outside the university is what we are trying to do; we are convinced it is possible. The operation at Badgersett is really only made possible by the advent of the small computer. With a much smaller amount of help than used to be necessary, we can keep track of many more things than ever before imaginable. Because we are growing many trees, it is relatively easy for us to do everything with "controls" — i.e., according to scientific method. Not knowing is the most expensive course of action. Whenever we can, even if it means more work, we try to make and care for the plantings in more than one way, and always with the essential controls.

We keep track of as much information about each tree as we can, to enable us to make culling decisions on a sound basis. This is a chore the computer makes possible; it gives us the ability to compare many trees by many characteristics, and to make judgments about which trees are superior. In the case of the chestnuts, we keep track of about fifteen different traits each year: specific aspects of vegetative health or bearing characteristics, for each tree over three years old. The result is a detailed portrait of each tree, year by year. When a row is getting crowded, we can make a decision about how much to thin it and, using the computer, identify (say) the worst 40 percent. Those trees are then culled, the better trees continue to grow, until the next time the row is too crowded, when the computer will be used to look at several more years' performance of each tree, making thousands of comparisons, and again identify the poorer trees for culling.

No farmer should make extensive plantings of tree crops without such demonstrations. As soon as possible, we want to have small-scale working commercial plantings. Our goal remains primarily research, but the research will be pointless unless put to use.

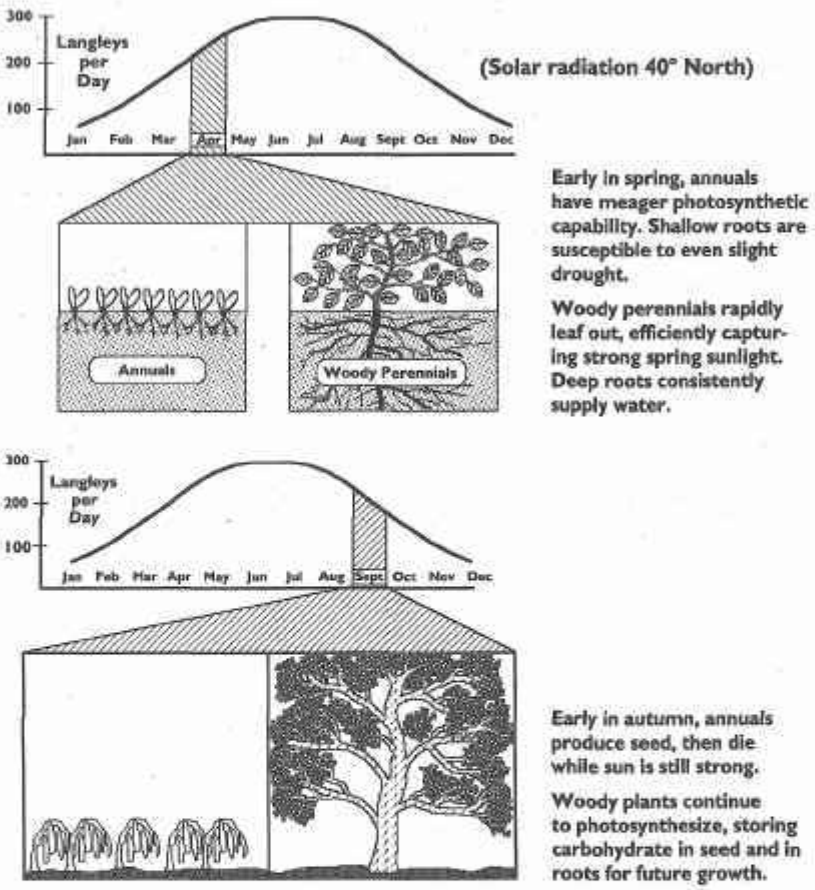
If we simply grow everything that is interesting, we will probably not be able to make much real progress on anything. Although we are concentrating on the hazels and chestnuts, we have succumbed to the temptation of other species, and have a few pecans and some hickories. The priorities remain, however: the hazels and chestnuts get cared for first, and other plantings may have to fend for themselves.

We attempt to search for desirable trees and traits by screening as many seedlings as possible. Our breeding strategy here is called "mass selection." Mass selection can be a useful technique for working with genetically complex traits, but to be effective it requires large numbers of seedlings. "Hundreds" may be too few, and "thousands" barely ade-

quate. This means we must plant as many seedlings as we can care for, grow them just long enough to begin to tell the good ones from the bad ones, and then get rid of the bad ones. Our official motto is: Kill more trees; as fast as possible.

This is an absolutely necessary doctrine for the improvement of tree crops. If a grower should plant ten trees, watch them grow, and pick the best one to develop, that one tree is nowhere near as valuable as it could have been if he had planted a thousand seedlings in the same space, and killed all but the ten best of them in the first five years, and then watched the remaining ten trees.

It is clear that we must identify the poorer trees as rapidly as possible, and remove them, and use their space and the time their further care and observation would have required to plant more trees. We don't want to be blind enthusiasts, and don't want to encourage that in others; history is full of pigheaded, destructive enthusiasts. We want everybody to look at the possibilities with both eyes open.



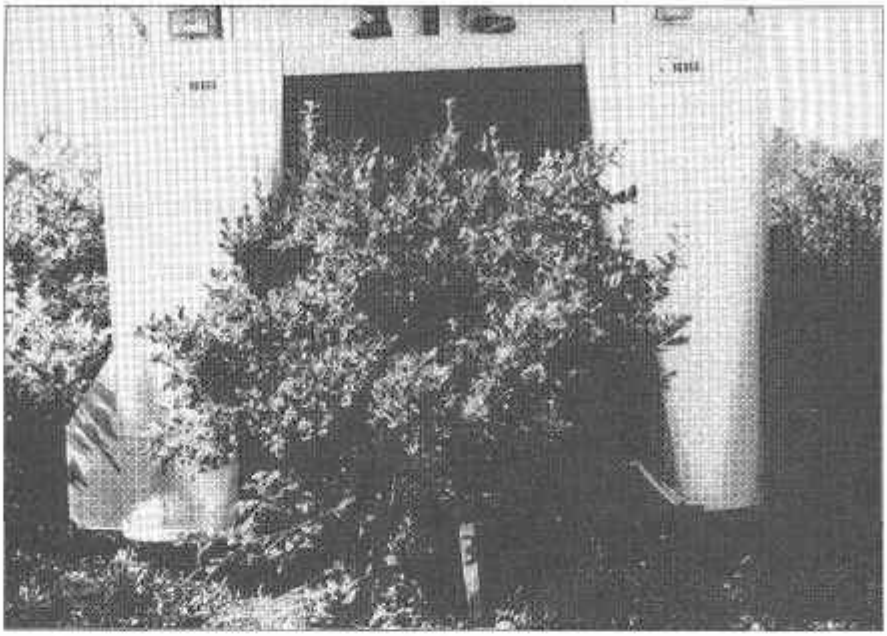
In general, test plantings are made with machine-planted, bare root stock, to allow us to handle more trees. They are planted at very close spacings, usually in double rows that make it easy to compare many young trees rapidly; any trees with extraordinary characteristics stand out all the better for this close juxtaposition. The close spacing also means the trees become badly crowded rather quickly. This is intentional, and is designed to counterbalance the very human desire to see each little tree thrive.

There is a very strong emotional tendency to maintain mediocre trees for years, in the hope that they will suddenly begin to show highly desirable traits. We know it is a long shot, but when one has found or made the seed, weeded the seedling in a seedbed, protected it from rodents, transplanted it, watered, watched, re-weeded, and fertilized it for several years, one naturally becomes attached to it. In the crowded planting, it becomes easier to cull a mediocre or borderline tree. When we see an unquestionably superior tree struggling for space with several undistinguished neighbors, the desire to help the better tree out makes it much easier to get out the saw.

This kind of culling scheme will result in initial selection for vegetative health and vigor, and/or precocious bearing, as culling must begin before all the seedlings start to bear. We think that healthy trees will be more

From CO_2 to Nuts

Annual crops do not really store carbon; most of the CO_2 they fix will be back in the air in a few months. Wild trees store carbon for a long time, in trunks and roots. If the balance of the system required releasing this carbon (i.e., cutting the trees), the fruiting ability of regular trees would be lost for years. With woody-agriculture-style plantings, however, the carbon sink could be cut and burned or composted to release the CO_2 at any time, and the cut plants would begin producing food again in 18 months. Or (since they are bushes) half of each bush could be cut, leaving the other half functional and productive. Or, if the carbon should remain bound, the bushes can remain uncut for years. Present estimates of the annual increase in atmospheric carbon are around three gigatons; if woody plants could be substituted for the traditional annual crops now being grown on one-quarter of the world's croplands, they would fix an additional five gigatons of carbon per year, with no decrease in food production.



Machines like this one are used to harvest bush crops such as blueberries. Here, a harvester rolls along straddling a row of coppiced nut trees. As each tree is engulfed, vibrating arms shake the nuts off the branches into collecting bins.

likely to have good nut and bearing characteristics than weak trees.

Speeding The Process

Precocious plants bear flowers and fruit at an unusually young age. We have been working to elucidate the genetics of precocity, and to create such individuals intentionally rather than by chance.

The one precocious chestnut seedling we have observed from our own controlled pollinations was the result of crossing two moderately precocious trees (both bore flowers in their third growing season). The one resulting nut was planted in a pot, and outplanted to a permanent location when it was three months old, whereupon it bore several male flowers, at the ripe old age of four months. In its next growing season, it bore both male and female flowers.

So far these extremely precocious trees are not well adapted to the burden of flowering at an early age. They grow very slowly in their first years, and their inflorescences are often deformed or atypical. They have no reserves to be used for nut production, and the presence of flowers (an adult phenomenon) could be expected to cause some hormonal imbalances in a plant that needs to put its energy into root and top growth, not flowering. With the creation of a population of such trees, however, some individuals may be expected to appear that will retain the precocity, but will also be more vegetatively vigorous. We hope in time to achieve a strain that both grows strongly and flowers immediately on germination of the seed.

We do not foresee such plants as being useful in orchards, but they would be very useful as breeding tools. One of the greatest barriers to tree improvement is generation time. We can start with a precocious tree that is known to throw productive offspring (having grandchildren is one definition of genetic fitness). Crossing should result in progeny with the extreme precocity trait fully expressed; they should all flower immediately after germination. If pollen from such seedlings were used to fertilize flowers on an older tree capable of producing nuts, the generation time for crosses could be reduced to one year. While it would often not be possible to screen such seedlings for the presence of desired traits, the use of parents with known genetics would make it possible to make crosses "blind," knowing that the characteristics sought are present, even if unseen. This could create the very real possibility of being able to breed chestnut trees on the same basis as annual crops, and would bring within reach much more complicated breeding projects requiring many generations, possibilities never even considered today.

Besides the work on extreme precocity, we have a number of experiments in progress in our chestnut plantings. In addition to fertilizer experiments, we are measuring the later performance of plants that were large, medium, or small after two years in the seedbed, watching the effect of early pruning on age of bearing, and evaluating the effect of coppicing on the growth form of trees intended for orchard use. For several years we ran controlled experiments on various deer repellents. We also keep track of a number of smaller observations on orchard establishment, care, and maintenance.

Some Remaining Obstacles

Propagation: If you are going to plant zillions of acres, you need hundreds of zillions of plants. Nuts have one big problem as seeds: they are a great

big tasty chunk of food, worth serious effort on the part of birds and mammals to search out and dig up. And they do. We also need to have good production of uniform clones for the machinable systems; machines have to have uniform conditions in order to work. Tissue culture offers its immense promise of all the plants we can use, cheap, but the start-up costs are high. There are answers for all this, but they take time to implement.

Weeds: Both chestnuts and hazels will shade out most of the usual weeds, once they are established, but a new kind of weed, not a problem in cornfields or orchards, develops: the woody weed. Birds use the bushes and trees of woody agriculture plantings extensively, and drop all kinds of weed seeds. At Badgersett, the list so far includes grape, wild cherry, box elder, elder, prickly ash, and raspberry. These are not a problem in cultivated fields, because they are plowed up; not a problem in orchards, because the land between trees is open, and mowed or cultivated. In woody ag plantings, though, the bushes/trees can be so tightly packed that woody weeds can get well established in between them before you know it. Then getting rid of them can be a chore. Multiply twenty years of bird droppings times 200 acres. That's a lot of cherry and raspberry and grape seed. It may be that hand labor will be needed to periodically clean them out; that's what we're doing now.

Pollination: Turns out to be a factor that needs forethought. Both chestnuts and hazels require a genetically different tree nearby for pollination, and both have special needs. Chestnuts are rather weak pollinators (don't produce much, and it doesn't travel far from the tree); in order to get a good crop, you need a big pollen-producing tree nearby, which means if you plant acres of uniform, young trees, there is likely to be a period when the trees could be producing more, but aren't, because of inadequate pollen. Hazels are strong pollinators (lots of pollen, travels well), but they are likely to have incompatibility problems (they're fussier about sexual partners than chestnuts), which will require paying knowledgable attention to the mix of cultivars in your planting. And we've found that deer will eat the male catkins voraciously just before they shed pollen. For several years, we have seen tons of males on the hazel bushes, up until they start to expand in the spring. Then, in a few days, all the catkins below four feet, all the way into the middle of the bushes, disappear. If you have lots of deer and a planting of only a few acres, this may mean that although your bushes are old enough to be producing a crop, and have lots of female flowers, they may not get pollinated until the bushes are well over four feet tall. This shouldn't be a problem in really big plantings; the deer couldn't eat all the catkins on twenty acres, for example (I think).

Pests: Another unknown is the possible buildup of diseases or insects over the long run, when the ground is not tilled. It may be that since the system is less perturbed, natural antagonists of the pests may build up stable populations, and better control the unwanted critters; then again, it may not. We haven't been doing this long enough to really know — only twelve years. (I can tell you, though, that the hazels are full of spiders, ladybugs, lacewings, and assassin bugs, all highly desirable insect predators.) Also, it looks like when we cut the hazel bushes to the ground for renewal, they lose a lot of chronic disease in the old wood; the new shoots are tremendously vigorous, dark green and healthy looking, and they stay that way for several years. (We still have lots to learn here. I can guarantee the readers that Murphy and his laws will show up sooner or later. Still, there is no reason problems here should be greater than in other crops.)

Vertebrates: In tilled fields, there is no stable habitat for birds or mammals. They may use the fields a little, but cannot live there; so the larger the field, the fewer vertebrate crop thieves. In woody agriculture fields, however, all kinds of vertebrates can make themselves at home, permanently. This will sound great to critter sympathizers, myself among them, but it could spell trouble for the crop. Mice eat a lot of hazelnuts before they are ripe, and so do bluejays, crows, etc. Most of the theft is not outright eating, but the storing of food for later. The effect on regional vertebrate populations of square miles of woody agriculture plantings remains to be seen, but it might wind up that we would be growing a lot of food for the animals, and not harvesting much of it ourselves. My guess is that this will not happen; animal predators and space requirements should serve to keep nut-thief populations in check, most of the time. Anyway, it would be a better problem to have than limiting herbicide runoff, losing soil, depleting aquifers, and loss of biological diversity from critters having no place to live. ❦

Information

. . . is available from:
Badgersett Research Farm
RR 1/Box 141, Canton, MN 55922
507/743-8570

Badgersett sells hazelnut and chestnut seeds; information on how to grow the seeds is sent with seed orders, or is available separately for $2.00.

***Badgernews*, our occasional newsletter, costs $3 (a one-time fee).**

Suggested Reading

J. Russel Smith's *Tree Crops* (*WER* #64, p. 37).

Annual reports of the Northern Nut Growers Association can be found in a good university library.

Northern Nut Growers Association: 9870 S. Palmer Road, New Carlisle, Ohio 45344.