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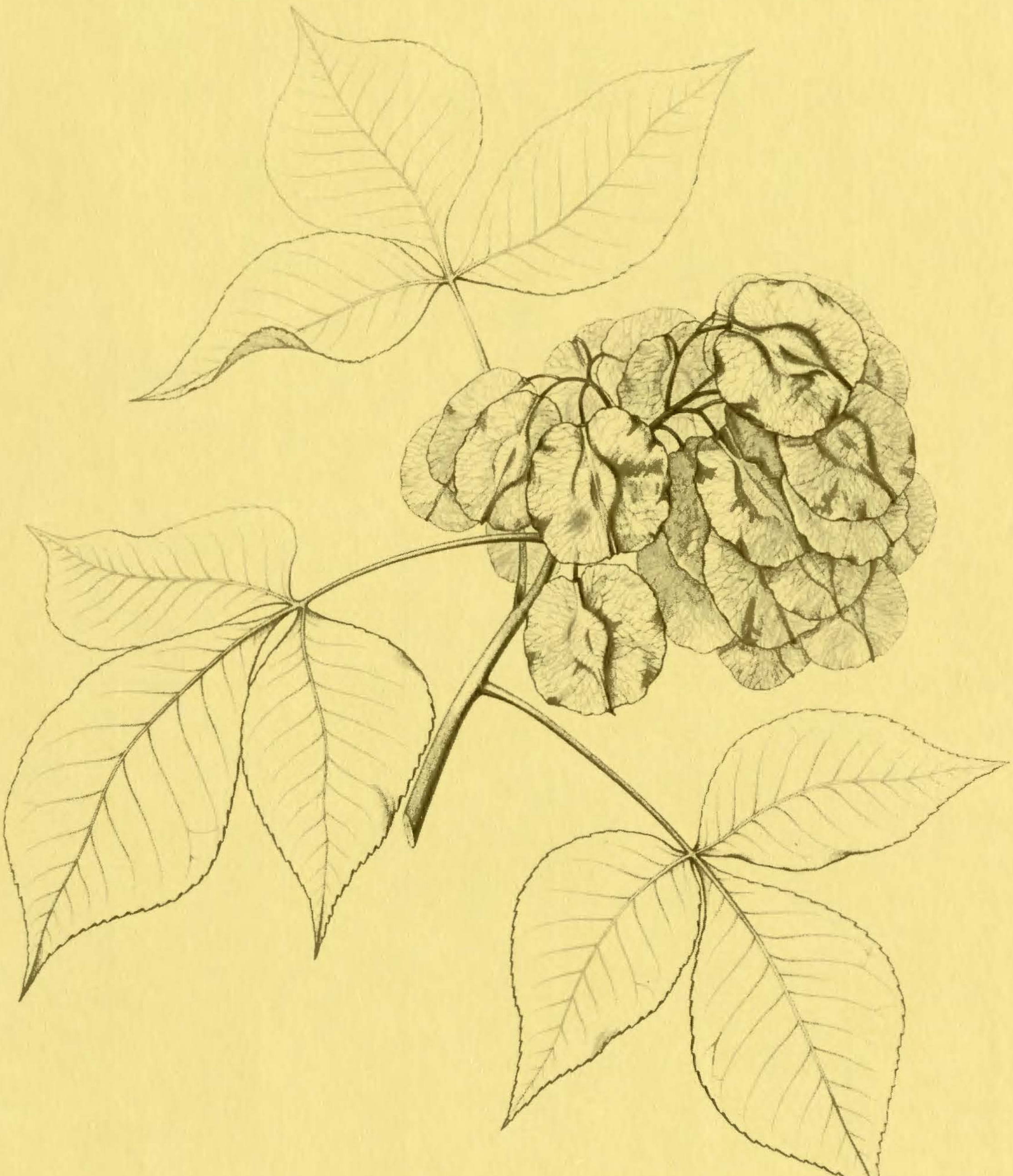

COVER: Wafer ash or hoptree, *Ptelea trifoliata*
From Charles S. Sargent, *The Silva of North America*
(Boston: Houghton Mifflin Company, 1891-1902), I, Plate XXXIV
Original drawing by Charles Edward Faxon.

In spite of its commonness, wafer ash is unfamiliar to many people and is a kind of "step-child" in American horticulture, scarcely mentioned in literature or nursery catalogs. As a cultivated plant it is better known in England. It is hardy and deserves additional trial in the landscape here, especially where open clumps of shrubs or small trees are needed. Wafer ash occurs naturally in rocky, calcareous sites from New England to Nebraska and south to Texas and Florida, but will grow readily in other types of soil if well drained. It grows in the open or in partial shade, and it generally reaches about ten feet in height.

The compound leaves of wafer ash, especially when young, may be mistaken for poison ivy. When the leaves are held to the light, many translucent dots are seen; these contain volatile oil and give off a pungent odor when the leaves are crushed. An olfactory adventure may help the reader decide how he feels about the plant's smell. The roots, bark, leaves, and flowers are all odoriferous, with descriptions of the various parts ranging from "fragrant", "lemony", and "aromatic" to "disagreeable", "strong-smelling", "ill-scented", and "decidedly unpleasant". The flowers are greenish- to yellowish-white. *Ptelea,* Greek for "elm", refers to the drooping clusters of large elm-like seeds which hang on the tree well into the winter. These have been used as a substitute for hops, giving the tree another common name.

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MATHEMATICS, ECOLOGY & A PIECE OF LAND

The Illusion of Predictability

By Alfred G. Etter

Several years ago I read an article called "Mathematical Systematization of Environment, Organism, and Habitat," by Edward Haskell. It was one of the first of many pleas for greater precision of terms in the study of ecology. The author claimed the predictability of the science was nil, and would remain so until it could be developed in a manner comparable to the physico-chemical sciences. The first prerequisite was a series of mathematical definitions. He then defined environment, habitat, and organism — three essential concepts — in mathematical terms.

This seemed reasonable, for obviously the very foundation of all life is multiplication from a single cell, or even from a single substance; and the individual bird, corn plant, or tree is the product. Within this product are contained all the millions of individual multiplications that produce growth. Animal and plant populations are only an extension of this same process. Environment is full of variables that can be measured, plotted, and columned and so lend themselves to the methods of the punched card and the electronic brain. We are often told that there is nothing mathematics cannot do. Is there any reason why earth processes and living things could not be resolved into systems of data that could be fed to computers to produce a more predictable world?

I took this question with me for a walk one warm March day. I entered a woods where gaunt fallen trunks with tangled roots lay gathering leaves. It was a peaceful place; where could I put the question to a better test than here?

THE NONCONFORMIST TREE

Before me was a blackjack oak with wide-spreading limbs. At best a blackjack is a sort of home-made tree, patched together with crooked branches and leathery duck-foot-shaped leaves. Scrubby specimens cover the rocky hills of southern Missouri, but here on the wind-blown soil near the Mississippi this one had had the time and food to become a giant. I tried to reach around it, but could reach only halfway. A blackjack twelve feet around might be two and a half centuries old. I took a cold mathematical look at it. Formulate as I might, it presented problems. It was too old, too eccentric. It had the jack-oak leaf, but there its conformity ended. It was neither integer nor fraction, even nor odd. It was an individual acorn

"Mathematics, Ecology, and a Piece of Land" first appeared in Landscape *in Spring, 1963. It is reprinted here with permission.*

that had fallen into the grass, and it had seen all the environment that Missouri had had to offer for two hundred and fifty years. John Donne has said, "There is not so poor a creature but may be thy glass to see God in." I suspected that by looking at the blackjack carefully I might see not only some celestial light but considerable reflection from the mundane world as well. Whether this light could be focused to yield an equation was another question.

In 1764 when a group of Frenchmen founded the village of St. Louis twelve miles southeast of the oak, they recorded that much of the land around was covered with prairie grass. In 1775, a small French settlement a few miles northwest was named Florissant, from the prairie flowers that surrounded it. In 1817 a party of surveyors was ordered into the field to block out the land between the two towns into sections. The big blackjack, after a century of living in an uncharted wilderness, ended up in the middle of section twelve. As the surveyor scanned the land along the north section line he made an entry in his field notes: "Prairie, good soil, scattering blackjacks and hickories." On the east side, however, he remarked, "Soil rich and good for farming, thickly covered with oak and hickory."

Section twelve lay in that broad transition zone where forest met prairie. A traveler of the day, making a trip from St. Louis to Florissant, described the country thus: "I had my first view of the unfenced fields of flowers and trees. It was like a ride through a garden or the private land on a gentleman's estate."

I returned to the woods and found several big spreading black oaks and a shingle oak or two that must have been contemporaries of the blackjack judging from their size and open-grown habit, but this old confederacy was all but lost in an imposing forest of tall straight oaks and hickories of uniform age. Where had they come from? A few of them had recently been cut for fence posts, and I counted the rings. Without exception, they had begun to grow between 1815 and 1830.

I could only conjecture how they had suddenly intruded on the prairie, but I later discovered some observations which had a bearing on the matter. In 1819, R. W. Wells, one of the same surveyors who had blocked out the land, had published a note in the first volume of *The American Journal of Science.* He was discussing the origin of prairies.

"I have seen, in the country between the Missouri and Mississippi Rivers after unusually dry seasons, more than one hundred acres of woodland converted (by fire) into prairie. And again, where the grass has been prevented from burning by accidental causes, or the prairie has been depastured by large herds of domestic cattle, it will assume in a few years the appearance of a young forest. . . . All the old French inhabitants of St. Louis and Saint Charles (a nearby town) will tell you that the prairies formerly came immediately up to those places. Now the surrounding country for several miles is covered with a growth of trees of four or five inches diameter near the towns where the burning first ceased, and gradually diminishing in size as you recede, until you at length gain the open prairies." Here were data that had the ring of fact. Could they be punched on a card?

The first man to own the big oak, according to old property records, was a certain John Engel who received it with a grant of eight hundred *arpens* of land in 1799 from the Spanish Governor of Upper Louisiana. In five years, he built a house, cleared ten acres of land, and put it under fence. The invasion had begun.

PRAIRIE INTO FOREST

When Engel sold out for a dollar an acre in 1804, Simon Wood moved in to stay for sixteen years. The activities he engaged in are not recorded, but it can scarcely be doubted that he found the prairies and parklands an easy place to pasture stock. Paths and clearings began to intercept the prairie fires. Sprouts survived that should have died. Weak places in the sod caused by gnawing and treading of stock provided beds for the seeds of elms, snakeroot, milkweed, mullein, and thistle. They in turn provided lighting places for birds that in their brief visits cast seeds—ready-scarified and acid-treated—into the soil. Hackberries, wild cherries, mulberries, dogwoods, and sassafras gained footholds this way.

Mice and squirrels planted treasures they never uncovered. 'Possum, coon, and fox dropped blackberry, grape, persimmon, and plum seeds along their routes. Hundreds of other seeds found ways to be spread into the grass; some had been waiting in the sod many years for a chance to grow. This transition zone belonged to anybody, and man had unwittingly favored brush and trees. The reign of scattered oaks and flowering prairie had reached an end. Though ranging stock might consume or trample many plants and so help somewhat to stem the tide, they could never develop the efficiency or appetite of a prairie fire.

In 1820 Simon Wood had to sell his land to a speculator who then allowed it to lie idle. Wood received $3 an acre for his farm. In thirty years it would sell for $50 an acre. Here were some statistics, but what changes in habitat, environment, and organism were measured by them?

A study of the ages of the tall straight trees in the woods showed that the invasion of the prairie by new oaks and hickories reached a peak shortly after this transaction, and then ceased as the vegetation closed over and shaded the ground. In this way changes of ownership have probably been subtly recorded on our landscapes more often than we suspect.

Looking down on this upwelling of new life around it, the blackjack was obliged to accept some of the responsibility for the crowd of trees, for many of them were little blackjacks. While it had flowered profusely in times past and shed its mast year after year, the fires and thick sod of the prairie had served as a sort of birth control. Now that the fires were gone, the oak became prodigiously fertile.

So it happens with living things. Life does not regard each acorn as sacred. A goodly share of them are assigned to destruction. Those that survive do so by time's or man's manipulation of the environment. Some few appear to have a destiny, as did this oak. One may bemoan the smothering of the individual by an irruption of sprouts, but that would seem to be an oft-repeated theme in nature. Man himself is not immune; take away the searing fire and even he floods the earth with himself.

THE SILENT REVOLUTION

When nature makes a change, it is thorough. This new colonization was a complex reorganization of species and environments. As grass yielded to brush and brush yielded to sprouts of hickory and oak, dickcissel, meadowlark, and prairie chicken moved away. Indigo bunting and towhee and chat moved in. A revolution occurred in the soil as the organic matter of the prairie became available to new micro-organisms. Molds and fungi flourished, and new empires of insects were established.

Where environments interfinger, these changes can proceed with great rapidity. Surplus insects, woodpeckers, squirrels, and quail periodically leave their ancestral home for unoccupied areas. Most of them fail and die, but when a large and uniformly usable territory suddenly becomes available they will move in and increase at tremendous rates. Likewise, these irruptions are often terminated by catastrophes, for uniformity in plant or animal societies carries with it a predisposition for sudden change.

The struggle for existence among plants is fairly predictable. The blackberries and elderberries and hazel become unproductive as the shade increases and the tap roots of trees drain the soil. Sassafras and persimmons fade, elms become spindly and die, and hickories and oaks begin their advance. On good soils blackjacks thin out as more vigorous trees take advantage of the fertility. Perhaps with the proper symbolism these successional data could be fitted into a progression of some kind.

A very placid, but unmathematical, view of these changes was painted by Edmund Flagg in a journal of a trip he made through the outskirts of St. Louis in 1836:

"The face of the country is neither uniform nor broken, but undulates imperceptibly away, clothed in dense forests of blackjack oak, interspersed with thickets of wild plum, crabapple and the hazel. Thirty years ago the broad plain was a treeless, shrubless waste without a solitary farmhouse to break the monotony. But the annual fires were stopped, a young forest sprang into existence, and delightful villas and country seats are now gleaming from the dark foliage in all directions."

Fifteen years later, the old blackjack was sinking in the rising sea of trees when James H. LaMotte, a West Point major, acquired the land and revealed his dream of settling down in the country when his service in the army was completed. Envisioning a stable of horses he wrote his wife urging her to "make the man at the farm put in timothy, even if we have to furnish the grain." A new element had been added to the equation.

The long-looked-for day came in 1856 when the Major retired, but his plans were soon interrupted by the Civil War. When it was over, LaMotte resumed his goal of clearing more land and building his home at the edge of a woods. In November of 1867, young Frank LaMotte wrote his father, then traveling in the east, "We are well and comfortably fixed at Wildwood, plenty to eat, drink and smoke. Carpets down, potatoes all in, fences up, etc." Finally the farm had a name, Wildwood, a happy choice that reflected the owner's love for the woodland at his door. In time, because of this love, a tradition developed that no trees should be cut and so the woods and the old blackjack continued to thrive.

WILDWOOD

The fields produced, the woods grew, and the LaMotte's Wildwood home became well known for beauty and hospitality. Then in 1892 the Major died. His wife lived on for twenty years at the old mansion, and in 1911 died at the age of 92, No heirs claimed the property.

Wildwood gathered ghostliness. Swifts flew in and out of the many chimneys and groundhogs heaped dirt about the summerhouse. Fringed carriages and riding equipment grew grey with dust and spider webs. The woods breathed on. Boys shot squirrels out of its hickories in August. Families wandered into the edges of the woods for autumn picnics. Some came, as did I, in search of an island of quietness, whatever the season.

* * * * *

I well remember the last time I visited the woods. I walked up the hill to the mansion. Hidden among old locust trees it was a beautiful remnant, lingering like the blackjack, and the grey barns in the valley. Soon the green twilight descended, encompassing all the mystery and truth that lived within the woods and about the home. I climbed the stile and went down the dim road. I had found so much time hidden away that I was breathless trying to encompass it, and ill prepared to face even the most trivial evidence of the twentieth century—much less to consider seriously how this amazing place might be pictured or defined mathematically.

* * * * *

Wildwood was finally killed by a bright yellow machine. The blackjack was tough. It gave the bulldozer a good fight, but its death was really instantaneous when compared to its two hundred and fifty years of living. The fallen trees were pushed into a few big pyramids and a raging fire consumed the last evidences of LaMotte's beloved woods and the blackjack oak.

Part of the big hole on the horizon left by Wildwood was filled by a sign: FOREST-WOOD—A PLANNED COMMUNITY OF 600 HOMES. The irony of the name Forestwood was continued in the street markers: Meadowcrest, Pondview, Oakwood, Hickory Lane. The mansion still stood, but its Wildwood was gone, and its farm was gone. It suddenly became apparent to me how it is possible to make the muddle of ecology into a predictable science. Simplify the environment until there is nothing left but space!

FORMULA FOR A TREE

Admittedly the world is built with multiplications. Environment, habitat, and organism bear a cause and effect relationship. The stuff called life may be resolvable into chemicals, patterns and bonds; but what formula could be drafted that would allow for all the adventures of the blackjack, what equation could predict the events of a single day in the woods? The woods was a symbol of the intractable, the inexpressible. Its beauty and order were the product of freedom, of millions of small decisions, of the meshing of infinite phenomena aided by tradition, tropism, instinct, intelligence, and desire.

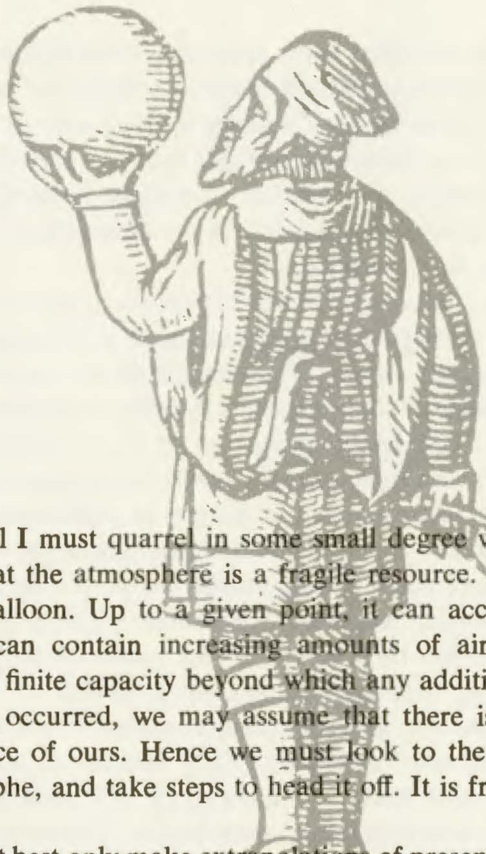
This complexity is confusing to man, hence his desire to reduce nature to something on paper so that every man on the street can claim to understand it. Because of some simple discoveries in this field it is man's idea that all life is mathematically designed, and that he can therefore control it.

THE ECOLOGIST'S ROLE

This is a dangerous assumption. As it becomes evident that nature cannot be made to fit into his calculations, he increasingly resorts to the same solution as that used in Wildwood, where the environment and the life upon it were remade so that they *could* be described with a mathematical vocabulary. The end product of thinking mathematically is to want to think more mathematically, to wish for an earth where everything is predictable, neat, efficient and numbered, and where man reshapes the earth to suit himself.

This is folly, and ecologists should be the first to say so. Man is hard put to it to design portable systems of productivity for space. Putting algae and men in a goldfish bowl is one thing. Building man an earth is something else. The truth of the matter is that man *has* an earth. He was born into it. He is a product of it. He cannot now decide that it is not to his liking, and change it willy-nilly.

Ecologists and all those of similar heart and mind have a responsibility to speak out concerning the limitations of mathematics and the impossibility of a completely predictable world. They should teach us to rejoice in complexity rather than simplicity, to object to a world already simplified to the point of boredom and ugliness and instability. Who is more aware than the ecologist of the intangible values of the landscape which make life dedicated to it? Who knows better that time is the only thing that can fashion an environment to suit a living thing, unless that living thing be caged? Who knows better that man is not, and never shall be, able to design a world for men—unless they too be caged?



*The Smoggy Crystal Ball**

By James P. Lodge, Jr.

Although it may seem ungracious of me, I feel I must quarrel in some small degree with the title of this symposium. It is not really true that the atmosphere is a fragile resource. Rather, the atmosphere is an elastic resource, like a balloon. Up to a given point, it can accept our wastes and contain them, even as a balloon can contain increasing amounts of air. However, like the balloon, the atmosphere has a finite capacity beyond which any addition produces catastrophe. Since catastrophe has not occurred, we may assume that there is still a little elasticity left in this atmospheric resource of ours. Hence we must look to the future, try to perceive the nature of possible catastrophe, and take steps to head it off. It is from this situation that I take the title of my paper.

The future is certainly not clear. We can at best only make extrapolations of present trends and thereby foresee the limiting situations. I am perfectly aware of the danger of this. If situations remain unchanged, things tend to grow by compound interest, which is to say exponentially. However, there are many forces that will tend to change the slope of an exponential curve. My favorite example of the dangers of extrapolation is the case of the growth in the number of scientists in the United States. Over the last several years, the number of scientists in the country has tended to increase about 3 percent annually, while the total population has increased about 1½ percent a year. This obviously means that in some date in the future, the United States will contain more scientists than people! Hence, extrapolations must be interpreted with extreme caution, although they can serve the useful function of raising a red flag to suggest that force should be applied to help change the slope of the exponential curve. Otherwise, the inevitable change of slope might occur too late.

For example, the electrical power industry has been growing rapidly over the past several decades in response to our rising standard of living. If that growth were to continue for sixty

**Adapted from a paper given at the Oikos V conference at the Morton Arboretum on May 15, 1970. The conference, this year entitled "The Atmosphere: A Fragile Resource", is sponsored annually by the Morton Arboretum, the Open Lands Project, and the American Society of Landscape Architects, North Central Chapter. Dr. Lodge is Program Scientist at the National Center for Atmospheric Research at Boulder, Colorado.*

years, the cooling water demands of the industry, whether met by ponds, cooling towers, or running streams, would roughly correspond to the total evaporation of the entire stream flow of the United States. Consider another sore of extrapolation. It is already clear that at least a few of the pollutants we put into the atmosphere circulate worldwide. If the United States were to arrest its growth at its present point and simply bring the rest of the world up to its living standard, the impact on the atmosphere (and, in fact, the rest of the environment) would increase almost tenfold.

Even such figures make it difficult to visualize the true extent of our impact on the atmosphere. Perhaps a good way to do so is to compute, in a particular way, the energy we require in everything we do. The amount of all the energy used in the United States—whether for home heating, transportation, lighting, manufacturing, mineral production, etc.,—can be calculated. This amount, because of its size and unfamiliar units, is meaningless. However, we may ask how many people would be required, working a reasonable eight-hour day, to provide the same amount of energy in productive ways—that is, how many human slaves would be needed to do by unassisted manpower the work now done by machines powered by the burning of fuel. (For example, suppose Commonwealth Edison had to run its generators by employing slaves on a treadmill.) The answer is that the mechanical energy slaves which now provide the energy for the needs of roughly 205 million Americans are equivalent to something over 100 billion human slaves!

Fortunately, these mechanical slaves do not require individual housing, but they have many other "human" attributes. They breathe in air, use oxygen, and exhale carbon dioxide. They eat fuel and convert it into energy and waste products. They drink water and use it to carry off their wastes and cool their bodies. (Remember the amounts of water already mentioned as being needed to cool electrical power plants.)

Pollution may be defined as the condition that results when the metabolic wastes of a culture accumulate to an unfavorable degree. It is obvious that the metabolic wastes produced by some 200 million humans, while inconvenient in some areas, are trivial when compared with the wastes of our mechanical energy slaves—the equivalent of 100 billion people. In addition to being less productive of waste, *Homo sapiens* has been about on the face of the earth for some millions of years, and food chains have grown up, through evolution, which dispose of his metabolic wastes and, ultimately, his body. Many of our technological wastes are new things on the face of the earth, and food chains do not exist to return them to the ecosystem. Possibly if our present culture were to last for a million years, bacteria would develop to degrade power plant fly ash, termites to ingest aluminum beer cans, and mildews to rot old auto bodies.

Of course, some of the compounds which we know as industrial wastes also occur naturally. Sulfur oxides come from volcanoes as well as from power plants, carbon monoxide from some (still unidentified) sea creatures as well as from automobiles, and so on. Hence, there are apparently mechanisms, perhaps organisms, that can process some of these compounds. My research group has studied the concentration of sulfur dioxide in the deep rain forests of the tropics and has found that it is both produced and removed by natural, probably biological agencies. (For example, epiphytes—air plants—rely on it for the sulfur they need.) It is a beautifully balanced system, and in the rain forest sulfur dioxide never reaches a concentration in the air of much higher than one part per billion. What is obvious, however, is that if we move in and raise these concentrations by hundredfold or more by industrializing the tropics, some organisms (perhaps epiphytes) will proliferate out of control, others will die of "overeating", and still others will be unable to tolerate these concentrations at all and will die. Normally vegetation is one of the best consumers of excess sulfur dioxide, and yet if the limits are over-stressed, the vegetation is gone and the mechanism vanishes. The elasticity of the system is exceeded and the balloon bursts.

I mentioned before that our energy slaves breathe in and use oxygen. Lamont Cole stated a few years ago that on a worldwide basis the oxygen cycle is a nicely balanced affair, but that in the contiguous forty-eight states our energy slaves are using twice as much oxygen as all the green plants in the same area are putting in through photosynthesis and that in this, as in many things, we are depending on "imports" to make up the balance. It's an arresting thought, and if we extrapolate again, we could very easily reach the conclusion that worldwide oxygen production will be surpassed by oxygen consumption within sixty years. However, this is a demonstrably invalid extrapolation, because there just doesn't seem to be enough fuel, i.e. carbon, on the earth for this to happen. What seems far more possible is that in some local area—some modern-day successor to Donora, Pennsylvania—some heavily industrialized city sitting in a river valley or in a pocket in the mountains may, on a cold winter night with the photosynthesis turned off and the furnaces turned on, actually use up its local oxygen supply. It may be that this will be the trigger we need to get a second Earth Day. I hope not. I hope there's enough momentum behind the environmental movement that we don't need another dramatic person-killing episode to put us on our way.

Well, this sounds very grim and, in fact, it is a bit grim, but is it inevitable? Are we locked into something that simply is a juggernaut running downhill? I think the answer is no, it is not inevitable, and the reason that I say this is that when you start really to examine the things we do—the conditions that produce this system—you find that many of them are quite unnecessary, don't make us any happier, and could very well be left undone. Let me give you a few examples of the kind of foolishness I refer to. One of the most obvious is housing. Years ago I lived for a while in Tucson, Arizona—then a little "cow-town". At that time the only air conditioning units in town were in the three movie theaters. Even though summer temperatures there got up to about 105°F. or so during the day, it was by no means unbearable because most people lived in adobe houses, and adobe walls one to two feet thick are very effective in keeping the heat out. You did have to remember to open the windows at night and to close them before sunup. But times have changed. It was a good many years before I got back to Tucson, and when I did, I discovered that development housing had arrived and that living in adobe houses was passe—nobody but an Indian would do it. The prevalent architectural style was the Cape Cod cottage featuring a picture window cunningly located to frame a picture of the picture window across the street. And, of course, the entire assembly absorbed heat, so the status symbol was having the biggest air conditioner on the block. To supply the power for these air conditioners there had to be more and more power plants, and eventually people began complaining about air pollution. The following year I paid a visit to Cape Cod and discovered that ranch-style houses were favored there and that the status symbol was the biggest furnace on the block.

Other examples of foolishness relate to our tax structure. In Denver there is a factory which is one of our worst sources of air pollution. I believe it was built for World War II, but judging by its structure and technology, it might have been for World War I. The main thing that perpetuates its profitability to its parent company, an eastern concern, is the fact that tax-wise it has depreciated to nothing and therefore its small margin of profit doesn't go for taxes. The factory is costing the state a good deal in efforts to get the company to clean up the damage it does to the environment. The place leaks sulfur dioxide in great quantities, and yet its continuation is very carefully favored and protected by the tax structure.

If you stop and think about it, you will reach the conclusion that nearly every aspect of our tax structure carefully favors environmental degradation. One of the most conspicuous examples is the deduction for having lots of kids. Another example is cars. In Mexico, the tax on a brand new car which pollutes very little is about 50 percent ad valorem. By the time the car gets to be about ten years old, it's practically tax-free, and so cars that die in the United States reincarnate in Mexico City, one of the most polluted areas in the entire western hemisphere.

And while we are talking about utter folly, let's stop and think a little more about automobiles. A little baby at birth today doesn't have a silver spoon in his mouth, he's got his hand on a ton and a half of steel that's going to be his for life for his personal transportation—all the while burning irreplaceable petroleum. He will also use it for highly necessary jobs—such as those performed by one acquaintance of mine who takes a large car out of the garage, turns it around, loads his garbage cans into the trunk, hauls them one hundred feet out to the street, unloads them at the curb, turns the car around, and puts it back in the garage.

And there are other questions. Are we really radiantly happier the whole day by virtue of having an electric nail buffer or all electric toothbrush? Would we really be exhausted at day's end if we opened cans by hand instead of electrically? There are so many of these things that we do. My energy and yours is really not that marginal.

Recently I have become interested in one seemingly trivial by-product of our culture that no one seems to have studied at all. Nearly all of us make use of some form of "aerosol bomb" for such tasks as spraying insects, applying deodorant, putting whipped cream on dessert, preserving a hairdo, or preparing whiskers for amputation. In all cases, the substance in the can that forces out the desired product is a member of a class of compounds known as Freons. Freons are also the working fluid in nearly all refrigerators and freezers and escape into the atmosphere whenever one of these leaks or is broken up as junk.

The Freons are used because they are remarkably non-toxic to anything. Unfortunately, this also means that they are very stable chemically. There seems in fact to be virtually no atmospheric mechanism that removes them. I have not been able to obtain any good estimates of production rates, but it is entirely possible that they are virtually immortal in the atmosphere. The Freon concentration in the atmosphere has now reached nearly one part per billion, which is a small concentration in any one place but a very respectable tonnage over the entire atmosphere.

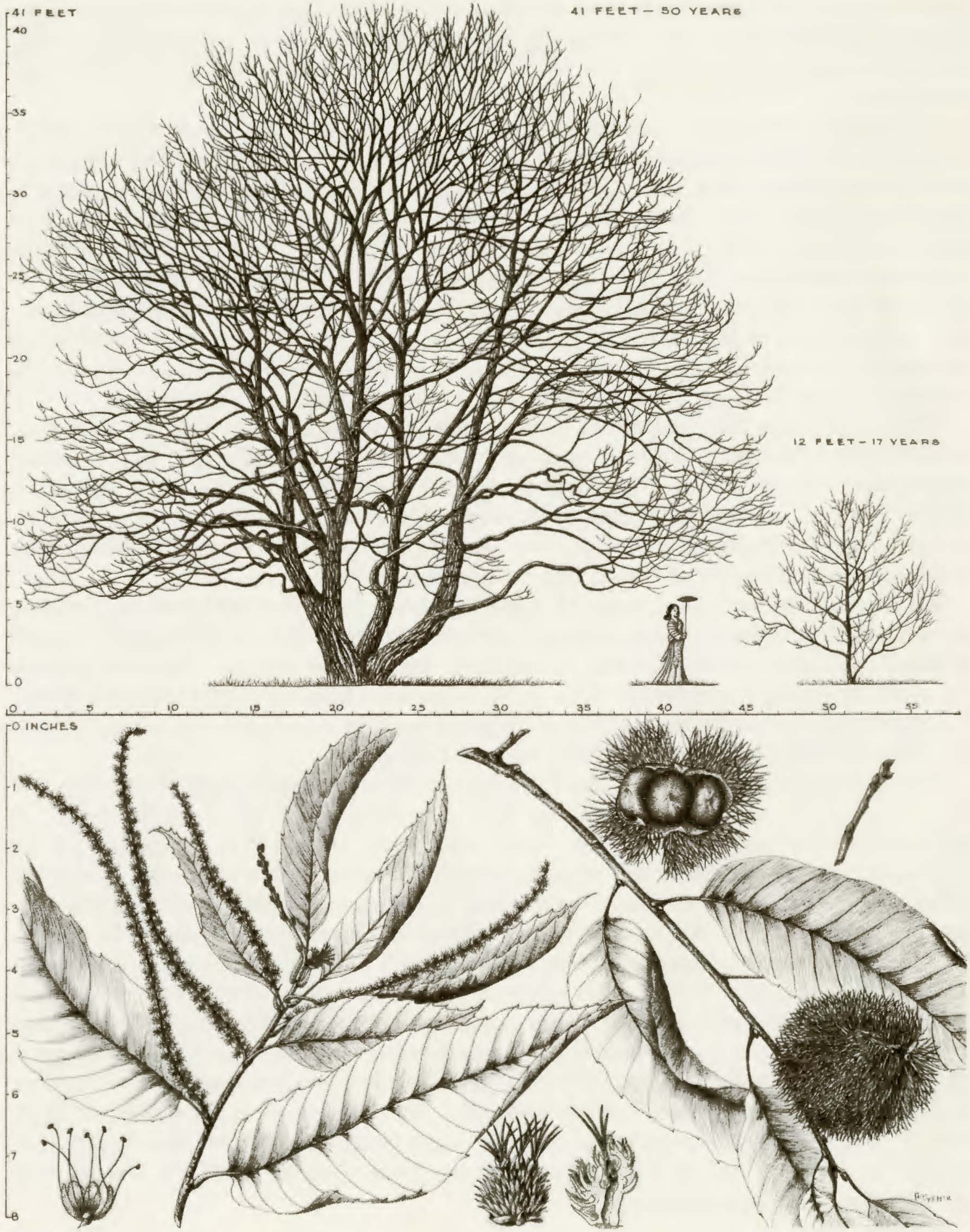
I said that the Freons are exceedingly stable and non-toxic, and that is certainly true. However, they will break down under extreme conditions. For example, a flame will decompose them if some moisture is present, and one of the principal products of the decomposition is hydrofluoric acid. Unlike the Freons, hydrofluoric acid is intensely toxic to plants. One part per billion in air, continued over any length of time, will completely ruin a harvest of apricots or gladioli. Other plants are far less susceptible but concentrate the fluoride until cattle browsing on the plants receive damaging doses. (This should not be interpreted as expressing a position on the subject of fluoridation of water. That is an entirely different matter and is not pertinent to the subject under discussion here. It is no secret that many trace elements are required for nutrition, yet are highly toxic when excessive doses are administered.)

This is not to say that the present concentrations of Freon are extremely worrisome, or even that future concentrations will necessarily lead to catastrophe. On this point, I cannot present any evidence. However, I have been unable to find anyone who can refute these possibilities. The facts are that once again we have sailed into a situation without any concern for the environmental impact. Even today, I am unaware of any research on the possible future of the continued liberation of Freons into the atmosphere.

In fact, virtually every environmental decision is being made in a near vacuum. To leave the subject of air pollution for a moment, I noticed that one of the items strongly advocated by many speakers on Earth Day was an end to the use of paper napkins. This is an interesting symbolic gesture and might even be useful. However, I have never heard of any evidence to indicate that the environmental impact of paper napkins was clearly worse than that of the added amount of detergent necessary to wash cloth ones.

What is perhaps more serious is that there is not a single atmospheric pollutant whose lifetime in the air is known. For a few, we have indications which are probably correct to within a factor of ten—something that is not true of the Freons. Yet to manage the air environment for the benefit of all, we need exceedingly accurate figures on the lifetime of pollutants. Over the next few years, my research group hopes to make a significant contribution in this area, but we cannot do it all. Unfortunately, federal funds available for university researchers to do environmental research have steadily decreased during the past few years.

To sum up, it is clear that we must ultimately stabilize the population of both this country and of the world. Yet what is more acutely needed is a "birth control pill" for our mechanical energy slaves, which are proliferating more rapidly than our people and which impose a greater burden on the environment. All too many of our actions have been taken with a total disregard for possible environmental consequences, and even retrospective research is sadly lacking. The "American Dream" of an ever increasing living standard may well be forced to become a casualty; it may be the price we must pay to demonstrate that there is today, and will continue to be, intelligent life on earth.


41 FEET
41 FEET — 50 YEARS
12 FEET — 17 YEARS
0 INCHES

Chinese Chestnut, *Castanea mollissima*

Beech Family (Fagaceae)

General Description:
A sturdy tree with low, wide-flung branches spreading from the trunk at a broad angle, *Castanea mollissima* reaches about forty feet in height and width at maturity. It grows slowly, developing an irregular form. The main trunk is often short and divides near the ground. The trunk and heavy branches are covered with gray furrowed bark that becomes smoother on the smaller branches. The long, coarsely-toothed leaves are slightly glossy and quite handsome. In the pure species, the lower leaf surfaces are very soft, this being the origin of the specific name *mollissima,* which means "very soft". In autumn the handsome foliage turns dull yellow and eventually russet, persisting into late winter. The flowers appear on terminal spikes in late spring or early summer; the staminate flowers are creamy-yellow and have an unpleasant odor at close range. In late summer and early fall, stiffly-prickled burs are apparent and may contain large, edible nuts comparable in size to the non-edible horse chestnut. However, Chinese chestnut requires more than one tree for pollination and thus the burs of singly planted specimens frequently contain no nuts.

Landscape Value:
Used principally as a lawn specimen and shade tree, Chinese chestnut can also be included in foundation plantings, particularly where large scale and coarse texture are needed. The texture and persistence of the foliage complements stone, rough wood, and timbered architecture. In the winter landscape, the foliage gives color, and interesting line patterns are formed by the tree's irregular branching.

Origin and Hardiness:
This native of northern China is hardy to Zone 5*, and unlike the American chestnut which has almost disappeared from the landscape, it is resistant to the chestnut blight.

Soil and Site:
This chestnut will tolerate most soils as long as they are well-drained. Rich soils are preferable, as are sunny, airy sites. Exposure to snow, ice, and wind is well tolerated, with little or no breakage.

Planting and Care:
Castanea mollissima is available in some local nurseries, and a number of cultivars—largely hybrids—are offered to nut-tree growers. The tree is not subject to serious pests or diseases, although occasional problems due to twig canker may arise. Spring is the best time for transplanting. A stout taproot makes transplanting of larger specimens difficult, but smaller nursery-grown stock, balled and burlapped, responds well when planted in fertile, friable soil with good drainage and reasonable moisture. Mature trees can withstand drought quite well. Chinese chestnut will not tolerate excessive pruning intended to restrict its growth, nor should such pruning be necessary if consideration is given to its scale when planting sites are chosen.

Location in the Arboretum:
Chinese Collection; Oakwood Loop north of the Scotch Pine forestry plots; Nut Tree Collection.

**Hardiness Zone based on Plant Hardiness Zone Map prepared jointly by the U.S. National Arboretum in cooperation with the American Horticultural Society. U.S.D.A. Misc. Pub. #814, May, 1960.*

Climatological Summary			
Data	*August*	*September*	*October*
Average mean temperature	*71.4° F*	*64.4° F*	*54.1° F*
Highest temperature	*93° F*	*90° F*	*79° F*
Lowest temperature	*50° F*	*33° F*	*29° F*
Days maximum 90° F or above	*5*	*2*	*0*
Precipitation	*2.27"*	*7.03"*	*2.77"*

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ILLUSTRATION SOURCES

Page 50: Photograph by Alfred G. Etter
Page 55 and inside back cover: Part of a woodcut from Brontius, Libellus de utilitate et harmonia artium, *Antwerp, 1541*
Page 60: Pen and ink drawing by Anthony Tyznik

PLANT TREES

THE MORTON ARBORETUM

LISLE, ILLINOIS

Founded by Joy Morton, 1922

A PRIVATELY ENDOWED EDUCATIONAL FOUNDATION FOR PRACTICAL, SCIENTIFIC RESEARCH WORK IN HORTICULTURE AND AGRICULTURE, PARTICULARLY IN THE GROWTH AND CULTURE OF TREES, SHRUBS, AND VINES BY MEANS OF A GREAT OUTDOOR MUSEUM ARRANGED FOR CONVENIENT STUDY OF EVERY SPECIES, VARIETY, AND HYBRID OF THE WOODY PLANTS OF THE WORLD ABLE TO SUPPORT THE CLIMATE OF ILLINOIS . . . TO INCREASE THE GENERAL KNOWLEDGE AND LOVE OF TREES AND SHRUBS, AND TO BRING ABOUT AN INCREASE AND IMPROVEMENT IN THEIR GROWTH AND CULTURE.