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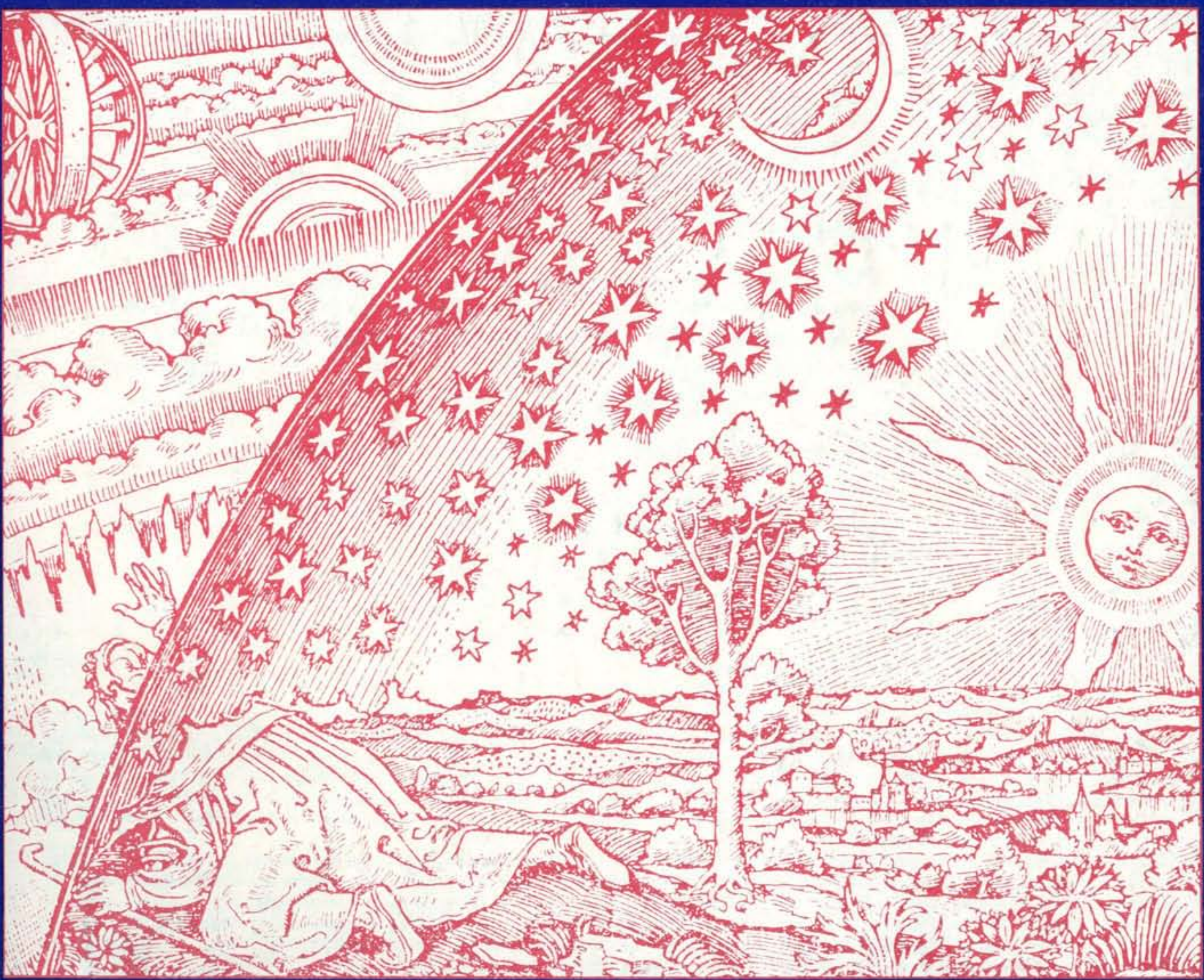
# THE FUTURE OF AMERICA



Containing papers by Eugene Odum, David Pimentel, Thomas Starr, Garrett Hardin, Preston Cloud, Wilson Clark, Georg Borgstrom, Kenneth Watt, George Armelagos & Phillip Katz, Sam Love, Royce LaNier, David Morris and John Milton which, among others, will be read and discussed at the New Atlanta Conference, Georgia State University November 17th-19th, 1977, Atlanta, Georgia, U.S.A. Sponsored by Atlanta 2000, Institute of Ecology, The University of Georgia, The Ecologist and Threshold, Inc.

# NEW ATLANTA CONFERENCE

**URBAN LIFE AUDITORIUM, GEORGIA STATE UNIVERSITY**
**November 16 — 19, 1977**

**Chairman: Congressman Charles L. Weltner**

Conference commences on the evening of November 16, with:

The PRELUDE:
Address by Eugene Odum and preliminary discussion.

**November 17 PRESENTATION Introduced by Joseph Campbell**

The papers prepared by the experts will be presented as five workshops:

1. Population, Climate and Food
2. Resources and Energy
3. Health
4. Economics
5. The American Alternative

**November 18 RESPONSE**

The citizens of Atlanta respond to the above and present the statements prepared by thirteen task forces who have been studying the future of their city for the past two and a half years in the light of the Arts, Communications, Economics, Energy, Environment, Governance, Health, Housing, Learning, Public Safety, Technology, Transport and Values.

**November 19 RESOLUTION, CHOICE AND RECOMMENDATION**

Conference looks at three alternative Futures for Atlanta: Business as usual, Highest probability, and The Ecological City and votes on which plan it will recommend to the City.

Closing speech.

Conference ends.

One special aspect of the presentation of the papers in this issue at the New Atlanta Conference is the unique way in which this information will interact with the citizens of Atlanta. The conference process, and the content contained in this special issue of *The Ecologist*, will be utilized in an interactive media program of Atlanta 2000. This program, entitled the Atlanta Metro Assembly, will present the conference as part of five television specials to the Atlanta public. To elicit and record responses of residents, approximately 200 viewing posts will be set up where the content of the specials can be discussed, questions and comments can be recorded, and balloting on issues relevant to the future of the City can take place.

Citizen response will then be tabulated and fed back to the citizens — followed by an analysis of the process and content by viewers from the viewing posts and by a panel of humanists, scientists and government officials. In this way the citizens of various Atlanta Neighborhoods have the opportunity to respond to the issues explored at the New Atlanta Conference and to become creatively involved in adapting this information to their own neighborhoods and city. The interactive media approach of the Atlanta Metro Assembly promises to allow both citizens and "experts" to provide a unique opportunity for the citizens of a major city to more effectively dialogue and define a more desirable future environment for their neighborhood, their city and their nation.

*CORRECTION TO CONTENTS*
**RESOURCES AND ENERGY SECTION**
**For Georg Borgstrom: Water Resources and National Destiny read David W. Orr and Cecil R. Phillips *et al* Toward a Sustainable Energy Society.**

# In this issue

Vol. 7 No. 7 Aug/Sept. 1977

THE FUTURE OF AMERICA



**This issue of The Ecologist has been produced in association with Threshold, Inc. of Washington, D.C.**



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# Foreword

## THE FUTURE OF AMERICA

We are proud to present to our readers this special triple-sized issue of *The Ecologist*. It is dedicated to President Jimmy Carter. We feel that he shows signs of being the first statesman since the beginning of the Industrial Age to have had the courage and foresight to seek to apply — against considerable odds — socio-economic policies that take into account the physical, biological and ecological constraints to which economic activities must ultimately be subjected. His attempts to deal directly with these constraints are most significant, since their operation will largely shape the future of America.

In the first three sections of this special issue some of these constraints are examined by nationally-recognized experts in their fields, and in each case the implications for public policy are carefully noted. Key constraints examined include: population, climate, food, health, and water, mineral, and energy resources.

The last section provides an attempt to describe the sort of society into which America could develop if her socio-economic activities are effectively to deal with these constraints and if she is to avoid the large-scale discontinuities that otherwise lie ahead.

The contributors to this issue will meet at The New Atlanta Conference in the Urban Life Center, Georgia State University, from the 17th to the 19th of November. Their mandate will be to look at the future of America as a whole rather than in separate parts. We expect that the picture they paint of it will be critically examined by other scientists and scholars who may view it from a different standpoint. We also trust that their contributions will help Atlanta 2000 (a local citizens' group to which the co-editors of this special issue act as consultants) to consider the future of their city and of their State in the wider context of their country and their planet.

The New Atlanta Conference is co-sponsored by four organizations: Atlanta 2000 (Dr. Robert Hanie, Executive Director), the Institute of Ecology of the University of Georgia (Professor Eugene Odum, Director), Threshold, Inc., of Washington, D.C. (John Milton, Chairman), and *The Ecologist*. The conference has been largely financed by the U.S. Environmental Protection Agency's Office of Land-Use Coordination, the Office of Research and Development, and the Office of the Regional Administrator (Region IV, Atlanta).

Arrangements are being made to publish the proceedings of the meeting in book form for world wide distribution.

*Edward Goldsmith and John P. Milton, Co-editors*

# OUR LAND AS IT WAS

## John Bakeless

**Teacher, editor, lecturer John Bakeless has made a study of the America that our European forebears discovered on their early voyages to the new world**

Primitive North America — the land as it was for perhaps 30,000 years between the coming of the Indians and the coming of the Europeans — was an incredibly rich and beautiful place. Everywhere lay beauty — autumn foliage in masses we shall never see again; crystal lakes and rivers, except for muddy prairie streams, and the great sweep of the Father of Waters; colored deserts; the glittering Rockies — which the first white viewers called the "Shining Mountains."

Among other blessings — shared by perhaps three-quarters of a million Indians and no one else — were prairies teaming with buffalo, in herds that would pass all day without end; lordly moose along the lake shores; deer everywhere. Wild grapes roofed much of the eastern forests; there were wild fruits of many kinds; plentiful fish in every lake or stream; oysters nine inches long — or longer — in great clusters, which some fortunate dwellers on Ma hattan simply pulled out of the clear waters before t eir shelters; lobsters beyond 20 pounds, easily caught wild turkeys in flocks so large their gobbling in the morning might be deafening; passenger pigeons that literally did darken the sky. There were grouse, prairie chicken, ducks of every kind, wild geese so fearless that at times they tried to frighten off approaching hunters.

There was nothing you could call pollution, though neither was there anything you could call sanitation. Human beings were too few to make much trouble for themselves, their power to pollute and destroy was too limited. If an Indian village grew, perhaps, a trifle whiffy it was easy to find a new, clean site a little farther off. The woods and plains Indians were migrants anyhow, following the buffalo or caribou herds, moving to winter trapping grounds, setting up temporary fishing or hunting camps, going to the sea-side to "salt" or pausing long enough to raise a crop of corn.

Indians with permanent villages seem to have had no sanitary troubles. The pueblo of Acoma in New Mexico, inhabited long before the coming of the Spanish and inhabited still, has always continued in its ancient way, obviously much happier than the white man's tortured cities.

No chimneys, automobiles or planes poured sulfer or carbon compounds into the sky. No electric power lines of tremendous voltage slashed the forests or disfigured the landscapes. No factories poured acid wastes into creeks and rivers. No generators loosed floods of scalding water to kill fish. No dams blocked shad or salmon from running upriver to spawn where they had themselves been spawned, and the rivers were not open sewers. Such littering as there was turns out to be useful to modern archaeologists. One finds a mess of broken pottery sometimes, scattered about ancient archaeological sites, and of course huge mounds of the shells of clams, mussels and oysters.

There were no piles of shattered automobiles, but fertile woods and plains; no huddled tenements, but bark or buffalo-hide tepees, earth houses, pueblos; no roadside advertising or filling stations, only green woods and prairies filled with waving grass and blossoms; no hot dog stands, only a few flickering campfires roasting venison or buffalo hump or fresh-caught shad or salmon, wild geese or pigeons. There was a certain risk of being scalped — but nothing like the income tax.

Man, to be sure, sometimes managed to be vile. Many Indians tortured prisoners. There was perpetual raiding, killing, burning and general destruction. But life in the villages was rather pleasant. Children were, perhaps, too much indulged. One chief was horrified when Lewis and Clark had a soldier flogged for dereliction of duty. You certainly ought not to do that to a warrior, he said. If you did it to children, you broke their spirit.

When little white boys were captured and raised among the Indians, they frequently objected to being rescued. Sent back under treaty agreements, they sometimes had to be tied to prevent their fleeing from freedom in white civilization to the joys of captivity in an Indian village.

The landscapes of this early paradise were wholly unspoiled. Forests, mainly evergreen, covered most of New England and adjoining Canada. Deciduous forests, with still some evergreens, took over somewhere around the Hudson River and swept on into the West. They gradually thinned to "oak openings" beyond the Ohio, eventually yielding to the prairies as they approached the Mississippi. The prairies were covered with waving grass (hence the buffalo) and brilliantly colored flowers.

Grass grew to tremendous heights. On the fertile Susquehanna floodplain it was so high a man on horseback could hardly see over it. There was plenty of man-high grass elsewhere, too. Along the Ohio and Mississippi and other rivers grew the cane, huge jointed stalks with flowering leaves. In frontier days, cane grew on some of the most fertile land and so grew 30 or 40 feet tall. Now all that land is occupied by crops, and modern canebrakes are pitiful shrunken copies of the old canebrakes of pioneer days, which might extend over 100 miles. A cavalry commander, looking at his troops and their horses straggling through one of these brakes, thought they looked like "a company of rats traversing a sturdy field of grass."

Beyond the prairies rose the Rockies and, farther west, forests of huge trees. Lewis and Clark observed trunks of 200 feet on the way to Oregon, and these were not the California "Big Trees" (redwoods, or Sequoias) which towered well above 300 feet. The big redwood tree from which Palo Alto, California, took its name was not really large as redwoods go — only 140 or 150 feet in height — and it was probably a good deal shorter when the Spaniards saw it, 300 years ago. But the first two astonished exploring parties who saw it had no idea that giants vaster still awaited them a little farther north and paused to measure it. As they went on, they found trees so big that "eight men all holding hands could not span one of them." One of the party amused himself by riding his horse into the cavity of one trunk. "Now I have a house in case it rains!" he exclaimed.

These trees were either *Sequoia gigantea*, or the other and related species, *Sequoia sempervirens*. Not knowing what to call these giants, the Spaniards named them for the color of the wood, *palo colorado*. Hence they are "redwoods" today — such of them as greedy lumber barons have left.

It seems a pity that the devoted missionary priests who wondered at the giant trunks never knew that these trees had been standing since their Master walked the roads of Palestine. Even more ancient were other conifers, the bristlecone pines, which the Spaniards never saw because they grow only at 8,000 to 11,000 feet in the mountains of eastern California. And even older than these is the rather rare box huckleberry whose rate of growth is known from observation. Several plants of it have been growing in Pennsylvania for a period estimated at between 5,000 and 10,000 years.

The new land held many pleasant surprises for the first explorers. Columbus noted that an offshore breeze brought "so fair and sweet a smell of flowers or trees from the land, that it was the sweetest thing in the world."

Among the pleasant scents that reached explorers' ships was the smoke of Indians' large cedar wood fires, perhaps also forest fires burning cedar groves. Giovanni da Verrazano, in 1524, caught the odor at 100 leagues (he may have overestimated the distance), "when they burned the cedars and the winds blew off the land." Raleigh's colonists in July 1584, off "Florida," which probably meant any part of the coast south of Virginia, reported "a most dilicate sweete smel though they saw no land."

One voyager says this was "so strong a smel, as if we had bene in the midst of some delicate garden abounding in all kinde of odoriferous flowers." A Dutch vessel, sailing for Delaware Bay, on Decmber 2, 1632, "smelt the land, which gave a sweet perfume, as the wind came from the northwest, which blew off land and caused these sweet odors." There were no wildflowers growing at that time of year, of course. The Dutch thought the fragrance was due to the fact that "the land is full of sweet smelling herbs, as sassafras, which has a sweet smell."

The pine forests, vastly larger than anything we have today, sent out an aroma of their own. A Quaker immigrant aboard the ship *Submission* out of Liverpool for Philadelphia, in 1682, noted in his diary: "The wind being west we smelled the pines, supposing ourselves not to be within 80 leagues." In the 19th century, Augustus John Foster, biographer of Dickens, noted that "long before we saw land we could smell the pines." Modern yachtsmen, well out to sea, occasionally have the same experience along a few parts of the coast today.

American woods are still sometimes fragrant. I myself have been suddenly stopped by a scent — a crowded growth of the little white swamp violet, not more than an inch or two above the ground, sending up a perfume so intense that it fills the air all around, or partridge berry blossoms, lying flat upon the ground.

If this can happen in shrunken modern woodlands from growths of wildflowers covering only a few square feet, imagine the intensity of sweet odors in springtime a few centuries ago, when the whole coast consisted of woodland, and all was filled with blossoming wildflowers.

It may be hard to believe today, but when Henry Hudson sailed his *Half Moon* into New York he was delighted with the grass and flowers along the New Jersey side of the river and noted happily that "very sweet smells came from them."

Fish were enormous, abundant and easily taken. One man killed a sturgeon by wading into the water with an ax. Using bayonets, Lewis and Clark's men once got enough salmon to feed them. Indians caught big Southern catfish by diving into the water with any available red object for bait, seizing the fish as it approached and dragging it to shore.

The run of shad in rivers, whence they have since been excluded, was enormous. As the fish began to run up the Susquehanna, you could look downstream and see them coming. Washington fed his troops at Valley Forge when the shad began to run by sending cavalry upstream to roil up the water, while soldiers down below gathered in the fish. Shad were so plentiful that it was a little disgraceful to eat them at all. One naughty girl taunted a playmate, the child of poorer parents: "Your family eats shad!"

One early settler noted "divers sorte of shellfish, as scallops, muscles, cockles, lobsters, crabs, oysters and welks, exceeding good and very great." Since a few scattered Indians could not possibly use this abundance, all species grew to enormous size. Oysters had to be eaten in several mouthfuls. Lobsters are reported — "so large, so full of meate, and so plentifull in number, as no man will believe that hath not seene." A visitor was "some cloyed with them, they were so great and fat and lussious."

Curiously enough, poison ivy was no problem at all in early days. It likes plenty of light. When the land was thickly forested, the vines ran up the tree trunks and spread out at the top — as they still do if trees are thickly clustered. When the Europeans cleared the land, they gave poison ivy plenty of light along roads and in meadows. The plant spread everywhere, and we are still suffering — perhaps deservedly.

Early settlers gathering wild greens were careful to avoid possible poisoning. Housewives among the first settlers of Boonesborough, Kentucky, in the 1770s watched their cows in pasture and gave their families only the greens they had seen the cows eat without harm.

On the whole there was little trouble with poisonous snakes. DeSoto marched his men through Florida and adjoining states when the whole area was certainly swarming with coral snakes and rattlers. Herpetologists suggest that the noise of a small army, its horses and the herd of pigs it drove along was enough to scare any snake away.

Philip Tome, the famous hunter of Lycoming County, Pennsylvania, once saw a "pile of rattlesnakes as large as an outdoor bake-oven. They lay with their heads sticking up in every direction, hissing." Indians sometimes raised their beds on forked sticks to keep the snakes out of the warm blankets; and two hunters in Pennsylvania, in about 1800, had to sleep in canoes anchored in midstream. There was a sensation in a rural congregation when a rattler was discovered crawling among the ankles of the worshipers; and, to make matters worse, the reptile had hardly been killed when another appeared. The sermon went on.

In spite of all, getting a living from this land was easy — if you knew how. The Pilgrim Fathers nearly starved in the winter of 1620-21 — with teeming fisheries, abundant oysters, clams, crabs and lobsters at their doorsteps. Conrad Weiser, Shikellamy, the Iroquois chief, and a party of experienced woodsmen nearly perished crosssing the "Endless Mountain" in Pennsylvania — but they tried it in winter, when everybody should have known there was no food.

Normally, game was ample and available. Wild turkeys, now rarely weighing more than 25 pounds, are said to have run up to 40 and 50 — so fat they sometimes burst as they fell to the hunter's shot. Little Indian boys amused themselves by throwing sticks at them. In some parts of Pennsylvania flocks ran along the road. Passenger pigeons flew in such masses that the air currents they set up could be felt on the ground — though there were good sanitary reasons for keeping out from under such masses. Nobody shot them. You took them with nets. As for small game, a single hunting party once brought in 4,000 squirrels.

America is still a land of abundance, but it is a new kind of abundance. And in achieving it we have destroyed the old kind — the pure air, the clear lakes and streams, the game, most of the incomparable landscapes of the land as it was.

# ECOLOGY-THE COMMONSENSE APPROACH

**by Eugene P. Odum**

**During the Industrial Age, our confidence in the omnipotence of science and technology, has led us increasingly to divert from the path that would have been dictated by the common-sense embodied in our traditional culture and so admirably reflected in its proverbs.**

**Ecology, seen as an approach, rather than as a scientific discipline, provides the rationale for a return to common-sense. It is in terms of this approach that we should consider the basic problems that our society faces today.**

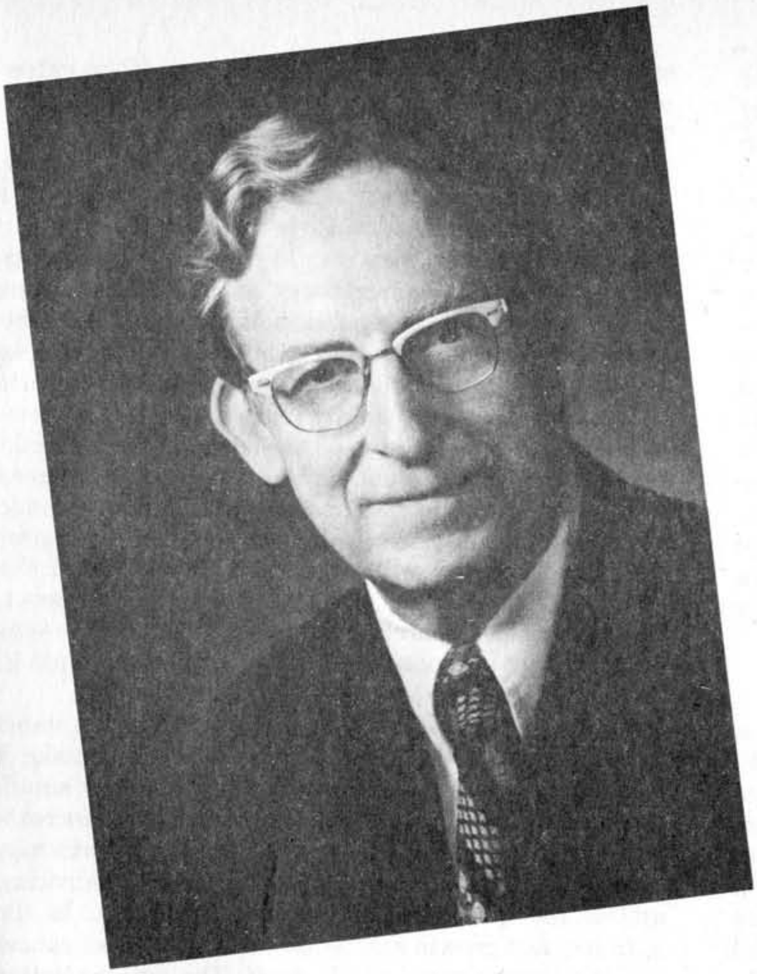
Sometimes the way to deal with complexity is to search for overriding simplicity. When situations appear hopelessly complicated, as do, for example, the energy and environmental dilemmas that we face today, then it pays to back off a bit and take a broad overview. When the traditional reductionist approach of piecemeal analysis fails to achieve long-term solutions then it is time to consider a more holistic approach in which interactions of the pieces, and ways of dealing with the situation as a whole are also considered. This is what ecology as an ''emerging new integrative discipline'' is all about as I have outlined in another article (Odum, 1977).

Surprisingly often when it comes to comprehending and acting on crisis situations the overriding simplicity turns out to be good old-fashioned common sense, or ''horse sense'' as it is sometimes called. For example when faced with a shortage of something the common sense response would be to conserve and reduce waste first, then consider the alternatives for maintaining or increasing supply. Yet too often of late we go for the technological quick-fix that promises to postpone the bother of readjusting, however slight, our life styles. In times of rapid technological growth the momentum produced by massive energy and material consumption is so strong that the negative feedback signals that warn of ''too much of a good thing'' are often not heeded until a real crisis occurs. It is also human nature to put off for tomorrow what should be done today. But we can not ignore for long the common sense wisdom that has sustained mankind for untold centuries, because to do so invites a Faustian bargain in which the promise of today's technological magic could be all too easily traded for a hell-on-earth tomorrow.

It is my theme that the natural laws that underline the principles of ecology can be applied in a common sense manner that might appeal to people both rich and poor (and in both ''developed'' and ''underdeveloped nations), who are not inclined to listen to these strident environmentalists that seek to accentuate rather than ameliorate the conflicts between man and nature. While detailed knowledge and extensive training and experience are necessary if one aspires to be a truly dedicated and objective professional ecologist, the basic principles of ecology as they relate to our everyday lives are not all that difficult to comprehend because by and large they are already part of our heritage, even if we are inclined to forget about them temporarily as we enjoy the fruits of material growth. To illustrate, let us consider what might be included in a layman's guide to ecology. Let us avoid the technical jargon that is appropriate to a college text or other professional treatise and see if we can communicate the basic concepts of a ''holistic'' ecology in everyday language.

### The Houses of Man

Since the word ''Ecology'' is derived from a Greek root meaning ''house,'' it is appropriate to think of ecology as the study of our environmental house. Actually there are two ''houses'' to be considered when it comes to coping with our environmental problems, namely, the house that man has built and the house of nature. Since these entities are actually open systems, not closed-in units as the word ''house'' might imply, and since energy is a common denominator we in ecology often designate the man-made house as the



Dr. Eugene P. Odum is Callaway Foundation Professor of Ecology, and Alumni Foundation Distinguished Professor of Zoology at the University of Georgia where he also founded, and in 1961 became Director of, the Institute of Ecology at the University of Georgia. He is past-president of the Ecological Society of America and received its ''eminent ecologist'' award in 1974. Dr. Odum's publications include five books and more than a 100 papers in professional journals as well as numerous more general articles on ecological themes. He has lectured widely and has served on commissions and panels seeking solutions to ecological and environmental problems. His two text books *Fundamentals of Ecology* (1953: subsequent editions 1959 and 1971) and *Ecology* (1963, 2nd edition 1975) have pioneered the holistic or ecosystematic approach to the teaching of ecology, and have been translated into many foreign languages.

*This article is based on remarks made at a reception for the author as the 1977 recipient of the John and Alice Tyler Ecology Award administered by Pepperdine University, May 23, 1977, Los Angeles, California.*

*fuel-powered urban-industrial system* and nature's house as the *solar-powered natural ecosystem.* It is also useful to think of agriculture as an intermediate system that links together the houses of man and nature. Since we now use high quality energy as well as human and animal labor to augment the abundant but low quality sun energy to produce food we can conveniently designate farming operations as a *fuel subsidized, solar-powered agroecosystem.* As more and more auxiliary fuel energy is used to power machinery, make fertilizers and pesticides, to irrigate and to transport and process food the agroecosystem comes more and more to be like the industrial system in terms of demands and impacts on the natural environment.

Because technological achievements have made us less and less directly dependent on the natural environment for our daily needs, modern man has come to think and act more and more as if the man-made house was independent of the house of nature. Our economic systems of whatever political stripe tend to place a very high value on man's works and almost no value on the works of nature which are taken for granted, or even downgraded in the sense that ''familiarity breeds contempt,'' as an old expression goes. The great paradox is that from a technological viewpoint the success of industrialized nations has been accomplished by ingenious *uncoupling* of man and nature, and the exploitation of finite, and now declining, nationally produced fossil fuels stored in the earth. Yet man-made systems remain as they have always been completely dependent on the natural environment, not only for energy and materials, but also for the even more vital support of life processes. As the intensity of man-made developments increases, the impact on the life-support system becomes increasingly critical with air, water and food increasingly contaminated or in short supply or both. Fortunately there is an increasing awareness worldwide that the energy, food, water and other ''crises'' that periodically come to public attention all have an environmental basis, and that solutions require a new or reoriented technology as well as restraints on population growth. It would seem obvious that serious attention needs to be given to the *recoupling* of man and nature so that the total environmental house can be preserved, and, hopefully, the quality of life therein improved. Thus, the ''new'' ecology that I preach is dedicated to the common sense notion of man and nature as a coupled system.

**The Whole is More than a Sum of Parts**

When parts function together to produce a whole (or a ''system'' in more formal language) new properties may appear that are not features of the parts as each might operate separately. For example, water has unique characteristics that are neither the same as, nor the sum of, the properties of hydrogen and oxygen which are the component parts. So it is with the systems of man and nature. Much can be learned by dissecting and studying the component parts of an organism or a forest or a city, but it is necessary to examine the intact or ''in situ'' or ''in toto'' system in order to have a full understanding of the situation in question.

In everyday life there are many expressions and sayings that indicate a general acceptance of what we might call the *holistic doctrine.* Thus, when someone takes an overly narrow view of something we may accuse that person of "not seeing the forest for the trees" or of having "tunnel vision." The trouble is that as a society we do not practice what human wisdom preaches. As we have already noted science and technology, especially in the last 50 years, have moved in the opposite direction, that is, towards increasing specialization, more subdivisions, more one-problem-one-solutions, and so on. The sad fact is that our really big and important problems such as those associated with energy, food, water, cities and population growth can not be solved, or even coped with, on the basis of piecemeal study no matter how sophisticated or technically advanced are the methods employed. Thus, "the whole is more than the sum of the parts" is an appropriate common sense translation of what we would call the "ecosystem principle" in an ecology text.

**Haste Makes Waste**

This familiar admonition makes a good heading for a chapter on "energy in ecosystems," since it expresses an important aspect of the entropy law, also known as the 2nd law of thermodynamics, one of the most important natural laws. The success of any system, whether man-made or natural, depends not only on the quantity and quality of its energy source but also on how efficiently the source is converted into useful work capable of maintaining the system as a whole. As energy is converted from one form to another to accomplish a useful function or transformation the quantity is reduced by an inevitable heat loss, but the quality of that which is passed on may be increased. Thus, in the well known food chain conversions it takes about 500-1,000 units (calories, for example) of low quality sun energy to make 10 units of higher quality plant material which in turn can be converted into 1-2 units of still higher quality meat.

It is important to remember that the flow of energy is always one-way; once useful work has been accomplished in a conversion that energy is no longer available. Energy can be stored but it can not be recycled as can materials such as water or iron. The food you ate and the fuel you burned today is gone forever and must be replaced by new food and new fuel tomorrow. Equally important, one can not be *both fast and efficient* at the same time when it comes to energy conversion. We all know that driving very fast reduces the distance we can go on a given amount of fuel. Haste does indeed increase waste; fast conversions mean less work accomplished for a given amount of energy and also more heat and other waste products generated.

When easily convertible energy is plentiful, then both man and nature tend to haste and make waste which in turn requires additional energy to cope with the disorder created by the growth in size and by the waste products produced. In theory, negative feedback then acts to slow down the haste and increase efficiency. We do observe that in natural ecosystems growth slows down, energy is used more efficiently and stores of high quality energy are established in the biomass as the ecosystem develops from a pioneer stage to maturity. The same things happen if the inflow of energy or its quality is reduced for whatever reason. The common sense notion of "save for a rainy day" becomes appropriate when saturation levels of use are approached since energy and resources are always subject to periodic fluctuations in the real world.

As already noted, man should respond to an energy crisis in the same general way as does nature, but energy conservation as a public policy does not have the appeal that the search for glamorous new sources provides. Unfortunately, finding new sources does not necessarily resolve an energy crisis if a lot of the new-found energy has to be used to develop and maintain the new flow and to deal with new and perhaps more toxic waste products. For example, fusion atomic energy might not prove to be the bonanza we expect since much energy will be needed to cool down the reaction from millions of degrees to a usable level. So far in fusion research the break-even point, where as much energy is produced as is required to produce it, has not yet been achieved even on a small scale.

Not only do natural laws rule against having speed and efficiency at the same time but they also make it difficult to have high quality and large quantity simultaneously. Increasing the quantity of resources increases the potential for rapid growth, but such growth may come at the expense of the quality of the individual and/or the quality of life for the individual. In the extreme, fast growth can become disorderly like cancer and threaten survival of life itself. The eutrophication (enrichment by pollutants) of natural lakes provides an illustration of the quantity-quality dilemma. When nutrients from sewage are put into the lake the number of organisms and the rate of organic production increases but "weed-type" organisms such as small "scummy" algae and "trash" fish replace the diatoms, attactive water plants and game fish. If enrichment is intensified more and more kinds of organisms are eliminated even as those which remain multiply like the out-of-control cells in a cancerous organ. One can not be certain that the discovery of a new unlimited and cheap energy source, granting it's possible, would really be a boon for humankind. It might just be "too much of a good thing" that would convert the world into one big, overpopulated cesspool, an undesirable "whole earth" if ever there was one!

All in all, then, the judicious solution to the energy, food, water or what-have-you crises is to cut down on haste in order to reduce waste, increase efficiency and buy time to improve the quality of human life; at the same time, without undue haste, we can look into our options for adjusting supply and demand. To act on such common sense judgement requires not only science and technology dedicated to such goals, but more difficult to achieve reordered political and economic objectives which today are much too strongly geared to promote growth and waste, or quantity "uber alles."

**Don't Put All your Eggs in One Basket: Variety is the Spice of Life**

These two common sayings would make good headings for a chapter in "community ecology" including the general subject of "diversity." Few of us would disagree that it is unwise, and usually downright foolhardy, to put all one's money, or whatever, into only one venture. Naturalists for centuries have marveled at the diversity of life in natural systems, and modern ecologists have generally agreed that there is efficiency and safety in diversity, although they are not sure just why and how diversification evolves. The idea is that a diverse ecosystem is better able to use the energy and resources available and better able to resist adversity. However, it is also clear that diversity has an energy cost of its own so that one can have too much as well as too little variety. Right now our concern in human society is with too little. Industrial societies have often thrived on the short-term basis by putting all the eggs in one basket. Thus, in the U.S.A. we put most of our transportation eggs in the auto basket, a lot of the energy eggs in the oil basket, too much of our hair spray in aerosol cans, and so on. Also, more and more we concentrate on one or a very few kinds of grain, or species of trees, for the food and forest baskets. All the while we seem fully aware that this sort of strategy invites the overshoot, the boom and the bust, as it were. One reason we do it is that high profits and rapid growth come when we concentrate on promoting single products. We assume that when the diminishing returns set in we can quickly and easily shift to another basket. But what if we do not have another basket ready when the one we have been using breaks, or what if the eggs we lost have not been paid for? Then there will be serious "transition losses" including perhaps economic depressions and social disorders as we struggle to recoup losses and organize another basket. If we can only heed the common sense warning in these matters and recognize and act on the premise that variety is not only the spice of life (quality factor) but also a valuable stabilizing factor, then we should be able to devise the means to promote diversification. As already noted there would be a cost to such a strategy, and we would have to be convinced that this cost is less than the transition losses inherent in the boom and bust model. The evolutionary success of diversification in nature would seem to indicate that this is indeed that case.

**The Bottom Line**

My theme has been that common sense notions representing human wisdom of the ages provide a basis for seeking holistic solutions of problems of energy and environment which appear hopelessly complicated when viewed piecemeal. Also, I cited several examples to show how the principles of ecology can be expressed in terms of this common sense wisdom. When we do take an overview of problems related directly or indirectly to environment it becomes clear that the time has come to recouple the two "houses" of man, the man-made urban-industrial system and the natural environment life support system. During the industrial age these two vital parts of our total existence have become too far separated in our minds and actions leading to dangerous inequities of value and performance. To recouple man and nature into a more harmonious whole requires that science and technology be integrated with reordered social, economic and political goals — a most difficult task. It is tempting to wish for a benevolent dictator who could act for the good of the whole so as to prevent, or at least blunt, the overshoot that comes with going too fast too far. But we are immediately reminded of another wise saying that "power corrupts"! Benevolent dictators do not remain benevolent for very long; being human they are likely to abuse their power to the detriment of basic human rights. The best we can hope for is a massive educational effort at all levels of the media so that an informed public can select leaders who see the whole as well as the parts; and who, we might add, can be recalled if they abuse their political power.

# America's Agricultural Future

by

**David Pimentel and John Krummel**

**American agriculture has made great advances during the past 200 years, in increasing yields and reducing human labor input in food production. What will the next 200 years bring to American agriculture? Obviously no one knows, but we can examine some of the possible alternatives based on trends in population growth, use of resources, and environmental degradation.**

An analysis of those factors that influence food demand and supply provides some insight into the future development of American agriculture. Food demand and the supply provided by agriculture is influenced directly and indirectly by a complex of interrelated factors (Figure 1) such as population, environment, energy and numerous other factors in the human social and ecological system.

**Population and Food Needs**

The need for food in the United States is determined by human population numbers, level of nutritional diets, standard of living, and agricultural exports.

In 1790 the U.S. population numbered only about 4 million (Figure 2). From 1870 to 1970 the population increased from about 40 to about 200 million or about 400%. Of this immigration accounted for about 38 million or about 24% of the increase (USBC, 1975; US Senate, 1911).

Today the U.S. population is growing at a rate of 0.9% per annum (PRB, 1975). If this rate persists, the U.S. population will increase to about 262 million by the year 2000 (Figure 2). This is about a 24% increase in the U.S. population during the next 25 years.

Assuming no increase in U.S. agricultural production, this 24% increase in population would mean that all foods produced in the U.S. would be consumed there. Further the large agricultural exports, currently amounting to about $22 billion (USDC, 1976), that are important in paying for necessary imports such as oil will be virtually eliminated.

**Nutritional Diets**

Actual demand for food in the United States, especially grains, has been increasing faster than has the population. The majority of the human population lives on about 2100 kcal per capita per day and obtains most of its protein from grains. In sharp contrast, the U.S. population consumes about 3300 kcal per day per capita and most protein comes from animal sources (Pimentel et al, 1975). For example, in the Far East about 56 grams of protein per capita are consumed daily, of which only about 8 grams are animal protein. Meanwhile, in the United States the protein consumed per capita per day totals 96 grams, with about 66 grams of animal origin (Pimentel et al, 1975).

In the United States, annual use of grain is about 2 200 lbs per capita. Of this only about 130 lbs is consumed directly; the remainder is fed primarily to livestock (Pimentel et al, 1975). Current per capita meat

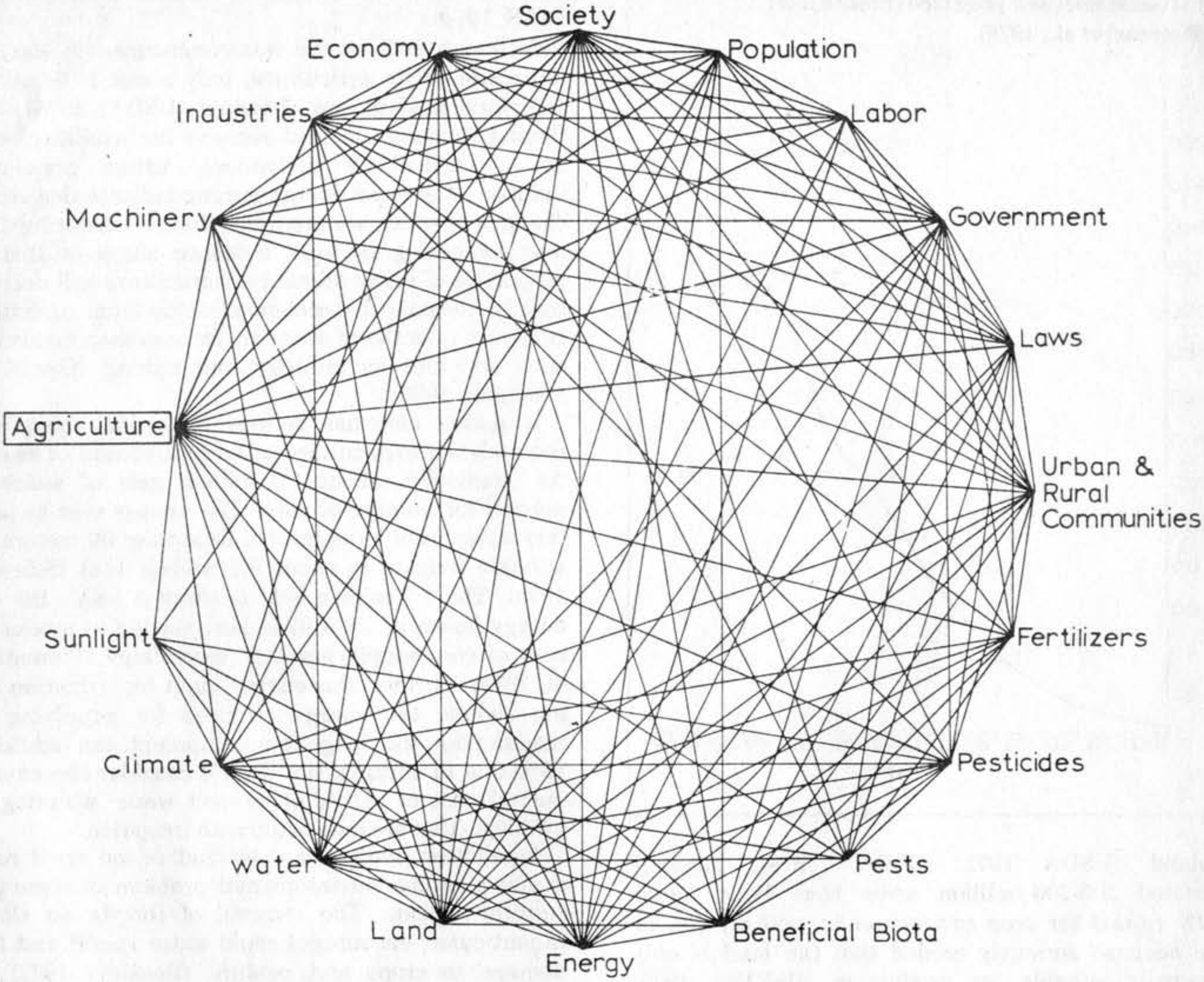



**Figure 1. The interdependency of agriculture and the ecological system.**

consumption in the United States is about 250 lbs per year (USDA, 1975). If the purchasing power of the lower income groups of the U.S. population were to be increased and meat consumption increased, significantly more grain resources would have to be channeled through livestock to supply this food demand.

**Exports and Trade Balance**

Food is one of America's major exports. In 1974-75 the United States not only supplied its own needs but also exported about $22 billion worth of grains and other agricultural products (USDC, 1976). This meant that because of the supply of agricultural products the U.S. had a positive trade balance of about $12.7 billion in 1975. Thus, the fertile cropland of the United States with its high production yields is a major factor in helping the United States maintain an overall healthy trade balance.

At present most of the food export trade offsets the U.S. importation of oil. (Now about 44% of U.S. oil is imported compared with only 35% in 1973). If the U.S. population increases as projected and with only limited arable land resources available, changes in the lifestyle of the Americans will be necessary to help pay for oil imports in the future.

**Food Supply**

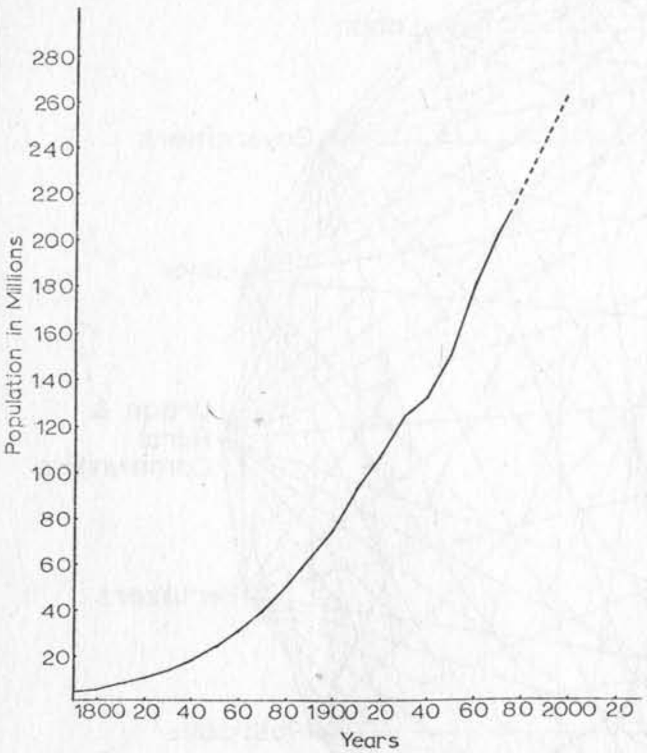
Food supply is influenced by such well recognized factors as arable land, water, climate, fertilizers, fossil energy, and other inputs. Also food supply is affected by food losses, public health, labor availability, and environmental pollution. The interdependence of food production and these many factors is examined below.

**Arable Land**

The U.S. has about 470 million acres of arable land (about 25% of its land area). Presently about 81%, 380 million acres, of this arable land is under cultivation (USDA, 1975). In addition, approximately 740 million acres are in pasture and rangeland, about 470 million acres in forest. An estimated 75 million additional acres are potentially arable. To develop this land would require swamps to be drained, deserts irrigated, and vast areas leveled and graded. These major reclamation schemes, however, would be expensive in both energy and dollars.

The availability of arable land has been steadily declining because of population growth, extension of urban areas, and land degradation. For example, from 1945 to 1970 over 72 million acres have been lost to highways and urbanization; about half of this had been

Figure 2. Population growth in the United States, actual (solid line) and projected (broken line) (in Pimentel et al., 1976).




cropland (USDA 1971; USDA, 1974). Another estimated 100-200 million acres have been either totally ruined for crop production by soil erosion or have been so seriously eroded that the land is only marginally suitable for production (USNRB, 1935; Bennett, 1939; Pimentel et al, 1976).

Erosion seriously reduces the productivity of land. The rate of soil erosion per acre of cropland in the U.S. is estimated at 12 tons annually (Wadleigh, 1968; Hargrove, 1972). This relatively high rate of soil erosion has resulted in a loss of at least one-third of the topsoil and has reduced the productivity of cropland in use today (NAS, 1970).

Fortunately to date the reduced productivity of U.S. cropland due to soil erosion has been offset by increased quantities of fossil energy in the form of fertilizers and other inputs (Hargrove, 1972). An estimated 5 gallons of fuel equivalents per acre is being used to offset the soil erosion loss on U.S. cropland (Pimental et al, 1976).

Soil erosion also degrades reservoirs, rivers, and lakes by annually depositing about 3 billion tons of sediments in these water bodies (USDA, 1968). Soil sediments, the associated nutrients (nitrogen, phosphorus, potassium, etc.) and pesticides have an adverse ecological effect upon stream fauna and flora (Pimentel et al, 1976).

**Water**

Large quantities of water are vital for growing crops. An acre of corn, for instance, requires about 1.3 million gallons (about 4 acre-feet) of water per growing season. In the United States, agricultural production accounts for 96% of the water consumed, whereas industry and urban areas consume less than 4% (NAS, 1974).

Although 96% of the water consumed in the U.S. is consumed by agriculture, only about 10% of U.S. cultivated land is now irrigated (USDA, 1975). Conflicting demands in arid regions for available water among agriculture (irrigation), urban population, industry, and fossil energy mining indicate that certain changes in water use are inevitable. Considering these four competing factions, evidence suggests that the proportion of water allotted to agriculture will decrease mainly because the economic yields from agriculture per given quantity of water are far less than yields from such activities as industry and mining (Gertel and Wollman, 1960).

Irrigation also has serious limitations because it requires the expenditure of large amounts of energy. As mentioned, about 1.3 million gals of water are needed for an acre of corn. The energy cost to pump this water from a depth of a little over 90 meters and sprinkle irrigate is about 8.3 million kcal (Smerdon, 1974). The 8.3 million kcal is about 3 times the total energy inputs of 2.8 million kcal needed to produce an acre of corn employing U.S. technology (Pimentel et al, 1973). Further, this energy input for irrigation does not include the energy required for supplying and maintaining the irrigation equipment (an additional 13% cost in energy), nor does it consider the environmental cost of salination or soil water waterlogging problems that are associated with irrigation.

In addition, too much water and/or too rapid runoff is also a serious environmental problem in some agricultural regions. The removal of forests on slopes, in particular, encourages rapid water runoff and flood damage to crops and pasture (Beasley, 1972). An estimated $1.3 billion in U.S. crops and pasture, for example, is lost annually by "flood water, sediment, and related watershed damage" (USDA, 1965). This obviously has an impact on U.S. agricultural production.

**Climate**

Climate determines the suitability and availability of cropland for cultivation. Consequently, changes in temperature and/or rainfall may be expected to influence food supplies. These two considerations must be evaluated on two different time scales. Within any given decade there are likely to occur, as aberrations from the norm, irregularities in temperature and rainfall patterns that are capable of either improving crop yields or inflicting enormous damage to agricultural yields. In addition, there are long-term climatic trends that may eventually have major effects on agriculture.

The mean temperature of the Northern Hemisphere reached a maximum at about 1940. Since then temperatures have declined about 0.1°C per decade (Bryson, 1974; Malone, 1974; Bryson and Wendland, 1975). Because a mere 0.6°C drop in temperature shortens the growing season about 2 weeks (Malone, 1974), yields may be substantially reduced in marginal crop growing regions. For instance, in the U.S. corn belt, shortening the critical corn growing season by 2 weeks would result in a yield reduction of nearly 14 bu per acre (Stockdale, Iowa State University, personal communication, 1975).

The increased consumption of fossil energy by a growing industry and a rapidly growing world population may also have an impact on climate and in turn an impact on agriculture. The consumption of enormous quantities of fossil fuels is expected to significantly increase the $CO_2$ content and particulate matter (aerosols) of the atmosphere (Kellogg, 1975; Singer, 1975; Schneider, 1976). Wagener (1976, Institut für Chemie, Julich, Germany, personal communication) projects that the $CO_2$ content of the atmosphere will increase from 300 ppm (normal level) to about 600 ppm by the year 2000. Particulate matter is also projected to increase. The overall result will be a slight warming of the world's climate. If indeed this projection comes about, the combination of the warming effect and increased $CO_2$ will increase terrestrial plant productivity a projected 39% (Wagener, 1976, personal communication). It is expected that the increased plant productivity would increase crop yields, though other factors must be taken into account. *(See Starr in this issue.)*

**Phosphate and Potash Fertilizers**

The major nutrients sustaining the growth of crop plants are phosphorus, potassium, and nitrogen. In the U.S. chemical fertilizer use has grown rapidly during this century and since 1950 applications to crops have increased as much as 16-fold. This large fertilizer use is one of the major reasons for the high productivity of American agriculture.

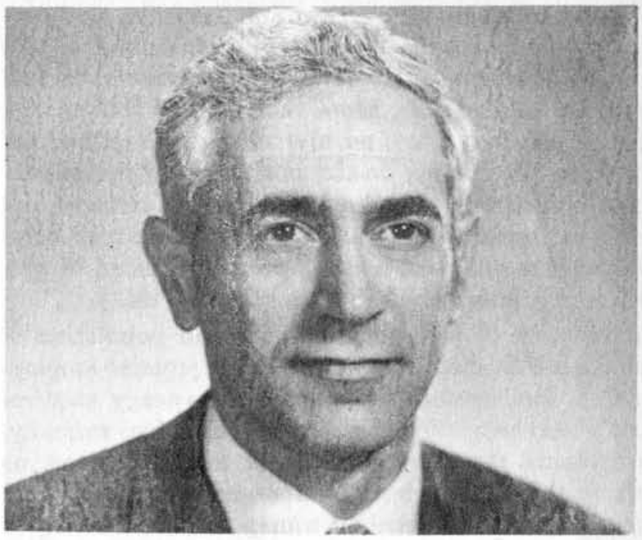
World reserves of phosphate and potash mineral deposits are large but, as with most other mineral resources, are unevenly distributed throughout the world. North America seems well endowed with both. Because of ample supplies, the United States uses large amounts in contrast to other nations, and will probably be able to continue this practice.

**Pesticide Benefits and Risks**

An estimated 1.1 billion lbs of pesticides are currently being applied annually in the U.S. (Pimentel, 1976). Pesticide use is expected to continue to increase and by the year 2000 the quantity applied may well reach 2 billion lbs. Although large amounts of chemical pesticides are used, the dominant means of pest control in the U.S. is bioenvironmental pest management (bioenvironmental controls for pests are employed on about twice as many acres as pesticidal controls (Pimentel, 1976). In spite of all pesticides and bioenvironmental (nonchemical) pest controls employed today, pests (insects, pathogens, and weeds) destroy more than a third of all crops grown in the U.S. (Pimentel, 1976).

Pesticides contribute significantly to reducing pest problems in agriculture and protecting the health of humans. Pesticides, however, also create serious environmental and health problems. For example, pesticide use in the United States results in about 14,000 human poisonings annually (about 200 fatalities) (EPA, 1974).

In addition, beneficial biota are often destroyed following the normal use of pesticides (Pimentel and Goodman, 1974). Natural enemies of pests are often



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eliminated with routine pesticide use and sometimes outbreaks of other pests occur when their prime biological control has been exterminated (van den Bosch and Messenger, 1973). When this happens added pesticide is usually required to control the new pests. Not infrequently this results in the treated pest population evolving pesticide resistance. More than 250 species of pest insects and mites are estimated to be resistant to pesticides in the United States today.

**Energy**

The use of energy to manipulate and manage the ecosystem is one of the important factors responsible for the rapid growth of the U.S. population. Note that the exponential increase of human numbers directly coincides with the use of fossil energy on a world-wide basis (Figure 3). Energy has been used to improve public health, to increase food production, to improve food storage and processing, and to distribute food.

Of particular concern is the fact that U.S. energy consumption has about doubled during the past 20 years (Darmstadter et al, 1971). This rapid increase in energy consumption reflects a life-style highly dependent on energy, with the result that known fossil fuel supplies are rapidly being used up. *Known world reserves* of petroleum and natural gas are expected to be more than half depleted within the next 25 years, and more than half the coal reserves are estimated to be depleted about the year 2100 (Hubbert, 1972). Note that this is about the same time the world population is projected to reach its maximum density of 10 to 16 billion.

U.S. agricultural output is highly dependent upon large expenditures of energy. For example, the production of a hectare of corn in the United States requires the equivalent of about 80 gallons of fuel (Pimentel et al, 1973). More than half of this energy input is attributed to fuel and nitrogen fertilizer expenditure. Of course, on the positive side the substitution of machinery for human labor has reduced the man-hour input to only about 6 to 9 hours per acre, compared to 463 man-hours per acre required to produce corn primarily by hand labor (Lewis, 1951).

If we were to feed the current world population of 4 billion a U.S. diet (high calorie/high protein) employing U.S. food system technology, the energy requirement would be 5,000 billion liters of fossil fuel annually. To estimate the energy needs of the future, let us assume the known petroleum reserves will be used solely for food and none for transportation, heating or cooling. Then our known reserves could feed 4 billion people for a mere 13 years (Pimentel et al, 1975a). Unfortunately, by 2000, we will be faced not only with the need to supply food for an estimated 6 to 7 billion people, but also with the energy needs of diverse sectors of the world economy other than those involved with food production. *(See Wilson Clark in this issue.)*

**Alternatives for Crop Production**

With current and future shortages of land, water and energy for crop production, alternatives for the management and use of these resources will be needed in the U.S. and world. Soil conservation in agriculture would benefit if agricultural practices shifted toward a greater use of crop rotations, strip cropping, contour farming, terracing (where needed) and cover crops during the nongrowing season. "No-till" cropping also has significant advantages in protecting soil but has the associated problem of increased pests that requires more pesticides than conventional tillage.

Many of the practices that conserve soil also conserve moisture. These practices include crop rotations, strip cropping, contour farming, terracing and "no-till" culture. With water shortages in the U.S. and other parts of the world taking place, water conservation in agriculture should receive greater attention as an agricultural alternative in the future.

Alternatives for reducing energy inputs are numerous but there are costs associated with these alternatives. Labor, for example, is a resource that is in abundant supply (although not always distributed where needed) and will become more abundant in most of the LDC's as the world population continues to increase. Hence, every effort should be made to make effective use of this labor within viable economic constraints. Corn can be produced primarily by hand and requires about 1,144 hours of manpower. In the U.S. mechanized corn production only requires 17 hours of manpower input per hectare. To increase the labor input requires careful consideration of both the economic and social aspects of the problem. The standard of living is influenced when raising corn employing 17 hours per hectare compared with 1,144 hours per hectare. For example, a U.S. grower with current crop production technology can manage about 50 times more corn than a farmer producing corn by hand. Thus the U.S. grower has a higher production rate and higher income.

Employing manpower, however, does have advantages and especially if large numbers are out of work. Manpower based upon a kcal output input ratio can do the same farm work using less energy than machinery. For example, the application of herbicides employing a tractor and sprayer requires about 4.7 liters of petroleum (4,700 kcal per hectare) whereas if applied by hand sprayer the labor input is only about 740 kcal per hectare (Pimentel et al, 1973). Other hand operations also are more efficient than many machine operations. Since there should be abundant manpower available as the human population continues its rapid growth, means must be found to make effective use of this manpower for the total good of society.

Both machinery and fuel comprise a large energy input in U.S. corn production. Certainly the use of relatively small, minimum-powered tractors offers opportunities for increased energy efficiencies in grain production. Also, the use of draft animals (water buffalo, oxen, bullocks and horses) offers some energy advantage as well as other advantages over tractors under certain conditions. For example, for one hour's work a tractor requires about 90,000 kcal of fuel whereas a water buffalo expends only 800 kcal per hour. Of course, a tractor can do from 10 to 100 times the work of a water buffalo in one hour.

Buffalos require daily care (labor) but they also produce milk and meat. Also tractors and buffalos utilize different fuels. Tractors use expensive fossil fuels whereas buffalos can be fed rice straw and other forage crops. In addition, buffalos can be fed grass and vegetation growing along paths, streams and other noncrop land. The rice straw and other vegetation that passes through the buffalo is still valuable as fertilizer. The milk produced by buffalos is extremely valuable as a protein source for people on minimum diets.

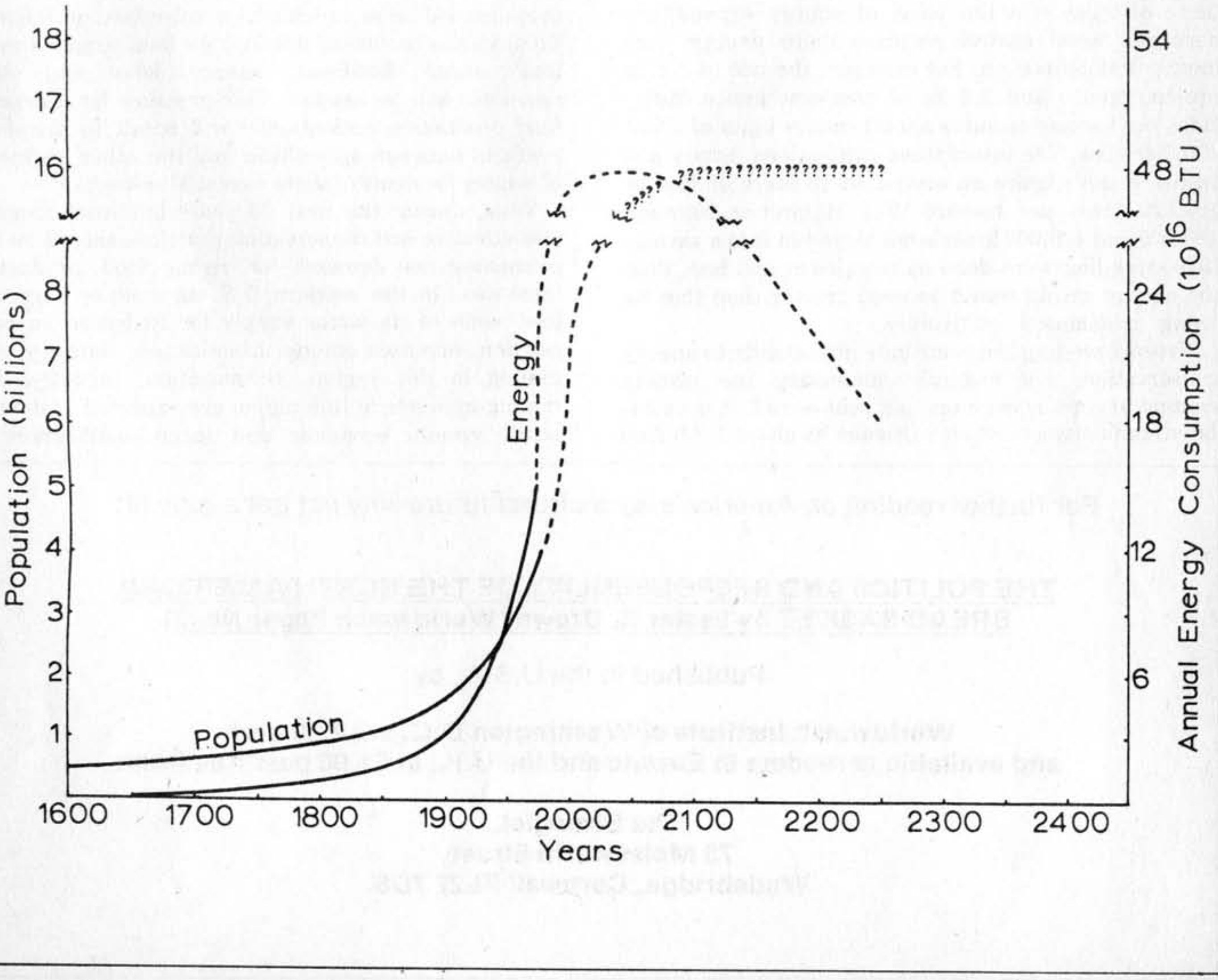
The single largest input in corn production in the United States as mentioned is fertilizers (NPK). Nitrogen, of course, is the largest input (Table 3). Thus, as energy supplies decrease other potential fertilizer sources such as livestock manure, some agricultural wastes and other organic wastes (leaves) can be utilized. It is now estimated that about 40% of the livestock manure that is applied is wasted because of the method of application. That is, the manure is applied during the winter and other nongrowing periods of the crop and during this time the nitrogen, in particular, is leached from the manure and is washed into streams and lakes causing pollution problems. Of course, to place this manure in large holding tanks would in itself require additional energy and would cause some difficulties in the spring. During the spring, the manure would have to be applied to the land and, of course, this is the time of year when the farmer is extremely busy turning the soil and planting his crop. Hence, it is not a simple answer attempting to make effective use of animal manure. The quantity of manure that must be applied per acre is relatively large if it is to provide the correct amount of nitrogen, phosphorus, and potassium. For example, to have about 125 kg of nitrogen per acre, 35 kg of phosphorus and 67 potassium, these needs would have to be supplied in one year by 3 cows, or 22 hogs or 207 chickens (Benne et al, 1961; Dyal, 1963; Loehr and Asce, 1969; McEachron et al, 1969; Surbrook et al, 1971). Of course, manure has added advantages beside adding nutrients to the soil. Manure adds organic matter which increases the number of beneficial bacteria and fungi in the soil. It makes plowing easier, improves the water holding and percolating capacity of the soil, reduces soil erosion and improves the ratio of carbon to nitrogen in the soil (Andrews, 1954; Cook, 1962; Tisdale and Nelson, 1966). The same advantages result from the use of crop and other organic remains.

It may be possible to plant legumes between corn rows in late August and plow this green manure under in the early spring to add nitrogen to the soil. For example, in the northeast United States Sprague (1936) reports that seeding corn hectares to winter vetch in late August and plowing the vetch under in late April yielded about 150 kg of nitrogen per hectare. It should be pointed out that this study was conducted during the time when corn densities were about one-half current corn densities. A question that needs answering is, what impact the high corn densities have on the light reaching the corn rows? If the vetch would survive, there is also the question about the reduced nitrogen yield per acre under these less favorable growing conditions for the vetch in the dense corn.

With rice production, Ghose et al, 1956 has reported that both rice and a legume, *Sesbania aculeata*, can be planted at the same time in the paddy; as the rice crops mature the legume is finally uprooted and worked into the soil by hand. This adds about 96 kg of nitrogen per hectare during this 8 weeks of growth of the legume.

To plant winter vetch or any other legume in a crop requires energy to produce the seed, apply the seed and to plow under or work the green manure into the soil. It should be pointed out, however, that green manures do offer another advantage in addition to saving energy and that is green manures protect the soil from wind and water erosion during the non-growing season of the soil. In addition, they add

**Figure 3. Estimated world population numbers (———) from 1600 to 1975 and projected numbers (- - - - - -) (??????) to the year 2250. Estimated fossil fuel consumption (———) from 1650 to 1975 and projected (- - - - - - ) to the year 2250 (after Pimentel et al., 1975).**



organic matter to the soil.

Another aspect of the use of commercial fertilizers is methods of application and timing of application. A careful analysis, for example, is needed to determine when is the best time to apply nitrogen fertilizer and how it should be located relative to the growing plant to be effective. Certainly in the midwest during the early 1970s when nitrogen fertilizer was being applied during the fall and winter months, this resulted in a serious wastage of nitrogen. During the fall and winter months nitrogen was leached and washed from the land. The lost nitrogen was ineffective for crop production and was polluting streams and lakes.

In addition to investigating how fertilizers should be applied we should determine how much is needed by the crop. The quantity of fertilizer that is applied can affect the actual growth of the crop and one can apply too much as demonstrated by Munson and Doll (1959). When more than 250 kg of nitrogen per hectare is applied to corn the nitrogen may become toxic to the crop, thus reducing yields.

Crop rotations offer several advantages. First of all crop rotations can reduce pests such as insects, diseases and weeds. In addition, rotating corn with other crops can significantly reduce the amount of pesticide that is used. Rotations also reduce soil erosion and water runoff.

Weeds can be controlled effectively by mechanical cultivation, herbicides, hoeing or combinations of all three of these. On the basis of energy expenditure herbicide weed control requires more energy than mechanical cultivation. For example, the use of 2.2 kg pre-emergence and 2.2 kg of post-emergence herbicides per hectare requires a total energy input of about 420,000 kcals. The use of three cultivations (rotary hoe twice) would require an estimated 18 liters of fuel or 180,000 kcals per hectare. The difference between 180,000 and 420,000 kcals is not large but it is a saving. If the weeding were done by manpower and hoe, then the energy saving would be even greater than that by using mechanical cultivation.

Cereal breeding can contribute importantly to energy conservation. For example, increasing the protein content of corn by even one per cent would, it is calculated, reduce the need for soybeans by about 1.8 billion kg annually in the United States (Sprague, 1955). Some increased energy would be necessary such as nitrogen to produce corn cultivars that had a higher protein level. But certainly the benefits would more than offset any of the costs.

Breeding corn and other cereals for insect disease and bird resistance would itself reduce the energy inputs of pesticides. At the same time this would reduce problems from pesticide pollution. Also less energy would be needed for corn production if new corn varieties could be developed for faster maturity, reduced moisture content, greater water use efficiency and improved fertilizer response.

Earlier it was mentioned that irrigation is an energy intensive operation. Although employing irrigation to increase the world supply of arable land may be impractical, there are circumstances under which we can improve water management for crops. For example, utilizing appropriate contours in terracing, water can be conserved for crop use. It is also possible to design appropriate water catches to slow the runoff of water and keep it available for crops. This same principle can be utilized by appropriate mulches and leaving crop remains on the surface of the land.

**Conclusion**

With the U.S. population increasing about 24% between now and the year 2000 and the increased need for food exports to pay for rising oil imports, much pressure will be on agriculture to raise food production. To meet the increased demand for food supplies more land, water, fertilizers, energy, labor and other resources will be needed. This pressure for increased food production undoubtedly will result in increased conflicts between agriculture and the other segments of society for many of these essential resources.

Thus, during the next 25 years land-use planning and effective soil conservation practices should be implemented as demand for rising food production increases. In the western U.S. agriculture may well lose some of its water supply for irrigation as competition increases among urbanization, industry, and mining in this region. Urbanization, industry, and mining interests in this region are expected to demonstrate greater economic and social justification for water than agriculture.

Energy conservation will have to increase on farms. Some of the conservation steps will include: (1) making more effective use of commercial fertilizers and livestock manures and substituting some "green manures" for fertilizers; (2) utilizing tractors, other farm equipment and fuel more efficiently than presently; and (3) some increase in the use of human labor.

In all probability the amount of irrigated land in the arid west will not increase much in the future as energy becomes short in supply and its price increases. Also the trend will be to increase market gardens close to the large cities on the East Coast. In the future it will be difficult to produce lettuce, for example, in the west and ship this lettuce across the nation. To ship a one pound head of lettuce (about 50 kcal) by truck requires about 1150 kcal of fossil energy (Pimentel and Terhune, 1977).

Food will become a more important resource in the United States, and the proportions of U.S. incomes spent for food will gradually increase in the future. The role of agriculture in the society and economy will also become more important. Agricultural incomes should improve and attract a larger proportion of the U.S. labor force into agriculture.

As agricultural production rises and production technology intensifies, the problems of environmental pollution can be expected to intensify. Probably the major agricultural pollutant will be pesticides, closely followed by fertilizers. Hopefully the pesticide use problem will encourage research to develop effective bioenvironmental (nonchemical) controls that minimize environmental pollution.

As priority conflicts arise between agriculture and the other sectors of the social and ecological system, environmental systems management of resources will have to be developed for agriculture.

A systems management approach for agriculture will help integrate the various production technologies employed in agriculture. This management will focus on conserving and effectively utilizing U.S. natural resources and will reduce pollution and preserve the essential resources for future generations.

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# THE ROLE OF CLIMATE IN AMERICAN AGRICULTURE

## Past, Present and Future

by

**Thomas B. Starr**

The dynamic nature of the earth's atmosphere has always had dramatic impact on human activities. Throughout history, extremes of hot and cold, drought and flood, and various forms of violent weather have wreaked havoc on the agricultural systems that we depend on for food. Whether they have been technologically primitive or advanced, small in spatial scale or global, these systems have always lain helplessly and mercilessly exposed to the vagaries of the weather. It is a virtual certainty that they will remain so exposed in the future, that crop failures will occur, and that many thousands of human beings will die of starvation and malnutrition-related diseases as a consequence. The only uncertainties that exist regarding this grim scenario are the same ones that have haunted the human species for millenia; we do not yet know where and when these tragedies will occur, or how extensive they will be.

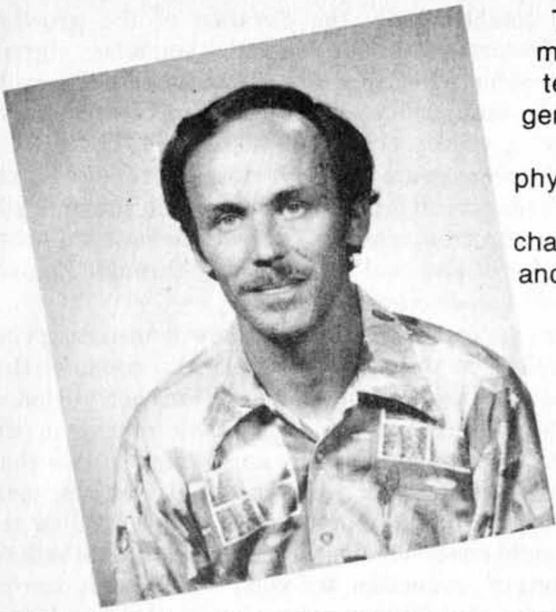
The vulnerability of grain agriculture to weather variability stems from the fact that no less than four months are required to complete the production cycle from seed planted to seed harvested each year. For winter wheat, the major food grain grown in the United States, the cycle is even longer, lasting about nine months, since it is planted early in the fall, lies dormant over the winter, and is not ready for harvest until early summer. Once the decisions concerning which crops, which varieties, and how much of each to plant are made, and once the planting operation is completed, there remains little opportunity for adjustment to changing conditions. Beyond this point, the agricultural system is locked in by its planting commitment, and for the most part must passively accept whatever weather conditions the growing season offers. During such a long time period, practically anything can happen, and something usually does.

Heavy rainfall and high relative humidities contributed to hybrid corn blight in 1971 and soybean failure in 1972 in the American midwest, and to harvest difficulties in the hard winter wheat belt in 1972. Excessive rainfall at planting time followed by high temperatures and drought severely reduced spring wheat yields in 1974. Early frosts ruined much of Wisconsin's corn crop in 1975. Extreme drought ruined corn crops in Iowa and Wisconsin, spring wheat in North and South Dakota, and winter wheat in Kansas and Nebraska in 1976. The litany of such weather induced crop failures is long, and the lesson should be clear: ideal weather conditions for an entire growing season are highly improbable.

Let us illustrate this maxim with a simple example. Divide the spring wheat growing season into six approximately equal phenological time periods: preplanting, planting-germinating, emergence-jointing, heading, soft-dough, and ripening-harvest. Assume that an equal probability three-way classification (above average, average, below average) of the mean temperature and total precipitation during each of these periods provides a perfect characterization of the spring wheat environment. Further assuming that these variables are statistically independent, it follows that there are $3^{12} = 531{,}441$ distinct growing season weather sequences, each equally likely, and each of which *a priori,* can result in a distinct yield value. The ideal sequence is just one of these, and hence the probability of observing the ideal sequence in any one year is $1/531{,}441 = 0.0000019$, an exceedingly small number.

Parenthetically, it is interesting to note that the average or ''normal'' sequence is also just one of these sequences, with the same infinitesimal probability of occurrence as the ideal sequence. Yet, in preparing production forecasts at various times during the course of the growing season, the United States Department of Agriculture had until 1976, assumed ''normal'' weather conditions for the remainder of the season. This is about as poor an assumption as could possibly be made, since the above illustration clearly demonstrates that the growing season is virtually certain to be abnormal in at least some respect. It is gratifying that the election of 1976 produced a new Secretary of Agriculture who has insisted that this unrealistic assumption be dropped from the Department's forecast procedure.

Still, in spite of the minute probability of having highly favorable growing season weather, it is obvious that American agriculture has flourished in the three



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decades since World War II. Yields of spring wheat, winter wheat, and corn have nearly tripled, with the most dramatic increases occurring from the late 1950s through the 60s. In fact, American agricultural problems in these decades revolved around how best to deal with surpluses, not deficits.

**A Remarkably Favorable Period**

The introduction of new high yielding varieties and increased use of inorganic fertilizers, herbicides, and pesticides are usually credited for those increasingly bountiful harvests. But weather also played a crucial role. In a recent study of corn yields over the last 100 years, James McQuigg discovered that the fifteen year period from 1956 to 1970 was characterized by remarkably benign growing season weather, i.e. weather which was very close to the ideal sequence, with little variability from year to year. He estimated, in fact, that the chance of such a long run of highly favorable years recurring is less than one in ten thousand! Again, the lesson should be clear: we have been very lucky; we have been blessed with highly favorable growing seasons for an unusually long period of time, and we should not expect to be so fortunate in the future.

Did we take excessive advantage of our good fortune during this period? Consider the fact that the slow process of traditional methods of selection tends to produce crop plants which are well-adapted to the full range of weather conditions that occur over the long term. The genetic diversity of these plants does not guarantee extremely high yields in good years. Rather, it minimizes the probability of complete failures in bad years. The response function of such plants to the natural variability of weather is thus broad and relatively flat, with only extreme conditions having significant impacts on yields.

In the 1950s and 60s we enthusiastically applied modern plant science to the selection process, choosing from the naturally diverse gene pool only those strains which perform best under very carefully controlled conditions and which respond significantly to heavy doses of inorganic fertilizers, provided that soil moisture is plentiful and temperatures are optimal. The response function of the new high-yielding varieties has thus become very narrow and highly peaked near optimal weather conditions. Under non-optimal conditions, these varieties are often outperformed by the traditional types. In short, we have finely tuned the crop production system to the favorable weather conditions of the 1950s and 60s, the likes of which may not recur for hundreds of years! In addition, the adoption of high yielding varieties has required a heavy non-interruptible flow of inorganic fertilizers, herbicides, and pesticides to maintain high production levels. All of these inputs require non-renewable, non-recyclable, non-substitutable resources for their production, notably oil, natural gas and phosphate rock. What will happen to modern agriculture when these are exhausted? Have we set ourselves up to for the fall?

**American Grain Agriculture**

It is appropriate at this point to look in slightly greater detail at the response of American grain crops to contemporary variations in growing season weather conditions. This will provide a rational and objective basis for assessing the impact on American agriculture of some of the climatic changes that have occurred in the last thousand years, and as they are envisaged to occur over the next fifty years. We shall focus on the three principal food and feed grain crops grown in the American Great Plains: spring wheat, winter wheat, and corn.

The spring wheat region, the northern half of the winter wheat region, and the western half of the corn belt lie in an area of the Great Plains extending south-eastward from the Rocky Mountains which is known for its dry climate. It is a dry region because the principal northwesterly flow of air over the Rockies is subsident on the leeward side, and this produces a dry mountain "shadow" downstream to the southeast. In the winter, with expanded and vigorous westerly flow and frequent polar outbreaks, cold dry air dominates the region, producing a precipitation minimum. For example, a total of only 90 millimeters of precipitates can be expected to fall in the spring wheat region over the six month period from October through March. In the summer, the westerly flow is less vigorous and contracted toward the North Pole. This permits frequent northward intrusions of moist air from the Gulf of Mexico which penetrate the Great Plains and bring rain. A total of 90 millimeters of precipitation can be expected to fall in the month of June alone in the spring wheat region. Still, this is a large amount only in contrast to what occurs in the winter months.

Over 80% of the American spring wheat crop is produced in North Dakota, South Dakota, northeastern Montana, and north western Minnesota. Approximately seven million hectares are planted to spring wheat in this four state region each year and about fourteen million metric tons are harvested in good years. Planting begins in mid-April and is usually completed by mid-May. Planting time is largely dictated by April temperature and moisture conditions. It is delayed when excessively cold and/or wet conditions prohibit planting operations. Harvesting starts in early August and is usually completed by early September. The weather regime during the growing season is part of an annual cycle which exhibits the 90 millimeter total monthly precipitation maximum in June mentioned above and a 21 degrees Celsius mean monthly temperature maximum in July.

What kinds of growing season weather variability about the mean annual cycle is spring wheat most sensitive to? The response of all plants to changes in their micro-environments is conditional in nature. A *single* specific set of environmental conditions at a given time will have *different* effects on total biomass production or yield, either beneficial or detrimental, and to varying degrees, depending on the plant condition and stage in its life-cycle at that time. Of course the condition of plants at a given time depends on the continuum of their past micro-environments, and hence plant response is *conditional* on its entire past history. Although this conditionally creates an awesome complexity which is exceedingly difficult to treat in causally deterministic fashion, it also provides a clue which helps to answer the above question.

The final product, be it total biomass or just the seed yield, represents an integration of the conditional plant response over the entire life-cycle. Since the conditional plant response at any instant is itself an integration of past events, the biomass or seed yield should be insulated from rapid short-duration environmental fluctuations. Such fluctuations, provided they are not too extreme in amplitude, are averaged out in the integration process. The exceptions to this, of course, are the very extreme events: the early morning frost that can freeze a crop out in a few hours, or the record mid-afternoon maximum temperature that can literally cook the crop in the field. Keeping these exceptions in mind as special cases, one is led to conclude that crop yields should be most sensitive to weather variability having characteristically long time scales, perhaps comparable to the full life-cycle itself: season-long precipitation deficits or surpluses, or season-long high or low temperatures, or combinations of both.

In a recently completed study of American spring wheat, I found that the anomaly sequence to which yield is most sensitive is characterized by a dry pre-planting period followed by a cold and dry April and hot and dry conditions for the duration of the growing season. Occurrence of this anomaly sequence signals serious trouble for spring wheat production. Years in which this sequence was an important component of the growing season (1933, 34, 36, 37, 54, 59, 61, 70, 74, and 76) were years in which yields were ten to sixty percent below trend levels. Years in which the opposite sequence occurred, namely, a wet pre-season, warm and wet April, and cool and wet May through August, produced bumper crops.

To gain an appreciation of just how sensitive spring wheat yield is to this anomaly sequence, consider that if the temperature and precipitation for each period of the growing season depart from their means in the directions mentioned above by an average of less than one-third of their respective standard deviations, yield drops by two quintals per hectare, about 10% of the highest yield observed. This is equivalent to 1.4 million metric tons of production, the value of which (at current $2.50 per bushel futures prices) is approximately 128 million dollars, a rather impressive figure.

One can ask one further question regarding this anomaly sequence: how often is it likely to occur? In the 1930s, it was prominent in four out of ten years; in the 1940s, not at all (the 40s were dominated by cool, wet growing seasons); in the 1950s, twice; in the 1960s, only once; and in the 1970s, three times so far. When will it occur again?

The American winter wheat region starts where spring wheat stops, extending southward through Nebraska, Colorado, Kansas, Oklahoma, and the northern third of Texas. About twelve million hectares are planted to winter wheat each year in these states, and good years result in total production of approximately twenty-four million metric tons.

Winter wheat is the classic example of a plant with a vernalization requirement. Flowering is inhibited unless the plants have been exposed to an extended cold period after emergence. This is an interesting adaptive strategy which protects against premature flowering in the fall which would lead to extensive freeze induced loss. Winter wheat is planted early in the fall, germinates and emerges in late fall, goes into dormancy over the winter, and then enters a rapid growth phase in the spring. Harvest begins in May in the southernmost states. The same combine machines that harvest in Texas in late May march north through the region to finish the job in Nebraska in June and July.

There is a mean annual cycle in temperature and precipitation with the peak in temperature occurring after the growth season is over. The highest mean monthly temperature during the growing season occurs in June and averages about 23 degrees Celsius. The precipitation peak occurs in May with an average total of about 81 millimeters. As in the spring wheat region, the minimum in precipitation occurs during the winter months, which average only 20 millimeters total per month.

Again, we can ask the following question: What type of growing season departures from the mean annual cycle is winter wheat yield most sensitive to? Recent research on this question by this author and independently by Patrick Michaels indicates the following: a dry pre-planting period, warm and dry winter months, followed by hot and dry conditions in March and April, and wet May and June periods is the worst possible anomaly sequence for winter wheat yields. A dry pre-planting period implies reduced soil moisture and poor germination. Warm and dry winter months result in excessive moisture stress, particularly when snowcover is deficient. A hot and dry spring slows down critical rapid growth; when water stress levels reach a threshold limit in wheat plants, photosynthesis is curtailed as the leaves seal shut to prevent further dessication. Moreover, respiration, which consumes the products of photosynthesis, accelerates at higher temperatures. Finally, wet May and June conditions make harvesting operations difficult. As in the case of spring wheat, if temperatures and precipitation during each period of the season depart from their means in the directions mentioned above by an average of less than one-third of their respective standard deviations, yield drops by slightly more than two quintals per hectare. This is equivalent to 2.4 million metric tons of production, with a current value of 220 million dollars. Bad years, years in which this type of anomaly sequence was prominent, occurred in 1934, 35, 36, 39, 50, 51, 53, 55, 56, 63, 67 and 76. It is not inevitable that more will occur in the future?

The American corn belt is contiguous to the spring and winter wheat regions, running eastward from them through Iowa, Illinois, Missouri, Indiana and Ohio. The corn production of this five state region is truly awesome, averaging some 76 million metric tons per year, well over half of the United States total and over one-fourth of the entire world's production. About 13 million hectares are planted to corn each year, with good years resulting in yields of about 60 quintals per hectare. With yields roughly three times as high as those of wheat, and with the price per bushel only slightly less than that of wheat, it is not surprising that corn, even though it is primarily a livestock feed grain, has pushed wheat out of the prime agricultural land of the corn belt and into the drier states farther west.

The annual cycle of temperature and precipitation in the corn belt is quite similar to that of the spring wheat region, except that temperatures and precipitation are on the average higher in all months. The average peak precipitation of 109 millimeters occurs in June, with July and August receiving 91 and 86 millimeters respectively. The mean monthly temperature peaks at 24.3 degrees Celsius in August, with June and July having 22.2 and 23.5 degrees Celsius respectively. Planting occurs in May and harvest in September.

A 1969 study by Louis Thompson concludes that July is the crucial month for corn yields. It is during this month that corn starts its "grand period" of growth. The average July is both too hot and too dry for corn. Thompson notes that a 2 degree Celsius positive departure from the mean July temperature drops yield by about 1.3 quintals per hectare. A 20 millimeter negative departure from the average July precipitation drops yield by another 1.5 quintals per hectare. Together, these hot and dry conditions in July alone result in a loss of 3.6 million metric tons of production, conservatively valued at 285 million dollars. Thompson also found that June and August temperature are important to corn yield, and that above normal temperature in those months resulted in further depressed yields. Years with poor yields, 1931, 1934-37, 1953-55, were all years in which July temperatures were well above the long term mean, and the really good years, from 1959 through the 60s, the period when yields sky-rocketed, were characterized by cool, moist Julys.

Before proceeding, let us summarize the analysis of the dependence of contemporary crop yields on weather variations in the Great Plains. For all three crops, the mean conditions during the critical stages of rapid growth are both too hot and too dry. In fact, mean temperature is lower than optimum only in the planting-germinating period for spring wheat in April. Further, at no time except during the harvest period for winter wheat in May and June is it advantageous to have drier than mean conditions. The lesson is clear: the American breadbasket is highly vulnerable to the specter of drought. In evaluating past climates and projected future ones, this fact must be kept in mind.

**The Indians of Mill Creek**

In 1968, Reid Bryson, a climatologist, and David Baerreis, an anthropologist, published a brilliant interdisciplinary study of the Indian Mill Creek culture of northwestern Iowa. The sites of the Indian villages lie on a climatically sensitive ecotone, or transition zone between two natural plant communities. To the west, in Nebraska and South Dakota, now winter and spring wheat producing states, was steppe-like short grass prairie, a drier area then, as it is today. To the east, in Iowa and Illinois, now corn producing states, was tall-grass prairie, dependent on more rainfall then, as corn is today. The Indians were both hunters and farmers. They hunted bison, which eat grass, and deer, which browse on trees. They grew corn as well.

Bryson has previously studied the climatic causes of shifts in the northern border of the North American boreal forest. In a 1966 paper, he established that this border had been pushed southward by the last major expansion of the Arctic, which started about the beginning of the thirteenth century. He was also aware of data published by Hubert Lamb in 1966 which indicated a marked shift toward mild winters in Europe, beginning about 1150 A.D., and lasting a couple of centuries or more. Integrating these pieces of information into a coherent picture of the hemispheric circulation pattern, he reasoned that an expansion of the westerlies could produce both effects, and further, should produce drought in the Great Plains simultaneously. Analyzing modern periods of expanded westerlies, he confirmed that such a circulation pattern was possible, since it had actually occurred. Furthermore, it resulted in reductions of July precipitation by from 25 to 50 percent at the Mill Creek sites! But they were not the only locations. July precipitation was reduced by the same percentages in all of Iowa, the southwestern half of Illinois, the northeastern half of Missouri, and substantial portions of North and South Dakota, Montana, Nebraska and Kansas.

Armed with this prediction of drought, Bryson and Baerreis set about analyzing plant pollen and the fragmentary remains of the Mill Creek culture for the confirming evidence; and they found it. Tree pollen indicated a sharp transition from oak group to willow group dominance about 1200 A.D. Prairie pollen held the same signal, an abrupt transition from a high percentage of composites — which include sunflowers and asters — to a high percentage of grasses, which have smaller leaf surfaces and require less moisture. Deer bones dropped from prominence in the trash pits, while bison bones increased in percentage. The total number of bones decreased significantly as well. Potsherds, indicative of the pottery required to store, cook, and serve corn, also declined, but not as soon as the animal bones. The Indians held out for quite a long time, but by 1400, they were gone. In his new book, *Climates of Hunger*, Bryson states:

> The Mill Creek farmers, and their contemporaries throughout the plains, were not victims of just the biblical seven years of famine, or even of a human generation of bad years.
>
> The changed climate that brought the downfall of the plains farmers probably lasted about 200 years. Our records from Europe, the plains themselves, and elsewhere show stronger westerlies between about 1200 and 1400. Then. . . the pattern switched back. Rains must have come again to the plains. In fact, it appears that the final decline of the Mill Creek people came just before the westerlies changed back again and more rains came to northeastern Iowa.
>
> If they had only held out a little longer, their culture might have made it through. Still, they didn't do badly. How would we, the civilization of twentieth century plains corn farmers, have done?

Not all of the past climatic history of the Great Plains is as foreboding as the period from 1200 to 1400 A.D. In a 1970 study of the differences between the mid-nineteenth century climate and modern normals, Eberhard Wahl and Theodore Lawson found that at least in some respects, the growing season then had actually been more favorable to crop yields than it has been recently. For example, in all of the spring wheat region, April-June precipitation in the 1850-1870 period averaged about 10% more than the 1931-1960 average values. Coupled with this were April-June temperatures about 0.5 degree Celsius cooler than modern values. The cooler spring extended through the corn belt as well, and these conditions would be beneficial to all three crop yields. July and August temperatures averaged about 0.5-1 degree Celsius cooler as well. And July and August precipitation increased slightly in the eastern half of the corn belt, and by as much as 10-20 per cent in the western part of the winter wheat belt. September-October temperatures averaged 1-1.5 degrees Celsius cooler throughout all three regions and precipitation was 10-20 percent higher. This is beneficial to winter wheat, but would shorten the growing season for corn.

In summary, the 1850-1870 period was cooler and moister than the 1930-1960 period throughout most of the three crop regions and for most of the growing season. While a return to such conditions might force a redistribution of crops planted in the Great Plains, and in particular might force the planting of shorter growing season corn, the overall effect is generally favorable to production. We turn now to what the future holds in the way of climate for the American breadbasket. Is it the 200 year drought of the 13th-15th centuries, or the cool moist conditions of the 19th century, or more of what we have had in the last twenty years?

### Climates of the Future

Proposed causes of climatic change fall into two general categories: (1) internal fluctuations within the atmospheric circulation system, and (2) external influences, such as continental drift, changes in the energy output of the sun, changes in the earth's reflectivity, in its orbital parameters, and changes in the composition of the earth's atmosphere.

The first category is the subject of a massive research effort which uses elaborate computer models of the general circulation of the atmosphere to make highly detailed forecasts. Such models, basically by brute force, integrate the fundamental equations of motion of parcels of air through time from a set of observed initial conditions. The result is a series of snapshots of the state of the atmosphere, usually on the order of twenty minutes apart, which depict how the atmospheric circulation evolves through time. The models work quite well for lead times of a few days or so, but beyond about two weeks, they are virtually worthless.

The problem lies in the nature of the fundamental equations of motion. They are highly non-linear. What this means is that errors in the specification of the initial conditions, or errors in the specification of the atmospheric boundary conditions, or errors in the parameterization of various atmospheric processes, or truncation errors made by the computers themselves during the calculation process, all tend to amplify with time. As the errors grow, the true signal becomes swamped in noise.

Edward Lorenz, in a recent study of the predictability of the detailed instantaneous state of the general circulation, concluded that there was an inherent limit of about seventeen days beyond which the computer models could not be expected to make any meaningful predictions at all. In the summary of that study, he quoted an unnamed meteorologist as having remarked somewhat disparagingly that "one flap of a sea-gull's wing would forever change the course of the world's weather." It is unfortunately all too clear that such approaches to forecasting will have little of value to say about the future prospects of American agriculture for quite some time.

### Sun Spots and Solar Output

In the second category of proposed causes of climatic change, we shall focus on changes in the sun's energy output, changes in the reflectivity of the earth, and changes in atmospheric composition. The first is truly external to the system. The latter two, however, are not, and it is truly ironic that human activity since the turn of the century has been inadvertantly affecting them to such a degree that long range climatic changes may possibly be forecast on that basis alone.

The 11 and 22 year sunspot cycles are well known phenomena. For centuries, people have attempted to link them to an enormous and diverse number of phenomena on earth, everything from business cycles to biological cycles. In particular, attempts have been made to link them to changes in the total energy output of the sun, which has a direct impact on the earth's surface temperature and hence the climate. But cause and effect have not yet been established. Beyond the fact that sunspots are associated with solar flare activity and that this in turn alters the characteristics of the solar wind which the earth passes through in its orbit around the sun, which in turn interrupts radio transmissions and produces brilliant auroral displays, little is known for certain. Still a definite cycle of prolonged droughts has occurred in the Great Plains. The bad periods, 1910-15, 1931-36, 1950-55, and 1970, 74, 76 all coincide quite closely with sunspot minima. Even if the relationship is no more than spurious correlation, even if the droughts are just parts of a quasi-regular internal climatic oscillation, should we not be prepared for the 1990's, and their effects on crop yields, soil erosion, and world food security?

**Dust from Human Activity**

The reflectivity of the earth regulates how much of the energy from the sun is absorbed by the earth's surface, and consequently it is an important determinant of the earth's surface temperature. The reflectivity of the earth changes when vegetation cover grows or shrinks, when snow and ice cover change, when cloud cover changes, and also when the dust content of the atmosphere changes. The dust content of the atmosphere arises primarily from volcanic activity and human activity: industrial smokestacks, wind blowing over open agricultural fields, automobile and airplane exhausts, farm tractors and the fires set by Third World farmers to burn the slash from cleared land. One current estimate of the dust load in the atmosphere, the amount suspended at any one time, is on the order of 30 million metric tons, about evenly divided between volcanic activity and human activity.

Increases in the dust load lead to increases in the earth's reflectivity and to decreases in the amount of energy from the sun which reaches the earth's surface. Thus, when the dust load is high, the earth's surface temperature cools. Evidence of the effects of individual volcanic events on surface temperature is clear. In 1815, for example, the Tambora eruption in Indonesia threw a veil of dust into the stratosphere that made 1816 famous as "the year without a summer." Throughout the middle latitudes of the Northern Hemisphere, temperatures averaged about 1 degree Celsius below normal.

Human activity levels continue inexorably upward in exponential fashion. It follows that the dust load in the atmosphere will continue to rise as well, and if it were the only controlling factor, the earth's surface temperature would continue to decline. On the basis of historical evidence, Reid Bryson and others have argued convincingly that periods of cool surface temperatures are periods of expanded westerlies, such as occurred in the thirteenth and fourteenth centuries, a period of prolonged drought in the American Great Plains. Is this what the future holds in store for us?

The question is complicated by the fact that human activity, primarily fossil fuel combustion, introduces more than dust into the atmosphere. It also changes the atmosphere's chemical composition, by adding vast quantities of sulfur dioxide, carbon dioxide, carbon monoxide, hydro-carbons, and nitrogen oxides. This in turn alters the atmosphere's absorptive and radiative properties, not in the visible and shorter wavelenghts, where most of the sun's energy lies, but in the long-wave infrared region of the spectrum, where most of the earth's heat energy lies. Carbon dioxide, in particular, acts as an insulating blanket around the earth, holding in energy that would otherwise be radiated away to space. This "greenhouse effect," as it has come to be called, tends to make the earth's surface temperature increase as the carbon dioxide content of the atmosphere increases.

Thus, human activity produces effects which tend to counterbalance, or offset each other, at least to some extent. The jury is still out on which, dust or carbon dioxide, will win out. Some experts hold the opinion that we are in for a dramatic warming, sufficient perhaps to melt both polar icecaps, with unimaginable climatic consequences. Others believe that dust will dominate and that, ultimately, we are bound for another glacial age, perhaps even a completely ice-locked planet. The state of knowledge regarding our atmosphere is as yet too imperfect to resolve the question.

There is however, an important lesson in the sensitivity of agricultural production to weather variability in the present, in the climatic history of our planet's past, and in the theories of climatic change for the future. We have finely tuned the system to a remarkably stable and favorable climate in the present. It was not always so, in fact, very rarely so, in the past. The climate theories warn us that the climate, in all likelihood, will be quite different in the future. Is it not prudent to plan accordingly?

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# POPULATION AND IMMIGRATION Compassion or Responsibility?

**by Garret Hardin**

**The population explosion is one of the main causes of world poverty. Fortunately, in the US, as in other industrial countries, human fertility is now declining. This does not mean that the US population will soon be stabilised, for we must also take immigration, especially illegal immigration, into account.**

**Last year, an estimated one million immigrants entered the US illegally, and their numbers are steadily increasing. Because they provide cheap labour and also out of a humanitarian concern for individual immigrants, many have urged that a blind eye be turned to this problem. This, however, we can no longer do. With emigration as a safety valve, overpopulated countries have no incentive to control their population, while, in the US, any gains made by birth-control will be offset by immigration. By giving compassion precedence over responsibility we can only aggravate the tragedy of the Commons.**

Unnoticed by most Americans, 1976 — the Bicentennial year — brought the beginning of a significant shift in attitude toward the problems created by the migration of other people into the United States. In contrast to the discussions of this topic a half century earlier recent attempts to weigh the issues involved have been blessedly humane and carefully reasoned. A high standard of civilized discourse has been set by the physician-president of Zero Population Growth, Inc., John H. Tanton, whose essay "International Migration as an Obstacle to Achieving World Stability" (*The Ecologist,* Vol. 6, No. 6, July 1976) won third place in a nationwide competition on topics related to limits to growth. Those familiar with this article and the personality of the author will recognize how much the present essay owes to Dr. Tanton.

The *net* legal immigration into the United States — in-migration minus out-migration — has been running about 400,000 per year in recent years. With no more data than this it would be easy to dismiss immigration as of little importance: after all, this figure amounts to less than 0.2 percent per year of the resident population of over 220 million. Loosely speaking, one might argue that it would take more than 500 years for such immigration to double the population. This observation, however, is not very acute.

It is important to note the demographic bias of immigration: people in the middle, fertile years are over-represented as compared with the elderly. Before they are culturally assimilated, immigrants contribute more than their share to the supply of new children. Moreover there is good evidence that even when compared with long-term residents of their own age immigrants are unusually fertile.

More importantly, the 400,000 who come in legally are less than half the total number of immigrants each year. It is obvious that the figure for "illegals" cannot be known with any precision, but numerous students of the problem (in government and out) estimate that the true number of illegals is not less than 800,000, and may be more than 1,200,000 per year. This is surely not an inconsequential number. In 1975, the net rate of natural increase — births minus deaths — in the U.S. was about 0.6 percent per year, or around 1,330,000 people in absolute numbers. If the total immigration (legal + illegal) is 1,200,000 it follows that immigration accounts for 47 percent of U.S. population growth. If the higher estimate for illegals obtains the immigrant contribution to population growth is 55 percent. Either of these figures underestimates the demographic importance of immigration because the greater fertility of recent immigrants means that a considerable amount of what is called "natural increase" is actually accounted for by the children of recent immigrants. These children are, by virtue of their birthplace, American citizens, but their assimilation into the culture is more expensive in both time and effort than is the assimilation of children of long-time residents.

In evaluating the significance of immigration one more factor needs to be taken into account: the trend. If the total rate of immigration were remaining steady over the years; or even more cogently, if it were falling, one might dismiss the problem as being practically unimportant. But neither is the case. Although the data on illegal immigrants are not very reliable, there is no real doubt that the trend of illegal entry is sharply upward. The U.S. Immigration and Naturalization Service (INS) estimated 400,000 illegals in 1973, and 600,000 in 1975; in 1976 the Service caught nearly a million illegals and estimated that there were another 1.5 million they did not catch. (The million caught overestimates the catching ability of the INS, for many of these were repeaters; the 1.5 not caught do not, of course, include repeaters.)

The trend is clearly upward, and for easily understandable reasons. Given a reasonable, minimum degree of comfort few peole would choose to leave their native land and move to another one, particularly one where the language is different. It is usually economic necessity that moves people. Impoverished Latin Americans enter largely through the portals of Puerto Rico and the Virgin Islands; immigrants from China and Taiwan come in illegally from Canada into the Pacific northwest; but by far the largest group of illegals is that entering from Mexico, coming across a two thousand mile border stretching from the Gulf of Mexico to the Pacific Ocean.

The economic motivation of the Mexicans is easily understood. The Coordinator General of Mexico's National Population Council has given the 1976 rate of natural increase as 3.8 percent per year — which means an absolute increase of 2.3 million people. This is 73 percent more *in absolute numbers* than the natural increase in the U.S. (though the U.S. population is 3.7 times larger). The unemployment rate in Mexico is estimated to be between 20 and 40 percent (as compared with 8 percent in the U.S.) and the differentials in pay on the two sides of the U.S. — Mexico border, for the same kind of work, is 10 to 1. Farther south of the border Mexicans earn still less. It's no mystery why Mexicans emigrate.

**Collusion in Law-Breaking**

How do Americans view the influx? They are ambivalent. The existence of limits on the statute books argues that we want to restrict immigration, but the massiveness of illegal entry suggests that we don't. How can the contradiction be reconciled? Only by noting that "we" does not always stand for the same group. Who is the *we* who would restrict immigration? And who the *we* who encourages it? If you don't know who the players are in this drama you cannot understand the play.

The most effective players are easy to identify: they are the business managers who think their survival depends on low-paid labor. In the cities this means owners of hotels, restaurants and laundries. In the country it means farmers, particularly those who grow vegetables and fruits that must be picked by hand. The political power of these commercial enterprisers is significantly augmented by that of thousands of householders whose lives are made pleasanter by low-paid domestic help. In San Antonio, Texas, a housewife can get a maid for three dollars a day thus freeing herself to earn three dollars an hour in work outside the home. In Washington, D.C. a scandalous legion of

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Americans employed by the legal government enjoy the low-cost services of illegal domestics.

Without thinking, one might suppose that what is wrong with the policy is the lowness of the legal quota for immigration: why not set it at a higher figure and thus meet the economic "need" for more workers? But this proposal misses the essential point that the illegality is part of the "need". The U.S. has minimum wage laws which are, say the employers, too high. Employers escape the requirement by hiring illegals for the unattractive jobs; the fortunate (and unfortunate) people who take these jobs know that if they inform on their employers they will be turned over to the immigration authorities and deported. From the employers' point of view illegality is an essential part of the system. But in public policy illegality cannot be defended. This point is generally not mentioned by the kind-hearted people who would like to brush the immigration problem aside. Simple and unadulterated compassion might lead one to say that we ought to open wide the doors and let in all who want to come. In fact, no substantial voice urges this policy. Those who call themselves compassionate generally try simply to evade the policy issue. This means, in practice, that they acquiesce in breaking the law.

There is an even larger issue that the "compassionate" avoid thinking about: the tragedy of the commons. Since 1833, when the English economist William Forster Lloyd first pointed out the logical consequences of uncontrolled access to common property, it has been clear that shortages cannot be solved by sharing. Given uncontrolled population growth wealth cannot be shared: only poverty can be shared. Were we to get rid of barriers to migration the gains one people might make by adopting a zero population growth policy would be totally absorbed by in-migration from neighboring nations not committed to population control. Mexico, the most immediate population threat to the United States, merely stands as an example of all nations that depend on the blow-off valve of emigration to solve their population problems; and the United States is merely an illustrative instance of all prosperous countries that have a low rate of population growth. The logic and the conclusions of the argument are general, not provincial.

The nearer we come to the limits of truth the more obvious it is that prosperity can be maintained only if population is contained. This means that a nation that hopes to remain prosperous must insist that its resources are not to be regarded as a commons to be dipped into by the world's poor. Exporting resources without recompense is one way of creating a commons. Importing poor people is another. Both lead to disaster for the rich, uncompensated for by any enduring gain to the poor. Poverty is the consequence of an unfavorable population-to-resources ratio. Technology makes some expansion of the resources component possible — a consideration Malthus missed — but the exponential growth of population can still overwhelm the resource base (which was Malthus' essential point). If we want to help the poor of the world to become self-reliant and reasonably prosperous we must persuade them to bring their population into balance with the resources of their own territory. Dismantling national barriers to create free commons is suicidal. Whether the barriers are liquidated by legal or illegal means is a trivial detail.

What are we to do to keep immigration from creating a ruinous commons? The difficulties can be treated under three aspects: technological, political and educational. Let us take up the easiest first.

**Technological Aspects**

Entry through seaports is easy enough to control. If we are not doing this sufficiently well now, we can do better. Entry by land is a more difficult matter. Our border with Canada is over 3,000 miles long; with Mexico, over 2,000 miles. At the moment — this conceivably could change in the future — the southern border is far more important so let us look only towards Mexico. Can we prevent illegal immigration across a 2,000 mile line?

There are a number of possibilities. First, we might build a wall, literally. Unfortunately, our memories of the events connected with the erection of the Berlin Wall almost preclude our thinking about a wall rationally. At our most restrained we murmur Robert Frost's line, "Something there is that doesn't love a wall." Experience indicates that fences are more acceptable to most people than walls, though even fences evoke some distaste. Better than a visible steel fence is an invisible electronic one. Good surveillance requires a corridor clear of surface encumbrances for a hundred meters or so. This presents no problem for most of the Mexican-American border, which is rather barren desert, but in border cities modifications would have to be made. In any case, the warnings given by electronic devices must be backed up by the prompt movement of personnel to the point of entry. Personnel must be paid for — and this Congress has been unwilling to do on any adequate scale (so the rest of the problem falls into the political category to be taken up presently). But the technical problem of the border can be solved.

The technical problem inside the border also has a solution. This is the problem of identifying people in the United States so that we know whether they are native-born, naturalized immigrants, or illegals. By comparison with Europe America has the slackest of identification systems. Our principal card of identity is the Social Security card, which is printed on cheap pasteboard. It can be counterfeited in the smallest job-printing shop. Worse, it is childishly easy to get an authentic Social Security card. There are people who make a good living furnishing them. Their technique depends on defects in the registration system.

When a child is born in the U.S. that fact is registered in the state of his birth; similarly when a person dies. There is no organizational mechanism for entering on the birth record the fact of subsequent death. Anyone who wants to can get a certified copy of a birth certificate — which need not be his own — by paying a small fee.

At this point the private enterpriser comes into the picture. He reads the death notices in newspapers, following up ones that give the place of birth. If John Smith, born in 1955 in Oskaloosa, Iowa, dies, the enterpriser writes to the appropriate city or state official asking for a copy of his birth certificate, enclosing money for the fee. He can even have several copies if he wishes with no questions asked as long as he pays for them. With birth certificates in hand the enterpriser can now guarantee to furnish anybody who wants it an official Social Security card based on a birth certificate. It's just a matter of matching the sex and approximate age of the immigrant with that of the birth certificate. The fee for a fabricated identity is $50 and up.

There is nothing inherently insoluble about this problem but it would take political action to solve it. Since mobile Americans are inclined to die in a state other than the one they were born in, the bureaucracies of different states would have to be made to co-operate, a difficult task in a nation made up of fifty states that jealously protect what they regard as "states' rights," which include the right to be non-cooperative.

Any political improvement in the system would be nullified, of course, by an identity card that was easy to counterfeit. This problem is pretty well solved now. Beginning in late 1976 the INS started furnishing carefully identified workers with identity cards that are virtually uncounterfeitable. Each card has invisible identification signs that can be picked up only by sophisticated electronic sensors. The card has the user's photo and signature securely embedded in it. In principle, nothing is completely counterfeit-proof, but the new card is believed to be at least as secure as a twenty dollar bill, which should be good enough. Validation of the applicants is the sticky problem. Present plans call for issuing new cards to about

700,000 applicants per year; at this rate it will take nearly six years to catch up with the backlog of legals now holding easily counterfeitable cards of identity. In the process of validation some illegals will no doubt slip through the net, but this will not be a serious matter in the long run if from now on we have an adequate system of patrolling the border.

**Political Aspects**

The best identity card in the world is of no use without penalties imposed on those who evade the system. Penalties imposed on the illegal immigrant are likely to backfire because, however well we understand the tragedy of the commons, our sympathies tend to lie with the particular individual who tries to survive by evading the INS net. Deportation is about the most we will stand for, and even that is hard to tolerate in particularly touching cases. The danger of public revulsion is much less if sanctions are imposed on the employer, if he is fined for having a lax check-off system of his workers. The public sees the employer as fighting for profits rather than survival; his plight does not touch public sympathies deeply.

The public may be willing to impose responsibilities on employers, but Congress must write the necessary laws. For many sessions Congressman Peter Rodino has worked on this problem. He has been successful in the House of Representatives, but none of his bills has surmounted the necessary secondary hurdle, passage in the Senate. Senator Eastland, the chairman of the Senate Subcommittee on Immigration and Naturalization, did not call a meeting of his group from 1965 to 1975, during which time he collected two million dollars for expenses. There is no suspicion of embezzlement; the chairman merely diverted the money to defray the expenses of other committees that he regarded as more important. Finally, under pressure, Senator Eastland did call a meeting in 1976 but nothing came of it.

Eastland, who is from Mississippi, has many friends with large plantations on which illegals work. Their position is reinforced by the owners of hotels and restaurants in the big cities. Despite their public devotion to the free enterprise system these people apparently feel that their businesses cannot survive if they are required to pay legal wages. The pressure a few large business enterprisers can exert on Congress is greater than that of millions of plain citizens. This fact is not peculiar to the immigration problem; it is a general problem of representative government. Private interest groups with concentrated power can all too easily override the much greater but more diffuse public interest.

What countervailing forces can be mustered against this concentration of political power? The most hopeful forces in sight are the labor unions. At the present time the total number of illegals in the country is estimated to be about the same as the total number of the unemployed — about 8 million. The equality of the two figures may be coincidental, but there must be some causal connection between the two. Laborers should be able to see that any addition to the labor force weakens their bargaining power vis-a-vis management. This is true whether the additions are legal or illegal in origin, though illegals constitute the greater threat. This should be obvious, but apparently it is not — at least not to most of the labor leaders. There are a few exceptions. The president of the powerful International Ladies Garment Workers Union has spoken out against illegal immigration. So also has Cesar Chavez, who heads up the United Farm Workers (the UMF); but Chavez's record deserves close examination for the light it throws on a tortuous problem.

The UMF is made up largely of Mexican-Americans working the farms and ranches of the southwest. Most of them are migrant laborers, following the harvesting season northward during the year. For a variety of reasons, organizational and psychological, migrant workers always have more trouble achieving their ends than do workers who stay in one place. Chavez has repeatedly pleaded with Congress to put an end to illegal immigration so that the low wages illegals are forced to accept will not depress all wages.

But Chavez is caught in a dilemma. Though an American, he is part of the Mexican culture and every Mexican-American has cousins he would like to see enter the country. The Mexican-American may recognize that if all cousins enter — and worse, if all the cousins' cousins enter *ad infinitum* — the overloaded commons will soon produce ruin for all. But first, the hyphenated American thinks, just *my* cousin . . . then maybe we can close the door! Chavez, subjected to conflicting pressures, is inconsistent in his public statements. This weakens his effectiveness as a countervailing force to big business. Compassion cooperates with the profit motive.

**Educational Aspects**

No significant change can be made in the immigration laws without substantial cooperation by those who control the "media" — television, radio and the press. The year 1976 saw a considerable increase in attention given to immigration by the media, but it is not obvious that it had much effect on public opinion. People seem to be apathetic about this problem, and the writers for the media tend to use flabby rhetoric in discussing the subject. There are reasons for this state of affairs.

First, there is the great force of tradition. Of all the literature of the past three centuries the phrases that still ring in the mind are the ones that are predominantly oriented around the plight of the individual, universalized in its implications. "No man is an island," said John Donne in the 17th century: "Every man is a piece of the continent, a part of the main . . . any man's death diminishes me." Better known to Americans are the lines of Emma Lazarus written in 1883 and inscribed on the Statue of Liberty twenty years later (and reinscribed on the Kennedy International Airport after another sixty years):

> Give me your tired, your poor
> Your huddled masses, yearning to be free,
> The wretched refuse of your teeming shore,
> Send these, the homeless, tempest-tossed, to me:
> I lift my lamp beside the golden door!

A century after these lines were written the foreign shores are teeming more than ever, while the gilt is flaking off the door. We don't really live by Lazarus' advice — if we did, we would remove all impediments to immigration. But any attempt to increase legal restrictions, or even to conscientiously enforce the ones we have, is sure to activate a talented cartoonist to limn a lachrymose Liberty. "Poets are the unacknowledged legislators of the world," said Shelley; were he alive today he would surely include cartoonists, columnists and the warblers of popular songs. Many of these are admirably acute in their perception of the sorrows of the individual, but lamentably obtuse in seeing that an aggregation of individually compassionate actions can add up to disaster for the whole.

Listen to Shelley again:

> Most wretched men
> Are cradled into poetry by wrong:
> They learn in suffering what they teach in song.

The trouble is, the masters of the media have not suffered enough — not in a way that is relevant to the immigration problem. Chavez's people lose jobs to, and have their wages beaten down by, a tidal wave of immigrants. This never happens to the media people — *and never will.* The reason is quite simple: language skills are virtually untransferable from one country to another. There are a few contradictory examples to this statement, of course: Joseph Conrad (Polish), Vladimir Nabakov (Russian), and Arthur Koestler (Hungarian) come to mind. But who else? That's just about the roster.

One might postulate that ability of a lesser order would be transferable, but the evidence points in the opposite direction. The ordinary journalist or TV writer may not produce Literature with a capital L, but he does know his idioms; and must, to hold his job. It is his idiomatic control of language that protects the rice bowl of the native journalist. The migrant farm worker can never escape the anxiety that a fresh horde of unassimilated workers from over the border may take his job away; in contrast, unassimilated immigrants pose no threat to the man or woman who deals with words.

Drawing on personal experience alone a journalist can be led to express the cruelest sentiments. In June of 1976 an editorial in the *Wall Street Journal* was entitled "The Illegal Alien Non-Problem." The anonymous writer had a simple solution to this "non-problem": simply declare all illegals to be legal. Since he did not say otherwise, one would assume he meant we should follow this policy in perpetuity — that is, that we should create a commons. One is reminded of the character in William Saroyan's *The Human Comedy* who had a recipe for putting an end to thievery: "If you give to a thief he cannot steal from you." True: and if we declare all immigrants legal we put an end to illegal immigration. But will that stop the suffering of Chavez's people? What would happen to all of us if we literally obeyed the injunction on the Statue of Liberty?

**Compassion and Responsibility**

The compassionate impulse is commendable but we will be ruined if we have not the imagination to see the consequences of generalizing such behavior. If we build policy on the doctrine that the need of people bred in another culture confers on them the right to be supported in ours we will soon find that their vast numbers — millions and millions — will overwhelm our own support system. It takes imagination to see what is required to survive in even minimally prosperous conditions. Journalists have an opportunity to help Americans develop this imagination. This means they must down-play the vignettes (photographic and verbal) of present suffering of the poor illegals who are the victims of a social system that has, in their native country, allowed population to outrun resources.

Immigration has its population roots outside our nation. The poor of the world increase in numbers by 50 million a year. Perhaps the majority of these would, if they could, move into a rich country like the United States (if they felt assured of compassionate treatment once they got here). Of course, most of them can't afford the fare; but if we really believed in the sentiment on the Statue of Liberty we should say, "Send these, the homeless, tempest tossed, to us — *and here is the money to pay their fare.*" But we don't; nor should we.

*There is no global solution to the population problem.*

Population must be dealt with within the boundaries of each responsible unit, in which (theoretically) all significant elements are capable of being controlled. The largest existing responsible unit at the present time is the nation; population problems cannot (for the foreseeable future) be tackled on any larger scale.

Adherents to the philosophy of Zero Population Growth ask Americans to reject the individualistic bias which implies that "The size family that is individually best for me is also best for the group." Those who reject this individualistic bias and who make their personal actions consistent with their new-found wisdom thereby make personal sacrifices for the good of the group. It is intolerable if such sacrifices are to be rendered worthless by a conversion of the national domain into a commons which will be overwhelmed by immigrants from other countries (where no such personal sacrifices for the sake of the group are made). How we are to control our own population *by acceptable means* is still not clear, but this much we know: population control is impossible without immigration control.

It is discouraging to note that half of the yearly increase in the American population comes from uncontrolled immigration, and that this fraction is rising. At the least, this is an inefficient way to run a country, and it certainly makes the preservation of native traditions more difficult. But discouraging though the present is there are encouraging signs that the tide is changing. This change is part of a larger shift in public opinion which, under the stimulus of necessity, is reactivating a recognition of the importance of responsibility in the design of social and political systems, making people realize that actions provoked by commendable compassion for the individual must be informed by the interests of the larger group. The larger group includes our posterity to whom we pass on the national resources for which we are the trustees.

*(The author thanks Justin Blackwelder, Judith Blake, Jane Hardin and William Ophuls for their valuable criticisms of an earlier version of this paper.)*

# MINERAL RESOURCES AND NATIONAL DESTINY

**by Preston Cloud**

**Mankind today stands at a point of change in history, a crossroads at which it behooves us to pause and examine our alternatives very carefully. The gap between rich and poor is widening. The early industrial nations such as the U.S. have consumed their richest and most easily discovered mineral and energy resources so avidly that they become increasingly dependent on imports for raw materials and therefore increasingly susceptible to cartel action by others. The recently industrialized or industrializing nations that are still rich in minerals and mineral fuels grow ever more keenly aware of the potential advantage this situation gives them and are understandably eager to exploit it. More consumers than ever before are consuming larger quantities than ever before, at higher per-capita rates than ever before, with larger and more pervasive environmental consequences than ever before. The period of grace for ameliorative action between the general perception of impending crises and their onset becomes ever shorter and may soon become too short for aversion of crises, if it is not so already.**

**The thesis of this paper is that the traditional "growth ethic" and materialistic values that have been so successful until recently in creating local prosperity in western societies are not conducive to the future well-being either of the industrialized world or the world in general. Although substantial local increases in material goods and comforts will be needed for still some decades to come in order to better the existences of the now deprived, wherever they may be, the idea of growth as a goal in itself has outlived its usefulness in the industrialized world. To strike a durable balance with nature and her support systems must become the new goal if industrial society is to survive. Earth being finite, there can be no such thing as infinite or even "near finite" growth connected with it, either of populations or of material consumption — let alone without the gravest environmental and social consequences. Pious protestations that something will turn up because something "always" has turned up are wishful thinking.**

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Modern industrial societies are, without exception, high-technology *growth*-societies. They are organized toward ever-increasing production as a central goal, with high and increasing degrees of specialization, mechanization, automation, and urbanization as distinctive manifestations. In addition to certain advantages, such processes also give rise to dis-amenities on a large scale, not only within the industrialized world but throughout the world. They have led to an unprecedented growth of population, to the degrading of much human input from individual self-fulfilling work to machine-tending or work-brigade drudgery, to ever-widening gaps between rich and poor, to an alarming dependence of industrialized peoples on vulnerable supply systems, and to a growing isolation of man from nature simultaneously with a growing unfavorable impact of man on nature. Industrial society thus exhibits not only civilizing but also degrading aspects.

*The productive capacity of industrial society, moreover, is utterly dependent on natural resources, mainly geological.* The rise of the U.S. to its present position of strength and influence has been as much a function of its rich endowment of minerals and mineral fuels as it has of the ingenuity, energy, and inventiveness with which these resources have been put to use. The decline of the powers that ruled the world when we were but a fledgling nation is just as surely related to their relatively diminishing control of similar resources. As the U.S. high-graded its domestic resources to attain a position of wealth and strength through rapid growth fueled by cheap raw materials, however, so has it laid the foundation for stress and decline should it fail now to reorient its thinking and strategy to its new and growing "have-not" position with respect to mineral resources.

That is why I say that the "growth ethic" that served our predecessors so well as a bountiful and nearly empty continent yielded its bonanza ores and provided ever new geographical frontiers for expansion and consolidation has outlived its usefulness. The time has come for the idea of growth in its historical, materialistic sense to be given a decent burial and forgotten. It needs to be superceded by new outlooks that take account of the fact that continued material growth in this nation can be sustained only at the cost of increasingly severe fiscal, environmental, and social penalties resulting from excessive use of energy, the mining and smelting of ever-increasing quantities and ever-lower grades of ore for ever-decreasing proportions of metal, the importation of growing quantities of minerals and mineral fuels, and whatever may be required to maintain our access to foreign sources while limiting such access to competitors.

Should you be unimpressed with the significance of mineral resources as the material basis for industrial society, consider Figure 1. It represents the *interdependent* flow of materials and energy in the U.S. in 1975. The fact that mineral raw materials, including mineral fuels and supplemented by over $40 billion worth of imports, represented only about 5.7% of the gross national product (GNP) for the nation in that year and even less in previous years has led economists generally to discount their importance. Indeed one highly regarded member of the economics establish-

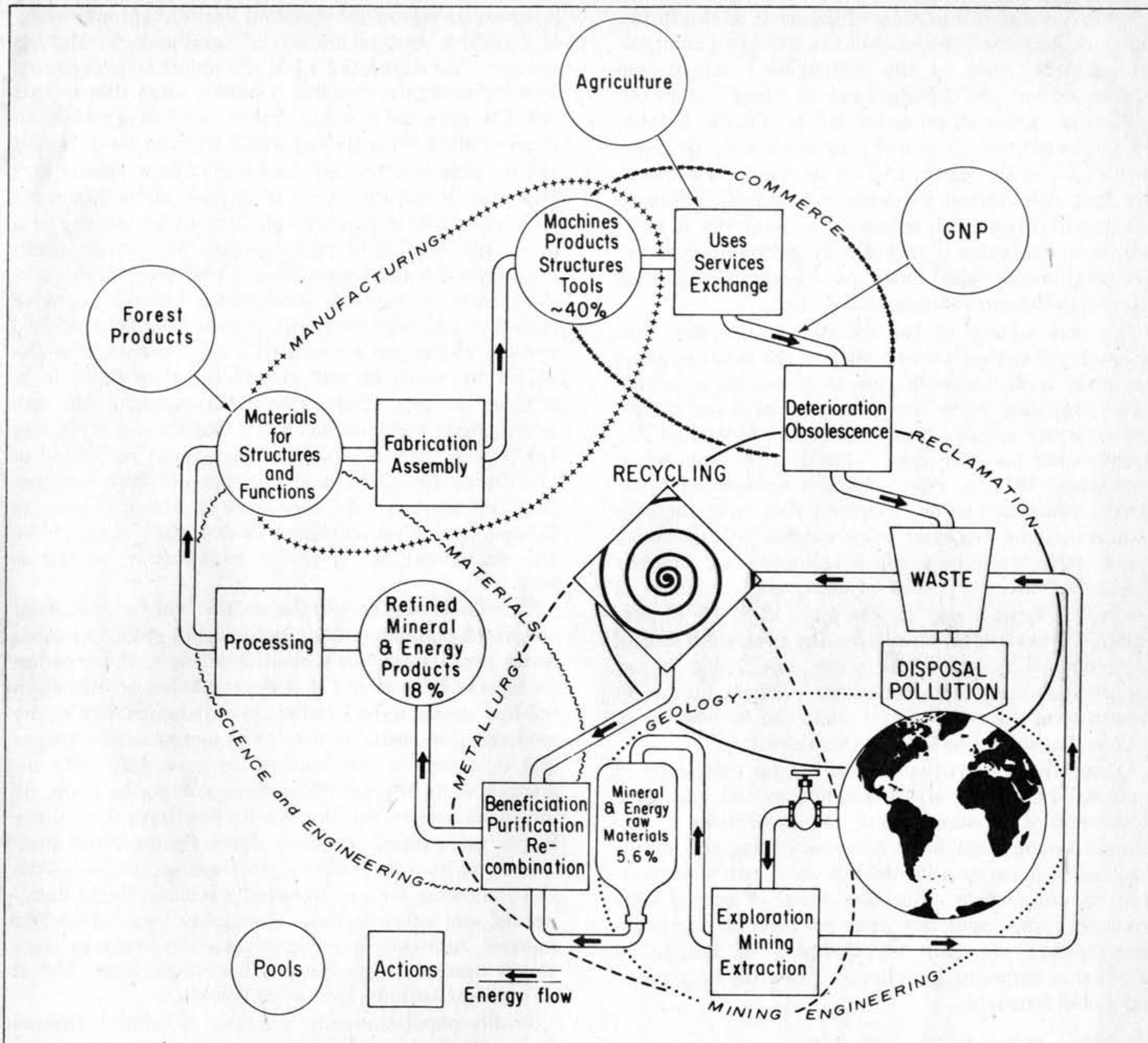


**Figure 1. Flow of Materials and Energy in the U.S.** (Percentages given are of 1975 GNP).

ment has actually claimed that: "the world can, in effect, get along without natural resources" (Solow, 1974), and many others write and speak as if they shared such a belief.

Observe in Figure 1, however, that beneficiation, purification, and recombination enhance the value of these raw materials from their initial 5.7% to a full 18% of the GNP in the form of refined mineral and energy products; and that further processing and material inputs scales this up to around 40% at the level of machines, products, structures, and tools. *All of these processes, in turn, depend on a constant flow of energy, while maintenance of the energy flow depends on a continuing investment of materials.* In a profound sense, mineral raw materials, including mineral fuels, underpin all the rest of industrial economy and, as Figure 1 suggests, threaten to be the bottleneck to its further advance. After all, even fields and forests need mineral fertilizers, and even those who work only with words, numbers, and ideas need material goods, transportation, places to live and work, and, increasingly, high-speed computers whose performance depends on stuff like gold, germanium, and gadolinium.

What is involved in sustaining that which is good in industrial society and in making a smooth transition to the future? How can the society to come most effectively preserve and enhance the civilizing aspects of industrialization, while reducing and eventually eliminating its dehumanizing effects? What steps are involved in moving toward a less intensively industrialized, more diversified, more equitable, and, above all, less populous condition — and how might we begin?

Let us take a hard look at the material basis of our current industrial society here in the U.S. And let us also examine the dangerous but widespread illusion that there are no limits to continued material growth — that Americans or mankind can somehow continue to consume and disperse the nation's or the world's capital stock of raw materials forever without a day of reckoning, that the gap between rich and poor can somehow be narrowed or even closed without major revision of present outlooks and norms.

As the present is a product of the past, so the future will grow from the present. Yet the theory of competitive markets, seen by the self-styled "mainstream economists" as the driving force of "free" or mixed economies, makes no provision for that future. Indeed, in addition to the exclusion of various common property assets such as air, water, and scenery and the assumption that all potential participants are fully informed and free to choose, it is inherent to the theory of competitive markets that it excludes the probable needs of posterity, along with those of other constituencies external to the current industrial system.

This discounting of the future as, in effect, an externality, like the environment and the poor, remains one of the most decriable aspects of current economic theory, brushed aside from the time of Adam Smith onward with the cold caveat that "every individual . . . intends only his own gain" (Smith 1776, quoted in Samuelson, 1973, p. 840). There is something in the current sense of justice, however, that calls for constituencies now marginal to or outside the economic system to be brought within it in some way. And the largest and most voiceless of these constituencies is posterity. The only way in which the interests of posterity can be represented within the present sector of the economic system is for those now living to pay attention to the consequences of their actions for the yet unborn — at the very least to avoid the foreclosure of options that should be left open for the future.

Among the options that should not be foreclosed to posterity, but which are threatened by the excessive abundance of consumers and the greediness of the affluent among them, is the option of having access to a reasonable quantity and diversity of Earth's recoverable mineral bounty. The new wave of ethical consciousness must somehow create a place in the economic system not only for thoughts of immediate personal or corporate gain but also for truly long-range and global foresights.

**Economics, Population Growth, and Mineral Production**

The occasional economic assessments of mineral potential that have been made are too simplistic. There is a geological parallel to Borgstrom's passionate plea to "those economic analysts who . . . take refuge in an abstract verbal world far removed from the stark realities of our globe and its staggering food needs" (Borgstrom, 1969, p.73). A comparable set of analysts is all too prone to overlook or minimize geological variables and technological limitations in the stubborn faith that market forces will provide whatever warning, inducement, or corrective action may be needed to avert or promptly restore interruptions in the flow of minerals sought. No matter how tough a nut we have to crack or how dim the technological prospects of opening that particular nut, the economist among us always postulates a nut-cracker.

Brooks and Andrews (1974), for instance, drawing attention to the plausible but misleading conclusion that "The entire planet is composed of minerals", state that "The literal notion of running out of mineral supplies is ridiculous". Under a loose and useless definition of "supplies" that, of course, is correct, and it serves to bolster the specious and dangerous notion of economic and technological omnipotence. But no one has ever suggested we'd run out of ordinary rock-forming minerals. Nor has it been denied that metals could be recycled to some extent — although even an impossible 100% recycling would account for only half of what is needed for each doubling of demand and that at a cost in energy. And, of course, some materials will find substitutes, although in many instances, with decreased quality of performance. The tough problems faced by the United States and the world, however, show no signs of diminishing before the naïve optimism that combines faith in unknown technological breakthroughs and a so-called "free" economy as the means by which infinite growth becomes possible in a finite system. Even confirmed cornucopians are beginning to waver on this point. Goeller and Weinberg (1975), for instance, follow their ringing manifesto of abundance for all forever with the acknowledgement that the absence of "insuperable technical bars to living a decent rather than a brutish life" depends on the attainment of "*a stable population*" (emphasis added).

Therein lies the crux of the matter. Neither industrial nor world populations are stable, and, what is worse, world population shows insufficient sign of becoming so, least of all soon and at supportable levels. Although the U.S. seems to be headed toward stabilization at the moment, the inertial effects of its age structure assure that its numbers will continue to grow willy-nilly for another 45 to 70 years. What is equally to the point, no industrial society can divorce its fate from that of the larger, more rapidly growing world. On the 200th anniversary of its independence, the real population of the U.S., allowing for an estimated 8 million illegal immigrants and other census oversights, was near 220 million. Although our population is increasing very slowly now, this represents 7 doublings since 1776 at an average doubling time of 29.6 years.

World population now exceeds 4 billion. Official United Nations projections show it to be currently increasing at a rate that yields a doubling time of 42 years — but that falls to as little as 20 to 23 years in a number of poor countries. The world can barely support its present population, even at existing preponderantly deprived levels. What are the prospects that it can support double that population in the year 2020, particularly at a comfortable and sustained level? Or that world population will stabilize before then? Or that starvation and instability of the global economic system will not lead to social chaos? And what are we in the U.S. prepared and able to do to cope with those problems or insulate ourselves from them? Certainly our own earlier rates of population growth provide no basis for a holier-than-thou position on the matter.

Growth of world population is a problem of deep concern, a trend that must be dealt with, either by eliminating it or by seeking to meet the staggering demands for materials that will be created by the housing, feeding, transportation, and employment of the increased numbers. Without dramatic economies and unforeseen advances in recycling, it will not be possible to meet such demands at decent and sustainable levels on the projected, or any, time scale except by improbably massive infusions of new virgin raw materials and at grave risk to the life-sustaining capabilities of the planet.

What would this entail? Few industrial economists besides Vanderbilt University's Georgescu-Roegen (1971, 1976) and his followers seem to understand that the really basic limiting factor in resource production, apart from a breakdown of society itself, is not likely to be currency so much as it is energy and the added materials required to produce this energy. The mining, extraction, and beneficiation of ores to produce metals is achieved at a large cost in available energy. For example, *about 16% of all energy used in the U.S. in 1975 was expended for a domestic mineral production that fell 25% short of demand. Energy required, moreover, increases exponentially as the grade of ore decreases* to some grade beyond which energy inputs rise abruptly and steeply.

Figure 2 illustrates the problem. It shows how, as the grade of ore decreases toward the left beyond certain critical values, energy costs climb dramatically. This, in effect, establishes *cutoff grades* — concentrations below which ores of a given type will not yield metals at tolerable prices and existing technologies. Nor is it easy to foresee what technologies might drastically reduce such energy demands. The 16% of the U.S. energy budget that presently goes for mineral production will increase substantially as we seek to reduce our dependence on foreign sources. *As the price of energy itself goes up, the hard-currency cost of non-energy mineral procurement will also increase, and with consequent braking effects on the economy.* Any attempt to maintain trends in mineral procurement and use at currently projected levels will, within a few decades, precipitate a train of new crises, not only in energy, but in a variety of materials as well, not to mention environmental feedbacks of increasing gravity.

Even the hoary economic fallacy that decreasing grades of ore are compensated for by increasing volume, the so-called arithmetic-geometric, or grade-tonnage ratio, has now been laid to rest as far as metal production is concerned for the very ores (porphyry

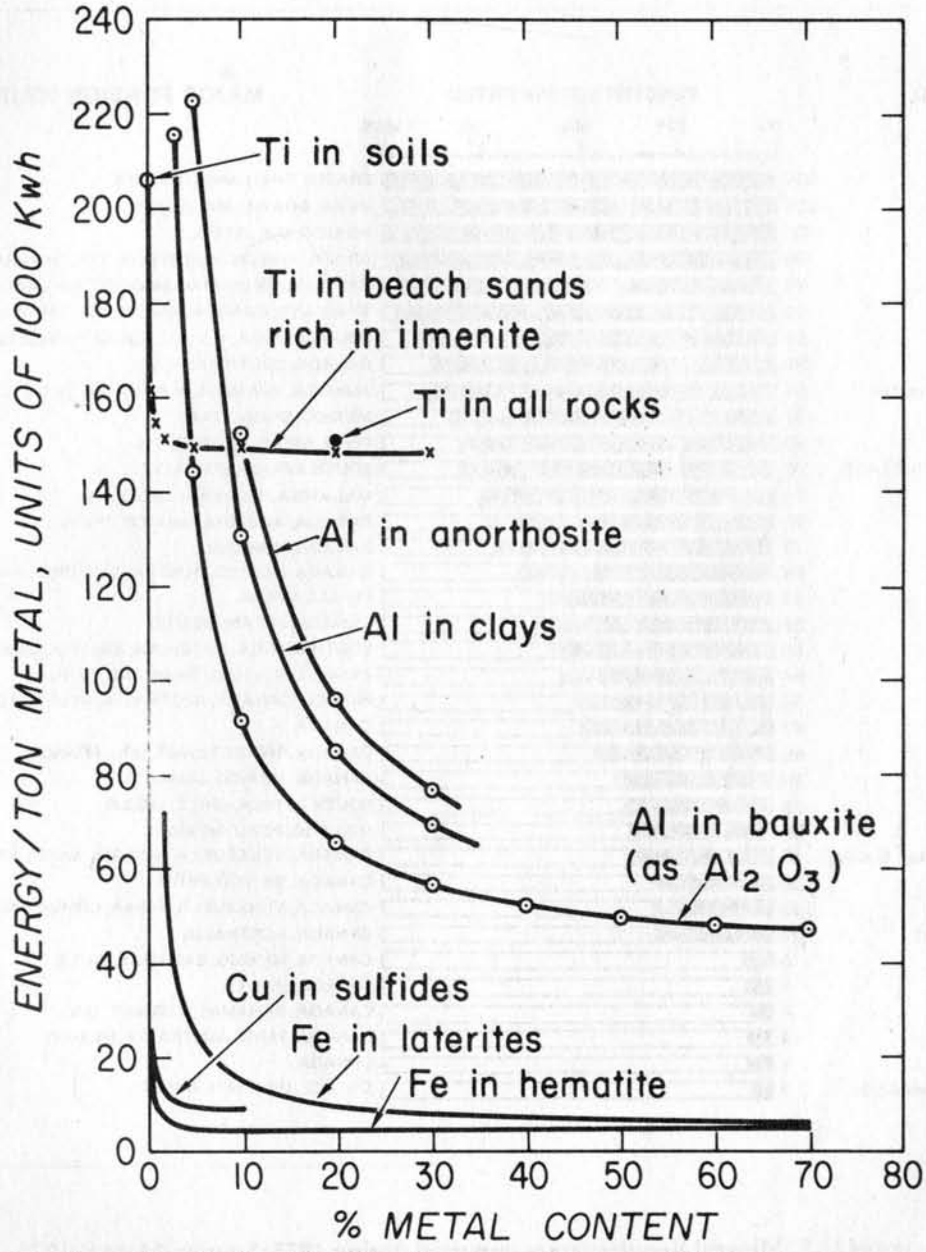


**Figure 2. Energy costs of metal production** (simplified from Page & Creasey, 1975).

copper) that gave rise to this concept initially. A comprehensive study of grades and volumes by Singer and others (1975) shows that this is not true for copper ores in general, and that, in particular, "large-tonnage very low grade deposits in the porphyry class . . . are . . . very rare".

The point is not that economics is not critical, but that an economic philosophy rooted in the concept of ever increasing material growth as the basic ingredient has dominated the affairs of industrial societies of all political shades to the point of conceptual bankruptcy, whereas other considerations are equally or more important and in some instances should be overriding. It is time to balance the decision-making process by introducing a better mix of economic viewpoints and a greater diversity of related insights, including geological ones, as well as by paying comparable attention to factors such as the long range value of economies in the use of most materials. Energy accounting must also become part of all materials production estimates, while the material costs of energy production need comparable attention.

**Mineral Reserves, Potential Resources, Total Stock**

Granted that the ability to foresee the consequences of our actions makes us responsible for them, why worry about posterity if the whole earth is made of minerals? Isn't it then all one big mineral deposit, equally and permanently available to all? Indeed that is implied by the suggestion, often made by the geologically naive, that as grade of ore decreases, we will turn to mining "common rock". Like many other reassuring oversimplifications, there is not only an element of truth but also food for dangerous complacency in this one. Indeed, to the extent we obtain lead and zinc from limestone and copper from sandstone, we mine "common rock" now. But the idea is misleading to the nongeological public in the same sense that the idea of an earth made up of minerals, while substantially true in a literal sense, is, in the context of Brooks and Andrews, simply mischievous nonsense.

The zinc-rich limestones and copper-bearing sandstones are, in fact, very unusual rocks. *It is the uncommon features of a rock that make it mineable.* It is the local concentration of elements beyond, and

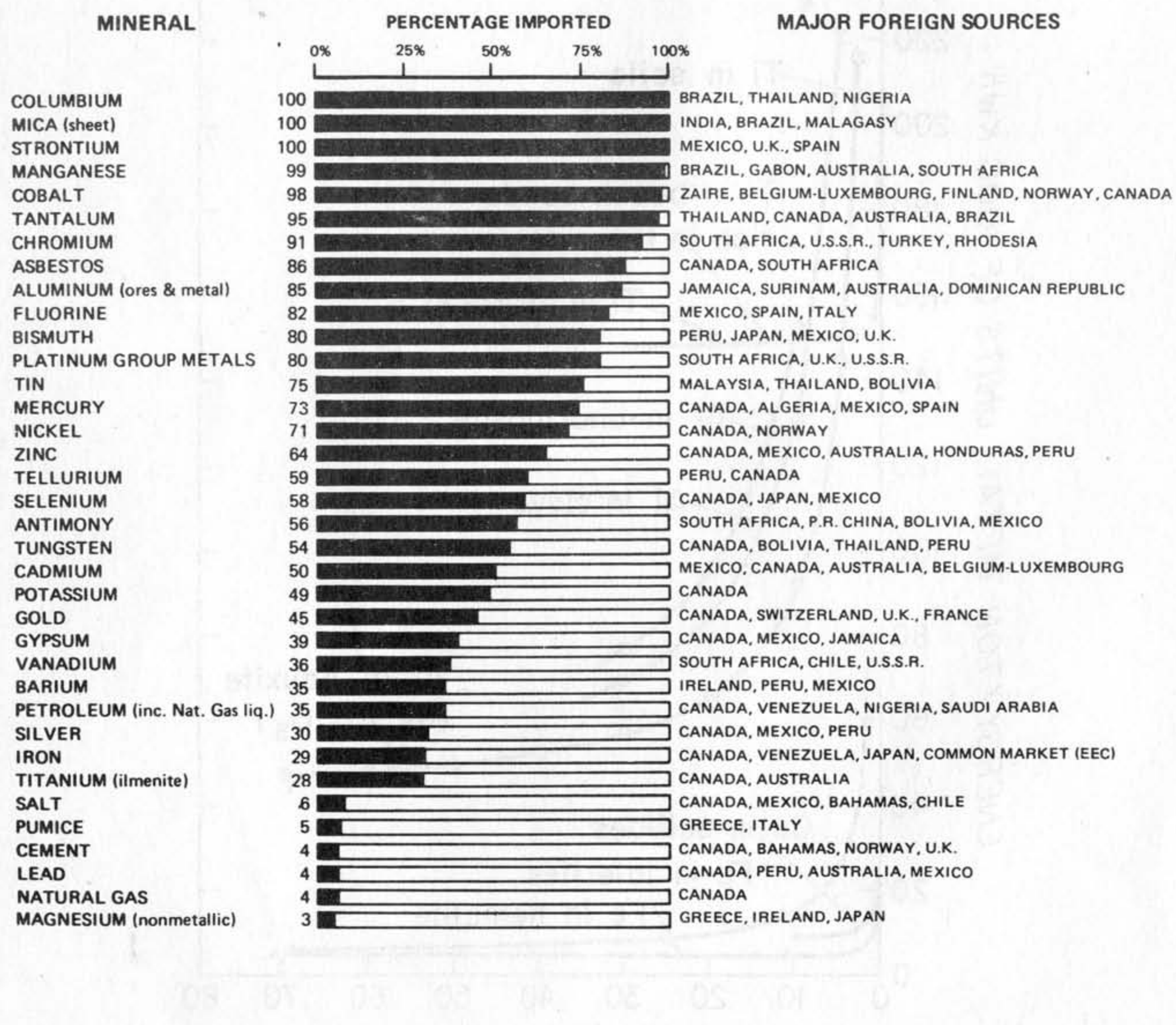


**Figure 3. Percentage of U.S. Mineral Requirements imported during 1975** (Source: Morga, 1976, Fig. 8)

usually far beyond, their normal abundance in Earth's crust to commercially exploitable levels that we designate a mineral deposit. Even if the whole earth were accessible to us, which it is not, we are not likely to mine many elements at concentrations approaching their average crustal abundance. Apart from the energy barrier, we would still have to stand somewhere while mining the ground beneath our feet. And we would still have to dispose of the volumetrically preponderant waste minerals that must be moved and broken down or fractured in place to the particle size of minerals sought. Other factors also would prevent the mining out of the entire earth or a significant part of it, including considerations of public health, safety, and environmental quality. And we in the United States need to be aware of our large and growing dependence on external sources of mineral supply — not only for oil from the Middle-East, but for many other mineral resources from many other areas, as indicated in Figure 3.

I have discussed the specifics of global resource sufficiency and its ramifications elsewhere (Cloud 1975, 1976, in press). Here the focus is on the U.S. I must point out, however, that, although the world situation may appear more hopeful for the future than that of the U.S., it does so only when viewed primarily as a source of supply for now industrialized nations. If one views global resources as the potential basis for global industrialization, their adequacy becomes dubious even in the near and intermediate terms. Indeed all indications are that a major scaling down of demands is called for on the part of the now industrial nations. Such a scaling down is called for not only by considerations of supply, but also by energy accounting, environmental protection, public health and safety, and equity.

In speaking of the projected lifetimes of either domestic or global resources, I must also clarify the different ways in which this can be done and define the terms that are used. One commonly hears or reads that reserves of a particular mineral will last for so and so many tens, scores, or hundreds of years at *current* rates of use. The problem is that, in growth societies like ours, *current rates of use are characteristically dwarfed by future demands.* In general each industrial generation has tended to consume minerals roughly equivalent to all of those used in all previous history. That is to say, the rate of use has been increasing exponentially, as compound interest causes a debt to grow rapidly when payments are not made. When such rates of growth are projected into the future, they lead to much more rapid exhaustion of reserves than would result from simple continuation of current rates of extraction and use. Mineral lifetimes based on such projections, however are themselves invalidated where continuing exploration extends reserves, as it usually does, although commonly at diminishing grades.

Thus it is important to understand that *reserves* of a mineral, a metal, or a mineral fuel are only that fraction of the *total stock* of that substance within Earth's crust that has been calculated to exist at commercially exploitable values under known technologies as a result of actual physical testing already accomplished. What we do not know for any mineral, metal, or fuel is exactly how much of its total stock can eventually be won from Earth's crust or a part of it under future technologies and bearable costs in energy and currency. This quantity, referred to as the *potential resource* (or simply *resource*), can be estimated with a fair degree of confidence for some minerals whose geological occurrence is well understood and reasonably regular, like coal, oil, and natural gas. It is believed to be very large for a few common and abundant metals and minerals like iron, aluminum, magnesium, and the silicates — although energy constraints at decreasing grades may limit access to aluminum, the silicates, and perhaps iron at some intermediate level, and domestic resources of the currently commercial ores of aluminum and iron are small. For most other mineral commodities, potential resources are much more uncertain and much less ample. And, we must remember, reserves and potential resources can be decreased as well as increased by economic factors.

Figure 4 compares reserves of key U.S. mineral commodities under current and expected fiscal and technological conditions with projected cumulative demands to the year 2000. In this figure the solid bar ends within the shaded box, known *reserves* are insufficient. (see over)

Figure 5 provides a similar look at projected lifetimes of reserves for the same mineral commodities, but with some amplifications. Projected lifetimes of established domestic reserves at projected rates of demand are shown by the solid bars at the left. Extension of lifetimes by hypothetical reserves 5 and 10 times as great are shown by the dotted bars in the center and the solid bars at the right. Lifetimes of potential resources estimated by the U.S. Bureau of Mines are indicated by small solid triangles above or below the bars. Additional notation indicates where geological evidence strongly implies potential resources to the right of scale. Except for mineral-rich South Africa, Australia, Canada, the USSR, perhaps Brazil, and omitting China, similar data for the domestic reserves and estimated resources of individual industrial or industrializing nations is equally unimpressive.

Nevertheless, U.S. Bureau of Mines estimates of potential resources, whose prospective lifetimes are indicated in Figure 5, are appropriately conservative. Geological evidence suggests that given intelligent research, aggressive exploration, and suitable prices, ultimate resources may be substantially larger and prospective lifetimes correspondingly longer for many or most of these commodities than is implied either by current reserve estimates or Bureau of Mines resource figures. Estimates that I (Cloud, 1975) and others (Erickson, 1973; Skinner, 1976) have made for copper suggest the likelihood of ultimately obtaining perhaps as much as ten times presently known reserves. Ultimate resources of other commodities may, under similar impetus, equal or exceed the suggested resource-reserve ratio for copper. Yet it is important to remember the environmental costs of producing such resources from ever lower grades of ore, and to keep in mind that *even great extension of known reserves adds little to lifetimes where demand is also growing* (see Figure 5). Not only is a vigorous program of research, exploration, and environmental protection needed. There must also be a vigorous campaign to reduce

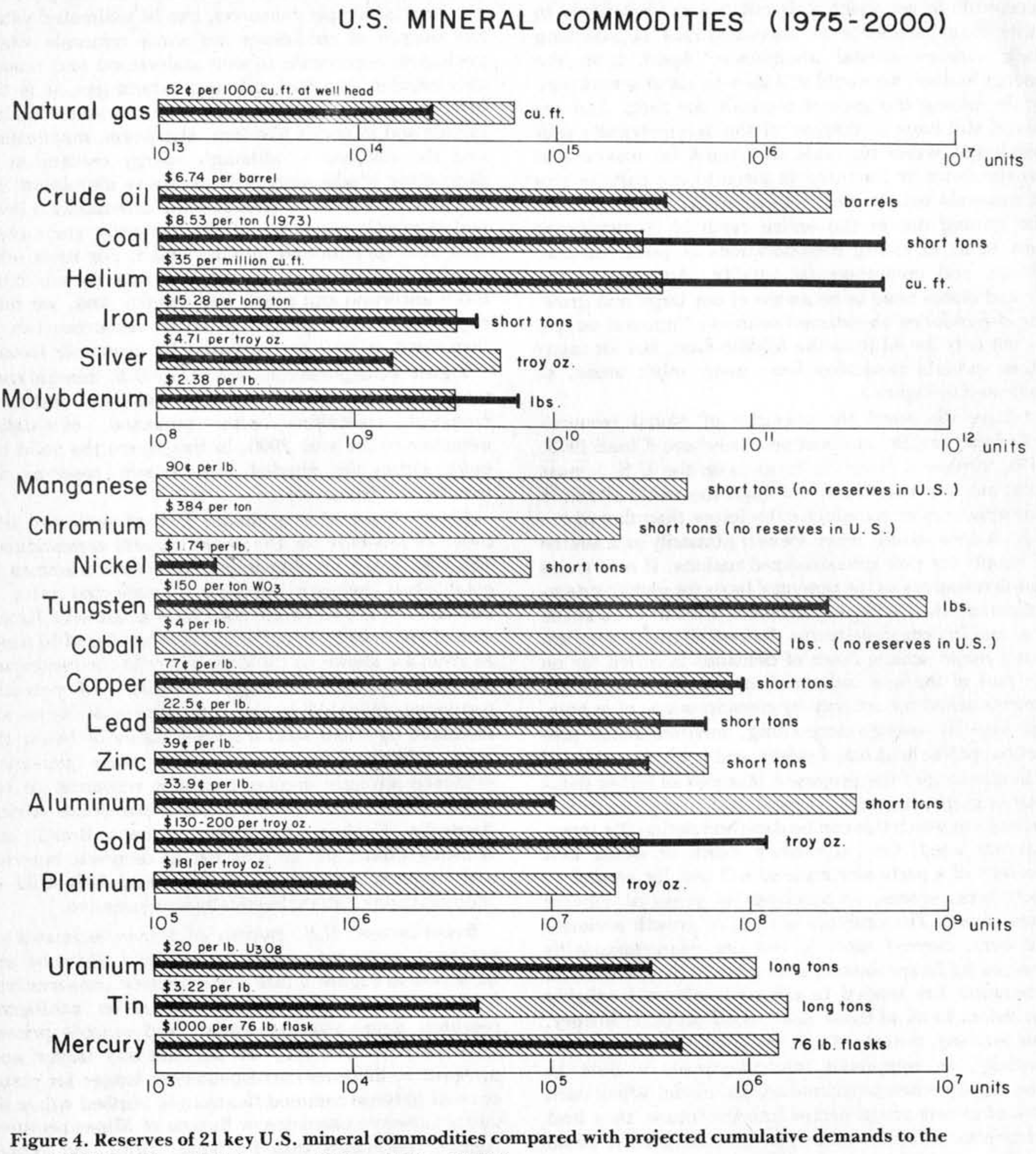


**Figure 4. Reserves of 21 key U.S. mineral commodities compared with projected cumulative demands to the year 2000** (data from U.S. Bureau of Mines 1976a, 1976b).

Shaded bars represent cumulative demand through 1999. Median lines show largest, most recent reserve estimates. Prices in 1975 dollars. Scale is logarithmic, unit quantities and scales vary as indicated and all lines begin at zero to left of diagram.

demand — to curb waste, introduce economies of use and operation, and shift our goals away from prestige-oriented over-consumption to enhancement of the human condition by materials-conserving means.

For, even given Erickson's exuberantly optimistic estimates, and the vast and continuing capitalization and investment in geological research and mining and extractive technology needed to realize them, near to intermediate term difficulty may still be in store with respect to continuing supplies of copper, gold, lead, mercury, molybdenum, silver, tin, zinc, and perhaps even antimony and phosphorus — not to mention oil and natural gas whose domestic production has already peaked and is now declining, or helium, which will essentially disappear with natural gas early in the 21st century. Nor should the material costs of energy be overlooked. A surge of drilling in search of new domestic oil, for instance, would generate great demand for

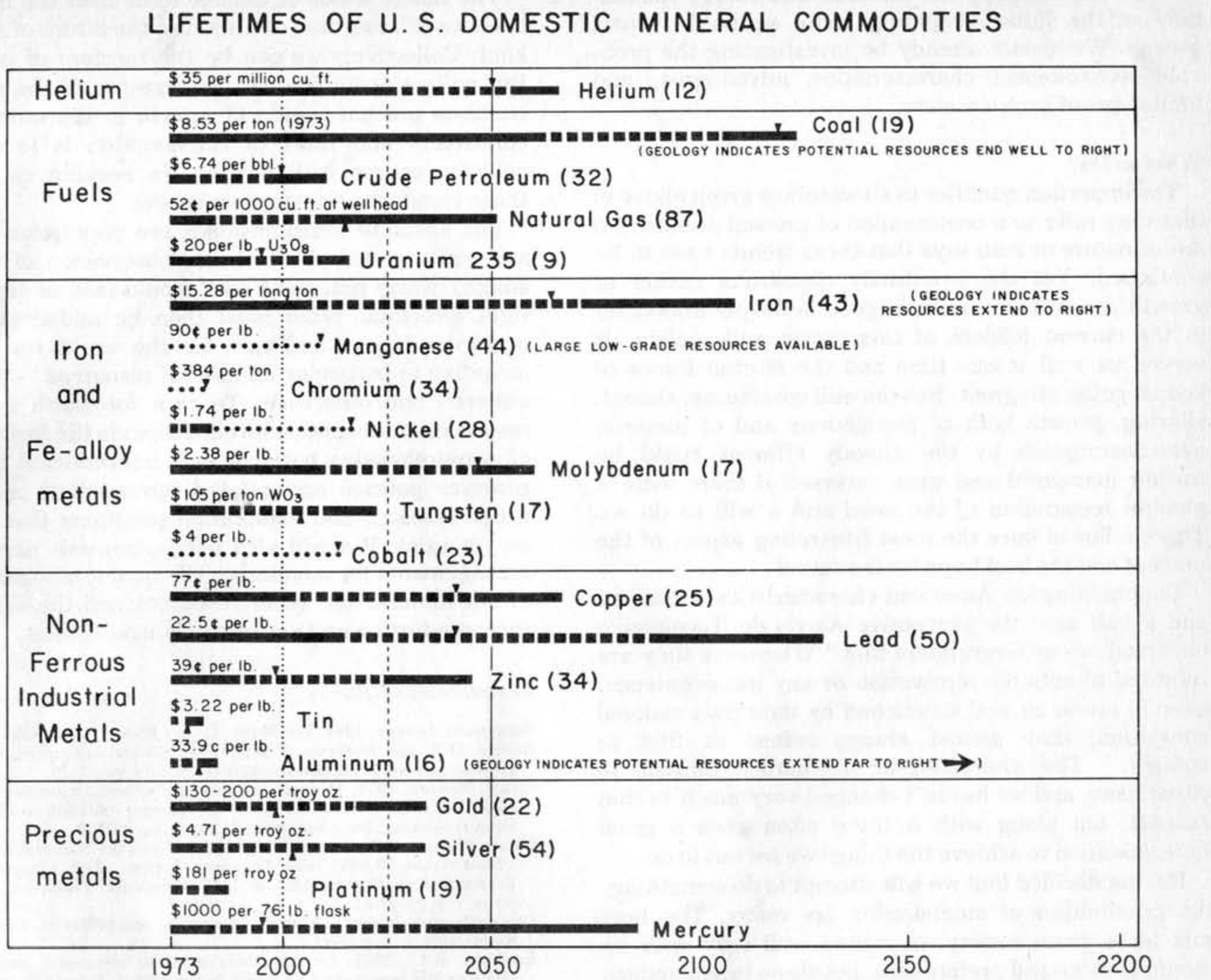


**Figure 5. Apparent lifetimes of reserves of 21 key U.S. mineral commodities compared with lifetimes of hypothetical reserves 5 and 10 times as great and with potential resource estimates** (data from U.S. Bureau of Mines).

Solid bars at left are for known reserves. Short-dash lines in middle are for 5x known reserves. Solid lines at right are for 10x known reserves. Solic circles indicate resources only, no or scant reserves. Solid triangles denote lifetimes implied by U.S.B.M. resource estimates. Bracketed numbers at right are years for projected doubling of demand. Prices in 1975 dollars.

barite, the critical component of drilling muds. Thus barite, in seemingly limited supply, could become a bottleneck in energy and mineral production unless and until a suitable substitute or new resources are found.

As for expected increases in d mand on the part of third world countries, I can only say "beware". In it lies the potential for much friction, exacerbated by the fact that the U.S. and several other now rich, industrialized, high-consuming nations are increasingly resource-poor, whereas many of the poor, non-industrialized nations that now supply raw materials to the rich are understandably eager to share the bounty.

Add to this the idea of somehow "closing the gap" between rich and poor without lowering anyone's material standard of living and you have a problem of first magnitude. To achieve the seemingly modest goal of bringing all of Africa to the 1975 level of living of western Europe by the year 2000, for instance, would require a sustained real growth rate of 13% a year from now until then. Are the now industrialized nations willing to wait for Africa to catch up? Can Africa, India, Latin America, and other third world countries ever catch up, even if the Europeanized world is willing to forego further increases in its own material growth? And, suppose the whole world does stabilize at 1975 rates of consumption for western Europe, what would be the consequences for the global ecosystem and the human habitat of 8 billion people consuming at such rates by the year 2018?

After, and probably well before Erickson's outside limits are reached (if indeed they can be), if present trends continue, the U.S. and a number of other industrial societies, regardless of how vast their energy sources, will be confronted with severe geochemical and thermodynamic constraints on the addition of new virgin metals. Those constraints will require adapting societal technology to one that can subsist on recycled materials plus rock silicates and the geochemically abundant metals — among which the silicates and aluminum in particular require vast amounts of energy for the transformation from raw materials to useful states. These geochemically abundant substances, plus coal, solar energy, and perhaps geothermal and fusion energy, will comprise the material and energy foundations of the future, hopefully more equitable, world society. We should already be investigating the probable technological characteristics, advantages, and limitations of such a society.

**What to Do?**

The important qualifier to all warnings given above is that they refer to a continuation of present trends. No law of nature or man says that these trends have to be continued. Yet the eventually disastrous notion of growth *per se* as an intrinsic good is deeply imbedded in the current folklore of this nation and society. It served us well at one time and the inertial forces to keep it going are great. But the still continuing, though slowing, growth both of populations and of material overconsumption by the already affluent could be further decreased and even reversed if there were a general recognition of the need and a will to do so. Therein lies at once the most frustrating aspect of the present and the best hope for the future.

Commenting on American characteristics a century and a half ago, the perceptive Alexis de Tocqueville observed of our forerunners that "Whenever they are required to undergo a privation or any inconvenience, even to attain an end sanctioned by their own rational conviction, they almost always refuse at first to comply." The characteristic is hardly limited to Americans, and we haven't changed very much in that respect; but along with it there often goes a great determination to achieve the things we set out to do.

Having decided that we will attempt to do something, the possibilities of amelioration are many. The best mix for a given society, of course, will vary with its circumstances and preferences, but three broad actions are essential. The industrialized third of the world to which the U.S. belongs and which consumes 90 per cent of the world's resources must limit its consumption as well as its populations, lest it foul its nest and incur the justifiable wrath of posterity and deprived neighbor alike. The two-thirds of the world that consumes the remaining 10 per cent of the world's resources must limit its populations and soon, lest its standard of living fall even lower. And the global population must eventually decrease to one that is indefinitely supportable at decent levels within the physical limitations of our planet and the working of natural laws. If these things happen, and if the world can somehow limit the spread of fission reactors, bypass the breeder economy, remain at peace, feed its teeming billions through the crisis years ahead, and move toward a more equitable distribution of its goods, the main steps in the transition to a hopeful future will have been achieved.

Whether or not the future looks hopeful, geologists know that the cycle of materials goes on and that species evolve and have an amazing capacity to adapt, even to the most austere circumstances. It may have been the fate of my generation to have lived through the high water mark of industrial civilization. But it is also within the power of generations now living to initiate the new trends that could best assure lives of quality to those who will inherit this planet — the only one we know anywhere in the universe that is suitable for natural occupancy by live members of our species.

The things we do or decline to do over the next few decades will brighten or prejudice the future of all mankind. Collectively we can be the masters of our fate. But no one or no few can manage for all the rest. To continue present trends of growth in the numbers of consumers and rates of consumption is to chart a collision course with destiny. In seeking to change these trends the time to start is now.

The absolute indispensables are population control and world peace. After these, observance of the old adage "waste not, want not" would take us far in the right direction. What must then be added is better understanding of and care for the world we live in, including in particular its natural resources — human, mineral, and otherwise. To care for Earth's human resources at acceptable levels demands the formulation of comprehensive national and international mineral resource policies and related intermediate and long range research and exploration programs that do not as yet exist. We will also need extensive permanent arrangements for monitoring the quality and adequacy of our mineral and other resources and the effects of their production and use on the human habitat.

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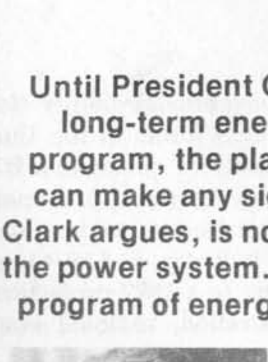
# RENEWABLE ENERGY SOURCES AND A CONSERVATION ECONOMY

by

**Wilson Clark**

**Until President Carter announced his Energy Plan, earlier this year, the US had no long-term energy strategy. But even with an active research and development program, the plan does not consider the possibility that alternative energy sources can make any signific ant contribution until early in the next century. This, Wilson Clark argues, is not due to insufficient technical know-how, but to the centralisation of the power system. Within the context of a decentralised society committed to a radical program of energy conservation, renewable sources of energy could supply as much as 90% of US energy needs by the year 2010.**



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There was little substantive discussion of long-range energy alternatives in the U.S. until the 1973 actions of the Arab nations focused world attention on petroleum dependence. First the actual oil embargoes, and then the rapid escalation of crude oil prices triggered social and economic shocks throughout the industrialized countries, as well as the poor nations of the Third World.

Within one year of the initial announcement of the Arab oil boycott, the OPEC nations quintupled the price of oil, triggering an international recession. The effects of this economic reordering left most economists baffled, since "traditional" economics could not explain the simultaneous appearance of massive unemployment, capital shortages and inflation. Some national discussion of growth limits and energy shortfalls emerged in conjunction with the debate over economic growth, but by 1976, the U.S. economy appeared to be returning to "normal". Hours-long lines of automobiles snaking from service stations receded into memory, as big-car sales outstripped available supplies. According to government and industry economists, the recession had ended, and with it, energy and materials shortages.

A temporary drawback clouded conventional wisdom in the frosty winter of 1977 — one of the coldest in recorded history in the eastern U.S. — when natural gas supplies failed to meet demand, and extraordinary conservation measures were temporarily imposed in northeastern cities. These two events — the oil embargoes of 1973-74, and the winter gas shortages of 1976-77 — heightened public awareness for discussion of energy policy in the United States.

The United States government has not, until quite recently, articulated a clear policy on energy supply and demand; rather, successive Presidential Administrations have reacted to crises at hand. Before the 1970s, there was little or no discussion of the nation's energy future — and almost all energy planning was left to the energy industries, with a minimum of federal oversight. Authority for energy development has traditionally been split among several powerful agencies: oil, coal and gas leasing in the Department of the Interior, nuclear development in the Atomic Energy Commission*, and electricity and gas regulation in the Federal Power Commission. [1] The domination of these agencies by the primary energy industries has been an unspoken rule for decades.

Some attempts were made by Presidents Nixon and Ford to re-tune the federal energy bureaucracy, under such slogans as "Energy Independence", but no substantive changes developed. Recently, President Carter announced a sweeping energy plan for the nation designed to meet the following goals by 1985:

- Reduce the growth of energy demand to less than two per cent;
- Reduce imported oil from 16 million barrels/day to less than 6 million barrels;
- Achieve a 10 percent reduction in gasoline consumption;
- Insulate 90 percent of all residences and other buildings;
- Increase coal production annually by at least 400 million tons; and
- Use solar energy in more than two and a half million homes.[2]

To accomplish these goals, the President has proposed a new federal Department of Energy (DOE), which would consolidate regulatory functions from existing federal agencies. In charge of this new super-agency would be James Schlesinger, the President's energy adviser (former head of the Atomic Energy Commission under President Nixon). Although the aforementioned goals of the Carter Administration emphasize conservation of energy and the development of renewable sources of energy, the National Energy Plan clearly states that: "During the remainder of this century, however, it (the U.S.) will have to rely for the bulk of its energy supply on the conventional sources now at hand: oil, natural gas, coal, nuclear, and hydroelectric power. Federal policy should stimulate the expanded use of coal, supplemented by nuclear power and renewable resources, to fill the growing gap created by rising energy demand and relatively stable production of oil and gas." [3]

According to the President's energy analysts, if the Plan is adopted, electricity production by oil and gas combustion will decrease, but in 1985, more electricity will be generated by coal and nuclear plants than would be the case without such federal energy planning.* [4] Even though the Plan focuses attention on the role energy conservation should play in the future, a significant omission in the document is recognition of the relationship of decentralization of energy supply and use to our future energy economy. This paper outlines the possibilities for reliance on decentralized, alternate energy sources in conjunction with broad energy conservation measures.

**Energy and the Future**

In 1976, consumption of conventional energy (fossil fuels, hydro-power, nuclear, etc.) forms in the United States amounted to approximately 74 quadrillion BTUs (Quads).** Of this total demand figure, approximately 27.4 Quads of energy were consumed in residential and business sectors, 27 Quads by industry, and 19.4 Quads for transportation.*** According to a 1977 projection of the Federal Energy Administration, national energy

* The AEC was disbanded in 1973, and broken up into two agencies: the Nuclear Regulatory Commission, responsible for regulating atomic plants, and the Energy Research and Development Administration (ERDA), responsible for development of atomic energy, as well as other sources.

* Coal-generated electricity would be equivalent to 8.3 million barrels of oil imported per day in 1985 with the Plan, and nuclear-generated electricity would be equivalent to 3.8 million barrels/day. This represents an increase of .1 million barrels/day oil equivalent for coal, and .2 million barrels/day oil equivalent for nuclear.

** One Quad ($10^{22}$ BTUs) is equivalent to the energy stored in 390 million tons of high-grade coal, or 170 million barrels of crude oil (10 days of U.S. petroleum usage). A Quad of primary energy will supply one-half of the total space heating and cooling requirements of all California residences for one year (State population = 21 million people). One Quad of incident solar radiant energy falls on 64 square miles of California's Central Valley in one year.

*** These calculations do not account for total energy usage in each sector; for example, the transportation figure does not include energy required to manufacture cars, airplanes, etc., which is accounted for in the industry sector.

demand in 1985 will reach 91.3 Quads, with the largest increases in energy demand occurring in industry, and for electrification.[5]

The pivotal issue in the national energy debate is reliance on imported oil and natural gas, the two fuels which account for 75 percent of U.S. energy use. In 1976, the U.S. imported 16.4 Quads of these fossil fuels; according to the FEA analysis, national consumption could require importation of 18 Quads in 1985. The principal FEA assumption (as is that in the President's Energy Plan) is that an assortment of conservation measures can reduce demand in energy growth to a level approximating two thirds of the growth rate of the period 1950-1976. Most conventional energy studies assume that conservation measures can "buy time" and slow down energy growth long enough to allow expansion of synthetic fuel plants, nuclear power plants, large coal-fired electric power plants, coal gasification facilities, etc.

The implicit reliance on centralized energy sources represents a continuation of past policies. In the case of electrical generation, where ratings of turbine generators have increased from 1000 kilowatts at the turn of the century to units of 2 million kilowatts today, there is increasing evidence that the larger units (and systems) of today's power grids are inherently reliable and create system instability. In a recent study, energy analyst Marc Messing concluded: "Throughout the long period of continuous technological development and declining fuel prices, economies of scale favored large new units . . . However, changing economic conditions and technological limitations seem to have exhausted the economies of increased unit sizes by the mid-sixties or early seventies . . ."[6]

A 1975 analysis of ERDA's national energy program by the Congressional Office of Technology Assessment, concluded that not enough attention had been paid to diversification of electrical resources, and underscored the potential for disruption of centralized systems. "The reliability of present day nuclear plants has been less than expected; breeders and fusion reactors can be expected to suffer from similar problems," noted the study, adding that centralized solar electric systems would be subject to disruption and sabotage as well.[7] The study recalled the 1965 "blackout" of electricity in New York and other northeastern states, and warned that "a similar event in an economy much more heavily dependent on electricity could be devastating."

(As we go to press news is coming in of the breakdown in law and order during the New York power failure on the night of July 13-14 1977.)

From an environmental perspective, the trend towards centralization poses a number of distinct threats to ecological stability, including enormous contributions of waste heat to rivers and watersheds; increased demand for limited fresh water supplies; accelerated air pollution from coal and synfuel facilities leading to numerous human health hazards; accelerated water pollution and the dangers of oil spills from increased shipments; and changes in local and global weather patterns from the added heat burden of power generation.

**Conservation Potential**

Several recent major energy studies have found that increased attention on the efficiency and nature of energy consumption could result in dramatic conservation savings. The Ford Foundation's Energy Policy outlined three possible future scenarios in the U.S.: Historical Growth, Technical Fix, and Zero Energy Growth.[8] The major assumption of the Technical Fix scenario was that "known technology" would be used to effect energy conservation in all sectors of the economy. The resulting savings by the end of the century would reduce the need for one-third of the energy required in the Historical Growth scenario. The Zero Energy Growth scenario, going further, assumed that major conservation shifts in industry and transportation would reduce energy growth to a stable level. In this case, actual consumption would be approximately 80 Quads in the year 2000, compared to 141 Quads for Historical Growth, and 105 for the Technical Fix scenarios.*

A more recent study, by the Institute for Energy Analysis (EA) at Oak Ridge, Tennessee, concluded that gross energy consumption in 2000 would range between 101-126 Quads.[9] A principal assumption of this study, which sets it apart from most prior forecasts, is that population growth would be smaller than prior estimates, and increasing energy efficiency would take on a greater future role, thus lowering projected future demand.

One current study unpublished as of this writing, is a major effort conducted by the National Academy of Sciences' Committee on Nuclear and Alternative Energy Sources (CONAES). It traces the effects of various energy supply and conservation strategies on future energy demand. One group within the CONAES study has concluded that with maximum conservation implementation coupled with changes in lifestyle, the United States could get by with one-third less energy (54 Quads) in the year 2010 than is currently consumed.[10]

A review of the principal national energy studies indicates that future consumption is difficult, at best, to predict, but the potential for energy conservation and development of alternate technologies can significantly reduce future consumption.

The potential for conservation is great, paradoxically, because the wasteful practices of the past have created new opportunities for efficiency and technological improvements. Critical examination of many end-uses of energy indicates that the *quality* of energy is frequently mismatched with the energy *need*. For example, heating a building or home requires relatively low quality heat, yet an increasing share of heating demand is being met with electricity, a high-quality energy source. For each BTU of heating energy supplied through electrical generation, two BTUs of primary fuels are converted to waste heat — and lost to the environment.

The major questions in energy analysis are not

* These net consumption figures do not include the additional energy wasted by losses in conversion of primary fuels to electricity. The total energy consumed in the Historical Growth scenario nears 190 Quads in 2000, due to this scenario's high electricity assumptions.

*whether* energy is wasted — but *where* and *to what extent*? To this end, the science of thermodynamics serves to reconcile energy needs and efficiency. A study group of the American Physical Society derived a new definition of energy efficiency (in 1975) which they termed "Second Law Efficiency", based on the second law of thermodynamics. This is the difference between energy actually used in a given system, and the most efficient possible use of energy in the same system. The group concluded that the overall (second law) efficiency of energy utilization in the United States is no greater than 10-15 percent.*[11]

America's major energy use sectors — industry, transportation, buildings — could be improved and modified for greater conservation by a combination of approaches — both social (lifestyle) and technical. The technical "fixes" alone, as pointed out in the Ford Foundation study, offer significant savings opportunities. They range from added insulation in buildings to more efficient cars and improved production processes in industry. As physicist Amory Lovins points out, ". . . there is overwhelming evidence that technical fixes are generally much cheaper than increasing energy supply, quicker, safer, of more lasting benefit."[12] In fact, conservation purchases are usually much less expensive investments than new sources of energy supply, since new sources of supply entail rapidly rising capital and energy costs. Conservation investments frequently are paid back — in energy savings — in a few months. One study of the metals industry concluded that better furnace insulation for one industrial process would cost $100,000 for complete installation, but would save $234,000 in natural gas per year, at current prices.[14]

A study of the conservation potential in the national building and housing stock by the American Institute of Architects concluded that: "If we adopted a high-priority national program emphasizing energy efficient buildings, we could by 1990 be saving the equivalent of more than 12.5 million barrels of petroleum per day."[15] Such a national investment makes sense, not only for retrofitting of insulation and other conservation measures in public buildings, but in private homes as well. As researcher Denis Hayes pointed out in a recent study, home insulation is one of the best "blue chip" investments a homeowner can make. "Common stocks, corporate bonds, and savings accounts pay interest rates of 5 to 10 percent — often at some degree of risk. Home insulation may earn 20 to 40 percent in saved fuel costs at no risk. Moreover, investments in home insulation will raise property values."[16]

Improvement of consumer technologies, such as home appliances, vehicles, and heating and cooling systems can be accomplished through relatively minor changes — such as adding insulation to home refrigerators, using lighter materials and building smaller vehicles, and adapting use of heat pumps rather than conventional heating/cooling systems. Several detailed energy studies have indicated potential savings of 40-60 percent of current use in residential and commercial sectors alone. The potential savings through conservation frequently equals the highest growth projections of the energy industry.[17]

An important lesson in energy use for the United States is the conservation record in Sweden, a nation which enjoys a similar standard of living, while consuming only 60 percent of the energy required to sustain the U.S. economy. In Sweden, less energy is used in transportation because of mass transit and smaller, better-engineered cars; less is used in industry because of better "housekeeping" and improved technologies; less is used in buildings because of more attention to conservation, as well as official encouragement of conservation through building codes, subsidies, etc. According to a Swedish business executive, the cost of fuel has been the key factor in all this: "We produced a generation of more energy conscious engineers than countries with fossil fuel more easily available."[18]

About one-fifth of Sweden's demand for hot water and space heating is met through the use of "district heating" plants, central plants which distribute hot water in localized areas. Common in Europe, district heating is largely unknown in the United States, since heating systems have traditionally been private home installations. However, a recent Brookhaven National Laboratory study indicates that "up to one half of the U.S. population could be served by district heating at costs that are competitive with the present costs of imported oil and also with projected costs of new energy forms."[19] Such systems serve thousands of consumers through a grid of underground pipes, and could use waste heat currently rejected from U.S. power plants. The district heating technology can be adopted to plants burning garbage as fuel, as well as industrial installations which could serve nearby communities.

A related technology is industrial "cogeneration", which refers to technologies which are used to recapture waste heat from electrical generation and other industrial steam processes. A report to the National Science Foundation by the Dow Chemical Company concluded that available cogeneration technology could supply U.S. industry with half its own needs for electricity by 1985, while saving fuel from conventional sources and eliminating the need for construction of fifty nuclear power plants.*[20] The Dow study concentrated on the use of cogeneration technology in conjunction with coal-burning plants, and noted that the main obstacles to cogeneration schemes, rather than conventional, can provide a generous 20 percent return on investment (before taxes) for the industries.

District heating and industrial cogeneration make sense from an economic and energy standpoint, since these approaches use available energy wisely and deliver greater quantities of low quality energy to consumers needing energy in this form. In this sense, the net energy of such processes is greater than conventional facilities which are built without regard for energy quality.

* A basic term which has been used to describe the thermodynamic factor in energy use is *net energy*. Net energy is the energy yield or output of a process, minus the energy required to extract, process and deliver the output energy. This concept has been developed and refined by Howard T. Odum and associates at the University of Florida.[13]

* Recognition of the potential for cogeneration is evident in the President's Energy Plan, as specific tax incentives are earmarked for this technology.

"Total energy" plants are similar integrated facilities which use primary fuels for electricity generation and recapture waste heat for building heating and cooling. A limited number of total energy plants have been built in the U.S. over the past two decades — limited mostly to commercial buildings and housing complexes. The federal government has developed a pioneering program for total energy technology in communities. This program, called MIUS (for Modular Integrated Utility System) is designed to reduce energy needs in communities by a minimum of one-third over conventional use, and several pilot locations have been developed.[21]

In all sectors of the economy, there are known technologies which could be implemented with dramatic effects on energy efficiency. The studies previously referred to, such as the Ford Foundation's Energy Policy Project, found that conservation goals can be met through "technical fixes", without economic disruption and without construction of great numbers of new central power facilities. In conjunction with conservation technologies and shifts to more efficient lifestyles, the introduction of renewable energy sources such as solar energy offers an even greater opportunity for reducing the need for centralized energy generation.

**Renewable Energy Sources**

The only large-scale use of renewable energy sources in the United States today is hydroelectric power generation — electricity produced by harnessing the sun's energy indirectly through the earth's water cycles. Hydroelectric power contributes about 4 percent of the nation's energy, but its potential is limited, due to the problems of finding suitable, environmentally acceptable sites for new dams.* A renewed national discussion of the potential for reliance on solar energy directly has been prompted by the construction and demonstration of several hundred solar-heated homes and buildings in the mid-1970s.

Home heating and water heating needs offer a significant opportunity for use of solar energy technologies, since solar-heated fluids in collector systems can deliver low-quality energy for heat economically. Solar heating for buildings can be achieved by either *active* systems, employing collectors (plastic or glass devices which trap heat) and assorted pumps, pipes, etc., *passive* systems, which depend on solar-oriented building design (south-facing windows, overhangs over windows, etc.), or combinations of the two. A stumbling block in the development of solar energy for building applications has traditionally been the storage of the sun's energy for use at night or during periods of poor weather. Storage problems have been largely overcome by the development of insulated storage tanks for water, rock bins, chemical storage solutions, and application of thermal techniques in wall design.

Since the introduction of inexpensive fossil fuels and mechanical heating/air-conditioning systems, the construction of homes and buildings has not been sensitive to climatic variables. Professor Ralph Knowles of the University of Southern California puts it this way: "Most of our buildings have been erected in the last 30 years. In Los Angeles such buildings were intentionally energy dependent. At a time when energy sources were thought inexhaustible, old climate-sensitive, indigenous stvles were abandoned in favor of modern residential, commercial and industrial types that required energy."[23]

Combining sound architectural design with solar collection techniques offers an economically and technically appealing means of decentralizing energy supply for basic heating needs. The technical demonstration of solar energy is by no means a recent event; the Swiss scientist Nicholas de Saussure (1740-99) built a solar "hot box" or oven, and used it for cooking. He was able to raise the temperature in the box to 320°F (160°) by chemically coating the glass cover. A number of solar devices were built and used in the 19th century for purposes ranging from desalinating water to operating pumping machinery. A fledgling solar collector industry developed in California and Florida in the 1920s, resulting in the widespread use of these devices for water heating. By 1951, there were 50,000 solar water heaters in the city of Miami, Florida alone.[24]

Rising fuel costs and special tax incentives enacted in many states (and promised in the President's Energy Plan) have given rise to a rebirth of the solar industry in the U.S., and a national trade association of solar manufacturers boasts almost 600 members, ranging from small businesses to some of the nation's largest corporations. Commercial prices for individual homes range from $800 for solar water heating systems (collectors, pipes, storage tank) to $8000 for complete home heating and water heating installations capable of supplying up to 90 percent of heating needs.* The growing popularity of solar devices prompted *Business Week* to recently predict a billion-dollar market for the solar home industry in the mid-1980s, in line with predictions of a number of government-sponsored energy studies.[25]

The utilization of solar energy for supplying low-quality heat for residential and building heating is quite advantageous from an overall energy perspective, since this "free" energy can replace conventional fuels as well as decrease the need for expensive transmission and distribution systems in conventional energy grids and networks. On a decentralized basis, solar heating technologies can be used in residences, commercial buildings, industrial heat applications, agricultural heating, and many other areas where low-quality energy (heat) is required. Various studies have indicated that up to 50 percent of U.S. energy consumption is in the form of heat; known solar technologies could theoretically meet this demand. Unlike conventional, nonrenewable energy sources, there is no need to be concerned about the "loss" associated with solar energy conservation. The source itself is limitless.

In a report to the Joint Economic Committee of the Congress, a New Mexico research group found that the "residential use of solar energy is feasible and could become widespread by 1990 with energy price de-

* However, small-scale development of hydropower may be technically feasible and eliminate large-scale environmental problems. Small plants in the 1-50 kilowatt range can provide mechanical power and generate electricity along suitable rivers and streams.[22]

* Only a few solar-assisted cooling systems are available in the U.S. and are primarily in the developmental stage, although the technology is known and may be commercialized in the next few years.

controls or in areas which suffer natural gas curtailment." The report added that "solar energy (of all energy sources) is the most sensitive to the availability of capital. For other sources of energy there are both fuel and capital costs associated with delivering useful energy. In the case of solar energy there are, in effect, no fuel costs." The study's conclusion indicated that the only major obstacle to rapid introduction of residential uses of solar heating is the limited availability of low-interest loans for purchase of equipment by consumers, and the continuing low costs of conventional fuels (such as natural gas) which should be decontrolled to better reflect their real value.[26]

A survey of the potential for solar energy use in residences and buildings in California found that solar water heating and space heating technologies were technically and economically feasible when contrasted to current consumer electricity rates. The study, conducted by researchers at the California Institute of Technology, estimated that a $10 billion consumer investment in solar water and space heating systems between 1977 and 1987 would replace up to 14 percent of the state's annual use of natural gas, an amount equivalent to "the supply capacity of some of the larger new gas supply projects such as the Arctic Pipeline or Indonesian LNG (Liquefied Natural Gas) projects." Nearly half of California's natural gas consumption is used for space and water heating, and the study estimated that two-thirds of the energy used for these purposes could be supplied by solar energy. However, the institutional limitations of current regulated energy prices and the lack of tax incentives to encourage solar development stand in the way of these goals. The study suggested stimulation of the private marketplace by establishing marginal-cost pricing for conventional energy sources; establishing a consumer loan fund for solar technology as well as legal tax incentives; and, encouraging electric utilities to own and service solar equipment.[27]

Other than the direct use of solar energy for space heating, water heating and low-grade industrial heating functions, there are a number of ancillary forms of energy. These technologies include the concentration of solar radiation by means of mirrors and other devices; and the direct conversion of solar energy into electricity through *photovoltaic* technology — the use of special materials which convert sunlight into direct-current electricity. In both technologies, solar energy can either be used for decentralized applications (rooftops, community uses, etc.) or in central plants (huge arrays of collectors connected to electrical grids).

Active solar systems for homes and buildings commonly employ "flat-plate" collectors, consisting of glass- (or plastic-) covered absorber surfaces (usually metal trays with copper tubes) which concentrate radiation and transfer heat to air, water or a liquid heat transfer medium. The concentrated heat is stored in rocks or water for later release. Sophisticated collectors combine other technologies for more efficient performance — using, for example, special chemical coatings on absorber surfaces to improve heat absorption and emission. With double-glazing and selective surfaces, collectors can achieve temperatures in the range of 230°-260°F (110°-126°C), compared to less complicated collectors which achieve temperatures ranging from 140°-180°F (60°-82°C).

Concentrating solar collectors make use of mirrors, special lenses and curved surfaces to concentrate radiation onto small areas where heat is absorbed. As opposed to flat-plate collectors, which can be fixed in stationary positions, the concentrating collectors are usually equipped with mechanisms which move the collector to "track" the sun's movement, and properly align the collector for maximum performance. Another promising technology is evacuated tube technology, which makes use of vacuum tubes containing an absorber surface (usually coated for selective absorption/emission). Numerous manufacturers are engaged in the production of flat-plate collectors (and associated systems), and several large companies have begun producing concentrating and evacuated tube collectors for decentralized applications (including Owens-Illinois, Corning Glass, Honeywell, and Itek Corporation).[28]

Photovoltaic devices employ semi-conductor materials such as silicon, gallium arsenide and cadmium sulfide (which have special solar-electric properties), which when arranged in parallel series on panels, can generate significant quantities of DC electricity. An outgrowth of space technology — solar panels power most satellites — photovoltaic devices are in limited use for remote applications. The primary drawback to wider utilization is their prohibitive cost. A complete spacecraft system may cost up to $500,000 per peak kilowatt of power, but the federal research goal is to bring the system costs down to $100-$200 per peak kilowatt for earth applications. As two solar specialists put it: "Thus, the goal in photovoltaic research and development must be to reduce costs eventually by a factor of about 500. This will require significant technological advances, in addition to the cost reductions made possible by mass production of millions of (photovoltaic) cells. Consideration of the cost of the high-purity silicon used in cells leads to the conclusion that advances in the technology for purification of silicon are also required."[29]

Although the advanced solar thermal and solar electrical technologies are not commercially competitive today with cheaper conventional fuels, the federal government and a number of industries have substantial research and development programs aimed at reducing costs. Much of the attention given to these systems has centered on their potential for centralized production of electricity. ERDA is testing a 5,000 kilowatt electric solar thermal plant (using concentrating collectors) in New Mexico, and plans to build a $100 million, 10,000 kilowatt plant near Barstow, California (in the Mojave desert) for pilot operation in the mid-1980s.[30]

Solar *bioconversion* describes processes and technologies which convert organic materials into useful forms of energy. In essence, bioconversion techniques seek to make better use of *recent* products of photosynthesis, rather than *fossil* products. Organic materials (biomas) are found in municipal refuse, agricultural and silvicultural wastes, manure and from special crops raised specifically for conversion to useful energy. Conversion technologies include direct combustion of wastes into fuels, pyrolysis (high temperature distillation) of wastes to produce synthetic gas, and anaerobic digestion (in absence of oxygen) of wastes to produce methane.

Energy stored in biomass is estimated to be 10 to 40 times the current annual human use of fossil and other conventional forms of energy globally, yet the basic problem in using biomass energy is the problem of collection. The U.S. Bureau of Mines estimates that over 2 billion tons of wastes are generated annually in the United States, yet most wastes are not concentrated for ease of recovery. Only 136 million tons are concentrated in cities, cattle feedlots, agricultural sources and timber industry locations.[31]

In St. Louis, Missouri, a waste conversion plant produces dry, shredded fuel from municipal garbage. This is used as a supplement to pulverized coal in a local powerplant; other wastes in the process (metals, etc.) are sorted out and recycled. A number of other combustion systems are being tested by ERDA and the Environmental Protection Agency, but air pollution problems from the combustion processes have not been fully resolved. Pyrolysis processes, which thermally decompose wastes anaerobically, are being tested in several states. A plant in San Diego, California produces an oil-like liquid from municipal waste, and a West Virginia plant is designed to produce gaseous fuels with about 30 percent of the heating value of natural gas.[32]

Anaerobic digestion of wastes has been used for decades in sewage treatment plants, usually on a small scale to provide methane for heat in various processes. Large methane plants have been proposed in Oklahoma City, Oklahoma and Denver, Colorado to convert cattle manure into gas fuel from large feedlots. A plan for the Denver area involves production of 2.2 billion cubic feet of methane annually from a large feedlot (200,000 cattle).[33] Small anaerobic digesters are used in many Asian countries — some estimates indicate that over 2 million small "biogas" plants are in operation in the People's Republic of China, and 30,000 in the Republic of Korea.[34] Some small plants are in operation in the United States, and a biogas system at Monroe, Washington converts manure into methane and high-quality fertilizer at a state prison farm.[35]

A number of technical studies point to the possibility of growing "energy crops" for direct conversion into gas and liquid fuels. Dr. George Szego of the Inter-Technology Corporation (Warrenton, Virginia) advocates such "energy plantations", in which fast-growing trees would be selectively cut and burned in conventional electric steam plants. To fuel a 1 million kilowatt electric powerplant would require something between 112 and 630 square miles of woodland, depending on location and the variety of trees.[36] Other schemes which have been proposed involve growing algae and harvesting the one-celled organisms for fuel, and growing crops (such as corn) for conversion to fuel. Amory Lovins argues that the U.S. beer and wine industry produces 5 percent as many gallons of liquid "fuel" (not all alcohol, though) as the oil industry produces gasoline. Therefore, he says, "a conversion industry roughly 10 to 14 times the scale (in gallons of fluid output per year) of our cellars and breweries would produce roughly one-third of the present gasoline requirements of the United States . . ."[37]

An appealing feature of Lovins' thesis is that solar bioconversion techniques could produce liquid fuels — whereas most renewable energy technologies are designed to supply space heating and cooling or electricity. With a 21st century transportation system having three times greater efficiency than the present one, the U.S. could get by entirely with organic fuels, he adds. However, a number of unresolved problems plague the potential future of bioconversion. They range from difficulties of collecting wastes* to the unforeseen ecological hazards of monoculture techniques in large-scale crop production.

Harnessing the winds for motive power has been a traditional energy source for many civilizations, including our own. According to the *Oxford Short History of Technology*, "as water wheels and windmills were the only important prime movers of early times, it is fair to say that the industrial revolution was launched with power units generating no more than 10 horsepower.'[39] By 1850, windmills in the United States represented about 1.4 billion horsepower-hours of work — equivalent to burning more than 11 million tons of coal.[40] Sporadic attempts have been made in Europe and the United States to reintroduce wind power, usig electric turbine technology, but no lasting systems have been built. During the Second World War, a massive 1,250 kilowatt wind electric station was operated at "Grandpa's Knob" in the central Vermont mountains, but wartime materials shortages forced its shutdown after a blade failure in March, 1945.[41]

However, significant interest in wind power has been generated by fuel shortages and the availability of federal research funds. In 1975, the National Aeronautics and Space Administration (NASA) began operations of a 100 kilowatt electric wind generator in Ohio, and current ERDA plans call for testing of machines slightly larger than the Grandpa's Knob generator. A 2,000 kilowatt machine is nearly completed in Denmark at a surprisingly low cost of $350,000; it is being built by the staff and students of Tvind college.[42] Both the Tvind and the NASA Ohio generator have twin blades and resemble aircraft propellers mounted on towers. The NASA wind generator utilizes two 2,000 pound aluminum blades, and the overall rotor diameter is 125 feet. This generator has a rated power level of 100 kilowatts in 18 mile-per-hour winds, which is sufficient to supply electricity to 20-30 homes.

A variety of wind generator designs are being tested in Europe, Canada and the United States. Blade designs range from the typical horizontal-axis rotors, in which the wind is intercepted head-on, to vertical axis rotors, in which the machine's blades are perpendicular to the earth's surface and the windstream. Vertical axis rotors have been built in a number of innovative and unusual configurations — the Darrieus rotor, for example, under tests by ERDA, looks like a

* Systems ecologist Howard T. Odum claims that *no* net energy yield has been observed from pilot algal bioconversion processes. The energy required to sustain the systems is greater than the product, according to his data. "As an appreciable yield develops, energy laws require a decline . . . (Early attempts did not consider) the algae free from its supporting ecological system which in nature requires mineral cycles, the diversion of much energy into various networks for stability, and the maintenance of extensive work for survival."[38]

giant egg-beater. Other designs make use of cups, rotating vanes, airfoils, and curved blades.

As is the case with other renewable energy technologies, wind technology is capital-intensive and initially expensive, even though the "fuel" is free. A substantial market exists in the United States for water-pumping windmills, and prices range from $300 to $2,000 for units capable of pumping several hundred gallons of water per hour from deep midwest and western wells (mostly for livestock).* These systems are economic because the pumping needs are frequently in areas isolated from electric transmission lines. Additionally, the relative economics of installing small gas or diesel pumps prove the worth of wind power. The wind machines are sturdy, don't need refuelling, and match energy requirements (intermittent) with supply.

On a larger scale, wind economics depend on availability of sufficient wind energy, the size of generators (for electricity), tower height, and whether or not energy storage is required. Storage of electricity can be accomplished by equipping an individual wind station with batteries (often more expensive than the generator and other equipment); futuristic schemes call for integrating fuel cells into the wind system (the DC electricity from the wind generator would be used to break down water into hydrogen and oxygen, which would be used to power the fuel cell — the hydrogen and oxygen would also be stored for later use).

As opposed to decentralized applications for solar energy (for heating and cooling), wind energy might best be harnessed in a more centralized fashion — by interconnecting wind generators into conventional electric power grids. As one NASA official commented: "Use (wind generators) as base power, with no storage . . . On a day when you have no wind — which will probably not happen for all windmills anyway, you use conventional fossil fuel power, and peak power plants."[44] A recent analysis by Jim Harding of California's Energy Commission contends that wind plants are ideal "baseload" power plants, and since medium-sized wind plants (200 kilowatt electric) "can be patched directly into the existing subtransmission grid, major transmission and distribution savings can be realized." Based on Canadian data on production costs of wind units of this size, Harding concludes that the generators operating at a 30 percent overall capacity factor would cost $3,050 per delivered kilowatt of electricity. This translates into 6.5c per kilowatt-hour to the consumer, a cost cheaper than projected future costs of nuclear power plants (which operate at capacity factors between 55 and 60 percent).[45]

Another recent study of wind potential indicated that mass-produced wind generators rated at 1,000 kilowatts, operating at 35-40 percent capacity at good sites would produce 3,000 to 3,500 megawatt-hours of electricity per year. "Assuming that the electricity grid can absorb all this energy at the time it is produced, then 100,000 wind-powered generators of this size would supply 300 to 350 million megawatt-hours per year, or about 15 percent of present U.S. electricity use. There is certainly no problem in producing the machines; a wind generator is less complex than an aircraft."[46]

Certainly, the potential for wind power seems enormous — the World Meteorological Organization estimates that 20 million megawatts of wind power can be harnessed at selected sites around the globe.[47] What will be required to tap this energy source is a full-scale commitment by industry and government, and the elimination of financing obstacles — perhaps through special tax incentives and loan approaches.

**Potential for Renewable Energy Sources**

In addition to solar, bioconversion and wind energy, a number of other environmentally compatible and renewable sources merit attention. These include the harnessing of wave power, conversion of heat trapped in ocean "thermal gradients" to electricity, and conversion of geothermal energy into useful forms (including electricity).* Schemes for harnessing the kinetic energy of the waves are being researched in Europe and the U.S., and an active program for developing ocean thermal power is underway by ERDA. Although research efforts are underway to demonstrate the centralized applications of various renewable energy technologies (primarily for conversion to electric power), the most promising, economically viable technologies at present are best adapted to serving small and medium energy consumers — ranging from individual homes to communities.

A recent comprehensive review of the potential for solar and other renewable energy technologies, conducted by the Stanford Research Institute for ERDA, found that a maximum development effort could result in the contribution of 48 Quads of renewable energy (solar, hydro and geothermal sources, not including maximum wind energy development) to the economy by 2020. In this "solar emphasis" scenario, residential and commercial heating by solar means would increase from 3 Quads in 1985 to 18 Quads in 2020, as retrofitting of collectors and new housing and buildings were fitted with collectors and improved design. Biomass conversion would contribute 11 Quads in 2020, solar industrial heating 4 Quads, solar-generated electricity 11 Quads, and 4 Quads from hydro and geothermal sources. In the same study, a "low demand" scenario was depicted in which solar and other renewable sources would supply 18 out of 102 Quads total in 2020. "The low demand case increases nonsolar energy prices to reflect some of the costs of environmental degradation, social dislocation, and depleting resources for future generations."[49]

Comparing various energy studies can yield conflicting and confusing results, however. Were the results of this study integrated within the goals of the previously cited CONAES panel, which predicts a 54 Quad society by 2010 (with technical and behavioral

* Until the advent of cheap electric power provided by the federal Rural Electrification Administration in the 1930s and 1940s from central grids, a lively market existed for electric wind generators in the 200 watt to 1 kilowatt range. These machines were sold by a number of companies; one of them, the Jacobs Wind Electric Company, accumulated sales of $75 million in ranch-sized wind plants between 1928-1957[43]

* Even though geothermal heat is not a "renewable" energy source, great reservoirs exist in the Western United States, and over 500 megawatts of electrical energy are currently being produced from geothermal reservoirs in the "Geysers" area of northern California. This state alone is estimated to contain 70 percent of the high-grade geothermal resource base of the U.S., and the potential for electricity production in southern California's Imperial Valley is estimated at 30,000 megawatts.[48]

changes), the result would indicate the possibility of 90 percent renewable energy conversion within the span of one human lifetime. In fact, Amory Lovins vociferously defends the possibility of converting to a "soft," decentralized path within this time frame. In his view, the solar and conservation alternative "does not require 'exotic' methods such as sea-thermal, hot-dry-rock geothermal, cheap (perhaps organic) photovoltaic, or solar-thermal electric systems. If developed, as some probably will be, these technologies could be convenient, but they are in no way essential for an industrial society operating solely on energy income."[50]

The primary obstacles which block the realization of such a future are not technological in nature. The technical fixes of conservation, such as better equipment design, additional insulation, use of small vehicles, and improvements in industrial processes can easily be *technically* coupled with emerging renewable energy technologies. The stumbling blocks are almost invariably institutional and economic. Even as the great stocks of fossil fuels wane, the industrial economy is geared to supplying them to consumers at costs which are subsidized by direct and indirect means. Environmentally, the costs of central fossil and nuclear supply systems do not take into account pollution hazards, social stresses, or the future burden of waste disposal (especially in the centuries-long case of nuclear systems). Socially, governments (state and federal) have rewarded energy extraction and use, but frowned on conservation and frugality.

Reversing the institutional trends offers the only valid hope of rapidly developing renewable technologies and conservation approaches.

**Building a "Conservation Economy"**

The framework of our energy future is being determined by the commitments and investments made today by government and industry. Lead times for the construction of powerplants range from two years for small fossil units to 8 years and more for large nuclear plants. Similarly, lead times for energy-related construction efforts (energy transportation facilities, industrial plants, highways, etc.) are long, and more importantly, their development determines the structure of future energy supply.

A priority issue requiring national resolution is that of national investment in energy facilities and other related industrial expansion. As analyst Meir Carasso points out, errors in energy forecasting can seriously alter economic realities. "In the 1975 State of the Union message (President Ford's) Energy Program indicated an expected annual increase of 6.5 percent per year in generating capacity for the 10-year period 1976-1985. A reduction in the level of electricity demand of 1 percent from 6.5 percent to 5.5 percent per year amounts to an elimination of the need for 100 new power plants, each of 1,000 megawatt capacity, and an attendant reduction in capital requirements of some $153 billion in 1976 dollars."[51]

Pursuit of the "conventional" energy future, which implies primary reliance on electrification, nuclear power, synthetic fuels, and increased coal consumption, raises the spectre of significant capital shortages in other sectors of the economy. According to President Carter's National Energy Plan, from 1973 to 1975, the U.S. invested $112 billion in plant and equipment for energy production — about 35 percent of all such capital expenditures in the economy. According to the plans the capital requirements to reach an energy consumption level of 48 million barrels of oil equivalent per day in 1985 ". . . would exceed $550 billion, about 37 percent of total U.S. expenditures for all plant and equipment throughout the economy."[52] Prior to 1973, energy construction expenditures consumed only 30 percent of available capital.

Clearly, the increasingly disproportionate share of capital devoted to centralized energy expansion tends to "crowd out" the capital market, preventing expenditures on alternative possibilities. A decentralist future implies investment in local communities, small businesses, and a diversification of the economy. Already, signs of capital shortages have begun to appear in these sectors. According to a 1977 study of the Small Business Administration (SBA), small businesses comprise 97 percent of all unincorporated and incorporated businesses in the U.S., and generate more than half of U.S. jobs, yet ". . . a set of impediments have developed that are preventing smaller businesses from attracting the capital without which they cannot perform their traditional function of infusing innovation and new competition into the economy." The study notes that venture and expansion capital underwritings for small companies (under $5 million) have dropped from 418 in 1972 to *four* in 1975. The study suggested a series of steps for the government, including changes in tax laws, more flexibility in depreciation allowances on assets, and better SBA loan policies.[53]

For those new, small companies which have been capitalized, economic analysis indicates that better management has produced more technological innovation and more employment than large, "mature" corporations. A recent comparison of five mature corporations and five new, small technology-oriented corporations by the MIT (Massachusetts Institute of Technology) Development Foundation found that the new companies produce far more jobs per dollar of capital investment. Five large corporations (including DuPont, Bethlehem Steel and General Electric) had an overall increase in sales of $15 billion (from $21 to $36 billion) between 1969 and 1974. The five new companies in the study (mainly electronics firms) increased in sales from a total of $145 million to $857 million in the same period, yet they created 34,000 jobs to the 25,000 jobs created by the corporate giants.[54]

This level of innovation and business scale will be required to fully realize the new industries and community-oriented businesses and organizations needed for alternative energy and resource development. The needed capital investment for such decentralized development will not be as high per employee as that required to sustain large institutions and corporations. Capital requirements per employee in the petrochemical and electric utility industries are in the $105,000 to $110,000 range, yet service and trade industries require only one-tenth as much capital per job developed.[55]

Not only are the capital requirements on the whole lower for less energy — and resource-intensive industries, but also the desired shifts in economic production from energy-intensive activities to conservation-related activities yield favorable employment ratios. Data synthesized by Bruce Hannon at the University of Illinois indicates that conservation shifts in the economy would have significant job impacts. He calculates that 930,000 jobs would be produced with the savings of each Quad resulting from shifts of intercity plane transport to rail transport; 750,000 jobs per Quad of energy savings entailed by shifting from "throwaway" to refillable beverage containers; 200,000 jobs from a Quad of energy savings resulting from an economic shift to personal consumption expenditures rather than new highway construction; and 60,000 jobs resulting from each Quad of savings realized by conventional refrigerators rather than frost-free units. While Hannon points out that not all conservation-related activities result in employment increases, he adds: "Clearly, shifts from the personal auto to buses, trains, and bicycles would expand employment and reduce energy use, as would increased residential insulation to reduce heating energy losses." To achieve the twin goals of full employment with accompanying per capita energy use reductions, he advocates a net tax on non-renewable energy sources, with the proceeds devoted to conservation efforts.[56]

A graphic example of the promising economics of conversion to conservation and renewable economies can be seen by contrasting investments in new central power plants to housing investments.

If, for example, one-fourth of America's 2 million annual housing starts (single and multi-family) included solar water heating, better climatic design and full insulation, 60 percent of the energy used in conventional structures would be saved. The conservation-solar additions would raise the construction costs of an average $41,500 dwelling by $2,000, for a total of $43,500. Between 1978 and 1985, the conservation and solar improvements would result in $7 billion in new capital investment in a total of 3.5 million new dwellings.*

This $7 billion in capital expenditure will save the eqivalent in electrical energy of 30 billion kilowatt-hours per year. This amount of energy would require the operation of over 6 new 1,000 megawatt nuclear power plants which would cost almost $10 billion, *not including* fuel or maintenance costs (or disposal of radioactive wastes). Additionally, the installation of the solar water heaters *alone* would create 105,000 new jobs in local construction trades, *not including* the manufacturing jobs involved in solar components. On the other hand, the total number of jobs produced by construction of the nuclear plants amount to only 34,000.[57] Contrasted to the long lead time (8 years) required to complete a nuclear plant to deliver energy, the solar-conservation alternative would begin delivering energy and jobs immediately. Thus, not only are more jobs created by decentralizing energy supply, but net benefits to the local economy are greater for both employment and investment.

Not only are specific economic shifts to decentralized, renewable technologies sensible from a purely short-range viewpoint, but these shifts are essential to a long-range economic conversion to a society which rewards resource stability and social continuity. As economist Nicholas Georgescu-Roegen points out, the current economy is primarily concerned with the rapid depletion of the low entropy mineral and energy reserves of the earth, with little concern for the future. "Up to this day, the price of technological progress has meant a shift from the more abundant source of low entropy — the solar radiation — to the less abundant one — the earth's mineral resources . . . The faster the economic process goes, the faster the noxious waste accumulates. For the earth as a whole there is no disposal process of waste. Baneful waste once produced is there to stay, unless we use some free energy to dispose of it in some way or other."[58]

Reversing the trend of high technology, high energy consumption, will not be easy, and the economic costs in the short run will be high — given the added expense of the initital capital intensity of renewable technologies. But the alternative is far worse — without a conversion to a sustainable conservation economy, the economic process seems destined to destroy itself, as the remaining reserves of concentrated resources are mined in an ever more costly spiral of untrammeled growth. There is little hope that *both* courses can be simultaneously pursued, if for no other reason than the finite availability of capital.

In the United States, the central institutions of corporate power and state power seem little inclined to make the necessary investments for conversion. The oil industry as a whole spends less than one percent of its profits on overall research and development (into all forms of future energy), and the federal government's budget for energy research and development allocates only 13 percent for solar and conservation.[59] The entire energy R&D budget of the government is less than the revenues spent by the U.S. food industry on consumer advertising.

A number of hopeful signs have begun to emerge, however, as individuals recognize the serious nature of energy shortages and economic limits. A May, 1977 Harris poll found that a majority of Americans (63 to 29 percent) believe that the country would be better served if emphasis were put on "learning to appreciate human values more than material values," rather than on "finding ways to create more jobs for producing more goods." By 66 to 22 percent, the public voted to "break up big things and get back to more humanized living," over "developing bigger and more efficient ways of doing things." An even larger percentage (79 to 17 percent) of people would place more emphasis on "teaching people how to live more with basic essentials" than on "reaching higher standards of living."[60] In line with this thinking, a 1976 report estimated that by 1985, over 35 million Americans would adopt a less-consumptive standard of living ("voluntary simplicity"), characterized by lifestyles of lessened resource consumption, more attention to home life than incessant travel, purchases of durable, longer-lasting goods, and more cooperation (communal housing, food cooperatives, etc.) — rather than isolated living patterns.[61]

* According to revised estimates of the goals of the President's Energy Plan, only 1.2 million dwellings are expected to have solar equipment by 1985.

The vexing question is: Will our social, economic and political institutions respond *in time* to ease the transition to a less-consumptive society based on income energy? As we face the critical technical and economic decisions, it will be necessary to muster wide social alliances for technical change. Writing in the 19th century, the Russian emigré philosopher Kropotkin observed that the Western industrial revolution was likely impeded by the "general decay of industries which followed the ruin of the free cities, and was especially noticeable in the first part of the 18th century . . . Surely it was not the disappearance of the artist-artisan, nor the ruin of large cities and the extinction of intercourse between them, which could favor the industrial revolution; and we know indeed that James Watt spent twenty or more years of his life in order to render his invention serviceable, because he could not find in the last century what he would have readily found in medieval Florence or Brügge, that is, the artisans capable of realizing his devices in metal, and of giving them the artistic finish and precision which the steam engine requires. For industrial progress, as for each other conquest over nature, mutual aid and close intercourse certainly are, as they have been, much more advantageous than mutual struggle."[62]

A comparable situation confronts this society, as the new industrial revolution will require a basis in value before the needed technical shifts to conservation and sustainable resources can occur.

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# Toward a Sustainable Energy Society

**by David W. Orr and Cecil R. Phillips** *

**The keystone of a rational energy policy must be a national commitment to energy conservation. Such a commitment will provide the time we need to develop and deploy energy technologies that are safe and sustainable, appropriately scaled, and economically sound. To achieve these objectives we recommend: (1) removing all subsidies for non-renewable fuels; (2) placing a royalty on non-renewable fuels in a manner that is equitable to all and beneficial to the economy; and (3) eliminating all institutional barriers to efficient energy use.**

**Conventional Energy Forecasts**

Present energy forecasts describe the United States as caught in the iron grip of inexorably rising demand. According to such forecasts population will increase by less than one-fifth in the next few decades, total energy demand will double, and demand for electricity will triple.

The physical realities of the conventional energy approach are becoming all too familiar: thousands of giant power stations, both coal fired and nuclear; ubiquitous transmission towers; vast stripmines; thousands of arctic and offshore oil and gas wells; and huge refineries. We are promised even more: a massive new synthetic fuels industry; oil shale development with even more stripmining; coal slurry lines; and the emergence of a plutonium economy and its attendant transport and support facilities.

The economic realities of the conventional course are equally dismal. Synthetic fuels are many times more capital and energy intensive than are traditional direct fuel technologies, and electrification is even more capital demanding. The costs of a high energy growth program are responsibly estimated to be as much as two-thirds of all net new capital investment between now and 1985. Such vast expenditures would, among other things, foster rising prices and deprive industry of the funds it needs to invest in more energy-efficient technologies. Moreover, such an investment pattern would push unemployment upward since investments in energy facilities produce fewer jobs per dollar than any other investment we can make.

The environmental risks of the proposed giant energy technologies are forbidding. Drilling for oil in arctic and offshore areas would introduce unprecedented technical risks to fragile regions. Coal, shale, and uranium mining would devastate hundreds of communities and millions of acres, often irrevocably. The predicted doubling of the amount of carbon dioxide in the atmosphere from the burning of fossil fuels will jeopardize climatic stability and world agriculture. Energy growth increases the likelihood that catastrophic events — including nuclear accidents, oil spills, natural gas explosions, and dam failures — would undermine both natural and social systems.

Ecological risks would be joined by social and political risks. Centralized energy systems would have to be protected against the terrorist attacks to which they are vulnerable, and against the legitimate dissent they are likely to arouse. The powers of the state would have to expand to try to divert needed resources into the energy sector to override local siting objections, to substitute elitist technocracy for democratic processes, and to regulate energy through bureaucracies far removed from the people they supposedly serve. The resultant changes in a democratic society ought not to be taken lightly in view of our recent experience of abuses of police power by the CIA and the FBI. More-

* This paper is an edited version of *The Wolfcreek Statement*, a document produced by a group of scholars following a three day meeting in Georgia, in October 1976. Participants were: James Benson, Charles Cicchetti, Herman Daly, Denis Hayes, Bruce Hannon, Amory Lovins, Eugene Odum, David Orr and Cecil Phillips.

over, the conventional path of energy growth could lead to the creation of "zones of national sacrifice" and to divisive interregional conflicts.

Similar divisions and conflicts could occur internationally. Expanded use of complex and expensive technologies developed by the wealthy states could in poorer countries create technological dependencies and commercial monopolies while simultaneously imposing inappropriate cultural patterns and values upon the new users. Even more important, American reliance upon nuclear power both directly and indirectly promotes the international spread of nuclear power and its inevitable companion: nuclear weapons capability.

The United States is now at an historic crossroad in its national life. Before us is the unprecedented task of moving from dependence upon a rapidly declining non-renewable energy base to dependence upon a new base that is as yet undetermined. Our present drift can only lead us into unresolvable conflicts between energy production and food production, between democratic ideals and emerging technological imperatives, and between safety and our seemingly relentless addiction to energy. History offers few, if any, examples of equivalent challenges. To a large extent the ultimate success of the incoming administration will depend upon its ability to create a rational, far-sighted energy policy to guide the nation through this transition.

**The Case for Conservation**

We reject the conventional approach to the energy problem and with it any notion that we must be compelled by the force of uncontrollable energy demands. But if, as we argue, our present course is unacceptable, is there a plausible, realistic alternative? We believe there is. A growing body of evidence suggests that an energy conservation program that would allow us time to create a sustainable energy posture is possible in the immediate future. But while desirable, such a program is not inevitable, and is indeed improbable without a major national commitment and a transition policy extending over a period of several decades.

The largest source of energy available to the United States is the energy we currently waste. Our country ranks only fourteenth among the eighteen members of the International Energy Agency in terms of effective energy conservation efforts. Sweden, West Germany, and Switzerland, at comparable standards of living, consume only 60 per cent as much energy per capita. In 1976 Americans wasted more fossil fuel than was used by two-thirds of the world's population. This excess, which currently comprises one-half of our energy budget, represents our nation's largest, cheapest, cleanest, and safest near-term source of new energy.

It is feasible for the United States to sharply increase its energy efficiency by the year 2000 and in the process greatly extend its energy supply. Energy consumption can be made more efficient by carefully matching the quality of fuel with the quality of work desired. Such matching would eliminate, for example, the burning of high quality natural gas and oil at temperatures in excess of 1000° to obtain room temperatures of 70°. Energy consumption can also be reduced by changing the patterns of consumption to favor efficiency through the use of mass transit, bikeways, cluster housing, district heating, and recycling.

The list of good ways to conserve energy is long. For example, ceiling insulation in a typical home costs about $300 but will save about seven barrels of oil each year for the lifetime of the house. These seven barrels, which are as valuable as new oil pumped out of the ground, can then be employed more productively elsewhere. The energy saved in just 10 years would amount to 70 barrels, which means that we are "producing" oil at $4.30/barrel. When heating oil costs $3 per barrel, insulation was no bargain. But today, heating oil often costs $16 per barrel, and insulation has become a cheap source of new energy.

Industry currently consumes 40 per cent of this country's fuel. Recent studies by the Conference Board and the Ford Foundation's Energy Policy Project suggest that enormous energy savings can be made with existing technology without denting industrial productivity. The primary metals industries use about one-fifth of all industrial fuel. By adopting technologies now widely employed in other countries, the steel industry can reduce its inordinate fuel demands by about 50 per cent by 1995. Using the new chloride process instead of the traditional Hall method to refine aluminum yields energy savings of about one-third. Recycled scrap aluminum requires only 5 per cent as much energy as aluminum regined from virgin ore.

Forty-five per cent of all industrial fuel is used to generate process steam. If this steam were first used to generate electricity and then used as process steam, considerably more electricity would be produced than the entire industrial sector now purchases from utilities. The additional fuel and capital needed per kilowatt-hour of industrial "co-generation" is only half that required by the most efficient new centralized powerplants.

From 30 to 50 per cent of the operating energy in most buildings can be economically conserved now. Moreover, the American Institute of Architects estimates that the use of advanced conservation technologies including solar devices, heat pumps, and total energy systems can conserve up to 80 per cent of energy consumption in new buildings. A national commitment to upgrading the energy efficiency of buildings would, by 1990, save the equivalent of 12.5 million barrels of oil a day.

Equally dramatic energy savings are within practical reach in the transportation sector. The use of manual transmissions would save one-tenth of all automotive fuel consumed. Switching to radial tires would save another tenth. Reducing the average vehicle size from 3600 pounds to 2700 pounds would save the nation one quarter of its present gasoline use. Carpooling, the use of mass transit, and greater use of railroads could further cut energy waste.

Aside from the intrinsic merit of saving scarce fuels, the case for energy conservation rests on at least four additional points. First, conserving energy by substituting labor for energy can help to reduce unemployment. A carefully designed program of energy conservation can create up to 930,000 jobs per quad* of energy saved. The return to a more labor intensive economy can also encourage meaningful employment and worker participation, both of which are conducive to personal development. Second, by increasing employment while encouraging energy thrift, we can reduce the rate of inflation. Third, conservation will reduce the environmental damage implicit in the acquisition, transport, and consumption of energy. Fourth, energy conservation allows us to reduce our reliance on foreign sources of fossil fuels, which has steadily increased despite a stated policy of "energy independence."

**The Long-Term Goal: A Sustainable Energy Society**

Energy conservation will give us the time we need to make a transition from an energy base consisting of geologic capital (oil, coal, natural gas, and uranium) to one based on renewable, safe, direct and indirect solar income. This time provides a reprieve in which we can examine alternative energy technologies. If our present knowledge advances even modestly over the next several decades, we may confidently expect a rising level of energy derived from the renewable income sources.

In most respects solar power is an ideal energy source: it is free, abundant, and safe; it implies no social or political regimentation; and it can either be used in its low temperature form or concentrated to high temperatures. Solar energy can be used directly as a source of low grade heat (which constitutes over one-half of our energy needs), and indirectly in the form of wind and bioconversion for industrial processes. Moreover, there is reason to expect that the direct conversion of sunlight into electricity will be commercially feasible within the next two decades.

Because sunlight is compatible with decentralized applications, many solar proposals dispense entirely with the expensive transportation and distribution networks that encumber conventional energy sources. But this saving must be weighed against the additional costs of collecting and storing a form of energy that is dilute, intermittent, and seasonally variable.

Objections to solar energy on grounds that it is more expensive than its alternatives are based on the practices of discounting the value of energy resources *in situ* and of granting of depletion allowances to encourage resource exploitation. The illusion of cheap energy based on this kind of thinking has led to extravagant use and rapid exhaustion of scarce supplies. Pricing non-renewable fuel at its renewable replacement cost, which is at least as logical and a good deal wiser, would make the price of renewable energy technologies competitive immediately.

A sustainable energy posture would also offer the advantages of greater political stability and immunity to disruption through sabotage. The vulnerability of decentralized technology systems to terrorism and the likelihood that they will be misused as weapons is negligible. Political stability would also be enhanced by the movement toward decentralized, small-scale, and adaptable energy production systems that reduce the need for distant, high technology experts and large regulatory bureaucracies. The positive implications for the conservation and expansion of civil liberties in such a society are considerable.

Internationally, the transition to a sustainable energy society would be the most significant contribution the United States could make to world peace. An alternative to present forms of modernization that are economically and ecologically unsustainable is obviously necessary. Modern states have climbed the ladder of prosperity only to find the upper rungs are loose. To those clamoring to make the same ascent, our protestations that the ladder cannot support our combined weight are inevitably and properly, interpreted as self-serving. In these circumstances the creation of an alternative that would ease our weight on the ladder and demonstrate an alternative model of sustainable energy development would mean more than all the foreign aid we could conceivable muster. Initially such a course would, by freeing resources needed elsewhere, signal our serious interest in global equity and would re-establish American moral influence in the world.

Equally important would be the effect of sustainable energy goals in lessening the prospect of energy wars and in arresting the steady slide toward nuclear proliferation. To remain on the current path with a sizeable U.S. commitment to nuclear energy can only encourage the spread of nuclear energy technology and, eventually, of nuclear weapons. To expect others to abstain where we have indulged lacks both prudence and wit.

**A Transition Strategy**

It is apparent that there are two mutually exlusive energy paths before the nation. One option is based upon continued drift down the path of "hard" technology. It is fraught with technical risks and with economic and social uncertainties. The second option, which begins with a national commitment to energy conservation, represents a more cautious, sustainable approach. But while the choice of either tends to preclude the other, only the hard path is irreversible. At issue is our willingness to gamble against great odds that we can achieve a high technology solution to our energy needs and that we would be wise enough to manage the result. The option represented by a sustainable energy approach is more modest in what it promises, but it is also much less likely to imperil our future. The time for decision is now — continued drift could soon remove any possibility of moving in sustainable directions. Continued depletion of fossil fuels and growing investment of our capital and our reputation in hard technology will at some unknown date effectively preclude flexibility.

We maintain that such a course is neither realistic nor prudent, and accordingly we recommend the development of a comprehensive energy policy that commits the nation to energy conservation and to a gradual, planned transition to renewable energy sources. A comprehensive energy policy must build upon voluntary energy thrift, but it must also be implemented by all levels of government in all sectors of society, including transportation, industry, construction, and agriculture. Finally, a comprehensive policy must outline both a goal and a realistic transition strategy that does not jeopardize democratic institutions.

* *Quadrillion BTU's. Total U.S. energy use in 1974 was 73 quads.*

*A. The Removal of Energy Subsidies*

From World War II to the early 1970s, the cost of oil, gas, coal, and electricity (corrected for inflation) fell, while the cost of virtually everything else rose. As a consequence, cheap energy was systematically substituted for labor, capital, and materials wherever possible. Thus, the problem of designing an energy efficient state is in large part one of assigning appropriate values to high quality fuels whose scarcity is not yet adequately reflected in the marketplace.

A first step in a rational energy policy, then, is to remove distortions in the fuel marketplace created by tax loopholes, depletion allowances, intangible drilling costs, foreign tax credits, and promotional rate structures. The effect of removing such subsidies and of enforcing anti-trust laws would be to curb waste and to provide additional sources of federal revenue.

*B. An Energy Royalty*

While eliminating all subsidies to energy growth is necessary, such a step is not, in our judgement, sufficient. To achieve the goal of conservation and to encourage the use of renewable sources, a general increase in the cost of energy relative to its primary substitutes of labor and capital is recommended. To encourage both conservation and a shift toward use of renewable sources, the government must control the cost of energy so that it rises as wages and interest rates rise. The best strategy to effect the desired substitution would also involve the least governmental administration. We believe this strategy would be to place a severance royalty on all non-renewable energy sources. The use of a royalty would avoid the creation of yet another large federal bureaucracy and the consequent inefficiencies and inequities characteristic of the regulatory process. Moreover, a royalty would encourage conservation through higher prices for primary fuels such as oil, coal, and uranium but the proceeds would be awarded to the government rather than to energy companies.

By increasing the price of fuels at the point of severance — the wellhead or mine — product cost increases would occur in proportion to the direct and indirect energy required in production and marketing. Changes in consumer prices would affect the pattern of demand so that consumers would shift from purchases having a high direct energy content (e.g. gasoline) and from those with a high indirect energy content (e.g. throwaway containers) and toward products and services that require less energy but more labor. Similarly, industry and commerce could be expected to react to price increases by changing to energy saving technologies.

The net effect of this process would be a gradual reduction of overall energy use and an increase in the use of labor. Hence, aside from saving scarce fuels, the most important and immediate advantage of an energy royalty would be a general increase in employment. As we have noted earlier, investments in anything other than energy will provide more jobs per dollar than expenditures on fuel. As examples: each quad of energy saved by the use of inter-city trains instead of automobiles provides 700,000 jobs; intercity buses instead of cars provides 330,000 jobs; and expenditures on a federal health insurance program instead of new highway construction would provide 640,000 jobs.

To avoid economic and social disruption, the royalty should be increased gradually over a period of several decades. Consumers and businesses would find it increasingly advantageous to economize on the use of non-renewable energy and to use labor and tax-free renewable energy instead. The rate and timing of the royalty ought to be flexible and in accord with an economically and socially optimal transition speed. The ultimate level of the tax should be set so that the cost of non-renewable energy is eventually equal to or higher than that for renewable energy. This provides an incentive to lower the cost of capturing, storing, and distributing solar energy.

The amount of energy savings derived from any given level of royalty is still highly conjectural, but studies suggest that a levy of 50 cents per million BTU's would over five years yield an 8 per cent reduction in energy use and generate $28 billion in federal revenues.

The revenues derived from this energy royalty can be used in a variety of ways. While the royalty would be borne equitably by all parts of the populace, the proceeds could be returned to the poor and elderly as rebates in order to redistribute income. Alternatively, revenues could be channeled into employment programs and the accelerated development of energy conservation and refitting programs such as home insulation. The royalty might also be returned to industry on a short-term basis in proportion to payroll taxes to stimulate employment.

*C. The Removal of Institutional Barriers*

In addition to the severance royalty, we recommend the elimination of critical barriers to efficient energy use: outdated federal transport regulations, restrictive home mortgage conditions, utility rates that promote growth, building codes that prohibit efficient technologies, and others. We favor the adoption of minimum efficiency standards for products such as automobiles, air conditioners, and appliances, and mandatory energy labelling of major consumer items. Both efficiency standards and energy labelling will provide market advantages to responsible manufacturers.

We urge the installation of solar technologies on all new government buildings and the use of "life-cycle costing" in all other major governmental purchases. We also believe that energy impact statements, perhaps prepared as part of more comprehensive environmental impact statements, should be filed for all major federal actions.

Among other things this would enable the new administration to offer the American people the opportunity to rediscover the ingredients of neighborhood and community, to reverse the spiritually eroding effects of unchecked materialism, and to restore a sense of meaningful national destiny. The latter direction will require strong Presidential and legislative commitments to develop a comprehensive, long-term policy.

# LABOR AND RESOURCE COSTS and The Economic Future

by

**Kenneth E. Watt**

**In order to be able to control our society we must know how it works. This means, first of all, determining what are the key variables that must be taken into account. These, according to Kenneth Watt, we have not yet identified. Particularly important is the ratio between resource and labor costs. It is generally considered that it is to everyone's advantage to maximise labor costs and minimise resource costs. Watt shows, however, that it is by adopting the opposite strategy that we can solve many of the major problems that our society faces today.**

The United States does not have a single predestined future for the next thirty years any more than any other country does, but rather faces an array of possible futures. Which particular future we will experience depends largely on certain critical decisions we make now, and over the next few years. But in order to see how policy decisions are related to their consequences, we must digress briefly to consider the dynamics of the U.S. social, economic, environmental, cultural, political system. To explain why this digression is necessary, it is useful to consider the following analogy. The system can be visualized as a machine, which is partly subject to control by manipulating certain levers, switches, steering wheels, throttles and control knobs. The "good life", if we can all decide what that is, can, in part, be obtained by deciding the appropriate settings for the levers, switches, steering wheels, etc. However, a principal problem confronting modern society is that few people have any understanding of how the machine works. Thus, the electorate often gives enthusiastic support to politicians who advocate a set of switch-settings that will produce the opposite effect to that desired.

### How The Machine Works

On the basis of my statistical analysis of 20th century data on the U.S. it is apparent that the most important single group of determinants of year to year changes in the constant-dollar economic growth rate per capita is glut (overproduction or market saturation). That is, if there is overproduction of any product or service relative to the demand for that product or service, the result is depression of the rate of growth of the entire economy. If the product or service is very important for the economy, the results can be disastrous, particularly if there is glut in several different sectors simultaneously. The Great Depression of 1929-1934 was partly due to simultaneous glutting of the housing and wheat markets. The dynamics of glut are enlightening. The phenomenon occurs because of overoptimistic assessment of future market needs. The most spectacular recent examples have been in the world tankship market, wide-bodied jet transports, luxury condominiums and resort hotels, and perhaps most importantly in energy generating plants. The message in this phenomenon is that contrary to the conventional wisdom that more is always better, more is not better. There is supreme irony in this, because American worship of "more is better" is precisely the central cause of low economic growth rates in the U.S., a country which probably attaches more importance to economic growth than any other. A complication is now occurring relative to glut in the U.S. Increasingly, the techniques of dealing with short-term glut in wheat, corn, soy beans and other raw materials is to export staggering quantities to pay for imported crude oil. But this has other kinds of deleterious effects, as we shall see.

After glut, the next most important determinant of events in a country is the ratio of average wages to resource costs. This ratio is responsible for an amazingly wide variety of phenomena in society, many of which ought to receive a great deal of discussion by politicians, but do not. Here are some of the effects we can already identify.

1. If wages are high relative to resource costs, the demand for resources will be very high. This implies higher depletion and pollution rates.
2. But if wages are low relative to resource costs, the incentive to produce conventional types of resources will be very low, and also, the economic incentive to conduct technologically innovative research and development on radically new types of resources, such as solar and wind energy will be very low.
3. The consequence of the preceding two effects is that high domestic demand, accompanied by low domestic supply must be met by importation. The most striking current example is energy in the United States, which has such a low price as to encourage extraordinarily high consumption, and low domestic production. The consequence is massive imports from OPEC countries (roughly half of all U.S. crude oil is now imported).
4. The consequence of massive importation of some raw materials is that there must be massive exports of other raw materials to balance the merchandise trade balance. (The U.S. can not export enough manufactured products to balance its international trade, because U.S. labor costs are too high). This massive export of raw materials produces an extensive array of effects on the U.S. economy. Stocks of many raw materials have been run down so low as to produce great price inflation. The result is a significant erosion of consumer buying power and real decrease in the standard of living. This, again, is ironical, because most Americans believe that HIGH energy prices cause inflation. In fact, LOW energy prices are also inflationary, through their effects on the prices of all other raw materials. Still another side effect of low energy prices comes about through the effect on land use. The amounts of agricultural produce the U.S. is exporting are so great, that there is sharply increased demand for agricultural land. (For example, about 66 million acres of wheat were harvested in 1974, in contrast to 44 million in 1970). Again, there is supreme irony in this, because while the U.S. has always been resistant to having a national land use policy, it now has one because of its unwillingness to adopt a national energy policy.
5. If wages are high relative to resource costs, this provides all managers with a tremendous motive to achieve higher productivity by replacing expensive labor with cheap energy (mechanization and automation). The result is higher unemployment rates, higher crime rates, and higher government expenditures for police protection.
6. The ultimate consequence of the five preceding classes of effects is a lowered economic growth rate. That is, a high ratio of wages to resource costs produces low rates of economic growth. This phenomenon can be demonstrated easily, either in statistical analyses of the data for many countries, or by using mathematical models of the U.S. economy based on U.S. historical data. Amongst the most developed economies in the world now, there is a striking relationship between the rate of growth in constant dollar G.N.P. per capita, and the ratio of average wages to energy prices. As wages go higher relative to energy prices, economic growth rate goes down. Again, we find an ironical situation: in 1970 many other countries had much higher economic growth rates than the U.S. (and lower unemployment and crime rates) because they had much lower ratios of wages to energy costs. But by 1975, total compensation per hour, including fringe benefits and leave time had attained the U.S. level in Canada and West

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Germany, and surpassed it in Sweden. The high growth rates in those economies may be at an end.

Another important determinant of system behavior in modern industrial societies is the birth rate. This has its effects through the subsequent population age structure. A low birth rate now means a small number of 20-year olds twenty years from now, relative to the number of older people. A large number of 14 to 24 year olds relative to the number of older people implies a tremendous economic drain on the working-age population for education, provision of new jobs in the labor force, and social costs of unemployment. This factor is more important right now than ever before in the U.S., because the number of young people seeking positions in the labor force for the first time is very high, but also, this coincides with very high wages which give all managers a motive to cut back on staff, rather than increase. Since the incidence of crime is highest amongst the young, population-wide crime rates tend to fluctuate with changes in the age structure of the population. Much of the present unusually high incidence of crime in the U.S. is attributable to an unusually high incidence of people in the teen and early 20's years, coupled with a very high unemployment rate in these age groups.

The problems created by excessive numbers of 14-24 year olds are compounded by a high rate of legal, and worse yet, illegal immigration into the U.S., particularly from Mexico. There are roughly 5 million illegal Mexican immigrants in the U.S.

**How Government Policy Affects the Machine**

Government affects the rate of economic growth by design, by accident, or by default, through its actions or lack of actions concerning the accumulation of glut. The U.S. government still exerts no direct control over capital investment, or housing starts, even though massive overinvestment in housing is now clearly revealed as one of the most important triggers of the Great Depression. Indeed, the government may now be an ally in a phenomenon analogous to the housing overinvestment of the 1925-1929 period. The present case concerns investment in energy generating, transmission and storage facilities. It may turn out that investment in these has been far too high, not having taken into account the effect on demand of future price increases, which are likely to be substantial. On the other hand, when government encourages the sale of cereal grains overseas, this reduces glut and stimulates the economy, up to a point. Of course, beyond that point, export of raw food commodities runs domestic stocks so low that inflation is excessive, and diminishes economic growth rate.

Government has recently been the primary force behind low energy prices in the U.S. This has had all the deleterious effects previously mentioned. But in addition, low energy prices have a most serious long-term implication: they increase national habituation to an energy-intensive life style at a time when we should be preparing for adjustment to a sharply reduced energy supply. The trouble with this habituation is that it can not be changed suddenly. Many of the concomitants of an energy intensive life style could only be changed over about three decades: urban sprawl, and an energy-inefficient transportation system would take a long time to be replaced. Thus the government is currently committing the U.S. to some precipitous changes when cheap energy runs out, whereas responsible government planning and management could make the transition to a high-efficiency life style much less traumatic.

Government should be vigorous in managing the national allocation of capital so that it is directed to promotion of an energy-efficient system in the future. In fact, many national governments have promoted just the opposite: overinvestment in supersonic transports and underinvestment in technologically novel railways is an example. The federal government in the U.S. has been very remiss in allowing local governments to plan for a future that just isn't there, as when Southern California and other localities are allowed to continue planning for people movement largely by cars.

Government has had a large and deleterious impact on the future in the U.S. by taking a number of actions which undercut the intensity of the search for new sources of energy. The principal means of doing this has been by keeping energy prices down, but to compound the problem, there has been grossly inadequate government funding for research and development of solar energy.

The government has had very shortsighted policies on population. Not only has the government been pronatalist (by means of the tax rates on unmarried adults, for example) but it has also ignored the problem of illegal immigration. While legal immigrants into the U.S. only cause 23 per cent as much of a population increase each year as the natural increase due to the difference between births and deaths, when illegal immigrants are added, immigration may be making as large a contribution to population increase as natural increase. The significance of this is shattering, when we consider that there is now a 7.5 per cent unemployment rate in the U.S., and many cities are being bankrupted by their welfare payment program, much of which goes to illegal immigrants.

The government posture of spending on national defense to keep the economy healthy locks the nation into a pattern of maintaining stability by the wrong means. This builds up an economic infrastructure which will ultimately make it more difficult to maintain national system stability by the right means, such as investment in urban renewal, mass transit, and new types of energy generating systems. The proponents of heavy spending on military and space programs argue that this develops the leading edge of national technological capability in a way that will shortly have highly socially useful spinoffs. This is simply not true. It is noteworthy that some of the giant corporations which have benefitted most from military and space contracts have produced outrageously bad equipment for public transportation and energy generation. It appears that many large U.S. corporations have become committed to a type of operation in high technology development which is inappropriate to deal efficiently with major practical social problems.

But the preceding catalogue merely indicates the symptoms of a much more basic problem in government policy. All current difficulties result from a philosophy which believes that the goal of a society should be to increase productivity by increasing labor productivity. This, in turn, is to be accomplished by increasing the amount of energy and capital associated with each unit of labor. One problem with this philosophy is that it ignores the implications for unemployment, eroded consumer buying power, crime, and economic growth. But another is that it is based on a misperception. The notion of increasing productivity by using less labor per unit of output, by replacing labor with capital and energy is the product of a brief period in American history, 1950-1966, when labor was in short supply, and it appeared that there was a glut of energy and capital. But that period was a temporary, and very atypical aberration relative to the long sweep of history. Beginning with the last few years, we are moving into a period characterized by a glut of labor, and a shortage of capital and energy. Thus, a more appropriate strategy for the future would be to increase the productivity of capital and energy by making all activities more labor intensive. This strategy is just the opposite of that now being actively fostered by the government. A wide variety of policy changes, of which the most crucial would be increased energy prices, would get us back on the right track.

**Political Impediments to Making the Machine Work Correctly**

Government does not respond to the will of the public at large, of course, but rather to the will of highly organized and politically active constituencies. Present difficulties in selecting and operating on rational policies in the U.S. are due to a complex stalemate amongst six constituencies.

Organized labor, and the liberal movement in general wants higher wages, higher levels of income security, and lower resource costs.

The consumer movement does not only want higher quality merchandise; their goals have now been broadened to include low cost energy.

Business wants a high rate of economic growth and high profits, and until recently, probably perceived low energy costs as one means of achieving these goals.

Large energy corporations lose profits by having low retail energy prices, but on the other hand, can overcome smaller competitors by taking advantage of economies of scale, and their access to very cheap Persian Gulf crude oil (cheap compared to U.S. outer continental shelf crude oil, for example).

Small energy corporations such as solar energy companies need high energy prices to prosper; otherwise it will always be cheaper for their prospective clients to use a cheap conventional fuel source, such as Persian Gulf crude oil.

Environmentalists and conservationists must be philosophically committed to higher prices for resources relative to average wages, because a change in that ratio is ultimately the only way to prevent turning the planet into a barren wasteland.

The problem with this stalemate is that several of the constituencies have a misperception as to what is in their best interests. Organized labor has not yet perceived that low energy prices are the great enemy of full employment, because they stimulate mechanization and automation. The consumer movement has not yet perceived that low energy prices mean high prices for everything else, through the effect on exports of raw commodities to pay for imported crude oil.

To compound the problem, all realistic and successful politicians soon discover that it means the end of a career in politics to attempt to educate a constituency about these matters. You get the largest possible vote by telling a constituency what it already believes and wants to hear. Thus evolution of public thinking about these matters is likely to be agonizingly slow relative to the crying need for rapid change. The media (such as this magazine) will have to be a principal vehicle for effecting change.

**The Future Hazards of Not Making the Engine Work Correctly**

Unless government learns to take a different view of the appropriate way to use labor, capital and energy, the consequences will include high inflation, pollution, resource depletion, unemployment, crime, a resultant police state, and a low rate of economic growth. Further, there could be sudden disastrous effects on the economy if it becomes too dependent on energy from foreign suppliers. Also, the U.S. could run out of cheap energy suddenly, without having the necessary lead time to get new energy technologies in place to replace oil and natural gas. Energy prices would skyrocket, and be terribly disruptive to a society in which the basic pattern of land use, urban housing and transportation systems all presupposed super-abundant cheap energy. It would be the ultimate irony to get locked into a type of economic system which is energy and capital intensive and labor extensive, just as we are running out of energy and capital, and have a glut of labor.

Perhaps the ultimate hazard is that government is programming society to be highly instable, when it should be programming it to be stable, through higher energy prices and otherwise.

While many readers will accept the argument that the United States is paying a price for trying to continue a life style that depends on profligate waste of resources, some will be curious about the exact size of this price. While a detailed presentation of the necessary mathematics and statistics would be boring to most readers, simple tables suffice to lay out the essential features of the argument. Table 1 assembles data on the key steps in the causal pathway relating energy use to inflation in the United States. Column (1) shows that there is a very rapidly rising real cost to drill for oil and gas in the United States, reflecting the depletion of shallow, readily accessible deposits, and hence the need to produce oil and gas from wells for which the drilling cost per foot becomes progressively higher. Since the government now sets the price of newly discovered oil at $11.00 per barrel, increased costs of production can not be passed on to the consumer. Consequently, oil and gas companies are faced with declining profits if they continue to produce and sell U.S. domestic reserves. Worse yet, they will not be able to build up the enormous capital pool they will need for future exploration and production. To illustrate the magnitude of this problem, it can cost up to 40 times as much per barrel to produce oil from deep

Table 1. The indirect pathway by which depletion of domestic resources affects the consumer (inflation).

| Year | Average cost per well to drill for oil and gas (thousands of dollars) (1) | Value of imported petroleum and products (billions of dollars) (2) | Wheat exports and shipments (billions of bushels (3) | Price of wheat (dollars per bushel) (4) | Average retail cost of ten pounds of white bread as a proportion of the average weekly net spendable income of a manufacturing worker with three dependents (5) |
|---|---|---|---|---|---|
| 1960 | 55 | 1.55 | .60 | 1.74 | .0253 |
| 1965 | 61 | 2.09 | .87 | 1.35 | .0216 |
| 1970 | 95 | 2.76 | .74 | 1.33 | .0210 |
| 1972 | 106 | 4.30 | 1.18 | 1.76 | .0182 |
| 1973 | 117 | 7.61 | 1.15 | 3.95 | .0193 |
| 1974 | 139 | 24.23 | 1.04 | 4.09 | .0228 |
| 1975 | 147 (est.) | 24.77 | 1.30 | 3.49 | .0218 |
| 1976 | 161 (est.) | 36.00 (est.) | | 3.71 | .0205 |
| 1977 | 176 (est.) | 40.00 (est.) | | 2.54 (est.) | |

outer continental wells (offshore) as from the readily accessible onshore pools in the Persian Gulf area. The response of multinational oil companies to this situation is to increasingly meet U.S. domestic demand for oil by importation of foreign crude oil. The explosive growth in the value of such imports is indicated by column (2). To raise the money necessary to pay for these vast oil imports, the United States began a very sharp increase in exports of a wide range of other commodities, beginning in 1972. Roughly 18 per cent of the value of oil imports is covered by wheat exports, in which there has been a great increase (Column 3). The result has been to sharply run down U.S. domestic stocks of wheat, and hence increase the domestic wheat price (Column 4). The result shows up in an increase in the retail cost of white bread relative to the net spendable income of a typical family (column 5). Net spendable income is gross income, after subtracting federal income taxes and social security benefit fund payments.

We now have the necessary numbers to make some estimates of the cost of wasteful energy use. Notice in the last column (5), that there was a long historical drop in the proportion of net spendable income going into bread, from 2.53 per cent in 1960, to only 1.82 per cent in 1972. Notice, further, that the sharp increase in crude oil imports from 1972 to 1974 (column 2) caused an increase in the proportion of average net income going into bread from 1.82 per cent to 2.28 per cent, just two years later (column 5). This represents a decline in real consumer buying power of 20 per cent in just two years. The failure of this trend to continue in 1975 and 1976 was due to a recession, which ameliorated energy demand in the U.S., and also two bumper wheat crops. However, energy demand has grown enormously in the U.S. in 1976 and 1977, resulting in enormous increases in oil importation. Unless the U.S. can continue to grow and export very large, and on average, constantly increasing quantities of agricultural, forest, textile and metal commodities, we can expect depletion of domestic stocks in all of these, and an explosive growth in inflation.

Three factors from now on will determine the impact of crude oil imports on U.S. inflation: energy prices, the weather, and the amount of land on which crops and forest products can be grown. If the price of energy were to be doubled, after a few years for the economic system to reach a new equilibrium, energy use would approximately halve. This would eliminate the need for energy imports, and consumer buying power would increase to the 1972 level. How large that increase would be would depend on the weather, and the amount of remaining land. My recent analyses show that the U.S. could experience weather bad enough to drive the mean annual temperature throughout the country to as low as nine degrees F. below the best recent years. Under those circumstances, the price of wheat would double even without massive exports. Under such circumstances, it would probably be mandatory to double the price of energy, to prevent uncontrollable inflation due to price increases in all other commodities. With respect to land, the U.S. now has under cultivation about all the land worthy of being farmed. Already, land shortages are showing their first effects on agricultural commodities, as revealed by the great increase in soybean prices in 1977.

The other way in which the United States will pay a massive future price for wasteful energy use is in unemployment and crime, and the costs of dealing with those problems. Table 2 indicates the sensitivity of unemployment rates to retail energy costs. From this table, it appears that increasing U.S. energy costs by about 2.36 times, to bring them into line with the last six countries in the table would result in a decline in the unemployment rate to about 40 per cent the present level.

These two tables taken together give a clear picture of the quantitative cost of future profligate energy use in the U.S. Consumer buying power will be 40-80 per cent what it otherwise might be, or less (if weather is very bad), the capital cost of obtaining energy will be a horrendous economic burden, and unemployment and crime rates will be double or worse what they otherwise might have been.

The ultimate result, of course, is rate of economic growth. Given how much attention the conventional

**Table 2. The relationship between retail energy price, and the per centage of the labor force unemployed.**

| Country | Per centage of the labor force unemployed in 1975 | Retail price of gasoline in 1975, in U.S. cents per U.S. gallon |
|---|---|---|
| U.S.A. | 8.5 | 59 |
| Canada | 6.9 | 65 |
| Great Britain | 4.9 | 127 |
| France | 4.3 | 149 |
| West Germany | 3.9 | 131 |
| Italy | 3.6 | 165 |
| Japan | 1.9 | 138 |
| Sweden | 1.6 | 124 |

wisdom has paid to the notion that high rates of energy use per capita are a mandatory prerequisite for high rates of economic growth, it is amazing that none has ever done a statistical analysis of this relation. It turns out there is a relation, but it is opposite to that usually expected: there is a highly significant INVERSE correlation between energy consumption per capita and rate of economic growth amongst the most developed countries.

**The Future Costs of Making The Machine Work Correctly**

Even if the U.S. economic, political, social and cultural system works well from now on, there will be costs, at least in the eyes of many people. There will have to be a more active role by government as a watch-dog, and preventor of catastrophes. Particularly, since only the government has the resources to mount such an effort, it may have to take the leadership in a crash program of public education. Many people would resent government taking on this function. But who else could?

Many people will resent giving up the "lush life" or high-consumption ethos. Hopefully, they will discover that the switch to a more Swiss or Dutch life style brings many compensatory pleasures. Compact cities with an extraordinary smorgasbord of intense cultural, social and entertainment opportunity in the urban core, and fast, efficient public transportation coupled with attractive land use at the urban periphery are a part of those pleasures.

Some other costs of a more rational national policy are not so obvious. For example, suppose the U.S. (and other developed countries, such as the U.K.) become wise to the immense social costs of high immigration rates, and become militant about lowering these sharply. There will be costs in the diplomatic effort required to maintain good relations with countries that may now perceive this as an important safety valve for their population problems. Another cost in international good will could occur if the U.S. begins to question the advisability of having low energy prices, and paying for the resultant massive import of crude oil with massive exports of other raw materials. This could hurt both the countries we now export great quantities of food to (e.g. Russia) and the countries we now import lots of crude oil from. In the case of a country such as Kuwait, which now exports oil at a much higher rate than that required to sustain domestic economic health, this would not be a problem. But in the case of a country such as Iran, for which massive sales of crude oil are a prerequisite for rapid modernization of a nation of about 35 million people growing by 3 per cent a year, the results would be severe. But in the long run, lowered international trade will have beneficial results. Too much trade now will encourage many countries to build up their populations to a level which can not possibly be supported over the long term by the equilibrium carrying capacity of the resource base of the country. What, for example, would happen to a gigantic population in Iran if the oil were all gone?

Another cost of keeping the U.S. healthy over the long run would be various government measures to discourage the freedom to reproduce without constraint. But this loss is more apparent than real. On their own, without any government action, the U.S. population has already decided to sharply lower birth rates. Many people had expected that because U.S. birth rates had declined so much since 1960, they would shortly bottom out and turn back up. Just the opposite has happened: in the last ten months birth rates have been dropping even faster than before. This is presumably an effect of the high unemployment rates amongst the reproductively active under-25 age group, and illustrates how the system can act in a compensatory fashion on its own, without government intervention. But this phenomenon can still be considered a cost of the extraordinary situation into which the economic system has worked itself: too many people for the available resources and the available jobs.

But to end on a happy note, conversion to a more rational type of economy, more labor intensive and less capital and energy intensive, would bring many benefits. This does not imply the backbreaking labor of the past, because of our great technological advances. What it implies is a labor-intensive society, with a great deal of labor being absorbed in high technology activities, where the high technology means high efficiency, not high power consumption. One harbinger of this trend is the extraordinary growth in hardware and software development, and use of micro- and minicomputers. But further, in a society in which labor is cheaper relative to resource costs, there is better emergency health care, more medical research, a larger number of book titles published per year per million of population, more art, more and better entertainment, more zoos, art galleries and museums per million of population, and so on. In fact, this is merely a description of the current difference between Europe and North America — Europe until very recently having had a much lower ratio of average wages to energy costs. In short, all countries must learn a great deal more about the immense significance of the wage/energy cost ratio, because this is the supremely important lever governing the performance of the social, economic, political and cultural systems in which we all live.

# TECHNOLOGY HEALTH AND DISEASE IN AMERICA

by

**George Armelagos & Phillip S. Katz**

**Health and disease has become a topic of intense interest in the United States. Health is one of the individual's most important assets and considerable sums are expended to maintain or improve it. Medical care services have developed into a vast industry which is second only to construction in its size and proportion of the Gross National Product (GNP). Medical care represents eight percent of the GNP, and five million Americans are employed in the delivery and support of medical services. Medical care and the adequacy of the health care system is an issue that will touch the lives of most Americans at some time. In this paper, we will examine a number of elements in the American medical system which affect its response to disease and health in the United States. Specifically, we are concerned with the role of technology in producing factors which affect the health of the individual and of the group. In addition, we will examine the response of the American medical system to disease, a response which has relied upon a biomedical model. The biomedical model emphasises improved medical technology, intervention, and a view of disease which does not always consider the impact of the environment upon the disease process. In order to understand the complex interaction of the physical, biological and social elements in the disease process, an ecological perspective is necessary. This perspective considers the systematic analysis of biological, social, and environmental variables and their relationship to health and disease.**

An ecological approach offers an opportunity to study the interaction of disease, culture and environment. The ecological approach in the study of disease was strongly influenced by Jacques May.[2] This approach considers the environment, the pathogen, and the host as the relevant variables in disease patterns. Although the study of disease usually examines changes in the biology of the human host or in the pathogen as keys to understanding disease patterns, non-biological features of the environment may be crucial factors in the disease process. These non-biological features of the human environment may include biotic, geographic, and physical elements, as well as culture, which represents the major feature of human adaptation.

Culture as an adaptive system includes all aspects of the technology, social organization, and ideology which are integrated to form adaptive strategies by human groups. Culture may be seen as the primary buffer between host and pathogen which insulates the human host from the rigors of environment. For example, clothing and shelter may provide effective protection against drops in temperature. The social interactions reflected in family relationships and other associations can provide a barrier to environmental stress.[3] Although culture inhibits disease transmission by eradicating pathogens or by improving the nutrition of the host, there is evidence that certain cultural practices enhance the transmission of disease. The increase in population density, sedentarism, and the accumulation of human wastes are all factors which increase the potential for disease.

In this ecological model, a medical system is viewed as a cultural institution which may be studied in terms of its technological, social and ideological components. The components of the system may effectively coordinate to control and eradicate disease and improve the health of the population. For example, smallpox and poliomyelitis have been effectively removed as threats to human life. Yet, there are instances in which the intervention of medical technology creates additional health problems. Adverse drug reaction and unnecessary surgery provide examples of medical intervention which have been discussed extensively in the literature. Social and ideological factors within the medical system respond to disease. We may, for instance, speak of the "culture" of physicians and the values and goals which they share. The culture of doctors stresses intervention and a technological emphasis in dealing with disease, with relatively less attention given to preventive medicine and health maintenance. An ecological perspective also increases our awareness of the culture and social organization of patients, and their impact upon the etiology and perception of disease.

The ecological perspective has evolved considerably in the last two decades. Earlier studies considered pathogens as the primary cause of disease, while ignoring other causative agents. An emphasis upon pathogens tends to reinforce a unicausal explanation of disease, in which the relationship of "one-germ — — one-disease" becomes the objective of epidemiological research.[4] In an earlier issue of *The Ecologist*,

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Jacobs, Goodman and Armelagos[5] suggest an ecological perspective which considers a wide array of disease-producing factors. They propose utilizing Audy's concepts of insult instead of the more restrictive notion of pathogen.[6] According to Audy, an insult can be any physical, chemical, infectious, psychological or social input which adversely affects the individual or population's ability to adjust to the environment. Disease is then defined in terms of the response to insults in which the coping ability of the individual or group is lowered. Health is measured by the ability of the individual or population to rally from insults.[7]

**Ecological Perspective in Technologically Complex Society**

The relationship of disease and environment in contemporary American society has never received the attention it deserves. Since disease has been thought to be a part of nature, it was viewed as an element to be controlled. In fact, one of the objectives of a growing technology-oriented society has been the ''eradication'' of disease. The analysis of health and disease has been influenced by the biomedical approach, in which nature is conceived in Baconian terms. In a Baconian model[8] the Universe is perceived in mechanistic terms in which trolling nature and disease. The organism is a part of this system and malfunctions in it must be corrected by intervention. Powles notes:

> The extent to which population biology — particularly evolutionary theory and ecology — have failed to influence medical theory is quite remarkable. This has led to serious weaknesses in much of contemporary medical thinking. For example, in absence of any evolutionary perspective on our current way of life, a biologically abnormal relationship to the environment is often implicitly accepted as normal. Thus, progressive arterial degeneration, rising blood pressure and a tendency toward diabetes with increasing age are accepted as features of normal populations even though they clearly predispose to the onset of overt disease.[9]

While an ecological perspective has been applied to less complex societies,[10,11,12] it should provide insights into the contemporary relationship of health and disease in complex societies, such as the United States, which have an industrial power base. Since the development of industrial society reflects a change in environmental interaction which can alter the patterns of health and disease, it should be of prime interest to the disease ecologist. Also, the rapid growth of industrial countries and their expansion into new areas necessitates a concern for the impact of their influence.

In addition to technology, the industrial societies may be exporting medical science and their views of medicine as well. As Mechanic notes, the western medical models exported to developing nations may stress a high-technology, curative approach to health which may prove useful to elites more than to the general population.[13] Often times this emphasis on western medical models can lead to detrimental consequences.

Western notions about infant health and infant feeding have been exported to many developing countries. The influence on infant feeding can have far reaching effects. Jelliffe notes that in a technologically dominated medical system it is natural to believe that man-made formulas would be an adequate substitute for mothers' milk.[14] While the mechanistic practice of formula feeding allows for regimenting patients in a hospital, and may be relatively harmless to American babies, it can be harmful for infants in developing countries. Mothers' milk is more hygenic, cheaper, and provides protection against enterotoxins[15] The impact on many developing countries is quite significant. Evidence exists that bottle feeding programs in Kenya may actually increase infant mortality and economic burden to society. Kenya spends 11.5 million dollars a year (equivalent to 1/5th of their foreign aid) for formula feeding which could be saved by breast feeding.[16]

Industrialization has brought with it conditions affecting the environment, health and disease on a world-wide basis.[17] The rapid urbanization which has accompanied industrialization also has an impact upon disease and health; the growth in the population of cities and migration from rural areas has often created an environment in which poverty, crowding and often poor sewage and water facilities promote disease. Urban life may also create stressful situations which may lead to mental disorders.[18,19,20] The development of industry itself may also be a factor in the creation of new insults affecting the human environment — industrial pollutants are now affecting the health and well-being of workers and the broader community. The over-all lifestyle in industrial society may also play a role in the nature and pattern of insults affecting individuals. Insults relating to lifestyle include alcohol use, incidence of ulcers, and hypertension. Communication and transportation facilities in industrial society affect health and disease in two ways: information concerning medical science and the western medical model have been communicated widely and, just as importantly, we now have the potential for the rapid world-wide transportation of disease as well as individuals. As Fenner notes, air travel is converting the world into one ecologic unit, and it is now possible for any infectious disease to be communicated to any part of the globe within forty-eight hours.[21] With the relatively long periods required for long-distance travel on trains and ships even twenty-five years ago, the period of incubation for an infectious disease was often shorter than the period of time spent travelling. In effect, ship travel acted to quarantine infectious disease. Modern air travel, on the other hand, has led to the widespread and rapid distribution of infectious diseases, such as the so-called Asian Flu.

**Technology, Disease, and Health**

The analysis of the role of technology in health and disease can proceed on two levels. Firstly, we can examine the way in which technology produces insults affecting the disease profile of the group and secondly, we may investigate how a technological orientation has influenced medical response to these disease insults. In an industrially based society, we most often consider only the advantageous role which technology plays in our survival. The development of the automobile for rapid transportation, labor saving household devices, and improved medical care are often cited as advances of our industrial technology. Improvements in health as measured by decreases in infant mortality, the increase in life expectancy, and the removal of many infectious diseases as threats have been attributed by many to improvements in science and medicine. For example, procedures for pasteurization of milk and vaccination against various infectious diseases have contributed to the overall health of those living in an industrial society.

**Industrially Related Insults**

Our view of health and disease in contemporary society tends to be compartmentalized. We accept advances in health care without considering the insults which are also created by a complex industrial society. The improvement of health in industrial society often obscures the large number of disease-producing conditions associated with urbanization and industrialization. Furthermore, the compartmentalization of health and disease reinforces our notions that the insults which result from technological processes are inevitable, and that we must simply learn to "live" with them. This separation of disease and health has also led to a situation in which the medical system is primarily concerned with responding to the symptoms resulting from an insult, and is often unconcerned about what is producing the insult. The ecological perspective which we propose argues for a consideration of the relationship of health and disease in a broad systematic context. We can evaluate the status of health by examining the ability of a group to react to a disease through the medical system as well as by its ability to control the production of insults.

Insults are created at many different levels in industrial societies. Injuries and trauma often result from the industrial-technological process itself. Rachel Scott, in *Muscle and Blood*,[22] notes that 15,000 individuals are killed on the job, 100,000 die and 400,000 are disabled from occupationally related injuries every year. According to a National Institute of Occupational Safety and Health (NIOSH) study, an examination of nine hundred and eight workers uncovered 1,116 medical conditions, of which thirty-one percent were occupationally-related.[23] According to Discher and colleagues, these injuries resulted in loss of hearing (twenty-eight percent of the cases), skin disease (eighteen percent) and respiratory impairment (twenty-five percent). Lassiter notes that a log required by the Occupational and Health and Safety Act (OSHA) and workers' complaints would have uncovered only a small percentage of these injuries.[24] Lassiter comments that ninety percent of disease conditions related to occupation are not uncovered or reported. There may be insult-producing activities in occupations which we usually do not consider to be dangerous. For example, ballet dancers suffer a high frequency of stress fractures and other orthopedic problems.[25] Since many of the conditions associated with occupation have been chronic and non-disabling, it is not likely that compensation claims would or could be filed. Often exposure to hazards occur during the production process and the disability may develop many years later. For instance, injuries related to Black Lung disease only appear years after initial exposure to coal dust.

While the American asbestos and chemical industries are not alone in the production of insults, they illustrate problems associated with a society's inability to respond to occupationally-related health hazards. The occupational diseases in the asbestos and chemical industry were not uncovered by physicians even when serious disabilities occurred. In addition, the impact on health was not restricted to the employees in these industries but also extended to others in the community.

Asbestosis results from the inhalation of asbestos, leading to the formation of scar tissue around the fiber. This condition is characterized by a number of respiratory problems. Those exposed to asbestos fiber may also develop a cancerous lesion (mesothelioma) after a fifteen to twenty year period. The failure of both the medical profession and industry to respond to this insult adequately has had a significant impact upon the health of asbestos workers, and also illustrates some of the conflicting pressures between physician, patient, and employer. The first case of asbestosis was recorded in London in 1900. The condition became so apparent medically by 1918 that insurance companies in the United States and Canada refused to sell personal life insurance to those involved in asbestos production.[26] The very late discovery of the extent of asbestosis in workers was not due simply to the twenty-year latency period involved in this disease, for the decisions made by doctors and company officials were also a factor. Johns-Mansville's company physicians argued that their studies, and those that they commissioned, revealed no clear-cut association between asbestosis and occupation. Their studies often utilized workers who had been employed less than the twenty-year latency period, insuring inconclusive results. Even physicians not employed by the company were reluctant to interpret patients' problems in terms of the industrial hazard associated with asbestos production. While we may often assume that physicians will report disease to those bearing it, company physicians felt a greater sense of obligation to their employers in this case than to their patients.[27] It was not until the 1960s that a physician, Dr. Irving Selikoff, from outside the industry was allowed to examine industrial and medical records as well as union retirement and death benefits. Selikoff was then able to demonstrate unequivocally the relationship between asbestos inhalation and subsequent disease.[28]

The number of workers and other individuals exposed to asbestos in America has been increasing rapidly. The production of asbestos has risen significantly since 1920, when two hundred thousand tons were produced. By 1975 some four million tons of asbestos were produced by fifty thousand workers. In addition, nearly forty thousand workers are employed in the installation of asbestos and up to five million work with asbestos-containing products. It is estimated that seventy thousand asbestos workers could die from mesothelioma in the next four decades.[29] For example, the garage mechanic grinding brake linings is exposing himself to asbestos fibers in the pads. In New Jersey, flaking asbestos from the ceiling of schools sprayed with asbestos has created a serious health hazard for students. Tests of baby powders indicate a concentration of from eight to twenty percent asbestos fibers[30] The use of spackling compounds, patching plaster, and taping compounds also expose the home-repair enthusiast to asbestosis fibers.[31] Studies have shown that these individuals, though not involved in asbestos production, may be exposed to five asbestos fibers per millimeter of air, which exceeds OSHA standards for safety.

The asbestos industry has attempted to resolve the problem of asbestosis in two ways. Firstly, there have been changes in the mode of manufacture of asbestos through automation, which has reduced exposure. Secondly, the industry, with full knowledge of the dangers involved, has begun to export the most dangerous aspects of production to foreign countries which lack or have weak occupational health laws. According to Kotelchuck, production of asbestos in Mexico, Taiwan, and Brazil increased from one hundred and eight pounds in 1969 to two million eight hundred thousand pounds in 1975.[32] In effect, we are exporting asbestosis as well as jobs.

Power and profits obviously play a role in who will be affected by asbestosis. We are not suggesting that the production of asbestos be abandoned, for this material is important as a life-saving fire-retardent. Rather, we would argue for more stringent controls in production, as well as a closer examination of the role of management and physicians in monitoring and safeguarding the health of industrial workers. It was only in January, 1977 that Johns-Manville and the International Asbestos Workers Union agreed to cooperate in funding a research project for developing treatment for asbestosis.[33]

The production of industrial insults in the chemical industry present an even greater threat. The number of chemicals produced is extremely large and the health hazard of these products is often unknown. Wade summarizes the magnitude of the problem thus:

By 1968 the chemical industry was producing 120 billion pounds of 9000 synthetic chemicals in large scale commercial use. Only a small proportion of those substances are exhaustively tested against the possible hazard. Only 3000 of the two million known chemical compounds have been adequately tested for cancerous propensities, and 1000 of these have shown signs of being carcinogenic.[34]

Attention to industrially related insults at first focused upon affected workers only; it is now clear that these workers' families and persons in the non-industrial community have also been affected. Illness, or potential illness related to the manufacture and discharge of Kepone, polybrominated biphenyls (PBBs) and polyvinyl chloride (PVC)[35] illustrate the impact of industrially-produced insults upon both workers and persons in the broader social environment.

For instance, there have been recent reports that the pesticide Kepone (Chlordecone) still causes serious illness among employees, even though the toxicity of Kepone was recognized fifteen years ago.[36] The original reports which discussed the toxicity of the substance and subsequent indications that it was affecting the health of the workers did not consider the impact on other humans in the environment. Recent studies have shown that an infant of one worker was exposed and made ill by simply having his diapers laundered together with his father's work clothes. It has now become apparent that aquatic organisms in the James River and Chesapeake Bay have been threatened by Kepone, and the danger to their survival will remain for years to come.[37] The future biological impact on the human population in this area remains to be determined.

The potential impact of chemical contamination is illustrated by an incident in which polybrominated biphenyls (PBBs) were accidentally introduced into the environment of Michigan. The impact of the PBB is interesting since the amount of PBB released was limited, yet the contamination of the eco-system of lower Michigan was quite extensive. PBB was accidentally fed to a large number of cattle when packages of fire-retardent were mistaken for a food supplement. Michigan Chemical Company, which produces "Nutrimaster", a food supplement, manufactures and distributes "Firemaster", a fire-retardant, which contains PBB, in similar packaging.[38] The confusion in packaging led to the mixing of two thousand pounds of Firemaster (PBB) in the food of animals. The spread

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of the chemical has been rapid. *The Detroit Free Press* on August 21, 1976 reported that PBB was found in the breast milk of twenty-six mothers from non-farming families; an official of the Department of Health suggested that PBB may be present in the milk of a majority of the nursing mothers in Michigan's lower peninsula.[39] The spread of the PBB was promoted by practices such as the cattle tainted with PBB being recycled as protein supplement, and the selling of 63,000 contaminated chickens to a soup company because they had stopped laying eggs. Despite the farmers' initial hesitancy and objection to the use of tainted cattle and the sale of chickens, state department of agriculture officials assured the farmers that the levels of contamination were not significant. The level of PBB in nursing mothers' milk has not been reported officially, but is said to average about ninety parts per billion. Presently, three hundred parts per billion in food is the acceptable level of contamination. There is, however, some indication that the acceptable level may be lowered to 150 parts per billion.

Although the impact of industrial pollutants on health is often measured in terms of the materials' carcinogenicity, there is evidence to suggest that these agents can also cause mutations in humans.[40] Polyvinyl chloride has been shown to create considerable genetic risk.[41] Fetal deaths increase from 6.8% to 10.8% following exposure of fathers to polyvinyl chloride. Chromosomal damage to sperm is suggested as the factor in the increase in fetal deaths.

Considerable interest has been generated in legislation which would require the testing of substances before chemicals could be produced industrially. The legislation (the Toxic Substance Control Act) has met with considerable opposition.[42] Chemical companies claim that proposed legislation would destroy the industry. Dow Chemical estimates that two billion dollars each year will be required for compliance with the law. In response to the Toxic Substance Control Act, Etcyl Blair, director of health and environmental research at Dow, states

> An administrator would be given near authority over the introduction of a new chemical product — that is, he or she could decide arbitrarily to ban a product or close a plant without any scientific determination that an actual health hazard existed. In brief, guilt is presumed and the defendant sentenced before any trial takes place.[43]

Apparently, Blair assumes that chemicals have constitutional rights.

The effects of carbon monoxide upon mortality,[44] industrial pollution and lung cancer,[45] and drinking water and cancer mortality[46] have been determined. Even the benefit of air pollution abatement programs has been studied, and it has been estimated that a fifty percent reduction in air pollution alone would save society 2.1 billion dollars in terms of decreased morbidity and mortality.[47]

Other chemicals which cause insults are also receiving more attention. Carbon tetrachloride,[48] radon from phosphate mining in Florida,[49] plutonium found in the respirable dust on the soil adjacent to a processing plant in Denver,[50] and selenium[51] are but a few of the industrially-related substances which may represent health hazards from the fly ash collected by electrostatic precipitators in coal-burning plants.

Our discussion of industrially related insults reflects the paradox of an economic and social system which spends large sums on health and yet allows industry to create insults. Industry's perception of the problem is of course colored more by economic considerations than by concern for the health of the populace. It is ironic and disheartening that even in the presence of strong union or governmental controls in many works situations, the worker may have little power to raise the standards and potential for health in his or her work environment. It is unfortunate that occupational medicine has never been seriously developed as a subject in medical school curricula even though occupational diseases are so prevalent in our society.

Physicians have not always played a responsible role in uncovering and treating insults produced in an industrial setting. As Hardy asks;

> who in society, if not his doctor, is responsible for discovering the cause of job-related diseases and initiating steps for job-control of the hazards, and arranging for the patient worker's medical care under the pitifully inadequate compensation laws now in existence?[52]

**Organization of Medicine and Perceptions of Disease**

The previous section has considered some of the ways in which industrialization has served to increase the insult load faced by Americans. The response of Americans to these insults, and ultimately the effectiveness of health care delivery, is intimately related to the institutional structure and cultural organization and philosophy of the American medical profession. The technological focus in American medicine is bound up in a biomedical approach to disease. Such an approach exalts science and a "scientific" approach to human problems. Hospitals, medical schools, government agencies, and organizations such as the American Medical Association have an important impact on the culture of doctors. They also affect the manner in which physicians perceive and treat both illnesses and the "carriers" of illness, the patient.

**Technology of Medicine**

In light of the American view of the environment as something to be controlled, and the general acceptance of the biomedical approach, it is hardly surprising that the treatment of disease is often seen as a "battle" in which physicians, aided by their scientific technology, hope to "conquer" disease. Such a view depicts disease as something beyond ourselves, as an entity which attacks us without warning rather than as something which we might also create and sustain through our way of life. This picture of disease is well illustrated by the comments of United States Senator Matthew Neely in 1928 in support of programs to "conquer" cancer:

> I propose to speak of a monster that is more insatiable than the guillotine; more destructive to life and health than the World War, more irresistible than the mightiest army that ever marched to battle; more terrifying than any other scourge that has ever threatened the existence of the human race. The monster of which I speak has infested and still infests upon every inhabited country; it has preyed and still preys upon every nation; it has fed and feasted and fattened . . . on the flesh and blood and brains and bones of men and women and children in every land. The sighs and sobs and shrieks that it has exhorted from perishing humanity would, if they were tangible things, make a mountain. The tears that it has wrung from weeping women's eyes would make an ocean. The blood that it has shed would redden every wave that rolls on every sea. The name of this loathsome, deadly and insatiate monster is "cancer".[53]

A scrupulous reliance upon the biomedical approach and a view of disease as entity to be conquered with the aid of science is too simplistic. Dependence upon such an approach raises serious issues relating to health and illness in America. Firstly, such views separate the individual from disease and imply unicausal explanations for illness. As we noted in a previous section, many of the insults facing industrial man arise primarily from lifestyle and the "by products" of industrial society, such as pollution. Emphasizing the role of science in the battle against disease not only takes away from an examination of the agents which create insults, but also overplays the successful role of medical science in treating disease in the twentieth century.

It was in fact the success in applying the germ theory in the control of infectious disease in the 1800s which gained legitimacy and prestige for the faltering medical profession. The acceptance of germ theory is noteworthy since there was considerable resistance from American physicians who felt that it would restrict free trade by forcing quarantines.[54] Medical science has been extremely effective in the treatment and near-elimination of many infectious diseases, but has been less effective in coping with the chronic and degenerative diseases which now pose the greatest threat to most Americans. Some researchers note that reductions in the level of many diseases may be due less to medical care than to a general rise in sanitary conditions and standard of living. Thus, lifestyle and cultural factors are and ought to be a key issue in examining health and disease, for they are crucial elements in the environment: they may be responsible for both the creation and removal of insults. For example, Fenner[55] notes that general changes in sanitary conditions in European cities had the greatest impact on the amelioration of tuberculosis as a threat, while salmonella food poisoning is presently rising as a potent threat to modern western populations. The expansion of salmonella is related to the increased international trade in animal food stuffs containing salmonella. The widespread use of household detergents which block the effective processing of sewage and the commercial distribution of "prepared" foods have expanded the potential range of salmonella insult. Furthermore, Fenner notes that there are other infectious conditions which have not responded to technological control,

> Despite extensive medical effort, there has been no corresponding decreases in respiratory viral infections, which now constitutes the major unsolved problem among the infectious diseases. Neither vaccines nor "air sanitation" offers any prospect of early alleviation of their effects.[56]

One may reasonably ask if the costs of medical technology sometimes do not outweigh the potential benefits for the health of the population as a whole. Indeed, the life-threatening diseases which will face most Americans, such as stroke, cancer and heart disease, may not be susceptible to eradication, despite an advanced technology and huge sums spent. And while American medical and public health research and personnel helped to bring infectious diseases under control in the first half of the century,

> improvements in the delivery of medical care have had little impact on health status even though as a nation we are spending approximately four and a half times as much on health care in 1975 as we did in 1960. [57]

Total government and private expenditures for health care were $12 billion in 1950, $26 billion in 1960 and $117 billion in 1975, and yet the past twenty-five years have not witnessed significant increases in life expectancy or reduction in infant mortality. W.H. Forbes[58] has examined the relationship between expenditure and results in the area of health care, and has found that we could halve or double total expenditure for health care without changing longevity. It is also an unsettling fact that the United States still has a higher rate of infant mortality relative to the other developed nations. The overall United States infant mortality rate is seventeen deaths during the first year per one thousand live births. This compares with ten per one thousand in Sweden and eleven per one thousand in the Netherlands; the United States rate for non-white infants is thirty per one thousand live births. This is due largely to the problems faced by the rural and urban American poor, and the type of health care facilities available to them.

The costs of medical technology are high, and they do not always guarantee medical effectiveness in the treatment of disease. It is particularly unfortunate that the development of high-technology units in hospitals and the expansion in number of beds may be done for prestige or other factors, and may lead to exorbitant costs and less-than-ideal medical care. Thus, a government-sponsored group has noted that open-heart surgery, in which a patient's blood is re-routed through a heart-lung machine, can function most efficiently only if the surgery unit performs a minimum of some two hundred operations each year, or four to six each week. In 1969 only fifteen of the three hundred and sixty American hospitals equipped to perform open-heart surgery actually performed two hundred or more operations, and over two hundred hospitals performed only fifty operations annually.[59] A major focus of American medicine in the past two decades has been the treatment of heart disease and heart attack through the use of surgery and intensive cardiac care units. Powles notes that the three thousand cardiac units existing in the United States in 1971 were utilizing up to ten percent of the country's trained nurses.[60] The allocation of so many medical personnel for such facilities is made even more distressing when we consider evidence that treatment in a cardiac unit as opposed to treatment at home may not significantly improve one's chances for survival following a heart attack.[61]

Although a technological emphasis has resulted in problems such as the under-use of costly surgical units and the questionable effectiveness of intensive care units, one must also marvel at the technical proficiency of American medicine in certain areas. Heart-lung machines, organ transplants, and microsurgery represent significant breakthrough. Kidney machines, for instance, now keep many individuals alive who would have otherwise died of uremic poisoning. And yet, the use of kidney machines points up problems relating to relative costs and medical priorities. An individual's use of a dialysis machine costs $10-20,000 yearly; in 1972 the U.S. Congress voted to have the government pay the costs of dialysis for those requiring it. Carlson, in *The End of Medicine*, estimates that the kidney dialysis program will cost approximately one billion dollars annually by 1985.[62] Carlson also notes that this money might have a greater relative

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impact upon health care if it were diverted to pollution control or maternal and child health programs. Given the technological focus of American medicine, and the American public's concern more for diseases which are life-threatening in an immediate sense (such as kidney failure) than for the effects of pollution, programs such as these will continue to absorb the public's interest and money.

The technological model of American medicine leads to an emphasis upon medical intervention rather than upon the maintenance of health and the prevention of disease. While the medical profession may deal well in response to crisis situations, there is less concern with preventive medicine and the ways in which our society and perhaps the actions of the medical profession may increase the insult load. Also, it is worth keeping in mind that a technological emphasis not only focuses upon individuals as the "carriers" of disease, but also serves to separate patient and physician. The physician is the controller of the medical technology, and has a high degree of power and autonomy.

The stress on technology and disease is an important element in the training of physicians. Indeed, we may speak of the "culture" of doctors, the values and institutions which organize their profession and their views of patients and of themselves. There is a growing concern on the part of the public that technical competency in medical intervention and in the area of life-threatening insults may not be enough.

Somehow, doctors have become removed from their patients, and there is reason to question the priorities of medical care and medical education in the USA. As Montagu notes,

> Doctors on the whole are uninterested in health since their training is focused virtually entirely on disease, and there is very little profit in health. It is not surprising that most people come to regard health as something one goes to the doctor to be restored to when one is sick. Hence, health becomes a function of disease, and one sees a doctor only when one is sick . . . the teaching and the practice of medicine have become de-humanized and they need to be re-humanized. This can be done first by revising our concept of what a doctor ought to be. He ought to be one who cares, for caring is the first principle of human communication, and the first step toward the recovery of the patient.[63]

The modern, technology-oriented approach to medicine has separated the curing and caring functions of the physician.

**Medical Culture and the Perception of Patients**

The American medical system has been shaped by a technological focus as well as by a fee-for-service tradition, a growing tendency toward medical specialization, a focus upon the hospital as the proper arena in which to do battle with disease, and an important perception of the patient as the bearer of disease.

The power invested in the physician is great from several perspectives — not only does the physician have the power to cure, but also determines who will bear the "sick" label and how notions of illness are defined by the lay public. As Freidson has noted, illness is a social as well as biological concept which, "like 'crime' and 'sin', refers to deviation from social and moral expectations".[64] Thus, physicians are not only in control of medical technology, but also play a role, along with the public, in stigmatizing certain individuals who show certain types of disease. The physician plays a crucial and unique role in having the sole legitimate authority to attach the labels of diseased and non-diseased: it is the physician who transforms a person into a patient.

The power of physicians to transform extends to the legitimation of drugs and medicine. The acceptance or condemnation of certain drugs may be affected by the perceptions of physicians and public health officials. For example, marijuana use has been identified as a greater social threat than the use of amphetamines. As Grinspoon and Hedblom suggest in their book, *The Speed Culture*,[65] use of marijuana was identified earlier in this century (and perhaps into the present) with Spanish-speakers and Blacks. Particularly in the 1930s marijuana use was vilified through public advertisements and the well-known movie, "Reefer Madness". Grinspoon notes,

> Perhaps through the unconscious process of displacement it became particularly easy for people to believe that the drug of the Blacks and Spanish-speaking must have something to do with crime, violence, sexual excess, addiction, and personality deterioration.[66]

It is perhaps ironic that at the same time marijuana was being brought to the public's attention by the Federal Bureau of Narcotics and the media, amphetamines were being introduced as a major breakthrough, or as Grinspoon sarcastically notes, amphetamines were promoted as an early technology-derived example of "better living through chemistry."

While marijuana use has been condemned, amphetamine use is only now being given the attention it deserves. Unlike cannabis (marijuana), amphetamines may be addictive and their use may be dangerous. While we do not wish to debate the positive or negative psychological impact of marijuana use, it is clear that the use of amphetamines may produce severe psychological disorder. When physicians prescribe a drug they also confer legitimacy upon it, transforming the "drug" into a "medicine." Moreover, while marijuana has been associated with the lifestyle and stereotypical behavior of ethnic minorities, amphetamine use fits well into the lifestyle of the American cultural mainstream, with its stress upon achievement, efficiency, speed (a term also used to describe amphetamines), and aggressiveness.

The technological emphasis of modern American medicine has led to a relatively greater concern with disease than health, and this may have an impact upon physicians' overall perception of patients. Thus the patient may not be viewed as a person, but simply as the carrier of symptoms:

> Today the physician's attention is focused not so much on the patient as on the nature of the disease that has invaded his body . . . doctors too often think of patients not as fellow humans to be listened to and comforted, but as temporary and dimly seen hosts to disease that it is the doctor's job to identify and subdue . . . In the duel between physician and death the patient is cast in the role of bystander.[67]

One outcome of this view, in which patients become the abstract bearers of ailments, is that physicians may find interest in patients only if they display unusual organic symptoms.[68] Medical training, with its stress on the hospital, hospital technology, and the challenge of treating patients in this setting may serve to encourage a lack of concern for family practice. In addition, the medical student or intern may be socialized to deal more seriously with "challenging" cases than with the treatment of routine ailments. A desire for challenging cases may be a factor in the increasing number of medical students turning toward specialties and away from general practice. This perspective on "interesting" cases, which might be treated scientifically through technology, may also have an impact upon actual treatment. While an emergency room staff may respond well and with great care and concern to challenging cases, those individuals with more routine problems may face long waits and the care of inexperienced interns.[69]

A unitary view of disease by physicians may also be associated with a unitary view of patients — there may be little concern for the ways in which ethnic or subcultural values as well as approaches to disease and health differ from those of the physician. The perception of patients as poor or as coming from a lower-class background may provide a barrier to effective health care. As Roth notes,

> people coming from a recognizable poverty subculture are likely to have less access to private physicians. They are considered the least desirable patients. The doctor has probably dealt with "their kind" during his years as a student and resident in out-patient and emergency clinics, and he has concluded that they are often dirty, follow poor health practices, fail to observe directions or keep appointments, and live in a situation that makes it impossible to establish appropriate health regimens. As one resident put it, this offers 'a less pleasurable way to practice medicine'. [70]

Problems relating to physicians' treatment of minorities and the poor often arise simply out of class or race prejudice, and yet even highly idealistic and perhaps non-prejudiced physicians may rapidly lose interest in caring for these groups when patients fail to meet their social as well as medical expectations. Doctors may expect a measure of gratitude and perhaps subservience on the part of the poor patient, and these are not always forthcoming. The physician may also find himself angry and frustrated by patients who he is genuinely concerned about but who break scheduled appointments and later demand to see him.[71]

One important outcome of a stress upon disease as a discrete entity to be fought with the aid of technology is that disease is viewed as "real" only when recognizable organic symptoms are present. In some instances, organic factors may be assumed if certain behavioral symptoms appear. For example, physicians have transformed hyperactive children with learning disorders into a clinical syndrome termed minimal brain dysfunction.[72] Even though there is no recognizable organic basis for this behavior, the use of the term minimal brain dysfunction "establishes" an organic cause for the behavior. The labeling of a child as "hyperactive" with "minimal brain dysfunction" by a physician justifies pharmacological treatment.

Doctors tend to place relatively more emphasis upon the organic roots of disease and less upon the psychosocial aspects of patients' symptoms or the overall impact of the cultural environment upon the patient. Those patients whose symptoms lack clearly organic roots are all too often dismissed as "crocks". This dismissal of crocks reflects the physician's narrow view of the insult-producing environment, in which the emotional, social or cultural problems faced by the patient are not thought to be a proper part of the physician's area of treatment.

The dismissal from the physician's office of persons who only display emotional problems or "psychosomatic" disorders may be made easier, for both the patient and physician, by the prescribing of drugs, such as valium and librium when a patient complains of "anxiety" or other ills. It is both interesting and somewhat ironic that despite the stress on organic ailments in American medicine, the most prescribed pharmaceutical in America, valium, is prescribed in the hope of alleviating anxiety and the psychosocial problems the physician may not be equipped to deal with. In 1974, American doctors wrote nearly 60 million prescriptions for valium. That individuals were going to physicians with ailments which are defined (by patient, doctor or both) as non-organic, is reflected in the fact that only 10% of these prescriptions were written by psychiatrists, and from 60-70% were written by family physicians. The pre-eminence of valium as a tranquilizer and the extent of its use is related to attitudes of both doctor and patient, and is also affected by the goals of the drug manufacturer. It is worth noting that the manufacturer of valium, Roche, spends millions of dollars annually in the advertising of valium, and not without good reason: $40 worth of diazepam when packaged as valium sells for $5600[73] and Hoffman-LaRoche has a gross yield of 250 million dollars annually from this product alone.[74]

The abundance of prescriptions for valium reflects the physician's reliance upon the biomedical model in treating symptoms, and represents an attempt to treat "medically" those emotional ills or anxieties displayed by a patient. Dependence upon valium prescription also reflects the workload and other pressures facing physicians, as well as the view by the public of physicians as almost magical curers who can scientifically remove any ill, organic or emotional:

> An enormous proportion of the walking wounded taking Valium are residents of urban and suburban areas who go to the doctor, but cannot afford or do not choose to go to a psychiatrist when they feel nervous or jittery. They say, "Doc, you've just got to give me something for my nerves!" What might well be the best prescription is something that the doctor usually cannot give: an hour of his time, listening to ill-defined complaints and offering understanding reassurance. The great majority of physicians are far too busy for that, so they prescribe something for "the nerves".[75]

Aside from the very real possibility of side-effects of valium which even a physician would term as "medical" problems (a Roche ad in the *New England Journal of Medicine* warns that valium use may bring a possible change in jaundice, skin rash, urinary retention, libido, vertigo, hyper-tensive states), the extent of prescriptions for tranquilizers such as valium points up a number of broader issues relating to physicians' and patients' acceptance of the biomedical model of disease.

Firstly, the public as well as physicians may share a view that all ills may be effectively treated medically and as if they had an organic basis. Secondly, the biomedical model emphasized by physicians and the professional pressures they face in their education and in their practices make it difficult for physicians to deal with psychosocial or emotional problems at the psychosocial or emotional level. These two points are related: the patient who goes to a doctor may be sorely disappointed if he or she does not receive a prescription, and the physician, pressed for time and perhaps skeptical of the symptoms expressed by the patient, may be only too willing to oblige. Thus, a drug is prescribed in the belief that while it may not help greatly, at least it will do little harm — valium may be prescribed for the anxious and antibiotics such as penicillin may be prescribed for those with the common cold or viral infections, though this drug cannot be effective in this capacity.

### The Medicalization of Life

Perhaps the most serious issue which the above materials point to is the increasing 'medicalizing' of American society: more and more areas of life are affected by medicine, and there is increasing acceptance of, and faith in, the role of the physician as a solver of human problems, medical and otherwise.

Illich discusses at length the risks inherent in the medicalization of life, particularly the loss of autonomy which individuals may face:

> Once a society is so organized that medicine can transform people into patients because they are unborn, newborn, menopausal, or at some other 'age of risk,' the population inevitably loses some of its autonomy to its healers. The ritualization of stages of life is nothing new; what is new is their intense medicalization. The sorcerer or medicine man — as opposed to the malevolent witch — dramatized the progress of an Azande tribesman from one stage of his health to the next. The experience may have been painful, but the ritual was short and it served society in highlighting its own regenerative powers. Lifelong medical supervision is something else. It turns life into a series of periods of risk.[76]

Illich is certainly correct in noting the increasing classification and labelling of people medically, by doctors, by life and health insurance companies, by employers, by ourselves, and Illich is particularly concerned with the increasing dependence upon medical system which these labels represent.[77]

Physicians as a group are unusual in the power and autonomy granted to their profession — it is they who define standards of health and illness and they have control over the use of medical technology.[78] They may be loathe to relinquish control over even the most elementary procedures or types of examination — for example, there is a certain degree of resistance by physicians to the growing number of physician assistants and nurse practitioners, who generally are called upon to give vaccinations and examine a patient in a screening capacity prior to a physician's examination. As Klaw notes, however, the two-year training period of physician's assistants equip them well to treat many of the more routine and minor ailments for which patients go to see a doctor.

Physicians are not only reluctant to give up their technology; they are also jealous of their right to make and evaluate medical decisions relating to the health status of patients, and become quite upset if other interests or professional groups infringe upon their autonomy.[79,80] While remaining extremely cautious about allowing others to violate their medical territory, the medical profession has not been reluctant to expand its interests beyond areas relating to organic desease in the strict sense. For example, violence on television is now being debated by some as a medical issue which physicians ought to consider.[81] The response to Somers' article, entitled "Violence, Television, and the Health of American Youth", indicated not only a willingness to deal with the communications industry on a medical basis, but also a high degree of candor concerning the power of physicians to effect changes in this area. Yet, medical education may not effectively train physicians to deal with the complex problems in social sciences in general, and the relationship of the violence in the media and child psychology in particular.

### American Medical Priorities and the Future

In the previous pages we have stressed the utility of an ecological perspective in examing the American medical care system. American medical care, and its ultimate effectiveness in treating disease and in maintaining health, is affected by numerous and sometimes contradictory interactions with the social-economic, biological, and physical environment(s). One crucial element in the overall environment which affects the medical system is a technological emphasis which has had consequences for both the actual delivery of health care and the social responses of patients and medical practitioners to one another. Moreover, the environment and lifestyle of Americans may be responsible for the creation of insults which the medical system is not equipped to eradicate.

In calling attention to the role of technology in the American medical care system we are aware of the positive aspects of improved medical technology. American medicine is quite effective in treating certain acute conditions, such as kidney failure through the use of dialysis machines. Many infectious diseases have also been treated with a high degree of success in recent years: among Americans in the age-group 15-44 there were approximately 30,000 deaths from tuberculosis in 1940 and only 407 in 1973[82]; syphilis has declined considerably; and the number of deaths from smallpox world-wide has dropped dramatically in this century. Dubos[83] and others have pointed out that the peaks of diseases such as tuberculosis may have occurred prior to effective "medical" treatment programs were begun, yet we cannot ignore the positive impact of medical technology in hastening the decline of certain conditions, including poliomyelitis.

The successes of medical technology, fueled by the expectations of a public eager for medical care, have led to a distortion of priorities in the American medical care system. We spend relatively little on medical education and preventive medicine while investing vast resources in the treatment of conditions such as cancer and heart disease which the medical system may not be able to eliminate and which may have their roots in areas of the environment not under the direct control of the medical system. Even those conditions which the American public may be resigned to live with, without any hope for eradication, are the focus of tremendous financial expenditures. Thus, a Food and Drug Administration report notes that despite the fact that Americans spend $735 million annually on over-the-counter-drugs to treat the common cold, these medicines may provide only temporary relief against individual symptoms and neither prevent the cold nor shorten its duration.[84]

The expenditure by Americans of vast economic and human resources toward the eradication of diseases such as cancer may be problematic even within the American context, but also points out a high degree of medical chauvinism which blinds us to serious insults affecting large numbers of individuals in developing areas of the world. American research facilities devote their resources primarily toward those insults facing Americans, and often are less willing, or perhaps less easily funded to examine non-American health problems.[85] The American preoccupation with cancer and heart disease is in many ways a function of our ability to successfully extend the life of individuals long enough for these insults to be a primary cause of mortality. Those living in developing areas are often not as fortunate: malaria and tuberculosis are still problems in many areas of the world; chagas disease causes death at an early age for many in Latin America; and vast numbers of people in Africa suffer from schistosomiasis, filariasis, sleeping sickness, and yellow fever.[86]

American medical priorities have been affected by both the institutional structure of the medical sytem as well as by the expectations of the public being served. For most Americans the family doctor is no longer the focus of medical care, and health care is dominated by institutions, such as hospitals, health insurance companies, drug manufacturers, and health planning agencies. The expansion of these institutions and their influence in recent decades is having considerable impact upon the direction of health care delivery, its cost, and its effectiveness. With the growth of these institutions the greatest support has been given to research, high-technology approaches to combatting disease, and an orientation toward the hospital as the primary setting for administering medical care.[87] It is unfortunate that the institutional structure offers relatively less support to preventive and community medicine, in which the focus of medical care is on maintaining the health of individuals and groups in their natural environments.[88]

The responsibility for the high costs and often distorted priorities in the medical system does not rest solely with medical institutions — increasing consumer demand for medical care is also a major element to be considered. Although the public expects that more science, technology and medical services will improve their health, the impact of the medical system upon the overall health of the population may be less than is assumed. Demands for more and more medical care services, both by medical institutions and the public, often ignore the fact that group health and the prevalence of insults may be more closely related to broader social, economic and cultural conditions than to the amount of medical services received. The expectations of the public with regard to medical care may provide a significant barrier to effective reforms which might control the cost of medical care and orient the public toward health maintenance instead of intervention once disease has already appeared.[89]

Alterations in public attitudes toward health and in the public's expectations of medical institutions can have a dramatic impact. It is likely that the overall health of Americans may be improved as much by changes in lifestyle, socio-economic reforms, and education as by increased medical services. There is growing realization that lifestyle plays an important role in the ecology of disease. If there is a health crisis in America today, it is largely a crisis of lifestyle in which destructive habits such as alcohol use, drug addiction, lack of exercise, malnutrition, overeating, cigarette smoking, careless driving, and sexual promiscuity create health problems.[90,91]

Improvements in the health of Americans may also be accomplished by de-emphasizing the role of technology in medical care. While we do not suggest a complete abandonment of technology, there is evidence it may be decreased significantly in many areas while improving the overall level of health. Dunn argues, for example, that although improvements in maternal care have resulted from vaccinations for the prevention of rubella and amniocentesis, there are indications that new techniques in the active management of labor can be dangerous.[92] He suggests a dorsal position in delivery creates serious problems in the birth process.

Less radical delivery procedures such as Lamaze-preparation reduce narcotic use, the frequency of forcep deliveries and recourse to nerve blocking anesthesia. Physicians, Barnes notes, are often unconvinced about the advantages of maternal education and claim it takes too much time and costs too much money.[93]

The health of Americans may also be improved if there is greater concern in the future for the cost-effectiveness of health care delivery and the distribution of medical resources. The expenditure of $120 billion annually on medical services is wasteful, particularly when we consider that greater funding of social, economic and environmental-control programs would have greater overall impact upon health than increased consumption of medical services. Even in those areas in which technology is effective and definitely can prove useful to improving the public's health, medical programs have not always employed technology in the most cost-effective manner. For instance, Schoenbaum *et al* point out that the U.S. policy of single rubella vaccinations, generally at an early age, is not as effective as it might be: vaccination of females at 12 years of age yields net benefits 80% larger than vaccination of children at age two.[94] The authors of this study conclude that either single vaccination of females at age 12 or vaccination at both ages two and twelve would be more cost effective than the current practice of single vaccination at an early age.

In examining cost-effectiveness, we would also be wise to consider the social as well as monetary costs of medical care services which are poorly distributed. Within the United States there are significant geographic differences in the number of medical personnel and services available as well as in the overall health of various segments of the population. Even when relatively high salaries are used to lure doctors to rural areas, they may choose to practise instead in areas which offer access to sophisticated technology and which do not require contact with the poor. The uneven distribution of doctors is illustrated by the fact that while the State of Mississippi has 82 doctors per 100,000 people, Westchester County (just outside of New York City) has 260 per 100,000.[95] Variations in the overall health of Americans also exist, and it appears that many of these variations relate to geography, race, and class. For instance, Mississippi in 1973 had an infant mortaility rate of 25.2 deaths per thousand live births while th state of Utah had a rate of 12.9 deaths per thousand live births. The infant mortality rate for black children is 65% greater than that of white children (26.2 versus 15.8 per thousand live births).[96] The life expectancy of American black men and women is also considerably shorter than that of whites: the life expectancy of black men and women is 61.9 and 70.1 years respectively compared with 68.4 years and 76.1 years respectively for whites.[97] There also exists an inverse relationship between disability and family income — the poor tend to suffer more from sickness and are less able to afford medical care than the wealthy. The role of the medical profession and medical institutions in erasing inequities in health and care has not been as effective as we might wish. As Kotelchuck notes, "Our modern health system did not create race and class distinctions, to be sure, but it reflects and reinforces them."[98]

Problems in the American medical system and its ability to deliver health care cannot be resolved without an integrated approach to the interaction of individuals with all aspects of their environment. Alterations in lifestyle, socio-economic change, and more effective pollution controls will probably have more future impact upon the population's overall health than changes in the medical system. Nonetheless, the medical system can be altered to provide more effective health care, and numerous proposals have been put forward in recent years toward this end. Some of these include: the implementation of quality assessment programs such as PSROs (Professional Standards Review Organizations); National Health Insurance; the decentralization of medical responsibilities, with greater use of physician's assistants and nurse practitioners to supplement MD's; and preventive medicine programs which would orient both the public and the medical system toward health maintenance. Each of these proposals has its advantages and drawbacks; while PSRO's and National Health Insurance may be implemented in the near future, we believe that the less easily implemented proposals for decentralization and preventive medicine would ultimately have greater positive impact upon American health care.

National Health Insurance will probably be implemented in some form within the U.S. in the near future. Unfortunately, many view NHI as a panacea which can cure the ills of the American system of health care delivery. A reliance upon NHI as a means of reforming the medical system avoids fundamental questions relating to the adequacy of the present system to deliver health care and its technological orientation. Programs such as NHI also carry with them the built-in dangers of rising costs and expanding bureaucracies — only the Kennedy plan, offered to Congress, places substantial limits on total expenditures, relating these to the overall Federal budget. Health insurance programs offer few incentives for either physician or patient to hold down costs and the amount of medical services delivered. As Abelson notes, "When the major fraction of medical costs is borne by a third party, demand for care is practically infinite."[99] Carlson[100] has rightly noted that the health of Americans might be best served by the utilization of fewer rather than more medical services, along with expanded programs of health education. NHI will prove a failure if it simply offers a means of paying for the increased services and costs which it fosters.

PSROs also suffer from a number of difficulties which may limit their effectiveness. PSROs, which have been dominated by physicians operating within hospital settings, run the risk of endorsing the status quo in the medical system, while contributing to rising costs and a technological bias in the delivery of medical services. The focus of PSROs, and their attitude toward health and disease may be quite narrow. As McNerney notes,

> Of surpassing importance, it must be recognized that the current focus of quality assessment is narrow whereas the determinants of health status range broadly. Unfortunately, quality assessment has become part of a general health-service distortion that fails to take into sufficient account life-style and environmental factors with major quality content. As a result, quality assessment is again geared more to technical regimens than to outcome. This complication is particularly bad. Assessment lacking relevancy compromises both quality and cost factors.[101]

The health of Americans can be aided significantly through well thought-out programs stressing preventive medicine. The foci of a preventive approach to health care would include: active management of the environment to control insults associated wth industrialization and other aspects of the environment; judicious and cost-effective use of physicians, medical screening facilities, and technology; improved health education, both for children and adults; an emphasis upon lifestyle as a vital component in determining health status. Preventive medicine, even more than many other proposals for change, faces an uncertain future and requires the cooperation of many groups:

> If a national, comprehensive preventive program is to be implemented and succeed, it must have the enthusiastic support of the medical profession, to which the public has entrusted its well-being; of the government, which alone has the resources to create a national approach and to provide the necessary incentives; of the medical insurance industry, which must cooperate with the government in this effort; and of the individual, who must accept a greater responsibility for his or her own well-being and exert the self-discipline required in modifying life-style habits.[102]

An emphasis upon preventive medicine, and particularly upon lifestyle, underscores the role that individual and group behavior play in the pattern of health and disease. The individual, by engaging in a sensible lifestyle, and the group by controlling insults, can effectively improve the health of the population.

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# Redividing North America

## by

## Sam Love

Sam Love worked as one of the co-ordinators of Earth Day in 1970 and subsequently was involved with Environmental Action. He edited their magazine and served as co-ordinator of the group until 1974. Since then he has worked as an energy consultant and writer on the future, appropriate technology, economics and ecology. He has appeared in the *Smithsonian*, *Washington Post*, *Community Planning Report* and many other periodicals and guest edited a special issue of *The Futurist* on alternative technology. He serves on the board of directors for the National Center for Science in the Public Interest and the Environmental Action Foundation.

**Decentralization is a prerequisite of an ecological society. But on what basis should it take place? Sam Love suggests that North America should be redivided in accordance with its natural divisions of plant and animal communities and geological formations, i.e. its bioregions. This would favor the development of different cultural groups adapted to living in such distinct areas. These regions would be given very much more political autonomy, permitting the development of much sounder societies. By being economically self-sufficient the intolerable vulnerability of America's economy to resource shortages, technological hitches and other serious discontinuities would also be drastically reduced.**

One of the most important future issues in American politics is now practically invisible. Yet a perceptive observer can see that the issue of breaking up North American nations into more viable small units is simmering underneath the surface of contemporary political rhetoric.

Advocates are emerging who are promoting the redrawing of the boundaries of North America along lines more in harmony with the continent's major biological and geographical separations. Achieving this new division through a peaceful transition, its proponents insist, would mark a progressive leap forward in evolutionary consciousness. It would reveal a new sensitivity to our biological life support systems that present national boundaries do not evidence.

The essence of the bioregional movement is a belief that a sharp contradiction exists between our conception of the geographical earth and the image sent back by the satelite cameras; one envisions a Rand McNally Globe with neatly boundaried, multi-colored countries and the other a dynamic, vibrant living organism demarcated by plant and culture groups, and geological features.

Complementing this new earth consciousness is a strong interest in decentralization of large scale social institutions and physical support systems. Throughout the industrial nations sentiment is evolving for a movement away from the giant systems that dominate our lives.

By decentralizing political decision making people can get more directly involved in decisions that affect them, thus making large scale bureaucracies less necessary and direct participation more feasible. Only on a local scale is truly democratic participation possible and many of the founders of America, such as Thomas Jefferson, strongly supported this idea.

Just as political decentralization has advantages that can improve the workings of the political system more local self reliance can reduce the vulnerabilities of the large scale industrial/urban infrastructure. Now the support structure of the modern society can be likened to a giant complex network. To comprehend this let's trace the material and energy flows that keep an urban area such as New York humming. We see vegetables flying in from California, grain from the Mid-west, hydroelectric power from Canada, coal from Appalachia, oil from the Mideast etc. The energy flows weave in and out of the network so that tracing the entire support complex from space reveals a pattern resembling a giant cobweb. And one characteristic of a cobweb is that the pulling of one strand disrupts the others. Stretching the analogy one step further we can say that we now live in a cobweb economy where such events as the Arab boycott, natural gas supply problems, and droughts are tugging on the support strands.

As a reaction to vulnerabilities of the cobweb economy, support is emerging for the creation of smaller, more stable units. By building their support networks on a smaller regional area, people would be much closer to the resource base upon which they depend and, hopefully, would be prone to husband it more wisely.

Internationally the idea already has currency. In Europe it is referred to as "regionalism." Ecological parties in Europe are embracing the smaller units and are even advocating that the Common Market could short-circuit nation states to create a "Europe of the Regions" where the Basques, Bretons etc. would be directly represented in Brussels.

In the U.S. respected publications such as the *Coevolution Quarterly*, published by the *Whole Earth Catalog* folks, have devoted considerable space to the idea. Fiction often precedes political reality and the bioregional breakup of the U.S. has already inspired a novel, *Ecotopia*, which focusses on the secession of California and Oregon from the U.S. It is being widely read in the ecological underground. The idea has also stimulated the creation of a San Francisco based organization, the Planet Drum Foundation, which distributes seasonal packets of material on bioregionalism.

Today the idea of a bioregional reorganization of the North American continent seems wildly Utopian, but a review of certain evolving trends makes it more plausible. Or at least such an examination forces one to ask how much stress the nation as a social organization can take before it fragments. Just a few short years ago the idea of Great Britain or Canada breaking up would have been scoffed at also; yet now the secession of parts of Great Britain or Canada is a real possibility.

One issue which is increasingly illuminating emerging regional schisms is energy. During hearings on electric powerplant siting in New Mexico, for example, citizens raised the question, "Why should we permit the strip mining of New Mexico to create electricity for advertising lights and swimming pool heaters in Los Angeles?" In the same spirit, bumper stickers appeared on the Gulf Coast during the winter of 1974 reacting to industrial shutoffs of natural gas in Louisiana. Aimed at people on the receiving end of a Gulf Coast to North Eastern United States pipeline, the stickers read "Let the Bastards Freeze in the Dark." This slogan boldly expressed the sentiments of people in Louisiana and Texas that their natural gas should stay in their region for use in their plants, not be shipped North to New York. Reportedly it also reflected sentiment that residents in the power centers of New York and Washington deserved a shortage because they had imposed a price ceiling on the Southeast's natural gas.

Similarly water problems are exacerbating regional tensions. Armed with a technology that allows the large scale diversion of water, North American nations and regions are making bold plays for water. One proposal, which illustrates the sheer magnitude of projects which are being considered, is the NAWAPA — the North American Water and Power Alliance. It would take water from the great rivers of Northwestern North America, raise it by pump 1,000 feet above the river level, carry it south via canals and finally dump it into the Rocky Mountain trench. As the $100 billion project reached the serious planning stage Canadians raised objections about the theft of their water.

Tensions are also increasing over weather modification. Cloud seeding to precipitate rain is becoming increasingly commonplace in the western part of the U.S. As its use has increased, questions are emerging about the priority of "hijacking" clouds for their moisture, thus preventing other regions from receiving rain.

How these issues resolve themselves could affect food production; another potential source of regional tensions. Agriculture in the U.S. is now a lopsided proposition, where most of the food is grown on large farms in the West and the South. Weather shifts, such as the current drought in the western states, are forcing hard questions about who gets priority on food shipments.

Considering the alternatives I find the bioregional possibility the most attractive. Even without the type of stresses that could precipitate a breakup, the strengths of the bioregional argument could conceivably be understood by enough people to build a constituency for reorganizing the United States. Governments and the officials who flock under their wing love concentration of power so support for such a change cannot be expected to come from the nation state's leaders. But even large bureaucracies are not entirely monolithic and every bureaucracy contains some anti-bureaucrats who are open to new ideas and are not enslaved by the careerist-save-my-slot mentality. Those who favor a bioregional alternative for the U.S. can begin to push certain policy steps now that can facilitate such a transition. These might include:

1. *Redrawing the boundaries of U.S. federal regions to be harmonious with the bioregions.* The federal government is already organized into 10 regions and many of the large governmental agencies have regional offices. Currently these follow lines of state boundaries, but no effort has been made to see how these correspond to bioregions.

2. *Regional research and development should be encouraged.* The energy crisis has highlighted more than the resource deficiencies of individual regions, it has also sparked an awareness of the unique characteristics of each. New England may not have oil but it does have an abundance of wood and small hydroelectric sites. In contrast New Mexico can utilize its abundant sunlight as an energy source. Until now we have thought of a national solution to the energy crisis, but considering the unique differences among regions in North America, regional research and development is more appropriate.

3. *Rename the federal regions to enhance bioregional consciousness.* Instead of referring to a part of North America as Federal Region Eight, it could just as easily be called the Great North Plains.

4. *Regionalize the Internal Revenue Service.* One of the principle sources of strength of the federal government is its power to control taxation and disburse revenues; but there is no reason that this function couldn't be carried out in regions. Functions such as defense could still be conducted on a multi-regional level by regional appropriation of money.

Reorganizing the U.S. and other nations along bioregional lines is not a panacea, it certainly will not solve all of our problems, but a deliberate move in that direction would signify that a new level of consciousness has been reached; a veritable leap in human evolution.

No doubt many will believe that such a change is ridiculous. Once I shared that nationalist perspective but my curiosity led me to explore how North America was divided before the cultural invasion of the white skinned Europeans. The subdivision of North America into the United States, Canada and Mexico is a relatively recent phenomenon. During research on North American boundaries I found a map portraying the boundaries of native cultures. I was shocked to see how closely many of the Indian boundaries followed the natural divisions of plant and animal communities and geological formations. Perhaps then the White Man's lines on the continent of North America will turn out to have been a mere historical aberration lasting only a few short centuries.

# The Rebirth of the North American City

**Current trends and emerging patterns in housing and transportation.**

by

**Royce LaNier**

**Present house building designs are wasteful of energy and natural resources. The suburbs in which they tend to be built are characterized by urban sprawl and wasteful land use and cause unnecessary damage to natural systems. Nor have they been designed to provide a satisfactory setting for sound human communities. If we wish to revitalize American cities we must redesign them to satisfy all such relevant social and ecological considerations.**

Throughout most of the world, U.S. cities are thought to consist of shiny new office buildings ringed with freeways and surrounded by single family houses; each with its own grass covered lawn and two car garage. Even within the United States, the suburban house is often considered synonymous with the American dream. This ideal has so shaped public policies of land use and finance as to virtually preclude any deviation from the pattern. As a result, more than twenty-seven million housing units were located in suburban neighborhoods in 1974. This figure represents more than one third of the total available housing in the U.S. and more than half the housing units located in metropolitan areas. Even the most casual observer of urban America will be familiar with *Life and Death of American Cities*, the magnum opus of Jane Jacobs. In profuse detail she has documented and analyzed the process of rural to urban migration, the phenomenal growth of industrial cities in the East and Mid-West, the early beginnings of the suburban experiment and the steady escalation of the trend toward outward metropolitan expansion. Eventually, a rigid pattern of social and economic segregation emerged with the central cities and older, near-in suburbs occupied only by the poorest families while the middle class, freed by the mobility of private automobiles and subsidized by vast public expenditure for roads, sewer lines and water supply projects moved further outward. By the mid-1970s the plight of the urban poor was further exasperated by a significant shift of manufacturing and office employment out of the central city to scattered locations in the suburbs. This was a natural response to demands for more convenient jobs and a fuller range of services by those families living in the suburbs.

Although it is still the predominate pattern, there are signs that America's love affair with suburban living may be waning. Certainly there is wide spread disenchantment with commuting from downtown offices to remote suburbs. Increasing rates of alcoholism and drug dependency among suburban housewives as well as rising crime rates among juveniles from middle class families have erased any remaining illusion that the suburbs provide an escape from social problems. Although direct causes are difficult to establish, boredom due to the lack of diverse opportunities for human interaction in the physically, culturally and economically harmonious suburban environment, may well be a contributing factor. The popularity of apartment living among young couples, singles, couples whose children are grown, and the elderly suggests a desire for living conditions which offer increased contact with other people and a greater diversity of readily accessible facilities and services. This trend seems especially significant in cities of the West and South where there is no long standing tradition of in town living. Despite the fact that the costs of renting an apartment generally exceeds mortgage payments, or rents on similar sized houses in these cities, substantial numbers of young people who grew up in suburban, single family, detached houses are choosing to live closer to jobs, shopping, to entertainment and to each other.

A smaller, though not insignificant, number have abandoned the city altogether; although most of them grew up in suburban communites and never really experienced urban living. Many in this group are seeking a simpler life style including their jobs as well as their living conditions. Co-operative, largely self-supporting communities of young people have grown

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up in several agricultural regions of the country; and small towns throughout the United States have experienced modest increases in population as young people from middle class suburban communities move in and take up various trades. American youth of the 1960s and early 1970s have not simply grown-up and assumed the life style of their parents. The most significant difference seems to be an attitudinal shift away from consumerism as a goal, towards a greater awareness of the impact of one's individual life style on the quality of the environment, on resource consumption, and on personal health.

Communal living is perhaps the single most dramatic departure from current patterns. Out of the communal movement has come a number of experiments with minimal impact technology including much of what has increased ecological awareness. The concept of autonomous living in self-contained houses, which rely on solar or wind power for energy needs and produce organically grown vegetables using recycled waste, more accurately reflects a philosophy of communal self-determination than one of global interdependency. Yet the experiments themselves offer models which, if applied on a broad scale, could potentially benefit society in significant ways.

The concept of minimal impact building design and the use of low-impact technology is already receiving considerable attention within the established construction industry. Recent, precipitous rises in energy cost have brought a new sensitivity to the potentials for minimizing fuel requirements in building through design as well as construction measures. Charles Abram's proposal for a Los Angeles suburban community where the houses were covered with earth berms and landscaped, and this author's proposals for underground, courtyard style houses and office facilities adjacent to the runways at the Dallas airport may not have been taken too seriously in the mid-1960s; but today, design of underground space has become a highly specialized field with increasingly broad application. In a 1970 publication, entitled *Geotecture*, the extent to which underground space has been used in the U.S. and globally was documented; and proposals made for future application. The use of underground space for commercial and industrial functions has become commonplace. A growing acceptance of the concept for public facilities is evidenced by the recent design competition for an underground complex to house exhibition space and offices for the Minnesota State Legislature. The ecological advantages of earth covered or underground architecture consist of minimizing the disruption of natural systems and maximizing the potential for energy conservation. Thus one often finds that an ecologically designed autonomous house is at least partially underground. The idea of living in totally underground houses evokes a negative image of air-raid shelters from most people, while the image of a house covered on one or more sides with landscaped earth berms or nestled into the side of a hill seems quite acceptable. Although any form of building will have some impacts on the natural environment, efforts should be made to minimize these and to devise ecologically appropriate patterns of development and forms of shelter.

**Ecological housing design**

Long before enactment of the National Environmental Policy Act of 1969, architects were concerned with how their buildings "fit" with site conditions and how they related to surrounding buildings as well as to the larger community. Victor Ogelby in *Design with Climate* and Ian McHarg in *Design with Nature* lay out the environmental principles which should govern orientation, form and siting of buildings. The late Frank Lloyd Wright so mastered integration of his intensely individualistic buildings with their sites that the end products often seem inseparable. Regional styles of residential architecture and traditional construction techniques are being revived after years of world wide standardization. Heavy masonry and adobe construction as well as courtyard style houses are again being built in the West and Southwest. Along the East Coast the tradition of townhouse construction with common walls is being revived as cluster developments, even in suburban communities and new towns. The South has yet to return in any significant way to its tradition of well ventilated, high ceilinged, wooden houses with broad overhanging roofs, but the potential exists; and the timing may well be right for conscious public policies, in all areas of the country, aimed at encouraging ecologically sound design of housing.

In the context of ecological design the energy conserving potentials of buildings also warrant special consideration. Fortunately there is a coincidence of factors here — siting of building, their form and orientation for maximum climatic advantage in terms of human comfort will also minimize the need for space heating and cooling, i.e. energy use. The development of optimum building forms for different climatic regions must consider both heat loss in winter and heat gain in summer. In general it is advisable to minimize east-west facades which receive greatest summer sun while the south face, which receives radiation in winter but not so much in summer, can be increased or decreased in accordance with local climatic conditions.

While orientation is obviously important in deriving optimum shapes for individual buildings, there are several additional approaches to reducing dependency on energy supplies. The differences, however, are in focus; seldom is any approach exclusively followed. One approach focuses on improving energy use efficiency primarily through selection of appliances and equipment with high efficiency ratings. A second approach involves the use of special techniques to capture solar or wind energy and convert it to other forms of energy for use in buildings. A third approach focuses on direct reduction of consumption of energy in building. This latter approach includes design for maximum use of natural energy as well as selection of materials in terms of their energy production costs and their thermal insulating capacity.

The first approach involves primarily an increased awareness of the variation which exists in the energy efficiency of normal mechanical equipment and appliances. Beyond this there is little an architect or a home owner can do to actually improve the ratios. The other two approaches require closer examination.

The autonomous house is a logical extension of the second approach — capturing and converting solar and or wind energy. Experimental examples have sprung up all over the country. Philip Steadman's book *Energy, Environment and Building* describes some sixty solar heated projects and a similar number using wind generated power. The projects are scattered geographically from North to South and from East to West. They are located in large cities and in rural areas. With the proliferation of manufactured products, and the prospects of federal tax incentives, retrofitting of existing houses is becoming more commonplace.

The third approach, minimizing energy use through design, is really just an extension of the design with climate concept only having energy conservation and minimum environmental impact as primary objectives. This emphasis leads to life cycle cost accounting for building and an evaluation of the energy costs involved in producing the materials used in construction as well as their insulating value or thermal capacity. It encourages greater use of materials which are renewable such as timber and fibre, or those which are readily available and useable with minimal processing. A logical extension of the concept is earth berming, earth covered and underground buildings.

Project Ouroboros, an experiment being conducted by students at the University of Minnesota, combines natural ventilation and sun control, conversion of solar and wind energy, and use of a sod roof and earth berms for insulation, with recycling of water to reduce waste, sewage composting for fertilizer, and indoor greenhouse gardening which also recycles the air. In terms of minimizing the ecological impact of one's lifestyle, the experiment is indeed interesting but the equipment involved in building Project Ouroboros or any of the autonomous houses could be viewed as excessively wasteful of scarce resources. The same concept, if applied to condominium or co-operative housing projects might provide an attractive option as the use of common facilities would allow a considerable reduction in the total equipment required to serve the collective needs of a community or a group of residences.

**Ecological urban patterns**

Urban planning has traditionally focused on co-ordinating the development of public facilities to meet the projected needs of a growing community. Urban design has traditionally emphasized the need for relating new facilities to the scale and materials of surrounding buildings and to the uses of adjacent land. The context of planning and design for future urban needs must now be broadened to encompass consideration of land availability to accommodate conflicting demands; energy sources, cost and reliability; water quality and supply; materials shortages; and critical limits in the capacity of the natural life support systems as well as the ability of the existing infrastructure to absorb increased human activity.

The "Cost of Sprawl" report issued in 1975 by the Real Estate Research Corporation clearly documents the case for reassessing existing patterns of low density scattered development. The real question seems to be who will take the lead in order to assure that a viable alternative pattern emerges. Present practices of subdividing land into individual lots, the layout of roads, the extension of sewer and water lines and the construction of single family houses is still looked upon as the legitimate exercise of the rights of an individual property owner. Yet this practice represents a commitment on the part of an entire community to maintaining suburban living patterns for at least the thirty years required to pay off home mortgages. It further implies a national commitment to maintaining the automobile or some similar means of individual transportation system despite the certainty of oil shortages and rising costs.

The United States has no explicit policy governing the use of land, the maintenance of small communities, the timing or character of growth in cities, the co-ordination of urban services, or the provision of housing. Yet the actions of federal agencies have a profound impact, perhaps even a deterministic effect, on the location, pattern, timing and density of development. According to the National Growth Report of 1975; federal funds support 90 per cent of interstate highways construction, 70 per cent of non-interstate highways, up to 80 per cent of mass transit investment and 75 per cent of the cost of interceptor sewers and treatment plants. A look at the planning assistance programs and the regulatory activities of the federal agencies leave little doubt that the influence of the federal government on the character of the built environment and consequently on the quality of life is indeed profound, despite fragmentation of authority and lack of focus or overall direction.

States, through their taxing authority and through the extension of zoning authority, annexation powers, and other enabling legislation to regional agencies or local units of government also have a vital role to play in establishing development patterns. Either state or regional agencies must take responsibility for establishing policies aimed at moderating growth patterns. Commuter taxes, parking restrictions, public transportation systems, express bus lanes on freeways and other such programs should be instituted to assist in moderating present patterns of travel.

Although both the federal government and the States have important roles to play, only local governments working with private land owners and developers can actually effect the necessary changes. Local government has at least the obligation to see that new developments are planned so as to minimize disruption of essential natural systems. They should also establish criteria for accessibility and serviceability, encourage the inclusion of mixed use centers for commercial, recreational, and employment needs as well as the clustering of residential units. In addition, energy efficient design and construction standards should be established and community service programs organised.

At the present time, few communities offer families any real choice of housing type or of living environment, yet there is evidence that changes are beginning to occur. Within cities themselves, long established patterns are breaking down. The central city, with its greater diversity of services, has become a fashionable place to live for those who can afford high-priced town-houses or expensive apartments. Even families with school-aged children are moving back into restored townhouses or newly converted condominium units in Boston, Philadelphia, Washington, D.C. and many other cities across the country. The renovation of older buildings is becoming a specialized field for a few designers and developers, an all consuming challenge for many families, and an increasingly costly undertaking for everyone. As a result of the rising demand for in town property, real estate speculation in cities like Washington, D.C. is running rampant, forcing up property values and displacing poorer families. The primary obstacles to the rehabilitation of urban neighborhoods for low and moderate income families as well as the middle class has been exclusionary or "red lining" practices, where lending institutions refuse loans in certain neighborhoods, and local property tax structures, which penalise those owners who do up-grade their properties by increasing assessments. Numerous examples exist to illustrate the impact of changes in lending institution policies on the cost of housing a city, the condition of particular neighborhoods, and the income levels of families living in particular parts of a city.

The renovation of urban neighborhoods is an essential step in the process of reducing nationwide increases in energy consumption and slowing the rate of outward growth of metropolitan areas. In most cities some momentum already exists. Generally there are buildings of architectural significance which have been or should be restored to their original condition or sympathetically adapted for new uses which will give them continued economic vitality. Usually there are extensive areas of residential building in or near the center of the city. Often these are far too large for a single family house as they were originally intended. Consequently they have, over the years, been subdivided into rooming houses, converted to commercial uses, or torn down to make room for other structures. Efforts have been made to revitalize such areas in cities all over the United States. San Francisco's streets are lined with beautifully maintained or restored houses of the Carpenter's Gothic style. These tall narrow houses stepping up the steep hills contribute significantly to the unique character and the human scale of that city. The older cities of the East Coast, the Mid-West and the South each have large sections which can be characterized as Victorian or Georgian or Colonial. New York has its brownstones. Dallas, Texas has a section of early twentieth century Prairie style houses. Even Ketchikan, Alaska has an historic district of clapboard fishermen's houses built along a wooden boardwalk on pilings at the mouth of a salmon stream.

In any community a few of the exceptionally fine houses should be preserved or restored to their original condition as examples of the life style of past generations. This can usually be accomplished by a few concerned citizens and a responsive federal grants program. It is far more difficult to modify tax structures, local codes, insurance rates and the practices of lending institutions to encourage broad-based renovation efforts aimed at maintaining the character of older neighborhoods by preserving the integrity of the structures while creatively adapting them to meet the life style and the economic circumstances of contemporary living. If this is to happen on a large scale, local lending institutions must become more closely linked to the economic well being of the area in which they are located and local governments must actively encourage home owners to maintain the value and utility of their property by offering incentives for renovation coupled with penalties for code violations or demolition.

Revitalization of urban neighborhoods includes more than historic preservation and adaptive reuse of existing buildings. Programs should be initiated to encourage retrofitting of older buildings with insulation and with solar hot water systems, with more efficient appliances and possibly with heat pumps or solar heating and air conditioning systems. Vacant properties should be filled in with new facilities in accordance with an urban design plan which also addresses open space and recreational needs as well as furnishing of the entire pedestrian network of the neighborhood.

The greater densities of most in-town neighborhoods and closer proximity to jobs and services also allows diversification of transportation alternatives. Walking or bicycling can be considered viable alternatives for getting to work or for shopping. Mini-buses and zone taxis work best in limited areas with a light rail or express bus system providing the linkage with distant sections of the city. Eventually the automobile can, along with the sailboat, become a weekend recreational vehicle. Eliminating the necessity of owning one or more automobiles would significantly increase disposable family incomes.

In addition to the energy saving aspects, and the economic bonus, societal benefits would result from reduced dependence on automotive transport. Air quality improvements would benefit both plant and animal life as well as human health. Decreases in traffic congestion and noise would lessen one of the principal causes of stress associated with urban living; and the increased exercise from walking to work or bicycling to the store would have a substantial effect on general physical fitness.

Despite evidence of widespread interest in returning to the convenience and economy of in-town neighborhoods, there is little indication of any attitudional shift away from the fixation with homogenity of neighborhoods which has led to economic and functional as well as cultural and racial segregation n North American cities. Unlike European cities, the diversity of in-town neighborhoods in the United States today is most likely a transitional phase. Many of the disruptive tensions which characterized the U.S. cities in the 1960s may well be related to the vulnerability of a highly compartmentalized system to change. As in natural systems, greater diversity of people and of facilities might provide a type of dynamic stability for human communities which would allow adaptation to changing circumstances without precipitous shifts in property values and ownership patterns.

# Neighbor

## by David Morris

**Economies of scale have broken up small neighborhood industries, and mobility and industrialisation have severed the bonds that used to hold neighborhoods together. To re-establish them, and to reawaken a sense of community spirit, a new approach to planning is necessary. Above all it must ensure the autonomy and identity of local neighborhoods. This means among other things that control over the capital they generate, the resources they own and the political decisions that affect them must be in the hands of the neighborhood.**

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# hood Power

> This principle (subsidiary) is that you should never assign to a larger entity what can be done by a smaller one. What the family can do, the community shouldn't do. What the community can do the states shouldn't do — and what the states can do, the federal government shouldn't do.
>
> *Daniel Patrick Moynihan*

A longing for neighborhood is sweeping this country. Even in mobile, ad hoc America a new generation yearns for a sense of place. We are, after a long period of amnesia, remembering that, after the family, the neighborhood is the basic building block of society.

In pre-industrial society this was recognized as a matter of course. Until our grandparents' era the neighborhood was the focus of much of our social and economic intercourse. Walking distance was all that separated business from pleasure. The town square, the water pump, the tavern, or the garden made do as meeting spots, for trysts as well as for business conferences. Local culture flourished. Planners, recognizing the unchanging purpose of why people live in communities, put all their talents into the construction of the communal nucleus — inns, churches, city halls. The rest of the city followed by itself.

Modern industrial development has broken down the blood bonds of neighborhoods and has fractured life between work and play. As one urban observer has written:

> The structural faults (of our cities), whether social, material, economic, or administrative can be seen to hinge upon one factor, dispersion and separation — separation of people from people, work from homes, homes from shopping and leisure activity, financial needs from financial resources, patterns of governmental authority from patterns of need for governmental action or aid.

The automobile has played a major role in this process. Leopold Kohr has described the multiplier effects which come with using the car to move out of the urban village.

> But having moved into a residential area has produced more than one technological distance. My wife feels we live too far from the market to continue shopping on foot. My children are too far from play grounds and school. We all are too far from the theatre, the recreation facilities, the restaurants, the library, the pubs, in fact from every location that was within pedestrian distance as long as we lived in town. In other words, my move into the outskirts has increased the distance to be negotiated not arithmetically but geometrically. The addition of a single mile has added not only one two mile journey per day, but a whole cluster of such journeys, and this not only for the family collectively, but for each of its members individually.

Public policy since World War II has reinforced the destruction of geographic community. Federal financing agencies, such as HUD and FHA, have for twenty years pursued a policy which can only be described as a search and destroy mission. Those neighborhoods which lacked an economic base were razed, despite the presence of a viable social structure.

These programs supported high-rises and freeways as efficient ways to house and to move large numbers of people. Even after these programs have been proven erroneous, they live on, sapping the energy of neighborhoods which have to spend years fighting against policies whose very designers have since admitted their folly. Thirty years after his support of high rises was translated into national, and even global, policy, Constantine Doxiadis recanted, noting:

> Such buildings work against nature by spoiling the scale of the landscape. The most successful cities of the past have been the ones where man and his buildings were in a certain balance with nature, such as Athens or Florence. Furthermore, these buildings work against society because they do not help the units of social importance — the family and the extended family, the neighborhood — to function as naturally and as normally as before.

As individual transportation systems fragmented work and play, and vertical construction destroyed the human scale of society, our neighborhoods have become increasingly single-purpose, residential areas. Even when they retain a business base, it is no longer one which acts to hold the community together. Neighborhood commerce is now a branch store or franchise operation. The manager lives outside the community. The products sold come from outside as well. And this trend has given way to an even more sinister and debilitating one. The local gas station has been replaced by a self-service station. The attendant sits behind bullet-proof windows, taking cash and pushing buttons. Branch banks are being replaced by electronic bank tellers, holes in a wall where you push a series of buttons to make a deposit or withdrawal. Supermarkets are introducing automated tellers.

These developments may be efficient when viewed from the corporation's bottom line; but they reinforce the growing image of the neighborhood as an outpost of civilization rather than its center. No longer can we get a flat tire repaired, or ask for financial planning assistance, or discuss produce comparisons. The human interaction of commerce is being eliminated.

Yet, despite this onslaught, human communities survive and persevere. Neighborhoods which have fought against freeways, high rises, local school closings, traffic dangers, and the like are now seeking some way to guarantee their security.

The strongest demands usually stem from those neighborhoods located on the ring around downtown, for it is here that the daily pressure of speculators and builders has been most intensive. But the revival of localism has spread beyond inner city neighborhoods to those residential communities on the edge of the city, and beyond, to the sprawling housing developments which constitute the new suburban communities. This sense of geographic identity and turf is being reinforced by a growing support for local self-reliance, for a return to a human scale of society, where decision-making can be done through face to face contact, and where production can be done within walking distance.

Neighborhoods have learned that struggling *against* something, be it a high rise, a park closing, or increased traffic, is a debilitating process. One is always confronted with a decision after the fact. As these communities gained organizational strength and maturity, they began to demand active participation in planning.

**Neighborhood Planning**

Planning which strives for community self-reliance will blend the ancient and modern. It will adopt the pre-industrial concept that geographic community should be the locus of society, that the urban village, with its rich human interaction and culture, should be preserved, and reinforced. It will integrate the modern advances in technology and science, which can reinforce holistic planning through contemporary ecological concepts.

The goal of this kind of planning is the transformation of neighborhood residents from consumers to producers, from passive observers of society to active participants in planning its future. In short, to make them citizens once again.

For the neighborhood to once again become productive it must utilize the wealth it generates. This means stopping the leakages of wealth from its borders. There are at least two kinds of leakages that decentralized planners must minimize. The first is the outflow of capital to the public and private sectors, money that could be recirculated within the area for local economic development. The second is the outflow, or just plain waste, of the enormous natural resources the community has access to. The energy that falls on its territory, the soil and rooftop space, the so-called organic and solid "wastes" which should rather be considered raw materials by local planners, the rich human resources, these are the natural resources common to all geographic communities.

By plugging the natural resource "leakages" in our communities, and recycling finance capital into local economic development, we can begin to build a productive base and regain a measure of self-confidence and cohesion which has been lacking in our neighborhoods for some time.

**Stopping the Leakages: Capital**

Although such studies are in their infancy, neighborhoods are beginning to recognize that the vast quantities of public and private money that flow through their boundaries tend to leak very rapidly, having few beneficial effects on the area. As Milton Kotler observed:

> The important features of a poor neighborhood are, first, the discrepancy between the aggregate expendable income of the neighborhood and the paltry level of its commerce, and second, the discrepancy between the considerable tax revenue the neighborhood generates and the low level of benefits it receives in public services and welfare. In both cases, the neighborhood exports its income . . . Its present internal commerce is dependent, as is its level of public services, on commerce and personnel outside the neighborhood.

For the public sector, one of the earliest studies, done in 1969, examined the Shaw-Cardozo neighborhood in Washington, D.C., a primarily low income area with a population of 87,000. Even in this low income area, $10 millon more flowed out of the community in taxes and fees than returned in services and public welfare. These figures in fact understated the impact on the neighborhood because the money which did come back in services went mainly to pay the salaries of teachers and police officers who live outside the neighborhood, coming only to perform their jobs.

The government is not the only source of leakage. One study examined the neighborhood balance of payments of Bedford Stuyvesant, a large neighborhood of 250,000 residents in New York City. It found a favorable balance of payments, primarily due to the huge impact of public assistance moneys from federal and local governments. However, it also found that the amount of money which flowed out of the community for drugs and gambling equaled the amount that came in as public assistance payments. Organized crime was the source of leakage in Bedford Stuyvesant. It was grossing more money than the federal government was collecting in taxes. Not surprisingly, the gambling operation in the area is the second largest single employer, next to the government itself.

Private business is, if anything, worse than the public and criminal systems. The money you deposit in the local bank rarely benefits you or your neighbors. The persistence of neighborhood activists led to the uncovering of the redlining practice. Insurance companies and banks have traditionally refused to make loans in areas they decided were declining. For example, zip code 60622 is an older ethnic neighborhood in Chicago. The area deposited $33 million in savings and loans, but received only $120,000 in loans. There were no first mortgages. When redlining occurs, a neighborhood *does* deteriorate. There is no money for home improvement, no financing for property transfers.

Even if the money is loaned it rarely goes to neighborhood enterprises. In the Adams Morgan neighborhood in Washington, D.C. (population 25,000) chain stores deposited 20% of the money in the local bank, while the locally owned and operated independent retailers deposited 80%. However, when loans were made, the giants gained 72%, the independent businesses 28%.

The proliferation of branch stores has aggravated the basic problem. The parent corporation establishes a branch or franchise only if it is profitable. Let's see what this means by reading the conclusions of a study of the books of one fast food franchise — McDonalds.

> Fully 20% of this store's costs immediately leave the community: advertising, rent (paid to a corporate subsidiary); a service fee paid to the corporation; accounting and legal fees; insurance; depreciation and amortization; and debt service. This restaurant, like all other outlets, purchases its food and paper supplies from other centralized corporate subsidiaries. These costs are 41.81% of total expenses. Management costs go toward paying salaries outside of the area . . .
>
> The one restaurant does about $750,000 in sales annually and earns about $50,000 in profits before taxes. Over $500,000 of the money leaves the community; as much as $67,000 more may also be 'exported.'

These figures are particularly disheartening since franchised businesses constitute the most rapidly growing part of the retail economy.

Neighborhoods which are striving for self-reliance will try to keep as much of this money within their borders as possible, recycling money the way (as we shall see) they recycle natural resources. For every dollar that is spent within a community, more than a dollar of local income is generated. We shall explore this topic in more detail later in this article, but one of the local economic development strategies for decentralized planning is that of import substitution. This means substituting local services and products for those previously imported. It is a concept which has been used with varying success in developing countries, and is gaining popularity in our capital starved and hemorrhaging big cities.

**Stopping the Leakages: Natural Resources**

Just as capital flows out of our communities, so do natural resources. And, as in the case of dollars, neighborhoods interested in self-reliant planning must develop mechanisms for capturing these resources for local use.

F.H. King, writing many decades ago, noted the ironic waste of nutrients in America.

> . . . The people of the United States . . . are pouring into the sea, lakes, or rivers, and into the underground waters 6 to 12 million pounds of nitrogen, 2 to 4 million pounds of potassium, and 75,000 to 3 million pounds of phosphorus per million of adult population annually, and this waste we esteem one of the great achievements of our civilization.

Our neighborhoods waste more nutrients than would be needed to provide the fertilizers to meet the total food needs of that area.

We can speak of agriculture in our cities, because most cities are not nearly as dense as we believe. Downtown Manhattan may, indeed, have densities of over 100 people per acre, but in the average American city there are fewer than 7 people per acre. In most cities there are millions of square feet of roof space on warehouses, office buildings and residences which can be utilized for energy generation, for food production, or for both. Utilizing intensive agricultural techniques such as hydroponics, one can raise a significant quantity of vegetables. One study done of a neighborhood in Washington, D.C., found that by utilizing only a portion of the roof space and the soil space, the neighborhood could supply over 40% of its fresh vegetable needs, and this in a neighborhood which is quite dense.

Solid waste is a resource. A neighborhood of 20,000 people generates ten tons of paper a day, an equivalent amount of organic waste, and significant quantities of metals, and glass. This material wealth can be processed locally and turned into products.

The energy beating on our rooftops and streets is wasted. The solar energy which falls on our neighborhoods each day could provide for all our energy needs. Yet only recently have the first signs of solar technology entered our communities.

The technology is available, currently, not only to collect low grade heat for heating our domestic waste and the interior of our buildings, but for higher grade heat for air conditioning. Solar cells and wind generators are available to convert solar energy to electricity. Increasingly sophisticated technologies are coming online, including storage systems. Given the availability of these technologies, it is about time we began to view our neighborhoods as energy producers, replacing the concentrated energy producers that currently dominate the international economy. Each solar collector that is installed represents a first step toward redefining one's house as a utility company. As communities begin to assess their energy potential, they cannot help but see how renewable energy technologies can replace imported energy.

We discuss below how the production economies of electric vehicles are such that they could be produced by relatively small plants for relatively small market areas. The electricity for these cars could come from solar cells or wind generators. In one study done of Washington, D.C., it was discovered that if all the parking lots were covered with solar cells, enough electricity would be generated to supply 65% of all the energy required for work-related trips by electric vehicles, and approximately 100% of work-related transportation trips during the summer months. It is probable that neighborhoods will substitute domestically generated energy for imported energy in future planning efforts. Why import oil from Texas or Saudi Arabia when we can use the wind and sunlight falling on our own turf?

**Why Self-Reliance?**

At this point, the reader may ask, why self-reliance? Why should our neighborhoods seek a degree of autonomy? Might this not fragment systems, and lead to a balkanized inefficiency in both production and delivery?

It should be clear that we are not advocating self-sufficiency, but self-reliance. By striving for self-reliance, a neighborhood will build a sense of cohesion and a degree of self-confidence. People will be involved directly in decisions which affect their own lives. The process itself is important. By trying to be self-reliant, neighbors need to rely on each other more, and in that spirit of co-operation they may prove ingenious.

Self-reliant neighborhoods must do more with less, creating new ways of providing high quality goods and services with lower cost and lower material and energy input.

The most important resource that self-reliant neighborhoods have is people. It is ironic that only recently has the value of the voluntary labour that neighborhoods produce in quantity been recognised. Cohesive communities have an important, even critical, barter economy. People watch other parents' children. Recipes are swapped. Emotional support systems are common. Bartering of goods and services goes on continuously. The strength of neighborliness should not be underestimated. Although there are no studies, I would suspect that those neighborhoods with a strong sense of self-identity contribute far more in neighborliness to their local economic structure than those which lack this identity.

Beyond this, there is the broader range of unpaid services, what Scott Burns has dubbed the household economy. Several studies have found that if we gave the minimum wage for such tasks as house cleaning, child care, and the like, we find that unpaid services are worth as much as the entire national income.

There are other important aspects of self-reliance. As neighborhoods become more productive, they retain a knowledge about production which makes the residents better citizens. Youth growing up in a community which has homes, light industries, food and energy production, can use the neighborhood like a school. In historic times, the youth dropped by the blacksmith's forge to learn how to shoe horses. Modern neighborhoods have very few, if any, places of learning outside the schools. Community businesses can provide the knowledge that residents need to evaluate larger entities. Just as the TVA was a benchmark for the production of electricity for private enterprise, so the neighborhood farms or production facilities will show how cheaply and how well things can be made compared to the price, and quality, of national brands.

Neighborhood self-reliance can promote world peace. It is trite by now to note that the rest of the world is neither so affluent nor so fortunate as is our country in terms of natural resources and technologies. Although a great deal of that problem is traceable to a maldistribution of income and to the kinds of political regimes in power, part of the problem results from a lack of natural resources and technology appropriate to the local conditions. It may be that as we utilize the creativity of our neighborhoods to develop ecologically sound systems we will both lighten our resource consumption and develop techniques that can have use beyond our borders.

In the last twenty years of this century we will be faced with an extraordinary need for experimentation, creativity, and invention. This is best done on a small scale. As James Madison once observed, a diversity of experimentation on the local level can only lead to progress. If the experiment fails, there is no great harm done. If it succeeds, the experience can be rapidly transferred and adapted to still other localities. It is this need for creativity and diversity which may be the greatest justification for neighborhood self-reliance.

**Economies of Scale: Production**

We have discussed the need to stop leakages and utilize our natural, financial and human resources for local economic development. Any discussion of decentralized production must confront the conventional wisdom that bigness is efficient. How far can one community go in producing the goods and services it requires?

Many discussions of this question stem from the need for a new definition of efficiency, one that stresses human involvement. These discussions raise profound points and merit serious consideration in future planning. Is it efficient to use a half glass of oil to produce a glass of milk? Is it efficient to produce thousands of cars a week, while each worker does nothing more than turn one bolt or screw? Is it efficient to centralize production so that hundreds, or thousands, of employees must travel miles to and from work, and spend hours commuting, rather than decentralize plants and lessen the human toil?

However, even if we approach efficiency in traditional terms, we soon discover that most production systems are very small. The myth of the efficiency and inevitability of bigness stems mainly from a confusion between plant size and company size. Companies have grown larger. Multinational corporations are colossal. But the typical plant has not changed very much. Indeed, even in manufacturing, most plants are small. Joe Baines, after an exhaustive survey of so-called economies of scale, concluded:

> If one begins with the fact that after a century and a half of rapid industrial expansion, of extraordinary technical progress, and of a generalized belief in the virtues of size, it still remains true that the average factory in the United States or Great Britain employs only two or three score people, then the mind intuitively begins to search for the diseconomies of scale, and what seems to be really worthy of our curiosity and our labours is some explanation of why the increase in average size has not been more evident.

There are about 275,000 companies in the United States, and 400,000 plants. Of these, 263,000, or more than 95%, own only one plant. Our large corporations are administrative and marketing mechanisms.

Several studies of consumer goods manufacturing sector have tried to estimate the minimum efficient production unit. These studies are remarkably consistent. They indicate that, for many consumer goods, plants can be very small. One study found that for almost 70% of all the industries for which a minimum efficient scale could be identified, fewer than 250 employees were needed; 44% required fewer than 100 employees. And 70% of the industries required capital assets of under one million dollars to enter the industry. These figures may seem high for a neighborhood of 10.30,000 people; but even if we were to scale these down to the point where they are not optimally efficient we would lose very little. Several studies found that a plant 50% smaller than a minimum efficient one would in most circumstances raise the cost per unit by 5-10%. Thus we may be able to scale plants down to where they produce for very localized markets and pay the price of only a slight cost increase.

Finally, production costs themselves are only a fraction of the retail cost. The cost of producing an item usually ranges from 25-30% of the final selling cost. The rest goes to advertising, distribution, overhead, profit, and the like. Therefore, it is possible for neighborhoods and small businesses to make high quality goods for local use at cheaper prices than big corporations, as long as the loyalty of local residents can be won. We may well see the Buy America campaigns resurrected as a Buy Neighborhood campaign in our cities and towns. Experience has already shown that cottage industries can produce cheaper soap than can Palmolive, cheaper aspirin than Bayer, and cheaper polishing wax than Pledge.

This is the picture we get from examining the current state of production. The future may be even brighter, for new technologies and materials advances are decentralizing even those industries such as steel and automobile production where the efficiency of bigness has held the most validity.

John Blair has noted the centrifugal nature of many new technologies:

> Beginning with the new technologies of the Industrial Revolution, the veneration of size has come to take on the character of a mystique, and, like most mystiques, it has come to enjoy an independent life of its own. The danger is that the size mystique will continue to grip men's minds long after the circumstances that originally gave rise to it have disappeared.

Today, plastics are replacing steel in many applications; and this is significant. One plastics executive compared the costs:

> . . . a thermo-forming mold made of epoxy costs approximately one to two per cent of an equivalent steel stamping die, and we have yet to find out how many pieces can be run from such a mold.

Electric vehicles are far less complex than existing motor cars, and can be produced in small shops. The tooling required to produce a plastic-bodied electric car costs between \$1.5 to \$3 million, compared to the \$500 million necessary to initiate production of conventional steel-bodied piston engine cars.

Plastic is not the only competitor with steel. R.J. Lyman, executive secretary of the Prestressed Concrete Industry, compares steel with his product:

> It is possible to construct a minimum plant in our industry for approximately \$250,000 today, but an average figure of \$500,000 is considerably more realistic . . . An average size plant in our industry will employ 50 to 75 workers.

In contrast with these limited capital costs, it has been estimated that the cost of establishing a small steel mill equipped with an electric furnace to produce merchant bar and angle is in the range of 8 to 10 million dollars, while a basic steel mill able to produce large and heavy structural shapes perhaps would require upward of \$50 million.

The smallness of scale of the electronics industry is legendary, but there are other materials advances which lend themselves to neighborhood use. New flywheels can make neighborhood electric storage systems a viable reality, while solar cells can generate sufficient electricity to provide all of our needs.

While it appears true that modern scientific and technological advances are making possible even smaller efficient production units, there is a rapidly developing movement around the world which presumes that in many cases we can *scale down* our technology without sophisticated scientific advances. This movement has many names: intermediate, community, appropriate technology. It began in developing countries. Imported technologies are often inappropriate for non-industrialized nations. With small markets, scarce capital, and an abundance of labor, these countries find that capital intensive machinery which requires large market areas is wasteful and often even injurious to the local economy and society.

The Intermediate Technology Development Group, based in England, has had the most publicized success in this area. E.F. Schumacher, the founder of the organization, relates several stories to buttress his thesis that small is possible:

> Zambia is fostering egg production because, although there's enough food, there's malnutrition from a protein gap. So I visited quite a number of poultry farmers and I found them in a most unhappy state. They were sitting on their eggs weeping. What was the matter? They had no packaging material; it had not arrived. They could not get their eggs to market. I inquired, where do these egg trays usually come from? They are imported from far away, and something did not work — a shortage of foreign exchange, etc. . . .

Schumacher went to the large multinational corporation that produced virtually all the egg trays in the world based in Copenhagen. They said the smallest machine they could make would produce one million egg trays a month. Anything smaller would be totally uneconomical. But ITDG produced one and it was successfully introduced in Zambia. "But you know what happened? The need for this machine is just as great in the rural areas of the rich countries. They say, thank God we can now do something ourselves and are no longer just a colony of the big city." Cities themselves, seeing their resources flow from their borders, may well echo the complaint.

Take the use of construction materials: Schumacher says that when we talk about building materials we talk about Portland cement. Why Portland cement he asks:

> Go around Europe, to Asia, and you will find the most magnificent, wonderful buildings. The Taj Mahal or the cathedrals of Europe were not made

with Portland cement, and they are still standing. Why have we fixed ourselves on Portland cement? Maybe you need Portland cement to build skyscrapers, but that is a minority phenomenon. Most buildings are not skyscrapers. What about other cementitious materials? It turns out that there are many other materials that can be made into cement at half the temperature of Portland cement. And for most normal human requirements, they are totally adequate and can be made on a small scale.

We can expect, with the growing awareness of appropriate technology and the federal and local government's interest, that neighborhoods may soon call on technical expertise much as the developing countries have done. These engineers and scientists will be asked to redesign production facilities (or other systems) so that local materials can be utilized, smaller markets can be reached, and more labor can be used in creative capacities. As this occurs, neighborhood planning will take on another perspective, that of actively deciding what kinds of tradeoffs the neighborhood will accept.

The question of tradeoffs is an important one, for there is no right decision. Planning, like politics, is the process of choosing that option, among many, which is most advantageous. The process of choosing a technology is a basic one and has many ramifications. For instance, the ITDG examined the manufacture of glass, in order to assess the potential for one developing country's producing its own. It found that soda ash, which is used as a flux, can be obtained from wood ash or from seaweed. If one adds only seaweed to the melt, one gets a slightly green glass. If arsenic, an extremely expensive trade ingredient, is eliminated, the final product has tiny bubbles in the glass. By eliminating these two basic materials, the process is simpler and cheaper. The price we pay is slightly green glass with tiny bubbles. Although such material substitution tradeoffs have not been done in most industries, these tradeoffs are the ones which must be explored by neighborhoods seeking a high degree of self-reliance.

**Economies of Scale:**
**Service Delivery: Prevention versus Treatment**

The service area of the economy has become as concentrated, capital-intensive, and remote from neighborhood participation as the goods production sector. The problem is that we have rarely noted the different dynamics between prevention and treatment. The more we prevent, the smaller the system, the less the capital expense, the greater the role for paraprofessionals, and the greater the citizen involvement. Prevention systems, whether they be in health, criminal justice, or other areas, tend to be decentralized. The rapidly rising cost of hospital treatment has caused a profound reaction. Numerous studies are now indicating that treatment systems have had relatively little impact on the state of health. Our life expectancy is due primarily to the improved diet and improved sanitary measures since the mid-19th century. Since the advent of innoculation campaigns, modern medicine has done little to improve the general state of health. Niney per cent of our doctors' visits are for minor maladies which, although painful, will disappear in a few days no matter what the physician does. A growing number of people visit emergency rooms of big city hospitals to get emotional support and reassurance. Neighborhood based educational programmes, with community medical clinics and laboratories, all of which can be staffed by paraprofessionals with relatively little capital expense, can deal with 95% of all our illnesses. Neighborhood cohesion might also dramatically reduce the incidence of mental illness. Eric Fromm once expressed confidence that an investigation would uncover direct correlation between the disappearance of the neighborhood bar and the rise of psychiatrists. Once men poured out their troubles to the sympathetic ear of a bartender who knew the family, community, and, often, the workplace. Now he spends 100 times as much money to pour out his troubles to someone unfamiliar with any of these things.

Growing numbers of studies indicate that the home is the best place for medical care. Lower incidences of infant mortality occur when midwives attend home deliveries rather than hospital operations. The cost, both in dollars and emotional energy, is far less if we pay the elderly to stay in the neighborhood than if we ship them away to nursing homes. Hospitals are now permitting the terminally ill to die at home, among loved ones, a process which has a profound impact on the neighborhood, a pulling together which the hospital does not permit.

In the criminal justice system these same concepts are at work. The concept of neighborhood team police has been proved successful. Here a team of officers work one specific neighborhood. Sometimes they live in the neighborhood. They patrol by foot and get to know the neighborhood. In Dayton, Ohio, the neighborhood itself has become a police force. Working with the regular police, they intervene in family quarrels and handle 80% of the complaints. Halfway houses have proved their worth compared to prisons. The cost of keeping one teenager in prison is now around $10,000. For less than half of that, this person can be kept in the neighborhood, under close supervision, and provided with job training and productive work.

The evidence grows daily. Neighborhoods can be the most efficient locus of most of our activities. There will need to be cities, and states, and even world governments, to co-ordinate certain activities. Larger corporations will be necessary to produce some materials. But we have only begun to tap the abundant resources and creativity on the neighborhood level.

Getting from here to there, though, will not be easy. Yet, what may appear like so much fantasy is, in fact, based on experience. Neighborhoods can, and have, started with nothing more than a zip code, and have begun to build an identity as a nation, as a turf where people co-operate to build self-reliance. Such co-operation can, and usually has, been catalyzed by a defensive struggle against external forces. Increasingly, though, the fight is for something, a struggle to create a viable economic base in the community. One neighborhood in the South Bronx which is working with the Institute for Local Self-Reliance is converting 700 tons of vegetable waste to rich compost which is being used to rebuild the soil of that area for massive urban farming projects. This project has economic development implications as well. After the neighborhood's soil has been rebuilt, the production plant will export the compost to the Long Island potato farmers, thereby helping to reverse the fiscal drain that is traditional in low income neighborhoods. Antoher neighborhood on the western edge of Newark, New Jersey, has formed a co-operative housing authority; the group now manages 54 buildings with a thousand tenant-owners. It operates a day care center and health facility. The maintenance crew is now installing solar energy systems for domestic hot water on the neighborhood buildings, and, once again, this will be done at cost for the neighborhood, and at a profit for export, bringing in more revenue for domestic development.

In Chicago, a neighborhood development corporattion controls a local bank. The South Shore National Bank now operates with significant neighborhood participation. It has, under neighborhood control, become a profitable venture, and recycles huge quantities of capital within the neighborhood. Other neighborhoods are utilizing geographically based credit unions, which now extend long term mortgages, and are beginning to utilize checking accounts to recycle financing.

In San Francisco, a food system which is neighborhood based and worker self-managed now grosses $10 million a year. It has retail outlets, wholesaling, trucking networks, and even some production facilities. It has become a significant force in the food sector in that city.

In St. Louis, a neighborhood runs a radio station.

Thus, from co-operative housing, to solar energy, to small enterprise development, to composting, food retailing, and banking, neighborhoods are beginning to regain a sense of autonomy, and destiny.

It is possible that federal efforts may soon catch up with the reality of localism. HUD has recently changed its policy from urban renewal to neighborhood preservation. Community Development Block Grants are increasingly being tied in with other neighborhood oriented funds, to develop comprehensive planning. The federally funded National Centre for Appropriate Technology will be providing technical assistance to neighborhood based organizations.

The Community Development Block Grants have not been used to encourage neighborhood planning. But in the few cases where cities have accepted strong community participation the results have been exciting. In Dayton, Ohio, neighborhood improvement boards set policy for CD monies. Several have financed energy conservation and rehabilitation works. In Buffalo, one neighborhood, faced with the transformation of a neighborhood cinema into a pornographic movie house, put in a bid with community development monies to purchase it and run it as a neighborhood theater.

One cannot end this kind of article without talking about the obstacles to neighborhood development. Certainly no city will willingly relinquish authority to its sub-units. No bureaucracy wants to think of itself as useless. No large utility company will kindly encourage its own obsolescence by supporting the spread of decentralized solar technologies. No major corporation can accept widespread small scale production units.

In fact, a city is a federation of neighborhoods. The reform movement of the early twentieth century wiped out much of the ward based politics, leaving us with most cities having at-large delegates and city managers. Yet a return to neighborhood autonomy and representation and a move toward neighborhood self-reliance is not the same as the elimination of the city. City, neighborhood, and individual residents can, and should, work together. The city is the basic political and economic unit in our society at the moment. As such, under our political system it holds immense power to encourage, or discourage, local self-reliance. Cities retain taxing power, bonding authority, financing power, and legislative ability. Through its bureaucracy it can make, or break, local initiative.

Cities which are imaginative can utilize their powers to promote decentralization. Cities can view their borders much in the way neighborhoods do; that is, they can move toward municipal self-reliance. Already Detroit and cities in New Jersey require certain municipal employees to reside inside the borders. Some cities are using their purchasing power to encourage local economic development. Detroit now permits city businesses to bid 5% higher on contracts and still receive them.

The city of Ocala, Florida, is involved in an innovative financing arrangement with a local solar energy company whereby the homeowner pays nothing down for solar technology and pays it off through the billing procedures of the city owned electric company. The city of Hartford used part of its community development funds to develop a finance feasibility study for the city, a neighborhood and a private company to go into a three-way partnership in the development and distribution of solar hardware systems.

Although we are only beginning on the road to local self-reliance, already there is an extraordinary pool of experience to be shared and built upon. Neighborhoods, and cities, must take into account new technologies, new concepts, and new modes of co-operation when they do future planning. Planning for self-reliance is an enormous task. But the benefits are also very great: an informed citizenry, reduced resource use, more cohesive communities. Local self-reliance can mean local democracy, an extension of our definition of citizenship from that of pulling down a lever in a voting booth once every few years, to that of actively deciding on the future of our communities.

# Living the American Alternative

**by John P. Milton**

**It is comparatively easy to envisage what rural life would be like in an American ecological society of the future. But how about the cities, those microcosms of the world's ills? John Milton paints a vivid picture of what life might be like in Greenways, a city of the future. Roof gardens, allotments, solar heating, neighborhood banks and a far greater sense of family and communal responsibility — are some of the features that combine to make Greenways a stable and enjoyable place to live in.**

December 1. 1996: John and Jane Smith awoke from a good night's rest at their three-bedroomed house in Greenway Community, located in the south-eastern part of Fairview City. They had custom-designed their home from a variable set of standardized components now available; these could be combined to allow a high degree of individual choice in designing living space. As in the traditional Japanese house, moveable interior partitions were shifted as family needs changed. The basic home structure had been contracted out to a local community building company; however, the interior finish work (i.e. painting, trim, installation of some hardware and cabinetry) had been done largely by the Smiths themselves. Most of the furnishings and decorations were also either self-made or obtained from local craftspeople within the neighborhood, Greenway's citizens believed in Winston Churchill's maxim that first we shape the buildings, then the buildings shape us. The Smiths built their home through a loan from the Greenway Bank, one of the many neighborhood development banks chartered in Fairview after the great financial crisis of the 1980s (a crisis caused in large part by the Mid-Eastern oil embargo of 1984). The neighborhood development banks (NDBs) had become major means of providing credit for neighborhood renewal and revitalization. The fossil fuel shortage of the 1980s had spurred the need for major self-sufficiency programs to install energy conservation and solar energy technology in a majority of American homes. The community-controlled NDBs became a primary vehicle for providing credit to speed this dramatic and essential energy conservation in city neighborhoods.

E.F. Schumacher had foreseen this necessary shift to smaller, more decentralized forms of technology, such as solar power, in the 1970s. At that time he noted: "Today it is true to say that 'economics of scale' was a 19th century truth, which, because of the advance of science and of technological skills has become . . . certainly over wide fields of application — a 20th century myth . . . We should now give some real thought to the possibility of reforming our technology in the directions of smallness, simplicity and nonviolence."

The Smith's home was powered by photovoltaic cells covering a portion of their roof. Once a costly item to produce when still hand-tooled in the mid-1970s, the President's federal "Sunpower Project" begun in 1980 had achieved a dramatic breakthrough, and now solar cells were being mass-produced at a cost of $.50 per peak watt, a price well below the current costs of fossil fuel power production. Nuclear power had proven costly, unsafe, subject to terrorist diversion and a terrifying long-term threat to the biosphere; by the 1990s it was largely phased out. A great advantage in favor of shifting to solar cells had been the plentiful supply of the basic raw material: silicon dioxide or ordinary sand. Because solar energy is widely disseminated in a naturally decentralized fashion, economics dictated that the most efficient capture points for solar cells be as close as possible to the sites of consumption and storage. Now most homes and businesses were powered by rooftop-mounted photovoltaic cells, even in the Northeast.

Sometimes this energy was stored in the compact, highly-efficient batteries brought out in the late 1980s. In many cases, however, household flywheels provided storage of solar-derived electricity. Light and very fast, these flywheels were mounted in an extremely low-friction semi-vacuum; large quantities of excess power could be shunted to the flywheels, then electricity could be drawn off again later as needed. The flywheel principle had been adapted to many other situations requiring efficient storage, and was now common throughout the United States.

In most American homes, sufficient household energy was being generated from solar sources to power even the small, inner-city electric cars that had become so popular in the late 1980s. Excess daytime power generated from the rooftop system was shunted to storage in the pollution-free electric car (as well as to flywheel storage). The Smiths used their own vehicle largely for occasional trips to other parts of Fairview. However, since both John and Jane worked within an easy walk to their jobs in Greenway, the car's use for commuting was unnecessary. In fact, the massive commuter traffic jams and automobile pollution symptomatic of the '60s and '70s were now dim memories to most Americans. Electric transportation combined with a substantial shift in bringing workplaces and homes together in urban neighborhoods had revolutionized transportation.

In addition to the electric cars, light electric buses ran in a network throughout the city of Fairview so that no-one was more than three blocks from a bus line. In some cities electric subways, cable cars and/or streetcars were the popular forms of public transit from

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neighborhood to neighborhood. To encourage the use of city and neighborhood public transit rather than individual vehicles, Fairview's electric buses could be used free of charge. Although a reduced number of highways were still in use to provide transportation outside and between cities, national priorities were now on high-speed, energy-conserving rail transit systems which had grown more and more popular as the price of fossil fuel and individual automobiles rose.

Efficient electric trains had been extended to most American cities. Other cities and smaller towns were served by comfortable electric buses whose electric storage capacity was supplemented by solar cells on the roof of each vehicle. However, airline usage had declined drastically as fossil fuel costs rose rapidly during the 1980s. In consequence, airlines now were largely limited to trans-oceanic travel. Also, trans-ocean transport by ship had seen a strong resurgence. The appearance of new designs such as the high-speed "wind freighters" had brought costs of ship travel down to very low levels. Renewable energy sources of wind and solar power were now the central sources of power for these new, fast ships.

Since public transit within cities had improved markedly — the need for the large, inefficient gasoline cars of earlier decades had declined. Non-electric, individual long-distance vehicles were still available (mostly steam and diesel cars), but most people rented them (along with long-distance electric cars) usually for vacation trips to the countryside. Most were available from car pools at the edges of the cities — which were also the termini of rail and electric bus lines.

Another transportation innovation was the widespread construction of bicycle lanes, trails and paths. Greenway's mild climate allowed easy use of bikes for much of the year between March and November. As well as being non-polluting, energy-conservative, easy to park, and a substantial contributor to the elimination of the auto congestion of earlier decades — the bicycle had also been found to promote health, especially as a prevention for heart disease. In the 1970s, both bicycling and "jogging" had begun to be widely practised for the same health benefits. Now nearly all people bicycled, walked or ran to where they needed to go in the neighborhood; the health effects were the same, but now fun and function seemed better served.

Walking had become a pleasure in Greenway with the conversion of many streets to areas for parks, gardens, bikeways and walking trails. Most of the small electric cars functioned quite well in residential alleyways, so numerous streets had become available for these other more important uses. Also, many over- and underpasses for walkers had been installed at intersections with major streets, and hundreds of trails now threaded along the new parks. This parkland had been restored from several abandoned highways, created with the local streamside protected areas legislation and introduced with the conversion of numerous automobile parking lots and plazas to neighborhood recreation areas. As with the use of the Smith's now very valuable rooftop space, the citizens of Greenway had realized much of the neighborhood's once immense areas of automobile streets and highways could easily be converted to more productive uses.

Both former street space and rooftop space were now planned to accommodate multiple uses, where compatible. Thus, rooftops not only served as solar collector space and sites for wind generators, but also provided room for vegetable gardens, home recreation, and the natural air-cleaning and cooling effect of green plants. Rooftop soil also served to better insulate the house.

The Smith's rooftop space included a mass-produced, modular, supplemental solar collector system for heating and cooling their house, as well as for water heating. Both these systems had been installed with the help of major tax incentive initiatives and low-interest loans from the Greenway Neighborhood Bank. John now worked at "Sunspot", one of the small, worker-owned businesses that had proliferated in Fairview to serve the high-growth neighborhood energy conversion market. John's company had converted many of the neighborhood's homes in Greenway; Sunspot provided design, installation, conservation and management services in an integrated approach to energy conservation and solar technology installation for a wide range of household and business dwellings.

At breakfast with their two children, John and Jane reflected on the old days when rooftop space went virtually unused in American cities. It seemed incredible now, but Fairview once had been a jungle of rooftop asphalt, tile and concrete: all taking up a substantial portion of the inner city's available solar space. Today an aerial view of the city unfolded a colorful mix of solar capture units, rooftop gardens, greenhouses, vegetable plots, wind generators, small parks and cafes.

In fact, one of the biggest uses of rooftop space, other than for solar technology, had been for green plants: both for food and fun. Hard work, structural improvements to strengthen rooftops, and the careful process of building organic soil had all been necessary to make roof space flower; in addition, the high unemployment levels of the 1980s actually provided the necessary labor for the Neighborhood Agricultural Extension Programs and Community Revitalization Corps work that made rooftop gardens a reality. As a result of all this, the Smith's neighborhood of 25,000 people recently even voted to change its name to Greenway in recognition of the successful spread of rooftop (and plowed up street) gardening that had occurred over the past decade. Some of the gardens were derived from soil and composted wastes carried onto the rooftops. Others were hydroponic: gardens grown in light perlite/vermiculite beds fed with an organic nutrient solution. While the Smiths breakfasted on a meal of eggs, mint tea and fresh fruit — all grown from Greenway's neighborhood gardens (both rooftop and conventional) they agreed the name change had been appropriate.

Now the neighborhood was largely self-sufficient for many of its basic food requirements. True, they were located in the Southeastern U.S., which was favored with a long growing season and mild climate, but many neighborhoods in New England and the northern Mid-West had done nearly as well through the judicious use of greenhouses and proper local food storage techniques. Some households in Greenway produced virtually all the food they required from their own home and grounds. Others took advantage of the co-operative gardens that had been established at the sites of the old surface parking lots, used for car parks before all such storage went underground or into special buildings. Also, the dramatic decline in the use of cars in the city's neighborhoods helped release this land for more productive purposes.

In reality, food production and distribution had become a significant part of the overall household and neighborhood economy in Greenway. In the mid-1970s immense quantities of energy were required to produce, process and distribute food from the Farm Belt. For example, Iowa soybeans required nearly three times as much fossil fuel energy as they produced in food energy; similarly, a glass of milk required half a glass of oil by the time it reached the table. The fossil fuel crisis of 1984 had caused the costs of fertilizer, heavy agricultural machinery, food processing and distribution to skyrocket past earlier already alarming levels of inflation. In this ecospasm of big agribusiness, it became more and more economic for individuals and communities to grow their own food; this led to a major national shift toward local community food production — much like the old "Victory Gardens" of WWII. Because food was produced locally, it could be consumed fresh (thus eliminating many of the costs of processing) and distributed inexpensively. It also tasted good.

Greenway had benefited from several additional innovations in food production: the site of a former local pesticide plant (it went out of business in 1983 when its major product was found to be highly carcinogenic) was now converted to a trout, shrimp and catfish farm. The sale of these excellent protein converters, not only were able to supply all the protein requirements of the neighborhood but also provided a sufficient surplus quantity to be sold throughout Fairview in other community markets. The trout alone were able to produce 16 ounces of flesh for every 24 ounces of feed they received, a much more efficient conversion that most forms of meat.

A key to Greenway's successful small scale agribusiness was a major shift to effective recycling of organic wastes produced by the neighborhood. The 1980s saw a major conversion of outmoded sewage disposal systems in cities and neighborhoods to waterless toilets, community composting centers, methane gas production plants and fertilizer production centers. These conversions allowed communities to create valuable fertilizer from their organic wastes and to recycle valuable nutrients (that formerly had caused serious water pollution problems) back into agricultural soil.

Jane worked at a small local business in Greenway set up to market and retrofit homes and buildings with a self-contained composting toilet—garbage disposal system. These no-flush biological composters had become economically viable in the late 1970s, but made no real progress until a regional series of demonstration houses refitted with them conclusively portrayed their design advantages, low cost and safety. At this point, state and local authorities began to approve their use as a desirable alternative to the costly, wasteful and pollution-prone conventional flush toilet and garbage disposal systems.

A number of factors combined to phase out the old, water-disposal, sewer-based approach. For example, water shortages had become widespread in most American cities by the 1980s. It was found that each American consumed an average of 150 gallons of water a day by that time — and nearly half that usage was for flushing toilets. Another factor was the cost and inefficiency of conventional sewage treatment facilities. In the Washington, D.C. area alone, over two billion dollars were spent on such facilities between 1972 and 1980, with an annual operating expenditure of 70 million dollars. By contrast, local studies found that if residents had opted for sewerless composting-toilets, the same population could have been served for a considerably lower total investment with much lower annual operating costs. In addition to costs and improved water conservation, the biological systems virtually eliminated water pollution sources from households and provided a valuable product: compost fertilizer. Since the average American can produce about 65 pounds/yr. of dry fertilizer from the composting toilets, this source became a significant contribution to neighborhood agriculture; the rising prices and decreasing availability of fossil-fuel based commercial fertilizers underscored the value of this urban revolution in organic waste recycling.

Not all communities opted as Greenway did for household composters. Some neighborhoods chose sophisticated, centralized methane production plants to extract methane gas as an energy source, then sold the remaining organic waste products as fertilizer. Other communities developed central neighborhood composting centers. In all cases, however, the principles were the same: to utilize organic bathroom and kitchen wastes as a useful resource and ensure its eventual recycling to the soil.

Because of this conversion, Greenway also found it necessary to set up local recycling centers for non-organic wastes. Separation began at home, where paper, metals, plastics, glass and chemical products went into different containers for community collection and recycling. As the price of many raw materials rose between the 1970s and 1980s, recycling plants became significant in the face of dwindling natural sources of many metals, paper and chemicals.

Other new industries had also sprung up to meet the challenge of dwindling resources. Nearly all Fairview City's containers were now either returnable glass or biodegradable plastics derived from plant (rather than fossil fuel) sources. The goal was to provide low-cost, efficient containers in a variety of types that would rapidly biodegrade into harmless or nutrient-rich products when returned to the soil. Virtually all the old, non-biodegradable containers (other than returnable or re-usable glass) were now prohibited throughout the nation. This shift into biodegradables spurred a redirection of production and growth for a wide range of chemical and container companies in many American cities; it also fostered new employment opportunities in industries whose growth had begun to lag as sales of older, unecological products had dropped off in earlier decades.

Solid waste recycling programs in America began to spread during the late 1970s as energy scarcities, labor costs, pollution effects and vanishing landfill sites combined to make recycling systems increasingly attractive. Citizens began to realize they were turning scarce energy and material resources into waste products at an appalling rate, further driving up costs. In 1975, the average American produced 4 pounds of municipal waste each day, totalling 145 million tons for the country as a whole each year — and costing six billion dollars to collect and dispose of. For nearly a decade thereafter, highly centralized and city-wide solid waste programs were viewed as the answer. However, it was eventually found that this approach was unduly expensive, was dependent on fixed volumes of garbage to process, and usually failed to encourage maximum utilization of such wastes (for example, much valuable solid waste was burned in incinerators — adding to air pollution and eliminating recycling potentials).

For these reasons, by the mid-1980s most cities shifted to a more decentralized approach. In Fairview City, for example, a private company called Recycling, Inc., had established fourteen community centers easily accessible to all the city's neighborhoods; separate bins for paper, glass, plastic, scrap metal and organic garbage (for those without household or neighborhood composters) were located at neighborhood marketing centers. Waste from these bins were collected by Recycle, Inc. and taken to its recycling plant for processing and later sale. At the plant, conveyor belts carried paper, plastic, ferrous metals and aluminum into four separate processors. Glass was separated into three colors by a laser, then processed. The organic material was fed into a large composter for conversion to fertilizer. Fairview's 2000 tons of solid waste per day provided Recycle with a healthy profit; also, the company's operations led to a substantial reduction in community costs over earlier times when 25 million dollars were spent annually on centralized solid waste disposal systems.

After breakfast, Jane walked their youngest child, Jimmy, over to the block day-care center. Like most such co-operative centers that had proliferated in Greenway, they were run by old people. Jane's own parents worked, on rotation, at Jimmy's day care center — and they loved it. Jane recalled how old people were once shunted off into retirement communities old peoples' homes and other segregated lifestyles. It was hard to understand how society could have been so hard on its older members and how people could have failed to realize how many opportunities there were for oldsters to participate actively and productively in the life of the community. In many cases, older workers in the co-operative day care centers had been joined by handicapped, disabled and part-time workers who also found fulfilling jobs there.

Most day care centers were closely related to the strong sense of "block pride" which had evolved in Greenway Neighborhood. Cohesive local community culture had led to co-operative care by parents, grandparents and other local people. Throughout Greenway, each block now had its own name, its own function, its own unique identity. Forming a level of relationship between the family and the larger community or neighborhood, every block acted as a kind of extended family, weaving together the families that lived there. The block day-care center had become an integral aspect of block pride, and now blocks vied with each other to excel in creative day-care programs for their children.

Other characteristics also served to strengthen each family's sense of participation in the block community: inter-community sports competitions, street festivals and block songs, flags and totems all fostered the growth of strong inter-family ties. This block cohesion was an important aspect of Greenway's success, and it provided a deep level of everyday social interaction for all the "block brothers and sisters."

This development of virtual extended families block by block in Greenway Neighborhood was reflected in local political representation in overall Neighborhood government.

The evolution of strong block culture had developed in concert with the resurgence of stable families. By the 1980s the serious disintegration of American family life set in motion by the stresses of urban-industrial society had begun to reverse. Economic, political and social decentralization trends had combined with a widespread renewal of growth towards community and neighborhood self-reliance; one result was the functional rebirth of the family as the basic unit of social organization. This, in turn, contributed to the evolution of greater community continuity and stability. Families now averaged two children or less, and demographic experts now forecast a slow reduction in overall national population size that would begin in a decade or two. Without the basic stability provided by healthy families, the growth of extended "block families" would have been impossible. Likewise, without the healthy functioning of local block communities, neighborhoods would have been much less stable and responsive to ecologically-sound alternatives.

Because of the growth of strong family, block and neighborhood culture, Greenway had been able to evolve local self-government. Greenway assembly (and its Town Hall Meetings) was the basic political unit; the Assembly was designed to maximize participatory democracy and its meetings were open to all members of the Neighborhood. All officers and an executive council were chosen by lot (as in ancient Greece). Following wide discussion of the lot system after publication of Morris' and Hess' *Neighborhood Power* in 1975, a variety of American communities had experimented with lot selection and found it a workable protection against the abuses of power so characteristic of 'representative' systems.

A popular court, also selected by lot annually, had the power to review the accounts and records of neighborhood officials for review by the popular court. There were no appointive offices in either Greenway's Assembly or Court system. Any community member could bring charges against any neighborhood. Also, block government worked, on a much simpler scale, according to the same political principles.

Other values had changed as well. Interestingly, the concept of separating work, pleasure, recreation and family which had peaked in the 1970s had altered considerably. A basic value of work now was that it be healthy, creative, psychologically satisfying and based on good collaborative relationships with one's associates. Many people had abandoned the old concept of working within one job or profession throughout life in favor of phased changes in work to round out the individual and provide continuing education and personal growth. This had had a profound effect on reducing job boredom and crime, while increasing the creativity of workers. Also, employees now almost always received share ownership of the companies they worked in; this involved all levels of workers in the productive direction and management of business.

These changes were part of a significant shift in American values that had occurred over the last several decades. "Smallness" had now replaced "bigness" in the minds of most people; citizens now perceived (in almost Jeffersonian terms) that smaller-scale structures, institutions and processes were more conducive to participatory democracy. With the widespread failure of many large institutions to cope with the rapid changes of the 1970s and 1980s, Americans began to look to themselves for answers to pressing problems. They sought once again more direct control over their own futures and the futures of their neighborhoods. They began to value the virtues of self-sufficiency, simplicity and harmony with natural processes — at a scale they could immediately influence.

Sheldon S. Wolin had anticipated the need for this value shift decades earlier when he wrote: ". . . the task is not to construct ever-larger structures but to decompose the organizations that overwhelm us, and to seek less abstract and remote dependencies. After all, this is what the revolt of two hundred years ago, the revolt against a vast, impersonal, and distant imperial structure, was originally about."

In 1996, these concerns had been translated into a concrete resurgence of neighborhood power. Local day care centers, worker-owned small businesses, and neighborhood energy, food and recycling systems were all part of this process. Educational approaches had also been affected.

While Jane was dropping off Jimmy at the day care center, John was walking to their community Learning Center with their daughter, Pamela. Many changes had occurred in education over the past few decades. One of the most significant shifts was from a simple approach of socializing children to society, to providing diverse "learning environments" closely tied to real problems and opportunities provided by Greenway. Another new emphasis was on providing learning opportunities throughout the life of the individual. Opportunities for growth were now seen as a constant and continuing feature of life for everyone, not a process which stopped with high school or college. These two factors had combined in the concept of "Learning Centers" where children, young adults, the middle-aged and oldsters all participated.

In part, this new approach had been started in response to the new job values of Fairview City's citizens. The concept of jobs being a primary expression and outlet for creative personal growth had led to the desire by many people to take on a spectrum of jobs and professions as they moved through life. The Learning Centers provided a basic service in helping with the retraining process. In many cases, colleges and universities provided more intensive and specialized outlets for adult learning needs. These new demands had come just in time, John reflected, for many colleges had been on the brink of closing down as young student enrollments dropped; the zero population growth movement of the 1970s had led to major declines in the numbers of children and students. During the time of the great economic recession and inflation of the 1980s, a negative population growth trend actually set in — further diminishing candidates for schools at all young levels. However, the 1980s and 1990s had seen swelling adult enrollments in schools, colleges, universities and specialized training centers. All this helped provide a dynamic new role for many learning institutions that had been under severe economic pressure.

Both John and Jane, although still young in their late 30s, had already passed through several careers. John had worked initially with a local agricultural cooperative in Greenway, devoting seven years to help build a system to collect and market the diverse production from local food systems and expand trade with other food producers elsewhere in Fairview City. After seven years, he felt he had contributed and learned as much as he could from this work and became interested in the widespread need for "energy-retrofitting" homes and business buildings. Greenway's Learning Center got him started with a comprehensive course in electronics and applied solar technology. This was then followed by two year's intensive training at Fairview University. Since he had completed seven year's work at the co-operative, he qualified for a modest retraining fellowship provided by Fairview City (60% of his former salary). Now he had been working and learning his new profession at Sunspot for two years, and felt a whole new life had opened up for him.

Jane had followed a similar pattern. Before working with the composting company, she had taught at the Agricultural Unit of Greenway Learning Center. The work had been exciting and valuable; being older than John, she had worked there longer — for twelve years. At the Unit she worked with children on urban gardening. In her two-year course there were few written exams. Instead, each child had to demonstrate what they had learned about composting, organic fertilization, biological pest control, French intensive gardening, etc. in specific agricultural projects that they worked out with Jane. In fact, the Unit had been so successful that the students were able to provide a significant amount of food for John's agricultural co-operative and all the produce needed for consumption at the Learning Center. Later, however, Jane wanted to work more directly with community composting systems; her previous experience allowed her to move directly into her new job without time off for retraining.

Greenway Learning Centre had a number of such decentralized "Learning Units" operating throughout the community. Others dealt with socially-vital tasks such as recycling, transportation, renewable energy utilization, intermediate technology, preventative health care, nutrition, meditation, neighborhood governance, environmental systems, community housing, community communications, and the arts. Of course, the basic building blocks of education were considered primary to learning also; maths, history, natural history, English and other important world languages such as Chinese and Spanish, were still basic and were taught at the main Learning Center. However, many communities had found that these basics were better learned when combined in real tasks and educational challenges of obvious importance to the community.

During Jane's two hour lunch break (in Greenway work hours were negotiated between individual and company needs as long as an average 30-hour week was maintained), she visited her neighborhood health center to consult on some strained back problems that she had been having.

Since the late 1970s a system of national health insurance had provided for most needs at no direct cost to the individual (above $100). However, this approach had been severely strained by the frightening rise of diseases linked to the functioning of the urban environment. By the mid-1980s the acceleration of cancer, heart disease, emphysema, ulcers, tooth and gum disease, and mental sickness had all been clearly linked to urban malfunctions. High job and home stresses; inadequate diets high in sugar, processed foods, toxic additives and other "junk foods;" lack of regular daily exercise; and widespread pollution of air and water had all combined to bring about appalling increases in disease.

Rising disease rates had led to burgeoning increases in the amount of money spent on doctors' and dentists' fees, hospital treatment and lost social productivity. The economic collapse of the 1980s only made things worse. People in low and middle-income groups found it impossible to pay for the social insurance programs set up to cover the rampant inflation of medical costs. Widespread dissatisfaction resulted in a sweeping national review of health and medicine. By the late 1980s, a new nation-wide program of preventative medicine had become firmly established as the only realistic solution to society's current ills.

The preventative approach was rooted in a nation-wide system of Neighborhood Health Centers (NHCs), each designed to serve a maximum of 25,000 people. By the 1990s these NHCs had been so successful, in combination with other environmental and social reforms linked to health improvement, that society's costs for health and medicine were declining rapidly. The shift to locally-produced fresh foods and stress on organic growing and processing techniques had eliminated cancer-causing food additives, pesticides and other artificial agents. Sugar, except for occasional use of honey, was used sparingly and tooth decay, gum disease, heart disease and problems of overweight had declined as a result. Elimination of much internal combustion engine traffic, industrial pollution-control, recycling, and composting of sewage wastes had resulted in dramatically cleaner air and water; the cleaner air helped reduce lung diseases such as cancer and emphysema, while clean water reduced the incidence of intestinal disorders and the carcinogenic interactions that once had been commonplace from combining chlorine and organic wastes.

The shift from red meat to vegetable protein supplemented by fish and chicken helped reduce saturated fat causes of heart disease and reduced cancer of the intestine. Cigarette smoking was still practised by some; this serious carcinogenic addiction was also clearly implicated in emphysema and heart disease, but the NHCs had vigorous programs to help break cigarette addicts similar to the programs initiated earlier for alcoholics.

In addition, most citizens now got much more daily exercise in walking and bicycling, in garden work, and in a whole new range of physical sports activities made possible by the spread of neighborhood parks and recreation centers. As well as being fun, this regular exercise now built into the daily life of the community reduced mental and emotional stress, helped prevent heart disease and contributed to the probability of living into a vigorous old age.

In addition to western sports and exercises, hatha yoga from India and T'ai Chi from China were now widely practised for health, relaxation and meditation. Both disciplines viewed health as a harmony between body, mind and spirit; they also stressed a similar harmonization between mankind and nature. Jane's T'ai Chi master pointed out that in ancient China, doctors were commonly retained and paid when an individual was well — when illness came, the doctors worked free. As a motivational principle, many Neighborhood Health Centers had adopted a similar approach in Greenway.

The NHCs were basic centers for community education in all these aspects of prevention; special cable TV channels, posters, brochures, and short courses were only a few of the techniques used to reach into the local neighborhood. When health problems did occur, the NHC staff provided a range of therapies. Drugs were still used where necessary, but numerous other techniques of what was now called "Holistic medicine" were also applied. For example, Jane's back problems were found to be due to a combination of not enough stress-releasing exercise and faulty posture. In the old days she might have been simply given a prescription for pain-killers and sent on her way. Now the staff treated her problem first with Japanese Shiatsu massage, hot whirlpool baths, and acupuncture — followed by intensive posture analysis and corrective exercises derived from hatha yoga and the Feldenkrais method.

Fairview City supported several excellent hospitals that were able to handle health problems beyond the capability of NHCs to handle. New medical technology for diagnosis, surgery and health management continued to be evolved and utilized here as in the 60s and 70s. However, hospitals were now transformed in other ways. Gardens, plants, fresh air, cheerful wall colors and paintings, games for patients to play, and other such positive innovations had transformed hospitals from dreary, antiseptic and soul-less environments to places that fostered chances for a return to good health. Patients were exposed to more frequent and compassionate interactions with medical staff. Regular massage was now an integral part of most daily therapy; even hospital meals had been transformed by the introduction of fresh, wholesome organic food instead of the processed food fanaticism that had been characteristic of hospitals decades earlier.

After visiting Greenway's Neighborhood Health Center, Jane stopped off at several local businesses and consumer cooperatives to get some things needed at home. Small businesses, consumer-owned cooperatives and worker-owned companies had flourished in Greenway following the economic resurgence of the late 1980s that had taken particular hold in urban neighborhoods and small towns throughout the United States. Jane recalled how appropriate the local chamber of commerce's motto taken from Bertrand Russell had become: "There can be no real freedom or democracy until the men who work in a business also control its management."

There had been numerous advantages to this growth of small-scale, local business. Neighborhood unemployment levels were drastically reduced, and with it crime rates fell, with the spread of numerous local companies providing new sources of employment. Widespread provision of neighborhood credit opportunities had been vital to this resurgence, however. Neighborhood Development Banks, Community Development Corporations, sale of shares in collectives and cooperatives, community sustaining funds built from neighborhood sales tax revenues, and credit unions were all techniques used for amassing sufficient local capital for investment in local business.

In any case, after a period of considerable struggle, neighborhood enterprises were now firmly established and healthy partners in the economic life of American cities. In Greenway, Jane visited shops entirely owned and operated within the community: a foodstore cooperative, a small business that specialized in recycling used clothes, a discount health and medicine store co-op, a local hardware shop, and a worker-owned media store offering newspapers, magazines, books, tapes and TV cassettes. During his lunchbreak John had also stopped at the same media shop to pick up a copy of the neighborhood weekly newspaper and a rental TV cassette for later play at home.

Before leaving work, John took time to read through Greenway's local paper. The newspaper had become increasingly important in the neighborhood over the past decade as a source of local news. As the interdependence of neighborhood activities grew and prospered, the need grew for a local paper to supplement city and national newspapers and media. The *Greenway Guardian* filled this growing need. It was published weekly and carried information usually impossible for city papers to handle on a regular basis: births and deaths, land transfers, neighborhood planning, local town hall meetings, other political events, local social events and sports, advertisements by local businesses, and educational columns covering subjects of community concern.

The *Guardian* filled an important neighborhood role in providing a public voice for the community through contributed articles, editorials and letters to the editor. As such, it acted as a catalyst for floating new ideas, community goals and local planning. In short, Greenway's newspaper had become a critical part of everyone's daily life.

John and Jane would often reminisce about the tremendous improvements in the quality of life that had taken place since the great crises of the late 1970s and the early 1980s. They recalled how serious many of the problems of a high-consumption, centralized, fossil-fuel based society had become. Then high unemployment levels, inflation and crime rates were major urban issues. The price and availability of oil and natural gas was growing rapidly more serious with each passing year — and other energy options were closing: nuclear power was proving unsafe, too costly and susceptible to terrorism; much of the nation's remaining coal reserves either required expensive deep mining or environmentally-devastating strip mines. Inefficient, energy-wasteful, and often unnecessary transport caused both spreading air pollution and ulcers during the twice-daily traffic jams clogging roads between city and suburbs.

In fact, pollution of air, water and land had become so serious that it became a major cause of many urban illnesses — particularly when combined with the poor nutrition, high work stress and inadequate exercise characteristic of those days. Wastes had exceeded the capacity of disposal systems to treat them and spilled billions of dollars worth of fertilizer into the nation's increasingly scarce water supplies. Food prices were subject to heavy inflation, and scarcities broke out as fossil fuels ran short to supply fertilizers, industrial farming, processing and vast distribution networks. Growing cities often spread over the nation's most fertile agricultural areas unhampered. Natural open spaces vanished under roads, industrial parks, housing developments and the impact of pollution.

However, citizens began to mobilize to combat these processes even in the 1970s. In 1978, Fairview 2000, an innovate, city-wide, citizen group dedicated to long-range goal-setting and participatory planning in Fairview published its report: *Alternatives for Greater Fairview City.* This challenging document marked an important threshold for the city and its neighborhoods. It developed three alternative scenarios for the city's future; one of these, the Fairview 2000 Scenario, caught fire in the minds of many citizens of Fairview and helped fuel a number of early constructive changes that had helped the city to meet the great crises of the 1980s. Demonstration projects of social and ecological self-sufficiency at the Neighborhood Level, citizen education projects, new local institutions to support the evolution of citizen participation in planning the future of Fairview, and new approaches to building citywide awareness/discussion of vital public issues, definition of alternatives and selection of goals — all these flowed from Fairview 2000's initial work.

Now in 1996, life in Greenway Neighborhood of Fairview City seemed rounder, fuller and more organic. People were able to relate once more to the problems of life at levels where they actually had some control to shape their own futures. As one consequence, men and women were a lot more relaxed — both with each other and themselves.

Technology had been made more biological and human. As in nature, tools, products, and ''wastes'' were completely recyclable; as in the biosphere, energy was tapped directly from the sun or its natural planetary movements via winds, tides and running water. Refocussing life at the neighborhood level had rehumanized social systems long dominated by megamachine ethics. Now one's immediate community was where one was born, learned, lived, played, worked, walked, suffered and re-created. Neighborhoods had become the social and economic molecules of the nation. Cities were now viewed as interactive federations of neighborhoods, federations designed to serve interneighborhood needs and problems (rather than the other way around as it had been before).

This was not to say that people no longer worked, travelled or played beyond their neighborhood. In fact, nearly all of Greenway's citizens communicated regularly with many other neighborhoods in Fairview. Also, Greenway citizens loved to travel. They viewed it as a prime component of learning. Indeed, most American neighborhoods encouraged travel to combat the problem of neighborhood provincialism. In Greenway this had worked — they now saw themselves as members of various levels of community: block, neighborhood, city, ecosystem, state, region, nation, hemisphere, biosphere. But, in essence, their deepest roots were embedded in neighborhood soil; their joy was in the ability to grow socio-economic structures that fruited and flowered at the neighborhood level. Simply put, John and Jane's lives were now in harmony with their place and their circle of community.

Over their front door, on a small placard was inscribed a perceptive quote from an early American master of Ecology: aldo Leopold:

''A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.''

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