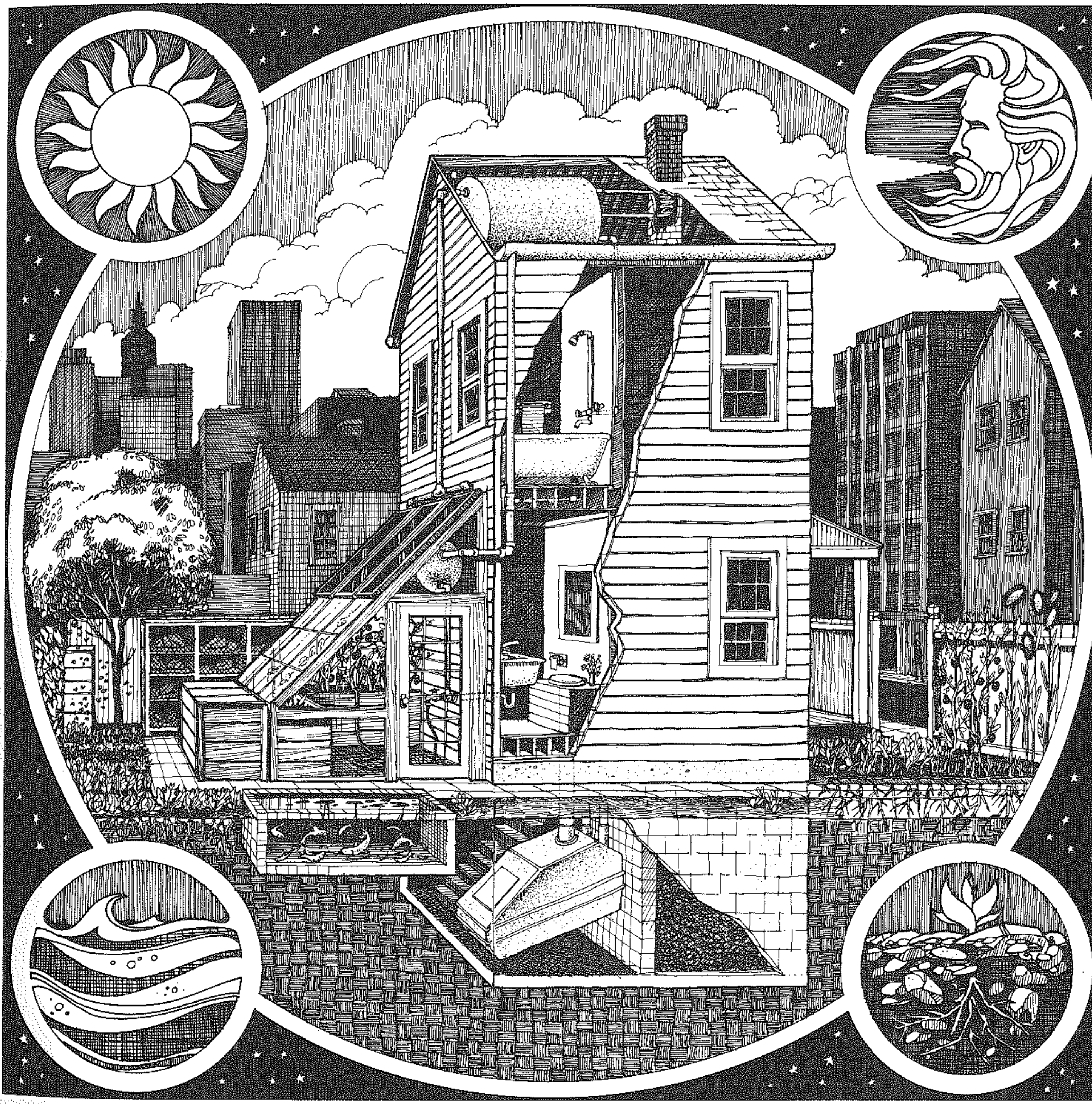
THE INTEGRAL URBAN HOUSE

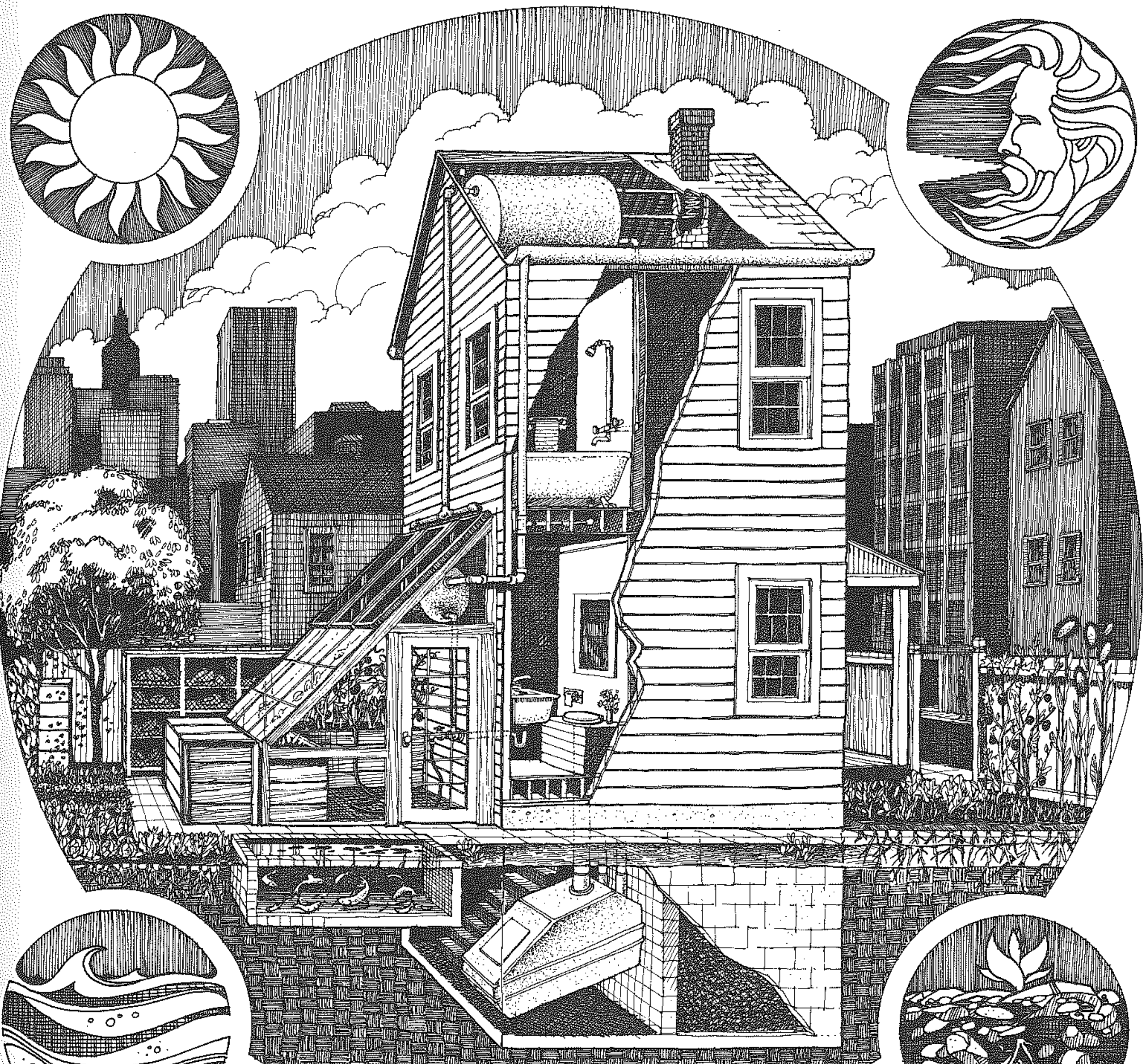


SELF-RELIANT LIVING IN THE CITY

by the Farallones Institute *Introduction by Sim Van der Ryn*

Sierra Club Books San Francisco

Part One:
The Concept



1. BEGINNINGS

This book is about an idea. We call this idea the integral urban house. The idea is not original with us, but its physical actualization has become an urgent concern of ours over the last several years. An example of an Integral Urban House exists in Berkeley, California (throughout this book the capitalized title Integral Urban House refers to the house in Berkeley, while the lower-cased words refer to the concept of an integral urban house), as a demonstration project of the Farallones Institute, a nonprofit educational and research organization with administrative offices in Berkeley, California. Other examples are the Ouroborus House in Minneapolis, the East Eleventh Street project in New York City, and the Office of the Institute for Self-Reliance in Washington, D.C. Many similar projects are being developed throughout the United States as well as in other countries.

Many people participated in the realization of the Integral Urban House in Berkeley. Some were founders of the institute along with us, providing the original support that made the project possible. Others were dedicated designers, builders, educators, urban farmers, students, and helpers who provided the many skills needed to create and experiment with the systems developed.

This Integral Urban House project in Berkeley is open to the public for casual visits and to students for critical examination. Hopefully, it serves as an inspiration and catalyst for new ideas on how to implement the primary goal: the creation of a self-reliant urban household, an urban residence that helps to support its residents while they support it. This house integrates the life-support systems of its residents in such a manner as to conserve energy and resources and provide a healthy environment in which humans may survive and thrive.

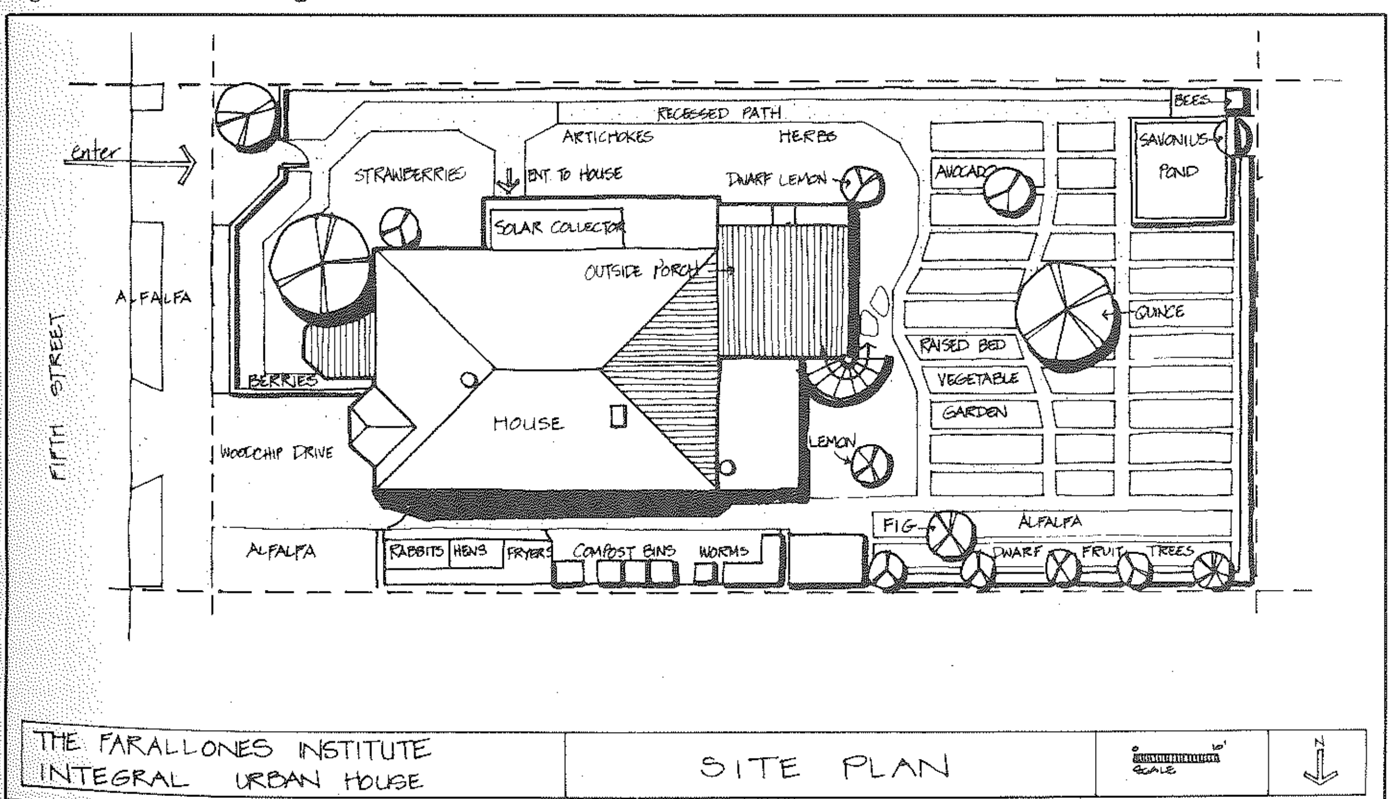
However, this book is not solely about the Integral Urban House we helped to create, because that is only one example of the idea. Indeed, we learned so much in the process of developing this one that we will surely do some things quite differently in the integral urban houses we help to realize in the future. Therefore, we shall be considering the idea in its broadest sense, drawing examples from other such efforts with which we are familiar, and giving details regarding those specific aspects with which we have had first-hand experience. We have no intention of implying that ours are the only available or suitable approaches to reaching the same goal.

The Integral Urban House as an Idea: The idea of the integral urban house arose from our felt need to elaborate a model life-support system that large numbers of people could use preparing for their future while simultaneously improving their daily life. Forecasting the future is usually a value-laden process in which, simply speaking, one documents past activities, events, and changes, and then, on the assumption that the same basic processes will continue to operate, projects the perceived patterns into the future. Clearly, certain worldwide patterns will not change radically in the immediate future. These include widespread social inequalities and continued population growth and their attendants—famine, poverty, disease, and human conflict.

Against this somber prophecy we propose that people need to feel that they have some control over their own lives in order to come together in constructive groups to reform their communities. And they need to believe in their own ability to create and maintain their basic life-support systems in order to feel at least somewhat in control. To use a metaphor for our automobile-addicted culture, we need to feel that we are in the driver's seat rather than merely passengers in our own lives.

Nowhere is the sense of victimization greater than among those of us who live in urban areas or who, though living in a rural setting, have adopted urban (nonagricultural) lifestyles. If you fall into one of these cate-

Figure 1-1. **The Integral Urban House, Site Plan**

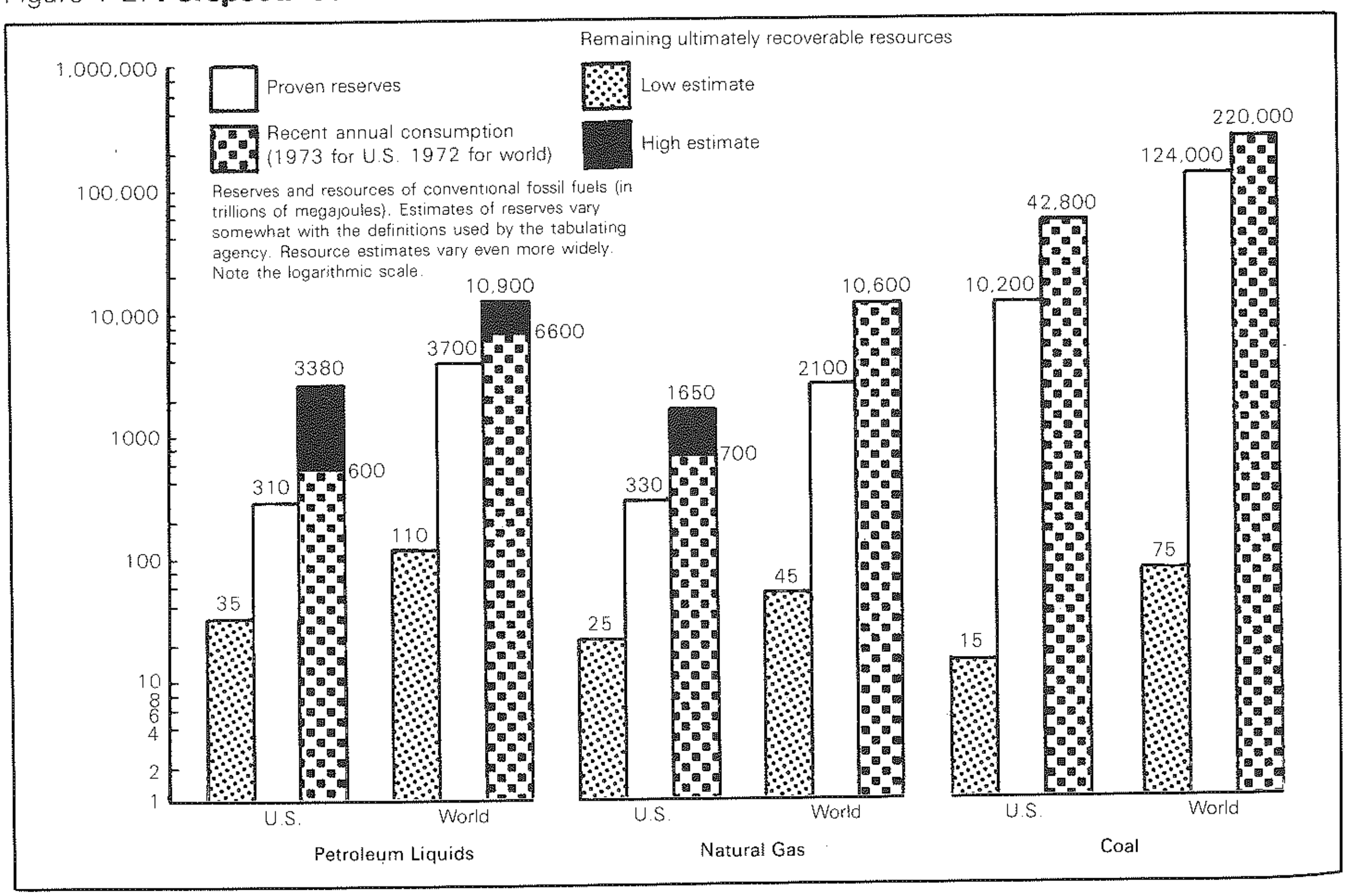


gories, what will you do when a transit strike closes your local grocery store, when there is no more gasoline at the local service station, no natural gas in the pipes to the furnace or heater, and so on? What are you doing as food, gasoline, electricity, and natural gas prices rise and water becomes scarce? How will you react as an increasingly large number of your acquaintances die from various types of cancers that experts now agree are in large measure caused by toxic materials in the environment? Ironically enough, the majority of these chemical compounds result from activities that are said to make our lifestyles possible. Table 1-1 shows how the mortality patterns have changed in the United States. Where we once died from infectious diseases we now are subject to degenerative diseases triggered by the stress of modern urban lifestyle, diet, and exposure to toxic materials. Table 1-2 is presented to give some perspective on the mortality figures in Table 1-1.

We do not think the solution to environmental crises is self-sufficiency, because such a condition is not possible even if it were desirable. If self-sufficient human communities exist at all, they are extremely rare. One might argue that no such community ever existed by interpreting "self-sufficient" to mean independent of other humans. Can an isolated Brazilian jungle tribe be considered self-sufficient when it is showered with radioactive fallout from nuclear tests conducted by major world political powers thousands of miles away? Tribespeople might protect themselves from poisonous snakes but not from, for example, increased ultraviolet radiation at

Source: Ehrlich, Ehrlich, and Holdren, *Ecoscience: Population, Resources, Environment.*

Figure 1-2. **Perspectives on World Fuel Reserves**



the earth's surface due to depletion of the ozone layers in the upper atmosphere, or large-scale weather modifications inadvertently caused by human activities on other continents.

In spite of the awesome interdependence of all humans, a large number of us, including the most apartment-constrained inner-city resident, can cultivate a measure of self-reliance, or what was once referred to as "Yankee ingenuity." We can learn to use what resources we already have right where we are to keep ourselves warm in winter; raise some of our own food on rooftops, porches, patios, backyards, and community gardens; obtain some of the nonhuman energy we need from nonpolluting sources; recycle and compost our wastes through homesite and neighborhood centers; and repair and maintain our own habitat (in spite of its capricious-seeming intention to pursue the laws of thermodynamics and lapse into disorder).

Five basic needs define our basic life-support systems (see margin). When they are not met it becomes difficult to maintain the simplest human interactions, much less engage in social reform or create works of technology or art that manifest culture. When you are unhealthy it literally costs more to support your life.

As our homes are now structured, satisfying most of these basic life-support needs requires that we be dependent on resources originating far away. We consume vast amounts of nonrenewable or, worse yet, dangerous forms of energy in the process of bringing these resources to ourselves and then carting away our wastes. Though we eat California lettuce and Mexican tomatoes in New York, we become vulnerable to the vagaries of complex distribution systems that are subject not only to human error but also to all the political and social pressures of the times.

Our schools did not teach us such simple things as how to manage flies

A first step toward self-reliance is to list our most basic needs

1. Food that provides us with sufficient calories or energy, and a balanced nutrition for our bodies to carry on normal metabolic processes as well as to resist invasion by pathogens or assaults by toxicants
2. Uncontaminated water to drink and clean air to breathe
3. A method of managing our own wastes so they do not create conditions that impair our health
4. Protection from the extremes of weather
5. Freedom from pests and pestilence

Table 1-1. **Ten Leading Causes of Death, United States: 1900, 1970**

Cause	*Rank 1900*	*Rank 1970*	*Percent of Total Deaths 1900*	*1970*
Accidents (non-vehicular)	**6**	**5**	4.5	3.1
Accidents, motor vehicle		**6**		2.8
Arteriosclerosis		**9**		1.7
Brights disease (chronic nephritis)	**5**		4.7	
Cancer	**9**	**2**	3.7	17.2
Cirrhosis of the liver		**10**		1.6
Congestion and brain hemorrhage	**7**		4.2	
Diabetes		**8**		2.0
Diarrhea and enteritis	**3**		8.1	
Diphtheria	**10**		2.3	
Diseases of early infancy	**8**	**7**	4.2	2.3
Heart disease	**4**	**1**	8.0	38.2
Influenza/pneumonia/bronchitis	**1**	**4**	14.4	3.6
Stroke		**3**		10.8
Tuberculosis	**2**		11.3	
			65.4%	**83.3%**

Source: Adapted from Omran, "Epidemiological transition in the United States."

Table 1-2. **United States Deaths from Various Causes**

Cancer deaths (1969)	323,000
World War II battle deaths	292,000
Auto accident deaths (1969)	59,600
Vietnam war deaths (six years)	41,000
Korean war deaths (three years)	34,000
Polio deaths (1952, worst year)	3,300

Source: Epstein, "Potential Carcinogenic Hazards Due to Contaminated Drinking Water."

and cockroaches without poisoning ourselves, process our own manure safely without using up gallons of pure water and the energy needed to pump it to us, use the sun and wind to create heat, light, and the energy to run machinery. Few of us learned the other simple home-scale technologies that are appropriate to the resources and climate of the regions we live in. Most of us grew up believing that improving the quality of our lives over that of our pioneer ancestors requires completely giving up a sense of self-reliance in the home to become totally dependent on energy sources far away and controlled by powerful international corporations almost entirely beyond the influence of the communities they serve.

Yet it is possible to construct, or renovate, a house so that it does an excellent job of protecting its residents from the weather with very little addition of energy from somewhere else. (Recent studies by the Federal Department of Energy suggest that houses built as passive solar systems could furnish 99.9 percent of the heat needed in a Los Angeles residence, 60 percent in New York, 57 percent in Boston, 52 percent in Seattle, and 42 percent in Madison, Wisconsin.) Similarly, process one's own household organic wastes in a space three by eight feet, and use the product to raise tomatoes or other vegetables in a five-gallon can. Water for drinking can be obtained from contaminated water through the use of a solar still. To some

Table 1-3. **Energy Used in Construction***

Materials	*Units*	*Btu/Unit*
Framing lumber (rough)	Board feet (bd ft)	7611
Glass, double strength sheet	Square feet	15,430
Ready-mix concrete	Cubic yards	2,594,338
Paint (oil and alkyd)	Gallons	488,528
Asphalt roofing shingles	Square feet	25,334
Steel, hot rolled structural	Pounds	18,730
Aluminum, rolled structural	Pounds	92,146
Insulation (4.5 inches thick)	Square feet	6860
Common brick	One brick	14,291

*The energy reported here is that used to mine, extract, transport, refine, fabricate and incorporate the materials in buildings of any sort, and includes administrative activities.

Source: Stein, *Architecture and Energy.*

Table 1-4. **Carcinogens Discovered in a Nationwide Drinking Water Survey***

Compound	*Number of Cities Detected*	*Concentration in Ppm†*
Chloroform§	80	less than 0.1 to 311
Bromodichloromethane§	78	0.3 to 116
Dibromochloromethane§	72	less than 0.4 to 100
Bromoform§	26	less than 0.8 to 92
Carbon tetrachloride	10	less than 2.0 to 3
1,2 Dichloroethane	26	less than 0.2 to 6

*Of eighty cities tested by the Environmental Protection Agency

† Ppm is the abbreviation for parts per million, or one gram in one million grams of water.

§ These have been found to arise primarily from the chlorination of drinking water, rather than from industrial sources.

Source: Harris, "Carcinogenic Organic Chemicals in Drinking Water."

degree—small though it may be in some cases but substantial in others—we can gain a measure of control over our own lives by creating integrated life-support systems in our homes that conserve energy and resources. These houses can then be used as bases for creating more self-reliant neighborhoods and communities. When we engage in such activities to increase our self-reliance the quality of life improves rather than continues to degenerate.

It is a paradox that the way to becoming more self-reliant is through increased understanding of our dependence upon the physical and biological processes of our planet and the social inventions that use them. By getting to know these processes, we can stop interfering with and destroying them and can make them work for us. Aiding in such understanding is one of the goals of this book.

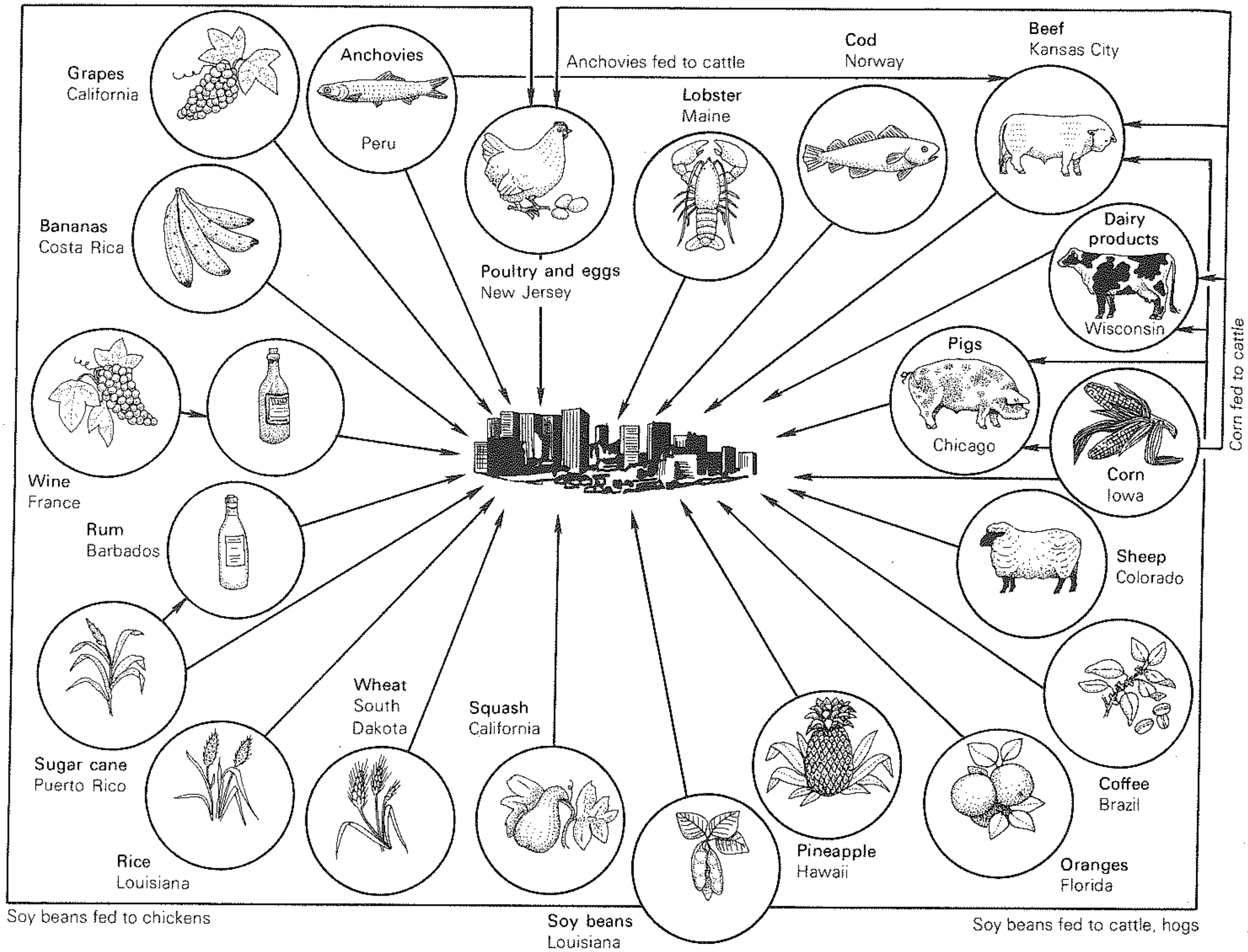
Why House? The house is the interface between the body and the environment, a physiological buffer. The house, though not necessarily the family home, is the key social environment (the birth, growing, living, dying, meeting, and learning place). The house structure itself, and the systems operating within it, are presently key consumers of energy, resources, and information. The house is a symbol of both ourselves and the world, our earth. It is a good place to begin to examine how we live now and how we might change for the better. Your "house" can be an apartment, a room, or any place where you get your necessities of life.

Why Urban House? It doesn't matter whether the population of the local community is eight million (New York City), one million (Baltimore, Maryland), one hundred thousand (Dearborn, Michigan), or one thousand (Arapahoe, Nebraska). People across the United States follow the same urban lifestyles we see illustrated on television: they buy their food at the store, prepare and cook it with a wide array of energy-consuming appliances, and throw their wastes, unsorted, into a can to be carted off to the dump. They manage the interface between themselves and other species they dislike by using chemical poisons. They work away from their home, if they are lucky enough to find a job (47 percent of United States farmers have off-the-farm income), and get to work by automobile. They live and work in structures that waste prodigious amounts of energy. And they go through their daily lives largely out of touch with the regional and seasonal rhythms of which they are a part except, perhaps, as these relate to the pocketbook, and in disasters like floods, tornadoes, and hurricanes.

The city is a funnel for resources. From the rest of the country resources pass through the city on the way to the dump—for example, trees → paper → dump. This funnelling effect is illustrated in Figure 1-3. At the same time, urbanites largely determine public policy. The price of agricultural land and the management of wildlands and forests, either by unconscious consumer behavior or deliberate decision through the political process, are largely under the influence of people who live in urban areas and/or follow urban lifestyles.

Why "Integral"? Integral means together, whole or complete, and at the same time, essential. We chose the term integral urban house because we

Figure 1-3. **The Urban Funnel: Food Passed through Cities to Dumps**



were striving for an integration of ideas about structure both as habitat and life-support system. There is a need for a new synthesis of biological and architectural ideas (biotecture or ecotecture, if you will). To integrate these areas, models for new ways of life and corresponding structures are needed that will show the way to a solar economy and demonstrate energy and resource-conserving methods and lifestyles. These models must show an integration with the biophysical region in which they are situated. One model for the country or the world is not enough.

New or Used: We decided to focus our efforts on the rehabilitation of an existing home rather than building from the ground up. We considered the tremendous investment of materials, natural resources, and energy that society has already committed to the maintenance of existing structures. To allow housing to deteriorate in favor of new construction would be essentially to waste precious resources. Also, we know that if our efforts were to become a national model, then demonstrating retrofit technologies would be most appropriate, since only a small percentage of the population has the capital to finance construction of a new home. The building costs associated with renovating houses are generally only a fraction of those for new construction. For example, Oakland Better Housing, a private firm that specializes in rehabilitating older homes in the San Francisco Bay Area, usually budgets $15 to $20 a square foot in construction costs for the complete overhaul of a house. Compare that figure with the typical construction costs of a new northern Californian house, $35 to $45 per square foot.

Housing rehabilitation is recycling in its most profound sense. In many rundown neighborhoods where inexpensive older homes are found the renovation of one could inspire other householders to refurbish their property. For example, when the Farallones Institute purchased what was to become the Integral Urban House, the neighborhood was in serious jeopardy of being lost to land speculators. Industry and Berkeley city officials were considering condemning the dilapidated homes on our block and converting the neighborhood into an industrial park. Our remodeling of the Integral House not only dignified this one particular residence, but uplifted the spirit of the neighborhood. Soon other energetic families purchased homes nearby and started rehab efforts of their own. In three years, eight homes in the neighborhood were restored and once again occupied by families. Vegetable gardens sprang up in backyards and the neighborhood became a community of integrity and purpose. Its residential character was restored and the effort of business to convert the block into an industrial park was headed off.

Changing One's Lifestyle

The realities of a growing human population and finite earth resources make clear that present United States urban lifestyles will have to change. Whether they will do so largely because of catastrophe or by design remains to be seen.

It is not easy to modify one's habits, as all of us know who have struggled to make such personal changes as losing weight, stopping smoking, or cutting out caffeinated beverages. Some years ago, before the Integral Urban House project, two of us (the Olkowskis) decided to make some massive changes in our daily behavior in order to achieve a personal lifestyle that was both more self-reliant and less environmentally destructive. It seemed essential that we experience first-hand the kinds of psychological and physical problems that might be associated with making the changes we felt would eventually be required in the society around us.

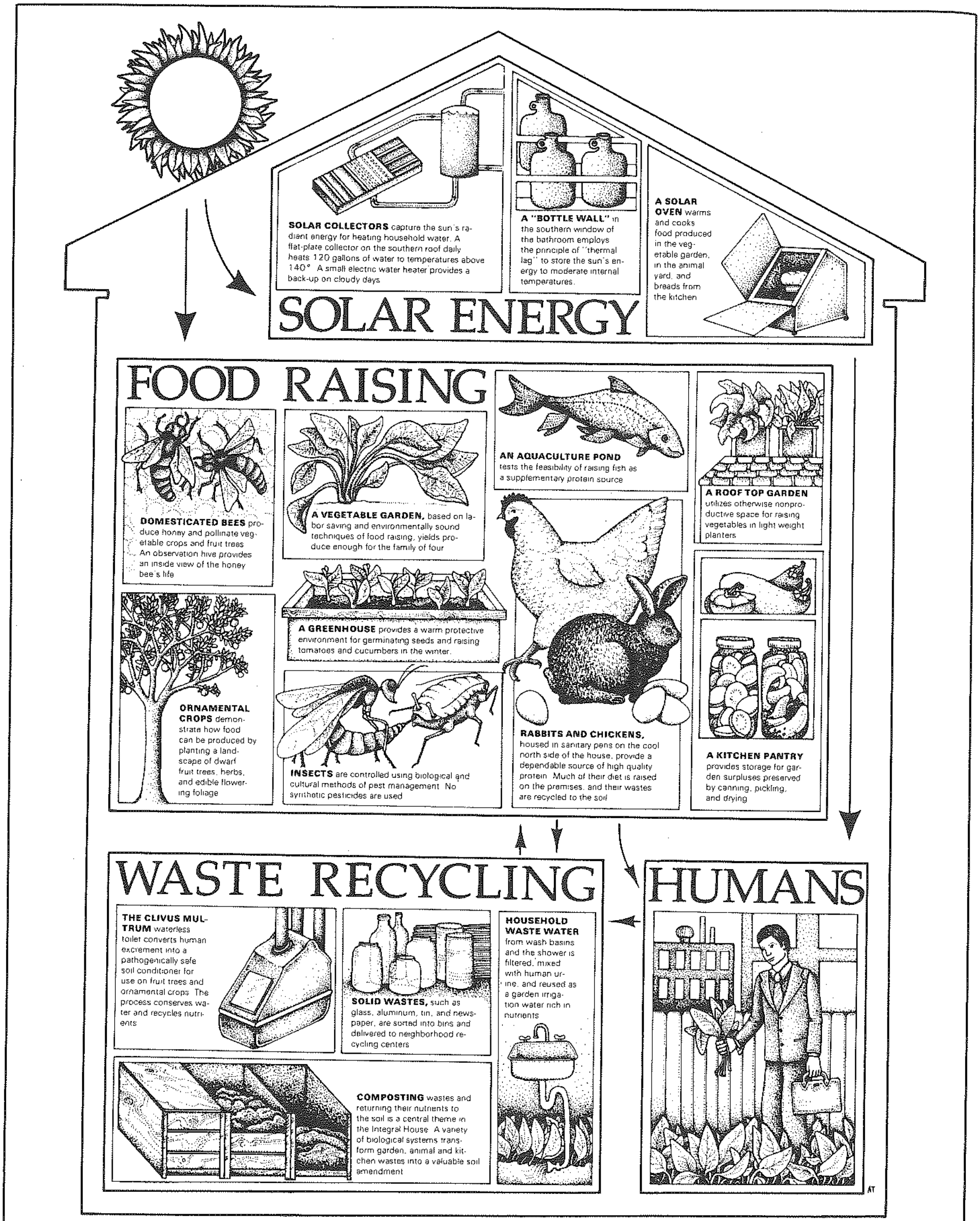
In our case, the motivation for change was based on a series of convictions derived from academic training as biologists and from certain current information sources. The challenge for us was how to change a whole series of our own behavior patterns in order to bring them into harmony with our general self-image and our beliefs regarding the consequence of our actions. Through initial introspection and discussion we came to the conclusion that certain factors were crucial in influencing the comfort we felt or the ease and speed with which we were able to take on new behavior patterns. It seemed that for each individual and each kind of behavior these factors would vary, and that their negative or positive contributions to ease of change could be measured and compared. These factors are as follows:

Motivation for change is based on understanding that:

- much significant environmental disturbance is directly due to the activities of humans;
- such disturbance is resulting in a deterioration of our own lives through a direct decrease in comfort and pleasure (some simple examples are the unwanted defrosting of foods in the freezer due to power blackouts, the clouding of a favorite view by smog, and increased noise from a new freeway);
- this environmental deterioration may be directly affecting our health and length of life—for example, by increasing our chances of developing cancer because of the chloroform in the municipal water supply (see Table 1-4), or exposure to pesticides in our surroundings and on our food (see Table 7-2, pages 148–49);
- this degradation is affecting the life of other species on the planet and increasing the physical constraints under which life operates (examples are heavy-metal pollution of the San Francisco Bay resulting from waste-management practices in the area, or the potential increase in ultraviolet radiation through use of fluorocarbons in aerosol cans);
- these recorded disturbances among other species, because of the interrelatedness of all living things, must ultimately affect all human lives and thus our own welfare;
- life coevolves with the environment, and environmental changes must ultimately affect the life that is dependent upon it.

Corn fed to cattle

Figure 1-4. **Habitat & Life Support System of an Integral Urban House**



1. Cultural and/or Personal Taboos: For example, some designs for composting or waterless toilets require physical manipulation or direct visual confrontation of human manure and other wastes.

2. The Apparent Immediacy of Catastrophe: For example, the California drought and consequent water rationing in the San Francisco Bay Area were perceived as threatening when cherished home landscape vegetation began to turn yellow and die. This situation paved the way for a speedy adoption of greywater (used water from sinks and showers) technologies.

3. Amount of Sustained Awareness Generated: Using the above example, constant daily media reference to the drought helped to create a climate of reminders.

4. Family and Community Support: The actual or anticipated reaction of family members, neighbors, and landlords to digging up the front lawn in order to plant corn, for example, could affect the home food-raising experiment considerably if the front lawn is the only sunny area available for the effort. This also relates to larger systems within the community that may exist to support that behavior. It is easier to begin recycling your newspapers in a community like Berkeley, California, where a regular monthly, city-wide pickup exists and where other people's neatly tied bundles are visible to remind you, than in a location where you must actively seek out the one or two places that provide that service to only a few households and only through special efforts on their part.

5. Amount of Stress Experienced from Not Changing a Behavior: A circumstance that encouraged us to recycle was that we could rarely fit all of the household garbage into the garbage can. In our large household, almost every week we had to deal with the hassles of trying to force all the garbage in the can, leaving some of it outside or around the house (particularly paper and cardboard), or paying extra to have it hauled away.

6. Amount of Information Available on Options for Change: We could switch to a car with better mileage performance only when reliable information from consumer testing services was easily obtainable to help us choose wisely.

7. Immediate Rewards Available: These we provided for each other through verbal praise and expressions of admiration. We were living up to our image of each other as responsible citizens and flexible individuals.

8. Self-Image: Obviously whether our self-image corresponded with "waste not, want not," or "fly now, pay later" influenced the amount of pleasure we could receive from activities with delayed rewards. For example, with respect to storing organic kitchen wastes, later to turn them into garden compost that would then be useful in the growing of plants, the ultimate reward of harvested food comes many months, or sometimes seasons, after the initial effort.

9. Concrete Models Available: With all the sets of matching kitchen or household containers on display in a typical large hardware/variety store, we have yet to see an attractive set marked "aluminum," "bi-metal," "glass," "paper," "organic wastes," and "nonrecyclables." Nor did we know of a single household we could visit that was so equipped at the time we began our recycling efforts. In fact, the reverse was true. Family and friends happily dumped all these wastes together in a single can, just as we had done. Nor was provision made for the convenient sorting of wastes in the design of any of the households that we were aware of. No practical hands-on models existed at all.

Table 1-5 shows how we rated the significance of each of these factors in relation to one desired behavior change, the sorting of garbage. You may enjoy a similar exercise in attempting to predict the success of a venture to change your own personal lifestyle.

By analyzing what we went through to set up a home recycling center—where the organic waste, glass, paper, metal, and other materials could be sorted for processing—and actually beginning to sort out our household wastes, several insights emerged. The process looked something like this:

Problem Perception: First of all we formulated the problem by bringing our ecological knowledge to bear upon the pollution problems evident around us and at that time just beginning to break into the national and local media. We saw that separation of wastes at the source in the home was the critical step, not the creation of a machine, for example, that sorts what was once sorted. That was 1969, the year of Earth Day as well as much Save the (San Francisco) Bay activity. The latter directed the public's attention to the fact that San Francisco Bay was rapidly being filled in by dumps, or "sanitary land fills," among other things. Within various predicted lengths of time, the Bay Area cities would run out of places to dump their garbage.

This table is a rating made by the Olkowskis of the positive and negative influences they experienced in 1969 when they were teaching themselves to sort their own garbage and recycle their household wastes.

Table 1-5. **Some Major Predisposing Conditions Needed for Behavior Change**

Predisposing Conditions	*Degree of Influence**								
	Negative								*Positive*
	4	*3*	*2*	*1*	*0*	*1*	*2*	*3*	*4*
Cultural and/or personal taboo					★				
Immediacy of catastrophe					★				
Sustained awareness of problem							★		
Family support			★						
Community support							★		
Stress if change didn't occur						★			
Positive incentives (verbal reinforcement)									★
Information on options						★			
Self-image									★
Availability of concrete model	★								

*A value of zero (0) represents neutral influence. The authors felt that personal and cultural feelings pro and con about handling their own wastes averaged out, leaving them neutral on this aspect. Community support was expressed by the willingness of the Consumers' Cooperatives of Berkeley to establish a weekend recycling center on one of their parking lots, and the City Health Department signifying their approval of the development of home composting systems by issuing a pamphlet on the subject written by the Ecology Center. Obviously, the total points on the positive side showed that the attempt at behavior change was very likely to be successful. It was, and has persisted, and has been thoroughly integrated into the rest of our living habits.

Goal Articulation: Nature recycles, humans do not. Humans should! (Our species is paying a heavy price for not recognizing that humans are a part of nature.) Once the goal of recycling our "waste" had been articulated, we spent a great deal of time talking about it. We were preparing ourselves for the question, What are *we* doing about environmental pollution? "If we are not part of the solution, we are part of the problem."

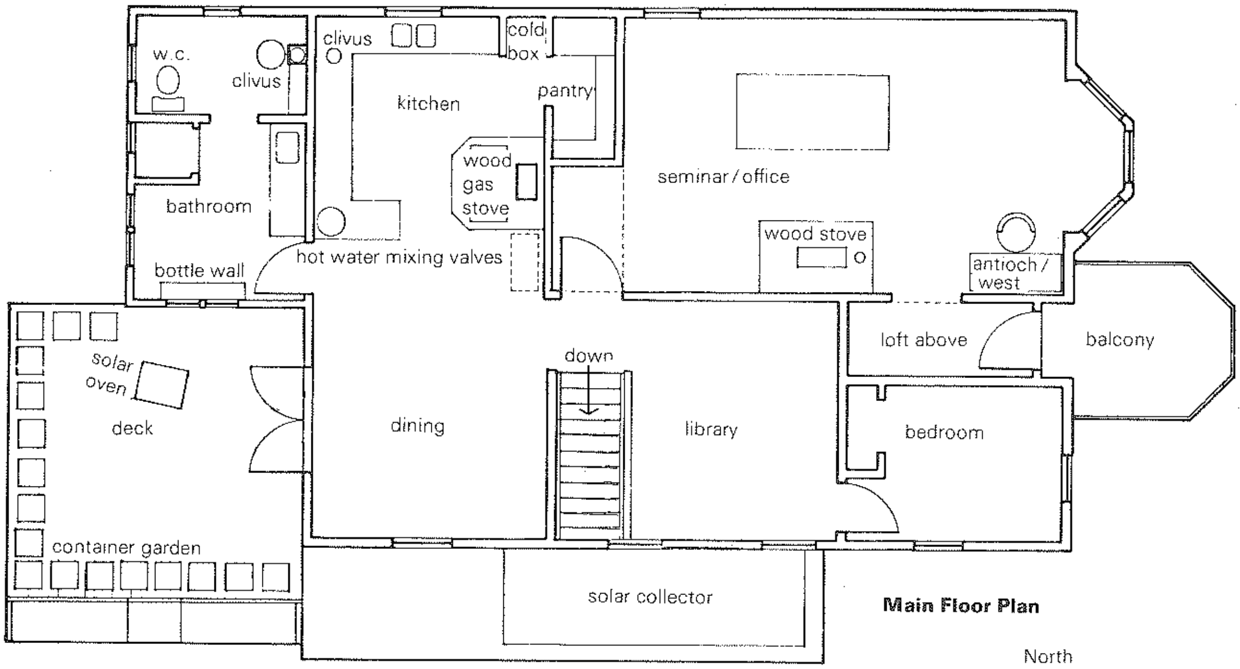
Visualization: What did the solution to the problem of recycling our homesite wastes look like? A period of extensive discussion ensued with attempts to visualize exactly how all the changes in our lifestyle could take place and what some of the consequences would be. We had to investigate a route for each type of household waste and imagine our personal interactions with the materials.

We knew it was simple to sort the waste at the home but now we needed a way to get the materials from the home back into industrial pathways. There were already models in the society for use of certain industrial secondary materials. One of the authors had participated in aluminum and paper drives during World War II. Another had participated in newspaper pick-up drives as a Boy Scout. It was really a matter of weighing the pros and cons of two obvious models: materials could be collected from the home to a collection center by a city service or brought by residents to a collection center directly.

We decided on the latter, since it seemed easiest to accomplish at the start. It also would be a good way of testing and demonstrating motivation in the community. The Berkeley Ecology Center provided a meeting place where others we were able to interest in the project could come together. These included Cliff Humphries who had started the group Ecology Action, whose members recycled newspapers in their own neighborhood. Eventually, through the help of Don Rothenburg, Education Director of the Consumers' Cooperatives of Berkeley (a consumer-owned chain of supermarkets and other stores with a consumer-community orientation), a recycling center was established on the parking lot of the CO-OP. It thrived. Within two years there were seventy-five recycling centers in the Bay Area, and others began to appear across the country. Obviously a social need existed and the motivation was there; all that was lacking was a model for behavior change.

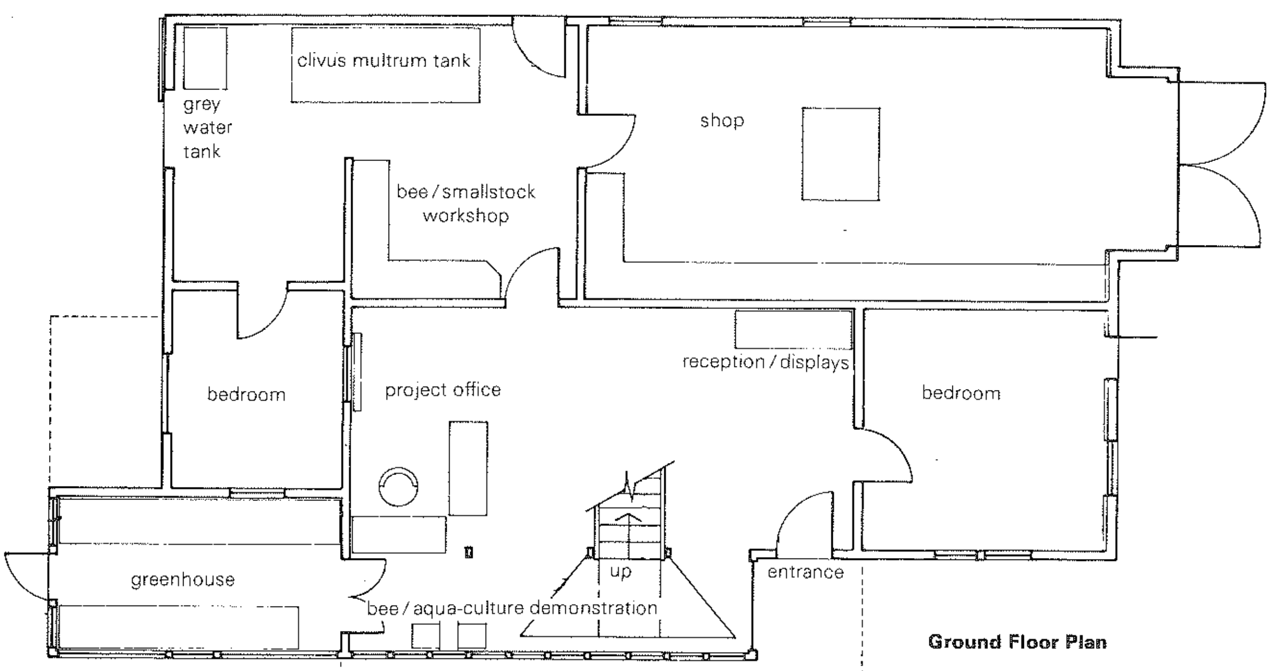
These recycling centers, however, did not deal with the organic wastes, only glass, metal, and some paper. The problem with organic kitchen wastes at the home level was more difficult to solve. No acceptable urban model existed for coping with these materials. Carrying the stuff out in a pail and dumping it on the compost heap may work in a rural area where residents live far apart, but smells and problems with rats and flies precluded this solution in the city. The period of visualization and verbalization around this problem was lengthy. Gradually, we worked out what seemed to be a viable solution. We would keep separate, clearly designated, attractive bins under the sink in the kitchen for each category of inorganic material. Organic wastes would be drained in a colander by the side of the sink, transferred periodically to one of several small covered plastic garbage cans just outside the kitchen door on the back porch, and covered with a couple inches of sawdust so the smell didn't attract flies. This material would then be stored

Figure 1-5. **Integral Urban House Floor Plans**



Main Floor Plan

North



Ground Floor Plan

North

until enough small cans of kitchen garbage, as well as weeds, leaves, and other garden debris, had been accumulated to enable the building of a one-cubic-yard batch of hot compost in a bin constructed for the purpose. (For a detailed discussion of this method, see pages 125–37.)

Internalization or Incubation: We found it significant that after we had clearly visualized the plan and accepted the proposition that implementing it was desirable a period ensued in which only continued talk but no action took place. Apparently, it was necessary to repeatedly confirm to each other the importance of the goal, the correctness of the model, and the details of the behavior change to which we were committing ourselves. As in Alcoholics Anonymous or Weight Watchers, we needed to reinforce our resolution through extensive verbalizing. This period of inactivity before taking the plunge we call internalization, or incubation. It seemed that something below the level of consciousness had to happen before we could actually shift our behavior in the desired direction.

Behavior-change Implementation: Finally, one day, we went out and bought the containers and began sorting our own garbage. It was easy. We couldn't figure out why it had taken us so long to actually do it. Once we were doing it and could describe or show the model, it was easy to effect a similar behavior change in others similarly motivated.

The Importance of Having a Model: One of our conclusions from this and similar experiences was the importance of having a model. This insight inspired us to develop the Integral Urban House in Berkeley as a model that people could come and visit. Another insight was the importance of providing adequate reinforcement for each other, through verbal approval, when we were the only ones we knew who were trying something different and everyone else thought we were a little crazy. Perhaps most important was the respect we gained for the difficulties of changing one lifestyle deliberately in the ways the Integral Urban House represents. Equally significant was the confirmation that the changes were worth making.

We believe that we have discovered a process for accomplishing environmental change that people in large numbers can easily adopt and learn. We have demonstrated that changes in behavior ultimately lead to environmental changes and that, conversely, in order to change any environmental condition one needs to first identify and evaluate the necessary behavioral changes. The Integral Urban House incorporates a set of solutions to the problems of living in the city that we have tested and believe to be valuable.

14. THE FRONT YARD

In most residential areas a space exists between the street and the front of the house—the front yard—where sunlight falls and plants are, or can, be raised. This is a sensitive area, an interface between the private and public lives of the residents, and often subject to conflicting demands of territory, status displays, and community access. These demands give the front yard its special character and problems. The challenge is to develop subsystems of the integrated household that usefully incorporate this space into the life-support of the house, and still communicate the desired message from the residents to the passing crowd of the need for privacy and security.

Various living and nonliving components are commonly used in this space to perform many functions—for example, signs to guide passing pedestrians; fences and hedges to screen the household from sight and to block traffic noise and the toxic chemicals from automobile exhaust; gates to keep the public out and to restrain certain household members such as animals and young children; and trees to provide shade, decrease wind velocity, and enhance the aesthetic appeal of the property (see Table 14-1). Compared with nonliving structures used in this area, vegetation has the advantage of providing microclimate modifications by increasing humidity and gas exchange, thus affecting human comfort in a positive way. But plants, being alive, may also pose special maintenance problems. They may introduce irritants such as pollen and wildlife or their products. For example, the honeydew excreted by certain shade tree aphids and related insects occasionally may be copious enough to create problems when picked up on shoes and tracked into the house.

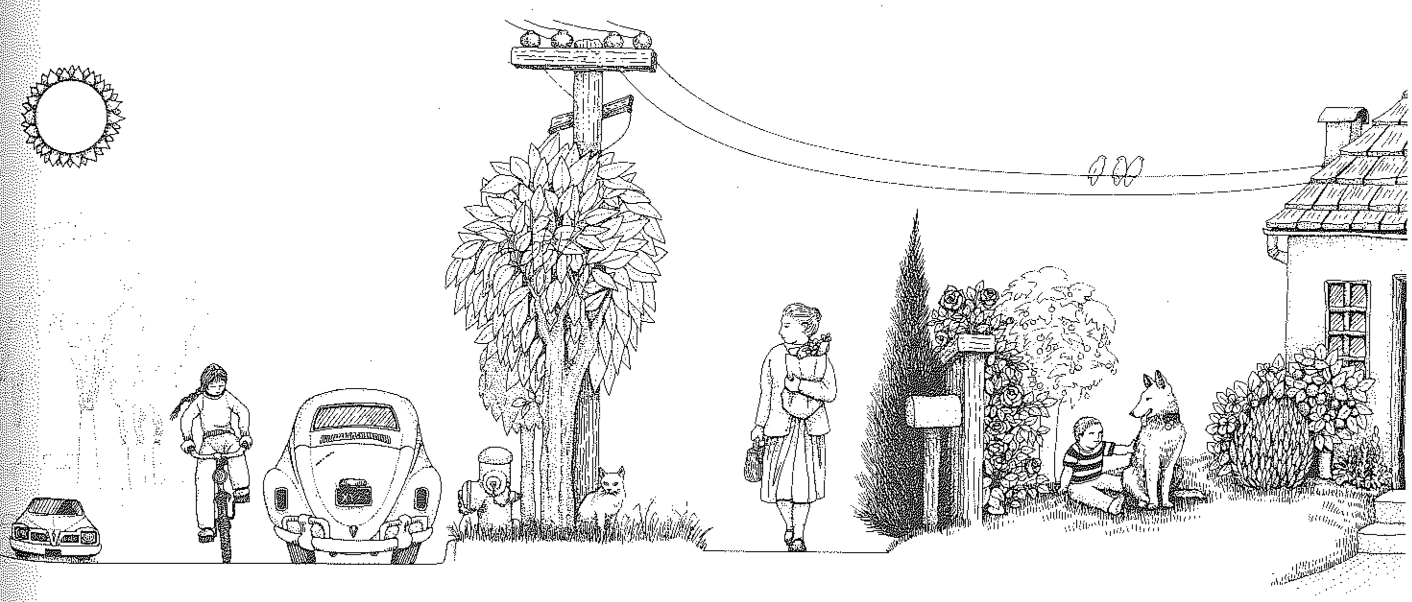
The Curbside Space

If we begin at the street and work back toward the house, the first space available is often a long narrow stretch of earth. It is bounded by curb and sidewalk along its length, and by driveways or walks at either end. Some communities strictly regulate the use of this area and restrict what can go in it; others leave its use entirely to the discretion of the residents. Some suburban areas, giving themselves over totally to the automobile, have eliminated a path for foot traffic entirely, so that this curbside space blends indistinguishably into the privately owned land surrounding the front of the house.

This strip, often rigidly defined by cement on all sides, may be the habitat of a shade tree, frequently but not always selected, planted, and maintained by the city parks or public works department. The choice and care of such a tree may be a source of major interaction between the residents and the city, since, by its very size and placement, a large tree is capable of dominating the entire front area, determining the amount of shade the yard and house receives, and thus profoundly affecting both the indoor and outside microclimate. In addition, because of competition from the tree's roots and deposits of leaf and branch litter, the kinds and amounts of other vegetation that may be grown in this area are also affected. Curbside shade trees may greatly affect the aesthetic and thus the market value of a property, a fact well-demonstrated by the dramatic visual change wrought by Dutch elm disease in areas where it has caused rows of stately streetside elms in towns across the United States and Europe to die suddenly.

The most important function of the curbside space may be providing access to the street or to parked cars. Thus, compaction from foot traffic may be its distinguishing characteristic. The primary requirements in this case would come from a desire to reduce mud, dust, or other impediments that could damage shoes and clothing or hinder easy passage. This desire for

Table 14-1. **The Front Yard—A Functional Analysis**



Element	*Street*	*Medium Strip*	*Sidewalk*	*Front Yard*	*House Entrance*
Function	Broadway	Access to street/vehicles	Pedestrian passage	Public interface, status display	Aesthetic enhancement, climate modification
Common Constituent	Cement/asphalt	Turf, concrete, soil	Concrete	Lawn/ornamentals	Shrubs, flowers
Alternative use	Vehicular traffic and bike path separate from each other	Dense vegetation for sound and air pollution barrier	Woodchip, tan-bark path for biological recovery	Edible ornamental plants/alfalfa	Dwarf citrus, espalier fruit trees, and vine crops

easy street access has led to the use of tough, low-growing ground covers such as grasses or, where low maintenance is desired, replacement of vegetation with inert materials such as cement, stones, bricks, and the like. Some homeowners may attempt to reduce maintenance by applying toxic materials, such as commercial herbicides, to reduce weeds. Many a lovely shade tree has been accidentally killed through use of such products on the ground surrounding it. The same lethal effect may be achieved by using this area as a waste recipient by dumping gasoline, cleaning agents, and so forth on the soil. The proximity of this space to the curbside gutter, a traditional place for disposal of wastes, may make this tempting.

Passageways

Perhaps as a reaction to the mud and dust of primitive frontier-town conditions, or as a product of the U.S. urban and suburban passion for sanitizing nature and rendering it less disorderly or hostile to the pursuits of humans, the general choices for passageway materials have been impermeable cement or asphalt. However, the illusion of permanence that these substances give may be broken by enlarging tree roots and shifting earth foundations, thus necessitating costly repairs to the sidewalk. These materials provide smooth surfaces for rollerskating, bicycling, skateboarding, strollers, shopping carts, and so on, but they are in fact unhealthy for extensive walking or running. In addition, impermeable surfaces create a problem when plant debris falls on them because lack of contact with the ground prevents normal decomposition. Disturbing the monotony of these cherished passageways with leaves and twigs results in the obsessive sweeping so dear to the neighborhood sentinel. Precious resources may be consumed in these efforts through the use of water washes from the garden hose or, worse yet, blowers with motors powered by fossil fuels.

Table 14-2. **Urban Run-off**

Width of Sidewalk	*Annual Rainfall in Inches*							
	6″	*12″*	*18″*	*24″*	*36″*	*48″*	*60″*	*72″*
2 feet	750	1500	2250	3000	4500	6000	7500	9000
3 feet	1125	2250	2375	4500	6750	9000	11,500	13,500
4 feet	1500	3000	4500	6000	9000	12,000	15,000	18,000
5 feet	1875	3750	5625	7500	11,250	15,000	18,750	22,500
6 feet	2250	4500	6750	9000	13,500	18,000	22,500	27,000

Annual Run-off from 100 feet of sidewalk (in gallons per 100 linear feet of sidewalk)

One of the most serious consequences of impermeable surfaces is that they inhibit the absorption of water. While they eliminate the problem of muddy feet, cement and asphalt simultaneously create the problems associated with run-off. Water that would otherwise sink into the ground where it falls, replenishing the soil water and cleansing itself of any air-borne or other pollutants by passing through layers of biological and physical filters, is channeled away. Problems of erosion, pollutant concentrations, and mosquitoes and other pest problems develop as the water is captured in ditches, gutters, catch basins, or storm sewers and is finally deposited into the nearest river, lake, or oceanside tidelands. As Table 14-2 shows, this run-off may be considerable, especially where sidewalks and driveways are broad.

What alternatives exist for these public and semipublic passageways? Permeable asphalts and cement are being developed in which the fine particles have been removed from the compound, permitting water passage. However, products strong enough for use as roadways have not yet been perfected. Gravel is a common substitute for driveways, particularly in more rural areas. It requires occasional renewal, since on steep surfaces it may wash away. Bricks are often used as walkway material. If they are set in sand between wooden curbs or edges, they will allow the passage of water. As with stone tile or wood stepping stones, control of undesirable grasses that may grow up in cracks or crevices between the bricks needs to be given some thought. The same problem might be created by the use of beds of small stones instead of vegetation in the curbside space. An increasingly common way to deal with unwanted plant growth has been to lay down a heavy sheet of polyethylene plastic beneath the stones or other permeable surfaces, but this defeats the goal of permitting water penetration, and is a questionable use of fossil fuels. A better solution is encouraging low, hardy plants, such as mosses, that may begin to grow voluntarily in those areas, or deliberately seeding in plants that can compete well with grasses, such as sweet alyssum.

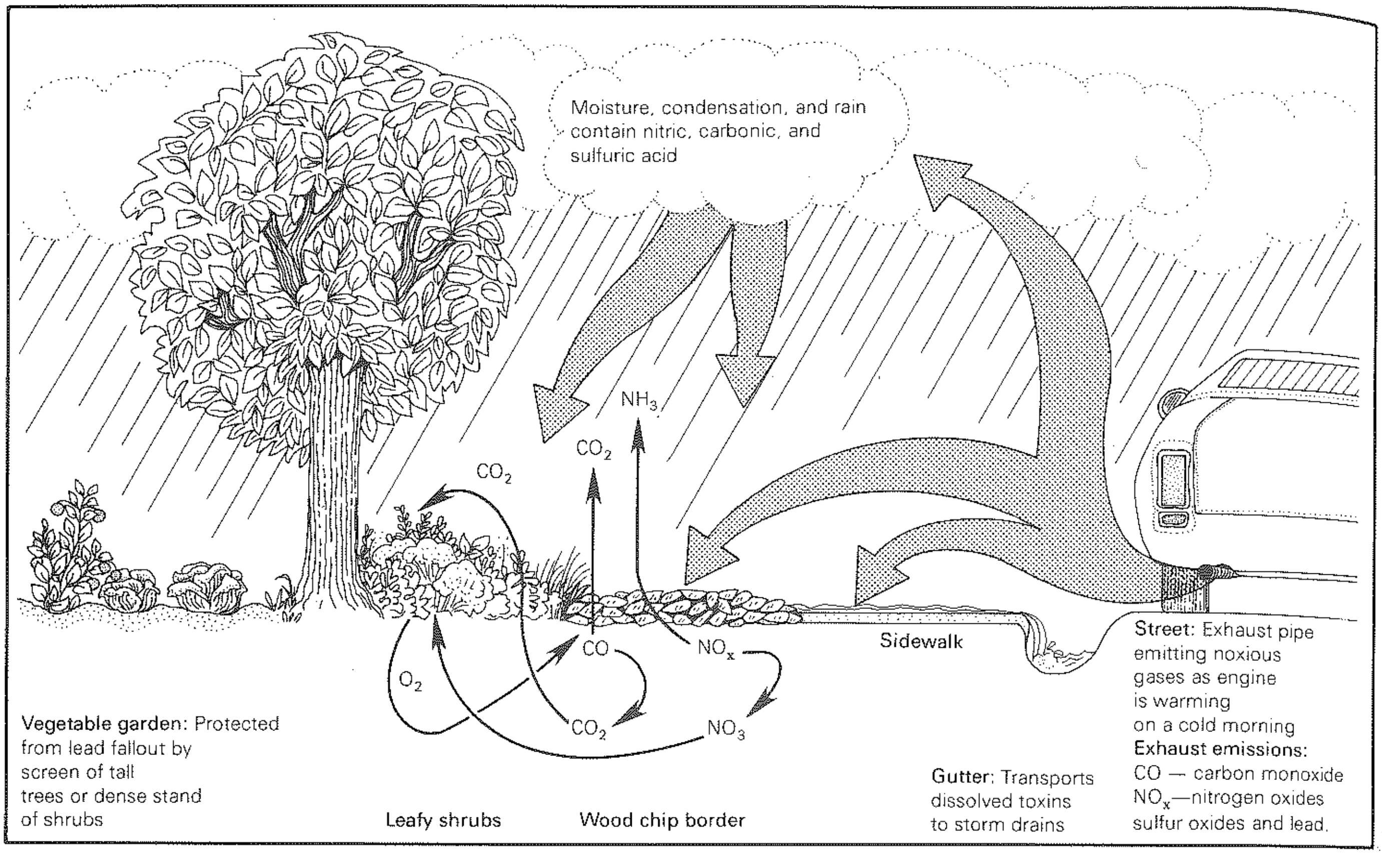
At the Integral Urban House in Berkeley one of our favored choices for heavily used walkways has been wood chips. This waste product is readily available in many cities, since it is created by running through a machine called a "chipper" the debris from the pruning of city trees. During certain times of the year, this pruned-off material may constitute a significant percentage of the plant debris produced by municipalities. The usual repository of these materials is the city dump. Recycling them for use as walkways and mulch seems preferable.

The chips make an attractive, pleasingly complex-looking surface. The same effect may be achieved by using bark products sold commercially as mulch. All such materials must be bordered by wood, metal, or stone edging to prevent it from migrating out into surrounding spaces.

The use of such organic material as a walking surface has many advantages. Rain and other water can percolate down through it, along with oxygen, permitting the soil organisms beneath the surface to survive. The continued existence of these organisms makes it easy to grow plants in those areas once again, should you desire to change the position of the walkway. Decomposition will proceed slowly on the underside of the chip layer, eventually adding nutrients to the soil and furnishing a home for earthworms and other highly desirable animals. Initially, however, the high carbon content of these materials will help suppress weeds in the pathway itself.

The effect of walking on such a surface is similar to walking on the soil itself. Feet are kept dry and clean when the ground is wet, but somewhat more care is required than when walking on the smoother surfaces of cement or asphalt. However, with more awareness of where you put your feet, surface irregularities are less likely to cause you to trip and stumble than when you encounter an unexpected break or bump in a surface you expected to be

Figure 14-1. **Some Mineral Cycles in the Front Yard**



The illustration shows the cycling of minerals in a biologically active surface compared with their runoff from an impermeable one. Automobile exhaust from a car warming its engine on a cold morning settles on an adjacent sidewalk or wood chip pathway, or is released into the atmosphere. Moisture in the air reacts with the pollutants to produce harmful acids such as sulfuric and nitric acid. Photochemical effects energized by the ultraviolet spectrum of sunlight produces still other pollutants. Periodic rains move the dissolved toxicants from the air onto the land. Runoff from the sidewalk and other impervious surfaces carry the pollutants into the city's gutters, and then into the storm drains, and ultimately into a body of water of some kind. Where wood chips or some other biologically active surfaces exist, rainfall is absorbed by the medium and the microorganisms thriving on the organic substrate detoxify many of the dissolved pollutants and can render some harmless or useful for plant growth. Although these relationships appear logical, research is needed to determine how much real benefit such walkways can provide. The decreased amount of permeable and bi-

perfectly smooth.

Most important, permeable organic surfaces provide an active microbial filter, adding to the physical filtering effects of the soil particles and sifting out and in some cases breaking down contaminants picked up by rain falling through polluted city air. The microbial community of a soil surface rich in organic material may also enhance air quality by converting carbon monoxide, a component of car exhausts that is poisonous to many organisms, to carbon dioxide, which is a compound beneficial to plant life. (This point was made by Dr. Oen C. Huisman, Department of Plant Pathology, University of California, Berkeley, in a personal communication with the authors.) This idea is illustrated in Figure 14-1.

Screens and Barriers

A great variety of screens and barriers are in use in cities. Nonliving barriers may range from a simple row of stones painted white to guide the nighttime traveler, to formidable fences or walls of wood, stone, brick, or concrete. Their vegetation counterparts may range from a border of blooming annuals that provides primarily a psychological barrier by marking the property limits or edging a pathway, to impenetrable hedges of rose bushes, cacti, or other thorny bushes.

Most critical to the comfort of the residents are barriers to invasion of privacy in the form of the sight or sound of the passing traffic. While the former may be easy to achieve, the latter is far more difficult, but it is also more crucial in terms of the health of the occupants within.

Noise: What is noise? A subjective assessment might include the notion of unwanted sound. From a psychological point of view, one person's music may be another person's noise. But noise is also a physical phenomenon, a disturbance, in the form of a flow of energy through matter.

Table 14-3 shows the intensity (loudness) of a number of common indoor and outdoor noises to which urban people may be deliberately or unintentionally exposed. With industrialization, a wide variety of labor-saving and automatic machines and appliances have become a source of noise within the home. Heating, cooling, and plumbing systems, television, music, dogs barking, people talking, and clocks ticking are all examples of indoor noise sources one becomes accustomed to ignoring and enduring in ordinary living or working settings.

As an environmental pollutant, noise is one of the most insidious, precisely because human beings tend to adjust to continuous high noise levels by screening them out of their consciousness. Noise does its damage to the body slowly. Thus, one grows accustomed to increasing deafness, remaining unaware that loss of hearing is occurring until it becomes quite severe. According to the Environmental Protection Agency, as many as 80 million Americans are harmed by noise, many of them while at work. Our personal observations indicate that most people are unaware that their health as well

ologically active surfaces in cities place human health and environmental quality in jeopardy. Urban environments are becoming simplified to the point where they are without any capabilities of biological renewal. The least we can do to help restore the biological vitality of these areas is to recognize the importance of soil and organic matter as nutrient cyclers and pollution detoxifiers, and to protect the existence of natural surfaces.

Table 14-3. **Sound Levels and Human Response**

Example	*Noise Level (Decibels)*	*Response*	*Hearing Effect*	*Conversational Relationship*
Deck of an aircraft carrier, jet operation	**140**	Painful limit of amplified speech		
Foghorn at 3 feet	**130**			
Jet takeoff (200′)	**120**		↑	
Discotheque				
Riveting machine	**110**			
Jet takeoff (2,000′)				
Garbage truck	**100**			Shouting in ear
N.Y. subway station				
Heavy truck (50′)	**90**	Hearing damage after 8 hours		Shouting at 2′
Pneumatic drill (50′)				
Alarm clock	**80**	Annoying		Very loud conversation at 2′
Freeway traffic (50′)	**70**	Telephone use difficult	Hearing impairment begins and gets worse	Loud conversation at 2′
Air conditioning unit (20′)	**60**			Loud conversation, 4′
Light auto traffic (100′)	**50**	Quiet		Normal conversation, 2′
Bedroom	**40**			
Soft whisper (15′)	**30**	Very quiet		
Broadcasting studio	**20**			
	10			
	0	Threshold of hearing		

Source: U.S. Environmental Protection Agency, "Noise Pollution."

What comes with a carriage and goes with a carriage, is of no use to the carriage, and yet the carriage cannot move without it?—an old riddle, (see next page).

Box 14-1. **Noise Control Strategies**

1. **Source reduction.** Muffle or redesign engines for jet aircraft, cars, and trucks; redesign or use smaller motors for appliances and home and office machinery; and use hand tools whenever possible rather than heavy power equipment.
2. **Use modification.** Reroute traffic around residential areas; redirect air routes; deny landing rights to loud aircraft; and time noisy activities so as to affect fewer people.
3. **Sound interruptions.** Use barriers (with a mass of at least 15 kilograms per square meter) to absorb or redirect noise; use soft, heavy materials in designing buildings and rooms to absorb noise and echoes; and eliminate flat surfaces and squared corners wherever possible.
4. **Protect the receiver.** Use ear plugs and earphones to muffle sounds or increase the distance between the receiver and the noise source.
5. **Education.** Make people aware of noise and its effects; file nuisance complaints about noisy neighbors, dogs, lawn mowers, and so on; and help create municipal antinoise laws.

as their daily productivity is being damaged by the noises they are regularly exposed to. They don't take noise seriously.

All inhabitants of modern industrial nations—as compared to tribal members living in remote jungle clearings—are likely to experience premature loss of hearing. On the average, men lose their hearing, at least of the higher frequencies, earlier than women. However, much of that loss is unnecessary and could be avoided by requiring that machines be constructed so that noise production is reduced, and that adequate soundproofing be integrated into building design.

More than loss of hearing is involved in exposure to noise, however. There is plenty of evidence that irritability, inability to concentrate, and general physiological stress may be produced by lengthy exposure to high-intensity sounds. While interior furnishing such as rugs, curtains, and any complex surfaces that prevent echoes can reduce noise originating within the room, traffic noise and other sounds from outside the house can be reduced only by distance or by mass placed between the noise source and the hearer.

Unfortunately, front yards are frequently too small to permit the erection of high walls of soil or concrete. City laws may prohibit high barriers in any case. To achieve any appreciable reduction in noise level using vegetation, several rows of high shrubs and trees between the source and the house are necessary. Such plantings may have various effects upon the dwelling's microclimate, acting as a windbreak and thus reducing heat loss from the house if the barriers are located to the windward, or providing shade if they are on the sunny sides. Planting areas that might be used for growing food and other processes utilizing solar energy will be affected by these barriers, so careful planning is needed. A summary of approaches to noise reduction is given in Box 14-1.

Raising Food in the Front Yard

Lawns: With interest in food-raising increasing, many people have begun to use their front yards for this purpose. In general, it has always been our feeling that the front lawn is a great waste of space. When all the fossil-fuel inputs are accounted for, an ornamental lawn turns out to be a considerable investment in terms of ground preparation (some areas require the importation of topsoil by truck after the house is completed because of the soil damage sustained during the construction), as well as seeding, fertilizing,

Answer: Noise

pest management, watering, mowing, and trimming.

The maintenance of some 16 million acres of lawns in America represents an enormous investment of energy and natural resources. Consider the amount of water, chemical fertilizer, pesticides, gasoline, and human labor devoted to the maintenance of such an expanse of vegetation. In fact, a study entitled "The Energetics of a Suburban Lawn," by John Howard Falk, concluded that the energy inputs into a lawn of a Walnut Creek, California, home amounted to 573 kilocalories per square meter of turf per year. That rate of energy use exceeds the rate for the commercial production of corn on an equivalent amount of soil. The tragedy is that the product of all that energy expenditure, the grass clippings, frequently ends up in plastic sacks by the curb waiting to go to the dump. Wiser gardeners either let grass clippings fall where they are cut, to act as a mulch, or rake them up, together with leaves, to use in the compost. See Box 14-2 on using grass clippings.

Grass serves many functions, some of them aesthetic or psychological. A grassy expanse in front of the house is a status symbol that is firmly entrenched in the minds of those who are descended from northern European cultures. Historically, lawns are associated with the manor house and those wealthy enough to be able to own and preserve some fields for looks alone. A lawn is a boast that the owner is not forced to pasture animals upon the green. Doubtless, in areas where natural rainfall is sufficient and mowing is feasible green grass is unsurpassed as a groundcover for reducing erosion.

Box 14-2. **Using Grass Clippings**

Grass clippings piled by themselves are slow to decompose, since the small, even-sized pieces tend to compact and exclude air, causing the interior of the pile process to go anaerobic. The odors thus generated may attract flies, which will breed in the pile. One of the species attracted to such conditions could be the biting stable fly, *Stomoxys calcitrans*, which in the adult stage can suck the blood of humans the same as a very large mosquito.

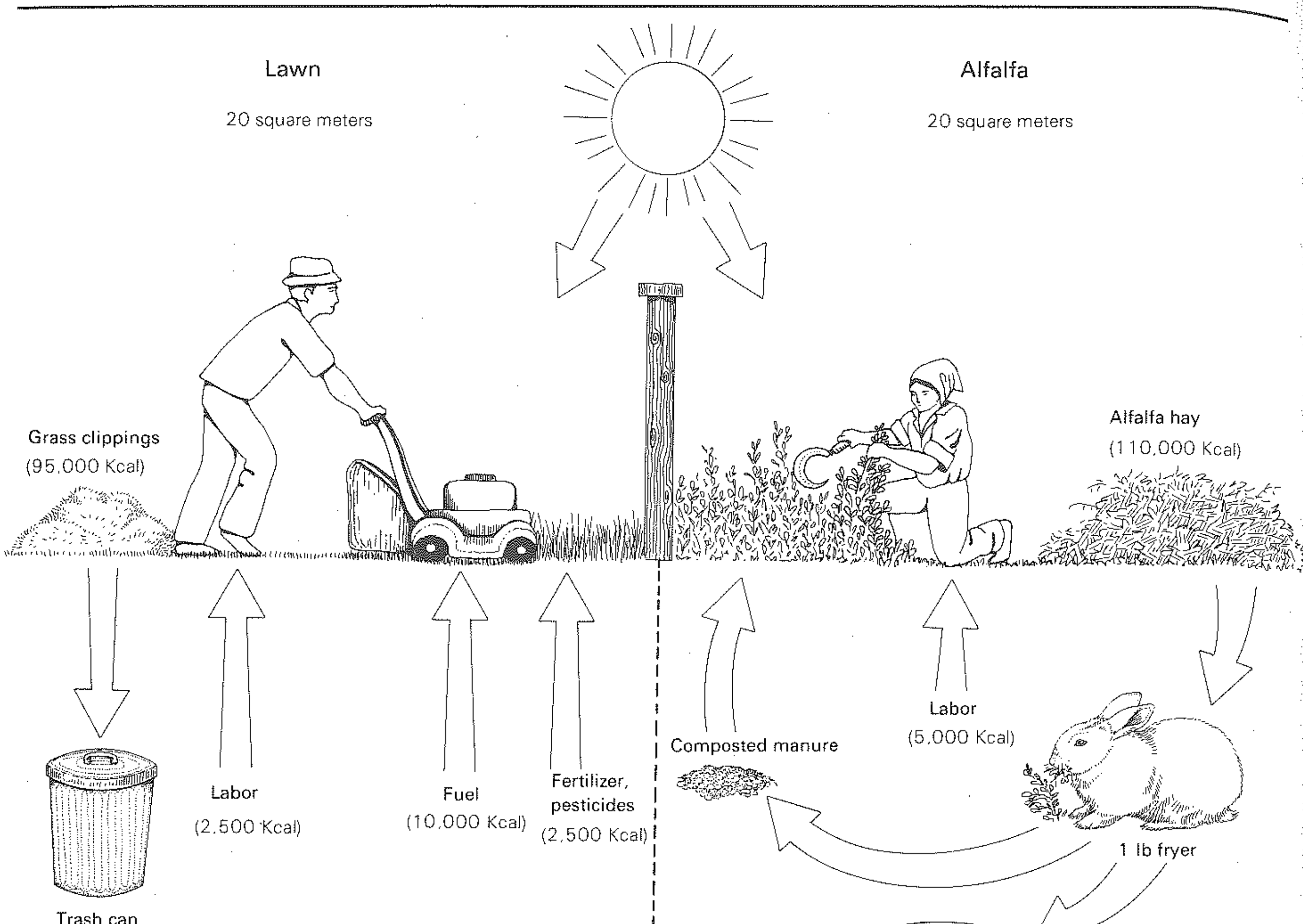
If grass clippings are to be used in a slow compost, some coarser materials, such as leaves, should be mixed in to allow more oxygen to circulate. An English system for handling such grass and leaf accumulations is to pile them up in a ring several feet out from and around the dripline of a shade or fruit tree. This composting method is suitable for cool, rainy climates; the decomposition will proceed slowly, primarily through the action of fungi. Material used to create the first pile in the circle during the spring will be ready for use the following year. Plant nutrients leached out of the pile by rains wash down to the roots of the tree. (For a more detailed discussion of composting, see Chapter 6.)

Grass clippings also make a good poultry food. At least a third of the calories in a chicken's diet can profitably be made up of grass without adversely affecting egg-laying efficiency. As with any green vegetable matter used as chicken feed, the vitamin A in grass clippings will turn the egg yolks a deep yellow-orange.

Where artificial watering means that lawn maintenance requires pumps, and consequently use of fossil fuels, or where terrain makes clipping difficult, other low-growing groundcovers (such as birdsfoot trefoil) should be investigated. These may offer the same spacious vista while being well-adapted to the soils, climate, diseases, insects, and other pests native to the area, as well as requiring very little maintenance.

Of course, few other ground-covers can offer the pleasure of grass for walking, playing, and sitting upon, or the resistance to the wear and tear of these activities. But ironically enough, the lawn in front of the house is rarely used for this purpose. The area is often perceived as being too visible

Figure 14-2. **Yearly Energy Budget of a Lawn Compared to an Alfalfa Patch**



	Energy Input, Kcal	*Energy Yield, Plant*	*Kcal: Human food*
Lawn	15,000	95,000	——
Alfalfa	5,000	110,000	15,000

Note: All notation represents annual totals.

to be a setting for household recreation activities. For this reason, as well as for those of space economy in a hungry world, where the front yard receives enough sun we have often recommended that it be used for raising food to sustain people or other animals.

Suitable Food Plants for the Front Yard: At the Integral Urban House, we have found alfalfa to be a very satisfactory substitute for a lawn. Our experience has been that even on this small a scale and using only hand labor in the cultivation and harvesting of the plant, the alfalfa beds are more productive per unit area than a lawn, while requiring only one-third as much energy for maintenance. The alfalfa plant is a legume, and requires no nitrogen fertilizer, in contrast to most lawns. All other essential nutrients can be supplied to the alfalfa in sufficient amounts by applying a compost top-dressing about twice during the season of most active growth.

We determined that for every unit of energy invested (exclusively human work) in the production of alfalfa, twenty-two units of energy were returned in crop production. In the case of the lawn, as documented in the study by Howard Falk mentioned above, each unit of energy invested (part human work, part fuel, and part chemical fertilizer) returned six units of energy as lawn clippings. If the grass clippings are discarded as wastes, the net production efficiency of the lawn would be more accurately described as zero (see Figure 14-2).

The alfalfa produced enough digestible nutrients per square meter to support the production of one pound of usable rabbit meat. The twenty-one square meters of median strip in front of our Integral Urban House produces twenty-one pounds of meat per year. In addition, the rabbit manure is composted and provides enough top-dressing to maintain the alfalfa crop, a benefit not considered as a part of this study.

Edible and Other Usable Ornamentals: Of course, not everyone will be interested in sporting a green of alfalfa for their front yard, but we have found several plants that provide both an ornamental display of foliage and flowers and a source of human or animal food. Along the front entrance of Integral Urban House, strawberries make an attractive ground cover. They are evenly spaced over the bed, and stepping stones allow us to hop from place to place when harvesting the fruit. A high border of chrysanthemums provides color, and the clippings are relished by the chickens. We use rhubarb chard for brilliant color accents in the garden, and perennial foundation plantings of artichoke and true rhubarb to provide food as well as pleasing textures and colors. Similar edible ornamentals suitable to different climates could well be used in other areas of the country.

For high hedge material, we have been growing mulberry trees, which we have dwarfed by planting them very close together and pruning severely. As mentioned earlier, we use foliage from this hedge to feed silkworms. In some areas of the country where the winters are mild, hedges of nonrunning bamboo are a possibility. The prunings from bamboo provide stakes to support plants in the garden. The flexible quality of these stakes, especially while still green, makes them useful for a variety of jobs around the house, as well as for decorative crafts. We have used flexible split-bamboo strips to support netting over the beds, to keep birds away, as well as to create tube-like greenhouses, as mentioned earlier (Chapter 7, Food Plants Outdoors). If a shade tree is part of your design for the front of your house, by all means consider using one that will provide fruit or nuts if such can be found that will grow in your area. The idea is to make use of each planting in as many ways as possible besides pure decoration. Now, after whipping up your enthusiasm for planting vegetables in place of front lawn, we would like you to stop and consider whether it's really a good idea to do so.

Lead and the Front Yard Vegetable Garden: There may be a very good reason not to grow vegetables in your front yard: lead pollution. Lead is now a common constituent of the air we breathe (see Table 14-4). In many urban areas, general air quality is a problem in and around the entire house. This is particularly true in neighborhoods that are both industrial and residential, in areas close to heavily traveled roads, in all residential communi-

This table illustrates the worldwide distribution of average levels of lead in surface air along the eightieth longitude meridian. The different cities which lie on the meridian are indicated. Notice that the whole world has considerable levels of lead, while highly industrialized and metropolitan cities such as New York, Miami, and Santiago have particularly high levels.

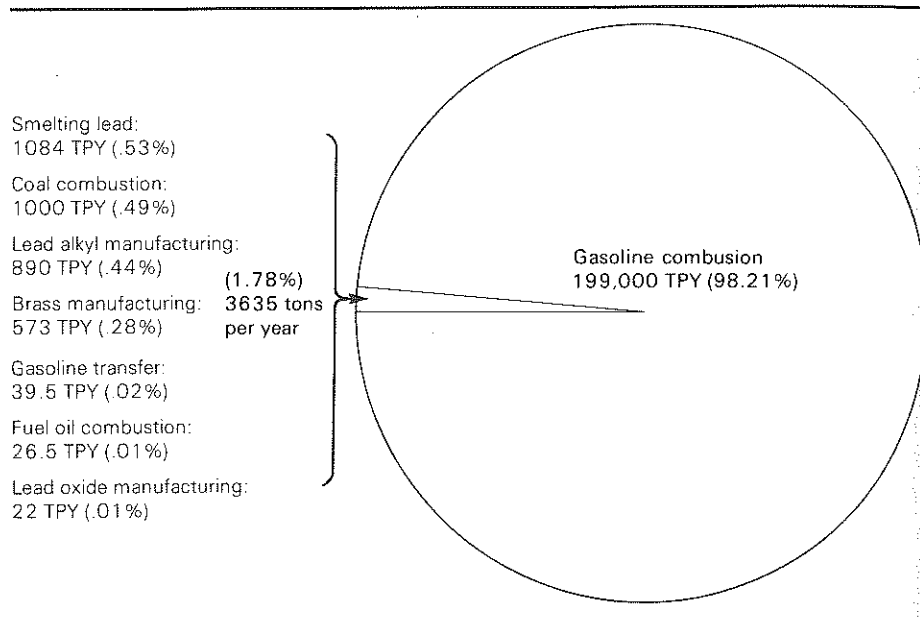
Source: Lovering, *Lead in the Environment.*

Table 14-4. **Lead Concentrations in Surface Air from Sites along the 80th Longitudinal Meridian, 1967***

Latitude	*Location*	*Lead Concentration (Nanograms/Cubic Meter)**
70°N	Thule, Greenland	0.01
	Moonsonce, Canada	.06
56°N	New York, New York	2.5
41°N	Sterling, Virginia	.74
39°N	Miami, Florida	1.7
26°N	Bimini, Bahama Island	.10
18°N	San Juan, Puerto Rico	.80
9°N	Balboa, Panama	.23
2°S	Guayaquil, Ecuador	.35
12°S	Lima, Peru	.50
16°S		
24°S	Chacahaya, Peru	.09
33°S	Antofagasta, Chile	.06
	Santiago, Chile	.87
53°S	Punta Arenas, Chile	.06

*Lead concentration measured in nanograms, which is 0.000 000 001 grams, which is 1×10^{-9} grams, or one-billionth of a gram.

Figure 14-3. **Lead Emissions in the US, 1968***



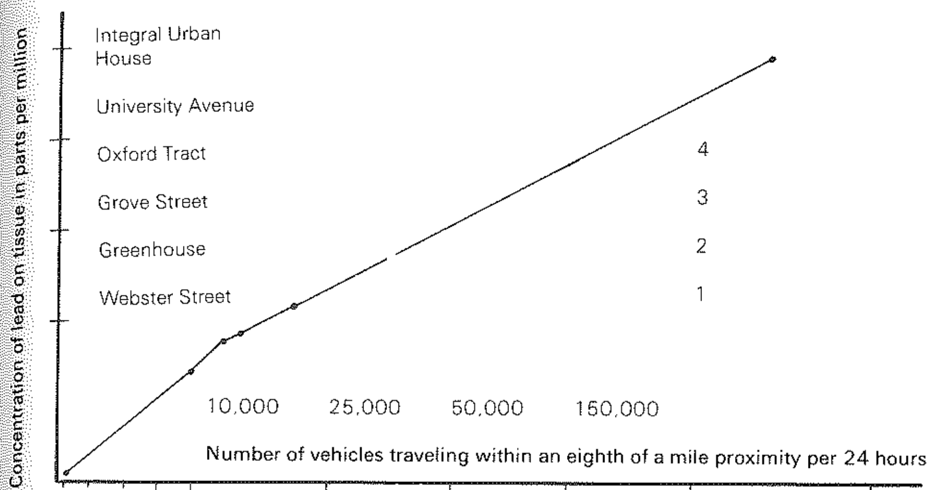
*percentages of total tons per year

Total tons per year: 202,635

Source: Lovering, *Lead in the Environment.*

ties where geography and weather combine to create frequent temperature inversions that trap a layer of polluted air over the entire area, and in residential areas in the path of prevailing winds that carry contaminants from industrial developments. Logically, we could have considered this subject at any point in this book where food-raising outdoors was discussed. However, because the source of much of this pollution is the gasoline engine of the automobile, and the common urban pattern is for houses to front upon the street, we decided to discuss this problem along with considerations on the

Figure 14-4. **Lead Concentration of Chard from Vegetable Gardens in Berkeley, California, 1976**



Location in Berkeley, California	*Amounts of lead on plant tissue in parts per million (chard)*	*Concentration of traffic within eighth-mile proximity/24 hours*
Webster St. near Claremont Ave.	.22	2,000
Greenhouse. Ellsworth St. near Dwight Way.	.48	7,000
Grove St.	.63	15,000
Oxford Tract. Virginia St. near Oxford.	.71	16,000
University Ave. University Ave. near Sacramento	1.14	32,000
Integral Urban House. 5th St. near Cedar (5 blocks from freeway).	3.57	139,000

Source: Student Research Report, Department of Conservation of Natural Resources, University of California, Berkeley.

Table 14-5. **Average Lead Content of Gasoline, 70–71**

	Grams per Gallon	
	1970	*1971*
Regular gasoline	2.43	2.22
Premium gasoline	2.81	2.67
Low-lead and no-lead gasoline	—	0.75

In filtered cigarettes, 24.1 ppm of lead has been reported. Smokers inhale 1.0 to 3.3 μg of lead per cigarette or 20 to 66 μg per pack. This lead in tobacco is believed to have originated with lead arsenate sprays used years before against insect pests.

Source: Waldbitt, *Health Effects of Environmental Pollutants.*

use of the front yard for food production.

Unquestionably, the combustion of leaded gas in automobile engines is the most important source of lead pollution in urban areas (see Figure 14-3). The average car, burning leaded gasoline, emits 5 pounds of lead into the air for every 30,000 miles traveled, or an average of 50 milligrams of lead per minute of traveling time. Approximately 180,000 tons of lead are poured into the air each day in the United States from autos, trucks, and buses. Throughout a city such as Cincinnati, this may mean 4101 pounds (1860 kilograms) of lead per day from gasoline—that is, 1.6 micrograms of lead for each cubic meter of air inhaled. Table 14-5 indicates the amount of lead per gallon of gas consumed. Knowing the gallons of gas used per mile, you can calculate the amount of lead contributed for each trip.

Lead is poisonous to humans and a problem in many living systems. In a student research project, samples of unwashed chard leaves from different areas in the city of Berkeley were tested for lead and correlated with traffic on neighboring streets (see Figure 14-4). Since the Integral Urban House is

Table 14-6. **Lead Content of Ashed Vegetables Collected near Roads**

Distance from Road (Feet)	*Lead Content in (Parts per Million)*	*Percent Reduction, Compared with Vegetables Grown at Road's Edge*
1–25	80	—
25–50	66	18
50–500	45	44
more than 500	20	75

Source: Lovering, *Lead in the Environment.*

Table 14-7. **Effects of Lead and Other Metals on Plant Growth**

Plant	*Solution pH*	*Metal Contents at Harvest (Ppm, Dry Weight)**	*Height at Harvest Inches*	*Cm*	*Effects of Metal on Growth*
Sweetpea	7.6	8200	60	152	Thin vines, no chlorosis, brittle roots,
	5.8	11	41	104	healthy, slightly chlorotic
Tomato	7.6	1500	31	79	Healthy, buds still developing,
	5.8	130	14	36	healthy, white tips on leaves
Bluegrass	7.6	2400	14–24	36–60	80% alive, still growing dk-blue-green smooth leaves
	5.8	2400	10–15	25–38	95% alive; still growing dk-blue-green rough leaves
Violet	7.6	430	7.5	19	Dark green, glossy; healthier than control plant; seed pods developed
	5.8	12	6	15	dark-green leaves

Note: The plants were grown in artificial medium—vermiculite, which contained 25 parts per million lead. Control plants were germinated and grown in a nutrient solution at pH 7.6; their lead contents in the dry weight at harvest were as follows: sweetpea, 18 ppm; tomato, 18 ppm; bluegrass, 33 ppm; violet, 13 ppm.

*Note that remarkably high levels of lead uptake result from growing in materials lacking in soil humus. 25 ppm of lead is not very high for urban soils.
Source: Lovering, *Lead in the Environment.*

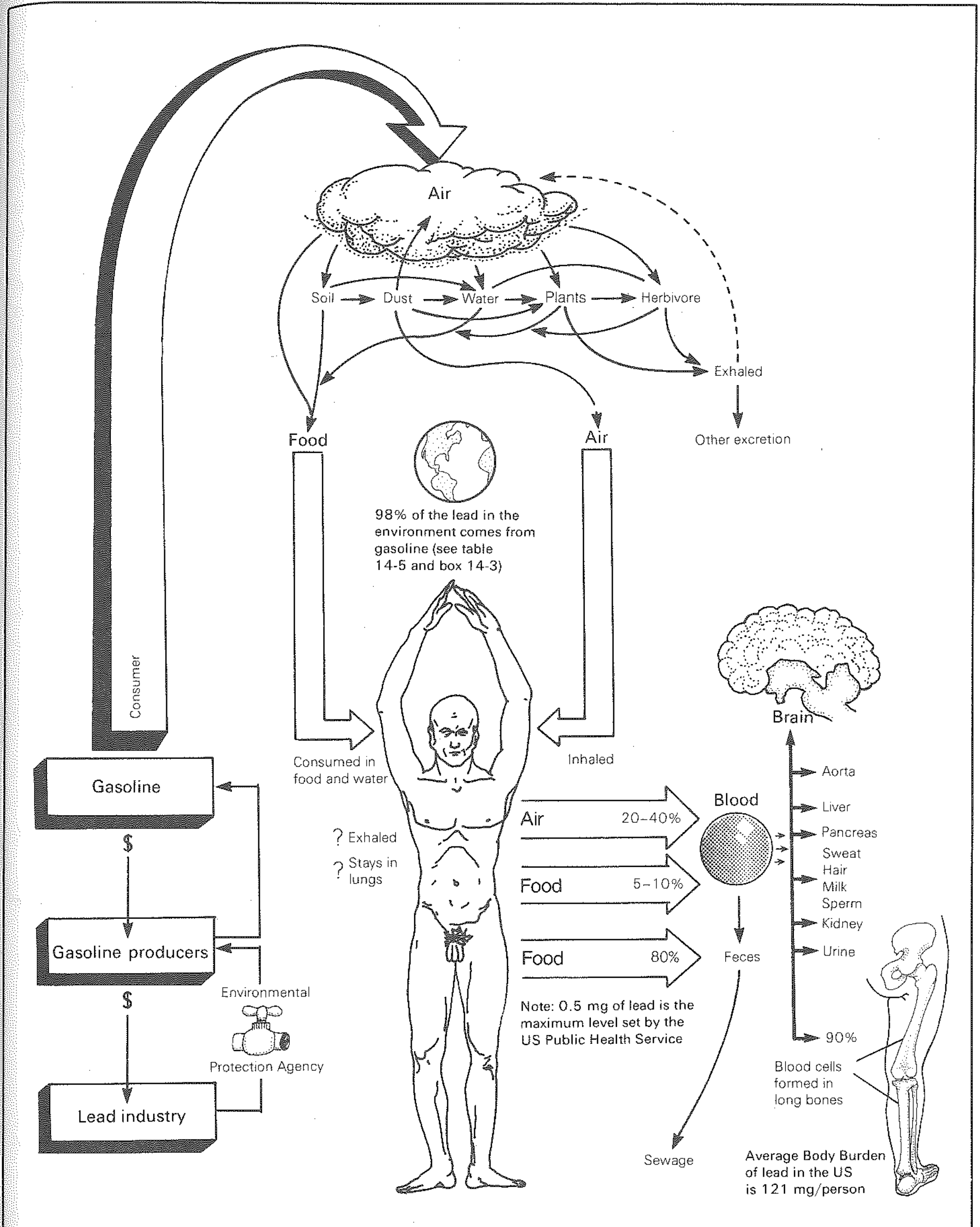
only six blocks from the freeway, not surprisingly the garden suffered the highest level of lead contamination.

However, other factors besides the proximity of the freeway may account for high levels of lead found on the vegetables at the Berkeley Integral Urban House. The house is located in a mixed industrial-residential neighborhood and is bordered by a paint factory, galvanizing plant, tannery, two trucking companies, a ceramic factory, welding shops, an ink factory, and two sand-and-gravel works. All these plants are polluting the area heavily with by-products of vehicle traffic and industrial processes. In contrast, the vegetables with the least lead in this analysis were grown in the backyard of an upper-middle-class, exclusively residential area from which through traffic has been diverted.

Table 14-6 shows how the amount of lead on vegetables decreases with the distance from roads. Table 14-7 shows how the amount that plants take up from an artificial growing medium varies with the acidity (pH) of the medium and the variety of plant. The appearance of the symptoms of lead contamination also varies with different kinds of plants. Another factor, not mentioned on this table, is the influence of organic matter in the soil. High concentrations of organic matter bind heavy metals, preventing them from entering food chains—another good reason for using a substantial amount of compost in the garden. Although this study shows that plants can take up lead through their roots, additional work is needed to relate this effort to different soil types and conditions.

Do the data cited here mean that one shouldn't grow food in urban areas? The fact is, if growing vegetables in this area is too dangerous, living

Figure 14-5. **A Model of Major Lead Pathways in the Environment**



Box 14-3. **Lead in the Human Body**

The average total daily uptake of lead for humans is estimated to be 300 micrograms per day, 20 micrograms of which comes from water and beverages. Using a 10 percent absorption rate, about 30 micrograms per day finds its way into your bloodstream from this route. Background levels of lead in the food supply if humans had not contaminated the environment have been estimated at .01 microgram per gram of food. Presently, the level is .2 microgram per gram, or twenty times higher than this estimate. Of course, the actual amount of lead intake is a function of the source of the food and water and personal physical differences, so they can actually be much higher than this average amount.

Figure 14-5 in the text illustrates the major sources and routes of lead uptake of importance to urban food producers. This figure indicates that if equal amounts of lead occur in air and in or on food and water, the most important route into the body and subsequently the bloodstream is through the lungs. This has been shown to be the case in the study summarized in Table A. About 20 to 40 percent of inhaled lead is absorbed through the lungs, while 5 to 10 percent is absorbed through the gastrointestinal tract. The lung route is even more important if one realizes that there appears to be little way for most of the remaining lead not absorbed into the bloodstream to leave the lungs, while ingested lead is largely passed out in the feces.

Observed clinical symptoms of low-grade lead poisoning (anemia, intestinal cramps, neurological damage, hypertension) start to be observed at blood levels of 60 to 80 micrograms per 100 milliliters of blood, and health can be damaged at levels of 40 micrograms in children. Ten percent of the blood level samples in the 1- to 16-year-old groups tested in Los Angeles exceeded 40 micrograms per 100 milliliters, and some were up to 60 mcg/100 ml.

Absorption of lead through the gastrointestinal tract appears to be regulated to some extent by the same processes controlling calcium and phosphorus absorption. Some antagonism to lead uptake occurs in the alimentary canal when calcium is present. Thus it is important that urban diets be high in calcium, which is found in a number of foods and can also be taken as a supplement.

Once lead enters the bloodstream, it tends to accumulate in the bones. There it may affect the formation of blood cells. Over 90 percent of the human body burden (in the United States the average burden is 121 micrograms) occurs in the bones.

The tissues and organs that accumulate lead, in descending order, are the liver, kidney, pancreas, lungs, bone, spleen, testes, heart, and brain. Many mysteries still remain concerning the entry of lead into the body, routes of dispersal in the body, and excretion levels. Lead poisoning, which often goes undetected, may result in mental retardation in children, early aging, kidney damage, and hypertension.

A laboratory that uses atomic absorption spectroscopy to detect lead does tissue analysis for the general public. (See Harrison and Win, "Determination of Trace Elements in Human Hair by Atomic Absorption Spectroscopy.") If you would like an analysis of your hair (which is the tissue most easily sampled and tested) and want to learn more about the testing procedure, write to Dr. G.G. Gordon, P.O. Box 187, Hayward, California 94543.

Table A. **Body Burden Lead Levels in the 1–16 Age Group**

Measurement	*Sex*	*Los Angeles*	*Lancaster*	*L.A./Lancaster ratio*
Blood lead	M	24	11	2.2
(μg Pb/100 ml)	F	17	10	1.7
Lead in hair	M	107	17	6.3
(short scalp hair)	F	70	12	5.8
Urine lead	M	18	10	1.8
(μg Pb/liter)	F	16	14	1.1
Fecal lead	M	1.7	1.4	1.2
(μg Pb/gram)	F	1.1	1.6	0.7

Note: Lancaster, California is a rural desert town in contrast to Los Angeles, which is a large metropolis. The average air lead levels in Los Angeles is 6.3 micrograms per cubic meter (μg/m³) while, in Lancaster, it is 0.6 μg/m³). Soil lead levels are 30 times higher in L.A.

Source: Council on Environmental Quality, 7th Annual Report.

here might just be too dangerous also. Most of the lead your body accumulates is taken in through your lungs, as Figure 14-5 shows. The vegetables are in the air for only a few months, but you are growing and living in it season after season. If it is too dangerous to raise vegetables in your front yard, it might be too dangerous to breathe there too.

What to Do About Lead Pollution: What should you do if you live in a heavily polluted environment? The following are some general guidelines:

1. If your street is heavily traveled, don't raise vegetables out in front of the house if you can find another place to raise them. Obviously, the same advice goes for side or back yards that lie along busy streets. Do plant high hedges to trap heavy lead particles in the air. Whenever possible these should be placed between the street and the garden or wherever they will

slow down winds blowing from lead-emitting sources.

2. Incorporate plenty of organic matter in the soil to bind lead and other heavy metals there so that they will not be taken up by plants.

3. Wash vegetables grown in gardens near busy streets very carefully. The studies of University of California students determined that 20 to 80 percent of the lead was removed by washing. A touch of vinegar in the wash water is helpful for rinsing off the lead. Any vegetable that has been protected by an outer covering (peas in a pod, corn on the cob, the inner leaves of cabbage, and so on) is less likely to have picked up lead fallout from the air. Exposed vegetables from areas known to be contaminated should be peeled or thoroughly washed before eating.

Box 14-3 describes the effects of lead on the human body. If you are concerned about yourself and your children becoming poisoned by the lead in the air where you live, either stop breathing or start working actively to get the lead out of gasoline. Of course, such efforts will take you out of your integral urban house and into the larger community.