The East Austin Housing Science Center:

Towards a More Environmentally Accountable Design Approach.

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Bachelor of Arts (Architecture)
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SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE ON JANUARY 18, 1991 IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE MASTER OF ARCHITECTURE AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Thesis Supervisor: Timothy E. Johnson
Title: Principal Research Associate

Abstract:

This thesis project focuses on the community design implications for a less resource intensive way of life in the US context.

The quantifying of the input, output and cycling of resource flows (energy, materials, water, biomass) at the site scale should provide a better understanding of the underlying support metabolism that an architect impacts with design decisions. This thesis attempts to identify opportunities and limitations for form generation by exploring the process of encouraging the sustainable utilization of on-site resources (primarily sun, wind, rain, plants and soil). To structure the understanding of these flows and tradeoffs involved, the development of simulation models and matrices is outlined.

Over the life of a community, society's understanding of these flows will change, as will other aspects such as economically viable technologies, resource availability, behavioral patterns, and perhaps even climate. This thesis will explore an architectural framework that will be more resilient to future opportunities.

To provide a design context for these decisions, I explored the phased growth of an affordable mixed-use, experimental community for the Center for Maximum Potential Building Systems on a 50 acre tract on the eastern city limits of Austin, Texas.

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Introduction

Thoreau asks "What good is a house, if you don't have a decent planet to put it on?" I can barely put a pencil to the paper, draw a concrete or wood or steel construct without feeling guilt for the off and on site destruction such a gesture would entail, or worse yet, for not knowing which is more damaging. I am discouraged by the toxicity of materials we build with and the placeless automobile context we condone. I am confused by claims and counterclaims about what is more or less environmentally benign.

Garrett Hardin, in his 1968 classic "The Tragedy of the Commons," addresses this issue of guilt. His essay begins that global resources such as arable land, when viewed as a common, is basically limited, thus population growth demands must eventually level out. Natural selection, Hardin notes, favors the forces of psychological denial, the individual who is not constrained by the collective perspective. Conscience is self eliminating. "Responsibility is the product of definite social arrangements" (Frankel). Yet society sends conflicting messages: "maximize production" and "practice moderation." That is, society attempts to "browbeat a free man in a commons into acting against his own interest," into being a responsible citizen, a simpleton.[1] We all operate on differing spectrums between what is tolerated and our personal standards; we tend to be numb to the rest.

This is a guilt driven thesis by a pessimistic idealist. I have an undeveloped sense of what I believe would be better, but feel at such a loss as how to contribute. Hardin's essay expands upon the pathogenic effects of such a state, how "the guilty pay attention only to themselves" (Goodman), "the double bind" (Bateson), how "a bad conscience is a kind of illness" (Nietzsche).

This thesis provides an opportunity to structure an approach to these issues. The first section introduces the concept of sustainability , with an emphasis on the community scale in the United States. The second section considers the architects role, especially in the considering the externalities in selecting building materials, and then proposes criteria and options for more environmentally and socially sustainable community design. The third section describes efforts to identify tools to help model the ecological complexity at the site scale. The fourth section is the design phase. Here, there is an attempt to bring together what was learned in the earlier studies to design a growing, affordable, self reliant community for the Center for Maximum Potential Building Systems on a 50 acre tract on the eastern city limits of Austin, Texas.

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[1] Hardin,G. "Tragedy of the Commons." *Science.* [1968] 1243-1248. Q.S399 p.162

1 Sustainable Design

Sus•tain•a•ble adj of sus•tain 1. To keep in existence, maintain. 2. To supply with necessities or nourishment. 3. To support from below. 4. to support the spirits, vitality, or resolution of. [American Heritage Dictionary]

The biosphere's ability to absorb and sustain human practices is seriously stressed. This section introduces cultural, ethical and personal aspects of sustainability at various scales: urban, communal and domestic. I discuss two built environments that strongly shaped my biases towards the automobile and multi-family housing. This section describes the vision, recommendations, and efforts of some who are attempting to address these issues at the community scale in the United States. One of these groups, the Center for Maximum Potential Building Systems has provided a design exercise about which to center these issues of sustainability.

1.1 Think globally, act locally

To think globally means acknowledging a near future of massive deforestation and desertification along with cities of whole new magnitudes. Having lived and worked in Haiti makes Thomas Malthus' dire predictions very possible to me. While it may become possible for an increasing number of people to develop and afford technologies to compensate for the degradation of the biosphere, the reality is that there will be even more who will not. In the Third World, as Hardy and Satterwaite note " the notion that environmental quality and pollution control are luxuries is eroding". [2] They add, ironically, "Since governments in the north started enforcing more stringent regulations, production in certain 'dirty industries' has increasingly been transferred to the Third World to cut costs - [asbestos, arsenic, lead batteries, etc.]. World sustainability now depends on the capacity of cultures to adapt and reduce their willingness to borrow from future cultures and on developing countries embracing new models not from industrially developed countries. Yet the mass-

2 Hardy. J.E., 1985.

marketed West has most seductive models to define "the good life," especially to the aspiring policy makers of developing countries. After returning from Haiti, "to act locally" meant to help redirect at least some of the West's wealth to explore and test more environmentally responsible models.

> A sustainable condition for this planet is one in which there is stability for both social and physical systems achieved through meeting the needs of the present without compromising the ability of future generations to meet their own needs.[3]

The central dimension is basic ethics - a consideration for those who will come after. There are social dimensions (the best for the most) and economic (towards a more stable state), but the core is ecological (the longer term integrity of the surrounding biosphere) .[4] Like the biblical principle fixed in English common law: "Use what belongs to you in such a way that you do not impair the rights of others" or as John Locke implores: preserve the productive base and "live off the

---

[3] *Our Common Future*, United Nations Publication, 1987.

[4] Brown, B.J., M.E. Hanson, D.M. Liverman, and R.W. Merideth, Jr. 1987. Global Sustainability: Towards Definition. *Environmental Management* 11: 713-719.

dividend, " sustainability is primarily a respect for the underlying life sustaining or biotic supports for the ecosystem of which humans are a part.[5] This calls for a longer term perspective of politically implausible moderation within reasonably conservative boundaries - rather than the shorter term maximizing of a system's potential economic output.

There is an optimum population size that offers the highest material standard of living for the potential of technologies available to the population .[6] Maintaining these same practices eventually results in degrading resources; with a growing population this rate of degradation is accelerated. "There is nothing that fails like success," observes Harvey Brooks,

> We should try to understand [what practices are] sustainable for how long, to understand what changes take the system to what boundary. We should try to understand how to keep society sufficiently open to new ideas, so that these past success formulas are not rigidly maintained beyond boundaries. [7]

---

[5] Repetto, Robert ed., *The Global Possible: Resources, Development, and the New Century*, Yale University Press, New Haven, HD75.6.G55 1985. and Woodwell, G.M. 1985 "On the Limits of Nature" in [Repetto 1985].

[6] Woodwell, G.M. 1985 "On the Limits of Nature" in [Repetto 1985].

[7] Brooks, Harvey. "What is Sustainability?" Presentation.

William Clark points to the "surprise free" analysis of the U.S. auto industry, its failure to respond to the oil supply shocks of the early 1970's and the vulnerability of evolving into a "technological monoculture." Most often, technological developments are oriented more towards improving the access (exploitation) to resources than improving or regenerating the underlying resource base itself.[8] This is reflected in the wood and fish products industries promotion of chipboard and "surimi," where technology is used to replicate the less available higher grade resource.[9]

"As the detailed management of the biosphere is beyond human capacity at the moment," observes Woodwell, "the most practical steps are those that limit human intrusion." This means:

Harvard GSD 13 Feb 1989.

8 Woodwell, G.M. 1985 *ibid.*

9 Regier, H.A., and G.L. Baskerville. 1986. "Sustainable Redevelopment of Regional Ecosystems Degraded by Exploitive Development." In Clark, W.C. and R.E. Munn. [1986].*Sustainable Development of the Biosphere.* Cambridge University Press, Cambridge. HD75.6.S87 1986.

1) Zoning segments of the biosphere to maintain diversity by some finite ratio between disturbed and undisturbed natural systems that would be appropriate to assure the preservation of both biotic diversity and the normal function of the biosphere.
2) Closing human dominated systems; control of the ins and outs of man dominated systems is but one step in the ascent towards reason in the management of the biosphere. [10]

1.2 Cities

The most intense human dominated systems are urban settlements, followed by agro-industry. In theory, cities offer the potential of certain efficiencies by concentrating large populations and freeing up more undisturbed areas. In reality, cities are notoriously dependent on imported energy and materials to support wasteful water practices and energy-inefficient buildings and transportation systems. Air quality, solid and toxic wastes (or by-products) are the current crisis. "Sustainable cities" seems an oxymoron.

Richard Meier is a leading thinker on addressing the challenge of exploding "third world" cities. He suggests that any new community added to the

10 Woodwell, G.M. 1985*ibid.*

metropolis "should be quickly become responsible for the production of food" through intensive gardening techniques while the urban periphery is used to enhance the efficiency of recycling processes. [11]

With existing American cities on the East coast barely maintaining a crumbling infrastructure and those on the West predicated on automobile dependence, to focus on creating new towns in pristine natural settings is all too tempting. Certainly in these new developments, every reasonable effort should be made to adopt proven state of the art concepts and technologies that can more easily adapt to a less resource intensive ways of life. The casual land planning of the American west has led to a leap-frogging over existing urban capital, meaning underused schools, parks, playgrounds, utilities, cultural and health facilities as well as the invasion of farmland and the extreme reliance on the automobile. [12]

[11] Meier, Richard. A Stable Urban Ecosystem. *Scientific American*. ? 1976.

[12] Robinson, I. "Energy and Urban Form." Byrne, J. ed. *Energy and Cities*. Transaction, New Brunswick, NJ. HD108.2.E525 1985.

However, studies by J. Zucchetto conclude there is ...

> no hard evidence that large urban systems are inherently more energy efficient than small ones are so that a future world of energy scarcity cannot be said to imply a selection for urban agglomeration. ...[That] municipal costs per person also exhibit a minimum at some level on the order of 2-300,000 people. [That] contrary to the 'conventional wisdom,' the spatial array of homes and destinations for personal travel in the suburban ring is increasingly conducive to energy efficiency or at least at lower rate of growth than prevails in the central city. ..There seems to be an emerging realistic and plausible point of view that a dispersed nodal pattern, with small places of varying sizes (10,000 to 300,000) interconnected by transport and telecommunications networks, is the pattern that is evolving.[13]

1.3 Thinking locally: quality of life

The call to act locally means to behave responsibly with a sense of one's share. To act locally means to aim for the highest quality of life allowed by economic, moral, social, legal and other constraints for the least effort. Responsibility and quality of life are central issues, and as Hardin points out, can

[13] Zucchetto, J. Energy and the Future of Human Settlement Patterns: Theory, Models and Emperical Considerations. *Ecological Modeling*, 20 [1983] 85-11.

Figure 1: Images of the Future

Decentralized

Optimistic	Pessimistic
1 **Metaindustrial** *Long-range prospect:* World-wide decline of urban-industrial civilization eased by return to local and regional economies. Integration of classical economies of the past into a new structure of civilization. *Prophets:* William Irwin Thompson, Murray Bookchin, E.F. Schumacher, Amory Lovins, Theodore Roszak, Lewis Mumford, Ivan Illich. *Cultural expression:* The meta-industrial village and the planetary city, decentralized biotechnologies, a symbiosis of nature, self, and society.	3 **Preindustrial (A new, final dark age)** *Long-range prospect:* World-wide collapse of interconnected global economies. Massive drop in population. Chronic cycles of plague and famine. A return to savagery. *Prophets:* Roberto Vacca, Paul Ehrlich. *Cultural expression:* A decimated landscape of deserted cities, mined for their "raw" materials, tribal bands wandering the countryside. Chaos and conflict over scarce resources.
2 **Superindustrial** *Long-range prospect:* World-wide development of postindustrial economies. Fifteen billion people earning $20,000 a year. Elimination of poverty and disease. Infinite supply of energy and materials through the exploitation of space. *Prophets:* Herman Kahn, Gerard O'Neill, Daniel Bell, B.F. Skinner. *Cultural expression:* On earth we would have the "city of efficient consumption," a Disneyworld of manufactured fun and adventure. In space, we would have efficient industry and fantasy islands.	4 **Hyperindustrial** *Long-range Prospect:* World-wide freeze on industrial growth. Revolt of the masses requiring massive, often severe, centralized control by state. Technical elite and military join together to prevent collapse of civilization. Privilege of the few maintained at the expense of the many. *Prophets:* Robert Heilbroner, H.G. Wells. *Cultural expression:* "Federal" architecture, poorly serviced, joyless "Pentagons" and bare necessities with zones and pockets of opulence. A "1984" police state.

Centralized

Adapted from the Alternative Futures Matrix in Nigel Cross, David Elliot, and Robin Roy, Designing the Future *(London: Hutchinson & Co., Open University Press, 1975), p. 27.*

represent a dilemma. Though these terms cannot be defined precisely, many people are looking for ways, social structures, that make social responsibility and a higher quality of life more compatible. These people often share and sell an optimistic vision of the future, one I find most seductive, one characterized as *metaindustrial.* The primary concerns of those striving for sustainability tend to be to: 1) continue support for human life on earth, 2) maintain agricultural resources and production, 3) stabilize human population growth, 4) limit growth economies, 5) foster self reliance and 6) assure the basic integrity of the biosphere.

Ernst Callenbach's 1975 novel *Ecotopia* wonderfully illustrates a future ecological nation. [14] A contemporary version of Edward Bellamy's *Looking Backward: 2000-1887,* Callenbach considers the secession of the Pacific Northwest from the United States and the establishment of a progressive society.[15] In *Ecotopia,* here are all

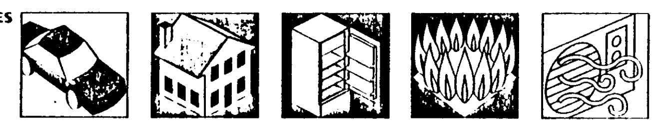
[14] Callenbach, Ernst. *Ecotopia: The Notebooks and Reports of William Weston.* Banyan Tree Books. Berkeley. 1975. PS3553.A424E35 1990.

[15] The standard excerpt from *Looking Backward: 2000-1887* has a time traveler waking up in Boston in the year 2000. "Who does your housework then?" I asked. "There is none to do," said Mrs. Leete, to whom I addressed this question. "Our

types of regenerative technologies; the architecture is made of "natural non-toxic biodegradable enzymes plastic" that can be broken down in "bio-vats." There are no cars, mostly trains and plentiful bicycles free for the borrowing. This work, along with Kirkpatrick Sale *Dwellers in the Land* and to a lesser extent Joel Garreau's *The Nine Nations of North America* make political the concept of *bioregions*. As defined by Sale, *bioregions* is an area "defined by its life forms, its topography and its biota, rather than by human dictates; a region governed by nature, not legislature." [16,17] This concept grows form the concept of biomes and biogeography advanced by Udvardy and others.

North America is a bountiful continent, the USA contains more than one third of the world's best arable land.[18] Without resorting to statistical manipulation, suffice it to say that the average American and Canadian consumes a disproportionate share of the world's resources to maintain a way of life. As world population increases, and more compete for less of the more easily available, higher grade resources, the USA will find it worthwhile to become much more efficient. In fact, this will become the real stimulus for near term industrial growth. In the field of energy, Amory Lovins has been particularly articulate in the growth-through-conservation approach.[19]

OPPORTUNITIES FOR EFFICIENCY



	CAR MILES PER GALLON	HOME THOUSAND JOULES PER SQUARE METER	REFRIGERATOR KILOWATT HOURS PER DAY	GAS FURNACE MILLION JOULES PER DAY	AIR CONDITIONER KILOWATT HOURS PER DAY
MODEL AVERAGE	18	190	4	210	10
NEW MODEL AVERAGE	27	110	3	180	7
BEST MODEL	50	68	2	140	5
BEST PROTOTYPE	77	11	1	110	3

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washing is all done at public laundries at exceedingly cheap rates, and our cooking at public shops. Electricity , of course, takes the place of all fires and lighting. We choose houses no larger than we need, and furnish them so as to involve the minimum trouble to keep them in order. We have no use for domestic servants." " What a paradise for womankind the world must be now!" I exclaimed. From Hayden, Dolores. *The Grand Domestic Revolution*. MIT Press, Cambridge, MA. HQ1426.H33 1983. p 135.

16 Sale, Kirkpatrick, *Dwellers in the Land: The Bioregional Vision*. San Francisco: Sierra Club, 1985 p. 43.

17 For an excellent critique see Alexander, Donald, "Bioregionalism: Science or Sensibility?" *Environmental Ethics*, Vol 12, Summer 1990. pp 161-173.

18 Bertrand, G. *Ecological Processes and Life Support Systems*. HC79.F5.S87 1984. p27.

19 Lovins, Amory B. *Soft Energy Paths: Toward a Durable Peace*. Harper & Row, New York. 1977.

The challenge will be to live better on less. If improving the quality of life for the most people is a goal, it can be lost in the confusion of individual biases. In the United States this is made even more complex by the experiences and aspirations of a great range of sub cultures, and becomes problematic when the "quality of life" for one subculture depends upon excluding those with conflicting perspectives. The built environment is just one aspect in one's sense of quality of life. It is a vital one, however, people work very hard to afford better settings. The sense that the quality of life is declining makes for nostalgia. Tony Hiss documents the struggles of the Klien farm, the last working truck farm inside New York city limits. [20] He points out the many benefits of such a place, and suggests means to promote higher quality humanized landscapes.

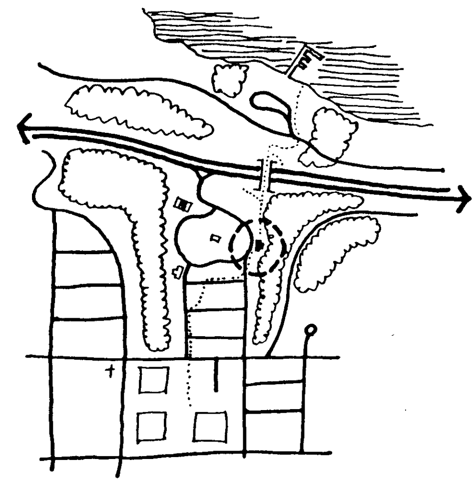
Sustainability calls for regenerating the existing urban fabric. The traditional clustering of businesses along busier bus serviced streets is a good type for encouraging pedestrians. Two places that come from my past, a neighborhood center and a multi-family housing complex, influenced my conception of a sustainable urban fabric.

[20] Hiss, Tony. *The Experience of Place*. New York: Knopf. BF353.H57 1990

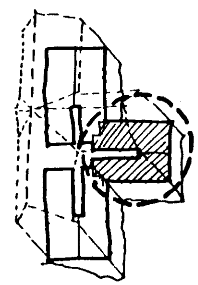
An example of a high quality neighborhood center is Montlake in Seattle. It is on an excellent bus route, with busses coming every fifteen minutes from the downtown, passing Montlake and looping back cross town via the University of Washington. From 1985-1987, I worked in a four person architecture firm.The office had a big shop window, with models displayed, and people could look in and see what we were doing while they waited for the bus. Across the street was a fix-it shop, pub, photo developer, and "The Daily Grind" cafe. Next to our office was a fancy five table restaurant, hair salon above which was a small office, and a public library. The hair salon was in what once was an entrance to a movie theater, which had been converted to apartments. Surrounding this node is moderate density detached housing, an elementary school, and a large Arboretum. Parking is generally balanced; street parking becomes available as some residents leave on their commute. The Arboretum is part of an Olmstead influenced greenbelt that extends for miles along Lake Washington, and links one to an excellent bicycle route network.

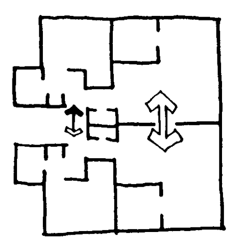
Another example of an alternative development type serves as a lesson for a future housing option. From age five to twenty, I lived in Shorewood, a post

World War II apartment complex made up of approximately forty three story buildings with 10 to 15 units each. What distinguishes this place was that it was bounded to the east and west by two wooded ravines, perfect for playing and growing. The complex was divided into two parts. The lower half was for adults, but we children could walk the half mile through it to use the semi-public beach. Dividing the two parts is Interstate 90, a concrete ribbon connecting Seattle to Boston. Spanning the freeway was a walkbridge that allowed access not only to the beach, but to bus stops on either side. As the highway was a funneling of outlying routes, this gave us excellent service downtown. To the south was a three school complex to which I walked the same half mile for thirteen years.



There were buildings for adults only and those that allowed children. Many families new to Seattle lived in Shorewood for a few months while their houses were being built. We liked it and stayed. Other friend's houses struck me as big and fat. When the two bedroom, one bath, 42 sf kitchen felt tight for four of us, we moved to another building in the complex in which two one-bedroom units were connected, and an extra living room became a studio bedroom. The walls were thin. We learned that "one man's ceiling is another man's floor."





The neighborhood center and multi-family housing complex cited are presented not as answers, however, they represent proven alternatives offering land, and probably energy, conserving, high quality community settings. The distinguishing aspects are 1) decent sub-urban density with an intensity and scale that makes walking more interesting; 2) the collection of people that justifies better transit service; and 3) the greenbelts that provide relief, escape, and community boundaries.

1.4 History Lessons: Domestic Technology

The United States has a rich legacy of people trying not only to define, but to actually live out ideas for more socially and environmentally sustainable communities.

Communitarian thinking was most popular in the United States between 1820 and 1850, decades of agitation for abolition, labor rights, equitable land distribution policies, women's right, educational reform, and penal reform... ' We are all a little wild here with the numberless projects of social reform' [Ralph Waldo Emerson in 1840]. [21]

[21] Hayden, Dolores. 1976. *Seven American Utopias: The Architecture of Communitarian Socialism, 1790-1975.* Cambridge, MA. MIT Press. 1976, HX653.H39. p. 9.

Another compatible history, that of the "material feminists" is particularly well addressed in the works of Dolores Hayden. She writes that the "material feminists expounded that women must create feminist homes with socialized housework and child care before they could become truly equal members of society ."[22] They saw multi-family housing as an opportunity to provide a density for the economies of scale that would allow shared facilities, especially food preparation and laundering. In 1874, architect Henry Hudson Holly proposed a

cooperative family hotel... with two story units, some with street access, some reached by a third floor corridor, all served by kitchen, laundry, dining room, and barber shop in the basement. Elevators, tramways, and steam tight cars were to be used for the quick and clean distribution of food to the private dining rooms.." [23]

At the turn of the century the apartment house was seen as a more sophisticated, evolved form of housing, while to others, such as the 1903 editors of *Architectural Record*,

The adoption of apartment hotel life by any considerable section of the permanent population of New York could not but be regarded with grave misgivings by all observers of American morals and manners. [For] a woman in an apartment

[22] Hayden, Dolores. *The Grand Domestic Revolution.* MIT Press, Cambridge, MA. HQ1426.H33 1983.

[23] Hayden, D. 1983 *ibid.* p. 192 and 193.

has nothing to do... If she makes anything out of her life at all she is obliged to do it through outside activities...[24]

Twenty years later, the Editor for the *Journal of the American Institute of Architects* would take a more sympathetic view: "Freeing men and women for social contact is vitally more important than cloistering them in a home ... shall we dare predict, then that the ideal home of the future will be kitchen less?[25] Hayden includes a range of progressive designs, particularly noteworthy is Alice Constance Austin's 1916 plans for Llano del Rio, California in her book *The Next Step*. She proposed a city fabric for 10,000 persons with kitchenless houses all connected for food delivery, transport, and utilities by a complex underground network of tunnels. Private autos would be parked outside the city limits. [26]

Owing to traditional societal roles, women have been charged with household scaled management. A 1869 classic on the subject was *The American Woman's Home: Principles of Domestic Science*, by Catherine Beecher and Harriet Beecher Stowe, complete with house plans:

[24] Hayden, D. 1983 *ibid.* p. 51.

[25] Hayden, D. 1983 *ibid.* pp. 250.

[26] Hayden, D. 1983 *ibid.* pp. 242.

The kitchen has become a streamlined, single-surface space, penetrating the center of the house with its mechanical core of water closets and heating and ventilation equipment. Flexibility is maximized with movable decorative screens hiding extra beds and dressing areas... inventions proliferate, so that the woman without servants , .. now has the most advanced technology .. far superior to the equipment available in most houses designed by male architects and builders for households with servants. [27]

Under the chapter "The Ignorance of Architects," they address indoor air pollution and

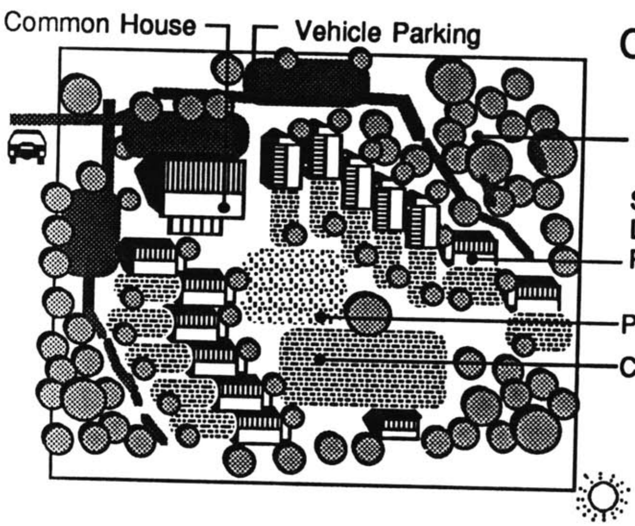
...evils resulting from the substitution of stoves instead of open fireplaces have led scientific and benevolent men to contrive various modes of supplying pure air to both public and private houses ... And yet from mistaken motives of economy, as well as ignorance... multitudes of householders are thus destroying health and shortening life, especially in regard to women and children who spend most of their time indoors. [28]

With a whole chapter, they make a case for earth (composting) commodes. They refer to the Chinese who are "in advance of our nation in neatness, economy , and healthful arrangements. In China, not

[27] Hayden, D. 1983 *ibid.* pp. 54.

[28] Beecher,Catherine and Harriet Beecher Stowe, *The American Woman's Home: Principles of Domestic Science*, Arno Press, 1971 TX145.B415 1971. p. 54.

a particle of manure is wasted.." They then cite a 1868 newspaper article quantifying the food fertilizing value flushed out to sea each year via the New York sewers.[29] In 1875, Ellen Swallow Richard became the first woman on the MIT faculty, and established the Woman's Laboratory. In 1890 she taught the analysis of water, air, sewage in the nation's first program in sanitary engineering and coined the term "oekology: the science of normal family life." [30]

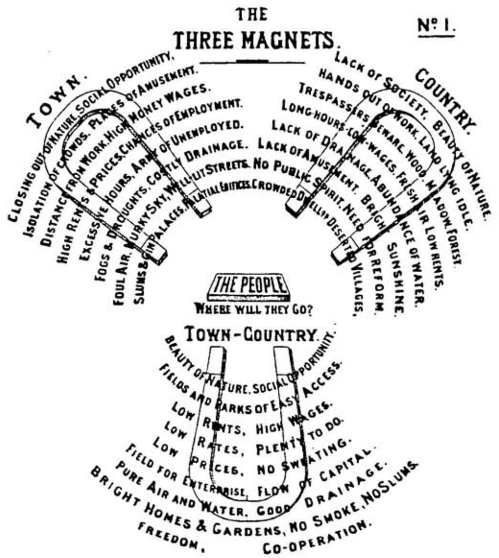


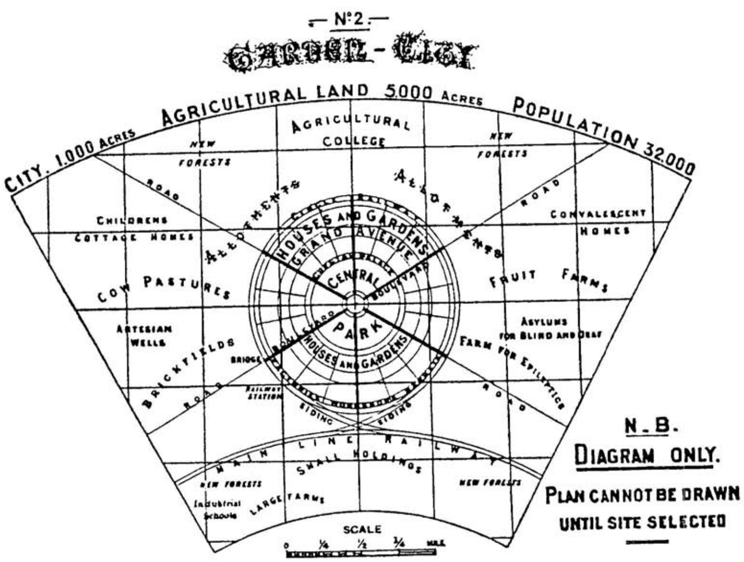
29 Beecher,Catherine and Harriet Beecher Stowe, *ibid.* p 403.
30 Hayden, D. 1983 *op.cit.* pp. 157.

One legacy of the kitchenless house is the *cohousing* typology.[31] With cohousing, the families have the option of eating their meals in a common dining hall with other families of their housing cluster.The private kitchen, the social hearth of the contemporary home, is still welcomed in the separate units, although usually smaller.

In 1871, at age 21 Ebenezer Howard, the principal figure of the British Garden Cities movement, came to the United States to an inherited farm. He was exposed, Lewis Mumford notes, to "the constant spectacle of new communities being laid out every year on new land, and was impressed by the possibility of a fresh start." [32] There was another impact on Howard, who " in his brief stay in the US, had seen how much harm can be wrought by land speculation." [33]

31 See McCamant, Kathryn and Charles Durett. 1988. *Cohousing: A Contemporary Approach to Housing Ourselves.* Berkeley, CA: Habitat Press. HT7287.72.D4M37 1988.
32 Howard, Ebenezer. *Garden Cities of To-Morrow,* Originally 1902. MIT Press. 1965. p.18.
33 Newton, Normon T. *Design on the Land: The Development of Landscape Architecture*, Belknap,/Harvard, 1971. SB470.5.N565C.2.





GARDEN CITY AND RURAL BELT

Environmentalism and social progressives did not begin in the sixties. Clarifying and defining the human /social /environment relationships is a fundamental question, not a fad. One could go back to Plato, lamenting the deforestation and erosion about the Mediterranean, or to those influential in the United States: Ralph Waldo Emerson, Henry David Thoreau, George Perkins Marsh, Frederick Law Olmstead, Teddy Roosevelt, and Gifford Pinchot. As William Clark, points out, in each age, there is a swinging pendulum of positivists & conservationists , "we must remember each individual is a captive of where he or she got captured."[34]

1.5 Agreed, but How? Now?

Scale is the most misunderstood environmental issue in the so-called appropriate technology movement. Between the giant corporation and the tiny houses, environmental alternatives require new social, economic, and architectural innovations as well as new, energy saving inventions. While the environmentalists are still developing a very effective accounting of the wasteful, destructive patterns of present resource use, they have not yet come to terms with the reconceptualization of the private home as the key to the next set of public issues they must address.[35]

34 Clark, William . "Ecology and Global Change." Lecture Harvard GSD. Spring 1989.

35 Hayden, Dolores. *Redesigning the American Dream: The*

R. O'Neill asserts the importance of the appropriate spatio-temporal scale to consider a phenomenon. For example, we as the public are beginning to understand the beneficial role forest fires. This came from the realization that perhaps the best scale on which to study large fires is not the forest stand, at which a fire is obviously devastating, but at the level of species diversity where the fire becomes beneficial. He adds that "problems result if one forgets the simultaneous influences of different process operating at many different scales."[36] The systems of the buildings and the systems of the city are symbiotic. To better understand "the appropriate spatio-temporal to consider a phenomenon" is paramount for intelligent decision making.

Houses add up to blocks, blocks to neighborhoods, neighborhoods to districts, districts to cities, cities to Metropolitan regions, et cetera. One can construct a hierarchical perspective of human impact on the biosphere, from the relatively "fast rate" lower level use of buildings whose production is filtered up as consequences to higher level slow changes at the city level. One of the foremost thinkers in the integrated study of human settlements was Doxiades spelling, who advanced a planning approach termed *ekistics*.

Anne Spirn, author of *The Granite Garden* states "Architects usually have no concept of how their projects will effect the city as a whole...The complexities of the urban ecosystem defies understanding, but the dangers of not comprehending are frightening." [37] David Bainbridge of the Dry Lands Research Institute, University of California, Riverside laments the absence of real cost accounting and the lack of ecological literacy in subdivison planning practice: - "the real problem is the difference between economics as the accountants and business people know it and economics as the ecologist views it."[38] He decries "efforts by the politicians to manipulate the market and provide seemingly cheap food, energy, water and housing." [39] He adds that "progress toward energy self-reliant neighborhoods will be slow until the market more accurately reflects the costs and benefits." [40]

Future of Housing, Work, and Family Life. New York: W.W.Norton & Co., HD7293.H39 1984.. p. 48.

36 O'Neill, R. et al. 1987. *Hierarchy and Ecosystems Book.* Princeton University Press, Princeton, New Jersey.

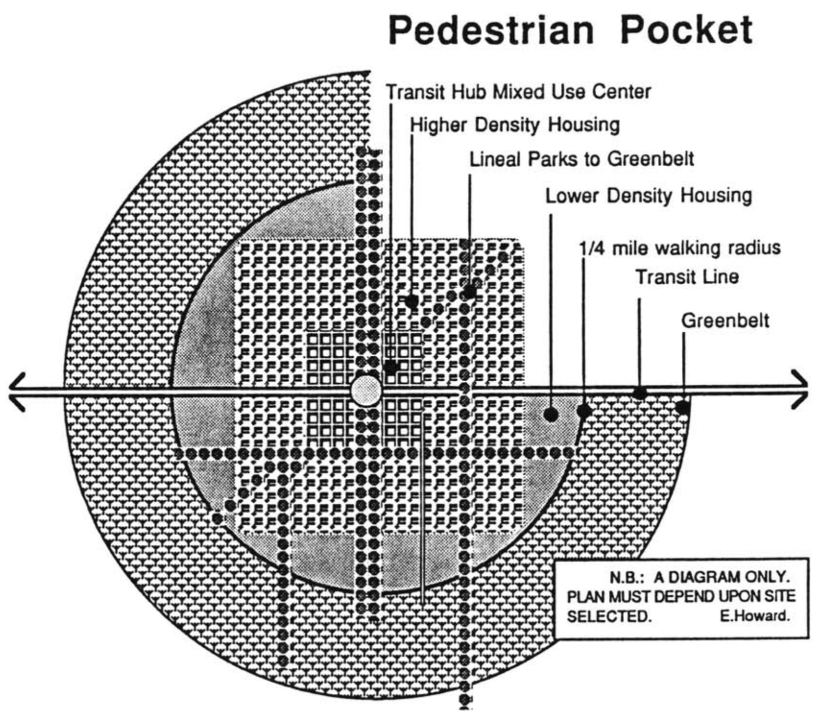
37 Spirn, Anne W. *The Granite Garden: Urban Nature and Human Design*. Basic Books, Harper, New York. HT166.S638 1984. p

38 Bainbridge, David. "Energy Self Reliant Neighborhoods." ASES Paper p. 398 .

39 Bainbridge, D., *ibid.*p. 399 .

Most working towards defining less resource intensive ways of are slowed by perceptions what is considered reasonable, that is, reconciling the gap between behavior modifications and technological possibilities. It would be good to say progress is being made to this end, but few who are strong in this type of accounting have addressed the house, building, or site scales. Perhaps the scale of the house and neighborhood is not the best at which to perceive and remedy disruptions to ecological flows, but it is a critical because this is the level at which the average person requires feedback in order to influence their behavior.

Existing cities are the near future reality. With so much embodied energy invested in existing structures, the effort should be on redirecting outward sprawl (or human intrusion) towards healing the damaged districts. One evolving typology is the pedestrian pocket, basically an intense pedestrian oriented mixed-use community centered around a well serviced public transit node.[41]



[40] Bainbridge, D. *ibid.* p. 400 .

[41] Kelbaugh, D (ed.) *Pedestrian Pocket Book.* Princeton Architectural Press, New York. HT169.55.P44 1989.

Making cities greener with more "Victory Gardens" is a very direct and effective way of improving the quality of a built environment, as well as a offering a means of focusing community interaction.[42]
Urban *permaculture*, as defined by Michael Corbett, is:

> ...looking for ways to supply food, clothing, shelter, health care and meaningful livelihoods, while also maintaining an environment conducive to physical and mental health, preserving the natural ecosystems, conserving natural resources and non-renewable energy sources, providing human settlements that will survive more comfortably during severe environmental (and economic) fluctuations and developing a culture that encourages human fulfillment and happiness.[43]

One particularly interesting attempt at urban *permaculture* has been proposed for communities in South Australia. After what appears to be careful and sensitive analysis of the communities specific challenges and opportunities, the *Urban Permaculture Consultants* recommended an urban forestry program and a community city farm .[44]

The *Integral Urban House* in Berkeley, California remains perhaps the most ambitious and well documented American attempt to create, on a one house scale, a more self-reliant, closed system that explicitly identifies and minimizes non-renewable inputs and harmful byproducts.[45]

There are a few facilities in the United States that combine regenerative research as well as serving as an educational and demonstration functions. The most notable facilities are the New Alchemy Institute in Falmouth Massachusetts; the Rocky Mountain Institute in Old Snowmass, Colorado; the emerging village of Cerro Gordo, Oregon and the proposed Institute for Regenerative Studies, on the campus of the California State Polytechnic University, Pomona.[46]

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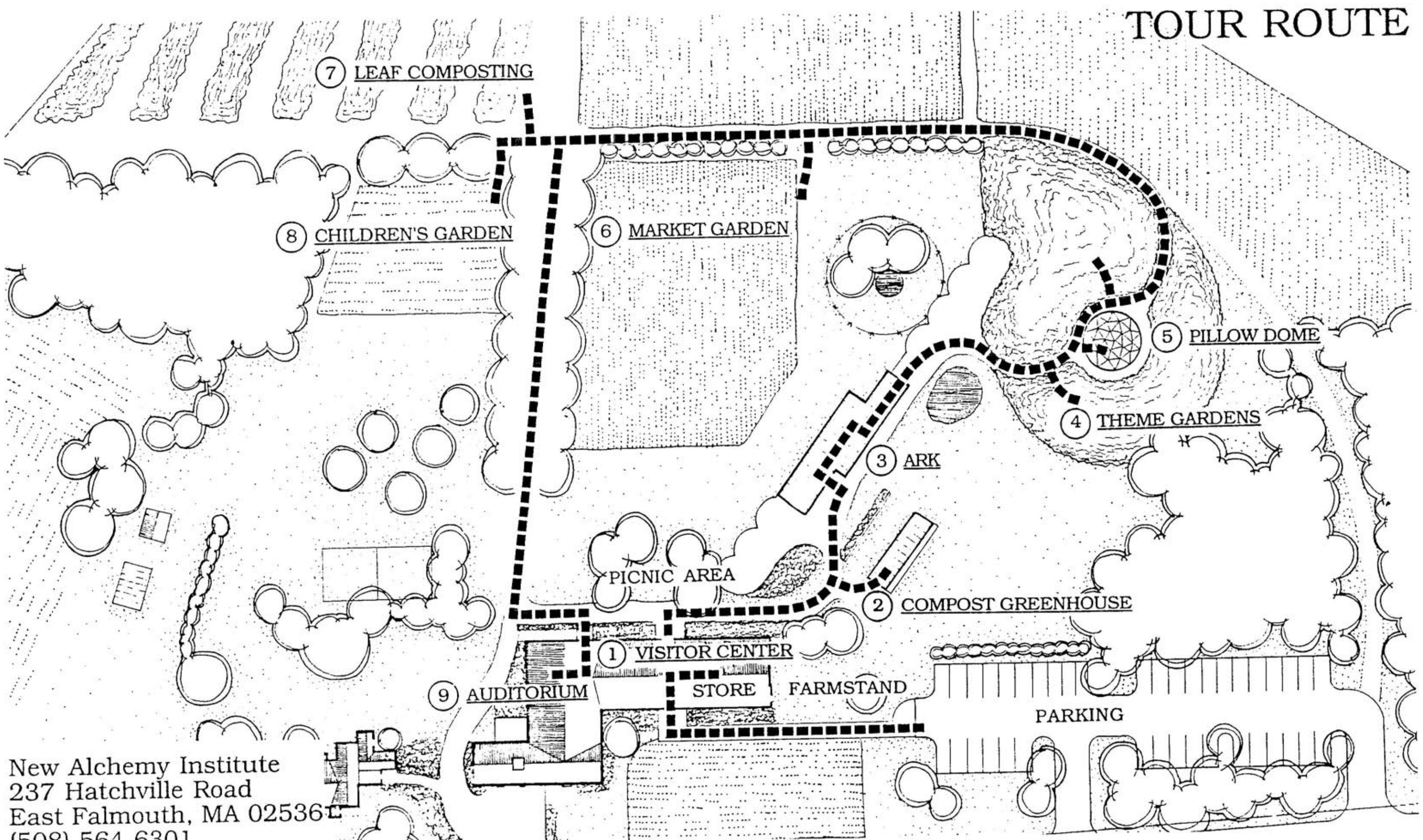
42 Britz, Richard. *The Edible City Resource Manual.* William Kaufman, Los Altos, CA. S 501.2 .E33 1981.

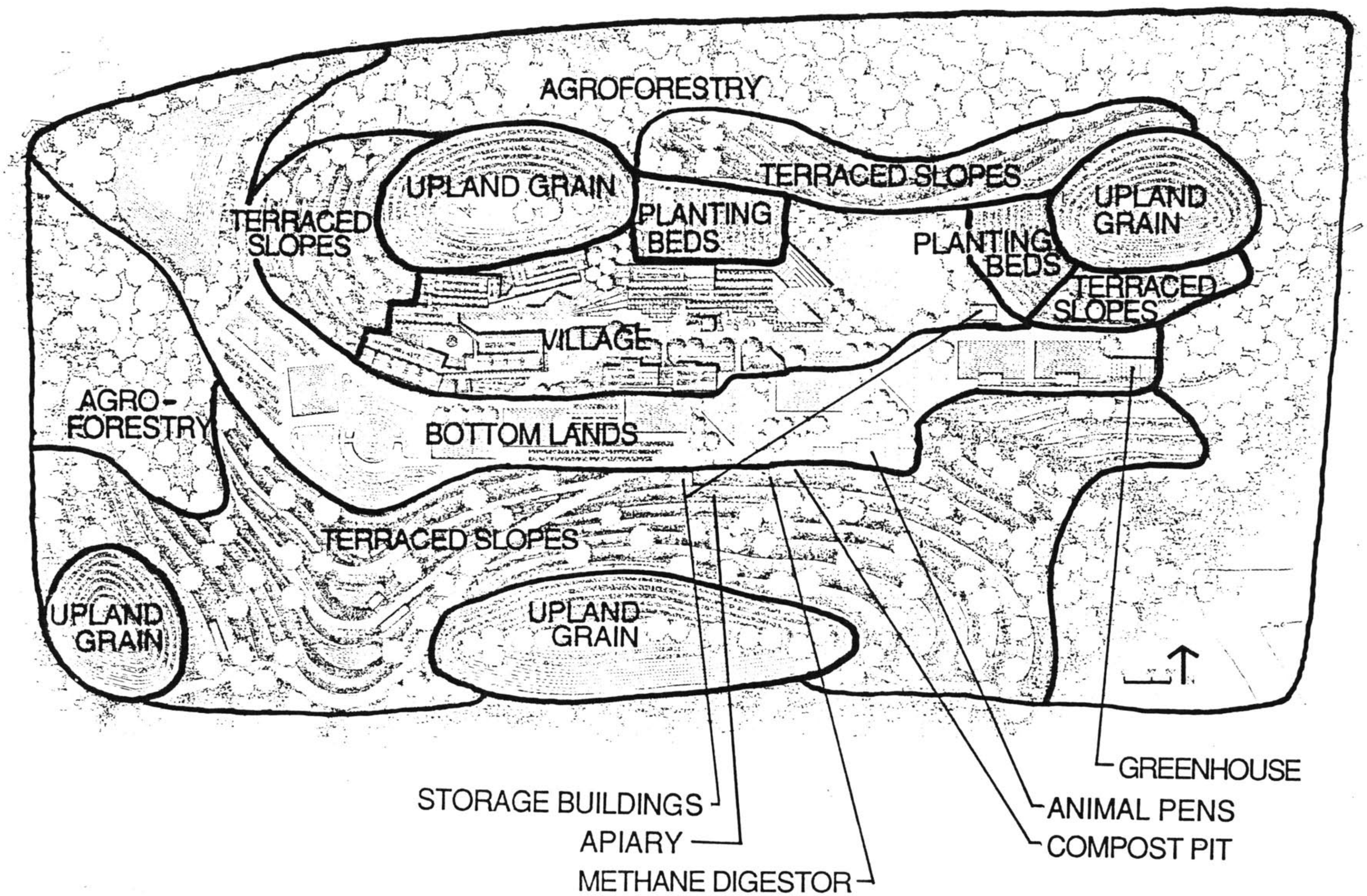
43 Corbett, Michael N. *A Better Place to Live*,HT65.C67x. 1981. and Naimark, S. *Boston Urban Gardeners. A Handbook of Community Gardening*. SB457.3.H26 1982.

44 Ball, Colin et al., *Sustainable Urban Renewal: Urban Permaculture in Bowden, Bromptom and Ridleyton*, Social Impact Publications, Armidale, Australia. HT178.A82.A37.1985.

45 Olkowski, Helga et al. *The Integral Urban House: Self Reliant Living in the City*. Sierra Club Books. TH4812.F37 1978.

46 Lyle, J.T. et al. *Design for the Institute for Regenerative Studies*. California State Polytechnic University, Pomona. 1987. p67-8.


TOUR ROUTE
7 LEAF COMPOSTING
8 CHILDREN'S GARDEN
6 MARKET GARDEN
5 PILLOW DOME
4 THEME GARDENS
3 ARK
PICNIC AREA
2 COMPOST GREENHOUSE
1 VISITOR CENTER
9 AUDITORIUM
STORE
FARMSTAND
PARKING
New Alchemy Institute
237 Hatchville Road
East Falmouth, MA 02536
(508) 564-6301



Institute for Regenerative Studies,
on the campus of the California State Polytechnic University, Pomona.

In a different league is *Biosphere Two* (the earth is biosphere one); a project to build an earth bound space station, an three and a half acre terrarium outside of Phoenix, in which 8 persons will live on completely tight cycled air, water, and nutrient flows. The intent was that the only inputs would be solar energy and information, but the air conditioning load became too great, so a sizable amount of natural gas will be demanded. As the project is privately financed, unfortunately much of the information gathered will be proprietary.

1.6 A Center

Borrowing from Woodwell, we may ask "As the detailed management of the city is beyond human capacity at the moment, what are the most practical steps?"[47] One approach would be to try to start from more modest scales of intervention and develop an appreciation for the interrelationships. Like the

[47] Woodwell, G.M. 1985*ibid.*

Farallones Institute with the Integral Urban House who defined a system at a more manageable scale, the Center for Maximum Potential Building Systems (CMPBS) in Austin, Texas has developed analytical procedures that focus on the "isolated town scale." Their first projects were with Texan communities with pressing needs and limited means: Crystal City had their heating fuel cut off just before winter, another needed truly affordable housing - and jobs. The challenge was to work with the resources within the communities. Based originally on the ecological land analysis planning methods developed by Ian McHarg,[48] the Center went on to develop methods for spatially representing not only the *area resources* (physical and biological), but also the *point resources* (specific people with the technology/ability to directly transform these natural resources [49]) and the *network resources* (the "arteries of information, currency, energy, and material flow") .[50] The Center strives to incorporate renewable and the relatively abundant indigenous

[48] celebrated for his work *Design With Nature*. Natural History Press. 1969.

[49] The point resources that the Center is concerned with identifying are those that supply food, water, shelter, sanitation, energy, materials or required financial or information means.

[50] Fisk, Pliny. "Regional Planning and Sustainability: A Conceptual Model for Urban Rural Linkage," Lecture at MIT, November 1988.

resources into the community's system, as well as the longer term efficiencies of recycling. That is, as Pliny Fisk states:

> By thinking of what is normally considered waste as a potential resource from the start we are able to establish new sets of networks by infilling [enterprises] which bring together normally unattached entities, thus producing a more stable urban environment .[51]

A principal focus of the Center's work has been identifying these potential enterprises - "or gap businesses"- as a means to allow an apparently resource poor community to satisfy needs at the local scale - while avoiding "waste." For example, they consider the potential of sulphur collected out of the precipitator stack of a coal plant as a structural building material, likewise with the fly ash from these plants .[52] By-products such as straw chaff, cotton hull and lint, and sawdust are potential insulative materials.[53] Perhaps the next step for the architectural community is to inquire not only about the composition of the city's waste stream, but to ask *who* is analyzing and testing the potential transformation of this resource - especially as building materials.

To provide some focus - a place, a time, a scenario- for this design thesis research, I began by considering sites with familiar climates and contexts in and around Seattle and Boston. Then Pliny Fisk, of the Center for Maximum Potential Building Systems (CMPBS) suggested their site in Austin, Texas for a design exercise. Although this went against my regionalist preferences to try to be better connected with the environmental, political, cultural, and historical contexts one is working within, it represented an opportunity to learn further from their approach. Furthermore, the eighties have been lean years for institutes such as the CMPBS; by selecting their site, there is the possibility such a design exercise may be of use to them.

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51 Fisk, Pliny. 1988. *ibid.*.

52 Fisk, Pliny. "Urban Design and Sustainability: City Gates: Enterprise Zones Using Metabolic Planning," Lecture Harvard GSD November 1988.

53 Fisk, Pliny III, and Gail D.A. Vittori, "Towards Sustainable Building: Community Economic Impact Using Indigenous Affordable Housing Strategies.".

2 Accountable Design

Ac•count•a•ble adj of sus•tain 1. Answerable. 2. Capable of being explained. [American Heritage Dictionary]

This section attempts to identify the architect's role and impact on less resource intensive built environments. Methods for better understanding the implications of building materials and assembling information for site analysis are presented. The goal of more socially and environmentally sustainable communities is proposed, followed by suggestions for criteria and options for meeting this goal. The early efforts to develop a point system to recognize more environmentally responsible house design is also included.

2.1 The Architect's Role

In terms of environmental consequences, architects normally make decisions at a relatively small scale, much less so than land planners, policy makers, civil engineers and ecologists. However, they do propose some of the building blocks that add up to make the larger context.

One succinct synopsis of environmentally benign or sustainable design, coined by Alex Gordon, is: "Long Life, Low Energy, Loose Fit."[54] Perhaps one should add life enhancing as well. These goals have direct implications on how architects consider program, building materials, and mechanical or support systems. Low energy calls attention to both energy embodied in building materials, in the climate tempering of the space, in the facilitating ways of life.

[54] Gordon, Alex, "Architects and Resource Conservation: Long Life, Loose Fit, Low Energy Study," *RIBA Journal*, January 1974. pp. 9-12.

At the building scale, "Long life" calls for considering what should stay and what may change, and adjust material selection accordingly. This also means defining that which is slow to change like structural system and bearing walls from the "fast rate" systems like the reconfiguring of partitions. At the civic scale it means revitalizing existing community nodes through renovating and refurbishing rather than leap-frogging to exurbia. This concept seems easier in more mature cultures with more established land use patterns such as in Europe. The US still has a first generation "wild west" mentality, with still so much land that is cheaper to start anew than to renovate the poorer quality structures that were constructed in the same short term thinking.

Loose fit calls for a flexibility in use or programming, a slackness that may compromise the performance of the initial building use or increase up front costs in order to accommodate other probable uses. Alex Gordon presented the case of a parking garage in which floor to ceiling heights were increased to allow the conversion of the garage to another use, such as office or warehouse.

While architects seem to prefer emphasizing their function of designing the form, their more banal professional role and responsibility weighs heavily in specifying the materials and, to a lesser degree, the systems. Current energy conscious practices leading to airtight building envelopes and reductions in air exchanges minimizes heating (and cooling) costs but present the problem of indoor air quality and calls for a review of the toxicity of building materials and especially of interior finishes. Likewise there is concern over the use of chloroflourocarbons in buildings for air conditioning, fire extinguishing, and insulation.[55]

Architects play a sizable role in the specifying of building materials. The primary considerations appear to be cost, codes (fire and thermal resistance), availability of the material and skilled labor, product liability, and appearance. Maintenance and durability are also considered, while toxicity (outgassing) is just emerging as a serious criteria for analysis. Off site environmental impact, in terms of initial resource extraction or recyclability of demolition wastes, has yet to enter the decision matrix, aside from costs. Likewise in considering embodied energy - though most would agree the greater the energy used to produce and transport a

[55] Heller, B.G. "Circumventing Chloroflourocarbons in Building Uses." *Architecture* . March 1989, p.125-6.

material, the greater the pollution generated. In the early 1970's there was the beginnings of excellent research into the embodied energy of building materials. [56] Should a client and design team want to consider these aspects, there is unfortunately no one, good source of information.

2.2 Appropriate Materials Selection

When the materials are ready, the architects shall appear. -Walt Whitman

Or as Kahn might suggest: "Ask the vinyl what it wants to be." The Plastic age began in 1979 when the annual volume of plastics exceeded that of steel.[57]

[56] Stein, Richard G. *Architecture and Energy.* Anchor Press. NA2542.3.S73 1977.
Stein, Richard G. et al. "Handbook of Energy Use for Building Construction" NTIS DOE/CE/20220-1 March 1981.; Hannon, B. et al. " Energy and Labor in the Construction Sector" *Science* Vol 202 24 Nov 1978. Q.S399; and Kegel, R.A. The Energy Intensity of Building Materials. *Heating, Piping, and Air Conditioning*. June 1975. pp 37-40.

[57] Meikle, J.L. "Plastic, Material of a Thousand Uses."in Corn, Joseph J. (ed.). *Imagining Tomorrow: History, Technology, and the American Future*. MIT Press, Cambridge, MA. T20.I43 1986.

There are many types of plastics, some 10,000 with a wide variety of properties; soon architects will come to be better distinguish between those that are reusable or recyclable such as thermoplastics and those that cannot, such as plastics with thermosetting resins.[58] Many new applications can be viewed in the *General Electric Living Environment Laboratory* in Pittsfield, Massachusetts . "Only 30% plastic, ... nothing will be wasted, .. recycling is an important concept of the plastic house."[59] Plastic is basically hydrocarbon and can be made from resources other than petroleum. In 1940, Henry Ford built a plastic car out of a casein-type resin from soybeans, stating "someday it will be possible to grow most of an automobile." [60]

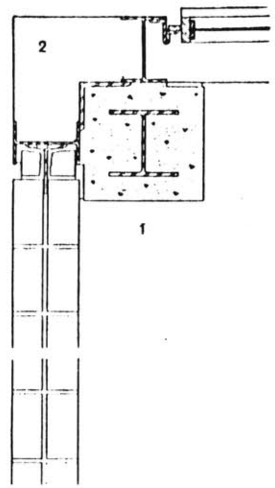
[58] Wilson, F. "Plastics, Past and Future: We are deeply in their age." *ARCHITECTURE*. April 1988 103-108. p104. and Saltus,Richard. Drops in the (plastic) bucket? *Boston Globe* Monday 27,1990 p.25.
There is even a Center for Plastics Recycling Research at Rutgers University New Jersey.
About 20% of the beverage bottles sold in the US are collected in the bottle-law states and shipped to South Carolina where the Wellman Co. has a virtual monopoly because of its patented process.

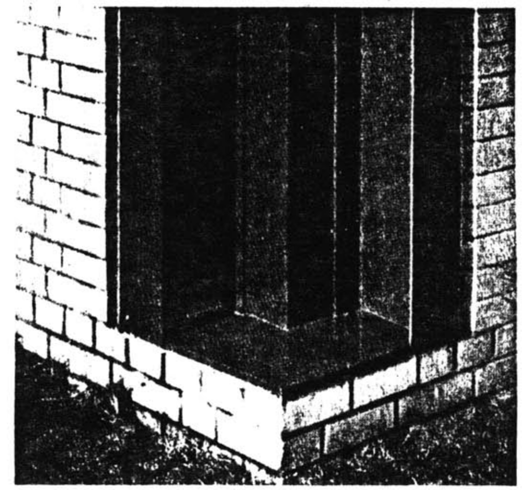
[59] Wilson, F. "Plastics for the People." *ARCHITECTURE*. March 1990 165-168.

[60] Meikle, J.L. " 1986. Op.Cit. p 89 and Wik, Reynold, "Henry Ford's Science and Technology for

Our buildings are built of layers, each serving performance functions, particularly thermal insulation, fire resistance, and moisture control. Like furniture making, most architectural systems consists of working with wallpapers and veneers replicating lost higher grade materials. The current "Deconstructivist" and "High Tech" efforts tend to rely heavily on mechanical systems for climate control and require energy intensive building materials.

There is a modest counter-movement towards "natural" buildings. This interest has developed due primarily to concerns over toxicity and indoor air pollution from the outgassing of glues, preservatives, finishes, and fire treatments.[61] The strong efforts





have been made by the *bau-biologists* in Germany and the *Gaia* group in Norway. Although the goals of non-toxic materials is compatible with those of environmental awareness, the unsettling aspect is that many proposals for reduced toxicity in buildings rely heavily on solid softwoods. Whether this is a major concern is difficult to know. In in Europe; where logging is limited to sustainable yields, find they are losing 5 -10 times this amount due to acidification.[62] In North America, apparently forestation has increased since the Europeans landed.[63] Still, "A tree farm is not a forest."

Rural America" *Technology and Culture 3* Summer 1962 pp 247-248

61 Pearson, David. *The Natural House Book: Creating a Healthy Harmonious, and Ecologically-sound Home Environment.* Simon & Schuster, New York. TH6057.A6P4 1989.;Hunter, Linda Mason. *The Healthy Home: an Attic-to-Basemant Guide to Toxin-free Living.* Rodale Press,Emmaus, PA. RA577.5.H86 1988.; Dadd, Debra Lynn. *The Non-toxic Home.*; Environmental Health Watch and Housing Resource Center. *Healthy House Catalog: National Directory of Indoor Pollution Resources*; Bower, John. *The Healthy House How to Buy One, How to Build One, How to Cure a "Sick" One.* Lyle Stuart Book, New York. RA770.5B69 1989.

62 Clark, William . Ecology and Global Change. Lecture Harvard GSD. Spring 1989.

63 Brooks, Harvey. What is Sustainability? Presentation. Harvard GSD 13 Feb 1989.

The standard AIA 201 contract forbids the use of used or recycled materials in new construction. Certainly the contract can be altered, but this represents the prevailing attitude in which, because of labor costs and the time costs of money, the amount of "new" building materials thrown away is considerable. This may change as landfill costs go up. There has been some investigations of demolition debris reuse as well as waste materials, primarily for use as aggregate.[64, 65]

[64] Wilson, David et al. *Demolition Wastes: Data Collection and Separation Studies.*MIT Department of Mechanical Engineering. 1979. TD794.5.D45.; Wilson, David Gordon. [1975] *The Resource Potential of Demolition Debris in the United States.* Resources, Conservation and Recycling. 1 [1975] 129-140.; Davidson, Thomas A. *Demolition Wastes: Quantities Generated, Size Distribution of Materials.* MIT Thesis ME 1979 MS1979.; and Clifton,J.R. Brown,P.W. and Frohnsdorff,G. *Uses of Waste Materials and By-products in Construction.* Part 1 & 2. Resource Recovery and Conservation. 5:1980:139-160, 217-228. *The Official Recycled Products Guide.* American Recycling Market, Inc. Ogdensgurg, NY, 800 267 0707

[65] An advertisement for McDonald's states that it wants to buy $100 million worth of recycled products for the construction, remodeling and equipping of its restaurants in the United States. The project is called McRecycle USA.

There have been interesting attempts at developing and reviving "low tech" materials, especially with earthen materials.[66] There was even an effort to develop a beer bottle into a building block, primarily for low income countries. This probably failed simply because bottles are already valued and recycled for their primary function.[67] As Austin is in a grassland, The CMPBS and others are building with with bales of hay.[68] Another promising use of straw chaff has been to compress the chaff into structural panels.

There is no definitive source of information on environmentally responsible building materials. Some of the sources architects review are McGraw-Hill *Sweet's* (which is basically advertising). There are periodicals with timely articles in *Fine Homebuilding, Progressive Architecture,* and the AIA's *Architecture.* There are newsletters such as

[66] For information on CRATerres work, see *Space and Society* #24 pp118-125. or CRATerre. *Construire en Terre.* Editions Alternatives. Paris. TH1421.C79 1979.

[67] Pawley, Martin. *Garbage Housing.* TH4812.P38 1975 Heineken World Bottle System with Habraken. Pawley comments that cereal packaging can have more protein than the contents. p. 34.

[68] Strang, Gary. *Straw-Bale Studio.* Fine Homebuilding. p70-72 December 1984.

Energy Design Update, and The Monthly Newsletter on Energy Efficient Housing. *Earth Access* lists endangered species of tropical hardwoods and suggests alternatives.[69] One of the more comprehensive compendiums is a British guide called *Green Design*, unfortunately the citations are casually documented and qualitative in nature.[70]

There has been a growing interest in labeling of materials to identify environmental impacts.[71] This label could be similar to California's toxic labeling laws, or the *Material Safety Data Sheet*.The "MSDS" sheets are available from the manufacturer for most all materials sold in the United States. [72]

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69 Nisson, J.D. Ned. Editor. *Energy Design Update . The Monthly Newsletter on Energy Efficient Housing*. Cutter Information Corp. Arlington, MA.

70 Fox, Avril and Robin Murell. *Green Design: A Guide to the Environmental Impact of Building Materials*. Architecture Design and Technology Press, London. 1989. See also Pearson, David. *The Natural House Book: Creating a Healthy Harmonious, and Ecologically-sound Home Environment*. Simon & Schuster, New York. TH6057.A6P4 1989.

71 In Germany safe materials can display the United Nations "Blue Angel" symbol; in Canada: there is a program called "Ecologo,"and in the United States: "Green Seal." Corporations are being asked to adhere to the"Valdez Principles."

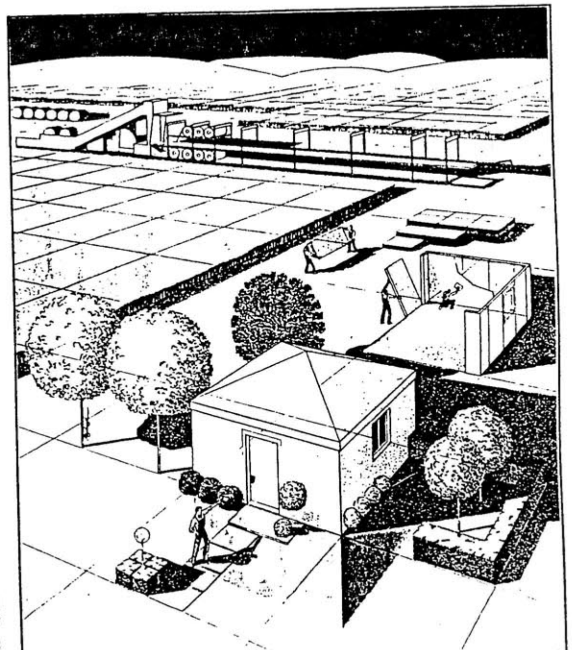
While the concepts and technology of the PYRAMOD™ System are contemporary, many of its aspects are easily traceable in the historical development of shelter.

For instance, the pyramid shape is a classical building and architectural design used throughout history because of the beauty of its line and the efficiency of its structure. Another example is the use of agricultural fibers as a building/shelter material which has its roots in ancient times. Straw has been used throughout the world because of its known toughness and durability.

In 1935 compressed agricultural fiber (CAF) was invented in Sweden using a combination of high pressure and temperature in a continuous extrusion process. CAF panels were found to possess numerous desirable properties such as thermal insulation and fire resistance. Over the past fifty years, hundreds of millions of square feet have been installed in Great Britain, Canada and Australia.

In 1983 the development of an improved processing mill was initiated to produce thicker and stronger CAF paneling. The result of this effort was panels which, for the first time, were capable of being used as primary load bearing structural material.

Mansion Industries acquired the world wide rights to the new mill design in 1985. Mansion continued this pioneering evolution with the development of a new state-of-the-art structural and architectural system that combines the superior properties of the CAF paneling and the classic beauty and efficiency of the pyramid shape. The result of this effort is the remarkable PYRAMOD System. This system, on which Mansion has patents and patents pending, consists of the new extrusion mill (ENVIROCOR™ Mill MM200-12), the new improved CAF paneling (ENVIROCOR), and the new design of structural building shells (PYRAMOD) and their versatile clustering into multi-room buildings.



The PYRAMOD houses are built with factory prepared kits of precut ENVIROCOR panels and adhesive materials. They are easy to erect, connect and finish without special tools and skills. The need for structural framing is eliminated.

Prototype PYRAMOD house

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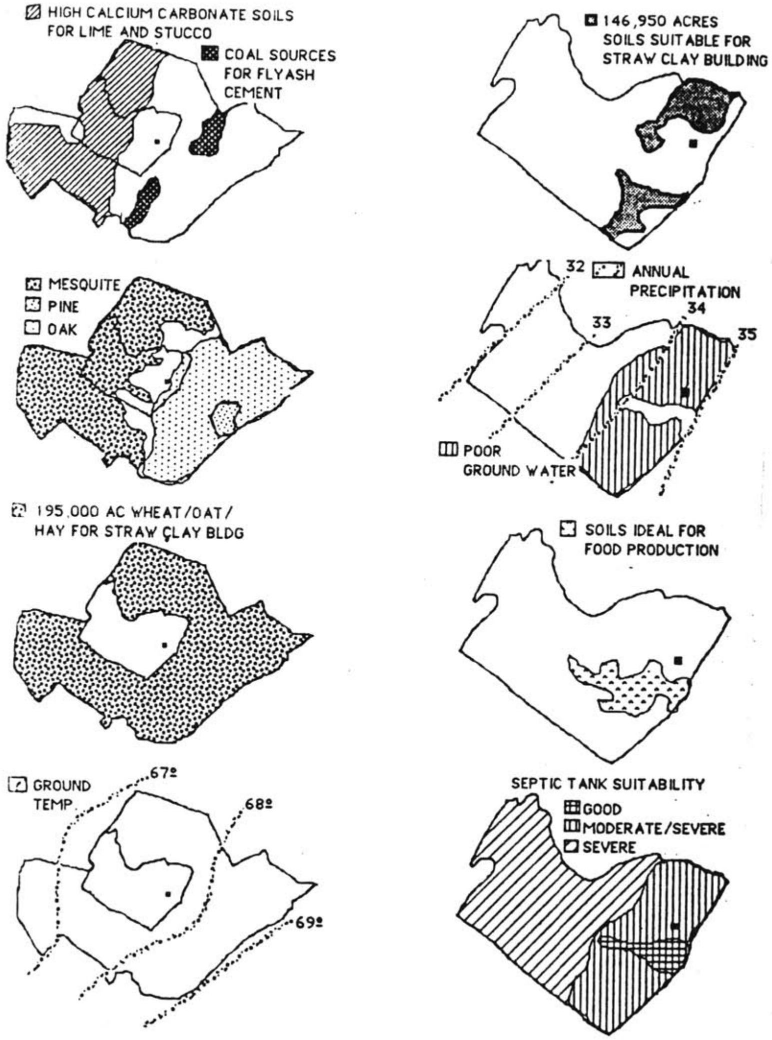
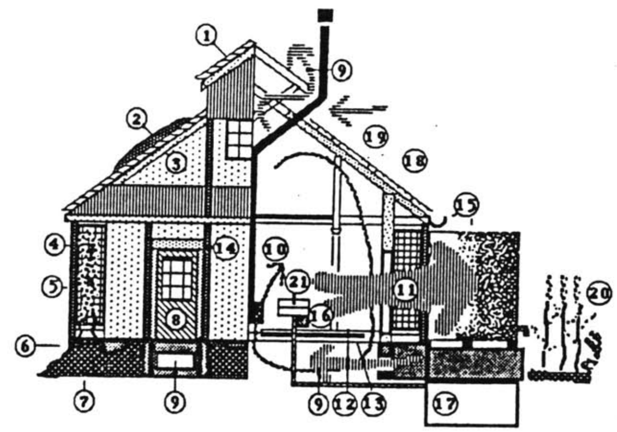
72 Bower, John. 1989. Op.Cit.





1. FLYASH ROOF TILE
2. BATCH SOLAR HEATER
3. STUCCO
4. EAST/WEST TRELLIS
5. FLYASH COLUMN
6. FLYASH FOUNDATION
7. BERMED EARTH
8. WINDOW/DOOR EXPAND
9. EARLY SUMMER VENT
10. SUB-FLOOR PRE-HEAT
11. LATE SUMMER VENT
12. MESQUITE FLOOR
13. PINE STRUCTURE
14. OAK/CEDAR TALL COL
15. CISTERN
16. ORGANIC WASTE
17. SEPTIC TANK
18. STRAW/CLAY WALL
19. SAWDUST INSULATION
20. ORGANIC GARDEN

Carpenter Residence, east of Austin, Texas,
by the Center for Maximum Potential Building Systems.

A format for collecting the data should include the items in this proposed format for a building materials database:

Material, Component, or Building System

Construction Specification Institute number
Financial costs; order of magnitude for season and locale, installation; maintenance, disposal.
Thermal performance; resistance, mass, emissivity, density.
Fire resistance.
Extraction: impacts, following sustainable yield practices, from recycled materials,
Fabrication; toxicity, energy demands, local suppliers.
Transportation: distance; location of suppliers.
Installation: toxicity, wastage.
Operation/ maintenance: outgassing, toxicity, expected life cycle.
Demolition: recyclability/toxicity.
Embodied energy : extraction, fabrication, transportation, installation, maintenance, anddemolition.
Other properties; reflectivity, acoustical performance.
Social and Cultural associations and connotations

Until a time such accountability becomes implemented, the next best step is for practitioners to directly trade experiences and information. There are study groups within the AIA in Boston and in Washington DC trying to bring together this information.[73] This data sheets could be reviewed by the trade associations for clarification, to encourage accountability, and to solicit information about competing substitutes. A low cost, accessible electronic database like *Hypercard* allows for wide distribution and facilitates data collection as each user would be able to add to the "cards."

2.3 Site Analysis

Though a site as property reflects the limits of the client's direct influence, in terms of natural, non-human systems, a site is an arbitrary boundary. How can information on the larger scale resource flows be structured to provide a more intelligent site understanding?

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[73] Winoy, Lars. "AIA Environmental Resource Guide," Draft, April 17, 1990.

One possibility is through a geographical information system (GIS) made compatible with a computer aided drafting (CAD) application and a database. This is already being done. After the *Exxon Valdez* Disaster, an *AutoCad®* compatible program called *GEOSQL®* was used to keep up-to-date information on the cleaning attempt. With a map of an island on the screen, one could "click" on a line representing a cove and a window would pop up with data on its current state. The same could be done for informing architectural design.

While the average architectural firm may not be able sustain the costs for a GIS, many city planning departments are establishing systems that could be used to coordinate the range of data that they want citizens to understand. Consider the following scenario:

An architecture or landscape architecture firm has access (rents, owns, shares) to an *AutoCad®* system. They purchase/rent the digitized USGS topographical map of their site vicinity as a base.Each of the lines representing streams, roads, buildings could become an object to which information -water flows, traffic counts, owner - is attached.

Like overlay drafting, one has a CAD "drawing" made up of multiple layers; thus one layer with water features or another with measured noise levels can be made visible or hidden as need be. In this scenario, one would go down to the local planning department, select the layers one might use - zoning, wetlands, traffic counts, toxic dumps, utilities, hydrology, protected aquifers, wildlife corridors, crime rates, vegetation, soil type, seismic risk, flood zones, fire hydrants and stations, school bus service - pay a reasonable service fee and walk out with the information on a disk (or as plotted sheets).

Other agencies and utilities could do likewise. In the future, the transit company could distribute disks with all the bus routes and schedules; the Audubon society, disks with bird sightings. Microclimate data could be made available, with differing months/conditions on different layers. Computer disks are like audio cassettes, easily erased and updated. The key is to remain somewhat compatible.

In short, one has an electronic *Sanborn* map. These maps were made by the Sanborn insurance firm to determine the fire danger probabilities of each city block. The plans had every building with height, structural type, and use noted. With CAD, one adds the "z-coordinate" of building height and shadow patterns could be generated, revealing solar access conflicts.

Right now, census data is commercially available in comparable formats. One has the potential for a spatial yellow pages. We are not too far away from having very accessible data on local human, physical, and institutional resources. With such a database, a more systematic linking can be made between one's building project, or active business, and the potential of the surrounding community.

2.4 A Goal and Criteria

The goal proposed in this thesis is the development of more environmentally and socially sustainable communities. Basically, this means more supportive places to live, to grow, to work. This means settings for higher quality lives with less resource degradation. These call for skills and perspectives that go well beyond architecture, but it is still helpful to ask how architecture contributes to the realizing of such a goal. In addition to accommodating a changing program, architects would do well to consider the design implications from:

i) an emerging understanding of the magnitudes of system flows: biotic, abiotic, financial, and toxins.

ii) encouraging a reasonably tight cycling of these flows at the site scale.

iii) suggesting building material applications that are easily recyclable, non-toxic and biodegradable and come from more abundant/renewable local resources or the reclaiming of what are considered waste byproducts.

What follows is a list of criteria by which one can measure how the goal of the development of more environmentally and socially sustainable communities is met. The criteria owes heavily to the efforts of Malcom Wells and Bruce Coldham. Each criteria is followed by my comments on how it may be evaluated.[74]

[74] Wells, Malcolm. *Gentle Architecture*. McGraw -Hill, New York. NA2542.35.W44 1982. and Coldham, Bruce. "Productive Community Settings for A Sustainable Society." *Proceedings of the 1986 Annual Meeting of the American Solar Energy Society*, Boulder CO June 11-14, 1986. TJ810.I575

Productive Site Evaluation:

- *Adequately analyzed the site in terms of soils, hydrology, plants, wildlife, sun, wind, climate, to determine the sustainable productive potential of these flows?*
  This is relatively quantifiable, though collecting specific site data is time consuming and may require specialists.

- *Adequately analyzed the surrounding context in terms of physical and human resources, and networks to identify opportunities for the productive potential of linking with local activities?*
  This is relatively quantifiable. See the methodology of the Center for Maximum Potential Building Systems.[75] Ideally, local governments could coordinate this local networking.

[75] Fisk, Pliny III, and Gail D.A. Vittori, "Towards Sustainable Building: Community Economic Impact Using Indigenous Affordable Housing Strategies" and Fisk, Pliny Fisk, "Regional Planning and Sustainability: A Conceptual Model for Urban Rural Linkage," November 1988.

- *Respects the special qualities of the site.*
  Special is a judgment call, however there are landscape assessment inventories available.

Biomass

- *Protects threatened wildlife/plant species habitat; Preserves fragile ecosystems - wetlands, indicator species, last preserves.*
  Generally defined and protected by governmental agencies, it would be good to improve the access to information for a particular site.

- *preserves green space.*
  A judgment call. Perhaps this can be quantified by loss of annual biomass activity with some factor for the amount of time it would take ecosystem succession to restore the same environment. The degree of clustering of human impacts could be considered. Perhaps there could be a weighting system that increases the value of existing vegetation as that in the proximity of severely degraded areas and vice versa. Another factor is the quality and appropriateness of the vegetation, an endangered species is more valuable than an invading type like kudzo. Calls for sensitive land planning.

• *Promotes native vegetation for landscaping .*
Minimal lawn area.

• *Generates top soil.*
There is a good place for composting with easy access. Often off-site imports are desired for a proper mix. Avoids loss of top soil to compaction by containing the extent of heavy machinery and vehicles into green spaces.

• *Produces clean (non toxic) fresh food.*
The site provides for the vegetable and fruit demands of the population. The factors include a combination of square footage, solar access, soil quality, accessibility, water supply and drainage.

Water

• *moderates runoff.*
The runoff and soil loss should be less than or equal to that before development.

•*Minimizes water pollution; high water quality leaving site or safely processed off-site*
Only high quality water should leave the site.

• *Minimizes aquifer depletion.*
Assuming the site is over an aquifer, water pumped from aquifer below (or pumped from a distance) should be less than or equal to the recharge from site rainfall . Evapotranspiration rates are minimized from use of windbreaks and shading over ponds and vegetation.

Air

•*Produces clean air/minimizes air pollution;*
Quantify by types of emissions - especially sulphur and carbon (include off-site implications as well). Quantify vegetation and capacity of leaves to filter.

Human Community

• *Design accommodates or allows slack for change,*
This is difficult to quantify, but it may include such options as: intensive recycling, photovoltaics, hydrogen cars, heavy bicycling; dwelling expansion; dwelling division. One could calculate the potential savings or replacement values for any of these practices and multiply it by a probability of occurence.

• *Affordable for housing and small scale enterprise; reasonable pay back period, reasonable risk.* Entry threshold to own an a dwelling is affordable to below median income people. Reasonable is a judgment call, resale value is a guide.

• *Minimizes maintenance costs.* Tends to favor tried and true materials.

• *Socially and Culturally appropriate; reasonable behavioral and convenience factors.*
• *Increases local community interaction; quality of life.*
• *Reasonable aesthetics; a pleasant place to be, expresses user identities and symbols*. Could ask people.Judgment call. Could be placed against measures such as those documented by Marcus and Sarkissian in *Housing as if People Mattered.*[76]

• *Supports the generation of local income.* Ratio of residential floor area to commercial with in walking distance.

• *Balances the desire to protect privacy and discourage crime, vandalism -* Judgment call; designed with defensible space concepts.[77]

Transportation

• *Reduces automobile dependency.* Encourages alternatives. Are basic services (itemize by priority) close by, within 5 minute walking distance? Is taking the transit or using a bicycle convenient to the site?

Energy & Materials

• *Reduces dependency on non-renewable resources.* See section 2.2.

• *Uses products of industries with sustainable yield extraction practices*. See section 2.2.

• *Generates usable by-products and minimum waste.*

76 Marcus, Clare Cooper, and Wendy Sarkissian. *Housing as if People Mattered.* Berkeley, CA: University of California Press. NA7115.M27 1985.

77 see Newman, Oscar. *Defensible Space.*

Education

• *Educates the users; provides feedback, gives perspective to the people on site scale resource flows in order to cooperate with regenerative practices.*

• *Rationally transparent ; are support systems accessible to educate user understanding. are users able to repair, and control systems directly?*

2.5 Design Options

In designing for a more self reliant community, it would be helpful to have a list of what measures should be considered at what scale for a particular climatic region and culture. An excellent format for this is that of the *Pattern Language,* but with the more careful documentation of *Housing as if People Mattered.*[78] This format was used successfully in Watson and Labs' *Climatic Design* and Edward Mazria's *The Passive Solar Energy Book.*[79] There is a need for a "Sustainable Design Sourcebook" to list, diagram and begin to rank design measures in terms of environmental trade-offs and feasibility. McPherson has a good table in the back of his work with the measures to be considered, the scale for implementation and professional domains involved.[80] Bruce Coldham has generated the most complete list , I have of come across, of such strategies at the community scale, primarily for the New England region.[81] Below is a list of strategies based on his work followed by my comments on primary form implications and trade-offs involved for the Austin context.

78 Alexander, C. M Silverstein, S. Ishikawa, *A Pattern Language.* New York: Oxford University Press, 1977.
79 Watson, D. and Labs, K. *Climatic Design.* McGraw Hill TJ163.5.B84.W38 1983. and Mazria, Edward. *The Passive Solar Energy Book.* Rodale Press, Emmaus, PA. TJ810.M32 1979.
80 McPherson, E. Gregory. *Energy Conserving Site Design.* American Society of Landscape Architects. Washington D.C. 1984. ISBN:0-941236-07-2
81 Coldham, Bruce. 1986. Op.Cit.

1. Economic:

• *Mixed Use*: local income generation with residential, agricultural and commercial activities in close proximity - Form implications: fine grained micro-zoning. Provision of business "incubators," small spaces at low rental rates for new business opportunities.Trade-offs: automobile traffic generation and parking requirements.

• *Owner builder participation* - Form implications: greater variety in housing types, sizing and site placement. Trade-offs: Personal involvement requires a lot of time and learning.

• *Cohousing* - Form implications: smaller dwelling units, clustered land planning, location of the common facility for a central food service. Trade-offs: sharing of facilities, increased communal interaction versus time required, privacy.

• *Small local repair shop* - Form implications: location, visibility, perhaps storage of salvageables..

• *Day care* - Form implications: programming needs, very safe play area and access.

2. Materials

• *Promote source separation & solid waste recycling* - Form implications: a recycling center and slack space for on site materials storage. Austin currently has a good curbside recycling program.

• *Product design - long life, repairability, recyclability* - Building form implications: materials selection, detailing allows for ventilation and accessibility.

• *Shorten road lengths, minimize paved areas* - Form implications: tighter clustering of units and common parking areas, more dirt roads and use of "turf blocks." Trade-offs:This varies with locale, but in Austin solar access and cross ventilation suggest greater spacing between units or single loading of streets.

• *Build support structures with resilient usage, dimensions* - Form implications: complex and controversial if the early design qualities are compromised too much for future options. [82]

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[82] This issue is addressed in Habraken, N.J. et al. *Variations: The Systematic Design of Supports.* MIT Press, Cambridge MA. 1976; Caminos, Horacio; Goethert, Reinhard. *Urbanization Primer.* MIT Press, HT169.5.C35 1978.; Boudon, Phillippe. *Lived in Architecture: Le Corbusier's Pessac Revisited.* Translated by Gerald Onn 1972. Cambridge, MA: MIT Press , 1979; and Moudon, Anne Vernez. *Built for Change: Neighborhood Change in San*

• *Match materials in assemblage of comparable lifecycles* Requires good information flows.

• *Local building materials to reduce energy used for transporting* - Form implications: complex issue. Requires better information flows. For Austin, the Center has identified a range of possible materials, including using straw or grasses, and caliche blocks.

3. Site planning:

• *Low rise cluster developments.*

• *Solar building orientation-* Form implications: east west elongation, minimal openings in the east and west walls. For an Austin winter, solar access envelopes suggest a north south spacing between rows of buildings at 3 times building height.[83]

• *Landscape for microclimate amelioration* [84]- Form implications: in Austin summer water losses from evapotranspiration can be reduced with east-west walls breaking prevailing southerlies.The south sides of buildings will provide buffered spaces in the winter, north east facing porches for summer season relief.

• *Wildlife and plant species protection.* - Form implications: location and shaping of green spaces.

4. Energy conservation:

• *Increase thermal performance of building envelope* - Form implications: with current technologies primarily fewer, larger windows and thicker sections with space for ventilation and (in Austin) radiant barriers.

• *Proper thermal mass* - Form implications:. Complication - in humid conditions, warm air will condense on cooler surfaces.

• *Increase passive ventilation* - Form implications: can be land intensive, single loaded rooms and buildings. In Austin, exposure to prevailing summer southerlies mean south facing rooms are at a premium. Trade-offs: requires the separation of buildings, which is compatible with food growing and solar access, but tends to extend service utilities and road lengths. Effectiveness is diminished when more buildings are added. Another tradeoff, people who suffer from

Francisco. MIT Press. NA7238.S35M68 1986.;

[83] See Knowles, Ralph. *Energy and Form: An Ecological Approach to Urban Growth.*MIT Press. 1974. NA2750.K56 and Knowles, Ralph. *Sun Rythym Form.* MIT Press. 1974. TJ810.K56

[84] McPherson, G. Op. Cit. 1984.

allergies prefer air conditioning. Perhaps the upper floors would emphasize cross ventilation and the shaded lower floor moderate air conditioning..

• *Night flushing* - Form implications: allow properly placed openings that can be safely left open at night and then seal the house during the day to avoid heat gains from the sun and warmer outside air. Reasonable in Austin for spring, fall and much of the summer.

5. Water

• *Efficient Water Fixtures* -Form implications: minimal.

• *Collect Surface Runoff*: Form implications: detention ponds. Trade-offs: As the water level fluctuates and can contain sediments and oil from autos, these appear difficult to design in a pleasing way.

• *Collect and Store Roof Runoff* - Building form implications: simplified eave design for gutters and cistern size and location - from a rain barrel at each downspout to a centralized, below-grade tank. Trade-offs: cost and location of the cistern , requires a pump for water pressure.

-• *Graywater separated for Plants irrigation* - Form implications: gravity flow from kitchens to landscaping desired. [85]

• *Methane digester* - Form implications: at the lower edge of the community, where prevailing winds leave the site. Economics are marginal.

• *Low water blackwater* - Form implications: minimal, same as *Efficient Water Fixtures*.

• *Plant waste treatment* - Form implications: small building at at the edge of the community, this is an emerging technology with promising potential at the community scale.[86]

6. *Food*:

• *Intensive local food production matched with nutritional requirements* - Form implications: Land use and building placement. Land use requirements for vegetable gardens are reasonable, but spring and fall solar access must be considered.

• *Aquaculture* - Form implications: as an interesting, emerging clean technology, it makes for a desirable addition to a "bioshelter." Trade-offs: requires lots of water but produces nutrient rich

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85 Milne, M. (1976) *Residential Water Conservation*. Davis: University of California. TD388.M54.

86 McLaughlin,J. "Solving Sewage Problem, Naturally: Chemicals Shunned by Firm." *Boston Globe* p.75. May 6, 1990.

water for plant irrigation. Economics are still marginal.

- *Raising small animals* - Form implications: location, prevailing winds.

- *Bioshelter community greenhouse* - Form implications: central building location, service access. Tradeoff: summer heat buildup of a green house.

- *Seasonal food storage* - Form implications: programming: cool, dark, dry space.

- *Buildings on non-prime agriculture* - Form implications: site planning. Trade-offs: productive potential and open space amenity versus land "values" and the advantages of density.

- *Precinct compost stations* - Form implications: location, convenient to gardening, service access, ideally where prevailing winds leave the site.

7. Energy Production:

- *Community Scale Energy Systems* - form implication calls for the clustering of buildings to minimize heat loss in distribution. Could gang up smaller units to share more efficiently scaled heat pumps, with individual metering. When one is designing for greater cross ventilation, as in Austin, this suggests a lineal arrangement.

- *Heat Recovery Techniques/CoGeneration* - as above, form implication calls for the clustering of buildings to minimize heat loss in distribution proven technologies, used by many large businesses.

- *User feedback* - primarily one of metering with minimal form implications. Coldham uses the term "rational transparency" to suggest making support systems more visible.

- *Passive Solar Space Heating* - Correct placement of windows and allowance of thermal mass. Tradeoff: Austin mild winter heating requirements, versus summer solar insolation avoidance. Consider variable exterior shading: trellis with vines or awnings of shade cloth .

- *Wood fuel for back up heating* - Reasonable if areas available for woodlots, a sustainable extraction rate can be calculated.[87] Concern: filtering types and quantities of emissions. For Austin, careful use of natural gas is still "responsible."

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[87] Titus,E. "Wood as a Source of Fuel: A simulation of supply and demand in New England." in Hall,D.O. et al. *International Symposium on Economics of Ecosystem Management* (1983: Chalkildike, Greece). HC79.E51594 1983.

• *Solar thermal collectors for hot water* - Form implications: actually quite small in area requirements, generally better to have south facing sloping roofs with an angle approximating the latitude, (in Austin 30°). Uses proven technologies.

• *Photovoltaics* - Form implications: either as tracking arrays, perhaps shading parking lots, or as collectors on south facing sloping roofs. In Austin the angle can vary 15° either side of latitude with only a 3% difference in annual production.[88] A steeper angle, 45° favors winter production, better for radiant heating and increased lighting demands. A shallow angle 15° favors summer production when electricity is most costly because of air conditioning demands. Proven technologies, marginal short term economics.

• *Energy Storage* - Form implications: area and accessibility for utility functions. The easiest form of storing energy is batteries. Currently acid based models available models are extremely toxic in both manufacture and disposal. Fuel cells such as the conversion of surplus electricity to hydrogen gas is a promising, but it is still emerging technology.

• *Sell surplus electricity to the grid* (PURPA) - Form implications: minimal. An alternative to on site storage of electricity, this suggests shallow sloping, summer oriented, photovoltaic collectors.

• *Wind power*- Form implications: - on towers, they provide a prominent symbol of site scale reliance. Siting for less disturbed airflows is critical, and few sites offer the sufficient wind speeds.[89] Wind generators should not be on roofs or integrated with buildings as they transmit a lot of vibration. Both small scale wind generators are wind pumps (for water) are proven technologies.

• *Interior daylighting* - Form implications: major, there should be balanced lighting from two sides. Trade-offs: summer insolation gains and winter heat loss. However, new glazing options are emerging that mitigate these concerns.[90]

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88 Sandia National Laboratories. *Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices.* Revised March 1990. SAND87-7023

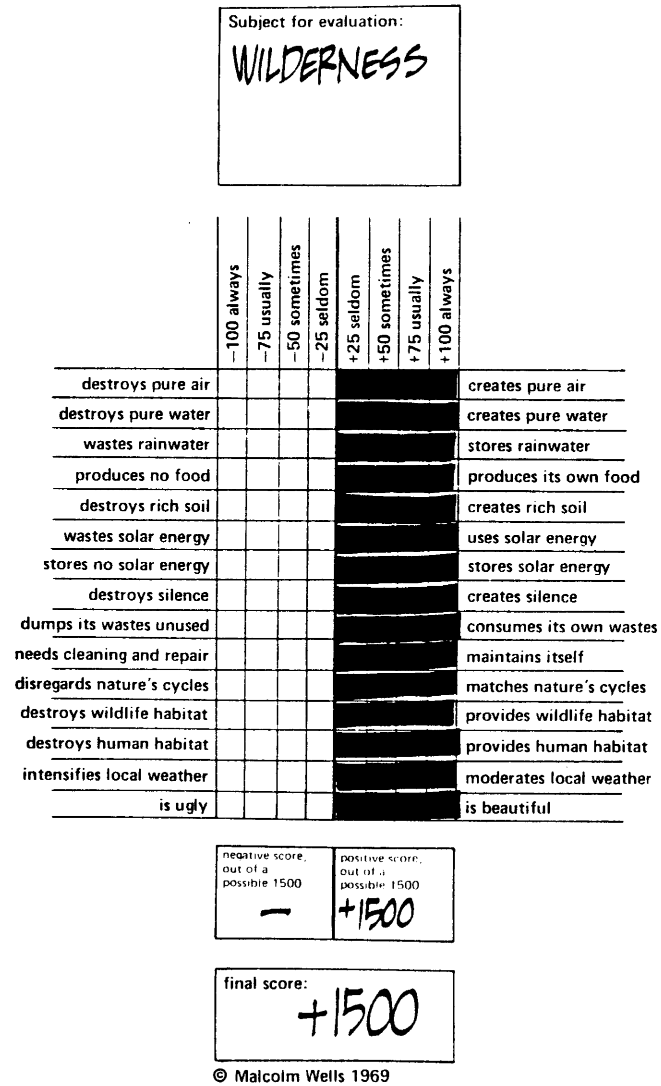
89 The Real Goods Trading Company, who sell both wind generators and photovoltaic panels, stress that there are relatively few situations where wind generators are practical; the "noiseless, maintenance-free photovoltaics outsell wind generators 100 to1." Real Goods. *Alternative Energy Sourcebook 1990.* Real Goods Trading Company. 1989.

90 There are commercially available triple glazed,windows

2.6 Evaluating for Sustainability

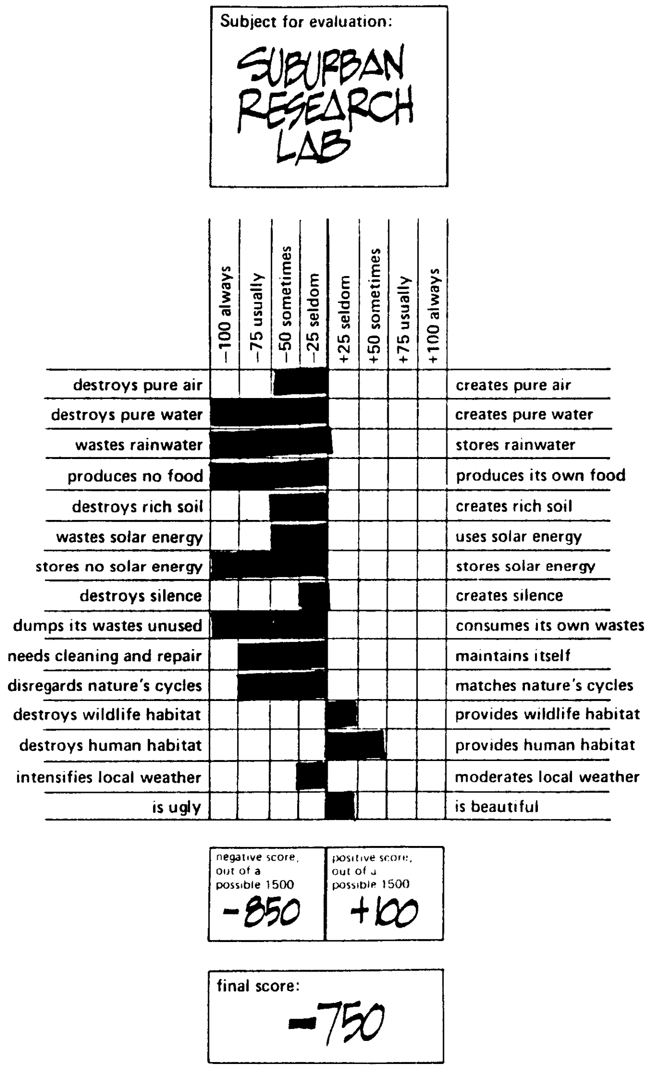
Malcolm Wells has proposed one of the better "holistic" evaluation methods to date. It is clearly relative but what is it relative to? As Donald McAllsiter states evaluation methods should be 1) systematic and replicable; 2) simple; 3) quick; 4) inexpensive; 5) legally acceptable and 6) comprehensive (includes all of the factors relevant to the decision). [91] McAllister,cautions:

> The notion of trade-offs is fundamental to evaluation. When comparing two alternatives, almost always we find that each has certain advantages over the other: by selecting one, we gain the advantages it provides but forgo the advantages of the other. The beneficial and adverse impacts of alternatives reveal the trade-offs that are made, implicitly if not explicitly, in the selection process.



with "center of glazing" values of R-8. The critical point of thermal loss has become the frame design. With the heat gained incidental relected light, a north facing R-6 window can outperform an R-19 wall.

91 McAllister, Donald M. *Evaluation in Environmental Planning: Assessing Environmental, Social, Economic, and Political Trade-offs*. MIT Press.1986. HC79.E5M315. p. 72.



© Malcolm Wells 1969

When the various impacts are described in different terms, the personal process of assessing trade-offs can be difficult if not frustrating. To the extent that they can be described in similar terms, and especially in the same measurement units, the comparison of trade-offs is greatly facilitated. The grand index method of evaluation represent attempts to convert impacts into identical units, so they can all be added to a single score.

Perhaps the quantification of values satisfies the mathematical tendency in us to come up with a precise answer, but it clearly neither makes a judgment more accurate nor more objective. On the other hand, a number scale can be a useful way to summarize a person's feelings of relative importance in a single indicator.[92]

The City of Austin has developed an "Energy Star" program for new houses that gives one, two, or three stars, depending upon the projected energy demands of the house.[93] It began as a voluntary program that realtors can use as an additional selling feature. It has been well received so far. Perhaps one day the three star will be seen as a minimum standard, and even more energy responsible houses will receive four or five stars. In the same way, the

[92] McAllister, D.1986. *ibid*. pp. 69-70.

[93] Seiter, Doug. "Austin Energy Star Program." pp 520-537. in 11th National Passive Solar Conference, Volume II, *Proceedings of the 1986 Annual Meeting of the American Solar Energy Society*, Boulder CO June 11-14, 1986. TJ810.I575 1986.

City of Austin, along with the CMPBS, has just begun developing a program to recognize environmental sustainability, taking in factors like on-site water demands and off-site implications of building materials. See Appendix 1 for a first cut at a "grand index" method. These approaches may have many shortcomings, but at least attention and discussion is directed towards these issues and the merits of various strategies.

Some aspects cannot and should not be quantified. Nor will the calculated criteria results take the place of judgment. Rather this is only another tool to inform decisions; a tool to more holistically compare the relative magnitudes of human impacts and more rationally direct one's responses. If the results do not come out "right," then perhaps the model should be refined or the criteria weighting reassessed. One could also test development models at the edge of social norms, adopting technical ideals, to suggest sustainable site carrying capacities. The resulting "optimized program," tempered by being reasonable within the given context, should provide a better perspective on the community's degree of self reliance.

3 Metabolic Design

Me•tab•o•lism: 1. The complex of physical and chemical processes involved in the maintenance of life. 2. The functioning of a specific substance within the living body. [American Heritage Dictionary]

The first part of this section surveys efforts to develop computer simulation models of ecological complexities. The second part presents my efforts to develop a dynamic model of site scale flows, primarily of water and food requirements.

3.1 Metabolic Planning

Kingsley Haynes coined the term "Metabolic Units" to denote a transformation process with inputs and outputs. These units could be houses, factories, or entire urban agglomerations. When inputs or outputs are linked, they make up "Ecological Units." Haynes wrote of the need to better integrate these units to reduce waste by-products. The Center for Maximum Potential Building Systems suggests the term "Metabolic Planning" to describe the process of integrating these transformation processes. The Integral Urban House in Berkeley represents one of the better documented attempts to integrate the system flows within the one house scale. In this and similar works are seductive diagrams of substantially closed systems; seductive in that they suggest Western lifestyles with minimal negative outputs. The frustration in trying to use these diagrams as a basis for design is that they are static, convey no sense of scale, and are difficult to adapt to local conditions. One must wonder "How many cows do I need to produce the methane to heat a cup of tea?" "How much roof area are we talking about for all these collectors in Seattle? In El Paso?" The layout of the built environment obviously seems to influence how resources are consumed, and thus allocated, in this world. Yet planners, engineers, architects and design teams make decisions in a context with a very poor idea of the *cumulative* impacts of human consumption practices.

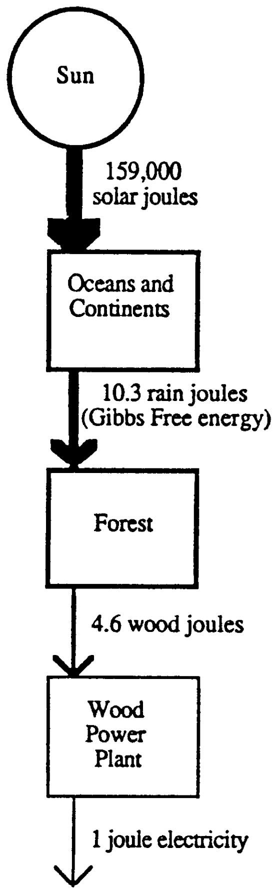
There are whole fields of study attempting mathematically model on computers the complex exchanges about us. In a 1965 Wassily Leontief had developed a computer model of the Structure of the US Economy, using US Department of Commerce Standard Industrial Classifications data, that suggests how the impact of spending in one sector is distributed across all the others.[94] In the mid 1960's Richard Stein directed an exhaustive study tracing the energy input fractions from 400 construction sectors for a range of building materials and systems.

Jay Forrester of MIT is another pioneer, beginning with studying the dynamics of industries, he extrapolated the systems theory and mathematics model larger complexities. His major point is that complex systems are *more often than not* counterintuitive to perceived simple "first order" feed back loops. In the complex system, cause and effect are usually so separate in time, space, and scale (states or levels) and processed through such a "multiplicity" of negative and positive feedback loops that one has little hope of making a real connection. The computer helps us to keep track of these lags. From this came the 1972 *The Limits to Growth: a report for the Club of Rome's project on the predicament of mankind,* which modeled global population growth rates against a diminishing resource base, and pointed out the Malthusian possibility of collapse. *Urban Dynamics* is basically a mathematical model of the growth process of an hypothetical urban area. Unfortunately for the broader acceptance of these tools, what were perceived as simplistic and draconian measures were recommended in the accompanying texts.

Howard Odum and the Center for Wetlands at the University of Florida have been especially ambitious in and committed to their ecological modelling approach. Odum proposes understanding a system by understanding its energy flows. "That any and every process and activity on earth is an energy manifestation measurable in energy units is a fact of existence."[95] Unfortunately, this requires learning a new language and translating all processes into a

[94] Leontief, Wassily W. Structure of the US Economy. *Scientific American*, 23 [1965] 4:25. TS416

[95] Odum, Howard T. *Environment, Power, and Society.* (New York: John Wiley, 1971). QH541.15.F6.027.



Solar Transformity. The Solar Emergy of these flows is 159,000 solar emjules/ unit time. Odum,1987.

the food chains, everything represents the common energy unit: *emergy*. Simplistically, likesummation of the energy it took to make it and maintain it, even information and education. One understands the relative impact of an action by diagramming and quantifying *all* the known the energy inputs and outputs. This can certainly provide for a revealing exercise. The energy "cost" of a new building would include the energy required to actually construct the structure, the energy required to fabricate and transport the materials, to feed the laborers etc. and would include as well the "cost" of reduced plant production of the lost vegetation and so on. [96] Odum acknowledges current shortcomings owing principally to the "novelty of the system" and the lack of data in an appropriate form. A 1987 study *Ecology and Economy: "Emergy" Analysis and Public Policy in Texas* provides a good introduction to the new perspective using this approach. For example, they quantify the large energy investment Texas has in their road structure, and how much and how quickly this energy is lost if not maintained.

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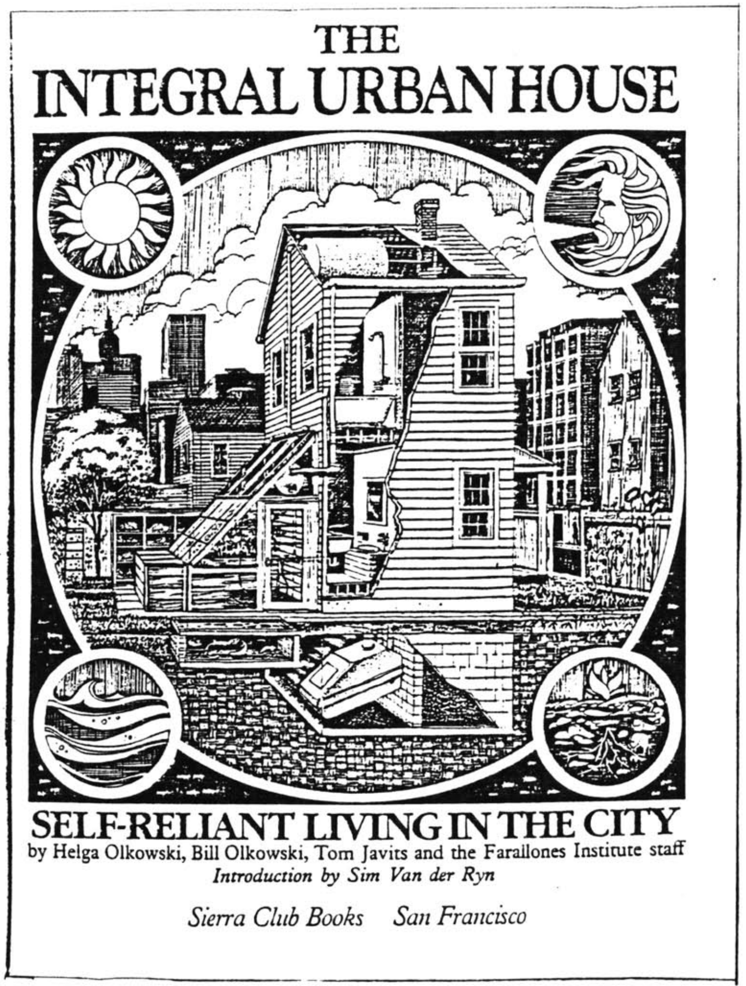
[96] Where this analysis "stops" appears problematic, somehow the embodied energy represented in say the sheet of plywood incorporates an "amortized" energy cost for the factory. Likewise for the loss of future vegetation, does one calculate a net present energy value?

People are more comfortable with the idea of *learning* from smaller scale simulation models: airline pilots use flight simulators to test the sequence of their responses. John Stermon of the System Dynamics Group at MIT has developed a *Management Flight Simulator* using the rapid expansion and subsequent collapse of the *People Express* airline corporation as a case study. People are invited to "fly" the company, that is take off (which is easy); the challenge comes in leveling the company off as a mature, sustainable business venture. As one "flies" one makes many allocation decisions and receives reams of feedback via normal business reports such as breakeven analysis, financial statements, and employee turnover. They have another modeling example, *Kaibab Plateau* that models the exponential growth of a deer population when the predators are removed. In 1907, a bounty is put on the predators, the deer population begins to grow exponentially, til 1920, at ten times their 1907 population, the supporting grazing lands are severely overtaxed, the deer starve and the population is wiped out. This simulation model tests the impact of varying the introduction of predators to achieve the maximum sustainable productivity of deer population.

Another group developing gaming models is *Maxis*, who have developed *SimCity* where one "flies" a city, or a just released model *Sim Earth.* While it is interesting to try one's intuitive approach and experience the frustration of riding waves of larger complexities, one is not yet allowed in to see the formulas, to see how the developers mathematically interpret structure of an urban system. The Center for Maximum Potential Building Systems has long been trying to find the time and means to develop such a model as a tool to help challenged or economically stagnate communities.This would take a multi-disciplinary approach which would adapt the Leontief type economic structure to the community, testing the sustainable yields of the local human-physical- institutional resource base and the linking of untapped "Metabolic Units."

My hope is to see the *Integral Urban House* as such a gaming model, in which one "flies" a house through different climates, behavioral practices, and technologies while receiving continuous feedback, especially on environmental and economic costs. Ideally, there would be the option of a long questionnaire to allow one to adjust the default values and perhaps adjust basic formulas in order to make the model more site specific.[97]



My intention is to begin to develop low cost tools or methods from research and experience that are then refined with new information. The computer provides an excellent medium. Once structured, applications are easier to update and refine than hand written calculations. After the learning curve, computers can help the average practitioner to adapt the rules of thumb to the specific project. On spreadsheets, most any calculation can be easily and quickly made to a reasonable magnitude - structural sizing, heat loss, costs. More importantly, the calculations are then saved as a base to modify for the next similar project. Given the popularity of using the computer for as word processing as a glorified typewriter, I am amazed at how few fellow students use the spreadsheets as a sophisticated calculator. Are their professors not making them aware of this tool? My introduction to spreadsheets came with the repetitious number crunching of wood beam calculations and later state energy code compliance figures. Not only were these as easily done on the computer as by pencil and paper, one then has a "template" as a basis for future modifications. These are valuable tools that many engineers and others develop for in house use who, though there are "template clearinghouses," probably do not find it not worth the hassle and liability of trying to market.

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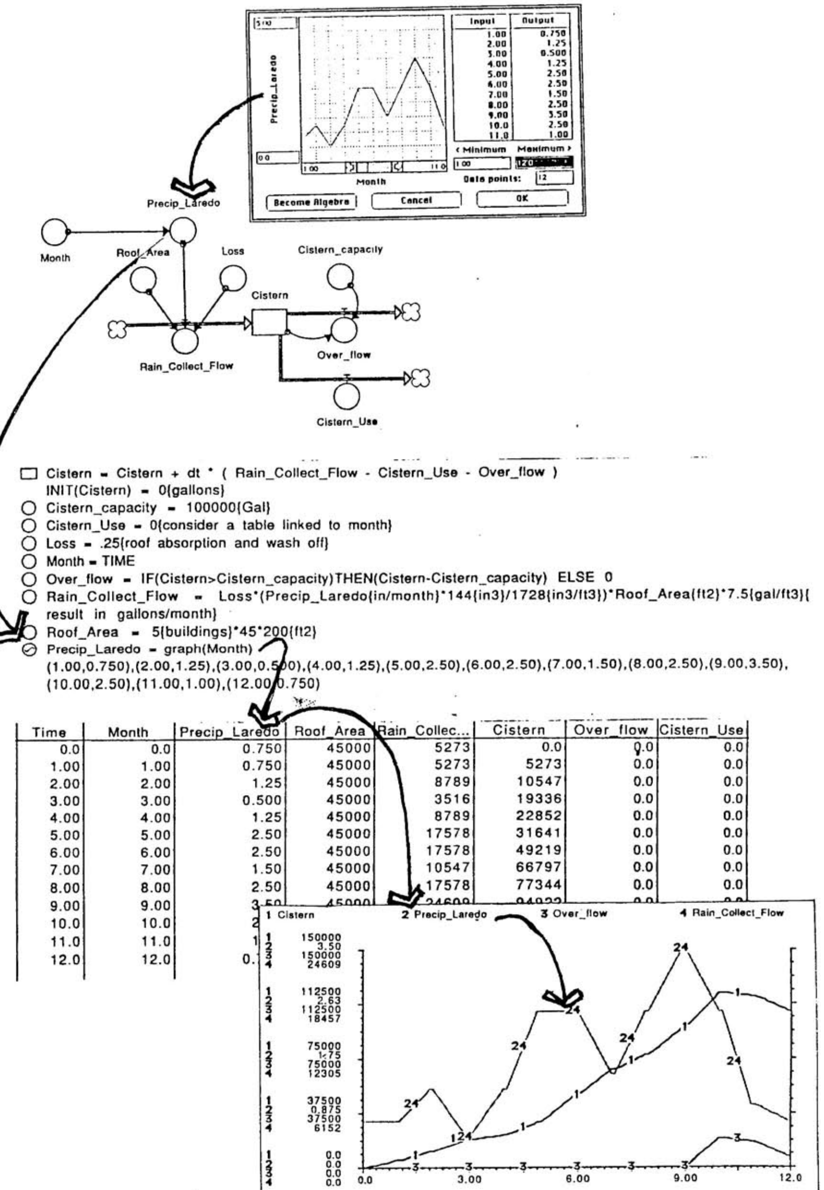
97 The questionnaire could resemble that in the back of Moore, Charles , Allen, Gerals, and Lyndon, Donald. *The Place of Houses: Three Architects Suggest Ways to Build and Inhabit Houses*. Holt, Rinehart, & Winston, New York. NA7125.M66 1974.

Moderately priced, software can make it easier to turn a spreadsheet into a dynamic model by going through multiple iterations and generating graphs and tables.[98] For a generalist architect type to develop such models for rain water collection or gardens is a challenging and revealing exercise in naiveté. Yet the process of identifying and quantifying input rates, transformation process, and outputs makes one more sensitive to what is involved. Like any computer spreadsheet, the supporting equations can be modified as the models are challenged by those more experienced and as one's understanding improves.

As a simple example, one could consider a roof water collection system. The inputs are the monthly rainfall (described in a graph as a function of the month) and a municipal backup source if needed. The storage is a cistern. The outputs are the wastage for roof cleaning and evaporation, the draw from the solar hot water heater (limited by hot water consumption), the cold water demands, and the consumption), the cold water demands, and the overflow from exceeding cistern capacity. Principal

[98] The MIT System Dynamic group models described above were done with *Stella®*(now *ithink ®*) with a *HyperCard®* interface for the *Macintosh®*; *DYNAMO®* a less elegant program works with *MS-DOS®* compatibles. The Odum group in Gainsville work with a similar product called *Extend®*.



Simulation model on Stella for Roof Rainwater catchment.

variables are precipitation, month, roof area, persons, sun, solar water heater capacity, and consumption rates.

Other examples include crop outputs, space heating demands, seasonal thermal storage, windgenerators. These models become more sophisticated as more is factored in, such as behavioral tendencies of the users or off-site outputs like the emissions from generating electricity consumed on site. These first models will be crude, but within a couple of years, could become quite refined. Eventually, suppliers may come to furnish system diagrams with quantified input/output ranges for their components. These subsystems models can then be aggregated to reasonably simulate a proposed community system.

There does not seem to be a popular interest in an integrated understanding of resource flows at the individual's and household scale. True, there are many manuals on how to live more responsibly; what to avoid and what to support. With conflicting scare statistics, that we know can be so easily manipulated, we are left feeling guilty or numb, with little in the way of helping to provide a balanced perspective. We can't answer whether we pollute more by using an automobile, cooling our house, or buying a particular consumer good. Obviously this is complicated by the many types and degrees of pollutants, but we hardly have even a basic idea of the magnitudes of flows. Occasionally, a periodical will have telling photo with a family and their year's supply of food (or waste).

The call to "act locally" becomes intuitive. It is probably more effective to fight for changes in policy and regulations than to become a martyr; that is, fight for the 1 gallon flush toilet as a standard than to install a composting toilet. Yet there seems to be a tendency to want to focus on ever larger scales and high profile events, removing responsibility from the level of individual decision. I say: " if only the context was more conducive to certain practices ..recycling, bicycling, public transit." This is partly reasonable, even if a person reduces their demands, or even dies, this does not make a lot of difference on the environment. But enough, more informed decisions and practices will add up.

Much of this literature caters to those , like myself, who maintain notions of do-it-yourself, back-to-the-land one lot utopias. [99] For calculating integrated

99 Some of these include Stoner, Carol H. ed.*Producing Your Own Power: How to Make Nature's Energy Sources Work for You.* Rodale Press, Emmaus, PA. TJ153.S795 ; Leckie, J.G. Masters, H. Whitehouse, L. Young. 1981. *More Other Homes and Garbage: Designs for Self-reliant Living.* San Francisco:

flows at the residential scale; the *The Integral Urban House* remains a classic in breath and depth. In this work, in which the emphasis was on food production, resource recovery, and energy generation on the house scale, diagrams are included to identify the understanding of material and energy flows within their system. Yet as tight as these cycles may become within the house system, we are left only to suppose the positive city scale implications.

Bruce Coldham's thesis on *Echo Hill* in Central Massachusetts is the most complete attempts that I came across at the larger community scale.

John Lyle, who leads the interdisciplinary team designing the Institute for Regenerative Studies, wrote *Design for Human Ecosystems.: Landscape, Land Use and Natural Resources*. This work is a very good introduction to thinking at the site scale with excellent diagrams and case studies, but little in the way of quantifying the magnitude of flows.[100]

Sierra Club Books. TH4812.078; and publications such as *The Journal of the New Alchemist*; *Mother Earth News*; *New Shelter;* and *Harrowsmith*.

[100] Lyle, J.T. *Design for Human Ecosystems.: Landscape, Land Use and Natural Resources*. New York: Van Nostrand Reinhold. HD108.6.L95 1985.

For system flows he refers strongly to the *Integral Urban House* and Howard Odum's work.

Few of Odum's associates appear to have published analysis at the community scale. One study was a first cut analysis of the impact on flows of various development approaches on a 3000 acre scale.[101] The goal was to determine a residential development strategy with least cost to natural productivity, with a primary analysis of developments impacts on local nitrogen cycles.

[101] Steller, D.L. 1976. "An Energy Evaluation of Residential Development Alternatives in Mangroves." MS Thesis (CFW-76-28). Gainesville,FL. See also Miller, M.A. 1975. "Energy Basis for Housing System County." MS Thesis (CFW-75-14). Gainesville,FL.

3.2 Site Scale Flows - Water and Biomass

For sustainable productive site scale, one is interested in those resources which are relatively non-depletable, regenerating or renewable, abundant, or limited. Non-depletable resources include precipitation, solar insolation and wind. The timing and intensities of these flows can vary considerably. Wind and solar insolation can be affected by what is built on adjacent sites. Renewable or regenerating resources include biomass, some aquifers, and top soil.These have sustainable yield output rates (which is less than maximum outputs), and require inputs. Abundant resources, though ultimately limited, usually refers to a soil types or mineral. This is a term relative rate of extraction relative to the existing supply. A resource can also remain abundant if its properties do not change significantly during use. A limited resource would be an petroleum field or a high quality aquifer with very slow or no recharge.

In the American west, water is a key determining resource for the sustainability of any venture or community. Austin receives a good amount, nearly 32 inches per year. Yet there are dry times, when water conservation practices must be practiced.[102] From reading about water in the west, the problem is not so much absolute shortage as one of an allocation of water rights and costs that foster questionable practices. Most water goes to agriculture. If the cost of water went up, other irrigation practices would become economical.

I did not find a step by step model of the hydrological cycle at the site scale. The USGS methods for calculating runoff came from Steller.[103] Runoff depends upon how much water the soil can hold, and is very dependent upon the intensity and duration of the rain event (storms). It was relatively easy to determine the curve numbers,[104] which is a function of the soil classification[105] and the groundcover. The principal difficulty came in estimating rain events. Even in referring to the recommended *Rainfall Frequency Atlas of the US* ,

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[102] I do not know what percentage of the municipal water supply comes from limited aquifers.

[103] Steller, D.L. 1976. *ibid.*

[104] USSCS, *Handbook of Hydrology* and *Urban Stormwater Hydrology*

[105] Werrchan, Leroy , Lowther, A.c. and Ramsey, R.N. *Soil Survey of Travis County, Texas.* United States Department of Agriculture Soil Conservation Service with Texas Agricultural Experiment Station. June 1974.

so much guessing was involved that this leaves this calculation very suspect.[106] As such it is difficult to predict how large a collection pond will be.

Once one assumes the pond, or swimming pool, evaporation rates are critical. These were found in the *Climatic Atlas of Texas* [107]. If the pond is shaded or covered they should be reduced, if in a windy location these should be increased.

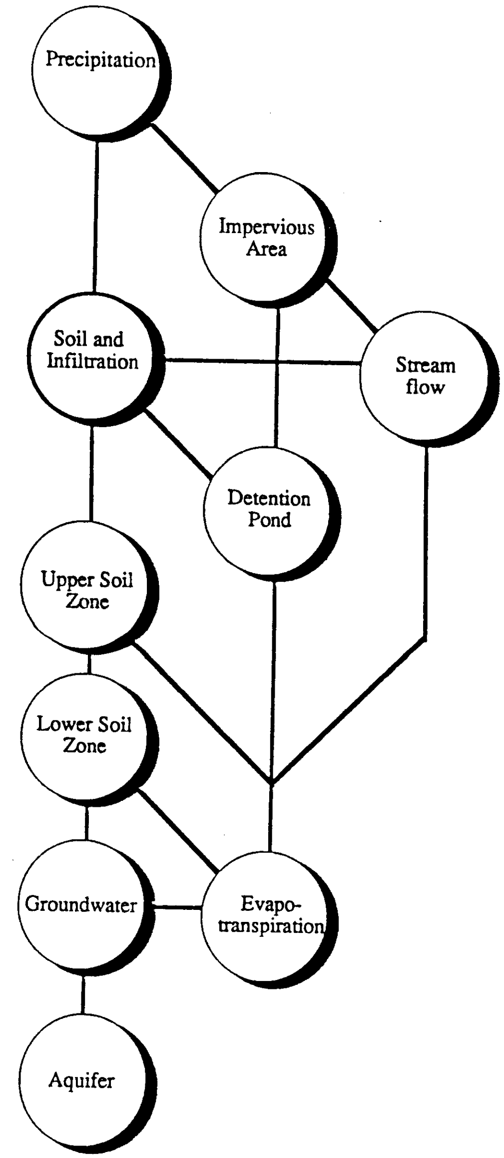
Roof rainfall collection is more straightforward. One takes 75% of the monthly rainfall, 25% being a general figure for losses, immediate evaporation, and cleansing. In urban areas especially, the first water running off roofs can be quite polluted. One could assume that there would be filtration devices at the kitchen tap heads.

Household water demand, practices and alternatives is carefully analyzed by Milne in *Residential Water Conservation.* [108] As Milne comments " the way a

[106] Hershfield, D.M. US Department of Commerce, Weather Bureau. *Rainfall Frequency Atlas of the US*; Technical Paper 40. 551.50973 U58 wt no. 40. 1961

[107] Larkin,T.J. and Bomar,G.W. *Climatic Atlas of Texas.* Texas Department of Water Resources. December 1983.

[108] Milne, M. (1976) *Residential Water Conservation.* Davis: University of California. TD388.M54.



nation uses its water is less affected by technological forces then by the taboos and traditions of its peoples."[109]

The tighter cycling of household water is often proposed, for example, installing a wash basin directly in the toilet tank as is done in Japan (which saves a lot of space in a half bath), and directing kitchen water to irrigation. Robinette has precautions for graywater from bath areas, it should not be used for ponding, on fruits or vegetables, and at a limited rate.[110] Included also are the fertilizing (N-P-K) values of graywater.[111]

A principal demand is landscaping, addressed in Robinette, G.O. *Water Conservation in Landscape, Design and Management.* [112] It is difficult to quantify the determining factors of plant water needs. A lawn may require 0.5 inches of watering three times a week or 78 inches per year (less 32" of rain).[113] By selecting native, drought tolerant plants, for an "xeriscape" on the other hand, minimal additional watering is required. A vegetable garden appears to demand less watering than a lawn. There are many ways of making the water more effective, time of day for example and especially soil cover.[114] The largest loss of water from the site is through evapotranspiration. One finds there is a tradeoff between ventilation and evaporation: encouraging summer breezes helps people but "costs" water. Robinette has a nice diagram showing strategies for reducing evaporative losses. [115]

After water is considered, vegetation/ crops/ biomass is the next basic need to consider. Clean air is the by-product most appreciated by humans. Apparently:

> A leaf surface of 300 square feet can produce, on a sunny day, approximately enough oxygen for one person in a day; since people breath all night and in the winter, 4800 square feet are needed to produce one person's oxygen supply. This converts to approximately 400 square feet of greenery per person.[116]

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109 Milne, M. (1976) *ibid.* p9.

110 Robinette, G.O. *Water Conservation in Landscape, Design and Management.*Van Nostrand Reinhold Co. SB475.83.R63 1984.. p.175

111 Nitrogen promotes leaves and foliage; Phospherous growth of roots; K Potassium potash flowering and fruiting of plants;.

112 Robinette, G.O. *ibid.* 1984.

113 Robinette. *ibid.* p. 35 and p. 203.

114 Robinette. *ibid.* p. 112.

115 Robinette. *ibid.* p.127

116 From Wagner, Judith Joan. *The Economic Development Potential of Urban Agriculture at the Community Scale.* MIT Thesis, 1980.

The next question is how much more greenery is required to filter our other externalities.

As for crops, we can ask how many hectares does it take to support one person. Assuming 1) the average person requires 2,700 calories a day, or 1,000,000 per year; 2) that the primary productivity of wheat is 4,000 kg per hectare or 1,500 grams of dry matter per square meter per year; with a net grain yield of 25-33%. As one kilogram of grain equals 3,500 calories and the wheat harvest yields about 14 million calories per hectare; we can say one hectare can support fourteen on a strictly vegetarian diet (or one acre can support about 6 persons). [117] For a meat eating population some of the grain must go to animals. If the efficiency of converting plant products to animal is about 20%; and if a person derives half their calories from animal products then ; 500,000 calories will require 2,500,000 calories in plant products. Such a person requires a total of three million calories in plant products each year, under these conditions a hectare will support almost 5 people, or about two persons per acre. [118]

117 Chrispeels, M. J. & Sadava, D. Plants, Food, and People. W.H. Freeman and Co. S495.C54 1977. p. 76 .

118 Chrispeels, M. J. & Sadava, D. *ibid.* p.76 .

Thus with one hectare of arable farmland "lost" to nonfarm use for every 12 people ; Chrispeels calculates the world can support about 15 billion on a vegetarian diet or 5 billion on a mixed diet. [119]

Food produced on site can include vegetables, fruits, grains and meat. One can determine how much land is available, determine in what categories (vegetables, fruits, grains and meat) they want to be "self sufficient," estimate the productivity or yields, account for processing losses, and calculate the population. Or begin with a population and its' food demand, and then calculate the site's potential contribution.

For crops, it is pretty easy to get a rough range of potential yields and crop requirements, such as water, nutrients, growing season. [120] To become more specific becomes problematic. First, there are competing claims between advocates of various methods, whether "agro-industry" or "bio-intensive." Another is the impact of various practices, such as the pattern and sequence of crop

119 Chrispeels, M. J. & Sadava, D. *ibid.* p 77

120 Jeavons, J., Griffin, J.M. and Leler, R. *Backyard Homestead Mini-Farm and Garden Log Book.* Berkeley,CA. Ten Speed Press. 1983. and Jeavons, John. *How to Grow More Vegetables.* Berkeley,CA. Ten Speed Press. 1982.

rotation. A major variable is the experience of the grower, which Jeavons addresses, which can account for a range in yield of some 300%.

One method is to begin by calculating carrying capacity based on the solar input.[121] Basically, plants can convert between 1 - 3% of the solar insolation that hits the leaves. Leaf cover does not usually cover all the ground, so another reduction is taken here. At the Integral Urban House for the month of June, this calculation would look like:[122]

	1600 BTU solar insulation per day
x	2500 square feet available for garden production
x	.33 percentage of usable land covered by plant leaves
x	.01 plant biomass conversion rate for vegetables
x	.35 percentage of net vegetable production actually consumed by humans
=	4900 Btu (or 1,234 kilo calories) of food energy available per day from the garden.

If the average person requires a minimum of 10,000 Btu food energy per day, this large garden supplies approximately half the needs of one person. This calculation could serve as the basis for a model if one knew how to add in the other factors: soil quality, temperature etc.

If water is consider as a determining factor, then the calculations becomes as complex as the interaction between evaporation, soil structure, soil nutrition, and growth rate. Evapotranspiration describes the total amount of water which is lost from a plant -soil system. A single corn plant in its growing season transpires about 200 liters of water; this means about 10 inches thickness on the field. [123] Watering is relative to plant growth, which depends upon temperature. There is an optimal temperature for photosynthesis;

> Most plants grow better if a high daytime temperature alternates with low night time temperature ... at night there is no photosynthesis , but respiration continues ... much of the sugar made during the day can be lost if the temperature remains high at night. [124]

[121] Bonner, J. "The Upper Limit of Plant Yield." *Science* 137 [1962] 3523:11-15. Q.S399 see also Chrispeels, M. J. & Sadava, D. *op.cit.*. pp.76 . 71 and 73 "well managed agricultural systems can convert up to 4.2% of the sunlight received during the growing period into dry matter."

[122] Olkowski, Helga et al. *The Integral Urban House: Self Reliant Living in the City.* Sierra Club Books. TH4812.F37 1978. p. 55.

[123] Chrispeels, M. J. & Sadava, D. *ibid.* p 80

[124] Chrispeels, M. J. & Sadava, D. *ibid.* p 69

This is difficult to factor, but is included in average yield figures. More difficult to model for organic farmers is the reduction in yields by not supercharging the soil with imported fertilizers. Another is to estimate soil building and recovery durations, will the crops be rotated or a field kept fallow? A long enough fallow period will restore soil fertility; organic fertilizers offer a more steady flow of nutrients, but may not release sufficient nutrients during the period of rapid vegetative growth. [125] This can have dramatic impact on the extensiveness of a plant's root system and thus on water required: "the transpiration ratio of corn grown on poor soil was 2000 but it declined to 350 when the soil was well fertilized." [126] In another experiment, the number of corn plants per hectare was doubled from 20,000 to 40,000; though the yield increased by 65%, but total water loss increased by only 20% showing the advantage of shading. One has to assume fertilizing rates were kept equal, and that the second method did not seriously deplete the soil's nutrient store.

With the huge agro-industry, there are obviously many models out there, I was not able to find one that applied to the small scale, nor sort through the

[125] Chrispeels, M. J. & Sadava, D. *ibid.* p. 103.

[126] Chrispeels, M. J. & Sadava, D. *ibid.* p. 81.

STEP ONE
SELECT TYPES AND QUANTITIES OF FOOD
1) Demographics: tabulate number of people in each age and sex class who will live in community; from local census.
2) Diet: Distribute across three alternative diet types - meat, poultry based, semi-vegetarian . From Ferguson report.

STEP TWO
FIND FOOD CROP YIELDS AND FERTILIZATION RATES
Note: 'land 'refers to the sum of climate, soil , and all other relatively permanent natural factors ; every land area is unique;
1) Determine capabilty class from county soil surveys published by the Soil Conservation Service;
2) Estimate regional yield ratios from the USDA annual Agricultural Statistics

STEP THREE:
CALCULATE TOTAL CROP AREA .

STEP FOUR:
ADJUST TOTAL CROP AREA FOR FERTILIZER RATE;
determined according to the availability of fertilizers; supply equals demand
STEP FOUR A: FERTILIZER DEMAND AND SUPPLY;
complex question; calculating recycled excretement as a fertilizer source
STEP FOUR B: ACTUAL CROP AREA DEMAND;
"Baule Units"; human population as a crop
STEP FOUR C: EFFICIENCY OF RECYCLING METHOD

Source: Ferguson, B. and M. McAvin, 1980. " A Method for Predicting Agricultural Carrying capacity.": *Compost Science/Land Utilization*. Nov/Dec 1980.

many conflicting claims and complexities. The most nearly complete, appropriate to the small scale, step-by-step method I found was developed by Ferguson and McAvin .[127]

One aspect I really appreciate in this model was the attempt to close the circle, at least in a calculating a balance, between the N-P-K values of human waste as a fertilizer and building soil fertility. These could be combined with the N-P-K figures for graywater. Another was the separation of diets types and demographics. A major uncertainty for was closing the gap of processing losses between net yields and food actually consumed.[128]

There is of course lots of information one can sort through. Jeavons has an interesting diagram on the comparative space requirements for different protein sources and good information on raising chickens, rabbits and other small game. [129] Aquaculture is a

127 Ferguson, B. and M. McAvin, 1980. " A Method for Predicting Agricultural Carrying capacity.": *Compost Science/Land Utilization*. Nov/Dec 1980.

128 One thing they recommend, that I regret not getting around to, was establishing good contact with the local county agricultural extentionists.

129 Jeavons, J., Griffin, J.M. and Leler, R. *Backyard Homestead Mini-Farm and Garden Log Book*. Berkeley,CA. Ten Speed Press. 1983.

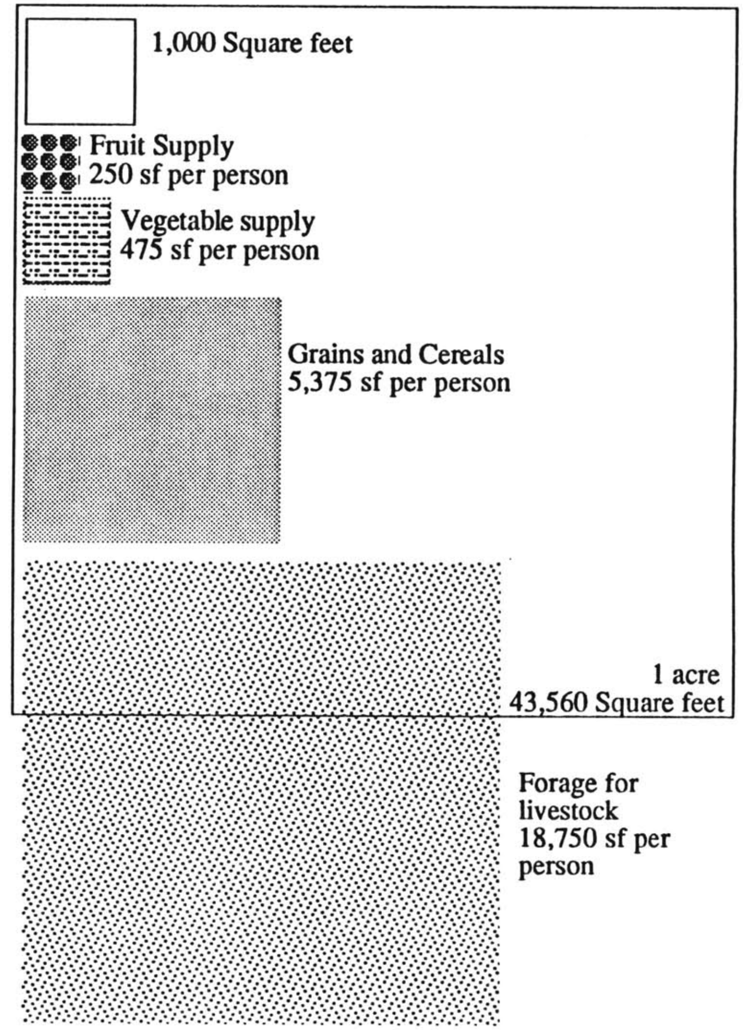
more exciting emerging field. Bioshelter aquaculture that integrate fish, hydroponic vegetables, and even waste treatment is developing as a viable, community scale option.

As it became apparent that I was not going to come across nor develop an appropriately scaled site food productivity model, I went to back to courser rules of thumb. This is practical in the sense that one wants slack for growth. As the site develops, the inhabitants food raising skills improve and productivity increases, though not proportionately. Jeavons estimates 100 ft2 to 150 square feet intensively gardened should yield around 300 lbs of vegetables and soft fruits in 4-6 month growing season. [130] As the Austin growing season is much longer, perhaps this can be increased 50% and still allow a fallow period. If the average person in the USA consumes 322 lbs vegetables and soft fruits annually, this means a minimum of 100 square feet of sun exposed garden area should be budgeted per person. However, vegetables and fruits are not land intensive aspect of food supply, grains and animal fodder are. So one returns to those from the Integral Urban House.

130 Jeavons,J. . 1982. *op.cit.* p 6 & 7.

Most unfortunately, when I followed up on their Asbrook reference. I was not able to find where these numbers came from, thus could not determine which factors can be adjusted in what way. These are supposed to be for the average meat eating American family in the 1950's. There are reasons for adjusting these figures up and down, but mostly down as this new community will probably consume less meat. As the density increases, the probability of raising small stock decreases, and the emphasis is placed upon local vegetables and fruit production. This is reasonable, as this is where proximity is critical, by making maintenance easier retaining freshness and nutritive values.

Another major site flow to consider is that of energy. One has energy flow diagrams for the nation and the world, depicting the sources, the transformations, the transmission/ transportation losses, the entropy, and the uses. These diagrams are quite common in *Scientific American* articles. This would be a good exercise for the typical Austin house.
grahphic ehrlic energy flows
Heat loss calculations are relatively easy. The major problem was in calculating cooling loads, especially in estimating the additional load from the summer sun hitting the roof and walls and in considering



Source: Olkowski, Integral Urban House, page 58 who refer to Asbrook, Butchering, Processing and Preservation of Meat. (when I reviewed Asbrook's work, however, I could not find what they refered to).

variable shading on the windows. The most difficult assumption was to decide to go with limited or no air conditioning, and whether the residents can afford very efficient heat pumps. Furthermore, it is relatively easy to estimate residential energy demands (though this can vary greatly with different people), getting data on commercial enterprises is more difficult.

The most complete site scale energy production model I came up across was by Donald Marier et al.[131] There are good manuals for calculating photovoltaic area, but one gets tempted into thinking very small scale, counting each light bulb and estimating lighting practices. [132] In general, one might want to calculate "backwards," figuring out appropriately sloped and oriented roof area, and determining the productive potential of an array. Methane production is also a interesting calculation, but productivity at the small scale appears to be labor intensive and dependent upon the skill level of the operator. Hydrogen and fuel cells could also be considered.

131 Marier, D, Wentraub, R., and Eccli, S. "Appendix 1. Combining Alternate Energy Systems." in Stoner, Carol H. ed. *Producing Your Own Power: How to Make Nature's Energy Sources Work for You.* Rodale Press, Emmaus, PA. TJ153.S795. pp 242-262.

132 Sandia National Laboratories. *Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices.* Revised March 1990. SAND87-7023 and Sandia National Laboratories. *The Design of Residential Photovoltaic Systems.* Printed December 1988. SAND87--1951/1. See also Real Goods. *Alternative Energy Sourcebook 1990.* Real Goods Trading Company. 1989.

3.3 Design Implications

The intent was to find through research publicly available, credible models. When a series of figures or a "cook book" rule of thumb were found, I would try insert (or extrapolate) the formulas unto spreadsheets and build up a library of templates. For example, by putting Bruce Coldham's thesis calculations unto a spreadsheet it becomes dynamic, that is, one could change a variable such as number of people or differing rainfall and see the impact. The challenge is to assemble the subsystem models, such as vegetables, grains, photovoltaics, windpower into an integrated model. I now have a chaotic collection of half started subsystem models on spreadsheets, all at differing rates of time, scales, and precision.

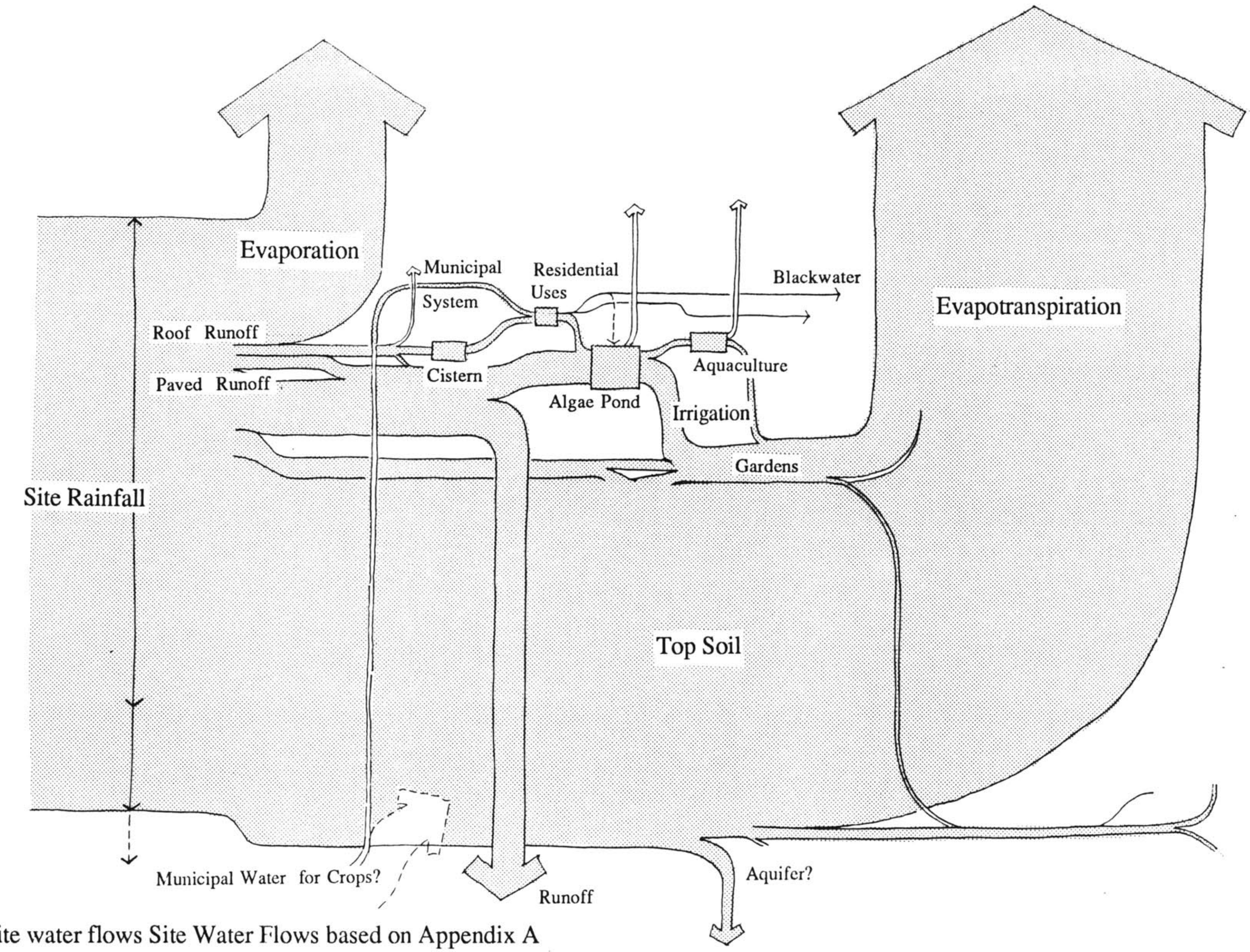
The most integrated spreadsheet model of the Austin site is included in Appendix B.It deals primarily with water flows and land requirements. I was unable to develop this model sufficiently to use as a real design aid. This was due in part to difficulty in obtaining information at the appropriate scale, particularly on commercial enterprises; time limitations; and my general confusion, particularly when defining subsystems. Perhaps a greater limitation was my unfamiliarity and detachment from Austin, which led to a simplistic assessment of the context as well as reducing the motivation to develop an information network. A serious model would best be built up over time from the perspective of a particular place.

For purposes of this design exercise, the model was used to determine a starting population of seventy persons that could grow the amount of food to feed themselves and collect sufficient rainwater for site needs. From doing this model, it is obvious that there are a wide range of attitudes, practices, and technologies that would change this population size dramatically. Basic development variables include housing density (height, lot sizes and setbacks), parking allowances, user lifestyles, land-use allocation, consumption/recycling practices, relative prices for resources. The intent was to propose various scenarios, run spreadsheets to generate a program, and accompany this with an illustrative schematic. As mentioned, the assumption about available models was incorrect.

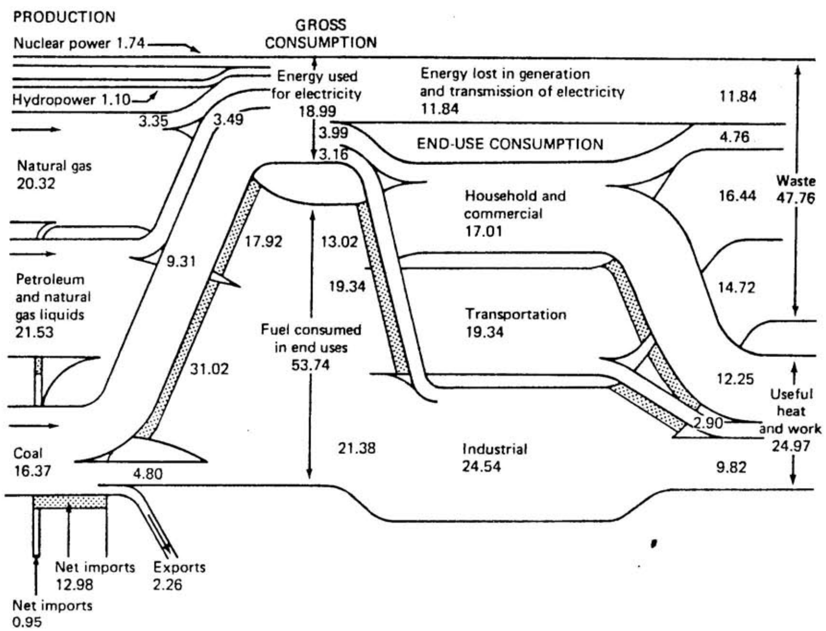
Christopher Alexander states:

No complex adaptive system will succeed in adapting in a reasonable amount of time unless the adaptation can proceed subsystem by subsystem, each subsystem relatively independent of the others."

The challenge for the designer is the definition and integration of these subsystems. Addressing this tension calls for judgment which requires knowing, to a reasonable order of magnitude, the ranges and thresholds of the subsystems. Faced with uncertainty, one is left to design in a more conventional way, from implicit and explicit patterns, perhaps with a heightened awareness. Though the models presented here were not developed sufficiently to aid in a "metabolic" design approach, the potential remains.



Site water flows Site Water Flows based on Appendix A



From *Ecoscience: Population, Resources, Environment* by Paul R. Ehrlich, Anne H. Ehrlich, and John P. Holdren. W.H. Freeman and Company. Copyright © 1977.

4 Resilient Design

Re•sil•ience 1. The ability to recover... 2. The property of a material that enables it to resume its original shape or position after being bent, stretched, or compressed; elasticity. [American Heritage Dictionary]

This section presents a design proposal for a community that grows out of bringing together people interested in experimenting with more socially and environmentally sustainable ways of living. It begins with a short history of the center, describes similar efforts, and presents the site. Design approaches addressing uncertainty and change are discussed. Three scales of design intentions are presented, progressing from the small scale to the larger: a growable/ dividable house, the first community of seventy persons, and a massing study for greater density.

4.1 The Story: A City Gate

Success, for the most part, is built on failure. - Ebenezer Howard..

The Center for Maximum Potential Building Systems began in 1975 as a place for "hands-on" demonstration projects, especially with architecture students from the University of Texas. There have been many lean years. From the beginning, Pliny Fisk has been the continuing force, carving a niche in community based "appropriate" building materials. As a graduate student at the University of Pennsylvania, he doubled in Architecture and Landscape Architecture. He was strongly influenced by the land assessment methodologies of Ian MacHarg, and has sought to adapt such methodologies to better integrate the process of building with the surrounding or local resource base. They became involved in projects notably in Nicaragua and in Texas: Crystal City, Carrizo Spring and Laredo.

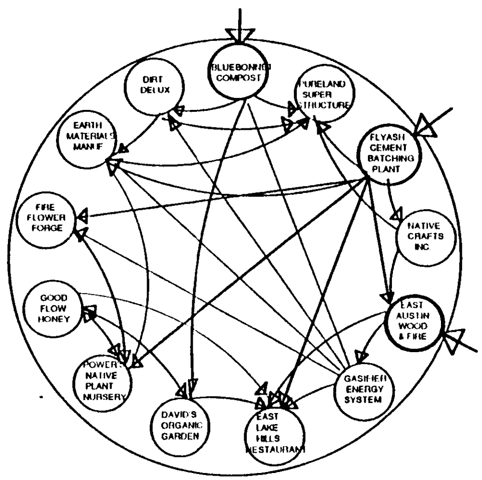
The Center's facilities are located on the eastern city limits of Austin, Texas. Since the heyday of 70's environmental and energy enthusiasm, the site has served as a base for the Center's off site efforts. For a while, a group of compatible enterprises were coming together in a way that Fisk likes to call Pureland. The coming or bringing together of such business in such away activities gave Fisk the idea for "City Gates."

As the site is just within the Austin city limits, on F.M. (Farm to Market) 969 the interface between consuming city and supporting farm suggests another scale of critical flows. This project could serve as a prototype for what the Center envisions as a new generation of *City Gates*: environmentally responsible industrial / agricultural / commercial centers at the urban fringes.

The phased development of the 24-50 acre site will reflect financial uncertainty as well as the evolving sophistication of the Center's planning methods. This will likely be a place of testing ideas, a place for "failing," of half completed projects carried out by persons living moderately, usually on grant dependent (often unsteady) funding. For example, the New Alchemy Institute has a real problem finding affordable summer housing for the many interns who would like to work there. The probability of incremental, modest growth has the advantage of continuous learning and evolving, rather than the overbuilding all at once, optimizing a understanding

PURELAND

INTEGRATED POINT RESOURCES USING TRIGGER INDUSTRIES IN A REGIONAL INDUSTRIAL PARK



PURELAND INDUSTRIAL PARK
INTERNAL SUPPORT DEPENDENCEY

○ SUPPLIER
● RECEIVER

	PURELAND SUPER-STRUCTURE	FLYASH BATCHING PLANT	NATIVE WOOD CRAFTS	EAST AUSTIN FIRE WOOD DEPOT	GASIFIER ENERGY SYSTEM	EAST LAKE HILLS RESTAURANT	DAVID'S ORGANIC GARDEN	POWER'S NATIVE PLANT NURSY	GOOD FLOW HONEY	CHUCK'S GARDEN ORNAMENTS	EARTH MATERIALS MANU	DIRT DELUX	BLUEBONNET COMPOST
PURELAND SUPER-STRUCTURE	●	●	●	●	●	●	●	●	●	●	●	●	●
FLYASH BATCHING PLANT	○	●		○	○	○		○		○	○		
NATIVE CRAFTS	○	●	●	●	●	○		○		●			
EAST AUSTIN FIRE WOOD DEPOT	○		○	●	○	○							○
GASIFIER ENERGY SYSTEM	○	○	○	●	●	○			○				
EAST LAKE HILLS RESTAURANT	○	●	●	●	●	●	●	●	●	●	●	●	
DAVID'S ORGANIC GARDEN	○					○	●	○	○			●	●
POWER'S NATIVE PLANT NURSY	○	●	●		●	○		●	○	●	●	●	●
GOOD FLOW HONEY	○		●			○	●	●	●				
CHUCK'S GARDEN ORNAMENTS	○		○			○		○		●		○	
EARTH MATERIALS MANU	○	●									●		
DIRT DELUX	○		●			○	○	○		○	○	●	●
BLUEBONNET COMPOST	○			●		○	○	○					●

of current state-of-the-art technology, which then becomes passé. Here one has the opportunity to learn from the learning, a place to see and touch the many failures and occasional breakthroughs. Such a place will have many facets: mecca and retreat; laboratory and community.

There are a few projects in the United States that are similar in scope. Certainly, there are many community economic regeneration efforts sponsoring small business incubators. One center, near Orland, Maine, is called "h.o.m.e:" *Homemakers Organized for More Employment.*[134] Located on a 23 acre farmstead, now a community land trust, stands a cluster of simple, rustic structures neatly labeled with their uses: market stand, learning center, a big crafts store, cobbler's shop, weaving shop, stitchery, leather shop, flea market, woodworking shed, pottery shop, museum, church, woodlot, sawmill, shingles factory, garage. For the last twenty years ago this facility has been supporting and developing cottage industries under the continued direction of a driven individual: Lucy Poulin. As mentioned before, the New Alchemy Institute and the Integral Urban house have served as places for average (rather than primarily for university or business affiliated) people

[134] Gaines, Judith. "In Maine, a H.O.M.E. With Heart". *Boston Globe* March 4, 1990. p42.

to see and learn from attempts to develop more environmentally benign approaches. Cerro Gordo, Oregon a "symbiotic community, " is and the more radical Arcosanti, Arizona are both "new towns." The Institute for Regenerative Studies looks to be a very promising center, as this will be a college dormitory in which students will live next to what they are learning to raise. Biosphere II should be an interesting project to visit, but it is not oriented to domestic technologies.

One stimulus for this potential "city gate" location could be a *Self Help Housing Resource Center*; a place to provide information, demonstrations, training and well as an incubator to spin off supportive businesses. The purpose of this center would be to provide for an easier flow of relevant information for residents and builders alike, with a particular focus on the legal and financial difficulties in securing housing on a low income. Simple low cost design services for proven housing designs with detailed material lists and price takeoffs would be made available. Related information on health, nutrition, gardening, and productive enterprises could also be facilitated here.The above services could be housed in full size prototypes to make tangible housing technology with direct cost information. A "Design Center" or showroom will have demonstrations of proven and of promising housing system technologies, like energy conserving appliances, batch solar water heaters, roof rain catchment, and family scaled food production. A cluster could be made up of full scale low cost housing prototypes and building technologies that have proven popular in other places, or appear worthy of experimentation. This could be a centralized place to invite research institutes to tangibly demonstrate what has worked in other places, or simply to try out new ideas. A building skills training center at a range of skill levels - from unskilled homeowner to professional builders. For example, perspective borrowers under certain self-build loan funds may be called upon to participate in a training session to earn certificates as a qualification. These sessions could be at the center or as part of off-site work crews that help on actual projects. There could be skill bank where people can barter their abilities. There could also be "incubator space" for the start up of small housing related businesses - aided by grants. As some of these business grow and need more room, they may have to move out. The goal is for most of these functions to spin off as locally controlled self supporting enterprises, for example: A Tool Bank or tool rental business; a materials supply yard - especially to encourage certain materials by procuring through combined buying power; a materials recycling yard provides additional employment, lowers costs, reduces pollution and landfill demand.

4.2 The Site

Austin is at a confluence: the western border of the the old south, the southern border of the North American breadbasket, and the northern border of "MexAmerica."[135] It is anchored by the state capital and the large University of Texas campus. It is divided by Interstate 35 with the affluent whites to the west, and less affluent blacks and Chicanos to the east. To the west are wonderful ribbon parks Zilker and Barton, to the east are airports. To the west is the Hill Country, where extensive environmental assessment studies are being conducted to define an protect the habitats for two threatened species: the rare black-capped vireo and golden-cheeked warbler. Until a comprehensive plan for habit protection is completed, very little development will be permitted. The pause is probably desirable. Stimulated by the oil boom, easy bank loans, and the high tech firms of the "Silicon Gulch" the population of greater Austin has nearly doubled to 750,000 in the last fifteen years. At the end of 1987 Austin had the highest office vacancy rate of any large metropolitan area: 39%.[136] Before the boom, Austin was the most affordable major US city, by the end of 1987 it had the highest per capita bonded indebtedness.[137]

Like much of the American plains, Texas generates images of the open road, long and straight with right angle at the corners of farm fields. In general a car is almost required. As mentioned, Austin is split in half by a freeway. My principal impression of downtown Austin is one large parking garages equalling the massing of the buildings separated by expansive parking lots. Yet Austin has many wonderful streets with open air cafes, bookstores, health food stores, a very active live music scene as well as beautiful lineal parks.

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135 Jarreau. *op.cit*. p.222.

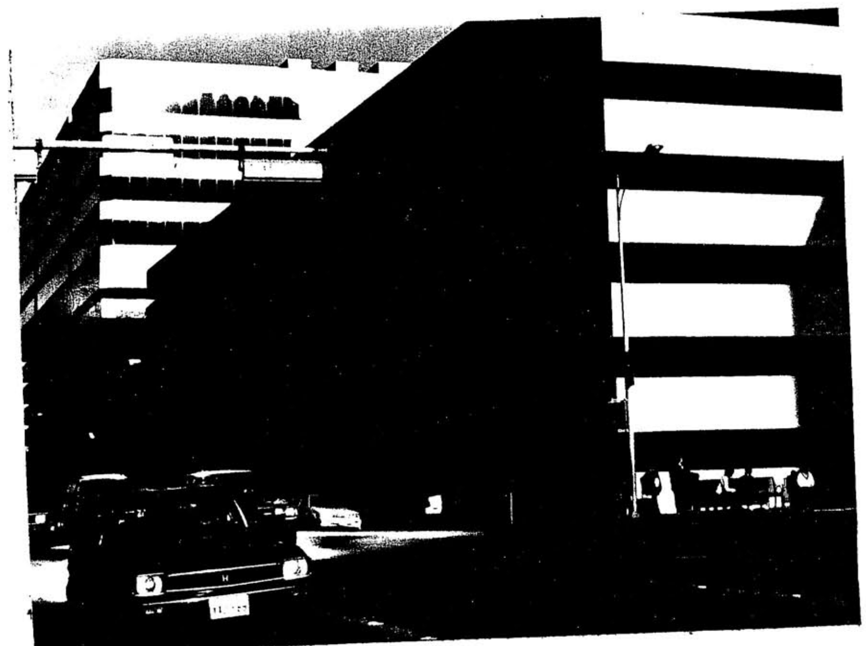
136 Moize, E.A. "Deep in the Heart of Texans" *National Geographic*. June 1990. Vol 177, No. 6. pp 55.

137 Northcott, K. "Tex Mess: Austin Finds its City Limits." *The Progressive*. April, 1987 p36.

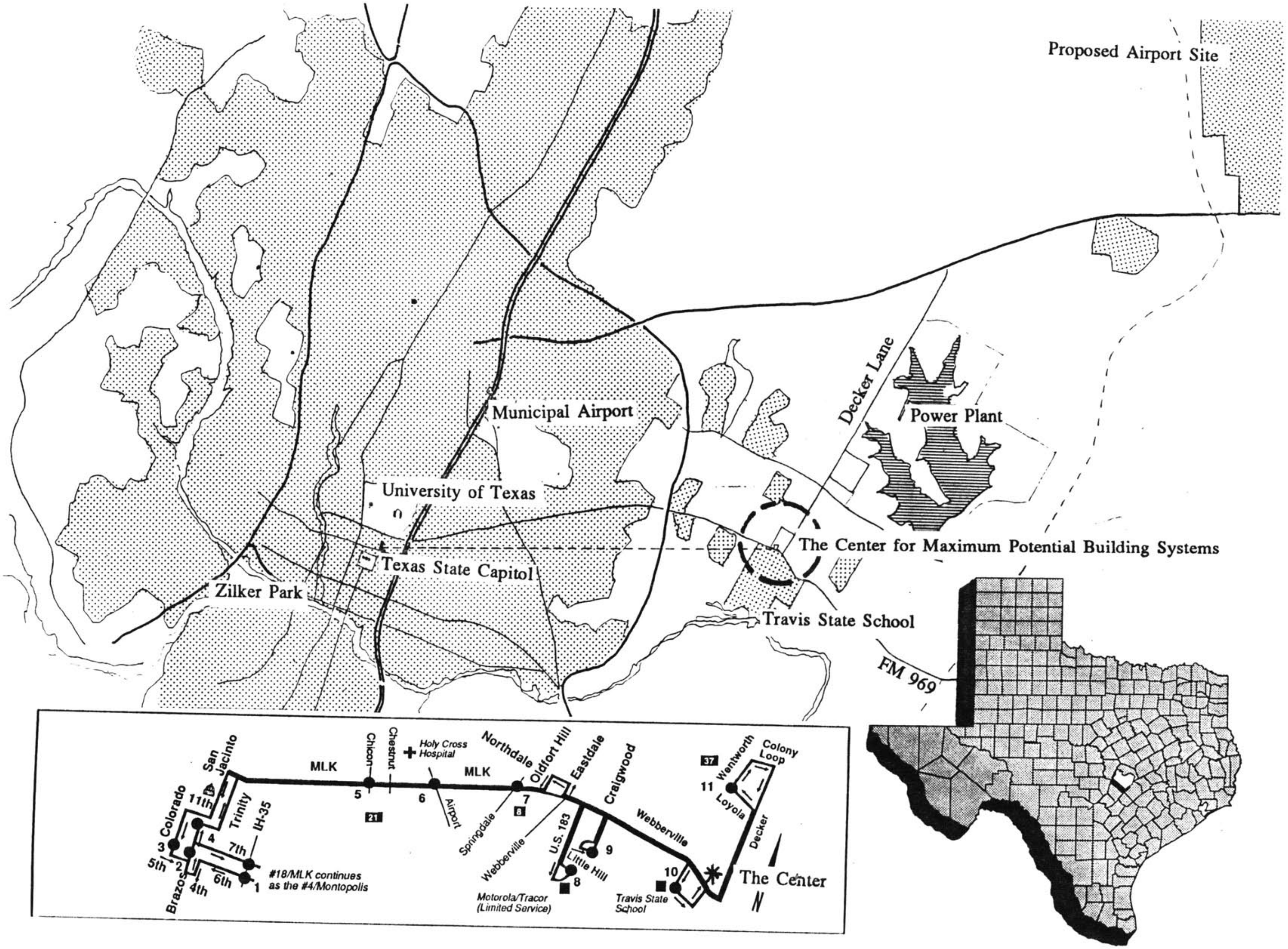
The Center owns 25 acres at the corner of FM 969 and Decker Lane; to the north , another 25 acres is owned by people with goals compatible those of the Center's. The site sits atop Roger's Hill, on the eastern city limits of Austin, above where the Colorado River flows out of Austin past the municipal sewage treatment facilities. The Center's land wraps around Roger's cemetery, largely overgrown with a few modest, maintained plots. Some of the tombstones have a most interesting homemade quality.

Farmstead east of Austin, Texas.

Along the south edge of the site there is an expansive view to the west, you feel high on the edge of town, you can sense and just make out the towers of the capitol and the University. Otherwise the site feels flat.The south and east site edges are defined by zooming cars. The southeast corner is the point where these cars slow down and touch ground for a few seconds, and pedestrians have a better chance to cross. The corner is a bus stop, with good, free service to the central business district via a few annoying detours. FM 969 is a principal road straight through town where it becomes Martin Luther King Avenue. The lanes are generous in width for cars but the white line is very close to the shoulder, bicycling is most uncomfortable.

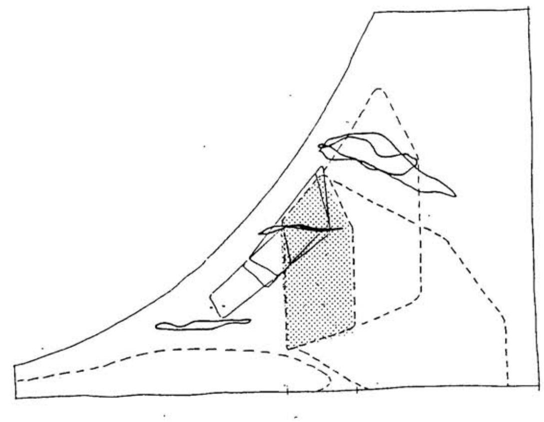


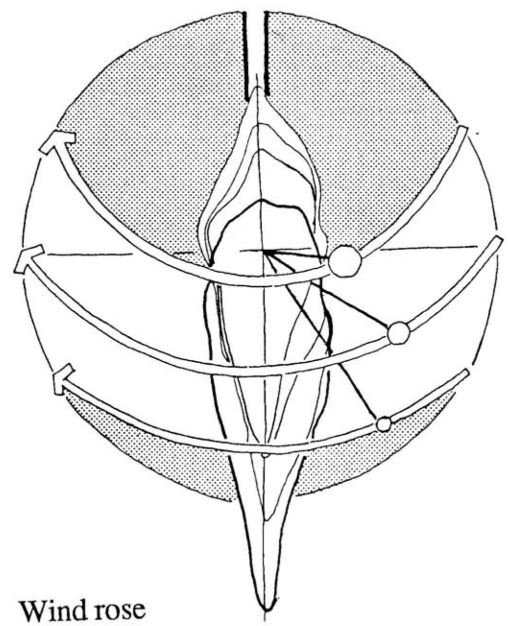
Downtown Austin, Texas.


Proposed Airport Site
Decker Lane
Power Plant
Municipal Airport
University of Texas
The Center for Maximum Potential Building Systems
Texas State Capitol
Zilker Park
Travis State School
FM 969
San Jacinto
Colorado
11th
Trinity
IH-35
7th
5th
6th
4th
Brazos
MLK
Chicon
Chestnut
Holy Cross Hospital
Airport
Northdale
Oldfort Hill
Eastdale
Craigwood
Springdale
Webberville
U.S.183
Little Hill
Webberville
Wentworth
Colony Loop
Loyola
Decker
#18/MLK continues as the #4/Montopolis
Motorola/Tracor (Limited Service)
Travis State School
The Center
N

The climate of Austin is humid subtropical with hot summers. Summer evenings are usually pleasant. Prevailing winds are strongly southerly, except in the winter. Average growing season is 273 days, between early March and late November. Winters are mild, with freezing temperatures occurring on an average of 25 days a year. Cold spells usually last just a couple of days, but are often accompanied by strong northerlies. Precipitation is evenly distributed with peaks in late spring and September. From April to September, precipitation is in the form of thunderstorms, while the winter it consists of light rain.

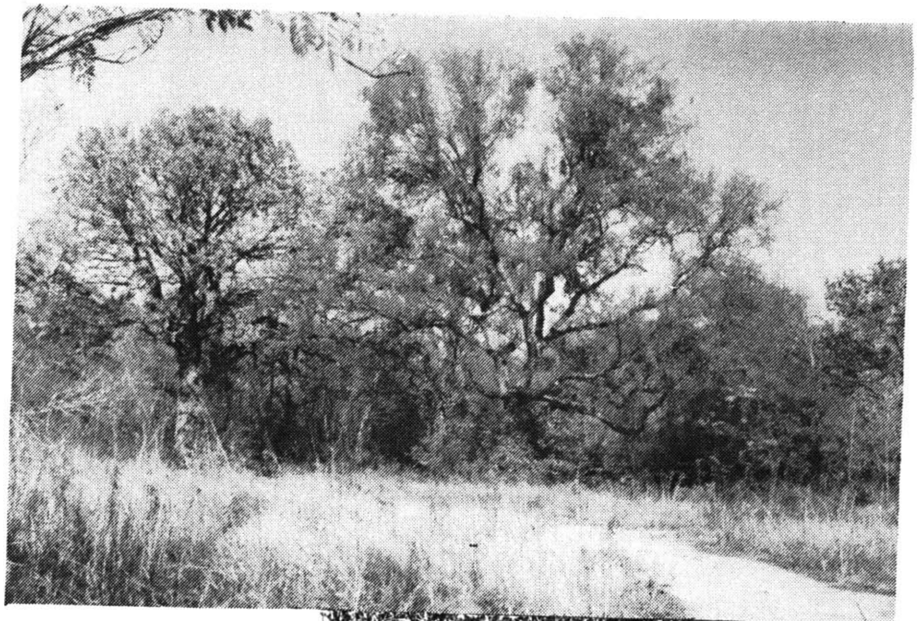
The site is basically flat, there is no running water on the site. The top soil is of moderate quality; the vegetation primarily grasses, mesquite, some cactii and majestic oaks. [138] Seven people live on the site now. They maintain a large vegetable garden and use the facilities as a playground, as a work yard, and as a staging area for projects such as the demonstration farm in Laredo and the fabrication of solar water heaters. Other uses of the site are beekeeping, auto storage, and "Dirt Deluxe," a top soil mixing operation. There is a strong orientation to the west, to





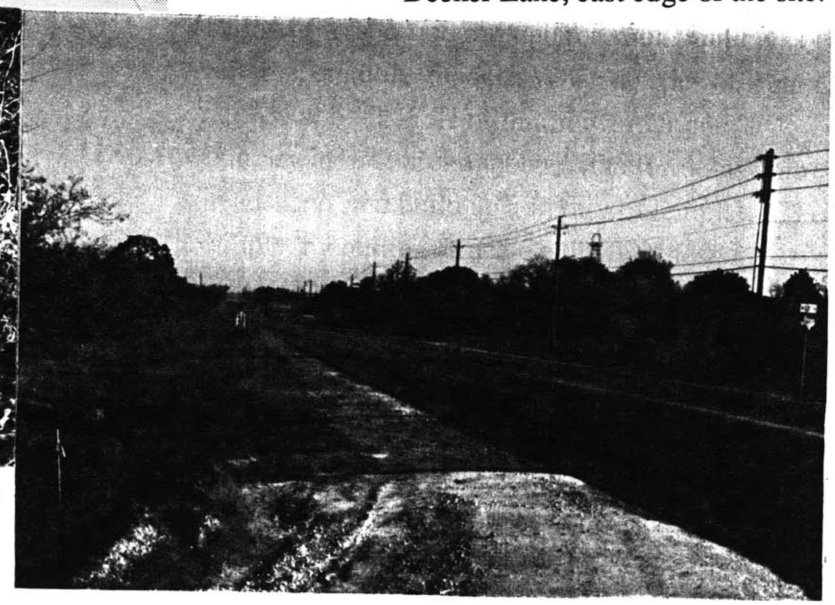
Wind rose

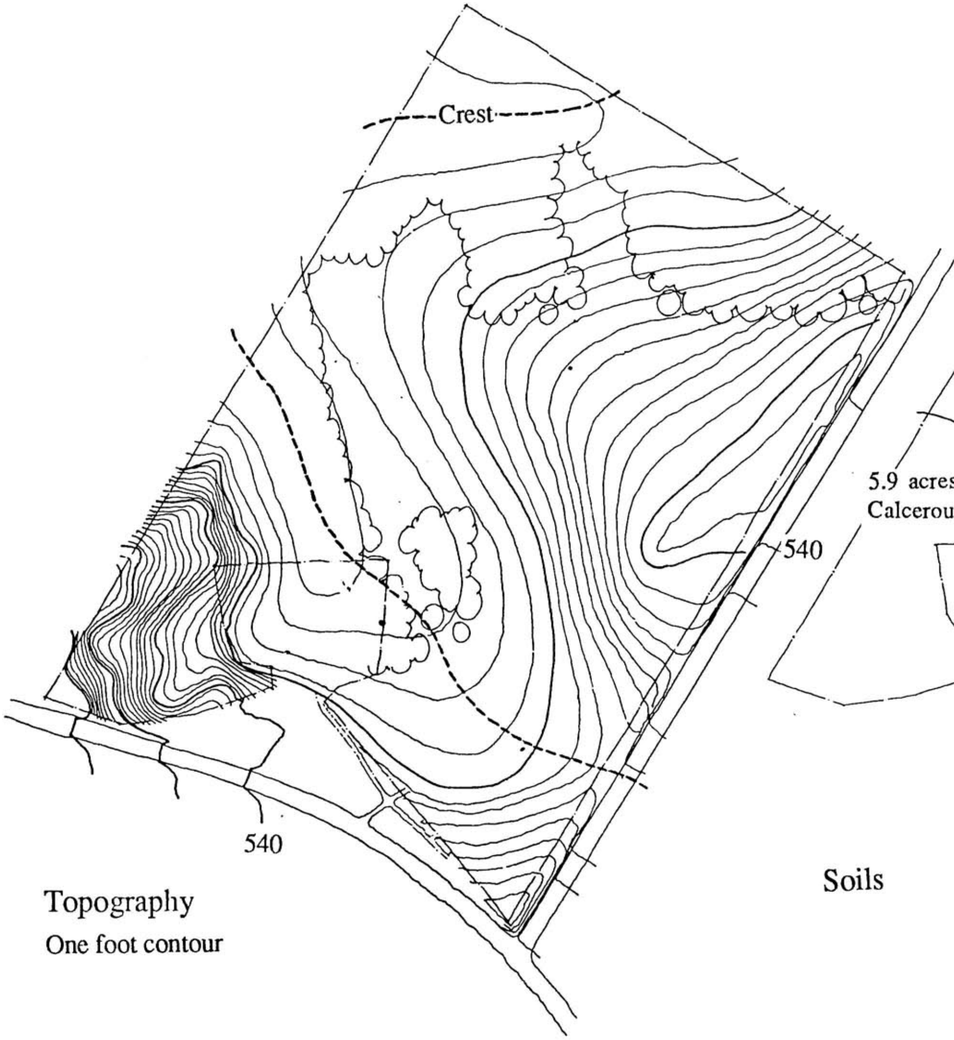
138 Werrchan, Leroy , Lowther, A.C. and Ramsey, R.N. *Soil Survey of Travis County,*



Decker Lane, east edge of the site.

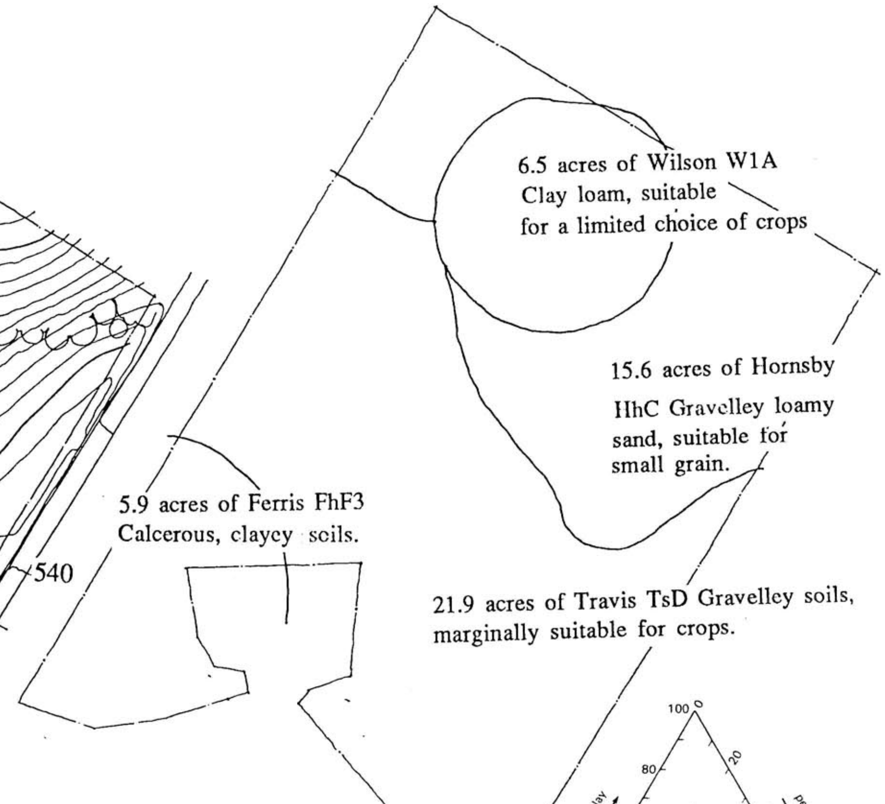
Grave marker, Roger's Cemetery





Topography

One foot contour



Soils

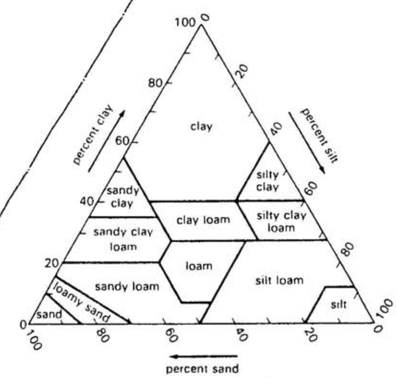
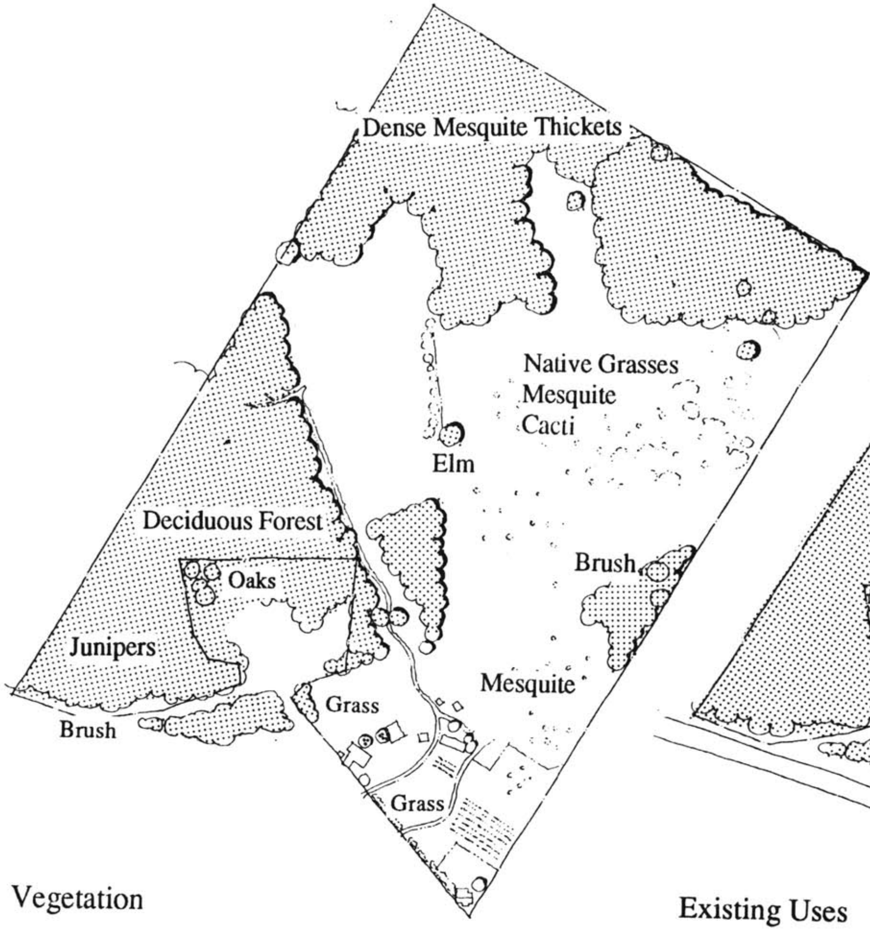
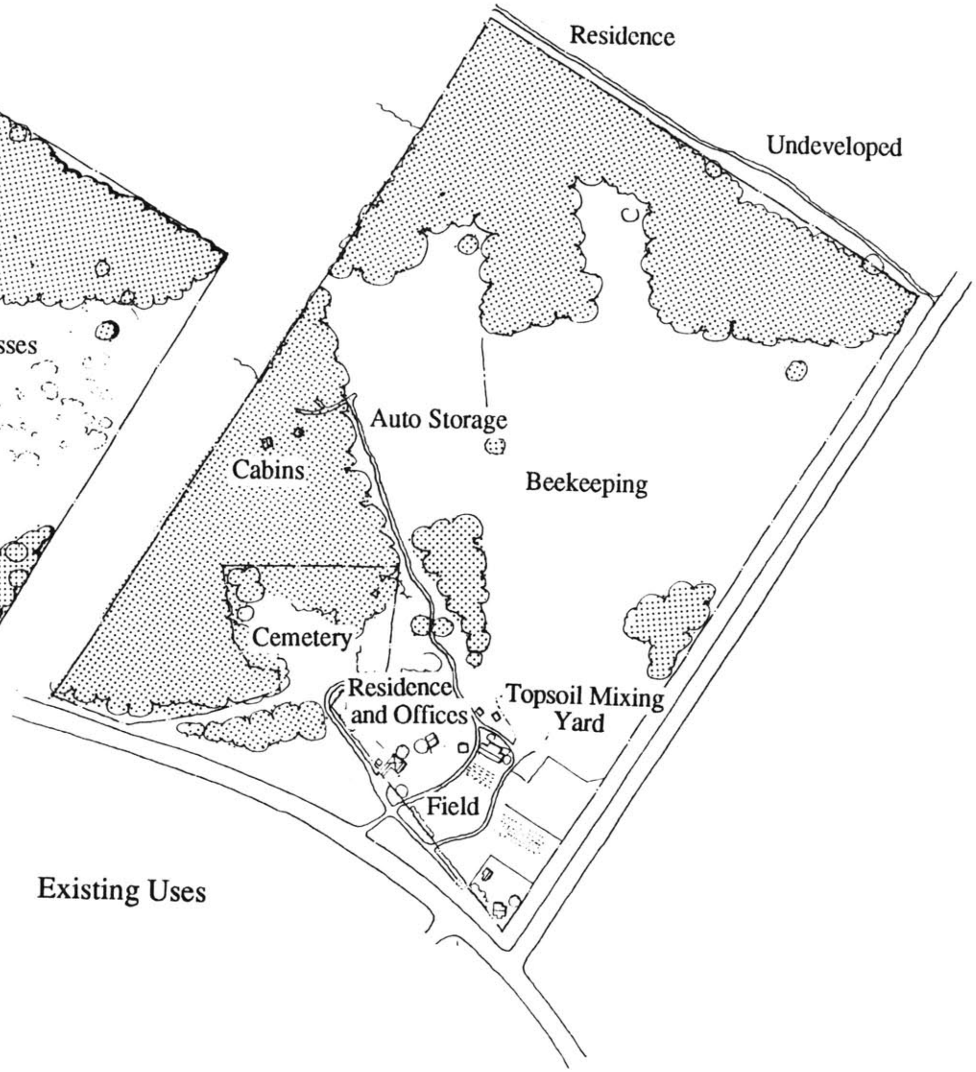


FIGURE 12-1. *The texture triangle shows the relative percentages of sand, silt, and clay in each textural class. (In the United States the term "loam" refers to a soil with more or less equal proportions of sand, silt, and clay. As used in Great Britain the term refers to a soil high in organic matter, a "mellow" soil.)* [Courtesy USDA.]



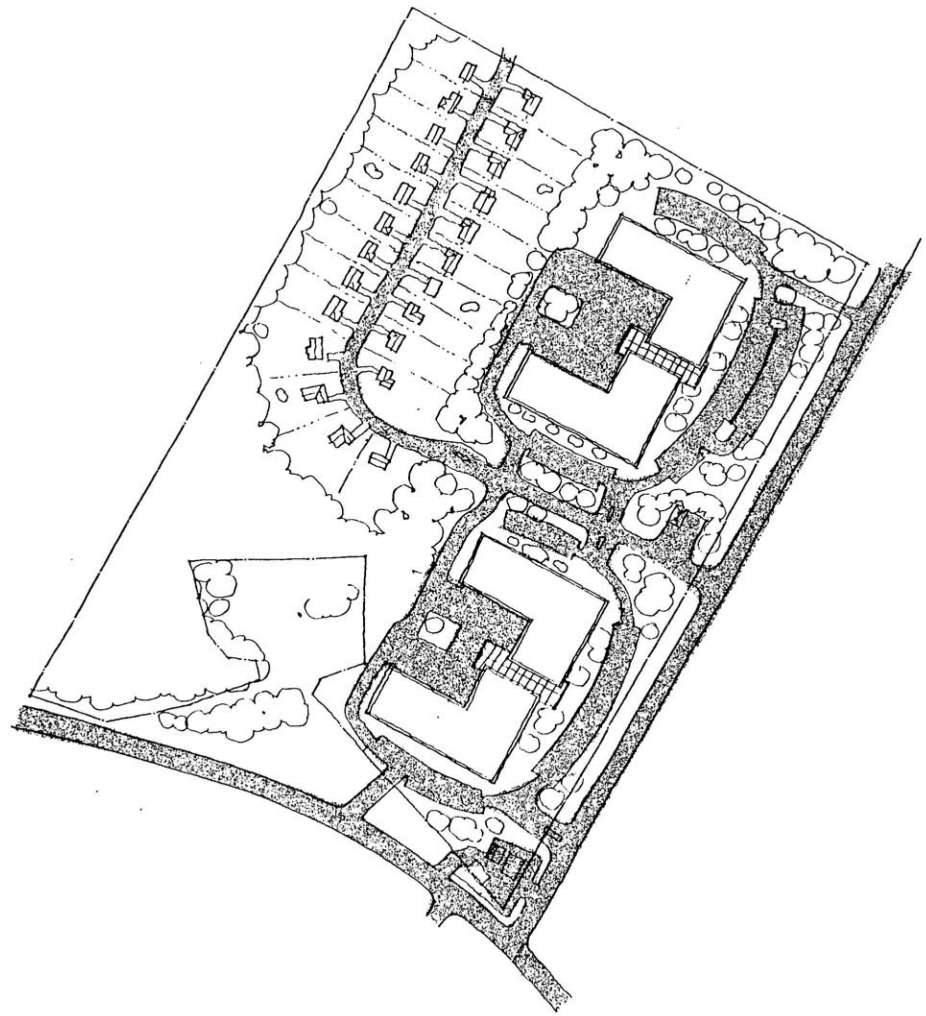
Vegetation



Existing Uses

town. For those new to the site, the left turn off of FM 969 is difficult; they may prefer to continue to the corner and turn off of Decker Lane. This sets up a counterclockwise circulation through the site.

Owing to the urban growth the boom, Austin began planning a much larger airport to the north east of town. This was another factor increasing the assessed value of easily developable industrial space such as on the Center's site. With the increased land value and tax load, the Center considered relocating further out of town to a farmstead with a pond and an easier regulatory context for small scale farming research. In Austin, family farms can qualify for tax relief, but only if a large percentage of the household's income comes directly from selling produce. If they were to sell, developments of similar properties a few hundred yards up Decker lane suggest that the "highest and best use" or the easiest profit, may well be the "post-industrial office building." These large, low per square foot cost structures qualify as loose fit: the ceiling height is such that it can serves as a warehouse and light industry, or be subdivided into two stories as a back office facility.[139] The truck loading area can be converted to parking.



Highest and Best Use

139 Fulton, William. "Zoning for the Post-Industrial Industrial Park." *Planning*. February 1989. pp22-27.

4.3 Resilient Design

Our technologies keep changing at ever increasing rates, reflecting desires/values, economic constraints, knowledge and practices/behaviors while in turn changing them. Many technologies allow more people to live more comfortably at lower costs. To build with "state of the art" approaches is risky, especially when adopting new materials and untested details. "Houses of the future" soon become dated, interesting snapshots of emerging notions. We have many adventurers living in overglazed solar ovens, others who suffered from too tight, poorly ventilated sleeping bags.

This should induce a certain humility and restraint in designers tempted to push conservation of energy flows as a concept.[140] Certainly this has happened with the architectural profession in general, as the flurry of 70's solar efforts were set aside as naive. We know that with good insulation, reasonably placed quality windows, radiant barriers, and air pumps the average suburban tract home can be made quite efficient.

Yet there are many people, tinkerers and others who would like to live in a place that expresses and teaches them about some of the flows and life cycles about them. Plants and water features suggest life; sunspaces and daylight, sun; the hearth, warmth; the roof, shelter. These are basic design elements; problems seem to arise if the allowance and adoption of a certain technology is overemphasized. This may be basic, but it is a trap that myself and others with similar environmental agendas seem especially vulnerable to. There is a tension to express innovation and heightened awareness in a non-threatening way. A whole building design is adjusted and compromised in order to try out an idea. Others take the view that vernacular approaches have "worked" before, without asking why the mythical average person came to prefer others, or how the existing context of resource availability and building skills have changed. As an architecture, we get strange fanciful, earnest but often ugly, hybrids. These are not necessarily failures if, rather than being hidden, they are learned from as they are inhabited.This site could provide a place to tap into this enthusiasm.

[140] see Banham, Reyner. *The Architecture of the Well-tempered Environment.* University of Chicago Press, Chicago. TH6021.B28 1984.

Aware of the dangers of over-optimizing a system based on present understandings, the designer usually turns to open systems, asking which elements become the more fixed frame and at what scale are interchangeable components emphasized. Many have worked and written focusing on this issue dimensions of adaptability: Habraken, Caminos, Boudon, Turner, Kroll. At the larger urban scale, Anne Vernez Moudon's *Built for Change*, is a detailed account and analysis of the life cycle of the evolving block structure of San Francisco. [141]

Like many southwestern cities, San Francisco was originally established along the Law of the Indies. Just a few years after US occupation, San Francisco was hit hard with the explosive boom of the gold rush and the speculators's Jeffersonian grid crashing across the continent. In the 1850's, pre-fabricated houses were shipped in from Boston and the more affluent, faced with "exorbitant" land prices, would hire professional squatters to take the risk and hassle of invading land. Moudon notes:

The simplistic and somewhat harsh nature of San Francisco's design and building principles contrasts greatly with the diversity found in the built city. This seeming paradox raises some interesting issues about the development of city form.

The prevalence of an individually based system of design decisions supported by a formal framework of mixed building traditions brought softness to the neighborhood environment. Industry catered to this system. It delivered standard and uniform building products that property owners could quickly personalize. [142]

In San Francisco "platting replaced planning; customs and traditions from past generations dominated design and construction processes."[143] The fine grained cellular characteristics that allow "different lot widths, house types, and building heights [to be] mixed within the city block is still one of the distinguishing features of San Francisco architecture." [144] The homestead associations begun in the 1860s helped make San Francisco a city of small houses. Moudon sees this as:

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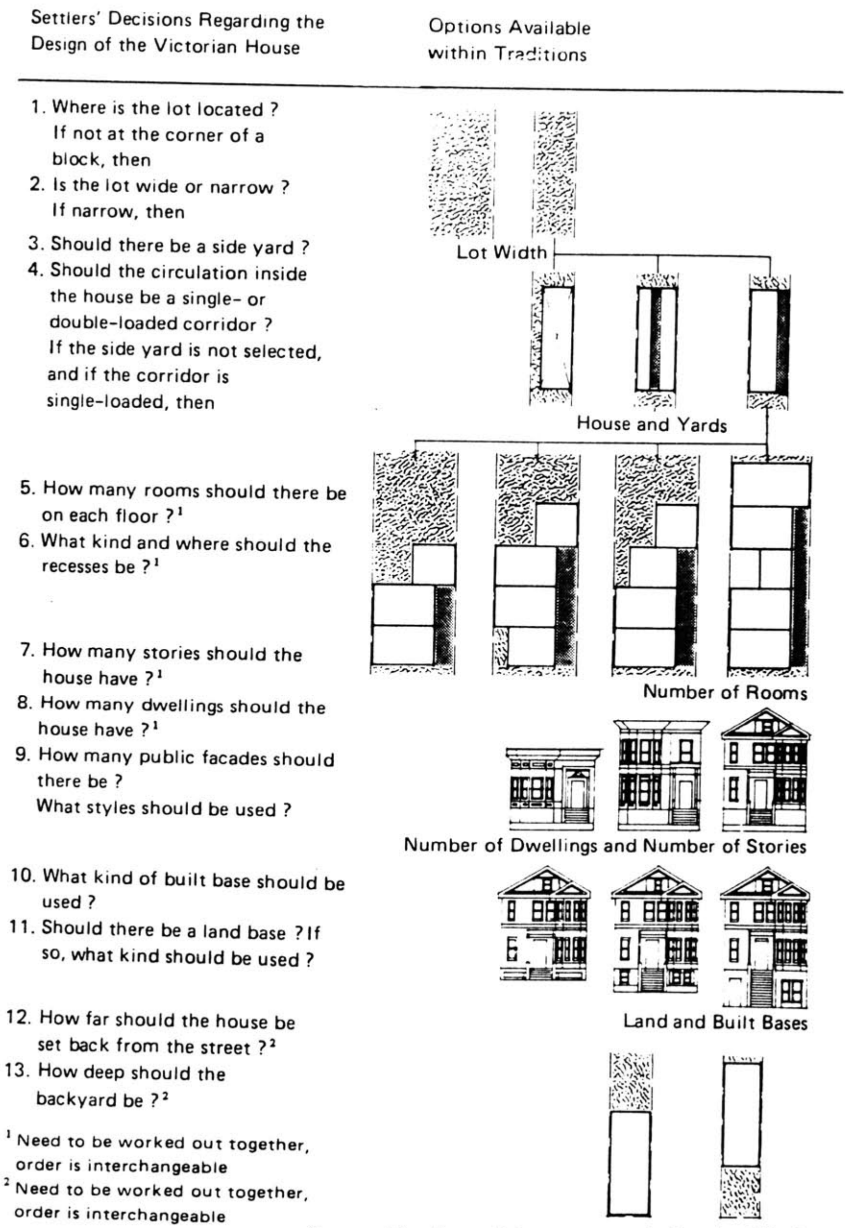
141 an excellent example of channelling student research towards a sharable product. Moudon, Anne Vernez. *Built for Change: Neighborhood Change in San Francisco.* MIT Press. NA7238.S35M68 1986.

142 Moudon, Anne Vernez 1986 *ibid* p.95.

143 Moudon, Anne Vernez 1986 *ibid* p.51.

144 Moudon, Anne Vernez 1986 *ibid.* p. 84.



Source: Moudon, 1986. p. 73.

...positive and healthy [for] the smaller the scale of the physical environment, the more continuous and imperceptible the change ..suggesting that the single most powerful determinant of urban architecture is the ownership structure of the land. [145]

The smaller the lots, the more affordable, accessible, and resilient the urban fabric. These lots can still be aggregated to form larger lots, though the reverse tends to be much more difficult. From the qualitative successes of the fine grained neighborhoods of San Francisco, Moudon suggests a return to room as a module for urban residential design.

In effect, planners need to know about the lots and buildings since neighborhoods are gradually modified through activities carried out at the scale of the lot. Conversely, architects need to know about the power of the lot to affect the way urban form evolves if they are to deal responsibly with the design of individual cells within the city. [146]

Given the uncertainty in the development of the Center's site, an all-at-once built-out campus approach, even if phased, would be folly. Rather, the emphasis should be placed on first moves based on understanding the potential of the site. In *nature*, life

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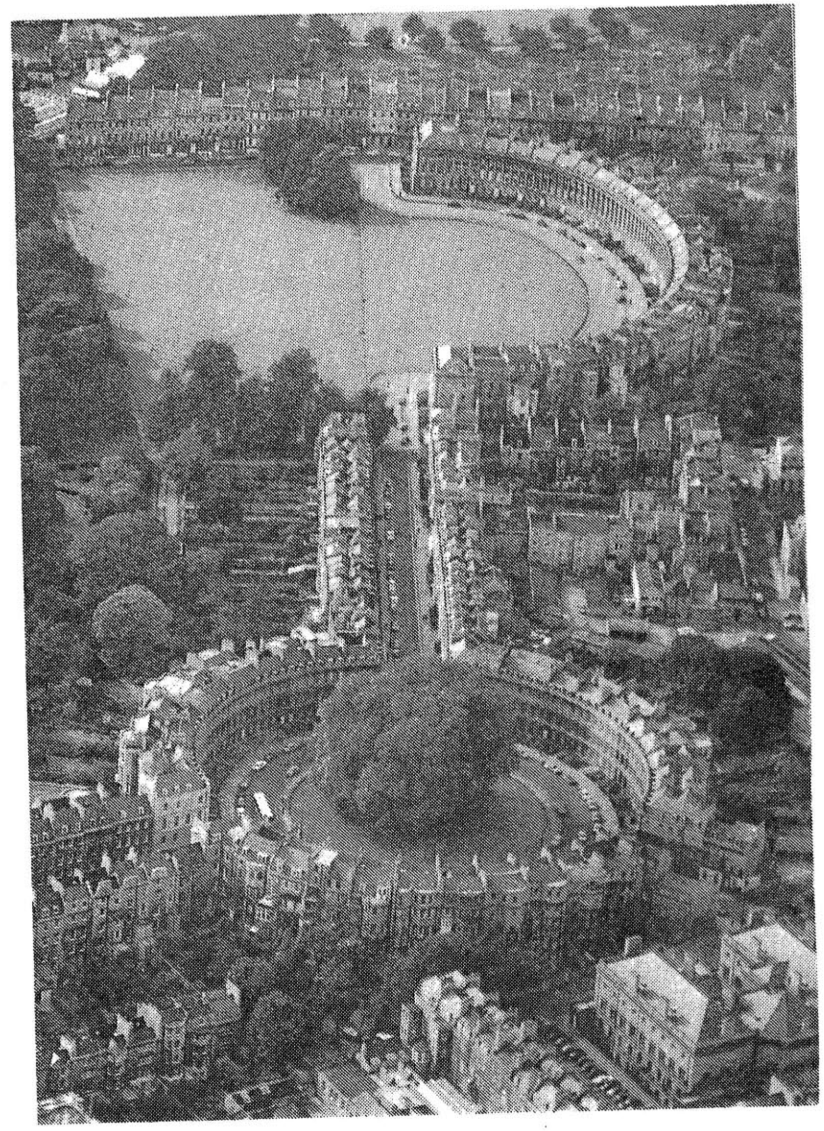
145 Moudon, Anne Vernez 1986 *ibid.* p. 133.
146 Moudon, Anne Vernez 1986 *ibid* p. 144.

spans increase with scale while metabolic rates decrease. Thus, in the scale of this project, the larger moves would do well to be increasingly conservative, that is, based on tried and accepted settlement patterns with the more radical experiments at the building scale.

Long life, low energy, loose fit. Moudon introduces the term resiliency. The question is to what degree can a form be modified - added, subtracted, multiplied, divided before it becomes something else and loses basic qualities of decent built environments.

Good design; I think of the bicycle and denim jeans: populist, affordable, durable, rationally transparent, robust, ages gracefully, offer medium performance, convivial, timeless. Should there be a *Levi's* house? Would it have been the Sears Victorian kit homes, is it the cottage, the *Airstream* trailer, the tract home, or the triple deck rowhouse? The principal difference between buildings and clothes is that one can change clothes for the context, with buildings one changes much more slowly. One can vary the facades: dignified front and casual backs. This is why I am so intrigued by the rear facades of the Crescents of Bath as well as simple back alleys. At Bath, one goes from



an extremely formalistic facade with an expansive lawn in front to a series of auto garages on the back side. As Kevin Lynch observed:

> Many people, if asked to describe the ideal house of their fantasy, will sketch one from whose front door one steps onto a lively urban promenade, while at the rear there is only silent country side. If a single door lies between excitement and serenity, the pleasures are sharpened on either side by the thought of what lies beyond. [147]

Architect Lars Lerup describes the prevalence of small scale clandestine building activities in Berkeley; which he finds tends to be high quality if people are modifying for their own use. He documents how his landlord, a Mrs. Ivy has directed the development of this small complex, in which "design [is] triggered by social events."[148] Many Architects and others have argued for being more open to the layering of life, for a more genuine complexity. As Lucien Kroll has proposed:

> Other Architects would oversee a second phase, or design of the street and plaza's enclosure. These architects would preferably be "enemies" with conflicting values so that a "stratified historical formation" could take place.[149]

[147] Lynch, Kevin. *Good City Form.* MIT Press, Cambridge, MA. HT166.L96 1984. p. 270-271.

[148] Lerup, Lars pp. 91,95 & 95.

For this reason, I would like to think in broader, skeletal first moves; a lighter frame to which users then add the complexity, the outbuildings, fences, rather than over design a finished cluster, campus or new town with idiosyncratic ideas and contrived complexity.

4.4 Housing

In this exercise, I will try to design an accountable, affordable, climate responsive, growable, dividable building for housing. One can assume that it will be built of compressed straw panels and very efficient windows.

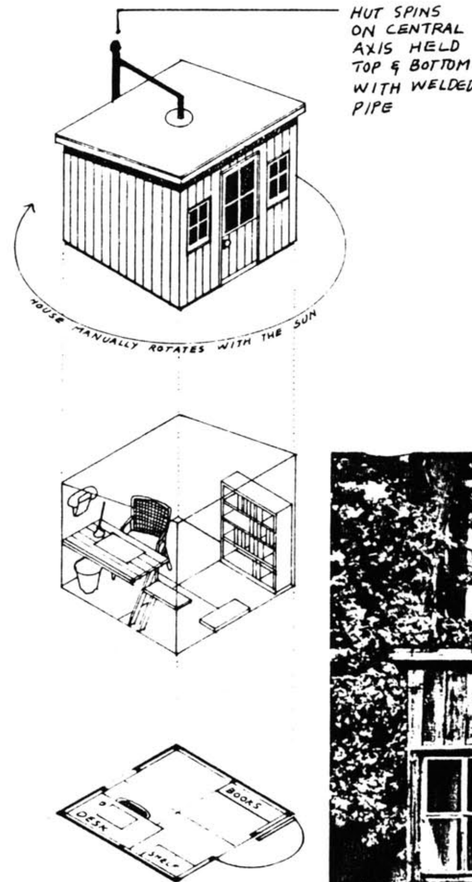
House ownership offers many important dimensions over renting: with a higher stake in condition of the surrounding community it is a politically and socially stabilizing factor. As there tends to be a greater interest in the physical state of the house and yard, one finds better maintenance, interest in soil quality,

[149] Kroll, Lucien in Moudon, Anne Vernez (ed.) *Public Streets for Public Use.* New York: Van Nostrand Reinhold Company. HT166.P82 1987. p 338.

and greater probability of upgrading. As the house usually serves as a household's principal asset or savings program; a desired combination is when the homeowner can easily rent out part of their unit.

On this site at the edge of town, people could build small cottages on modest lots, and grow a community. In the United States, one precedent is the annual religious rendezvous that began as tents, then tents on wood platforms, and later formalized as cottage communities, such as Oak Bluffs and Vineyard Haven in Massachusetts.

Les Walker's studies: *Tiny Houses* as well as *American Houses* documents some of the delightful possibilities at this scale. There is the elephant house, where the trunk becomes a garbage chute. Perhaps the finest is George Bernard Shaw's writing hut, a eight foot cube on a pole so he could turn his window for the desired light and view.[150]



Walker, Les., *Tiny Houses*. p. 137.

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150 Walker, Les. American Shelter: *An Illustrated Encyclopedia of the American Home.* Woodstock,NY: Overlook Press NA7205.W34 1981. and Walker, Les. *Tiny Houses.* Woodstock,NY: Overlook Press NA7205.W36 1987. p 137.

The aggregation of cottages may also facilitate the accommodation of changing household structures in the US. Even nuclear families accommodated in to smaller connected houses, with children's and parents' realms. When the children leave the household, the parents can free up a living unit for rental. I often wonder whether the volume of housing, like food, in the United States is probably sufficient, whether the challenge is one of better allocation. We have large houses in the desirable suburbs lightly occupied. The owners are prevented by zoning, room layout, and neighbors from dividing their unit to accommodate smaller households. This exercise explored the growing a big house from a small cottage, while always being able to divide it back into a rental for smaller households.

Another aspect of resiliency and loose fit is social. Obviously the physical environment strongly influences human interaction, exactly how this is interpreted seems to be in the domain of architect's sensitivity. Humans continually change in their desire for collectivity and identity, for togetherness and privacy. One of the advantages of *cohousing* is that it encourages a larger scale of collectivity while allowing those who find the togetherness too limiting to easily live as separate households. Should group cohesiveness diminish, *cohousing* designs tend to be able to convert to a more typical cluster housing grouping of private homes.

In this community, the building types would be expected to be demonstrations of passive and "minimal-energy," especially for climate moderation. In Austin the cooling degree days equal the heating degree days, the most climactically stressful time is during the summer with high humidity. Apparently, banks are unwilling to finance houses without air conditioning. As a northerner I am not very tuned to the Austin climate, this is of course a major design liability. I know the winter can get cool, and I have a bias to providing the options for enjoying sun.[151] One point of departure is to study regional precedents from a time before mechanically controlled interior environments.

The Texan agglomeration of cultures is reflected strongly in the early architecture reflecting where builders were trained: from the movable buffalo hide

151 I visited the site twice, for a few weeks in November and March; both cooler months. In November I lived in the four room cottage at the south east corner, in March I tented as part of a group attending the national conference of the *American Solar Energy Society* .

tepees to the thatch covered huts of the agrarian east Texas tribes, the double log house and frame of the Anglo-american; the adobe and *palisado* of the Mexicans , the medieval half timber or *Fachwerk* of the Germans ; the galleried and hipped roofs of French Louisiana tradition. Some of the primary elements are a raised floor, stairs up to gallery, hipped roofs, and breezeways. [152] With guiding principals of symmetry, columar porch gallery, and horizontality over the picturesque medieval verticality, it was an easy transition from the East Texas pioneer log house to the Classical Greek revival .

In Austin, the early dominant type of housing was the dogtrot made of logs. [153] Terry Jordan's study has isolines on a map of Texas correlating the decrease of average square footage per log pen (room) as one moves west and wood availability decreases. The dog trot and central-hall houses offered a breezeway for meals and rest. [154] Second stories were easily accommodated, and the dogtrot became the "saddlebag" or "I-house." Front porches and shed rooms were common. The dogtrot in a sense is two

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152 Alexander,D.B *Texas Architecture as Visual History* p. 6.

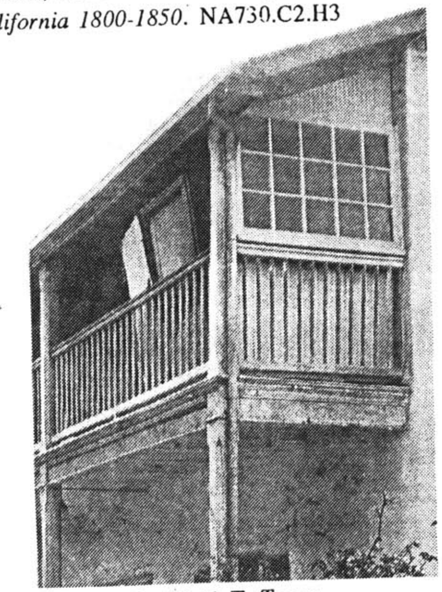
153 Jordan, Terry G. *Texas Log Buildings: a Folk Architecture.* Austin: University of Texas Press. NA8470.J67 1978. p. 105.

154 Jordan, Terry *ibid.* p 123 .

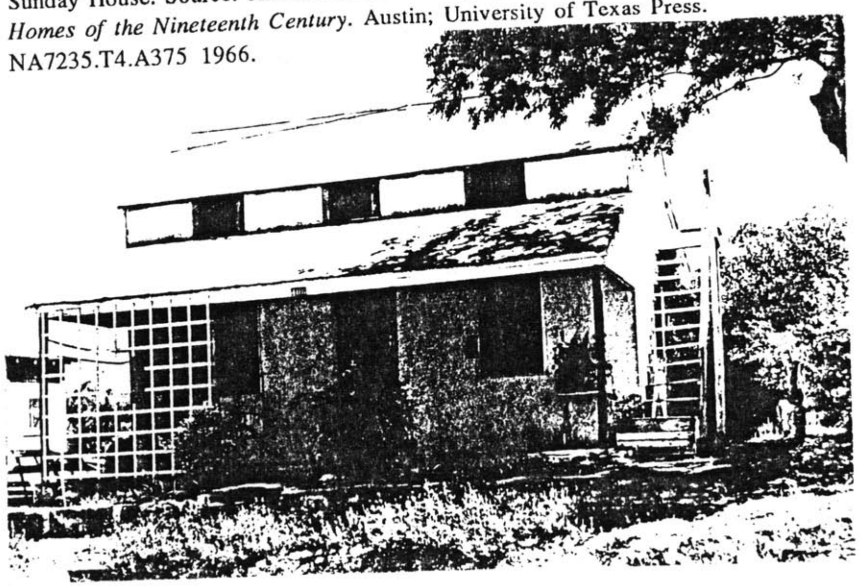
Dogtrot House. Source: Alexander,D.B. Photographs by Webb,T. . *Texas Homes of the Nineteenth Century.* Austin; University of Texas Press. NA7235.T4.A375 1966.

Gallery porch. Source: Heimsath, Clovis. *Pioneer Texas Buildings: A Geometry Lesson.* Austin: University of Texas Press 1968.p. 50.

Tempered porch space. Source: Hannaford, D. and Edwards, R. *Spanish Colonial or Adobe Arcitecture of California 1800-1850.* NA730.C2.H3 1931. p. 9.



Sunday House. Source: Alexander,D.B. Photographs by Webb,T. *Texas Homes of the Nineteenth Century*. Austin; University of Texas Press. NA7235.T4.A375 1966.



houses under one roof. With exterior stairs along an end wall or enclosed by the porch structure; it saves interior space and allows two households to share the same building.[155] Often the front southwest corner of the gallery would be trellised; enclosed as a room for guests or"wayfarers" or a widowed grandparent. In a great many houses, a freestanding log pen outback was used as cookhouse to for less heat in the house. Doors and windows were minimized, as each opening weakened the log pen and increased the vulnerability to "Indian attacks."

Texas offers a range of interesting house types. In Fredericksburg one finds the Sunday House built for the country folk who came into town for church, notable for its scale and attic sleeping loft, accessed by an outside stairway. In Castroville one finds the influence of Alsatian French, with homes set very close to the street leaving room at the rear for a private tree shaded garden.[156] In 1855, Frederick Olmstead called nearby Seguin the "The Concrete City," perhaps due to the enthusiastic adoption of a local invention, plastered limecrete.

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155 Heimsath, Clovis. *Pioneer Texas Buildings: A Geometry Lesson*. Austin: University of Texas Press 1968. p.47.

156 Braken, D.K. and M.W. Redway. *Early Texas Homes*. Dallas: Southern Methodist University Press: Dallas. NA7235.T4.B7 p 22.

tepees to the thatch covered huts of the agrarian east Texas tribes, the double log house and frame of the Anglo-american; the adobe and *palisado* of the Mexicans , the medieval half timber or *Fachwerk* of the Germans ; the galleried and hipped roofs of French Louisiana tradition. Some of the primary elements are a raised floor, stairs up to gallery, hipped roofs, and breezeways. [152] With guiding principals of symmetry, columar porch gallery, and horizontality over the picturesque medieval verticality, it was an easy transition from the East Texas pioneer log house to the Classical Greek revival .

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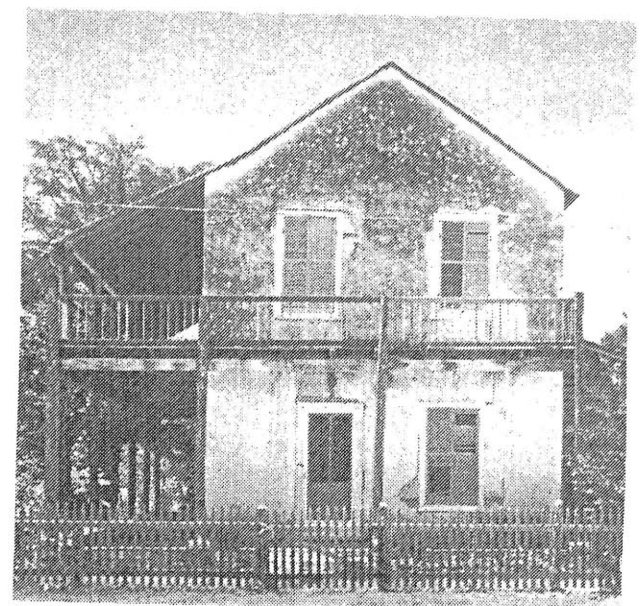
Dogtrot House. Source: Alexander,D.B. Photographs by Webb,T. . *Texas Homes of the Nineteenth Century*. Austin; University of Texas Press. NA7235.T4.A375 1966.



Gallery porch. Source: Heimsath, Clovis. *Pioneer Texas Buildings: A Geometry Lesson.* Austin: University of Texas Press 1968.p. 50.

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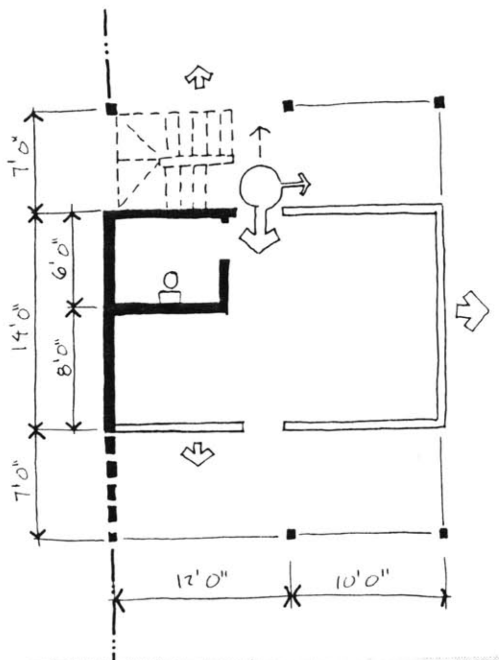
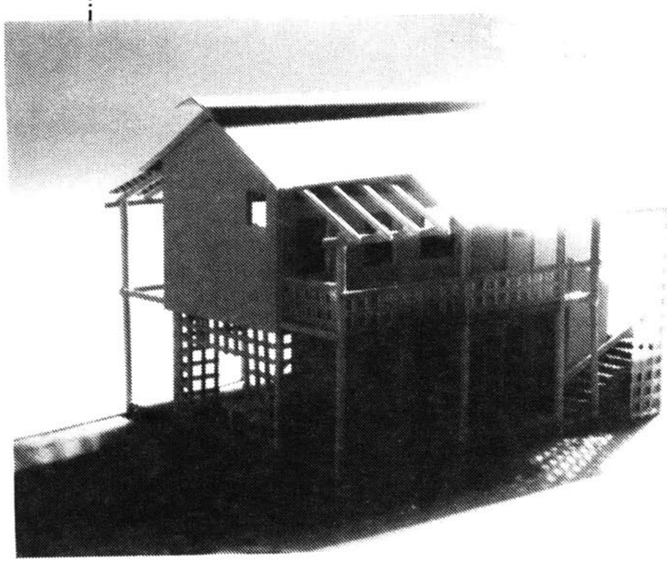
152 Alexander,D.B *Texas Architecture as Visual History* p. 6.

153 Jordan, Terry G. *Texas Log Buildings: a Folk Architecture.* Austin: University of Texas Press. NA8470.J67 1978. p. 105.

154 Jordan, Terry *ibid.* p 123 .



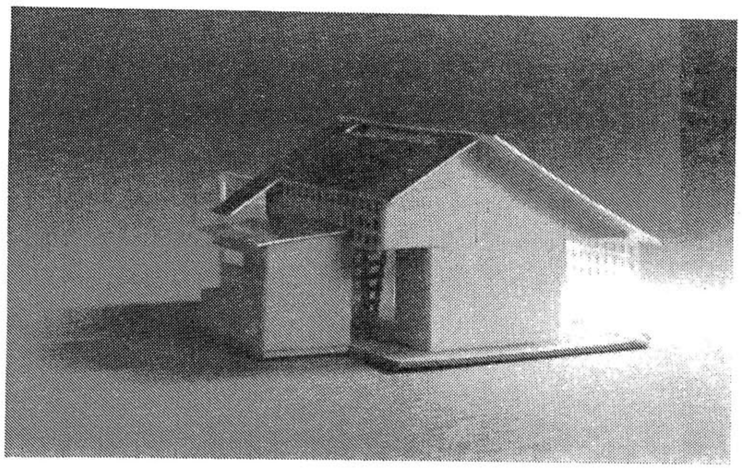


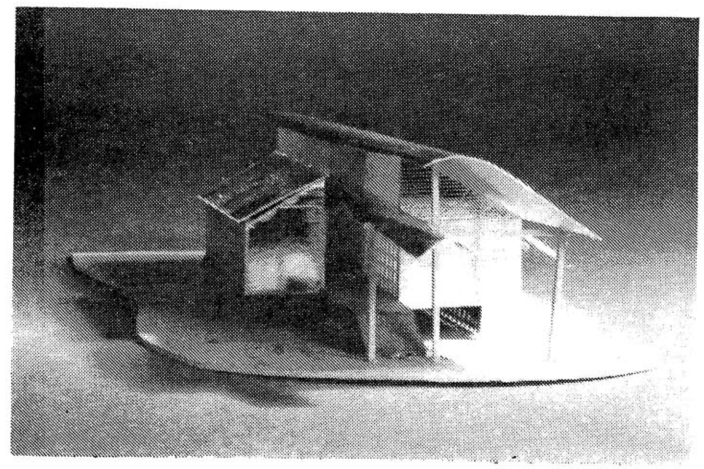
vines. Both document the appropriateness of night flushing in which one opens the house at night to cool the interior mass and then closes the house during the day to retain "coolth." When it is too hot and humid at night as well, one has the tradeoff between maximizing ventilation or providing a zoned refuge with air conditioning. To offer relief from the daylight glare, one should be able to darken the interior environment.

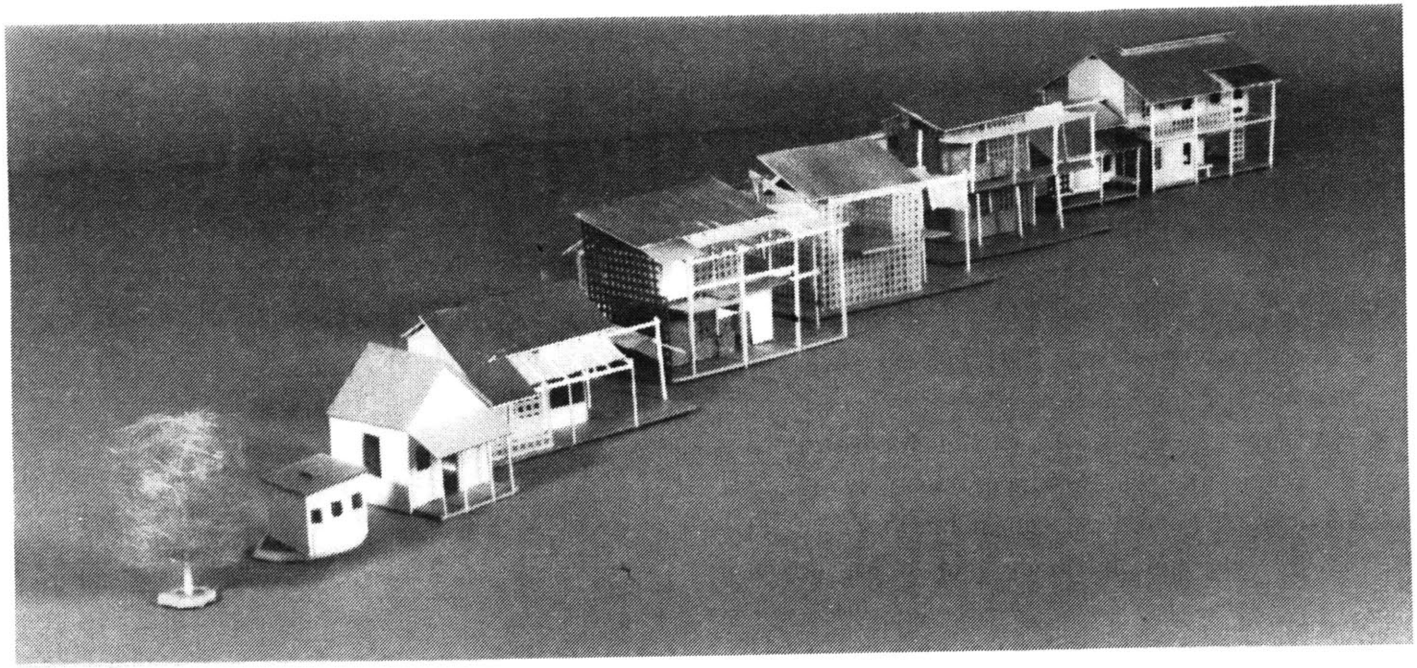
As I remain uncertain about the relative values of winter solar gain and summer cross ventilation versus summer solar avoidance and daytime sealing to retain the night time coolth, the basic approach was one of using the south facing porch as a buffering zone. In the summer and fall, movable shade cloth overhangs would be pulled across to shade the porch, in the winter and spring, the cloth would be pulled back to allow the sunlight to hit the windows.

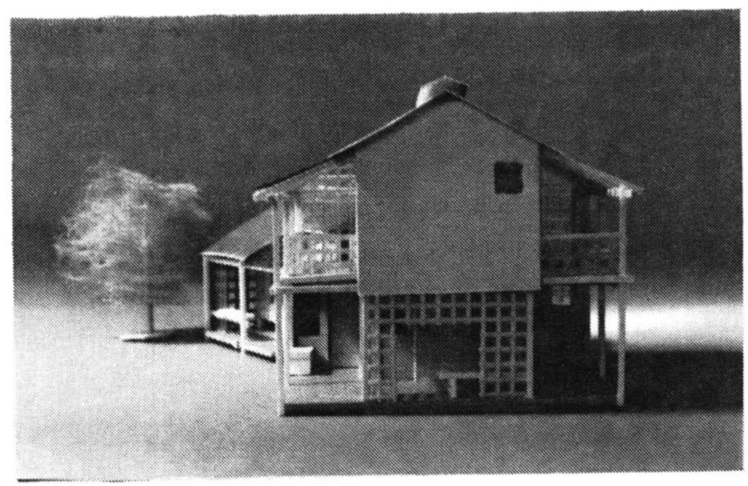
In plan, the concept is to grow eastward from a zero lot line west wall buffering the afternoon sun.The earlier design schemes considered placing the moisture and heat producing service spaces to the north. This was rejected as this service spaces became prominent elements if the street was to the north.

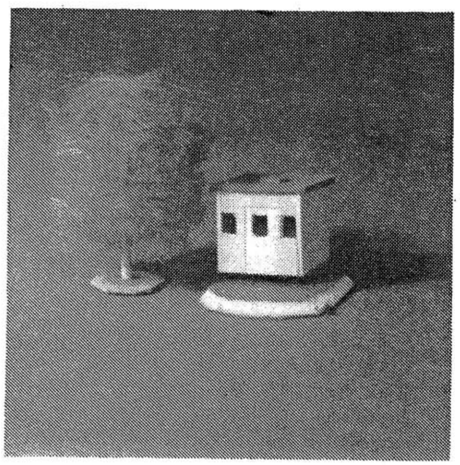
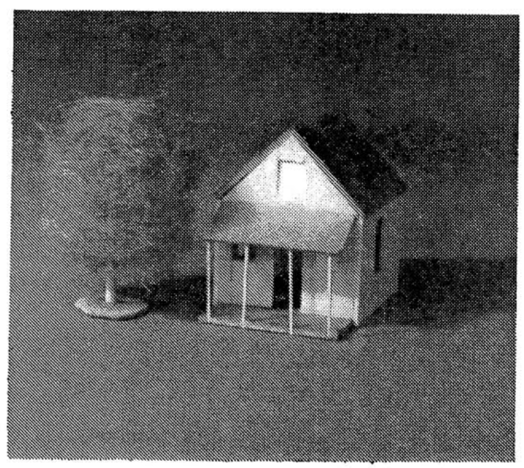
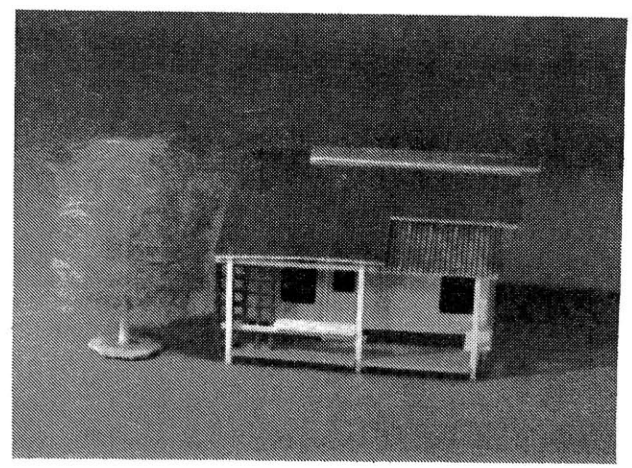
STEP1 LIFT UP STEP2 TO NEXT···

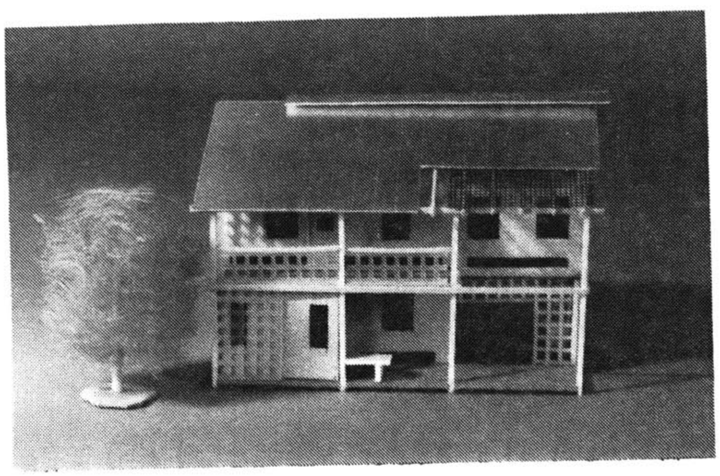


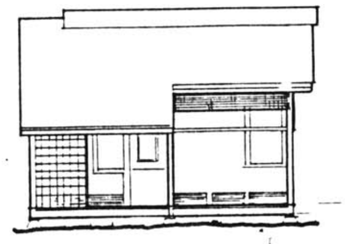


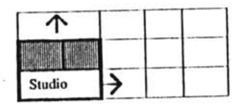


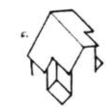


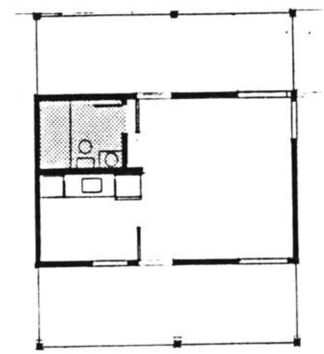




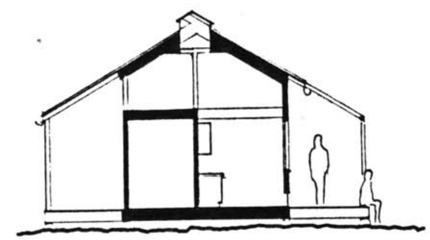




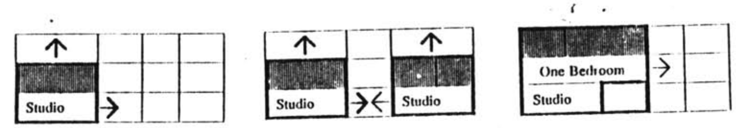


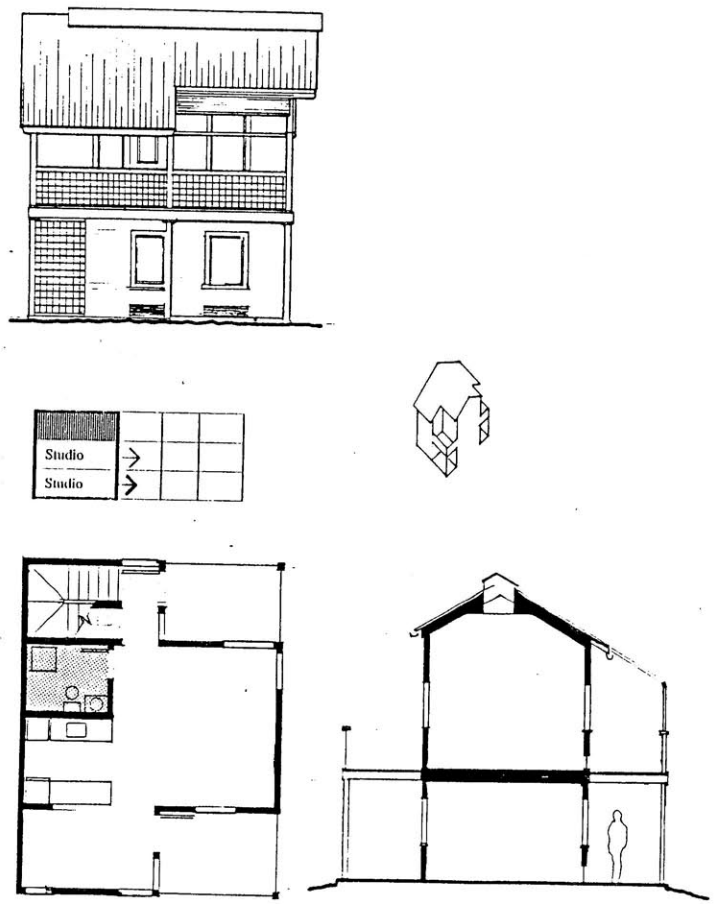




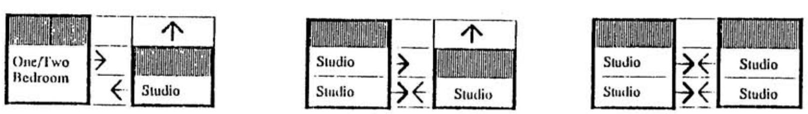


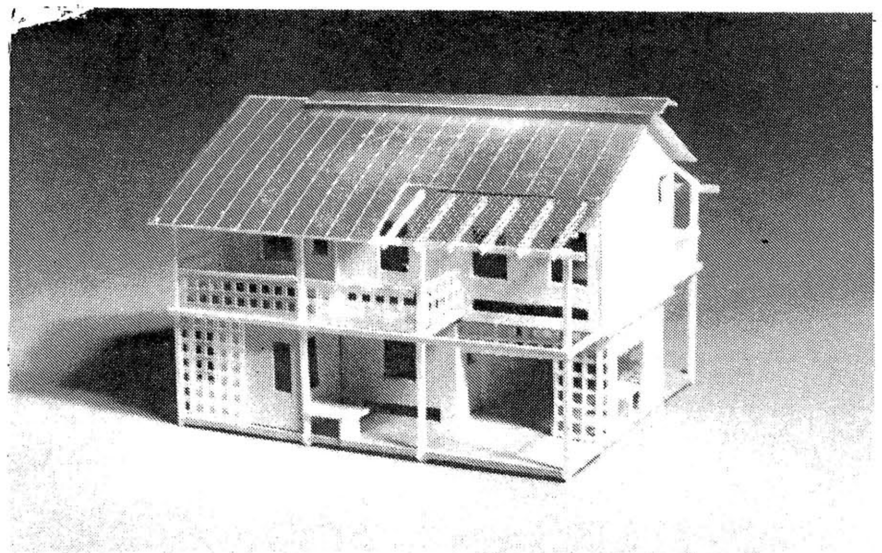
310 sf Cottage , section, south elevation.



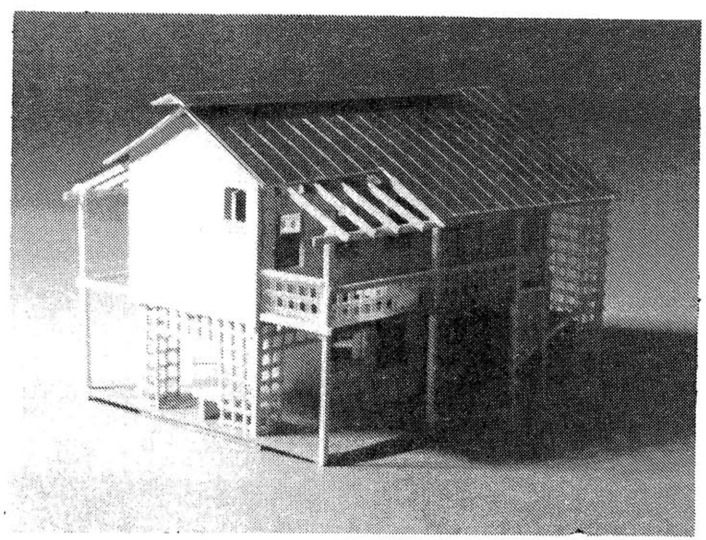


950 sf Two story house, south elevation, section,

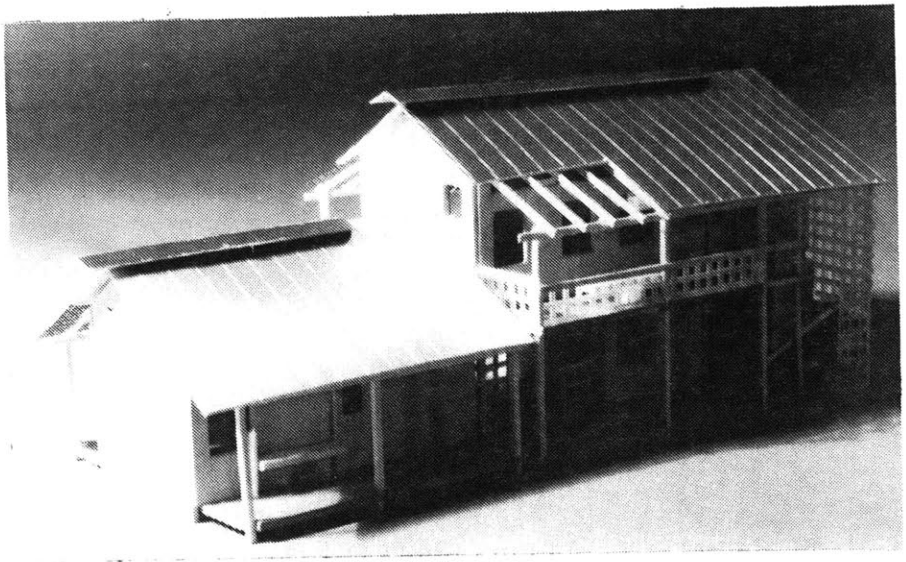


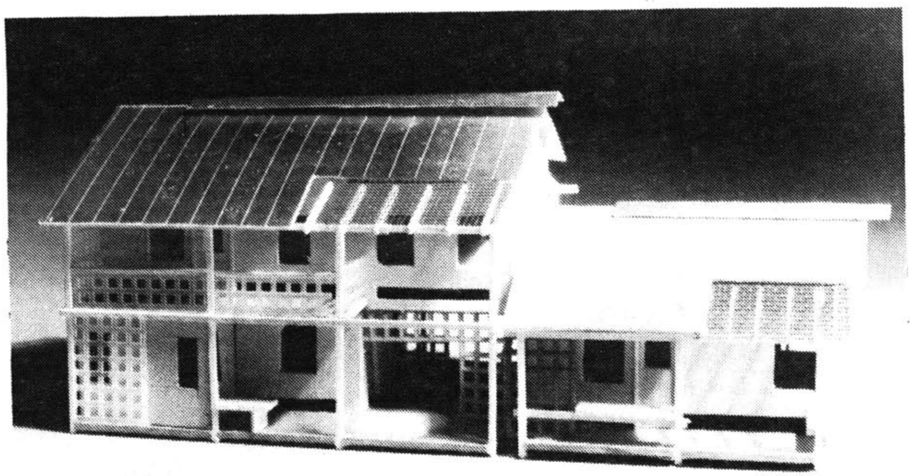


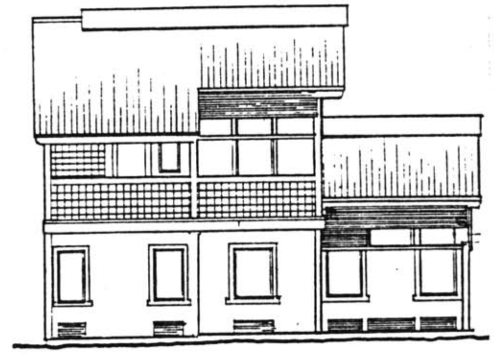
Southeast corner.

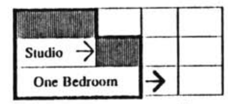


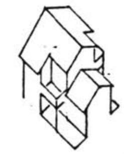
Northeast corner.

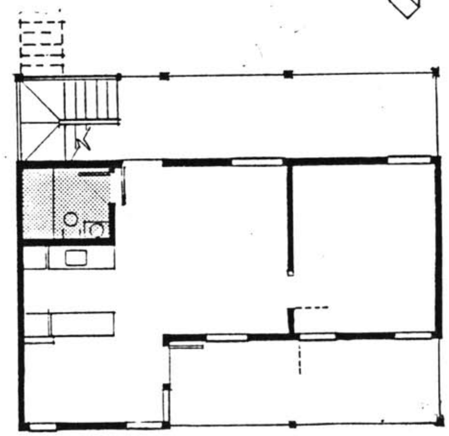




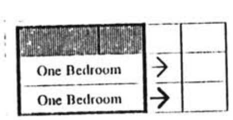


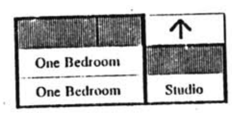


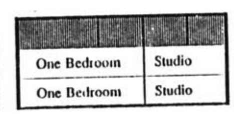


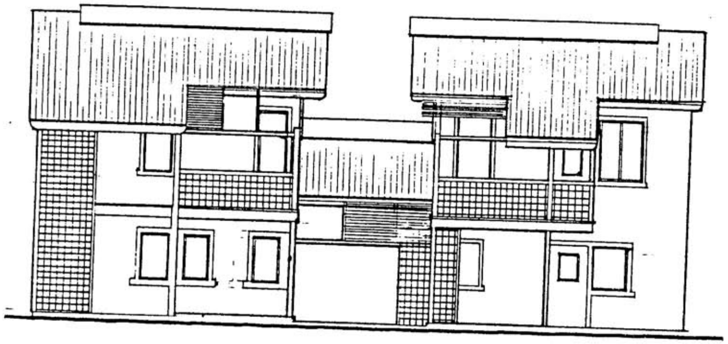


310 sf Studio above 560 sf Unit, south elevation.

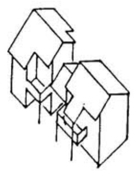


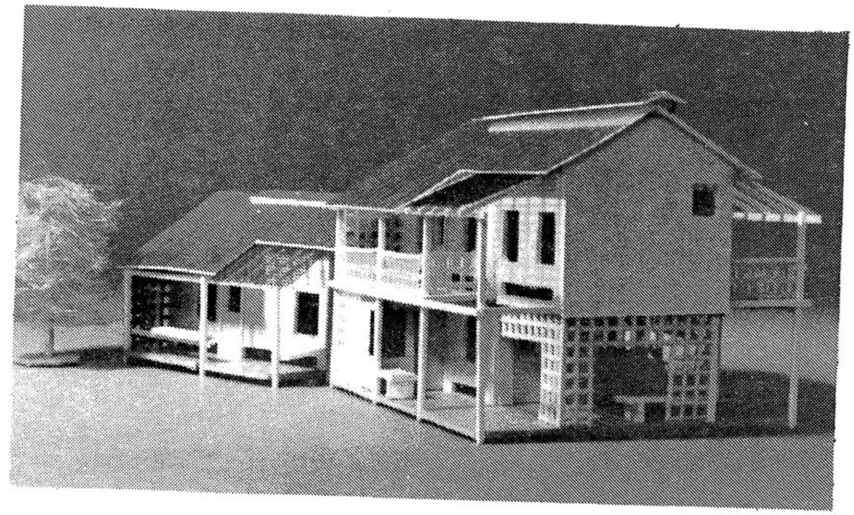


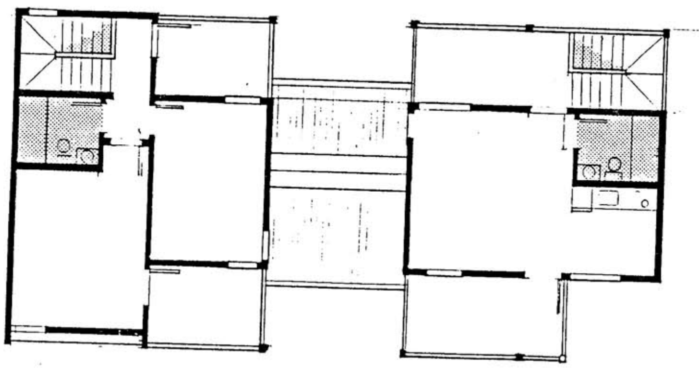


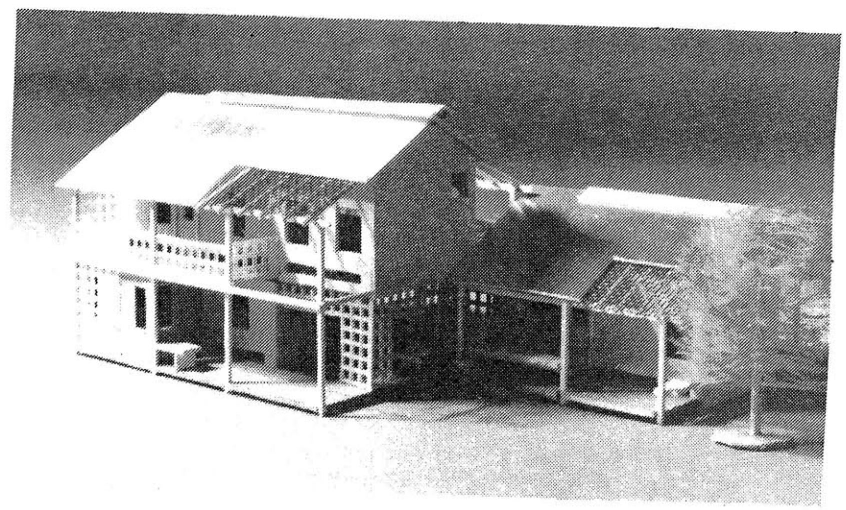


south elevation.

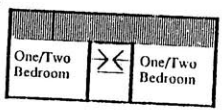


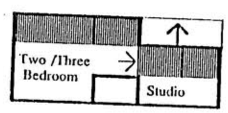


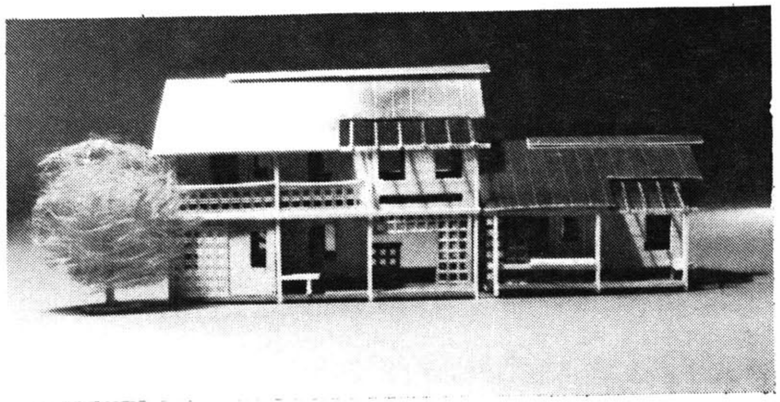


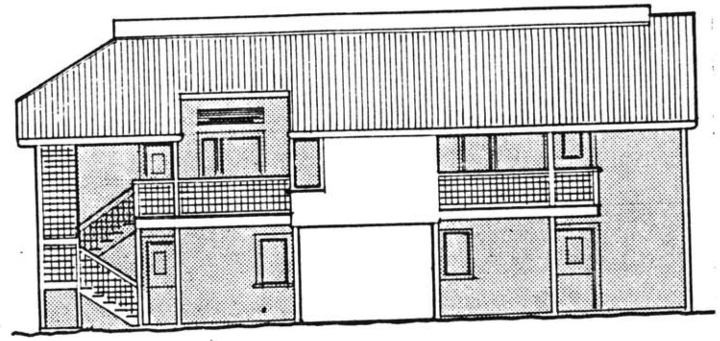


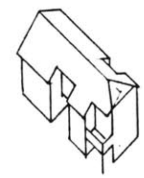
950 sf Two story house next to two 310 sf studios,

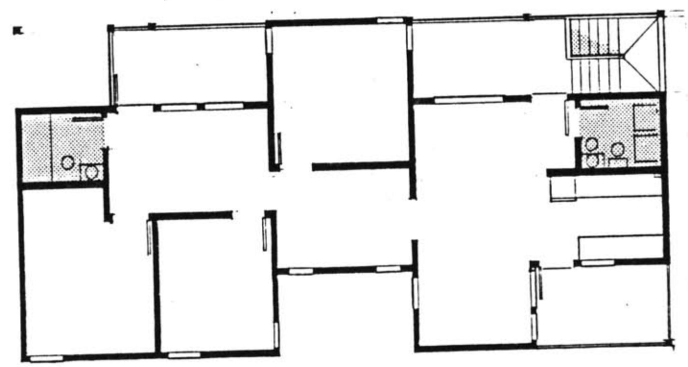




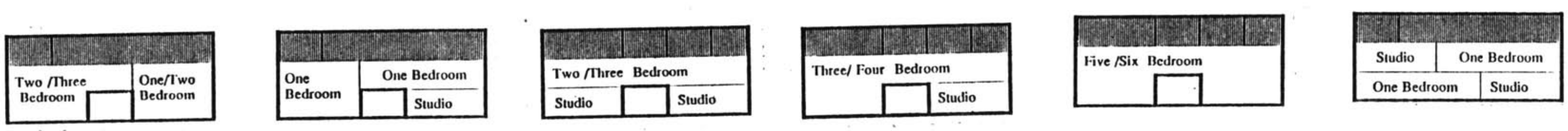








1090 sf Three bedroom above two 400 sf studios,

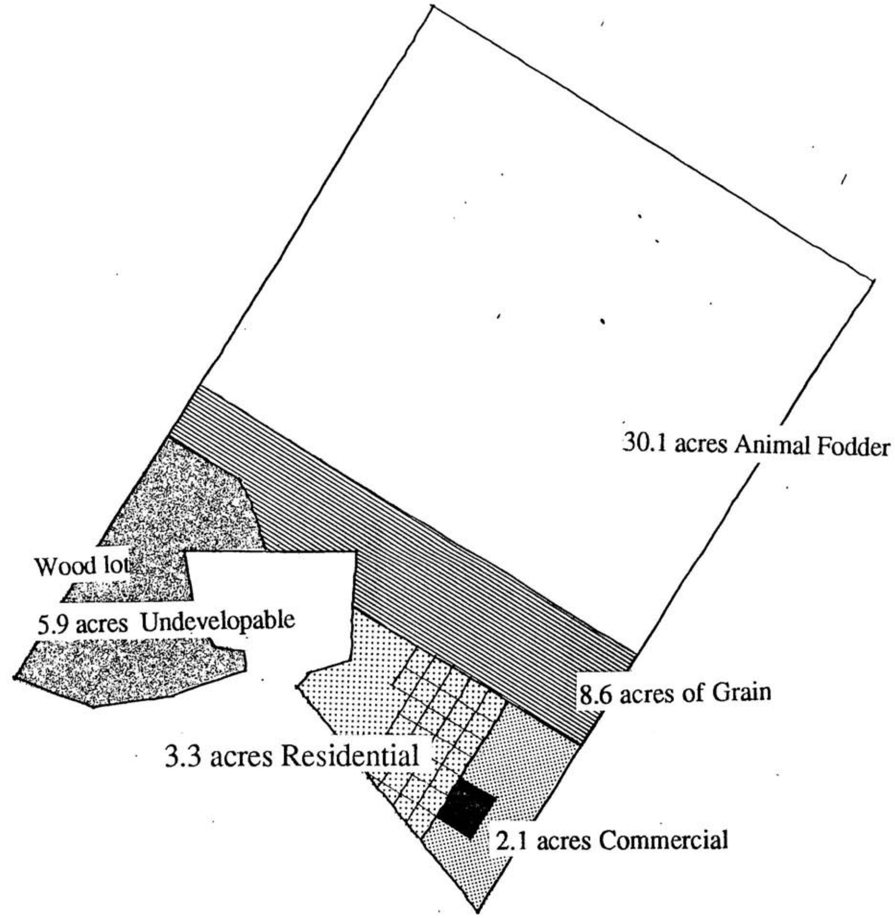


4.5 Low Density: First Moves

Imagine an urban countryside, a highly varied but humanized landscape. It is neither urban or rural in the old sense, since houses, workplaces, and places of assembly are set among trees, farms and streams. [159]

For this exercise, I assumed that the site would develop slowly. Clearly, the initial decisions should be taken with the growth of the whole site in mind. As a point of departure, I am using the calculations from the model in Appendix B and described in section 3.3. From a food and water point of view, the land should support approximately 70 meat eating persons. It is likely that this population will eat less meat. It is unlikely that they will raise beef at this scale, but experiments with poultry and aquaculture are possible. The intent is provide a balance between providing food, earning income, and recreating, and provide for growth.

... where it will not interfere with privacy, the landscape is made more transparent. Clues to its hidden functions are left on view. Economic processes are exposed. The connection between production and consumption is immediate... [160]



Rough Allocation of land required to support 70 persons.

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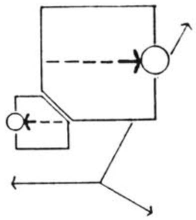
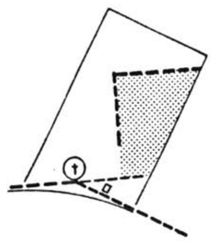
[159] Lynch, K. *op.cit.* p. 294.

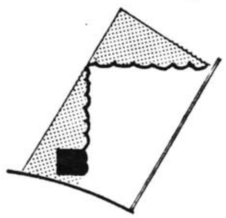
[160] Lynch, K. *op.cit.* p. 312.



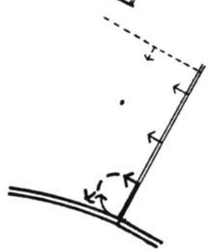
Watersheds



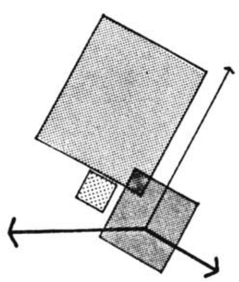
History



Site Edges



Access



Micro-zoning

One: Respect the special features of the site. The grand oak trees, the casual cemetery. Preserve any lineal greenbelts and ecologically productive zones.

Two Preserve the better soils for agricultural experiments. Form a farming corporation/coop and try to get some land protected as a land trust.

Three Determine the concentration of water and possible pond location.

Four Micro zone. Start with the development of light density housing on small lots out near the agricultural labs to provide for frequent caretaking. Save the more active, visible, and noisy areas for commercial uses. With minimal disturbance to existing uses, start develop of light industrial and sustainable goods shop near the corner. Call for higher density housing as one moves toward the community center.

Five Concentrate the housing center activities around the existing Center's office. With its visibility, modest view, historical character and continuity with the site, it should become a visitor reception center.

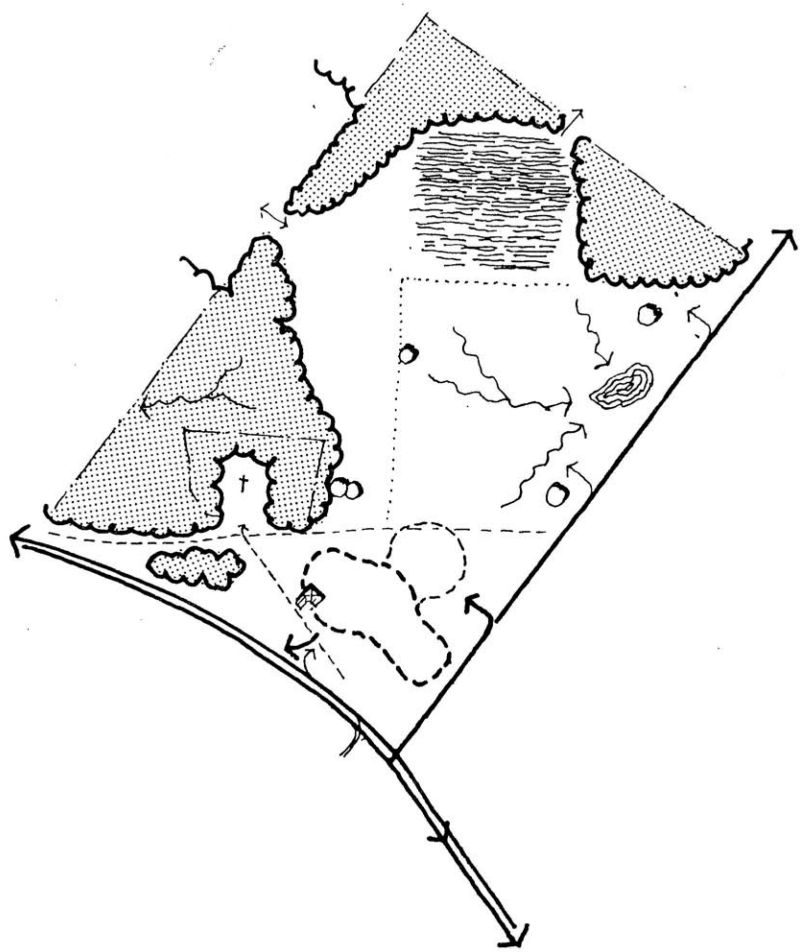
Six Provide a path or spine for circulation and orientation. First street, farm lane for the houses oriented east west to maximize ventilation Locate the housing on east west streets, alleys and farm lanes, the more commercial on the north south.

orienting buildings to the apparent movement of the sun makes the compass directions legible and increases our sense of the structure of time. [161]

Seven The relationship with the Automobile is most critical. Provide overflow in a large lot, with the option for a park and ride facility in the triangular lot to the south. Disperse automobile access around the site rather than concentrate; slowed down to pedestrian speeds with narrow streets.

Eight Plant trees! Where the first trees are planted later becomes a site factor influencing future organization; consider reinforcing the "main street."

For much of this design process, I pushed for the early framework of a future *pedestrian pocket.* As *Farm to Market 969* / Martin Luther King Avenue continues straight downtown, in the future the route would become a corridor for concentrating services, especially public transit. In this scenario, the corner becomes a major transit node for a small business



[161] Lynch, K. *op.cit.* p. 147.

district, surrounded by higher density housing and a greenbelt. This is rather unlikely, certainly for a long time. In the meanwhile, the corner is not such a desirable place save for commercial visibility. In the design proposal, this option was left open.

A sense of streets and alleys or farm lanes seem to fit on the site. Alleys offer many advantages, in a planned unit development their access can be regulated, and it offers a less formal option. In San Francisco , Moudon observed that houses on interior streets alleys cost less [162] while the most densely developed subdivided lots were blocks with alleys.[163] She also recommends reaching a congested state as late as possible in the natural process, that is the backs should be kept open as slack.[164] In theory smaller lots lowers the threshold to enter the community, thus increasing diversity; larger lots can still be assembled if desired.
For the site layout exercise, I experimented with a lot width of 30 feet , with the larger houses combining two lots.

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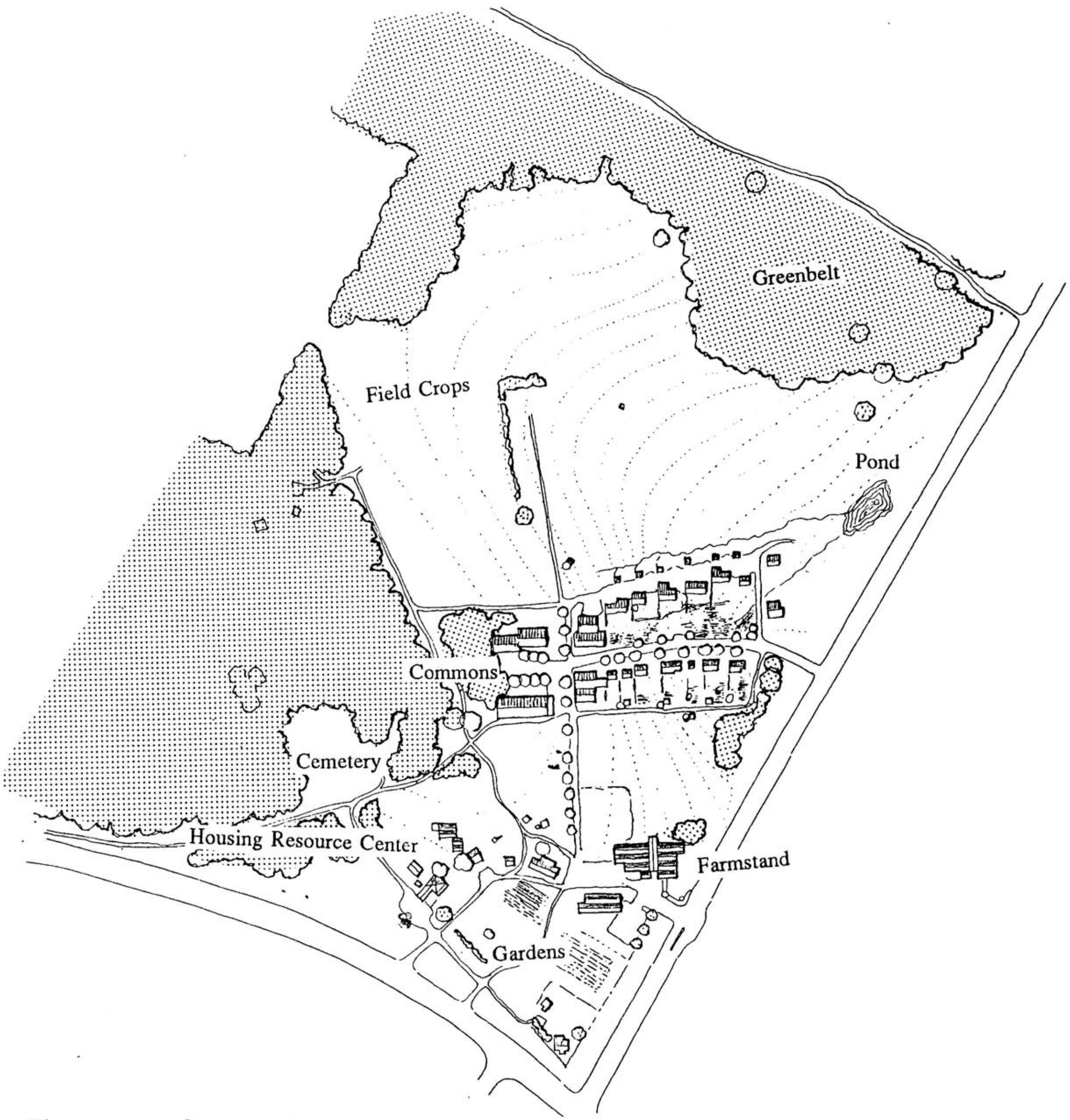
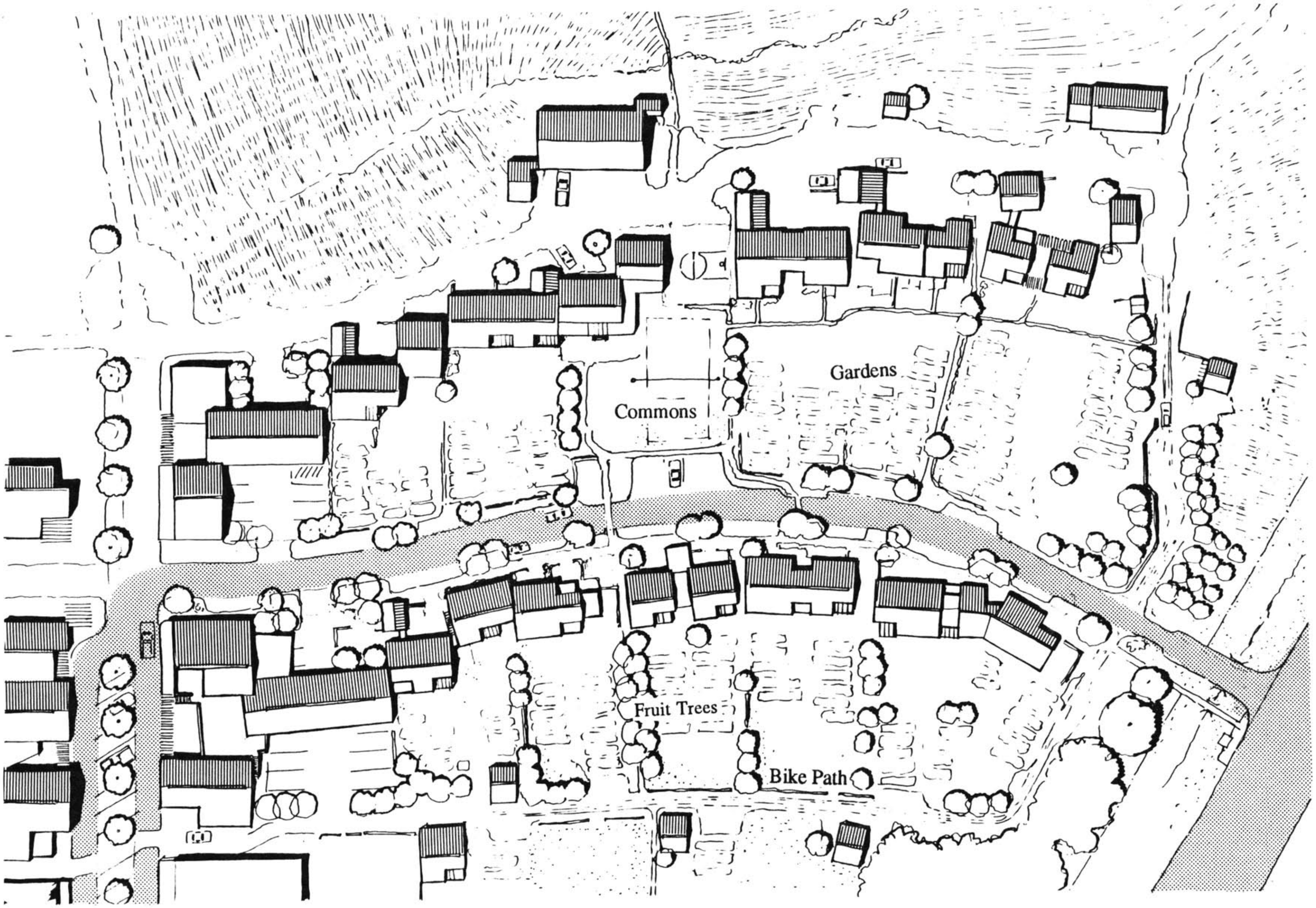
162 Moudon,1986. *op.cit.* p. 49.

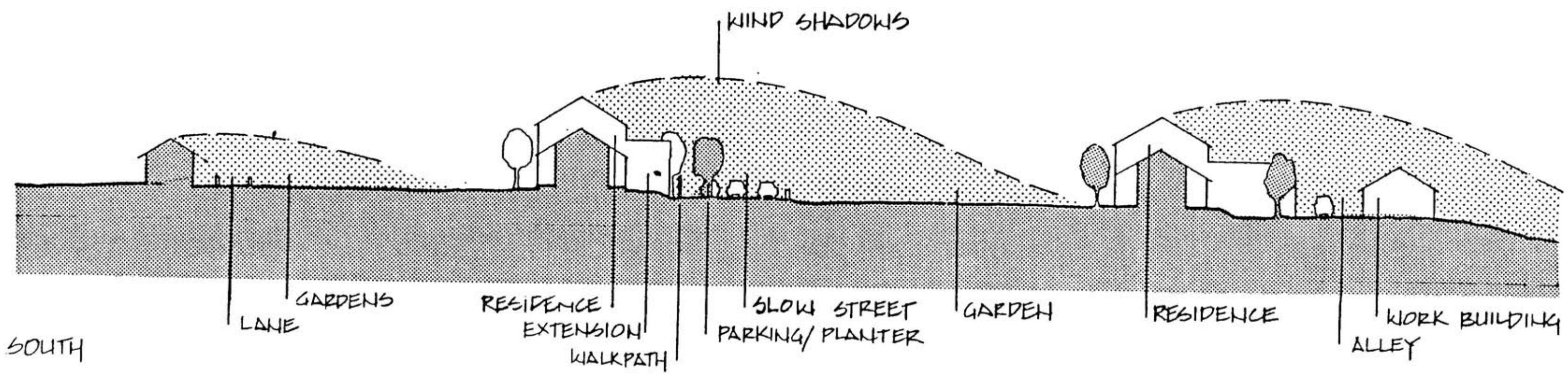
163 Moudon,1986. *op.cit.* p. 96.

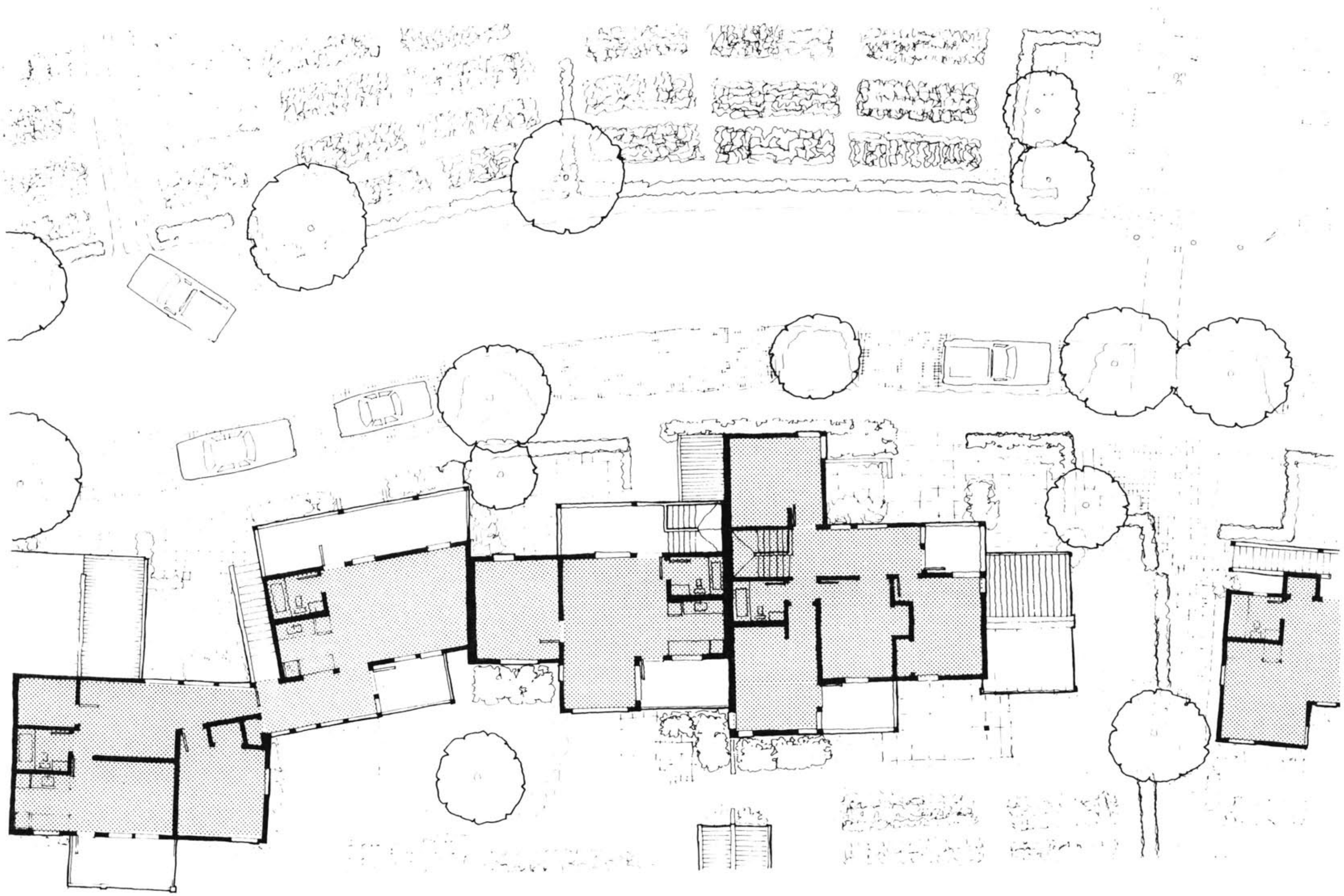
164 Moudon,1986. *op.cit.* p. 168. In San Francisco, the blocks were 275' in the north south x 412.5' in the east west orientation; the lot depth ratio 1:5 for 27'6" frontages.



First moves: for seventy persons.


Gardens
Commons
Fruit Trees
Bike Path
Main Street


WIND SHADOWS
GARDENS
LANE
SOUTH
RESIDENCE
EXTENSION
WALKPATH
SLOW STREET
PARKING/ PLANTER
GARDEN
RESIDENCE
WORK BUILDING
ALLEY

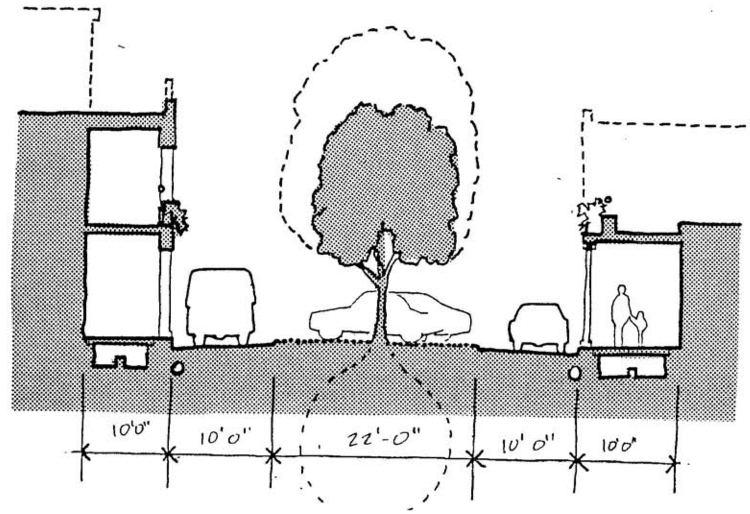


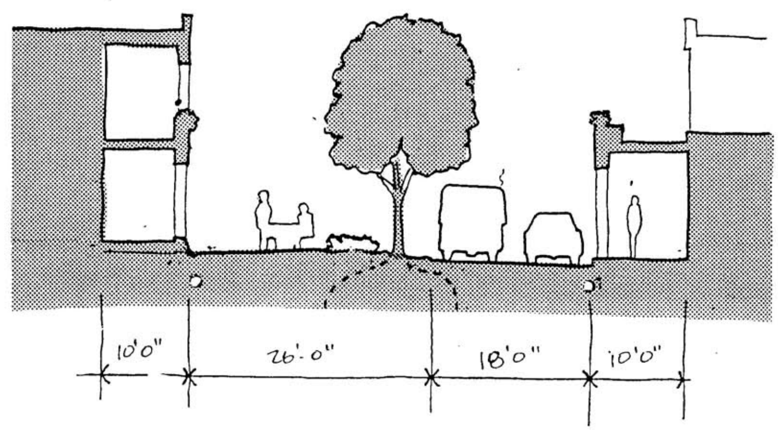
4.6 Higher Densities- A Small Village

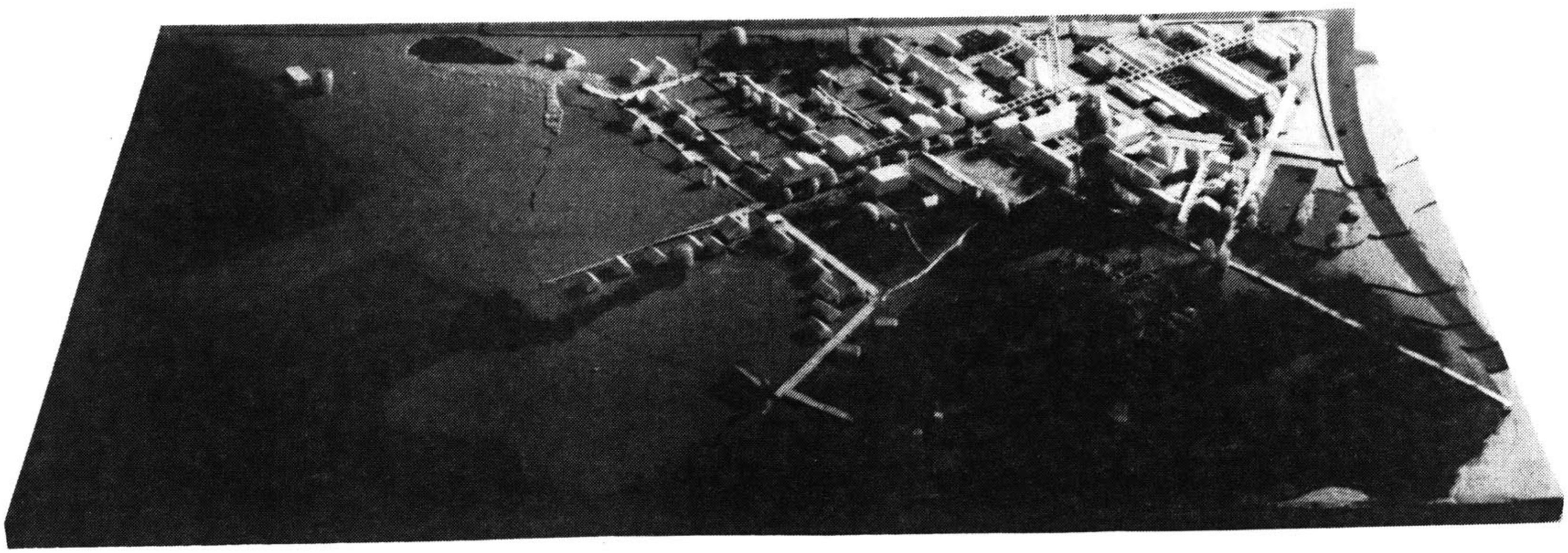
If the project "succeeds," more people will want to live here. Perhaps other communities could be established elsewhere. Certainly, there are advantages to clustering and greater density. These include the sharing of infrastructure and the potential for the greater pooling of resources.

A north south pedestrian access establishes a spine about which life and activity and orientation of the community should center. Along this spine, there would be a gradient of decreasing intensity as one moves north away from the central square; from the corner back to the greenbelt, from active to passive, human dominated to more natural "hinterland," gray top to green, driving to walking/riding, hot to cool.

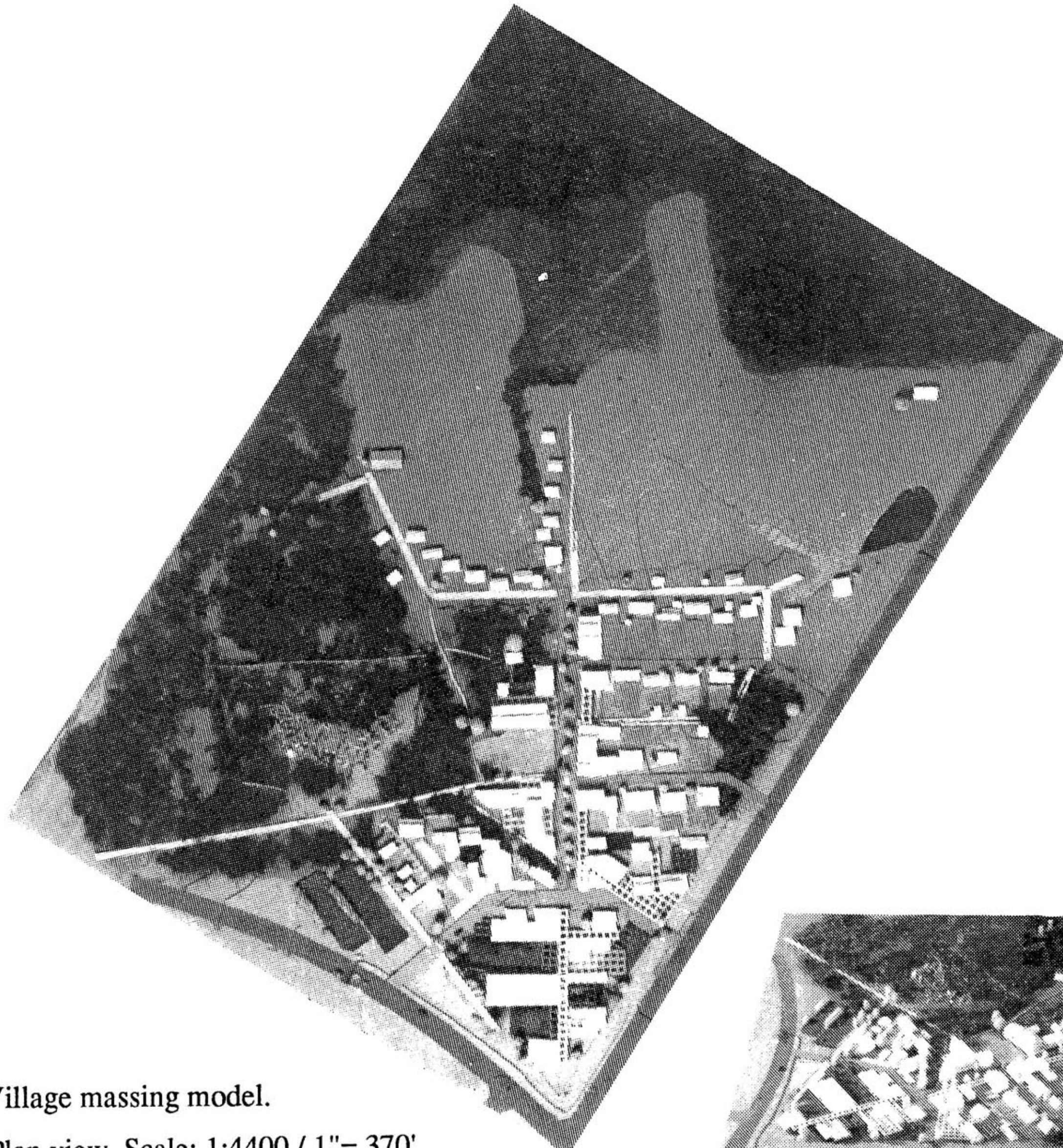
After studying Seaside, "a new traditional neighborhood development," I came to agree that it is better to reinforce the spine with auto access, taking comfort in realizing that traffic flows can easily be regulated using slow street techniques. Ideally, people will come to find it is most convenient to travel around the site via bicycle.







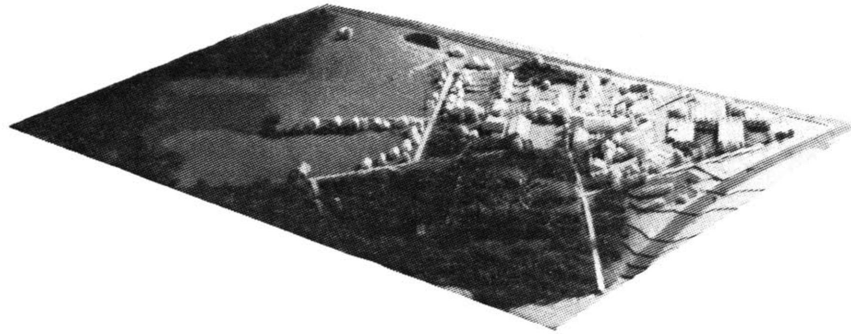
Village massing model. Viewed from the northwest.

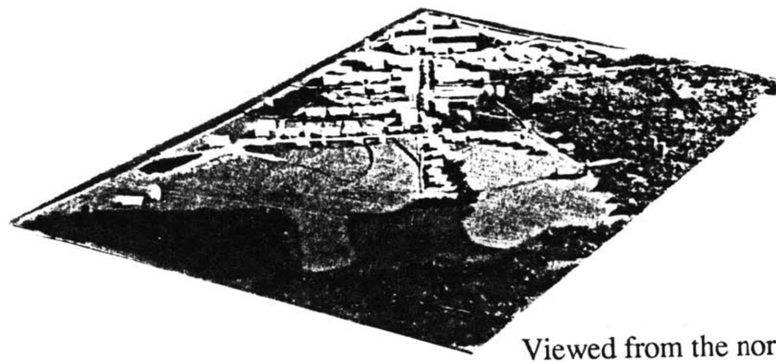


Village massing model.

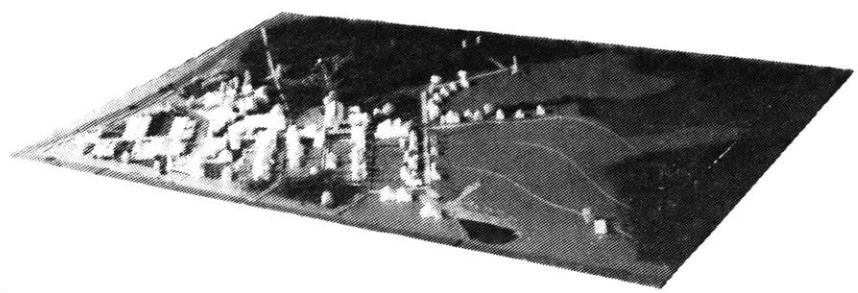
Plan view. Scale: 1:4400 / 1"= 370'.

Viewed from the southeast.





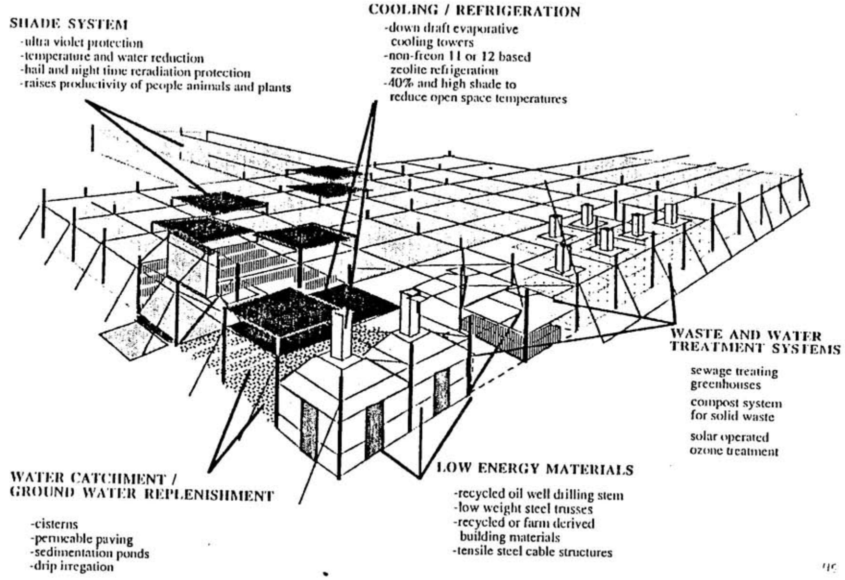
Viewed from the north.

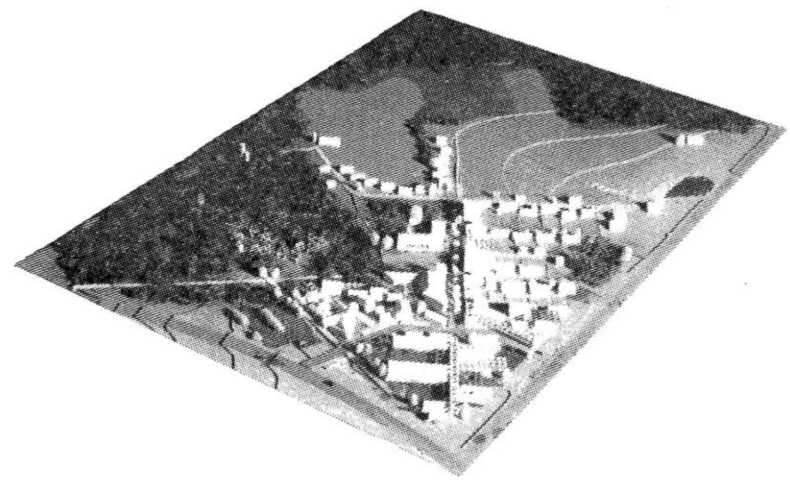


Viewed from the east.

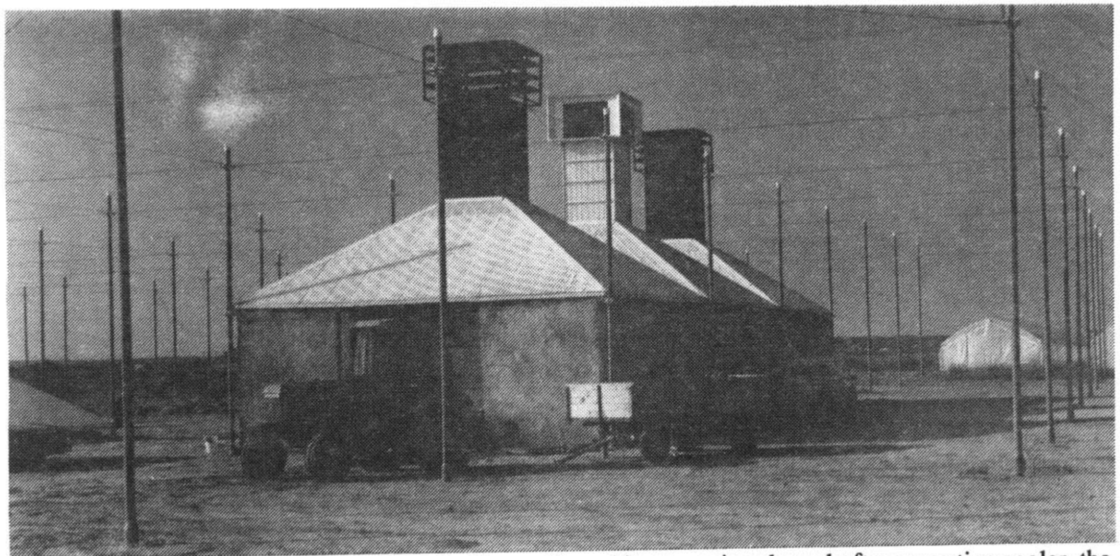
The longer term project intent is for an "Integral Urban Business Park" a multi-use complex incorporating a research and development institute, a small business incubator, an education and visitor center, and light manufacturing facilities. As each of these will grow and decline at different rates, a resilient building fabric should be emphasized. This area could be built with the lightweight, dismountable system developed by CMPBS for their Laredo project. When the grid of steel hats is interspersed with openings and spaces with shade cloth, one has the possibility for a festive market out of a reusable, flexible space system. The study model shows an attempt to put the tent system on top of a pre-cast concrete (and thus also dismountable) platform to allow parking, warehousing, light industries below. Between the wings could be space for landscaping, more parking or work yards as demanded.

Density is somewhat self correcting. As more people come together, a critical mass is achieved the vitality increases, while parking and circulation suffer.





Viewed from the south.



The Demonstration Farm Project in Laredo, Texas. The white tower is a downdraft evaporative cooler, the black an updraft thermal chimney. The walls are from bales of hay, the poles are used oil drilling rods. The

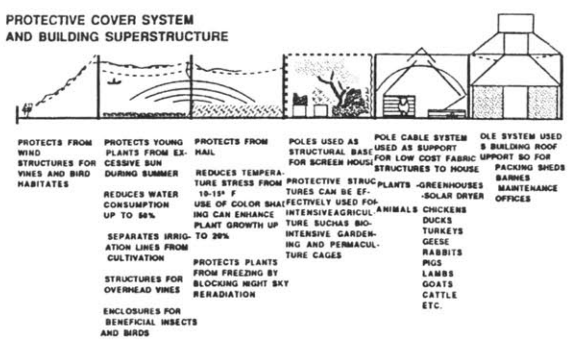
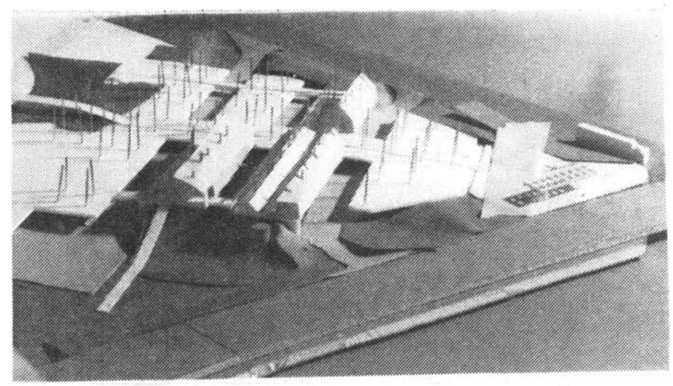


Fig. 3. SHADE AND WIND AS DOMINANT FORCES IN THE LAREDO DEMONSTRATION FARM



Study model from the west considering the "Laredo system" atop precast concrete platforms to allow flex space or parking below.

4.7 Evaluation

The goal of designing for more socially and environmentally sustainable communities was proposed in section 2.4, along with criteria to help explain what this means. As mentioned, the criteria come largely from the works of Malcom Wells and Bruce Coldham. These are listed in italics, followed by my comments on how I tried to address these issues.

Productive Site Evaluation:

• *Adequately analyzed the site in terms of soils, hydrology, plants, wildlife, sun, wind, climate, to determine the sustainable productive potential from these flows?*
Two site visits, one of three weeks in November 1989 and another of two weeks in March 1990. The whole site was paced off and major features located using a compass. Principal plant species were identified and locations of larger trees were charted and mapped. The USDASC Soil Survey of Travis County, Texas was consulted to identify soil properties and agricultural potential. The USGS topographical maps were studied to determine drainage patterns and possible pond locations. Residents were questioned to determine the presence of wildlife on site. Analyzed climatic data, especially that provided by Center for Energy Studies at University at Austin. Calculated shadow patterns and solar access envelopes; analyzed wind roses to understanding prevailing wind patterns. With mathematical models, developed an idea of the on site productive potential of photovoltaics, crops and runoff.

• *Adequately analyzed the surrounding context in terms of physical and human resources, and networks to identify productive potential of linking with local activities?*
Relied upon the studies and experiences of the Center for Maximum Potential Building Systems as well as City of Austin planning documents. This is reflected in the proposal for a self-help housing resource center and that of the "city gates."

• *Respects the special qualities of the site.*
Celebrates the existing tree stands and respects the contemplative atmosphere of the cemetery. Clusters human activities towards the busy southeast corner and preserves a greenbelt thus establishing a gradient from human dominated to

natural "hinterland," built to green. Generates plan with reference to historical features of the site. Bicycle paths follow earlier one-lane road grades. North-south "main street" follows the original fence lines of an old farmstead. Former gas station/ country store will serve as the principal reception area for the CMPBS.

Biomass

• *Protects threatened wildlife/plant species habitat; Preserves fragile ecosystems, wetlands, indicator species.* and • *preserves green space.* There are no immediately apparent threatened species nor obviously fragile ecosystems on the site. A greenbelt was preserved along the north and west site edges that allows for linkage to off-site wildlife corridors.

• *Promotes native vegetation for landscaping.* A third of the site is left as a preserve and is likely to be of native vegetation. About half is domesticated for food production. Private lawns are kept to a minimum and a "common" is provided for group use. Residents are encouraged to use xeriscape practices.

• *Generates top soil.* Creates a land trust to preserve the richest soil on the north side of the site. Allocate areas for composting facilities. Recycling of nutrients will be encouraged by an aquatic waste treatment plant located to the north of the housing. This plant is at a lower elevation than housing and is located downwind. The byproducts of treatment will be used to fertilize fallow fields to the north of housing. In the gardens around the houses, there is a tradeoff between regenerating top soil structure and accommodating the growth pressures for a moderate density, clustered community.

• *Allows for the raising of fresh, non-toxic food.* Initial site program is based upon providing for the food needs for seventy people who eat meat. As it is likely that many residents will be vegetarian and that agricultural productivity on the site will improve over time, increases in site population can be accommodated.
Priority is placed on raising fruits and vegetables on site over grains and forage. Buildings are spaced in such a way as to ensure solar access to gardens. Irrigation water supply is wind

pumped from the on-site pond and augmented through cistern collection from residential rooftops.

Water

• *Moderates runoff.*

The runoff and soil loss are probably not greater than that before development. Existing grades are not disturbed. Contour farming is practiced. Runoff will be collected from roofs and paved areas. "Turf block" pavers and porous asphalt will be used in the less travelled areas. Most runoff is detained by the pond.

•*Minimizes water pollution; high water quality leaving site or safely processed off-site*

Quantity of sewage water leaving the site is greatly reduced with low water flush toilets and kitchen graywater used for irrigation. At higher densities, an aquatic waste treatment facility on site becomes feasible, and then no sewage water would leave the site. Water that might become toxic in the industrial area was not adequately addressed.

• *Minimizes aquifer depletion.*

After water is used in the buildings, it is used on for vegetation. Through the careful use of water in agriculture and xeriscaping, water demand is greatly reduced.The buildings are arranged to act as windbreaks to reduce the evapotranspiration losses from the crops.

Air

•*Produces clean air/ minimizes air pollution.*

The sizable green space preserved will help to filter air pollutants. Air pollution is reduced on site when hydrocarbon derived energy consumption is reduced; for example, by orienting buildings to take advantage of passive cooling and heating, providing for photovoltaics arrays, and using wind power to pump water.

Human Community

• *Design accommodates or allows slack for change.*

This is accommodated by a street and alley structure. The alley could be potentially developed as a second, non-vehicular street with small additional buildings. Much greater density can be achieved, but at the price of cross ventilation.

Commercial uses and residential uses are separated on the site with the expectation that these two uses will grow at different rates. Commercial and residential uses can grow towards each other and the variable dominance of one land use over another will respond to local needs.

At the small building scale, slack for change is accommodated with the careful placement of vertical circulation, zero lot line walls and plumbing cores. Porches offer buffered zones and can be enclosed to provide greenhouses or other types of interior spaces.

In the light industrial area, a flexible, lightweight and reusable system is proposed.

• *Affordable for housing and small scale enterprise; reasonable pay back period, reasonable risk.*

The structures proposed are small and begin with very simple plans. As the roads are quite narrow and perhaps unpaved these should be lower in cost than the roads of a standard development. The cost of infrastructure goes up, however, because of the single loaded building arrangement in order to allow for better ventilation. This may not be "reasonable" and should be reviewed.

• *Minimizes maintenance costs.*

Many of the building materials and systems will be experimental in nature and probably bio-degradable, and will thus require more attention.

• *Socially and Culturally appropriate,*

The assumption is that people who will want to live here because they prefer to participate more in a small scale community with common interests - gardening, building, researching. Rather than propose a design that demands a strong communitarian commitment, this proposal begins with cottages that can either grow together or remain detached as a more conventional suburban fabric.

• *Increases local community interaction, quality of life*

As there is great diversity on the site within walking distance, encounters on streets and paths should increase. Furthermore, the community will share many interests, especially gardening.

A diversity of housing options should attract a wider range of people. For example, above the offices on the "main street," single room occupancy units offer lower priced housing for students, some elderly, and others.

• *Reasonable aesthetics.*
The proposed buildings were adapted from vernacular housing types, with a strong emphasis on the welcoming porch. This community will likely be an interesting or curious place, with lots of do-it-yourself experiments.

• *Supports the generation of local income.*
Much of the built area is oriented towards small scale enterprises. These ventures can be accommodated in homes, along the alleys, on the "main street," at the housing resource center, and in the light industrial zone.

• *Balances the desire to protect privacy and discourage crime, vandalism .*
The scale , clustering, and chances for interaction in this community is such that most residents will know each other. In the vicinity of the houses, territoriality is well defined.

Transportation
• *Reduces automobile dependency.*
To the degree possible at the site scale, this has been addressed. The whole settlement is contained within a five minute walk. Housing is clustered along the east edge, with short walks to bus stops. Car access through the site will be slowed to pedestrian speeds. The easiest way to get around the site will be via bicycle. Bicycle routes are integrated with the proposed back alley / farm lane layout. These paths will connect easily with future city bicycle routes towards the city and to Decker lake northeast along Decker lane.

Energy & Materials
• *Reduces dependency on non-renewable resources.*The energetics were not directly addressed. This appears to offer a less resource intensive way of living.

• *Uses products of industries with sustainable yield extraction practices.* This would generally be understood by those living and working here. The structures would be built with materials the CMPBS is developing, including caliche and straw.

• *Generates usable by-products and minimum waste.*Tighter cycling of resources is probably easier in a community with people who share similar concerns.As the CMPBS *Pureland* diagram suggests, to link the inputs and outputs of businesses is a goal of the Center both at the site scale and the urban/ rural scale.

Education

- *Educates the users; provides feedback, gives perspective to the people on site scale resource flows in order to cooperate with regenerative practices.*

  Just by living here, people will see more and learn from each other. The site is small enough and open enough for people share in the rich seasonal life of this humane landscape: spring sowing , mid-summer gathering, and then a fall harvest festival.

Design alone cannot assure the meeting of the above criteria; the variability of human attitudes and behavior is of much greater importance, but the design can make it easier or more difficult. The most troubling design tension for me to address was the Texan sense of spaciousness, the open land desired for growing food, and the spacing of buildings for ventilation versus the definition of community clustering and pedestrian scale. Another tension is that of "leap-frogging" out of town and starting a new development versus improving the existing urban fabric.

Closing Thoughts

Sustainable designs attempt to moderate local human impacts on the underlying global life support systems. The emphasis is less on becoming self-sufficient (save to be autonomous of irresponsible practices) than to recognize interdependence and accountability. The ecologist and designer must ask: how do/will humans transform and alter the flows of biotic and abiotic resources that temporarily pass through a site?

The intent of this thesis was a survey of the state of the art on environmentally responsible design and to identify tools and methods available to the average practitioner. In seeking answers, I conclude with more questions, doubts and confusion.

There is a lot of excellent work going on. The challenge is to make these lessons or conclusions accessible to the generalist. My greatest frustration in researching was and is the level of communication on these subjects. On one hand, there are plenty of excellent assessments of a qualitative nature, with plenty of advice, but little to help one in directly comparing trade-offs. This is necessary if one is to implement concepts with some sense of balance. On the other hand, many studies were quite technical, quantitative, and very project specific, with little suggestion as to how to extrapolate conclusions to other applications. The obvious desirability of working in multi-disciplinary teams becomes even clearer. For levels of communication, I think the *Integral Urban House* is an excellent beginning, the next step should be at that of *Scientific American.*

The strongest confirmation I relearned is that one should become committed and emotionally connected to a locality. This effort in Austin represents a cursory and disappointing first cut; I am looking forward to returning to the Puget Sound region and starting over. To study flows is information intensive. Information availability about sites varies greatly; it may be very strong on water flows and non existent on wind. It takes time to learn who knows what; it takes time in a place to learn for yourself.

The common, largely intuitive, design approaches toward more socially and environmentally sustainable communities may generate the images needed to inspire some changes. For the credibility to practically alter mainstream design practices, a parallel emphasis should be placed on making it easier for designers to become accountable for the relative environmental impacts of design decisions. With an improved exchange of public domain computer aids that evolve through shared refinements, we may soon see desk top tools actually used to make more environmentally responsible design proposals.

First accountable, then responsible, someday sustainable.

Page 61

The Boston Globe

THURSDAY, AUGUST 2, 1990

Iraq reportedly invades Ku

ASSOCIATED PRESS

KUWAIT – Government officials said today that Iraqi troops crossed the border into Kuwait before sunrise and seized scattered regions in the northeastern sector of the small, oil-rich country. Kuwaitis engaged the Iraqi invaders with heavy artillery and were trying to ... them, government offic...

ed by telephone from Bahrain said.

In Washington, the United States condemned the Iraqi action last night and called for an emergency meeting of the UN Security Council to deal with the dispute.

ditional withdrawal of all Iraqi forces."

"The situation is very bad," Kuwait's ambassador, Sheik Saud Nasir Sabah, said in Washington. "There is a massive invasion everywhere."

In Kuwait, an unidentified ship tried to get close to the Royal Palace and the Royal Guard opened fire on it, according to members of the guard. It was unclear what happened to the vessel.

Bush cites threat to US 'way of life'

By Fred Kaplan
GLOBE STAFF

WASHINGTON – President Bush ... fended his decision to send thousands ... to secure Saudi Arabian oil fields, say ... freedom and "way of life" are at s... Gulf confrontation with Iraq's Sad...

Bush, in a pep talk to Pentag... and employees, maintained that ... is "striking a blow for the princi... make right."

And in a long-distance war ... he advised: "No one should d... our determination."

The president spoke ...

The king is carrying a secret message to Bush from President Saddam Hussein that proposes a settlement to the crisis, Iraq's ambassador to the United States, Mohammed Mashat, said yesterday.

Mashat did not reveal the contents of the message, but some news reports have said it offers to convene an international conference to discuss an Iraqi withdrawal

BUSH, Page 3

US gulf costs outstrip energy research costs

Here's a sidelight on the Iraqi crisis from energy analyst Christopher Flavin of the Worldwatch Institute.

The US government is spending about the same in 10 days to maintain forces in Saudi Arabia as it spends in an entire year on energy research and conservation programs th... ...uld reduce our dependence on ...l. After a decade of cuts, ...now have a total annual ...illion.

Some key questions remain unanswered

By Fred Kaplan

Brinksmanship taken to the brink

By Fred Kaplan
GLOBE STAFF

...NGTON – The US-Iraqi meeting in Geneva ...oved as bleak as the grimmest pessimists had ...

Even so, both sides continued to hold out the possibility of a peaceful settlement, putting any ... the thin reed of a mission to Baghdad ...ons secretary general, Javier Perez de ...

...ace at all, President Saddam Hussein ...n minister, Tariq Aziz, have ...

Increased Use of Automobiles Is Called a Worldwide Threat

Special to the New York Times

WASHINGTON, June 12 – Severe traffic congestion and automobile-related health problems will continue to ... internationally unless the use of ... according to a study ... Institute, a United ...

...proved dramatically in most cars. In the United States, for instance, the average car now gets 18 miles per gallon, compared with 13 miles per gallon in 1973. New cars are doing even better, with European and Japanese models averaging nearly 30 miles per gallon.

"Things do look good on the surface," Mr. Renner said. "But the sur... may contribute to its ..."

Thanks

to Tim Johnson,
for giving me plenty of rope, and holding on

to Pliny Fisk, Bruce Coldham, Sarah Harkness, Fernando Domeyko, Charles Harris, and Gail Vittori for caring and sharing so much

to friends for thesis assistance - *especially* : Tim, Bill, Sebastian, Laura, Damon, Rob, Peter, Julie and Avigail

to Mr. Kibby, who started me drafting
to Harry Leavitt, who started me thinking,
to Brian, Martin, Steve, Scott and Birte
to UW Professors Robert Small, Elaine Day Latourelle, and Neal Twelker
to Giselle Hyvert, Peter Stoner, Terry Heinlein, Gail Sullivan, and Neal Mitchell, for guidance and support in the real world
to Mark and Laura for the Nutella
to Laure

to my Mother and my Brother for sanity, which comes in handy
to my Father, who wanting one son to be an engineer, had thought MIT might straighten me out.

If we do not succeed, we run the risk of failure.
-Dan Quayle.

SustainAustin Rough Draft

K.Brinchmann Nov 1990

Appendix A

A sustainability rating system on the one house scale...
A positive system, give points/credit where earned.
Lots of room for improvement, moves to recognize
For now, oriented to single family housing, be interesting to try multi-family and small apartments

Priority of meeting need/demand

Concern of env. costs in meeting demand

[ ] an outlined box requires info on the study/case hc

Basic Data - Population/Density

Bedrooms	3	x	1.3 persons per bedroom
Floor Area	1,500		385 sf/person
Lot Area	5,000	sf	
Paved Area	1,000	sf	

Space Heating
20%

Heating Degree Days DD 65° **1760**

- **format, calculations for ene**
- **Austin norms for consumpti**

1) Calculate Basic Heat Loss from another spreadsheet
(should include envelope resistance, internal and solar gains, infiltration losses)
2) Gains due to solar and internal loads.
3) Mechanical System (to make up balance)
Efficiency

Actual Off site demand

Weighting / Overall Category	Measure	Units	Environmental Impact Higher 0		Lower 10	Case	Score	Weighted POINTS Earned	Distribution	Possible Points
17%	CO_2	lb/kWh	2.5	1.25	0	1.00	6.0	**20**	3.92%	**33**
17%	Toxic Waste	lbs/BTU?'	0	0	0	0.00	0.0	**0**	0.00%	**33**
17%	Sulfur Dioxide	lb/mmbtu	1.2	0.6	0	0.60	5.0	**17**	3.27%	**33**
17%	Nitrogen Oxides	lb/mmbtu	0.6	0.3	0	0.30	5.0	**17**	3.27%	**33**
17%	Particulates	lb/mmbtu	0.03	0.015	0	0.02	5.0	**17**	3.27%	**33**
17%	VOCs	lb/mmbtu	0.006	0.003	0	0.003	5.0	**17**	3.27%	**33**
100%										

Note: These figures not connected wit

Q. Sustainability on an absolute per house or per person basis? Per person.
Shouldn't have the large house on large lot be considered more sustainable
just because more efficient materials and systems can be afforded. Overall, framework for "living lightly."
Implicit quota system? Suggesting norms (quota) on which to improve. By saying better, also saying worse.
Better to state norms on a per person basis?

ouse

Units	Rationale/Comments
4 persons in household	
s.f.	walled in floor area
s.f.	Lot area neither directly good or bad
	impervious asphalt concrete

ergy star rating

13,000,000 BTU/yr	relatively easy to quantify • **format, calculations for energy star rating** • **Austin norms for consumption**
4,000,000 BTU/yr	just to make explicit
Gas burner	
75%	Oil 70%, Gas 75% eff very soft specify if this includes transport/transmission loses as well as in
11,250,000 BTU/yr	not the best formula

Quantities	Units	Rationale/Comments
3297.19	lb/year	Nat Gas 1.0, Coal 2.5 (note convert kWH to BTU)
0.00	lb/year	no idea
6.75	lb/year	• look up mm assume thousand thousand - million??
3.38	lb/year	Hydro, Nat Gas, Coal, Nuclear
0.17	lb/year	Hydro, Nat Gas, Coal, Nuclear
0.03	lb/year	Hydro, Nat Gas, Coal, Nuclear

h estimated consumption nor prorated per person.

Electrical
15%

Loads BTU/CDD ?
Built in Appliances
Lighting/
Daylighting

Weighting	Measure	Units	Envi High
Overall Category			
	Passive		(sho
20%	Daylighting		low
0%			low
0%			low
	Mechanical System (to make u		
	Efficiency %		
	Actual demand	BTU or kWh	
13%	CO2	lb/kWh	
13%	Toxic Waste	lbs/BTU?'	
10%	Sulfur Dioxide	lb/mmbtu	
15%	Nitrogen Oxides	lb/mmbtu	
15%	Particulates	lb/mmbtu	(
15%	VOCs	lb/mmbtu	0.
100%			

Water
10%

Annual Precip "/yr

Weighting	Measure	Units	Envi High
Overall Category			
15%	Household Wate	gpd	
25%	Landscape Wate	gpd	
12%	Other Water	gpd	
18%	Water recycling		
	Annual Site Rainfall		
10%	Source Aquifer?	%yes	1
10%	Rainfall > Demand		
0%			low
90%	Erosion		

Space Cooling
20%

Coolth Loss Bal: BTU/CDD ?
Passive (s

Weighting	Measure	Units	E H
Overall Category			
7%	Reduced Solar Gain		lo
7%	Night Flushing		lo
7%	Cross Ventilation		lo
7%	Paving		lo
	Mechanical System (to mak		
	Efficiency %		
	Actual demand	BTU or kWh	
13%	CO2	lb/kWh	
13%	Toxic Waste	lbs/BTU?'	
10%	Sulfur Dioxide	lb/mmbtu	
13%	Nitrogen Oxides	lb/mmbtu	
13%	Particulates	lb/mmbtu	
13%	VOCs	lb/mmbtu	
99%			

Water Heating
5%

Demand gpd ?
Solar preheat? Temperatu
Mechanical System (to mak
Efficiency %
Actual demand

Weighting	Measure	Units	E H
Overall Category			
17%	CO2	lb/kWh	
17%	Toxic Waste	lbs/BTU?'	
17%	Sulfur Dioxide	lb/mmbtu	
17%	Nitrogen Oxides	lb/mmbtu	
17%	Particulates	lb/mmbtu	
17%	VOCs	lb/mmbtu	
100%			

Vegetation
10%

points for concentra
Site degredation or

Weighting	Measure	Uni
Overall Category		
34%	Biomass	lbs
23%	Topsoil	lb/
3%	Composting	
35%	Vegetables	sf
5%	Wildlife Habita	
100%		

Building Materials
12%

Repeat for each of
Building materials + lo

Weighting	Measure	Un
Overall Category		
20%	mbodied energy	BT
30%	toxicity	
30%	iodegradability	
20%	reusability	
100%		

Transportation
5%

population density within walking distance

Weighting	Measure	Units	Environmental Impact Higher 0		Lower 10	Case	Score
Overall Category							
20%	transit	minutes	120	60	0	30.00	
30%	services	feet	5000	2500	0	500	
30%	city center	miles	20	10	0	8.00	
20%	bicycling	pleasant,	poor	ok	fine	fine	
100%							

Future Options
2%

Weighting	Measure	Units	Environmental Impact Higher 0		Lower 10	Case	Score
Overall Category							
100%	PV on Roof	s.f	0	390	780	750	
0%			0	0	0	1	
0%	Recycling		0	0	0	0	
0%	Rain catchment		0	0	0	0	
0%			0	0	0	0	
100%							

Community Context
0%

part of larger/ "macro" scale efforts
recycling, victory gardens, community groups, releaf,
overlap with transportation
sharing exchange
neghborhood facilities, some factor to encourage development in already sustainably orie

Weighting	Measure	Units	Environmental Impact Higher 0		Lower 10	Case	Score	Weighted POINTS Earned	Distribution	Possible Points
Overall Category										
0%			0	0	0	0.00	0.0	0	0.00%	0
0%										

Totals

99%	510	100.00%	978

Try to make "tangible:"

Annual Fuel Bills

Oil gal	98,000	BTU/gal
Gas CCF	75,000	BTU/CCF
Electrical	3,412	BTU/kWh

Balance: Rain on site to water consumption:

For example

Rainfall	32 "/year
Site Are	5,000 s f
	99,733 gals yr
• Loss?'	15% Immediate Evaporati
	84,773 gals yr

PV potential of roof (or tracking array over parki

Vegetables

Appendix B

Initial Site Program

Initial Res Population	70	prs	Annual Precip	32	°/yr
Land Area	50	ac	Heating Degree Days	1760	DD 65°F
Developable Land Area	44	ac	Cooling Degree Days	2914	DD 65°F
Density	1.59	pers/ac	Avg Horz. Solar	1478	Btu/ft2 day

DEMOGRAPHICS

Resident Population 70

	Austin Census	Proposed				Daytime Pop		Nighttime Population
1-9 yrs	15%	15%	11	Daycare	90%	9	100%	10.5
10-19 yrs	16%	16%	11	School Ag	60%	7	100%	11.2
20-55 yrs	55%	55%	39		30%	12	100%	38.5
55+ yrs	14%	14%	10	Retired	80%	8	100%	9.8
	100%	100%	70			36		70
				Commute Off Site		34		
				Commute to Site		20		
				Daytime Population		56		
				Daytime Working Population		39		

	sf/typ unit	
SF Attached	1,000	4
SF Detached	1,200	10
Multi Family	700	10
		24

Source: Austin Census

N.B. Assumed overnight visitors equals number of residents travelling from site.

<<Select typ dwelling type (1=SF Attached, 2=SF Detached,3=Multi Family)

Dwelling Units

*data Family Type	% Whole Assumed Households	Adults per DU	Children 1-9 per[?]	pers/DU		70 Population Adults	Children 1-9 per[?]		ft2/DU	floor area	stories	foot print	1.4 Dimension Ratio Width	Depth
Couples w/Children	40%	2.0	1.7	3.7	10	20	17	2	1,200	12,000	2	6,000	34	17
Single Parents	16%	1.0	1.5	2.5	4	4	6	1	1,000	4,000	1	4,000	44	23
Couples w/o children	37%	2.0	0.0	2.0	10	20	0	3	700	7,000	1	7,000	37	19
Single	8%	1.0	0.0	1.0	2	2	0	3	700	1,400	1	1,400	37	19
Totals	100%		avg	2.68	26	46	23	avg		24,400		18,400		
			DU	26					947					

Source: US National Census

N.B. Garage Roof Area and footprints

Residential Land Use

	pers/DU	Typ Bldg Footprint	Expans Potenti	Veg Garden	Fruit Trees	Rec/Play Priv/Spac	Parking 1.5 x 203	Lot ft2/DU	Rough DU/ac	Circulatio Factor	Rough DU/ac	No DU	Lot Area ft2	Circulation	Land Area [acres]
Couples w/Children	3.7	600	0	2,313	925	500	305	4,643	9	25%	7	10	46,425	11,606	1.42
Single Parents	2.5	1000	0	1,563	625	400	305	3,893	11	25%	8	4	15,570	3,893	0.48
Couples w/o children	2.0	700	expand	1,250	500	100	305	2,855	15	25%	11	10	28,550	7,138	0.87
Single	1.0	700	0	625	250	100	305	1,980	22	25%	17	2	3,960	990	0.12
Totals			expand Up									26	94,505	23,626	2.89

Paved Area

		pkg per DU	ft2/space	
Res. Parking		1	208	5,408
% uncovere	100%			5,408 ft2
Visitors		0.3	208	1,622 ft2
Roadway	390 ft lengt	21 ft	width	8,190 ft2
Paved Area				15,220 ft2

Common Space

		ft2/resident			
Play field (soccer field about an acr		150		10500 ft2	grass
Playground (include tot lot for day c		25		1750 ft2	
Dance Hall/Meeting		6	420 ft2		
Day Care	9.45 Childre	100	945 ft2		
	0.1 Adults/Children				
	0.9 Adults				
Common Buildings			1,365 ft2	12,250 ft2	

Commercial

	employees	ft2/eac	Building ft2	Parking Employe	Visitor		Garden Green Space	Hard Space	
Self Help Housing Resource Center									
9 ce/Demo Dwelling	7	150	1,050	718	718				
2 Library	1	500	500	103	103				
2 Warehouse	2	500	1,000	205	205				
1 Materials Yard	1	5000		103	103			5,000	
			2,550	1,128	1,128	Parking		2,255	11.0 spaces
Employees	11							7,255	
>. assume .5 cars per employee									
>> assume every other employee is actually meeting with a visitor									
Farmers Truck Market									
Stands	10	400		0	4100	Parking		4,100	20.0 spaces
>> assume on Saturdays??									
Small Coop Grocery	3	400	1,200	308	615	Parking		923	5.0 spaces
>> assume for local community; assume 6 parking places									
"Real Goods" Appliance/Hardware Store	3	400	1,200	308	615	Parking		923	5.0 spaces
Recycled Bookstore	2	400	800	205	410	Parking		615	3.0 spaces
Organic Restaurant/Cafe									
	3		200	308		Parking		308	2.0 spaces
7 tables			175		717.5	Parking		718	4.0 spaces
Vegetable Garden								terrace	
126 meals		21 equivalent persons					13,125		
Fruit Orchard							5,250		
>> assume 1/2 for local community; assume 1/2 parking place per table									
Organic Nursury	1.5	100	150	154	308	Parking		461	2.0 spaces
& Garden						Gardens	10,000		
Organic Chickens	0.5								
28	lbs/res yr	1,960	lbs/yr						
1	lbs/ft2/yr		1,960						
665	eggs	####	eggs/yr						
25	eggs/ft2/yr		1,862						
Organic Rabbits	0.5								
12	lbs/res yr	840	lbs/yr						
1.08	lbs/ft2/yr		778						
Organic Aquaculture	0.5								
yes pond 5	lbs/res yr	350	lbs/yr			Pond	1,704		
no tanks		0	lbs/yr						
Light Fab-ication/Shop	1.5	500	750	154	308	Parking		461	2.0 spaces
Dirt Delux	1.5							20,000	
Alternative Fuel Station	0	Vehicle Sharing, maintaining							
Bike Shop	0	future							
Day Care (from above)	0.9								
On Site Jobs	38.9								
Daytime Working Population	39								
Incubator Office Space	0	150	-11	-7	-7	Parking		-14	0.0 spaces
On Site Jobs	39		11,614	2,555	8,193		30,079	38,003	54 spaces

Building area	11,614	25%	
Parking Area	10,748	25%	54 spaces
Green Space	30,079	0%	
Work Yards	27,255	0%	
	79,697		
Circulation		5,591	
	85,287	2.0 acres	

Land Required to Produce Average US diet

		ft2/person	total		community 70	populations 100	500
A	Leafy Greens	38	38	0.06	0.06 ac	0.09	0.43
B	A+ Dinner Vegetables	113	150	0.18	0.24 ac	0.34	1.72
C	Entire vegetable Supply	475	625	0.76	1.00 ac	1.43	7.17
D	C +Entire Fruit Supply	250	875	0.40	1.41 ac	2.01	10.04
E	D + Grains and Cereals	5,375	6,250	8.64	10.04 ac	14.35	71.74
F	E + Livestock Forage Crops	18,750	25,000	30.13	40.17 ac	57.39	286.96

Source: IUH p58; Asbrook, Butchering, Processing and Preservation of Meat
>> periods of surplus and want - preserves, storage, trade
>> Austin: 9 month growing season vs poor site soils, temperatures, humidity
>> Should make above figures reflect an increased vegetarian population

Vegetarian Diet

Person		2,700 cal day		
		985,500 cal yr		
Yield (primary productivity)		12,000 kg/ha	10,688 lbs/ac	178 bu/ac
Yield (grain)	29%	3,480 kg/ha	3,100 lbs/ac	52 bu/ac
Grain		3,500 cal/kg		
Source: Chrispeels/Sadava		12,180,000 cal/ha	4931174 cal/ac	To support
N.B. A wastage factor should be		12.4 prs/ha	5.0 prs/ac	veg pop.
				70 pers
				14.0 ac

Meat Diet

Converting Plants to Animal products				
0.5 Calories for Grain		492,750 cal yr		
0.5 Calories for Anima		2,463,750 cal yr		
		2,956,500		
Yield (primary productivity)		12,000 kg/ha	10,688 lbs/ac	
Yield (grain)	29%	3,480 kg/ha	3,100 lbs/ac	To support
Grain		3,500 cal/kg		meat+veg pop.
		12,180,000 cal/ha	4931174 cal/ac	70 pers
		4.1 prs/ha	1.7 prs/ac	42.0 ac

Original Cal per day per Capit	Present Affluent Society Consumption		Avg	Two to Three Generations Hence		Avg
1 Food	10,000	20,000	15,000	5,000	10,000	7,500
2 Transport	20,000	30,000	25,000	5,000	10,000	7,500
3 Domestic	15,000	30,000	22,500	5,000	10,000	7,500
4 Utilities/Manufacturing	50,000	100,000	75,000	10,000	30,000	20,000
			137,500			42,500

1 Food	Urban Gardening, algal/leaf meat substitutes
2 Transport	Ride sharing, intermediate vehicles, slowways, telework.
3 Domestic	clustered housing co-ops, neighborhood scale systems, suburb infilling, un
4 Utilities/Manufacturing	solar power, pumped storage, hydrogen, decentralized automa

F

	Residenti	Commercial		acres		
Building Area - Res	19,765	11,614	31,379	0.7	1%	
Res- Lot w Fruit and Veg	76,105		76,105	1.7	4%	
Veg and Fruit		18,375	18,375	0.4	1%	
Paved Area and Circulation	31,543	16,339	47,882	1.1	2%	
Work Yards		27,255	27,255	0.6	1%	
Ponds		1,704	1,704	0.0	0%	
Recreational	12,250		12,250	0.3	1%	
Other Green		11,704	11,704	0.3	1%	
Undevelopable Land - Open/ Woodlot			257,004	5.9	12%	
	SubTotal		483,659	11.1	22%	
				38.9 remaining		
Grains	376250		376,250	8.6	17%	100%
				0.0 offsite acres req'd		
	SubTotal		859,909	19.7	40%	
				30.3 remaining		
Animal Fodder	######		######	30.1	60%	100%
				-0.1 offsite acres req'd		
	######	86,992	######	49.9	100%	

N.B soil not great for wheat

SOIL BASE	Acres	Inches below Grade		Permeability " per hour	Avail.. Water Capacity Range " per " soil	Calc	"layer	"in 12"	topsoil	pH	Shrink Swell	Engineering Topsoil	Bldg Foundation	Ponds	Septic	Drain
FhF3	5.9	0	Clay	<.06	.15-.20	0.175	6.3	2.1	3.4E+05	7.9-8.4	High	-	Poor	Good	No	
Ferris		36	Silty	I<.06	.15-.20	0.175	2.5			7.9-8.4	High					
		50					8.8									
Hhc	15.6	0	GravLo	.2-.63	.08-.11	0.090	1.6	1.1	4.6E+05	5.6-6.5	Low	Poor	Good	Modera	No	
Hornsby		18	GravS	.2-.63	.14-.16	0.150	7.8			5.1-6.0	Low	Gravel				
		70	GravC	.2-.63	.12-.13	0.125	1.5			6.1-8.4	Low					
		82					10.9									
TsD	21.9	0	FineSa	2-6.3	.08-.1	0.090	1.3	1.1	6.4E+05	5.6-6.5	Low	Fair	Mod	Good	No	
Travis		14	Sandy	.06-.2	.11-.14	0.125	4.5			5.1-6.5	Moderate					
		50	GravS	.63-2	.08-.1	0.090	2.3			5.1-6.5	Low					
		75					8.0									
W1A	6.5	0	Clay l	.2-.63	.16-.18	0.170	1.0	2.0	3.6E+05	6.1-7.3	Low	Minimal	Poor	Good	No	
Wilson		6	Clay	0.06	.16-.18	0.170	9.2			6.1-7.8	High					
		60					10.2									
	49.9	Acres							1.8E+06							

Source: Soil Survey of Travis County

Land Use Allocation based on soil type

	FhF3 Ferris	Hhc Hornsby	TsD Travis	W1A Wilson
Acres	5.9	15.6	21.9	6.5
Topsoil	0	1	3	1
Crops	0	2	2	4
Foundations	1	3	2	1
Ponds	3	2	2	1
Septic	0	0	0	0

higher the number the more appropriate - relative scale

		Priority				
armstead/Landscape	0.9	oundatio	0.0	0.9	0.0	0.0
Cultivated	11.1	Crops	0.0	0.0	4.6	6.5
Paved/Building	1.8	oundatio	0.0	1.8	0.0	0.0
Pasture/Range	30.1	Crops	0.0	12.8	17.3	0.0
Meadow	0.0		0.0	0.0	0.0	0.0
Woods/Forest	5.9		5.9	0.0	0.0	0.0
Other/Pond	0.0	Ponds	0.0	0.0	0.0	0.0
	49.9		5.9	15.6	21.9	6.5
			ok	ok	ok	ok

RUNOFF

	Acres	Hydro-logic Group	'imary Use	% of Area	CN	Weighted CN	
FhF3 Ferris	5.9	D	ıstead	0%	86	0	
			Cultivated	0%	81	0	
			Paved	0%	92	0	
			Pasture/Range	0%	85	0	
			Meadow	0%	78	0	
			Woods/Forest	0%	80	0	
			Other/Remain	99%	84	83	83
Hhc Hornsby	15.6	C	ıstead	6%	82	5	
			Cultivated	0%	88	0	
			Paved	12%	90	11	
			Pasture/Range	82%	80	66	
			Meadow	0%	71	0	
			Woods/Forest	0%	73	0	
			Other/Remain	0%	81	0	81
TsD Travis	21.9	C	ıstead	0%	82	0	
			Cultivated	21%	88	18	
			Paved	0%	90	0	
			Pasture/Range	79%	80	63	
			Meadow	0%	71	0	
			Woods/Forest	0%	73	0	
			Other/Remain	0%	81	0	82
W1A Wilson	6.5	D	ıstead	0%	82	0	
			Cultivated	100%	88	88	
			Paved	0%	90	0	
			Pasture/Range	0%	80	0	
			Meadow	0%	71	0	
			Woods/Forest	0%	73	0	
			Other/Remain	0%	81	0	88
	49.9						

Source: Soil Survey of Travis County

RUNOFF per month per soil type

	Soil Type				FhF3 Ferris			Hhc Hornsby			TsD Travis			W1A Wilson				
	Acres				5.9			15.6			21.9			6.5				
	Weighted Curve Numbers				83.1			81.3			81.7			88.0				
	Rainfall Event	Avg No of days with Precip of 1"or more	Max 24 hr "/24 h	* Precip	inches runoff	ac/ft	gallons	inches runoff	ac/ft	gallons	inches runoff	ac/ft	gallons	inches runoff	ac/ft	gallons	ac/ft	gallons
≫	Jan	<0.5	3.44	0.0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.0	0
≫	Feb	1.0	3.73	1.6	0.45	0.2	72,414	0.39	0.5	163,343	0.40	0.7	237,954	0.66	0.4	117,190	1.8	590,901
≫	Mar	<0.5	2.68	0.0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.0	0
≫	Apr	1.0	3.86	1.6	0.45	0.2	72,414	0.39	0.5	163,343	0.40	0.7	237,954	0.66	0.4	117,190	1.8	590,901
≫	May	1.0	3.61	1.6	0.45	0.2	72,414	0.39	0.5	163,343	0.40	0.7	237,954	0.66	0.4	117,190	1.8	590,901
≫	June	1.0	6.50	3.0	1.46	0.7	234,148	1.34	1.7	565,978	1.36	2.5	810,876	1.82	1.0	321,919	5.9	1,932,921
≫	Jul	<0.5	5.46	0.0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.0	0
≫	Aug	<0.5	4.68	0.0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.0	0
≫	Sept	1.0	4.61	2.0	0.71	0.3	113,640	0.62	0.8	262,972	0.64	1.2	380,700	0.97	0.5	171,902	2.9	929,214
≫	Oct	<0.5	7.22	0.0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.0	0
≫	Nov	<0.5	3.98	0.0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.0	0
≫	Dec	<0.5	4.02	0.0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.0	0
			7.22	9.8													14.225	4,634,838

* at this density 100 persons, a minimum of runoff

N.B. Need the USSCS Hydrology: National Engineering Handbook & USSCS Urban Hydrology for Small Watersheds

See:
Rainfall Frequency Atlas

reduce home water consumption with on-site recycling

Residential	norms gpd/pers					
	3		0.5	2.0	assumption	
	21		60%	12.6	flow reductions (85% w/air assis	
	14			7.0	assumption	
	32	5.25 gal/flush	0.825	5.0	3.3liter IFO	
	70	gpd/pers		27	gpd	9.8
5 Car Washing		200 gpcar?				hot gpd
6 Swimming Pools	11	801 gpd 50'x150' pool @evap per 0.017" ? shade, covers				
To digester	5	352 gpd				
To algae pond	17	1,160 gpd				

Dwelling Units	26 du
Inst/Comm ft2	11,614 ft2
Choose Scenarios	
1 water tight cycling yes no mur	
2 diet modifications in context of ı	

1 Drinking & Cooking
2 Bathing/Personal
3 Laundry and Dishes
4 Toilets

2.00 gpd/prs muni	5.0 gpd/prs black
19.60 gpd/prs roof	16.6 gpd/prs gray
21.8 resgpd/potable	
19% gpd/prs recycled	77% gpd/prs recycled

Commercial	employe	gpd/pers		gpd/potable	gpd/gray
Daytime Working Population	39	5 gpd/emp gray		194	
		2 gpd/emp black			64
assume some of the water consumption carried in residential figures					
Visitors (emp x 2)	78	2.5 gpd/vis gray		194	
		1 gpd/vis black			64
7 Housing Resource Center			1 1 ɔloyees	20	
1 Truck Market	10 once/weel		1.43 ɔloyees	7	
1 Coop Grocery			3 ɔloyees	50	
1 Hardware Store			3 ɔloyees	20	
1 Bookstore			2 ɔloyees	10	
1 Restaurant/Cafe			3 ɔloyees		
	2 gal/meal		126 meals	189	
Organic Nursury			2	30	
Organic Chickens/Rabbits			1	100	
1 Aquaculture Pond					1,262 gpd water flow either down size fish crop, make deeper ponds, use interior t
					180 avg gpd evap losses
					1,442 gpd waste water
#REF! Light Fabrication/Shop			1.5 ɔloyees		75 gpd/toxic
#REF! Dirt Delux			1.5 ɔloyees	37.5	
8 Alternative Fuel Station			0 ɔloyees	0	
2 Bike Shop			0 ɔloyees	0	
Day Care (from above)			1 ɔloyees	22.5	
				874 gpd/potal	128 gpd/gray

Biomass	Avg
	Bioregion
	3 kg/m2
	13.4 tons/ac
	acres
	lbs
	water conte
	gallons

7 Irrigation
Sprinkler

Source: Milne

Water	Roof Area [ft2]	Water Sup [gpd]	Paved Area [ft2]	[gpd]	Demand gpd/potat	gpd/black	
Residential	18,400	757			1,512	352	
Common Buildings	1,365	56					
Aquaculture							1,442 ok
Commercial	11,614	478			874	128	
Paved Parking			47,882				
[ft2]	31,379		47,882	1,970			
Avg Rain Collected		1,291		1,970	2,386	480	
					1,095 municip	extra	irrigation
				2.21 acre/feet	2.67 acre/fe		4.88 acre/fee

>> lead on roofs [auto exhaust into rainwater]

	Irrigation [acres]	ic ft/ac /yac	ft /ync	Precip ft /y	Margin for evap losses [%]
Crops for Residents	1.00	2.0	2.01	2.7	33%
Crops for Comm	0.30	2.0	0.60	2.7	33%
	???				
Fruit Supply for Res	0.40	2.0	0.80	2.7	33%
Fruit Supply for Comm	0.12	2.0	0.24	2.7	33%
			3.66		

N.B. limited to one growing season?

N.B. Assume drip/ water conserving irrigation, fertile soil conditioning, mulching

Preciptation

Days		Precip Norm ["/Mo]	Max ["/Mo]	Min ["/Mo]	Max 24 hr "/24 hr	Average Gross Lake Surface Evaporation Rates "/Mo
31	JAN	2.35	7.94	0.07	3.44	2.40
28	FEB	2.58	6.39	0.28	3.73	2.60
31	MAR	2.13	4.98	0.22	2.68	3.60
30	APR	3.55	9.93	0.10	3.86	4.25
31	MAY	3.71	9.98	0.81	3.61	5.25
30	JUN	3.22	11.43	0.00	6.50	7.00
31	JUL	2.18	8.40	0.00	5.46	8.75
31	AUG	1.94	6.21	0.00	4.68	8.80
30	SEPT	3.44	8.11	0.07	4.61	6.80
31	OCT	2.38	12.31	0.00	7.22	5.60
30	NOV	2.12	7.91	0.01	3.98	3.80
31	DEC	2.53	5.91	0.00	4.02	2.85
	Annual	32.13	12.31	0.00	7.22	###
	Avg "/mo	2.68				5.14
	Avg "/day	0.09				###

Source: Climatic Atlas

Roof Area	31,379	ft2
Losses	25%	
	gals/mo	
JAN	34,474	
FEB	37,848	
MAR	31,247	
APR	52,078	
MAY	54,425	
JUN	47,237	
JUL	31,980	
AUG	28,459	
SEPT	50,464	
OCT	34,914	
NOV	31,100	
DEC	37,115	
Annual	#####	
Avg/mo	39,278	
Avg/day	1,291	

>> assume 99% solar space heat in winter

NB: 71 persons max w/animal fodder

NB: 249 persons max with cereal grains

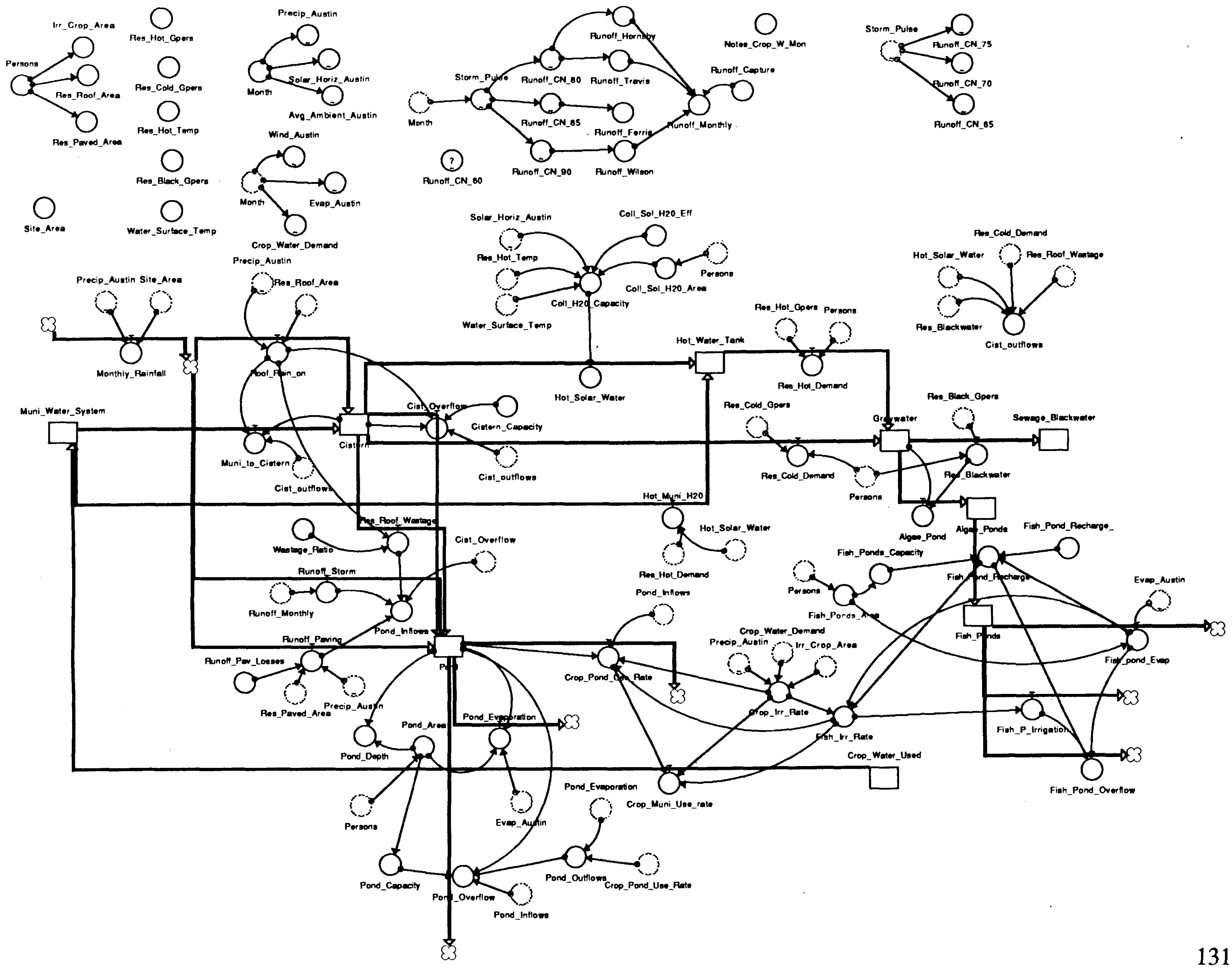
?? two growing seasons?

54% res potable water	Soil	Siting, Runoff
54% res & comm potable demand	Water	Collection
x	Sun	PV, Roof, Siting
x	Wind	Siting
	Biomass	>> Nitrogen balance

nutrients out - sewage, leaching, produce

Gallons per year

Rainfall	43443840	1.4% Roofs	6.3E+05	## Ciste	4.7E+05	0.0% Res Potabl	5.5E+05	14.7% Res Toil	1.3E+05
Municipal	4.0E+05			## Pond	6.3E+04	0.0% Comm Pot	3.2E+05	5.4% Comm T	4.7E+04
				## Evap	9.4E+04	0.0% Pond/Over	0.0E+00	79.9% Grywtr>	7.0E+05
						46.1% Muni demar	4.0E+05	Blackwat	1.8E+05
						Graywater	8.7E+05		
		2.2% Paved Area	9.6E+05	## Pond	3.4E+06				
		10.7% Gen Runoff	4.6E+06	## Offsit	2.2E+06	0.0% FishPonds	4.6E+05	Biomass	
						0.0% Evap FishP	6.6E+04		
		10.0% Evaporation	4.3E+06						
		2.8% Top soil Ve	1.2E+06						
		72.9% Top soil Oth	3.2E+07						
		Topsoil cap	1.8E+06						



Irr_Crop_Area
Res_Hot_Gpers
Precip_Austin
Persons
Res_Roof_Area
Res_Cold_Gpers
Month
Solar_Horiz_Austin
Res_Paved_Area
Res_Hot_Temp
Avg_Ambient_Austin
Wind_Austin
Res_Black_Gpers
Month
Evap_Austin
Site_Area
Water_Surface_Temp
Crop_Water_Demand
Runoff_Hornsby
Notes_Crop_W_Mon
Storm_Pulse
Runoff_CN_80
Runoff_Travis
Runoff_Capture
Month
Runoff_CN_85
Runoff_Ferris
Runoff_Monthly
Runoff_CN_60
Runoff_CN_90
Runoff_Wilson
Storm_Pulse
Runoff_CN_75
Runoff_CN_70
Runoff_CN_65
Solar_Horiz_Austin
Coll_Sol_H20_Eff
Res_Hot_Temp
Persons
Coll_Sol_H20_Area
Coll_H20_Capacity
Water_Surface_Temp
Res_Cold_Demand
Hot_Solar_Water
Res_Roof_Wastage
Res_Blackwater
Cist_outflows
Precip_Austin
Res_Roof_Area
Precip_Austin Site_Area
Monthly_Rainfall
Roof_Rain_on
Hot_Water_Tank
Res_Hot_Gpers
Persons
Res_Hot_Demand
Hot_Solar_Water
Muni_Water_System
Cist_Overflow
Cistern_Capacity
Cistern
Res_Cold_Gpers
Res_Black_Gpers
Graywater
Sewage_Blackwater
Muni_to_Cistern
Cist_outflows
Cist_outflows
Res_Cold_Demand
Res_Blackwater
Persons
Hot_Muni_H20
Hot_Solar_Water
Algae_Pond
Algae_Ponds
Fish_Pond_Recharge_
Res_Roof_Wastage
Wastage_Ratio
Cist_Overflow
Res_Hot_Demand
Fish_Ponds_Capacity
Fish_Pond_Recharge
Evap_Austin
Runoff_Storm
Pond_Inflows
Persons
Fish_Ponds_Area
Runoff_Monthly
Pond_Inflows
Fish_Ponds
Crop_Water_Demand
Precip_Austin
Irr_Crop_Area
Runoff_Paving
Runoff_Pav_Losses
Pond
Fish_pond_Evap
Crop_Pond_Use_Rate
Crop_Irr_Rate
Res_Paved_Area
Precip_Austin
Pond_Evaporation
Fish_Irr_Rate
Fish_P_Irrigation
Pond_Area
Pond_Depth
Crop_Water_Used
Pond_Evaporation
Crop_Muni_Use_rate
Fish_Pond_Overflow
Persons
Evap_Austin
Pond_Outflows
Crop_Pond_Use_Rate
Pond_Capacity
Pond_Overflow
Pond_Inflows