BUILDING VOLUNTARY SUSTAINABILITY:
How Urban Design Can Promote Care for Ecological Systems

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ABSTRACT

Human behavior is, in aggregate present state, unsustainable by the ecosystem of the earth. This thesis develops a behavior change model of how societies can move from unsustainable to sustainable behavior, and, because behavior is in large part a result of personal conviction, the factors that result in voluntary behavior change towards more environmentally sustainable behavior. The three key factors that trigger a desire to behave sustainably are intellectual understanding of ecosystems, engagement with ecosystems, and feedback on personal ecosystem impacts. Urban design is a key element in how the ecosystem is presented and culturally interpreted, and this thesis examines how urban design can be used to promote care for the ecosystem by offering experiences that provide the factors of behavior change. Several example cases are provided, as well as an examination of how we sense natural systems and design suggestions.

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Preface: Cities that Feel Right

I have travelled since before my memory starts. In fact, some of my earliest memories are of being in New Zealand when I was two years old—far from California, where I was born. I inherited travel. My mother was born in Mumbai to English parents. She grew up in Kolkata and travelled back and forth to England for boarding school starting when she was nine. My father was born in New Zealand and began travelling after college. He made friends with an MIT student in Austria, and came to Boston, where he met my mother. Eventually, they moved to California, but international families and a thirst for adventure found them on the road a lot. I first flew when I was nine months old. Since then I’ve been to hundreds of cities in twenty-five countries on six continents, which is an extraordinary opportunity to have had. I travelled around the world for eight months at one point, and I spent the majority of that time walking around cities. That is, to my surprise at the time, what I love to do; particularly if there are castles around. For the first time during that trip I spent significant amounts of time in countries that are developing, and not inhabited largely by people of European descent.

All of my travel amounts to a significant experience of cities in general, architecture, public spaces, sidewalks, and transit systems. Each city is a revelation in one way or another, because they communicate so much about how other people live and what they think is important. The changing modes of building shelters and making art are particularly extraordinary. I began my long trip with five weeks in China, then moved through Southeast Asia, the Middle East, Eastern and Western Europe, and finally Morocco. Some of my impressions of the places where I was and had been emerged quickly, and some accumulated over the course of months, or developed after I returned to the States. My experience is that cities feel different. They convey different senses of physical place and meaning, and some of them feel dramatically better than others. Upon reflecting what it was that I liked about some cities and disliked about others, I came to the conclusion that I dislike cities that feel artificial; that do not give any hints about their geographical, geological, or climactic place, or, in other words, cities that don’t provide the connections to ecosystems that I believe are central to caring about ecosystems.

Doha, Qatar, where I ate at both Chili’s and Cinnabon, and Dubai, UAE, are cities that have sprung up from the desert mostly in the very recent past. They both, to be clear, have castles, which are quite and made out of mud bricks, and indicate that there was civilization here in the fairly distant past. In the castle in Dubai there is a museum, which contains a walk-through display of what it was like in Dubai in the 1950s, which was very much how it was hundreds of years before that. It looks like the Middle Ages. Until the discovery of oil nearby, Dubai was a small and unimportant fishing village. Now it is a global trading and pleasure center. In both Dubai and
Qatar lots of people, particularly the very small percentage of the people living there who are native, spend a lot of time driving around in huge SUVs and going to the mall. The buildings are largely from after 1950, and most of them are heavily air-conditioned glass and cement boxes. This means that the majority of buildings in these cities are built in a largely international style, which is fitted out with climactic controls so that occupants are comfortable. All of the building materials, besides sand, are imported. There is also a native style of building which relies largely on mud bricks and a little wood, and which features wind towers, which are towers that extend above the roof-line and are designed to catch wind and bring it into the building past dampened fabric, which cools the air and then the building. This style is no longer used except for display cases. Cities built in the international, climate-neutral style have a very different feeling than those that are built of local material, with the local climate in mind. They could be anywhere, and provide few external clues to where they are in the world if you stand outside them and look up. After seeing many of these buildings all over the world the begin to be both eerie and disheartening to someone who loves to experience unique places, both built and natural.

There are many cities around the world that were built largely before the industrial revolution, and these tend to have quite a different

---

**Figure 1. Where in the world?**

These buildings in Doha and Dubai express little about their ecosystems.
feel than those built afterwards. Pre-Industrial buildings rarely rise above four stories, and they are built out of basically local materials, which yields a generally uniform color and texture to the buildings. In Lecce, in southern Italy, buildings in the pedestrian-only town center are built out of limestone. The limestone in this area is very soft when it comes out of the ground, and gradually hardens on exposure to air. This means that Lecce not only has streets lined with buildings that are the most beautiful golden color, but also that many of them are carved and decorated to within an inch of their foundations. Lecce is a compact town, like many in Italy, which was built with the expectation that most people lived in town and went out to their fields to work during the day. There isn’t a lot of open space within the old city walls, and even outside of them gardens are small and houses cluster together and abruptly cede the way to farmland. Lecce, though it is now a modern city, is structurally dripping with history and context, and it results in a tangibly different experience to walk down the street in Lecce than to walk down the street in Dubai, though in both places streets are often lined with buff buildings and few trees. When you are in Lecce, almost everything that you would buy on a trip to the store is from Italy. In Dubai, that is the case for almost nothing, and yet it is a shopping mecca. If you ask for places to visit when you are in Dubai, the barista at Starbucks will list shopping malls for you. In Lecce, you are directed to experience art and local culture, by a barista in an old cafe.

Sometimes when we travel we wake up disoriented, and our first thought is “where am I?” Similarly, when people see photos I took while travelling, or even photos taken near home, they always want to know where they

Figure 2. Urban and Rural in Lecce
Compact development cedes abruptly to farming
Source: Google Maps

Figure 3. Referenced Culture
On closer consideration some buildings in Doha, though modernist, contain formal references to traditional Islamic architecture
Figure 4. Golden Landmarks
Top to bottom: Dubai, Doha, Lecce
were taken. We always want to know where. Understanding our environment or the environment in a photo places ourselves and the events we see in images in context. Without this context we are, literally, lost, which can be an acutely disturbing experience. If a place is built in such a way that it doesn’t provide context of occupants about the uniqueness of the place the results can be equally disturbing. These non descript places are often described as ‘soulless,’ as Dubai is by Galani and Hadas (Galani and Hadas 2008). Though Dubai has many exceptional and superlative buildings they do not spring from, and contain little reference to, the place where they are. Let us take soulless-ness as the anti ideal.

If, then, soulless places like Dubai are ‘bad,’ and soulful places, where every vista reinforces one’s sense of place, like Lecce, are ‘good,’ what next? What does the ideal development look like, and what is life like there?

Figure 5. Historic patterns

Narrow streets in Lecce (above) and Marrakech use buildings to provide shade for pedestrians.
INTRODUCTION

“These days the environment, the source of life for all beings in the world... is undergoing extensive degeneration. At this time it is extremely important that every human being, according to his or her ability, consistently puts effort into ensuring the conservation and protection of this planet’s environment and its inhabitants.”

- The Dalai Lama, 1994

This thesis is about making human behavior more ecologically responsible using urban design, architecture, and technology. Behavior change happens all of the time, but what I am interested in is a specific kind of change: a widespread voluntary change towards sustainable individual behavior. Human behavior today is, globally, unsustainable. It stands to reason that we should change our behavior. I have developed a behavior change model that illustrated how we can promote this behavior change. I argue that there are four primary paths between unsustainable to sustainable behavior, which include: societal collapse; legislation and policy; technology and design; and behavior change. These paths are significantly interrelated, as I discuss in Chapter One. The relationship between design and behavior change is particularly interesting. Design can be used to make unchanged behavior more efficient, and it can also be used to encourage behavior change. In order to produce voluntary, conscious, or self-motivated behavior change towards sustainable behavior I argue that three factors are instrumental: Knowledge of natural systems; engagement with those systems; and feedback on how behavior impacts the system. These three combine to yield empathy and care for the systems, and thus more sustainable behaviors. This behavior change model and the three factors of voluntary behavior change provides the structure of the thesis.

In Chapter One, I describe the basis of the behavior change model and the reasons that urban design-based change is needed. I describe why, if we are to be more sustainable as a species, it is vital for us to be aware of and feel connected to natural systems. This argument is supported using data from a variety of fields, including psychology, semiotics, system dynamics, and planning. Chapters Two, Three, and Four address how urban design and technology can and do lead to the three behavior change factors: knowledge of ecosystems; engagement; and feedback. I address how the built form currently does and does not make us aware of natural processes, and how we might design our infrastructure in such a way that we can see and
kinesthetically experience both natural systems and our connections to them. The appendix contains a case study of how these ideas can be applied in practice.

The photographs, all taken by myself unless otherwise noted, reflect my experience of international and domestic US cities. The behavior change model was developed and is valid on an international basis, though the majority of analysis and design suggestions are US focused.

Natural Systems and the City

When you walk down the street in a US city, are you aware of the natural systems that support you? We: you; me; the homeless; children; the President; bankers; dogs; and everyone and everything else are utterly dependent on natural systems in order to remain alive. Do we all know this? We have been taught in school that the vegetables in the grocery store are grown somewhere or other, with their roots possibly stretching out through the earth, but really when we walk down the street and go about our lives in a developed country we have very little contact with the natural systems that sustain us, so much so that we don’t much notice that they exist.

We have designed our cities in such a way that our infrastructure brings all our needs to and behind our doors. It is possible, without undue effort, to construct a life in which one works, exercises, eats, bathes, and socializes without going outside, or even leaving an apartment. We have generally made ourselves very, very comfortable. Meanwhile, out of doors, outside the city, or generally out of sight, natural systems are in trouble. We are facing a climate change of unknown proportions. Much of our land and water is polluted, we are losing topsoil and rainforest acreage at horrifying rates, and so on. However, it is extremely difficult for us to see these things, and we do not experience their impacts in our day-to-day lives. Because we are so insulated from our environment we don’t feel or understand our connection to it, and therefore, critically, we have trouble caring about our impacts. This is not because we are callous, but simply because it is difficult to care about something that you don’t know or understand.

Responsibility for the Streetscape

Walter Gropius wrote, “Beauty is an integral part of the whole of life. Why then have our cities become so ugly?”[Hosken 1968] And indeed large swaths of the city are unattractive, inhumane or neglected, not to mention unsustainable. Much of the city: the streets, sidewalks, rights of way, and so on, are publicly owned, which amounts to about 30% of the land in any given city. Furthermore, in the vast majority of US cities and towns the municipality has the right to control (to a greater or lesser degree) the outward appearance of privately owned buildings, as well.
That is to say that city administrators have, at least in theory and legislation, a great deal of power over what the city looks like. In general is it planners within the city administration who address issues of the design of the physical fabric of the city, so it can be said that planners share significantly in being responsible for cities being ugly. The overwhelmed planner’s escape hatch is to point out that many forces are at work to shape city form, and planners cannot control all of them. This is both true and insufficient. Once abandoned, the public sphere often falls prey to both the tragedy of the commons, when collective ownership leads to overuse, and the tragedy of the anti-commons, when too many stakeholders cause a functional paralysis leading to collective inaction [Heller 1998]. No one takes ownership for a complete space (street, neighborhood, or city), and everyone does their little bit for themselves in their own style, which leads to discontinuity and a lack of thought for the general good, and attendant ugliness. Using the language of built form, cities speak to us about individuality, power, money, and domination over the land, not harmony and compassion. Cities are not organic phenomena. Almost everything in the city is the product of human intention, or is influenced by us. We need to look closely at the city so that we may discover what we have made, what values we are currently presenting in built form. Then we can reflectively decide what we want to value and build in the future.

Planners and architects are particularly interested in sustainability because the physical form of the city represents one of the most significant ways that we influence our biosphere. Residential and commercial buildings use 1/3 of the energy used in North America [Biello 2008]. The US Green Building Council’s (USGBC) development of LEED certifications for both buildings and neighborhoods, and LEED’s wide-spread adoption serve as evidence of this concern, as do the plethora of recent books on the subject of sustainable development. What is surprising, however, is that many LEED buildings are formally largely undifferentiated from “regular” buildings, often intentionally so. The only way you can really tell if you’re looking at a LEED building is to look for the plaque in the foyer. Most of the technologies and formal elements that are designed to make the building “green” are hidden away on the roof, in the ceiling, and in the basement. As an indication of dedication to communicativeness, in the LEED New Construction (NC) rating system [US Green Building Council 2009] only one point out of one hundred is available for providing occupants with a view of the outdoors, indicating an interest in the senses of occupants, and only 5 possible points are available for ‘Innovation in Design,’ and it is not clear that those credits could be applied to communicative environments, This is because each LEED point or innovation must be judged ‘compliant,’ and it is difficult to conceive of a qualifyably educational or engaging ecosystem experience. Both LEED NC and LEED for Neighborhood Development (ND) provide plentiful points for low impact development and ecosystem protection, but they do not specify aesthetics or the legability of the buildings or landscape. The LEED program is essentially
a ‘better mousetrap’ system that is structured around the idea of creating buildings and neighborhoods that have a reduced ecological footprint throughout their lifespan, regardless of who are using them. This is a noble goal, but it does not make for clear communication about the importance of sustainability, or personal or collective connections to, and impacts on, the environment. We do not generally live in cities that make clear to us through their form how ecosystems work, that we are part of ecosystems, or how our individual and collective actions play important roles in the functioning and health of those ecosystems. Planners and designers who make city form can change this.
CHAPTER 1: UNSUSTAINABLE HUMAN BEHAVIOR

“We have met the enemy and he is us.”
– Walt Kelly, 1970

As a species we are living in such a way that if we continue using the earth’s resources in the same way we will run out of resources. In other words, we are using up our natural capital and not replacing it. There is no shortage of research to support this. In 2008 the World Wildlife Foundation’s (WWF) International Director-General James Leape stated that that we are facing a serious, “ecological credit crunch caused by under-valuing the environmental assets that are the basis of all life and prosperity.” [The World Wildlife Fund 2008] In the WWF’s Living Planet Report 2008, part of a report series issued every two years that is widely accepted as a statement of the earth’s ability to remain a living planet, they further find that ¾ of the world’s people live in countries that are ecological debtors, drawing on more ecological resources than their country can provide. They go on to write that globally, we passed the Earth’s ecological carrying capacity in approximately 1985. If we need any further evidence of ecosystem degradation and the danger of our lifestyles, we may also note that in the last 35 years alone we’ve caused 30% population loss in the global wildlife population, and both the US and China are each using 21% of global bio-capacity [The World Wildlife Fund 2010]. We have two choices. The first is to continue on our current path and go deeper into ecological debt, which will lead to the eventual collapse of human civilization along with the larger ecosystem. The second choice is to adjust course and rebuild a biocapacity reserve.

We need to change our patterns of habitation so that they can be sustained by the system in which we exist. We are an adaptable species, so perhaps this kind of change won’t be too difficult, but I believe, as many people do, that becoming truly sustainable will require significant behavioral and structural change, particularly in the car dependant US. Human ingenuity and technology will not just ’fix it’ and allow us to continue enjoying our current lifestyles. In order to make large scale behavior change possible it will be very useful, if not imperative, to teach/make/allow millions of people understand their connection to and impact on ecological systems.

Tokyo, Japan
If people don’t understand or care about the environment, why would they change their habits?

There is no shortage of information on sustainability and sustainable practices available through myriad media, and yet millions of people grow up in concrete jungles like The Bronx, where trees are scarce, open space is dangerous, and all inputs and outputs are moved as invisibly as possible. Food arrives at the corner bodega in a can, is mixed with water from a pipe, heated with electricity from a wire, and consumed, in a brief moment of intimacy, using a spoon. After that, the unaccountability begins again. Water appears in the kitchen sink and restroom to carry waste “away,” and the can gets dropped in a recycling bin and taken “away.” The production and delivery of this food was made possible by natural resources like coal, crude oil, sunlight, clean water, metal ores, fertile soil, plants, microbes, and so on, and all the waste will eventually return to the ecosystem as well, but the person in The Bronx will likely never see any of that happening, or have to think much about it. Even if our subject is interested in and capable of obtaining information about the functioning of natural systems and human impact thereon, or watches a nature documentary on the television, the information contained in media is often so abstract that it is insufficient to catalyze action. Psychologists have found that it is almost impossible to care about something that you don’t experience (Clayton 2009), and we often have little experience of nature. Therefore as Douglas Farr says in Sustainable Urbanism: Urban design with Nature, “The lack of human contact with nature has inured and possibly blinded us to the terrible damage we do to our planet.” Farr 2008] That means that if we want people to care about the functioning of the ecosystems that support them we need to provide them with personal experience of that ecosystem. We not only need to go outside more, we need to integrate ecosystems into the city,
because people, especially children, learn constantly from their environment, and if the city is constantly shouting, “What ecosystem? We humans have it all figured out,” then a nature documentary, informative sign, or pamphlet on recycling won’t do a lot to contradict that message. The city is a communication tool, so the city is a teaching tool. It would be wise to decide exactly what we want to teach, and build that decision into our city.

**Definition of sustainability**

What is sustainability? There is an ever vaster literature on the subject, and many different angles to look at it from. The Brundtland Commission’s definition, that sustainability is, “development that meets the needs of the present without compromising the ability of future generations to meet their own needs,” (Brundtland 1987) is powerful and profound, and captures the essence of the intention to live in a way that can be maintained indefinitely. In order for development to be sustainable it must be Ecologically, Socially, and Economically sustainable (The Three Pillars Model), and that economic sustainability depends on social sustainability, which depends on ecological sustainability. For example, if we are all starving because we have no food (ecological collapse), because we encouraged over-farming by socially valuing production over all else (social failure), our market system is irrelevant. This thesis focuses specifically on influencing overall sustainability by improving ecological sustainability. The hypothesis is that it is possible to improve ecological sustainability using city form and design to evoke voluntarily behavior change from unsustainable to sustainable behavior.

**Model: Avenues Towards Voluntary Sustainable Behavior**

Our underlying ecological problem may be simply stated: current human behavior is unsustainable. No one of our behaviors or policies are specifically to blame, but in aggregate we cannot go on behaving and using the planet in the way that we currently are. If that is the case then the overarching solution is obvious: we must begin behaving sustainably. The question then is
how to get (x) billion people to make that transition. I have developed a model that diagrams four ways that we can get from sustainable to unsustainable behavior, and their interactions. The four key avenues, or ‘factors,’ in the transition, when seen as part of a system, are Behavior Change, Design/Technology, Legislation, and Collapse. Let us look briefly at each of these variables and then proceed to a more in-depth analysis. First, Behavior Change. What is behavior? The Merriam Webster Dictionary defines behavior as, “anything that an organism does involving action and response to stimulation; the response of an individual, group, or species to its environment.” (Dictionary 2010) So, our behavior is our actions, our stimulus response, and our responses to our environment. It may also be describes as our ‘habits.’ (Orlikowski 2010) Technology includes urban and architectural design, product design, graphic design and communication, media, user interface design, and the vastly numbered and various technologies that we are equipped with. Legislation is, “the exercise of the power and function of making rules (as laws) that have the force of authority by virtue of their promulgation by an official organ of a state or other organization.” (Dictionary 2010) Company policy is the private sector equivalent of legislation, and both are essentially sets of rules that govern behavior. The fourth avenue from sustainable to unsustainable behavior is collapse, which is the same as societal failure. After a collapse all or most of the members of a society die or leave. These avenues to sustainable behavior are not one-way streets. They may each backfire or be misapplied and in fact make behavior less sustainable than it was originally.

In Figure 8, at left, the connections between unsustainable behavior, the problem, and sustainable behavior, the goal, and the four factors or avenues to sustainable behavior are made clear. The clearest connection is through collapse. Because collapse entails a dramatic decrease in population through death or migration the end result, from the point of view of the ecosystem, would be more sustainable human behavior, because no (or very little) unsustainable human behavior is assumed to be better than some unsustainable behavior. The dashed line between collapse and sustainable behavior reflects the question of whether there is any behavior at all if there is no population behaving, and the fact that it’s our least appealing option. Legislation does not itself make for sustainable behavior, because legislation is immaterial, though it can be used to promote technological innovation or adoption (as in the case of many cities mandating that municipal buildings be LEED certified), or it can be used to change behavior through incentive (solar subsidies) or disincentives (gas taxes). Legislation can also make behavior less sustainable, as seen in the diagram in the leftwards pointing arrow, like when noxious chemicals are made legally available for use, or sewage treatment plants aren’t required to clean pharmaceuticals out of their discharge streams. Technology and design can make existing behavior more sustainable without changing the behavior itself, help to change behavior, or make
behavior less sustainable. The detailed linkages between behavior change and technology are investigated below.
Change Theory: Getting to Sustainability

The sustainability argument exists because there is indeed a problem of overpopulation, shortages of water, shortages of resources of all kinds in varying degrees, shortages of land, which leads to wars... But the reaction to it is largely to deal with symptoms, not causes, to deal with how to get more power, how to refine salt water. And these are things that make the problem worse rather than better, because they create the illusion that we don’t have to deal with growing population or growing industrialization — which are the two powerful driving forces underneath it all.


Many intelligent and dedicated people are looking for ways to make human habitation on earth tenable over the long term. Potentially helpful measures range from small scale actions such as personally using less hot water, to large scale interventions, like a country planning to be carbon neutral within the next decade. One of the difficulties that we face in striving for sustainability is in understanding which measures are fundamental solutions to the problem of sustainability, and which are symptomatic solutions. The “Shifting the Burden” System Archtype [Senge 2008] (Figure 4) is a simple and helpful system dynamics model. In the center of the diagram is a problem. When you have a problem, there are two things you can do to improve your situation. On the one hand, you can do a thorough investigation of your problem and address its cause, which is a fundamental solution. On the other hand, you can do something that alleviates the symptoms of your problem, and makes you feel better, and you hope the

Figure 9. Shifting the Burden to Symptomatic Solutions
fundamental problem goes away. That is a symptomatic solution. So, you have a choice between a fundamental and a symptomatic solution. The difficulty with fundamental solutions is that they are not always easy to see, and may take longer to enact than a symptomatic solution. The difficulty with a symptomatic solution is that you do not actually solve your problem, and your solution may have unintended negative side effects that make arriving at a fundamental solution more difficult.

For example, if you have a fever and a cough, what do you do? You may not know what is wrong with you. You could take some medication and get on with whatever you were doing, or you can take the time to go to the doctor, take some tests, get a diagnosis, and solve your problem. This is a fundamental solution. If you have a small cold maybe an aspirin will be sufficient to make you feel better, symptomatically, the problem will resolve itself, and a visit to the doctor would be a waste of time. On the other hand, if you have pneumonia, taking an aspirin when you should be getting medical attention might make you feel better in the short run, but delaying going to the doctor could exacerbate your condition, make you more ill, and make your recovery period longer, and the fundamental solution more difficult to reach. In Jay Forrester’s quote above, desalination and increased power capacity are symptomatic solutions, while “dealing with” overpopulation and industrialization are fundamental solutions.

If we use this model to look at the case of urban sustainability, or sustainability in general, it is tempting to believe that we ingenious humans will come up with technological solutions, like

![Figure 10. Shifting the Burden of Sustainable Behavior to Technology](image-url)
carbon sequestration or ‘clean’ coal power plants, that will make our problems go away. These are symptomatic solutions, however. It is true that technology make us more comfortable, but technological solutions that don’t address our out-of-scale lifestyles do little to effect the kind of change that will make us sustainable at a global scale. Like any good symptomatic solution, technology does make things look better, and can therefore lead to complacency, which discourages action and in the long term makes a fundamental solution, like significant behavioral
change, more difficult to find and implement. In the case of sustainability there is of course no one fundamental solution, but while we cannot technically innovate our way out of the problem and continue to enjoy the exact lifestyles that we have now, measures like connecting people to their ecological contexts and educating them about the systems around them have the potential to be a massive enabler of the kind of lifestyle changes that will be a part of a fundamental sustainability solution. The following model elaborates on the avenues between unsustainable and sustainable behavior and their interrelationships.

Behavior Change

Clearly, a transition from unsustainable to sustainable behavior entails a change in behavior, but there are a variety of important ways for behavior to change, and they are not all as effective or long lasting as each other. Behavior can be changed voluntarily or involuntarily, and certain changes may be more heart felt, and therefore less likely to be discarded if inconvenient. Our behavior is, importantly, is not always the same as what we is think is ’the right thing to do,’ or what we wish we or others did. Changing behavior entails changing either what we are reacting to, or how we are reacting to our environment. This is not always a simple or straightforward process. Sometimes constraints or changes in our lives cause our behavior to become less sustainable, for example if we need to begin driving to work because transit service is cut. Figure 11, at left, provides increased detail about the stages of behavior change towards sustainable behavior and the linkages between behavior change and technology that were established in Figure 8.

Factors in Behavior Change

In this model, voluntary behavior change towards sustainable behavior has a number of stages or prerequisites that lead up to it. First, a person must be aware of and educated about the systems that they are living in. This can be accomplished through education, media exposure and experience. Second, a person must be aware of their place in the system, and engaged with it. Traditional classroom education has a role to play here, but deep learning generally has to be experiential, kinesthetic, physical. This step can involve the development of a ‘sense’ or place. After an awareness of a larger system and feeling of place within that is developed a feeling of caring about the larger systems can begin to emerge. This is further complemented by experiencing one’s own impacts on the system. The critical stage of impact experience is accomplished through not only abstractly acknowledging that one has impacts, but also through feedback. Feedback can range from delayed, indirect and obscure to immediate and intuitive. All of
this, if successful, results in a desire to change behavior, which then results in 
voluntarily behavior change, which I argue is the most lasting and significant kind of behavior when we are trying to change the behavior patterns of the global population. In the case of sustainable behavior change the three experiences: Knowledge of the Ecosystem; Engagement with the Ecosystem; and Experience of Impacts on the Ecosystem and the ways that they can be promoted through design are critical considerations for urban design and planning.

*Design/Technology*

Design and Technology can be used to change behavior in a variety of ways, including by enabling or encouraging more sustainable behavior, or by making unsustainable behavior either impossible or more efficient. Some technology makes our accustomed behaviors less sustainable, like switching from driving a Prius to driving a Hummer. Technology and design can influence each of the three key experiences described above. The possibilities of technology and design are potentially infinite, so it is impossible to describe them all, but a few examples will help to illuminate the connections. Urban design can help to provide knowledge about the ecosystem by integrating natural systems into the fabric of the city, and media and technology can provide education experiences about the systems at work. Urban design can provide opportunities for engagement with the natural world by allotting space to community gardens, parks and wild areas. Experiential educational programs can help in this regard, as well, by offering people the opportunity to have nature-related experiences that they might not otherwise have access to, like long distance hiking programs for inner city youth. Design and technology also have the critical capacity and potential to provide us with feedback on our impacts on the natural world. The natural world is not always as easily readable as might be necessary for us to intellectually or intuitively understand our impacts.

Technology and design can also make our behavior more sustainable without us desiring to have more sustainable behavior, or understanding any systems. There are a number of ways that this can be accomplished. The first kind of technique is of the 'better mousetrap' variety, which means that we are improving our tools, but not getting rid of the root problem. Better mousetrap solutions are symptomatic, not fundamental. We can simply make existing behavior more sustainable by making the tools at hand more efficient, more sustainably sourced and designed, or longer lasting. There are a vast number of technologies that fit into this category, including fuel-efficient cars and busses, congestion reduction measures, energy star appliances, and recycled paper. Another way that design and technology can force us to be more sustainable are by restricting our unsustainable behavior in a variety of ways. For example, developments can be built that do not allow parking, thereby inhibiting users from driving as much as they might
otherwise. We can design lights that won’t turn on until the environment is suitably dark. Design can not only discourage negative behaviors, it can also encourage positive behaviors. Two of the favorite projects of urban planners and designers are to build transit-oriented developments and walkable streets, each of which seek to lead people towards desired behaviors (using transit and walking, respectively) by providing pleasant ways to do it, and pleasant places to do it in. These kinds of designs do not require us to consciously choose to be more ecologically sustainable, but change our habits nonetheless. Each of these methods save us from making a choice about our behavior, having to think about our relationship to ecosystems, or having a deep knowledge or experience of, for example, complex ecological systems.

**Legislation and Policy**

It is very tempting, when looking at the scale of change necessary to make human behavior sustainable, to envision a legislative solution. (We will require sustainability!) The difficulty with that kind of solution, which requires what business people would think of as massive organizational change, is that it won’t work, even if you nominally have the power to legislate it. Peter Senge, author of *The Fifth Discipline* and professor at the MIT Sloan School of Management, writes about this issue in his recent book *The Necessary Revolution* [Senge 2008]. People will not rapidly change their lifestyles, or even their work styles, just because someone told them to. This kind of change will only result from changes in education, experience, and feedback, aided by legislation and (hopefully) ridiculously high oil prices.

Both legislation and policy can of course be very effective in encouraging, discouraging,

**From Unsustainable to Sustainable Behavior: Technological and Design Tools**

![Figure 12. Technological and Design Tools](image-url)
demanding and prohibiting behavior. Some of the most powerful tools at planner’s disposal are policy based, like zoning and building codes and guidelines. I do not mean in any way to dismiss the efficacy of policy, but argue that policy alone cannot make us behave sustainably.

**Collapse: Past and Future**

“Is it our human nature to modify our surroundings? In recent centuries, our numbers have multiplied and our ability to use (or misuse) technology has grown. Perhaps our nature has gotten us in trouble.” (Bell 2001)

Conventional wisdom states that our forbearers lived more sustainably and in closer connection to natural systems than we do, as do people who eke out subsistence livings. It is true that their lifestyles were generally more sustainable, and the idea of returning to past forms in search of sustainability is romantic, however, the question remains whether or not this sustainability was intentional, or if by going back to older forms we will be more sustainable. There are now many more of us than there were, so we have a much greater aggregate impact than our forbearers, as our ecological footprint shows. Furthermore, it is not a foregone conclusion that cities have ever been intentionally or holistically sustainable. They have been limited in their destructiveness by the availability of technology and resources. Several civilizations who overstepped their ecological bounds are believed to have fallen because of over population and possible climactic changes. This is noted by both Bell, in *Environmental Psychology*, and Jared Diamond, Professor of Geography and Physiology at UCLA, in *Collapse: How Societies Choose to Fail or Succeed* (Diamond 2005). Collapsed societies include the Anasazi and Cahokia of North America, the Moche and Tiwanaku of South America, The Maya, and societies of Mycenean Greece and Minoan Crete, Great Zimbabwe, Angkor Wat, and Easter Island.

Diamond states that scientists long suspected that ecological problems, and, more specifically, civilizations unintentionally destroying the environmental resources that they depended on (ecological suicide or ecocide), were at least party to blame for most collapses. This has since been borne out by discoveries made in recent decades. Diamond describes the ecological damage as falling into eight categories: deforestation, soil damage, water management problems, overhunting, overfishing, negative effects of invasive species, human population growth, and increased ecological impacts per capita. He writes, “Many people fear that ecocide has now come to overshadow nuclear war and emerging diseases as a threat to global civilization. The environmental problems facing us today include the same eight that undermined past societies, plus four new ones: human-caused climate change, buildup of toxic chemicals in the environment, energy shortages, and full human utilization of the earth’s photosynthetic capacity.” (Diamond
In other words, its biocapacity, which the WWF agrees is overtaxed. Diamond argues that these threats will become globally critical within the next few decades, and that if we don’t find a way to sustainably address them we could fail, as a species, at a large scale.

One would think that living close to the land would enable one to be sensitive to one’s impact on natural systems, but that appears to be no guarantee of sustainability. There is now massive ecosystem destruction by people living at a subsistence level who effect widespread deforestation, habitat destruction, and animal population decline in their quest for survival. For example, in Sub-Saharan Africa 52% of all energy used comes from burning trees and brush, women bear an average of six children over their lifetimes, and the population is set to double in 20 years. (Agyei) This puts tremendous pressure on the land and people. Deforestation in Africa occurs at four times the world’s average rate (BBC 2009). This is not a new problem. Deforestation has been an issue for many societies, like Japan, some of which developed effective forest management techniques, and some of which, like the Norse Greenlanders and Easter Islanders, failed (Diamond, 2005). Returning to the ways in which our ancestors lived would almost certainly be “less bad” than the resource reliant way that we are living now (It takes one ton of resources to support the lifestyle of one American. Per day.). We would use less of our resources per person, but it probably would not be “good,” or sustainable. Beyond the possibility that our cities have never been sustainable in the first place, it is unlikely that we as a society in the US can “go back” to older city forms. Very few of our cities have those forms as the base kernel of development, and as a very new country full of recent immigrants we do not have a shared cultural memory or those forms. They are not in our cultural heritage, though they might be in our biological heritage.

I do not intend to say that we have nothing to learn from our ancestors, or from people who lead less technologically mediated lives. We certainly do. Today we have an abundance of resources available to us that our ancestors simply did not have. Globalization, the industrial revolution, and the computer age have brought with them many wonders, like large scale international shipping, the “out” sourcing of toxically produced materials, and indeed most of our manufacturing in general, internal combustion engines, utility networks, synthetic fertilizers, circuit boards, and networked everything. Because our ancestors did not have these resources, they constructed lives that did not rely on them. They adapted to their environment, and adapted it in some ways to suit them. These adaptations were in many cases very clever, and can be useful to us as we learn how to tread more lightly on the earth. For example, indigenous architecture is often well adapted to the climate it is found in, and was built using local materials and much less energy than modern buildings, and we can do much the same thing. For centuries we have been in dialogue with our environments through our buildings (Spirn 1998), and we can re-enter
Behavior: A Systems View

Organizational change and systems theory, as pioneered by Peter Senge in his book *The Fifth Discipline* (Senge 1990), offers a useful view on this model. In this theory, we are all equipped with mental models, which are much like beliefs. These are internal models that each of us has that help us to understand and function in the world. They are often based on past experience, but can come from a number of sources. We use these models to judge events, predict outcomes, and decide on subsequent behavior, or action. Mental models are often generalizations that dialogue at any time. One of the things that our ancestors did to make themselves comfortable was to burn stuff. This is not a technology that we have left behind. We still burn stuff: for heat; power; transportation; anything, really, but now we burn scales of magnitude more stuff than anyone else ever has.

### Behavior: A Systems View

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or stereotypes, and are sometimes incorrect. For example, many people think that MIT students are nerds. The MIT bookstore sells bumper stickers that say, “Nerd Pride.” Nerds are generally considered to be intelligent, and socially and physically awkward, so many people expect MIT students to be the same. That is a mental model, and it’s correct in some cases, and incorrect in many others. People act in accordance with their mental models, and this mental model can have many potential effects, both positive and negative, like intimidating prospective students who might not think that they’re smart enough to attend MIT, making athletic prospective students steer away from the school, or encouraging private companies to put significant consulting opportunities in the hands of graduate students.

The mental models at issue in this thesis are those associated with knowledge of the ecosystem, engagement with the ecosystem, understanding impacts on the ecosystem, and behavioral intentions. How do we change prevailing mental models from, “I am supported by human endeavors and technology, we are in charge of the earth, and I don’t like and am afraid of the wilderness.” at one extreme, to, “I understand that I am supported by intricate natural systems, and that I am a part of those systems. I can sense my impacts on the systems, and desire to have a positive net effect.”? This is a significant shift in mental models.

Mental models are our framework for understanding how the world works, and as such have a great deal of influence over our habits of thought and habits of action, or, in other words, our behavior. Many of our thoughts and actions are habitual. Our days are filled with familiar behaviors. For example, when we get up in the morning, make coffee, go to work, or prepare for bed, we often perform tasks in the same way that we do them every day. They are habits. We often don’t think about them much at all, and they can be quite difficult to change. If I move my bureau I will not immediately adjust my behavior to its new location, but will instead go habitually over to where it used to be, in search of clothes, only to find it not there. This can continue for several days until I accumulate enough experience to change my habit. This pattern of repeated response is true of habits of thought, as well. We may believe that all business students are boring, selfish, aggressive republicans, and if we are not inclined that way ourselves we may avoid them or enter into debate on contact, without checking to see if the situation at hand warrants activation of that habit of thought. Habits of thought and action are naturally tied together, but can also move somewhat independently. In the case of addiction, like an addiction to sugar, someone like me could read scientific articles that cite evidence that sugar isn’t good for me, and I might become convinced that sugar is indeed bad for me. My mental model can change, and I can determine that I won’t eat any more sugar. Then a cookie can appear, I will think, “that’s not good for me,” and I will eat it. My mental model has changed, as has my habit of thought, but my habit of action has not. Over time perhaps my habit of action will align itself with my habit of thought.
Habits of action can also change without habits of thought changing. The well-trodden path from the MIT/Kendall T stop in Cambridge leads from the T stop through the MIT Medical building to the main MIT campus. The entryway to the MIT Medical building is either through a regular pull door or though a rotating door. The two doors are next to each other. The regular door causes eight times as much air transfer on use than the rotating door, and as such requires eight times the electricity to compensate for each use. There are signs on all the doors saying as much. This is an effort to change people’s habits of thought, and subsequently their habits of action. Many people, approximately half in my experience, continue to use the regular door. It’s objectively easier to use, quicker and easier to pull, and it’s a habit to use it. The habit of thought might be, “it’s a pain to use the rotating door, I don’t like it, and so I’m going to do what’s easier for me.” If it were made easier to use the rotating door than it is to use the regular one, presumably that behavior would change without necessarily changing the habits of thought. If, for example, the regular door were located around the corner from the rotating door, was physically harder to push, or required triggering it to open and waiting for a few seconds before it opened, more people would choose to use the revolving door, because that would be the easier choice. They would not necessarily make that choice out of ecological altruism.

It is possible to change habits of thought through habits of action. We do not always need to change the thoughts first. When we smile, we feel happier. When someone walks to work every day, they might begin to believe that it’s the right thing to do. In the case of behavioral change from unsustainable to sustainable behavior, in a systems view the goal is sustainable behavior, and we can break “behavior” down into habits of thought and action. We could change habits of action using technology and legislation, like by providing recycling bins and fining people who don’t use them properly, as they do in Switzerland and a growing number of US cities. However, this kind of change is involuntary and as such not the focus of this thesis. This thesis is about how to change habits of thought. That said, there is an argument to be made that changing habits of thought can be facilitated of accomplished by changing habits of action (Orlikowski 2010).

Environmentalism and Conservation Behaviors Through the Lens of Environmental and Conservation Psychology

In order to provide further theoretical and scientific context for this work, I will briefly describe
some of the core findings of Environmental Psychology and Conservation Psychology, and how they relate to this project. Environmental Psychology (EP) is the study of behavior and experience, and the built and natural environments. Essentially, environmental psychologists study how we interact with our environments, both how we act upon the environment and how it effects us. In this case ‘environment’ indicates simply the place in which we are, not necessarily a natural system. EP holds that our actions do not take place in meaningless vacuums, and that in fact our environments give our actions meaning, or at least make those meanings explicit, in the same way a stage set renders an actor’s actions comprehensible. Conservation Psychology is a sub-category of Environmental Psychology that specifically examines how people come to care about and for the natural world; what would make them want to conserve natural resources. Interestingly, Conservation Psychology is explicit in valuing natural system conservation and trying to find ways to encourage that, and does not claim scientific neutrality, while it does claim scientific rigor. Because the two fields are closely related I will simply refer to Environmental Psychology unless there is need for differentiation.

In the standard textbook *Environmental Psychology* Bell, et alia, begin with the example of air pollution. This is an environmental problem that is heavily influenced by human activity. Because it was caused by human behavior it makes sense to look to behavior modification to fix the problem. The authors then set out to find the, “principles of learning, attitude formation, and social interaction [that] help explain why we ever engaged in and accepted polluting behavior in the first place.” (Bell 2001) Conservation Psychology sets out to apply those findings to investigate behavior change. In order to understand behavior change, we must first understand the origins of current behavior. Research has shown that behaviors result from our attitudes towards and beliefs about nature, as well as our societal and locational context and constraints, and our perception of what is best for us in the moment. On the subject of whether our attitudes about nature are inherent or a product of our learning, our attitudes are found primarily to be learned, although we also have common biological reactions to natural settings.

Our attitudes towards nature depend a great deal on cultural context. It is common now to value nature and the wilderness very highly, but this has not always been the case, even in the European tradition. During the Middle Ages the wilderness was considered terrifying, disgusting, and base, and travelers sometimes traversed it blindfolded. This was partly because of the Christian theory that held that we had been created and placed in the Garden of Eden, which was paradise, and following original sin we were cast out into the profane landscape, which we despised. During the Enlightenment focus turned towards the wonders of the natural world, and earth began to be viewed not as a purgatory, but as a marvelous manifestation of God’s will. When settlers arrived in what became the United States they found themselves in a wilderness
that, given their European agricultural backgrounds, they felt they had to battle and subdue for their survival. During the Romantic period in Europe in the 18th and 19th centuries people began to value the wilderness for its mystery and beauty. This method of thought gradually travelled to the US, but we remain a largely anthropocentric society. We value nature for its utility (to us). There is, however, a growing conception that an intact ecosystem is worth more than the sum of its parts, that perhaps we are an equal and integral part of the natural world, not apart from nature, or possibly that nature has its own value regardless of our relationship to it, and we should preserve it as such (deep ecology). As Susan Clayton put it in Conservation Psychology, “To a significant degree, our thinking about nature is affected by our language and the wider social conversations we have about the environment.” [Clayton and Myers 2009]

So, our attitudes and therefore behavior toward our environment is primarily learned, but if we have weak beliefs of attitudes, or there are other constraining factors at play, we will not always act in accordance with our beliefs. Clayton sums it up in this way:

“Psychological defenses interfere with the rational perception of environmental realities. Defensive thinking results when our basic wants, such as the desire for comfort and pleasure, are incompatible with our rational or moral judgment. Faced with a conflict between a desire for self-gratification through unsustainable behavior and the knowledge that the environment is threatened by such a behavior, we repress our awareness of the conflict, deny the threats that face us, displace them onto other communities, and rationalize our continued unsustainable behavior as having no alternative. Denial and other defensive thinking are particularly likely when people believe they can do nothing to lessen the danger”

However, there are factors that make an individual more likely to behave in an environmentally responsible way. These include education, direct experience of the natural world, strong group association, a strong sense of place, and, crucially, feedback. Clayton’s last point, that we become paralyzed in our movement towards sustainable behavior when we believe that our actions can do nothing to alleviate a catastrophic situation, or, in other words, we become overwhelmed by the magnitude of the problem, is particularly well taken. It is imperative that the feedback we get on our actions and impacts does not overwhelm us, but instead gives us the impression that we have some level of control, and can have a positive impact.

Education about environmental matters, including biology and so on, is of course crucial if one is to act intelligently on those matters. If people understand the implications of their choices they can choose more wisely. ‘Education’ cannot however stop at media and expect to be effective. Research in Environmental Psychology does not support the view that simply giving people information about issues like environmental problems will make them more ecologically aware.
and motivated to act more responsibly. There is an important distinction to be made between knowledge, true incorporation, and behavioral change.

*The Importance of kinesthetic experience in motivating behavior change*

Environmental and Conservation psychologists state repeatedly that education about ecology and the natural world must be rich and direct. Clayton begins with the idea of incorporating story and metaphor, vivid language, feedback on behavioral impacts, and substantive curricular approaches into education, and also points out that, “research in Environmental Education has tended to support the idea that direct experience in nature is important, particularly for the affective and motivational components of environmental citizenship.” (Clayton and Myers 2009)

In other words, it is terribly important that we go outside and become familiar with nature first hand, or that nature is built into our everyday experience. It is also important that we go outside early, when we are forming our conceptions of the world and how we move in it. Early familiarity in any environment increases a child’s sense of control and safety in that environment. Many environmentalists cite childhood as the time they formed a relationship with nature, and experiences in the natural world tend to trigger non-dual experiences. In other words, children realize that they are nature. Clayton’s critical conclusion is that, if we would like to encourage environmentally responsible behavior, “results all point to the importance of incorporating nature into the everyday landscapes where children spend a great deal of time” (Clayton and Myers 2009)

My hypothesis, then, that it is important to provide a sense of ecological connection within and through the city form, and that that will increase our environmental sensitivity and responsibility, is corroborated by psychological findings.

Environmental Psychology also finds that individuals who are highly identified with their group and therefore the place that the group depends on for resources are more likely to voluntarily limit their resource use in the interest of the larger group. Communal manages resources can be sustainable managed in some way and the tragedy of the commons can be avoided if individuals internalize the common interest.

*Sensation Trumps Media: A Personal Experience*

If we accept the argument that if people know about natural systems and understand their place in them, then they will care more for the natural system, the question becomes how we educate people about those systems. I have spent approximately 21 years of my life as a student. I
have read a great deal. I am trained as a painter and graphic designer, and I spent several years working in advertising. When I think of ways to effectively communicate information, I naturally think of books, articles, posters, videos... media, in short. Informative placards, even. In this case, where we are talking about educating people in such a way that they will take what they learn to heart and dramatically change their lifestyles (no Suburban SUV, no Suburban house) and behavior, communicating through media is insufficient, as I learned from my own experience. I grew up in Northern California, where people are pretty “green,” and everyone cares about the environment. There have been books listing easy ways to save the earth around my house for as long as I can remember. I grew up spending a lot of time out of doors. I knew about pollution and so on, and I was confident enough that someone else was going to do something significant about it about it that I felt comfortable installing CFL bulbs in my home and thinking about something else. I was headed of a life in graphic design and advertising, and I took the opportunity to travel for eight months around the world. I went out of curiosity, not because I was
interested in going on a quest, finding myself, or anything along those lines. I was fairly sure that I had been found, thank you.

A few weeks into the trip I visited Yangshuo, China, near Guilin and a few hundred miles northwest of Hong Kong. Yangshuo is a popular tourist destination, largely because of its extraordinarily beautiful setting. It’s a small village on a lovely river, the Li, and it is surrounded by tall, unlikely limestone karsts. One of the things that Yangshuo is famous for is the cormorant fishermen. This is a very traditional method of fishing, and involves the fisherman putting a ring around a cormorant’s neck so that the bird cannot swallow large fish, which it brings back to the fisherman. In Yangshuo, I learned, this was once a way to make a living, but now it’s done only for tourists, because there are no big fish left in the river. I was deeply shocked. No fish? I didn’t know if it’s because of pollution or overfishing, but a river devoid of fish struck me as a catastrophe. Later, I visited small villages and saw, just outside, middens piled high with plastic bags. There were cattle eating trash and plastic in India, and a village’s waste stream made up of manufactured rubbish being thrown off the side of a road into a stream in Morocco. As these experiences and the accompanying dismay accumulated, it dawned on me that I wanted to do something to make human habitation more sustainable. I had been in possession of all the data indicating the human behavior is unsustainable, but I needed to see it before it really hit home. I am not the only one, it turns out, whose traditional education was insufficient to trigger behavior change until it was paired with experience. Psychologists who study behavior motivation, particularly as it relates to environmental behaviors, agree that neither knowledge nor belief necessarily determine behavior. After all, no one thinks that littering in a national park is a good idea, but there’s still trash on the ground.

**The Benefits of Natural Settings**

Although we devote masses of time and money to the development of elaborate shelters and human habitrails for ourselves (and our hamsters) we also occasionally make ourselves sick by building shelters that do not cater to our biological needs, and our physical health can improve dramatically when we are in contact with natural systems. There are many theorists who have
written on our attraction to and perhaps need for the natural world. Environmental psychologists have shown that experiences walking in or looking at natural settings will reduce our stress levels and blood pressure, increase our ability to pay attention, and help us heal faster when we are sick. In a seminal study, Ulrich found that patients who underwent surgery for the same complaint recovered faster, needed less pain medication, and had fewer post operative complications when they had views with pleasant landscapes out of their hospital windows than patients whose windows faced brick walls (Ulrich 1984). Steven and Rachel Kaplan have developed and successfully tested a theory called the Attention Restoration Theory, which states that it takes us a certain amount of effort to focus throughout the day on our tasks, and to avoid distraction. This draws down our cognitive abilities, which can be exhausted, but can also be restored in the appropriate environment. Natural environments are particularly good at restoration, and study participants who walk through a natural area demonstrate significantly better attentiveness after their walk, while participants who also walk during a study, but walk through the city, do not show improved attention. The Health Council of the Netherlands reported in 2004, in a review of current knowledge, that the benefits of the natural environment include improved mood, self discipline, concentration, and stress reduction, and that health in general appears to be improved by access to natural settings [Prof. JA Knottnerus 2004].

All of this is to say that the semiotics of the city are telling us that natural systems aren’t important, though we may disagree with our own biology (which likes being outside and seeing trees and things). But even if we don’t believe this, the fact remains that our attitudes promote unsustainable behavior, which is learned, not inherent [Bell 2001]. Part of our learning about our place in the environment and our subsequent behavior towards it comes from the structures that surround us and what they communicate. As Fred ‘Rusty’ Gage said:

As neuroscientists, we believe that the brain is the organ that controls behavior, that genes control the blueprint, the design, and the structure of the brain, but the environment can modulate the function of the genes, and ultimately the structure of our brain. Changes in the environment change the brain and therefore they change our behavior. Architectural design changes our brain and our behavior.

(Quoted in Zeisel 2006, p. 11)

Let us now look at the ways in which the city communicates.
There are several ways to gain knowledge of an ecosystem. The first, and most easily remembered as a learning experience, is in school, or through books and media. This is an extremely important way to learn about the functioning of the natural world, and what is gained is intellectual or theoretical understanding. We can also engage in experiential learning, when we go out and are taught about the ‘out-of-doors.’ We gain additional knowledge through every-day experience. In Cambridge, residents may walk by the Charles River, observe its flow, the geese living on its banks, and its changes throughout the seasons. Although this is not a structured learning experience, they learn things from it nonetheless. This chapter looks at what and how we learn from city form, how city form is used as a communication tool, and how we physically perceive the elements of natural systems. An understanding of these topics can guide us towards effectively creating places that communicate ecosystem knowledge.

City Form is a Tool for Communication

Read (v):

- Interpret the significance of, as of palms, tea leaves, intestines, the sky; also of human behavior
- Interpret something in a certain way; convey a particular meaning or impression
- To hear and understand. Make sense of a language (Princeton University 2010)

In landscape, each rock, each river, each tree has its individual history. A river’s history, a tree’s, is the sum of all its dialogues, nothing less but nothing more; they contain no emotion, no moral. Human cultures embellish their stories in gardens, buildings, and towns. Stories humans tell have a plot, often with beginning, middle, and end, a deliberate narrative: stories of survival, identity, power, success, and failure. Like myths and laws, landscape narratives organize reality, justify actions, persuade, even compel people to perform in certain ways.

- Anne Whiston Spirn (Spirn 1998)

Cities are not simple collections of buildings and infrastructure. Cities are also cultural artifacts. Humans shape them, sometimes over thousands of years, and they are products of the cultures that created them. While all people adapt their buildings to their needs and climate they do it
differently, and using different details, given the cultural norms of their society. As a cultural artifact, city form is also a tool for communication. Walking down a city street is the same as walking through a costume shop for human values. Every structure is encoded with the values of the owner, the builder, and the culture they are part of. When you walk down a city street you read the city, and understand these statements of value and aspiration. Much like when you read a book you look at data, which is the city in front of you, and your brain sorts the data into basic spatial symbols: sidewalk; building; street; trash can, and more complex symbols: Corinthian column; broken window; huge brick building with Corinthian columns and broken windows. After symbol identification takes place you evaluate the kind of place you are in, and how to interact with it, by interpreting the meaning of these symbols in context. Like words, particular symbols in the city carry general and specific meaning for each viewer given their context and the viewer’s experience. Just as we do not all get the same meaning from the same book, we do not all read and understand the city in the same way, and yet enough of us agree on the meanings of words and structures that we communicate quite well despite variations in interpretation. Places are differentiated to us in many ways, including through familiarity. In The Language of Landscape, Ann Whiston Spirn argues that, “The language of landscape is our native language,” [Spirn 1998], and that we are imprinted with our native landscape when we are infants. Humans have indeed been reading and understanding landscape since we emerged as humans, thus is makes a great deal of sense that we are physically predisposed to read meaning in our surroundings, whether they are savannahs or busy intersections. The city as a cultural artifact embodies information about the history of culture as it emerged in the abstract, but also how it emerged in relationship with the environment, and with the landscape. The form of a city is then a result of our dialogue with the natural world and with each other.

The process of learning a language and the process of learning a place are both neuroscientific processes, and neuroscientific studies can help us to understand how we do both, and therefore also how we can control the meaning of a place so that it creates a particular neurological reading. John Zeisel writes:
Applying neuroscience concepts of non-semantic, semantic, and elaborative semantic meaning to space-terms developed to describe how people understand and interpret words-yields a potentially useful taxonomy of place. Non-semantic places are those we hardly know, like one of the many street corners we pass on a trip downtown that holds no special meaning for us. We hold semantic knowledge of places that are set in our brains in context, but not in a context with a deep personal or intellectual meaning for us. A place with semantic meaning might be a well-known vacation spot, such as Disney World in Florida, or the Piazza San Marco in Venice. An elaborative semantic place is one that is firmly embedded within a personally meaningful context. The places we live in and those we grow up in evoke elaborative semantic memories (Zeisel 2006).

Therefore, if we would like people to see the natural world as made up of personally meaningful or elaborative semantic places, we should provide people with the opportunity to live and grow up in places where natural systems are embedded. It is interesting to examine how places that are full of semantic meaning, like Disney World, incorporate natural systems. Later in this chapter I do just that, and describe my visit to Disney World in search of natural systems.

We build buildings, streets, cars, and so on with the expectation that they will communicate our values and intentions to someone who sees them. Clearly, most buildings are intended to say, “The person who built me is fantastic,” for one reason or another, and the ways that this are said are myriad (tall shiny bank building, charitable project, etc), but what I am interested in is what buildings “say” about natural systems. How can we look at a building and parse out its intended relationship to the natural world? One can discover this by examining how it treats each element,
and the gestalt thrust or intention behind its design. I am looking out at a building in central Cambridge, Massachusetts, and I will use it as an example.

Case Study in Natural Connection: Pink Building in Cambridge, MA.

The building was built in 1920, and is generally unexceptional for the area. The building was built to provide for the needs and desires of its inhabitants, and it is a very sophisticated shelter. It is a large single family house, and is three stories high with a basement, wood construction (except the brick basement), shingle siding, small front and back porches, pitched roofs, gutters, dormers, and small front and back yards. The windows are of an average local size: about 2 by 3-4 feet, vertically oriented. It has a central chimney, wires going into it from an electrical pole on the street, water and gas meters on its side, and a small pipe for heating oil that leads into the basement. Each of these characteristics are relevant to the building’s place in the larger natural system of which it is a part. What it was not necessarily designed to do, but what it does nonetheless, is communicate to the family that lives there about their place in the environment. Let us look at the role of each building characteristic.

As the residents of the building live inside it they of course do not usually think about the structure they are within or how it is designed to meet their needs and protect them from the elements, unless it is damaged in some way and their needs are not being met. However, they do have a daily, kinesthetic relationship with the building. They interact with windows, thermostats, stoves, electrical systems, water systems, stairs, doors, and so on, and they act and dress differently when they are inside or outside the house. They are physically aware of shelter, whether or not they are intellectually conscious of it.

Some of the systems that the house is outfitted with allow for a closer connection to the natural system that they are a part of than others. For example, windows allow for a very direct relationship with light and air, because light and air are just outside and can be accessed at the source, as it were. Other systems, particularly those that require metering or delivery by a truck, are less tangible or accessible. Water, oil, gas, electricity, and communications appear in our buildings as if by magic, and the only effort we need to make to assess them is to flip a switch or possibly turn a knob. If we pay for them, they will come. This means that we never see where these comforts, or ‘utilities’ come from in the wider world. We don’t see the snow fall in the mountains, melt into streams (get polluted, in the case of Cambridge), flow into a reservoir, get purified, treated, added to, and pumped into our houses so we can have a shower. Nor do we
### Figure 19. Building Elements Expose Our Relationship to Natural Elements

<table>
<thead>
<tr>
<th><strong>BUILDING FEATURE</strong></th>
<th><strong>ROLE</strong></th>
<th><strong>FEATURE ADDRESSES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>3 STORY</td>
<td>Density. Multi-story buildings take up less (earth) space, and are easier to heat</td>
<td>Earth, Heat</td>
</tr>
<tr>
<td>WOOD CONSTRUCTION, SIDING</td>
<td>The skin and internal structure of the building, along with the roof, are the fundamental elements of a human shelter. They protect us from light, wind, rain, and heat loss</td>
<td>Light, Wind (air), Water, and Heat</td>
</tr>
<tr>
<td>BRICK BASEMENT</td>
<td>The basement is brick, and probably cement, to provide a stronger underground structure than a wooden wall would, and to prevent the entry of water</td>
<td>Earth, Water</td>
</tr>
<tr>
<td>PITCHED ROOFS</td>
<td>Pitched roofs easily shed snow and rain that might collect on a flat roof, and, as part of the building skin, they protect us from light, wind, rain, and heat loss</td>
<td>Light, Wind (air), Water, and Heat</td>
</tr>
<tr>
<td>GUTTERS</td>
<td>Collect water as it comes off the roof and channel it away from the building</td>
<td>Water</td>
</tr>
<tr>
<td>DORMERS</td>
<td>Windows in the roof allow light and air/wind in, or keep inside and outside air separate. They allow for adaptation to weather conditions, and for visual analysis and enjoyment of the outdoor environment.</td>
<td>Light, Air, Sight</td>
</tr>
<tr>
<td>YARDS</td>
<td>Allow residents a private outdoor area, used for recreation, gardening, and sometimes food production</td>
<td>Earth, Food</td>
</tr>
<tr>
<td>WINDOWS</td>
<td>Allow light through the building skin, as well as separating or not separating indoor and outdoor air. They allow for adaptation to weather conditions, and for visual analysis and enjoyment of the outdoor environment.</td>
<td>Light, Air, Sight (security, connections)</td>
</tr>
<tr>
<td>CHIMNEY</td>
<td>Vents excess heat and fumes from heating building with a wood or oil fire. Central location allows it to heat the core of the building</td>
<td>Heat, Air</td>
</tr>
<tr>
<td>WIRES</td>
<td>Bring electricity, telecommunications, and entertainment into the building. Electricity may be used for many things, including lighting, heat and refrigeration. Other wires bring connection with the larger species</td>
<td>Light, Heat, Connections</td>
</tr>
<tr>
<td>WATER METER</td>
<td>Water is piped throughout the house and used for washing, bathing, transmitting heat, and drinking</td>
<td>Water</td>
</tr>
<tr>
<td>GAS METER</td>
<td>Natural gas is used for cooking, and sometimes boilers or water heaters</td>
<td>Heat</td>
</tr>
<tr>
<td>HEATING OIL PIPE</td>
<td>Oil is burned in the furnace to heat tap water and heat the house</td>
<td>Heat</td>
</tr>
</tbody>
</table>
see coal the strip mined in Virginia, put on a train to the Northeast, and burnt to provide us with electricity that sometimes travels hundreds of miles to reach us. And, although we can access air that is just outside our window, we do not have an experience of air as a global system that moves across the globe and gets polluted in the same way water does. Crucially, we also get no feedback on our impacts on natural systems. We get bills. These bills in no way reflect the amount of money that it would take to offset our impacts; they reflect the financial costs and profits of the utilities that deliver them to us.

Figure 19 details the roles each of this building’s primary features, and which natural elements and human needs the feature addresses. The building itself is extraordinarily sophisticated in its adaptation to the elements. Over the course of centuries humans have learned very well how to build relatively weather-tight shelters. Now that we have acquired that knowledge, in general it is the function of the building to shield residents from the wilderness (natural systems without human impact), and to filter human experience of natural systems in such a way that the systems are both controlled and pleasant. In this way the building conveys the experience, and thus the semiotic meaning, of humans being in control and therefore in charge of natural systems.
We are safe in our houses.

If one is engaged in building or designing a shelter, or even if one is particularly curious about the building one is in, the case is quite different. It is possible to understand the workings of a standard building, and to then see how it reflects interactions with the larger ecosystem, but buildings are generally not designed in such a way that this interaction is highlighted. Utilities are hidden because they are considered ugly and base, perhaps, and it is more aesthetically pleasant, and more in keeping with the message of control, if they are hidden.

*The building is a microcosm of the city*

Let us take a slightly wider lens and look at the city in light of this analysis. The city, too, is designed to protect us from the elements and to provide for our needs, but it is not sealed in the same way that a building is. The structure of a city addresses elements at a different scale than a building does, and its responses are also different. One of the central ways that the city provides us with services is through ‘infrastructure’ (literally ‘below’ or ‘inferior’ to the structure), which is etymologically telling, because lots of city infrastructure is indeed buried under or in our structures. It is hidden out of sight because it is not considered beautiful, but is instead a base reminder of the mechanics and biological flows of daily life, however a city contains more evidence of connection to natural systems than a building does. This evidence includes not only rivers, parks, hills and community gardens, but also water treatment plants, power plants, above ground wiring, transportation systems, and so on. These systems support the entire populace of the city and in some cases are too big or unwieldy to be hidden. The fact that a city addresses and engages with natural systems at a larger scale than buildings do, and that those systems are sometimes more visible, does not mean that those systems are uncontrolled. Boston is a good city to look to as an example because it has been so significantly altered.

When European settlers arrived in Boston it was almost an island made up of three large hills, connected to the main land by a thin peninsula. The Charles River where it ran next to Boston was a tidal mudflat. Since then the original Shawmut peninsula that Boston was founded on has been expanded greatly. The narrow neck is no longer visible, two of the three hills have been leveled, many creeks have been channelized or culvertized, the Charles has been dammed, the estuary is now fresh water, and the banks have been shored up with walls. The roads in Boston are impossibly confusing, and the popular understanding is that they’re that way because they follow cattle paths, but their structure actually springs from Boston’s gradual expansion out into the harbor and mudflats using haphazard fill accretion. It was not until large, planned fill projects like the Back Bay and the South End were established that streets were plotted out in a grid. The structure of Boston is a testament to increasing control of natural systems, rather than
adaptation (Whitehill and Kennedy 2000).

Like a building, cities communicate to their inhabitants that natural systems are under control, at least most of the time. This is, of course, untrue. We do not have control over natural systems, particularly at a global scale. We can make use of natural processes, invent artificial processes, and construct amazing shelters for ourselves, but we are still dependant on the continued functioning of natural systems. In building our cities we have presented ourselves with two illusions: one, that we are not part of natural systems; and two, that we are safe.

### Engaging the senses

With the goal of creating places where people can sense the existence of natural systems it is worthwhile to look at how we literally sense those systems. Springtime in Massachusetts brings an experience of rain. I, luckily, do not need to rely on the news to tell me that it’s raining. I hear it hitting the roof, windows, and pavement. I can feel it on my skin, see it in the air, and smell the moist earth. I generally don’t taste rain, but I do have a clear sense of the taste of water. Water

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>SIGHT</th>
<th>TOUCH</th>
<th>SMELL</th>
<th>TASTE</th>
<th>HEARING</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EARTH</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>LIGHT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WATER</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>SIGHT</th>
<th>TOUCH</th>
<th>SMELL</th>
<th>TASTE</th>
<th>HEARING</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANIMALS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOOD</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>WASTE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLANTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 21. Experiencing Nature
is sensually a very rich element, and it fully engages all five of our senses, while other elements engage fewer. We can also look specifically at how we sense some important natural systems.

Figure 21 diagrams which of our five senses we use to experience the four elements: earth; air; water; and light, and five systems that we rely on: energy; food; waste; plants; and animals. Just as water is an evocative element, food and animals also engage all of our senses. Food, often made out of animals, and water are two of the true essentials in human survival, so it’s perhaps not surprising that we are well equipped to sense their presence. This also means that perhaps it is easier to highlight their functioning with city form. Indeed, one of the most popular ways to make a development more ‘green’ is to concentrate on the treatment of water, particularly through surface level treatment. The emphasis on water can be taken to an extreme. In an interview with Jay Olmsted and Dwight DeMay of Hart Howerton, where ecologically responsible planning is taken seriously and approached systematically and holistically, Jay described the current situation in planning as being one in which recent college graduates are so focused on addressing runoff in an ecologically sensitive way that many other aspects of sustainability were falling by the wayside in their work and interests [Jay Olmsted 2010]. The environment is full of many elements and systems that must be considered alongside water.

Figure 22 details the ways in which we experience each of these elements and systems in the city, and the ways in which we hide from them or manage them. In no case do we leave an element or system uncontrolled, or un-reacted to. We pave and till the earth, block, channel, and heat the air, pipe water, and create artificial light. We burn fuel for energy, domesticate plants and animals, and make sure that all waste gets out of sight. Our external influence is tremendous.

By understanding through which senses we use to detect elements and systems, and by listing ways that we organically and inorganically come into contact with them we may begin to see how elements can be structurally integrated into a space design so that they pack the most sensory and intuitive punch. If, for example, we would like to highlight our dependence on the sun as a source of energy and light, then we can look at how we experience light: visually through shadows and contrast, and peripherally through our sense of touch, which alerts us to the feeling of warmth from the sun. The design would then incorporate elements that allow us to sense contrasts and possibly to feel sunlight on our skin. Façade articulation and detailing is a tremendous opportunity to provide an experience of shadow play, as are rooms that are constructed to allow us to observe the movement of sunlight and shadows throughout the day. In contrast, buildings with little façade detailing and interior spaces that are without natural lighting do not provide us with an experience of the sun (except through its lack of effect) in as rich a way,
<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>PHOTO</th>
<th>HOW DO WE EXPERIENCE IT?</th>
<th>HOW IS IT HIDDEN OR CONTROLLED?</th>
</tr>
</thead>
</table>
| Air     | ![Air Photo](image) | • Altitude  
• Clean air vs. polluted air  
• Windows  
• HVAC, fans  
• Breath  
• Clouds  
• Airplanes  
• Moving trees  
• Sensation on skin/in hair  
• Windmills, banners, wind socks, chimes  
• Sailing  
• Windows  
• Turbulence  
• Wind tunnels in cities  
• Venturi effects | • HVAC  
• Air Filtration  
• Invisibility  
• Insulation  
• Clothing  
• Windows and buildings keep it out  
• Wind breaks  
• Roofs |
| Earth   | ![Earth Photo](image) | • Dirt vs. filth  
• Topography  
• Gardening  
• Parks  
• Metaphysical- our physical form and substance | • Pavement  
• Remoteness  
• Earth works and bulldozing |
| Light   | ![Light Photo](image) | • The Sun  
• Shadows  
• Night, the Moon and stars  
• Light bulbs  
• Camera flashes  
• Blindness | • Buildings channel and shield natural light  
• Electric light  
• Glasses  
• Canopies  
• Sun Screen  
• Clothing |
| Water   | ![Water Photo](image) | • Tears, spit, urine, blood  
• Showers, sinks, hydrants, reservoirs  
• Rivers, streams, oceans, waves  
• Clouds, rain snow, foggy breath, condensation  
• Cups and bottles of water  
• Sewers and stem pipes  
• Radiators  
• Reflections  
• Thirst | • Pipes and spigots  
• Bottles  
• Tanks  
• Reservoirs  
• Umbrellas  
• Roofs  
• Gutters  
• Pots, bowls, glasses, buckets, etc.  
• Channels and canals  
• Fountains and artificial ponds |

Figure 22. Sensing Natural Elements and Systems
<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>PHOTO</th>
<th>HOW DO WE EXPERIENCE IT?</th>
<th>HOW IS IT HIDDEN OR CONTROLLED?</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANIMALS</td>
<td><img src="image1.png" alt="Camel" /></td>
<td>• Gradient of experience: Screen-saver → pet → farm → zoo → safari park → wilderness&lt;br&gt;• Nature shows&lt;br&gt;• Raising and interacting with animals&lt;br&gt;• Hunting&lt;br&gt;• Eating meat&lt;br&gt;• Seeing animals in the world</td>
<td>• Domestication&lt;br&gt;• Farms and zoos&lt;br&gt;• Fences, various restraints&lt;br&gt;• Hunting&lt;br&gt;• Buildings and shelters&lt;br&gt;• Remoteness of wilderness</td>
</tr>
<tr>
<td>ENERGY</td>
<td><img src="image2.png" alt="Electricity" /></td>
<td>• Electricity&lt;br&gt;• Solar, wind, wave farms&lt;br&gt;• Gasoline, heating oil, fire&lt;br&gt;• Power stations, wires, lighting systems, cars and transport&lt;br&gt;• Motors and electronics&lt;br&gt;• Foreign affairs</td>
<td>• Wires&lt;br&gt;• Renewable and non-renewable generation&lt;br&gt;• Batteries&lt;br&gt;• Portable fuels</td>
</tr>
<tr>
<td>FOOD</td>
<td><img src="image3.png" alt="Soup" /></td>
<td>• Farms, Farmer’s markets&lt;br&gt;• Gardens&lt;br&gt;• Cooking &amp; eating &amp; feeding pets&lt;br&gt;• Grocery stores, trucks (trains)&lt;br&gt;• Flying over the US during the day&lt;br&gt;• Films</td>
<td>• Farming&lt;br&gt;• Remoteness&lt;br&gt;• Hydroponics and greenhouses&lt;br&gt;• Refrigeration&lt;br&gt;• Preserving&lt;br&gt;• Silos, granaries, storage containers&lt;br&gt;• Grocery stores&lt;br&gt;• Corporations&lt;br&gt;• Transportation Networks</td>
</tr>
<tr>
<td>PLANTS</td>
<td><img src="image4.png" alt="Grass" /></td>
<td>• Gradient of experience: Screensaver → Indoor plants → garden → park → wilderness&lt;br&gt;• Eating plants, cooking and raising them&lt;br&gt;• Seeing plants out in the world&lt;br&gt;• Nature shows</td>
<td>• Farming and gardening&lt;br&gt;• Refrigeration&lt;br&gt;• Grocery and flower stores, nurseries&lt;br&gt;• Parks and Arboreta&lt;br&gt;• Remoteness of wilderness</td>
</tr>
<tr>
<td>WASTE</td>
<td><img src="image5.png" alt="Trash Can" /></td>
<td>• Trash&lt;br&gt;• Trash cans, dumpsters, trash trucks, greasy streets, rotting smells&lt;br&gt;• Toilets, sinks, sewers, drains&lt;br&gt;• Urination and defecation&lt;br&gt;• Recycling&lt;br&gt;• Rotting food&lt;br&gt;• Compost, mulch, worm boxes&lt;br&gt;• Fall leaves&lt;br&gt;• Dead animals&lt;br&gt;• Excreta</td>
<td>• Refrigeration&lt;br&gt;• Disposal and Landfill (goes “away”)&lt;br&gt;• Burying&lt;br&gt;• Waste at sea (trash gyre)&lt;br&gt;• Waste bins and bags&lt;br&gt;• Trash trucks&lt;br&gt;• Trash shoots&lt;br&gt;• Recycling</td>
</tr>
</tbody>
</table>
though they do usually have some windows. If one were to construct a place that provides experiences of each of the elements they can all be examined in this way and incorporated into the design.

There is an important distinction to be made between functional natural systems and natural elements used as decoration. There is no established definition that I know of that clarifies the distinction, and it is not entirely clear where the line between the two should be drawn, however, there is an obvious difference between a complete ecosystem, or an area that is part of a complete ecosystem, and a small tree in a parking lot planter or the potted plant on my desk. Perhaps the point of differentiation between decorative and functional natural elements is whether or not they rely on human activity for their survival and maintenance. There is a slippery slope there as well, however, because some functioning ecosystems are reliant on humans. For example, Prospect Park in Brooklyn, New York is a large urban park designed by Fredrick Law Olmsted. It contains woods (the only woods left in Brooklyn), meadows (the largest mown lawn in the US), waterfalls, streams, and several ponds and lakes. It’s about four and a half miles around its perimeter road, and it serves as an important stopover spot for migrating birds. One of the areas in Prospect Park that is richest in natural life is the large lake in its southern corner, which supports a wide variety of bird, fish, and plant life. Oddly, the park’s entire water system is fed and filled by the municipal water system. In fact, if you stand near the top waterfall, where the city water is the freshest, you can smell the added chlorine. And yet the ecosystem is in some measure successful. Perhaps it is best to say that it is possible to experience natural elements along a gradient of wildness. In the case of plants, the gradient goes from abstract visual representation, through realism, sculpture, decorative house plants, window boxes, street trees and park trees, to rainforests, or, in other words, from human abstraction to wildness.

As a species, we find value in each of these experiences of plants, but it must be clear that at a certain point, somewhere between a little tree planted in the middle of a parking lot and a mature street tree in a well vegetated neighborhood, we move from symbolic representation of “plant” to a plant that makes a difference in a larger ecosystem.

When we put a tree in a parking lot it is a decoration. It doesn’t provide much habitat, is probably non-native, and will likely die within a few years because of the compaction of the soil surrounding it. Nevertheless,
it is beautiful, and it softens the experience of asphalt. It might shade a few windshields. When we look at the city and experiences of ecosystems in the city a natural element that is part of a larger functioning ecosystem provides a richer learning experience than a window box does, because it is clearly connected to and reliant on a larger system. Parking lot trees, through their isolation and placement by human whim, convey the experience of humans being able to manipulate and control particular aspects of nature. They could therefore present an anti-sustainability lesson, except insofar as we take pleasure in the tree as a beautiful and natural element to enjoy and care for, a care that could then be applied to wild trees as well.

Case Study: Disney World and Celebration, Florida

If one wants to research the state of the art in making people happy, one of the best ways to turn is towards Disney. Disney is in the business of making people feel happy, safe, loved, excited, and willing to spend piles of cash, and the intent behind the design of the theme parks was to have guests leave with smiles on their faces (Spirn 1998). In order to find out what part kinesthetic ecological connection played in the equation I visited Orlando, Florida. In Orlando Disney has established Disney World, a massive development larger than the island of Manhattan, which is the site of four theme parks, two water parks, twenty-four themed hotels, and many shopping, dining, and entertainment venues. I am not alone in looking to Disney for examples of pleasing, even ‘good’ design. In The Language of Landscape, Anne Whiston Sprin writes about Disney’s efforts to create bright, cheerful places, and how popular features of Disney Land and Disney World have been copied repeatedly by developers of malls and gated communities. Spirn also points out that James Rouse, the developer of Columbia, Maryland and other popular destinations, told the 1963 class of Harvard’s Graduate School of Design that Disneyland was the greatest piece of urban design in the states at that time.

Just across the freeway from Disney World is Celebration, FL, a planned community and town that Disney began designing in 1990, and which it still holds a stake in, though it has divested most of its interests. At Disney
World, I expected that every positive association would be played upon, and every expectation for a gleeful and magical place would be fulfilled, and at Celebration I expected that things would be about the same, but scaled back for an older crowd living everyday lives. I thought, essentially, that Celebration would be a plastic town filled with animated mannequins. I expected Disney to build very artificial environments, but I also knew that people are very happy when they can see and sense the natural world. Nature makes people feel connected and relaxed. What I did not know was how Disney would integrate artificial reality and natural systems.

_Disney World_

Disney World is one of the most well-known and popular theme park and resort areas in the world. Of the four theme parks Magic Kingdom is the oldest. It opened in 1971, and was followed by Epcot in 1982, Hollywood Studios in 1989, and Animal Kingdom in 1998. For many people it is an important rite of childhood to visit Disney World (or, on the West Coast, Disney Land). Many people devote entire vacations solely to Disney World, and never leave the Disney property. Often visitors dedicate a day to visiting each theme park. People of many ages visit Disney World, including young couples and groups, families with children, and retirees. It is pretty unusual to visit Disney World by yourself, and if you do it you will get some odd looks. I personally tested
this hypothesis. I visited three theme parks in one day: Epcot Center, Animal Kingdom, and Magic Kingdom, in that order.

I arrived at Disney World just after the kind of freeze that only comes to Florida once in every twenty years. Much of the state, which is usually green year-round, was brown and freezer burnt. Disney World was green. It is a lush development. The highways that cut through it are wide, with wide grass verges edged by thick trees and undergrowth. The vegetation is so thick that you don’t see the parks or hotels until you are right at the door. Everyone is abnormally happy and helpful and, despite the overall vastness of the development, no one space feels vast. Everything is at a human scale, even when the intent is to be impressive, each area feels cozy and manageable. The giant furry cats and bears and princesses walking all over the place help with that impression. One of the ways that being at Disney World differs dramatically from the typical American Lifestyle, in which we spend an average of 6% of our time outdoors (Farr 2008), is that much of the time spent there is spent in the open air, which inherently leads to more awareness of being in a larger natural environment.

Epcot

Whether or not they are aware of the fact that scientific research finds that the natural world makes people happier, the designers of Disney World have got it figured out. The entryway
to Epcot Center is lined with mature trees, and once one passes the fountain and giant silver globe at the entrance to the park one enters a large central courtyard that is a natural element extravaganza. A dramatic geometric awning shades the sunlit space, under which is a central fountain. Surrounding the space are lovely plantings, and attached to many directional signs are kinetic wind sculptures, spinning happily around. It is extraordinary. Sun, water, wind, and flora are all celebrated in the same space. The environmental awareness continues. Just beyond the central courtyard, which is edged by places where you can drop heaps of money on food and Disney Stuff, there is a water play fountain for little kids. There were kids in there even in January. There are two exhibit centers near the entry of Epcot: The Sea, and The Land, both of which educate visitors about the ecologies in those regions, and include exhibits like “Circle of Life: An Environmental Fable,” an animated film narrated by one of the characters in The Lion King. Even indoors in the Land building there is a jungle theme, with biota painted on the walls.

Figure 26. Photographs of Animal Kingdom

This page, clockwise from upper left: Mount Everest, with a ride inside and Tibetan prayer flags catching the wind outside; a gorilla in a lush enclosure with an attachment to his blankie; visitors having a safe experience of wildlife; and the authentically weathered bar in the Africa section. Each of these photographs convey an experience of the natural world, but all of these experiences are mediated in different ways. First and most obvious is that all of these environments are artificial. In the cases of the animal displays, visitors are also separated from the animals. Perhaps on a certain level this doesn’t matter, and these places still provide visitors with stimulating and educational experiences. Disney World may provide the opportunity to learn and have new experiences in a safe environment.
The rest of Epcot center consists of small activity centers located around a large lake. The centers each represent a different country in the world, display typical architecture and landscaping from that country, and sell food and souvenirs from or reminiscent of that country. I think that there are rides, too. Overall, the experience is one of relaxed stimulation around a beautiful lake. The scenery is lush, and there are lots of native birds around, as well as large shade trees. Architecturally, most of the displays are of expertly painted plaster, but they convey a use of the traditional materials used in each country, including stone, mud, wood, and thatch.

**Animal Kingdom**

The Animal Kingdom theme park, not surprisingly, focuses a great deal on communication about ecology. There are posters around about conservation in the park, but the topic at issue here is kinesthetic communication and experience, not verbal or media driven communication. In that, too, Animal Kingdom is well conceived. All of the pavement looks like cracked earth, paths are surrounded by giant artificial rocks, and the entire park is centered around the Tree of Life: a gigantic baobab-like tree whose extraordinary trunk appears to have all the charismatic mega fauna of the world emerging from it, and whose giant limbs seem to spread over the park. There are Asian and African centers in the park, both of which include realistically ‘weathered’ villages made out of native materials, are near water, and have flags and so on the catch the breeze and visitors’ attention. Several sections of the park are dedicated to experiences of conservation, including one walk through an African “conservation school” where visitors can pretend to be a biologist complete with laboratory, and walk through a lovely aviary, equipped with water features and fish. The other area is the “Planet Watch: Open Your Eyes to the World Around You,” which I did not get to visit, but assume is similarly experiential. One of the most interesting things that I saw at Animal Kingdom was a large gorilla walking around with a blanket over his shoulders. We’re not the only ones who like to be cozy.

**Magic Kingdom**

Magic Kingdom, the oldest of the three parks that I visited, is not as ecologically focused or richly landscaped as the other two, but still contains significant amounts of organic sensory stimulation. Generally, the park is focused on the cutest ‘Main Street, USA’ that you’ve ever seen, filled with smiling people and lined with fun shops and eateries, at the end of which is a fantastic castle. Stimulation and reminders of natural systems are provided by flags on every other building, flowers on the lampposts, small trees lining the street, and gently sloping landscaping surrounding the castle. The rest of the park is also landscaped, but not to a significant degree, and unlike the other two parks there is no central water feature, and no boating. A subtler reminder
of natural forms is found in the extensive decoration of the buildings along Main Street, which curves can remind us of vegetal forms. As Stephen Kellert discusses in Building for Life: Designing and Understanding the Human-Nature Connection, even these highly abstract reminders of natural forms, “exert a powerful hold on human emotion and imagination.” (Kellert 2005)

Celebration

Celebration, FL, was conceived by the Disney Development Company in the early 1990’s and is sited on approximately 4,900 acres just south of Disney World. The master plan was developed by Cooper, Robertson & Partners and Robert A. M. Stern, and EDAW designed the landscaping and paths. The Urban Land Institute named Celebration the “New Community of the Year” in 2001. I was surprised to personally find it very pleasant. Driving in took me along a broad street or as much ecological messaging as the other parks there are nonetheless areas of beautiful landscaping, opportunities to observe different natural materials (represented by artificial materials) being used as building materials, and a great deal of organically inspired decoration, like the dragon-shaped lamp bracket seen below right in Fantasy Land.
lined by very tall palms beyond which were wide sidewalks. The office buildings next to the road were not the glass, metal, and brick modernist standards that are the defacto new architecture of the last 15-20 years. Instead they were interesting and Art Deco inspired. In the neighborhoods every street was tree lined, and the architecture was a slightly odd mixture of traditional styles from around the country, although they say it’s all Floridian (Celebration Town Center 2010).

In Celebration, nature is all around you, in its most idyllic state. The maintenance effort is intensive, as is the case at Disney World. All the units face greenery of one kind or another, often with no buildings across the street. There are ponds, palm trees, and golf courses scattered around, and Main Street ends in a lovely lake-side promenade where one can have a meal, sit in a café, or catch a movie. Parking is all behind buildings, in alleyways, or in central building courtyards, for multi-unit buildings or in the down town area. Fake snow comes out of the lamp posts on Main Street at Christmas time, and maple leaf-shaped confetti comes out around Thanksgiving, but only on the weekends.

Disney Design Lessons

Disney World, for all of its ecological communicativeness, is a fairy tale in landscape form. The landscape has been shaped to the designers’ wills. In the creation of Disney World marshy areas were drained, alligators are politely asked to leave, and screened from coming up onto beaches. Stone and wood buildings are made out of plaster, as are large boulders at Animal Kingdom, where the weathered buildings are all freshly painted to appear weathered to the right degree. All of the maintenance of the grounds is done when the park is closed, and all the flowers are kept fresh by constant tending and replanting. There is nonetheless an argument to be made that Disney allows visitors that have experiences of the natural world that are pleasant, and might encourage them to have more such encounters, though the Disney staff will not always pick up after them. Disney Land could be considered a training experience in acquiring knowledge about and an affinity for natural systems. In this way, Disney World could function as a stepping stone towards sustainable behavior, while being utterly unsustainable itself.
Overall, it appears that the designers of Disney World were fully aware of the beneficial effects offered by the ‘soft fascination’ (Kaplan and Kaplan 1989) of having nature nearby. The designers also playfully highlighted those systems, as in the central plaza at Epcot, and made them safe to get close to, as with the gorillas in Animal Kingdom. If we are to extract design lessons from Disney World I believe that the most important are:

• It is possible and desirable to highlight natural systems at a variety of different scales, and to incorporate as many as reasonably possible into each space or neighborhood.

• Do not skimp on detail. People delight in texture, a variety of materials, and differences between buildings. If you must build a warehouse decorate is with a painted façade.

• Make all of your spaces human-scaled. People must feel safe in each space, not overwhelmed by bulk or height except in very exceptional cases of monuments or landmarks like Cinderella’s Castle.

• It is possible to communicate ecological connection while simultaneously creating a totally artificial environment. Sustainability and the feeling of ecological connection are not equivalent.
Summary

In this chapter I have examined the ways in which cities and other human developments respond to natural elements and systems in a variety of ways, and how those developments communicate to their inhabitants. I have also looked at the ways that humans perceive different elements and where we usually experience them, so that designers may begin to understand how natural elements may be incorporated into places where the elements will kinesthetically educate people about their functioning. I have also examined Disney World, where the positive associations that we have with the natural world have been thoroughly taken to heart by the designers, but where natural elements are as often as not entirely artificial. Perhaps it does not matter that Disney World’s landscapes are artificial; they still bring visitors the awareness of being surrounded by natural systems, which may then lead to an increased curiosity about and knowledge of those systems.

Knowledge of ecosystems is, in the strictest sense considered here, a purely intellectual understanding, but it is also one that is most easily gained through a process of kinesthetic learning (Clayton and Myers 2009). Kinesthetic learning and experience of ecosystems often leads to engagement with ecosystems, which is more fully addressed in the next chapter. Though the form of the behavioral change model that this thesis explores states that knowledge of ecosystems precedes engagement with them, and that they are separate, in reality knowledge and engagement of ecosystems often interact, combine, and develop concurrently with one another.

Figure 28. Photographs of Celebration, FL

Opposite page, clockwise from upper left: an office building on the main road into Celebration; sidewalks are separated from streets by grassy verges, especially on busy streets; downtown Celebration is oriented towards and along the edge of a small lake; architecture is varied and traditional. Dense housing often fronts on open space. Celebration is a fairly typical New Urbanist development, and it’s a very pleasant place to be, though the conscious addition of ‘character’ can be slightly extreme and therefore mildly disturbing, as in the case of the lampposts downtown making ‘snow’ out of bubbles at Christmas time.
CHAPTER 3: ENGAGEMENT WITH THE ECOSYSTEM

What does it mean to engage with the ecosystem? Perhaps it is easiest to begin with what engagement doesn’t look like. It is possible to live a life that does not include going out of doors. Generally, ecosystems are found out of doors. Many city dwellers can be said, generally, not to engage with ecosystems. Utilities and food come and go, and a city dweller doesn’t much notice them, except insofar as they influence her comfort. I can use myself as an example in this case.¹ At one point, I lived in a small apartment in downtown Manhattan, and I worked in Midtown. I took the subway between the two. Manhattan is a very dense urban environment, and there were no significant parks around either of the places where I spent most of my time. There were a few open spaces with trees and grass in them, and a few fountains and patios, but both Central Park and the Hudson River were fairly far away. I was busy at work, and working long hours, and it would have been entirely possibly for me to live happily on Manhattan without addressing questions about the sourcing of my water, dinner, or electricity. My life was paved and fully constructed, or so it seemed to me. I had learned about biology and a little ecology in school, but I didn’t have a use for that information in me day-to-day life. I tried to recycle. Here I was an educated individual who roughly understands the workings of ecosystems, but I was not really engaged with them, at least not consciously. Everyone is necessarily connected to ecosystems, because they are required to support life, but consciousness

¹ This is a slightly false example because I was very unhappy about living a paved existence, was reading everything I could get my hands on about the environment, and soon moved to Brooklyn where I could be near Prospect Park. Nevertheless, the general pattern of the life of a busy city dweller is sound. I have met many people who are living the described life.

Figure 29. Lecce, Italy: Above, produce in Tokyo
of this connection is not required. The key differentiation between knowledge of and engagement with ecosystems is kinesthetic experience and a felt relationship. Engagement with an ecosystem, if taken to its logical conclusion, entails an experience of non-dualism; a realization that we are not separate from the environment. We may design places that foster that feeling of non-dualism. As Anne Spirn puts it, “Design which highlights nature’s processes for our contemplation permits the experience of a sense of unity with a larger whole which is the universe in which we live.” [Spirn 1988]

Engagement with the natural world comes when we begin to have a relationship with the ecosystem, or with natural elements. This is not to say that we aren’t born with an innate understanding of an affinity for the natural world, but the connection can become tenuous or unconscious. Conscious connection comes in myriad forms which can be initially seen as a deepening of engagement, beginning with simple enjoyment of natural elements, using a screensaver made up of nature scenes, or having a potted plant or pet. We may engage with, or begin to more clearly see our personal place in, natural systems if we become interested in food safety and the sourcing of our own food. We may enjoy walks in the park, or we may become increasingly engaged and go hiking, garden, fish, or farm. Each of these activities gives us a sense of our relationship to natural systems, and our innate reactions to them. The more we depend on natural systems for our livelihood the more closely we will attend to them, of course, but it is also possible as a city dweller to get a sense of one’s involvement in natural systems, particularly if they are near at hand and treated structurally as functional, important, and meaningful.

The Elements

Just as I addressed the ways that we sense specific elements and systems and the ways that we may learn about them in Chapter Two, in this chapter I will address the ways that humans engage with and sometimes shape each element. The following pages draw on photos that I took mainly during a trip around the world in 2006 to examine how each of the elements and systems we have discussed thus far appear physically in urban and town form, what our relationship appears to be given these photographs, and how each element could ideally be incorporated and celebrated in city form. Each element’s design suggestions are focused on emphasizing and communicating the presence of the element, not treating the element sustainably.

One primary observation, which is not captured in the examination of each element and system separately, is that humans, like many other animals, thrive in the liminal edge spaces where elements come together, instead of where one element predominates. We thrive on the water’s
edge, where the land meets the water and the air. Perhaps this is why we so enjoy spaces, like Epcot’s central plaza, where multiple elements are visible at play at once.

I am indebted to Anne Whiston Spirn, Professor of Landscape Architecture and Planning at MIT, for the concept of looking specifically at how each element is addressed in cities. In her book, *The Granite Garden* (Spirn 1984), she too looks at air, earth, water, plants, animals, and waste. She examines the place of each and difficulties found with each in modern cities, and recommends measures to address those difficulties, many of which involve enlisting ecosystem services instead of technology. To Spirn’s elements I have added the element of light, as well as food and energy systems.
Element: Air

Air connotes freedom and the unreachable. It is movement without form. We can harness it and pipe it, but we can’t hold it. Instead, it holds us. We can feel it moving past our skin and in our lungs, and we can see and hear it playing in the trees and fluttering flags, but air itself is invisible except for its effects or for what it’s carrying, like clouds or visible pollution. Sometimes we can smell the air, especially if it’s been over the sea or through the kitchen. In modern cities there is a great deal of effort concentrated on keeping untreated or uninvited air out of our buildings. Many buildings are sheathed in windows that don’t open. We are trying to keep ourselves comfortable, reasonably, but sometimes indoor air pollution is worse than outdoor air pollution. We pollute the air, both inside and outside. The air is a receptacle for all the carbon dioxide we release into the atmosphere, and as such could contain the greatest threat to human kind in recent memory, though we can’t survive without it.

Throughout history the movement of air through a building has been used to regulate the temperature of the building, and architects are again becoming quite skilled in managing the passive heating, cooling, and air flow of individual buildings. Planners, too, often model and consider the wind flows through developments so that they can avoid wind tunnels and canyon effects in cities. We are beginning to understand how to manage the urban heat island effect by managing the absorption of sunlight so that it doesn’t heat the air too much in cities.

Because we cannot spontaneously leap into and be held up by the air, being in the air, or being high up, has been a status symbol for ages. In the case of a penthouse, status is associated with the best view. In a cathedral height connotes nearness to god and power through the ability to build tall buildings. The ability to fly on planes carries some status with it now as well, though less than it did when plane travel was more expensive. People who can fly are seen as wealthy and worldly.

DESIGN: Because the air is largely invisible, integrating it directly into visual design is impossible. However it is possible to facilitate the experience of air and wind through elements that interact with it, like flags, waving plants, and wind chimes, and by allowing enough open space for people to experience its flow across the landscape and to construct their own wind sculptures. Another way to encourage an experience of air is by constructing or designing spaces from which there is a far-off view, which is necessarily seen through the air and experienced as spacious. Locally relevant treatments of air (channelling cool breezes and blocking cold wind as needed) may also provide connections to air if they are designed to highlight air’s passage.

Left to right from top left: airplane propeller over New Zealand; wind and space in the Apian Alps, Italy; oil refinery in Qatar; flags on fishing pots, Essaouira, Morocco; sailing in the Norfolk Broads; seagulls near Istanbul; skyscrapers in Shanghai; Roman columns in Bergama, Turkey.
System: Animals

We experience animals along a gradient of mediation and a gradient of wildness. The most mediated and abstract way that we experience animals is as symbolic figures used in art and design. These can be highly abstract, and may consist solely of eyes on a blank canvas, for example. Representation of animals can also be detailed and three dimensional, and melds with the reality of animals with taxidermied specimens. Animals are an import source of food and services for many people, and continue to work side-by-side with farmers and others to this day. After a certain point in our history we began to be affluent enough to have animals as pets, and to use them as status symbols, like expensive Texas Longhorn cattle, who serve as lawn ornaments and tax loopholes for wealthy land owners in Texas. There are other animals, like squirrels and pigeons, who live in cities and depend on humans for their food, but who are semi-wild. Further along the spectrum there are truly wild animals, who live independently of humans, but whose lives are often impacted by us nonetheless.

Animals have tremendous symbolic and emotional power for us, and can be great sources of joy, companionship, and entertainment. In Animals in Translation, Temple Grandin argues that we co-evolved with dogs, and that they were for a long time indispensable to our survival (Grandin and Johnson 2005). Many of us care deeply and instinctively for animals, but animals, particularly wild ones, are largely excluded and built out of the city, unless they can in some way adapt to city living. One of the greatest risks to animals is continued habitat destruction, fragmentation and change.

DESIGN: It would be ideal to build our cities in such a way that they don’t exclude animals, but provide safe and functional habitats for everyone. One of the ways to do this is by providing adequate habitat areas, as described by Richard Forman in Land Mosaics: The Ecology of Landscapes and Regions (Forman 1995). Habitat areas are ideally of sufficient patch size and shape for inhabitants, and the amount of species that live only in internal areas, and they allow for movement between habitat patches, like along corridors, or closely placed ‘stepping stones.’ Roads generally fragment habitat areas, as does fencing, but to a lesser degree. Removing or mitigating dangerous barriers to animal travel would be a significant infrastructural challenge, but not insurmountable. Providing for habitat in the fabric of the city is potentially easier and more sensible than largely separating human and animal habitats, particularly because it has the added positive effect, when combined with urban areas, of providing vital and highly valued open space and access to nature. Providing adequate space for animal habitat would build a clear communication of valuing other life forms into city form. Wildlife viewing stations, signs that indicate inhabitants’ presence dynamically may allow connections to wildlife to form. Own own buildings may provide habitat for animals, like birds and insects, on decoration or articulation of building facades, or on green roofs.

Left to right from top left: painted jaguar in Naples, Italy; Thai temple guardian animal; fish for sale in Kunming, China; boxed roosters near Guilin, China; horses and buggy in Büyükkada, Turkey; parade horse in Brasov, Romania; squirrel eating birdseed, New York state; wild elephants in Thailand.
Element: Earth

Earth is constantly spread out beneath our feet, whether we can see or touch it or not, and we use the earth for myriad purposes: to build our dwellings, contain and filter nutrients, foster plants for our food, and be firm under our feet. Although it appears inert, earth is part of a dynamic and complex system of nutrient and energy exchange. We have revered the earth and soil for generations, but in modern cities it is no longer treated as a valuable resource. Instead it is paved over, compacted, and considered base ‘dirt’- certainly not something you’d want on your hands.

Older, established cities and towns that relied on local agriculture and natural processes, not inorganic or trucked-in fertilizer, for their sustenance built their structures on land that was not prime farming land, and which was protected from floods and other natural dangers insofar as it was possible. For example, Dali, China, shown in the left column third down, is built where the mountains meet the fertile flat lands, which slope gently towards a lake on whose edge other villages are located. In this way farmland is available for farming on, and is nearby enough to work easily. In some places, like Amalfi, Italy, shown at left, there was no arable farmland, so terraces were carefully carved out of mountainsides over generations. Unfortunately, lots of recent development, particularly in the US, has been on prime farmland, which is often clear and flat. This destruction of farmland not only strips local economies of long-term economic resources, it also reduces our local food security.

DESIGN: In order to communicate that the earth is a valued resource and a source of bounty we need to stop designing our cities as if earth is an inconvenience that must be covered over for easier parking or driving, or that should be contained in little curbed beds filled with non-native plants. Earth is our prime growing medium, and its fertility is not easily or quickly restored. Without it, we face societal collapse. We need to engage in widespread soil management, and to leave greater swaths of it alone and uncompressed. One of the ways to put people in direct contact with the wonders of the earth is to encourage gardening and to allow plenty of space for public gardens. Apartment dwellers can create dirt in vermicomposting bins under their kitchen sinks, and the dirt can be collected by the city. Earthen building materials can also bring the feel and look of the earth into homes, and exploiting the site of the city’s geological character will emphasize the presence of earth under the city. Much of the difficulty inherent in changing the cultural valuation of dirt is that it is in many cases undervalued and considered as akin to filth. This value will not be changed solely by stopping road works, but will also need to be shifted by concerted educational effort that teaches children about the value of dirt.

Left to right from top left: mud bricks outside Ait Ben Haddou; Ait Ben Haddou, Morocco; Roman building materials in Hierapolis, Turkey; Roman carving in a village wall outside Egirdir, Turkey; farming outside Dali, China; terraced homes and farms above Amalfi, Italy; painting of the Earth, West Guinea; earthen tiles, Konya, Turkey.
System: Energy

We have always burned organic material to make ourselves more comfortable, cook our food, and to exploit heat’s ability to transform materials in various ways. We have also used renewable energy sources, like the movement of the wind and water, for thousands of years. Initially, our burning and power production was done immediately next to the spot where it was needed, as in the case of a windmill used to pump water out of a field in Holland. Now, our energy and electricity are much more portable or transmittable, and we have located unappealing power plants outside of the city and neatly under the bonnets of our cars. We depend greatly on electricity, but it is largely invisible except for the fact that it makes equipment go somehow, and the almost silent, static power lines it flows through.

Power is considered base and unappealing in production, and sexy in effect. Modern power production often involves blasting the tops off of mountains in order to get at the coal within them, then trucking the toxic substance to a power plant where it is burnt, and releasing a wide variety of noxious chemicals into the atmosphere (National Resource Defense Council 2008). That is not something we really want to see, but we do think that light is pretty and useful, so we visually highlight lighting fixtures. Because we have so successfully hidden energy production, and consumption is unintuitively metered, it is very difficult to understand how much of it we are using. This makes it very difficult to monitor one’s personal energy usage and to understand how to reduce it in real time.

DESIGN: One way to make the wired-ness and levels of energy consumption in our lives more apparent would be to build infrastructure with the wiring unhidden. Making that attractive would be an interesting design challenge. Local power generation would cut down on power lost in transmission, and make localities more aware of the machinations involved in power production. Technology introduces lots of possibilities for real-time direct feedback on personal and aggregate power usage, some of which are mentioned in Chapter Four, which covers feedback in depth. We can fairly easily be given direct, intuitive, immediate feedback on the effects of and consumption inherent in our actions, which would facilitate our learning to change our behavior. Every appliance could be built to monitor and report its own power usage, or they can be monitored centrally. To increase awareness and kinesthetic learning about power, school children and adults could be taken on learning journeys to mining and power plant operations.
**System: Food**

Food is a wonderful thing. Throughout our history the acquisition of food has consumed much of our time and energy. Food is still a major focus of our lives, and markets that include food sellers are a major focus of the city, particularly in older cities, though suburbs still often center on a grocery store. In less industrialized countries the steps between producer and consumer are often fewer, and it is clearer where the food is coming from, how it was produced, and what is in it. This is not the case in the US. In the US, our average food miles are astronomical. Produce, which is more perishable and less transportable than preserved goods, travels an average of 1,500 miles from farm to plate (National Resource Defense Council). Much of the food in the US is also processed to such an extent that it’s not clear what the ‘food’ is really made of in the first place. When we go to the grocery store, particularly if it’s a large corporate chain or a discount supermarket much of the food comes in a perfectly formed box, so that standing at the end of the aisle it is almost impossible to tell what kind of food you are looking at if you don’t read the label or look at the picture on the box. This food is also trucked into the city late at night, so for all intents and purposes according to the average person’s perception the food in the grocery store appears by magic. Our visual connection to our food has been obscured.

Our separation from our food system leads us in many cases to disregard or fail to understand the importance and fragility of our food system. The opportunity to directly participate in our own food production makes us more connected to and aware of food as something that does not magically appear in restaurants or the grocery store. Direct participation requires allotments or community gardens as interventions in the city form, as well as encouraging space for farmer’s markets, where we can come into direct contact and relationship with our food and its producers. Another way to come closer to the production of our own food is to visit farmer’s markets, where food is generally unpackaged and we can speak to the producers of our food. The concept of eating local food has become very popular in the last few years, so much so that the New York Times has a special online section for articles relating to local food (New York Times 2010).

**DESIGN:** The two clearest steps that we can take to make our food system more intuitively present and part of a larger ecological system are first, to unobscure our food and its travel by handling it in the light of day, outside of boxes, and to allow space within the city for personal and communal cultivation of food in yards, community gardens, and allotments. We can also label food with its origin to enable food mile tracking.

Left to right from top left: Thai food prepared by the author, Chang Mai, Thailand; orange grove in Florida; fresh vegetables outside a restaurant, Dali, China; spice merchant in Istanbul; farming outside Dali, China; fish merchants in Doha, Qatar; kebab shop in Xi’an, China; fruit and vegetable vendors in Marrakech, Morocco.
Element: Light

Light is something generally viewed and joyful and pure. We are happier and healthier when we live and work in places with lots of natural light (Prof. JA Knottnerus 2004). Sometimes we produce it and sometimes, particularly when it is associated with too much heat or burning, we screen ourselves from it. It is a cliché that houses of the poor are crowded and dark, while the rich live in bright, spacious neighborhoods. Ideally, we would design cities that make as much use as possible of natural light and the heat from the sun, and rely as little as possible on artificial light. Architecture is making great strides towards passive housing, which is heated and ventilated naturally, and which often incorporates a great deal of daylighting. This expertise has not yet been translated beyond the building scale to the neighborhood scale in an easily applicable way, though there are a few examples of successful green neighborhoods that incorporate a lot of daylight. We can reclaim the expertise of our ancestors and use narrow streets and translucent canopies to shade hot streets. Professor Dennis Frenchman at MIT is now working on the issue of plan replicability and computerization of optimized solar exposure and energy efficiency.

Light makes it possible for us to use our dominant sense: sight. We can feel the effects of sunlight on our skin. Light itself is invisible, but is revealed in the difference between lit and unlit. We don’t see it travelling, we only see it being produced and reflecting. The movement of light and shadows across buildings, particularly those with relief details, makes us aware of the earth’s path through the sky and our place in a larger system. The production of light, which we do a lot of in modern life, generally requires burning some kind of fuel, mostly coal in the US, but we have no experience of that production or its consequences, because it happens so far outside the city, and because all we have to do to turn the lights on is flip a switch. It is tremendously easy for us to consume resources in this way. Ideally, it would be clearer where our light is coming from, and how much damage we are doing to natural systems whenever we forget to turn off the bathroom light.

DESIGN: Articulation and decoration of building facades would allow us to more easily observe the effects of the passing of the sun through the sky. Building design that utilizes and highlights natural light inside would have the same positive effect, as do outdoor spaces that have a variety of sunlit and shaded areas. Lighting systems that give us feedback on how long they have been on and how much power they have consumed would enable us to keep track of our power usage in real time, and to adjust our habits to reduce that usage.

Left to right from top left: light falling on tiles in the Topkapi Palace, Istanbul; the sky between temple buildings, Beijing, China; Wat Phra Keo, Bangkok, Thailand; building in Lucca, Italy; bathroom in St. Mards, France; souk in Marrakech, Morocco; enjoying the sunshine in St. Mards, France; traditional streetlights in Plymouth, MA.
System: Plants

Plants, like animals, can be experienced along gradients of mediation, use, and wildness. These photos capture the range of our relationship to and engagement with plants, from abstract and decorative to ornamental, a source of food, and material for utilization in tools and shelters. Plants for a long time have been our primary source of food and medicine, and many cultures have rich and long histories of relationships with particular plants through which those plants begin to carry significant abstract and symbolic value for those cultures. In the US we are a country of immigrants in what is a relatively recently inhabited (by westerners) and developed country. This means that in some cases our historically close relationships to particular plants and crops has been broken. This is particularly true as the majority of us move into cities.

As is the case with food and energy, our primary cultivation and use of plants occurs outside the city, so we never see it or have a relationship to it. If we saw the trees it took to build a stick-frame, suburban house, let alone a subdivision, before they were harvested, and what the land looked like afterwards, we might think twice about building something new, or adding on the fourth bedroom. Similarly, if we had to grow all our own vegetables, we would be less inclined to waste our food, or to only eat cosmetically perfect food.

DESIGN: as with other systems under consideration, like food and animals, the integration of plants into city form requires space that is unbuilt, or possibly built space that is prepared so that plants can live on it, like green roofs. As Kaplan and Kaplan (Kaplan and Kaplan 1989) and Ulrich (Ulrich 1984) noted, the presence of plants and small natural areas has a great positive physical and psychological effect on us, whether or not they are of a high design quality. They also clean the air, provide habitat, and mitigate the urban heat island effect, so one hopes that the recommendation to incorporate more of them would not meet much resistance. This means that we should not build great barren plazas in front of hotels and bank buildings and pretend that they will be great public spaces. Plants should be celebrated and well accommodated in the urban form. Native plants should be chosen in particular, as they lend distinctiveness to the place and educate passerby about the local ecosystem.
WASTE
System: Waste

Waste is disgusting. It is biologically repellant, particularly because it smells. Our solution in the US to the ‘problem’ of waste is to truck it ‘away.’ In India cattle eat it, and are often poisoned, and in many developing countries people make their livelihood picking through waste, while often living on the dump. No one wants to create a design that puts a pile of trash in front of city hall, because trash is disgusting, but a large part of the reason that it’s disgusting is because we’re not capturing the rotting food and organic matter in the trash and treating it as nutrients. Another difficulty with the approach of throwing waste ‘away’ is that there is actually no ‘away’ (Rogers 2005). Waste represents a tremendous resource, and it was regarded as such in our history, because it is largely made up of nutrients, which were more precious when we did not have the impression that we could forever fabricate fertility using petrochemicals. The exposure of the waste stream in city form would require a cultural revaluation of waste and a change in personal behavior, particularly in waste sorting. Significant policy and municipal waste treatment changes would be required to make each city zero waste. Oakland, California, has a very progressive public works department, where they do promote zero waste through advertising, public events, robust recycling programs, and providing residents with bins for composting, which is added to yard waste and picked up by the city (Public Works Agency 2006). The fact that the green compost and yard waste bins stand on the streets of Oakland next to the garbage cans is in itself a communication about the value of refuse, and should help to promote the separation of waste to late adapters. Eventually we will reassess and rediscover the cradle-to-cradle (McDonough and Braungart 2002) practice of recycling all exhausted products. If this compost is to be redistributed to residents as fertilizer it would be important to test the compost for toxic substances.

DESIGN: if the issue of cultural valuation of waste changes, and personal behavior shifts towards composting and waste sorting are resolved, then the urban design issue of highlighting nutrient reclaimation is potentially uncomplex, beyond allotting space for different kinds of treatment, like industrial composting, but perhaps public awareness of waste systems could be galvanized by neighborhood composting or by redistribution of processed municipal compost.

Left to right from top left: back street with trash cans in Celebration, FL; cow eating trash in Konark, India; rest stop trash can, Mississippi; skate rotting on the beach after a freeze, Santa Anna Island, FL; shielded waste area, Celebration, FL; burning trash in Naples, Italy, where waste is an ongoing problem; rotting buildings and people living under discarded tarps, Kolkata, India; compost pile in St. Mards, France.
Element: Water

I grew up in California, where there are often droughts, and one of the prevailing slogans of my childhood was “Water is life, don’t waste it.” And indeed we need a significant amount of water to keep us going, not only for us to drink, but also to water the plants and animals that feed us, and for the purposes of washing and cooling a vast number of things. We experience water in a variety of ways, and the form of the city reflects this shifting relationship. On the one hand, municipal water comes and goes through our pipes in a way that is equivalently as magical as the way power travels through wires. It is useful and always available, and we don’t have to think a lot about it. It will come, and it will generally be safe to drink. Wastewater, runoff, and inconveniently located rivers and streams are often piped underground and out of the way as quickly and conveniently as possible. On the other hand, water is a vital and precious resource. Our relationship to water has not always been easy, and we have historically valued it more explicitly in the form of our cities, which are often situated on the water’s edge for ease of fishing and transportation, than we do now. Water is used ceremonially and decoratively in fountains and ornamental ponds, where it is celebrated for its clarity, reflectiveness, and changeability. We structure our cities and buildings to protect us from water not only in the form of floods, but also weighty snow and rain, and seeping damp, that can damage our dwellings. The photos at left capture many of these aspects of our relationship with water, including utility, decoration, ritual substance, transportation highway, food source, annoyance, and play surface.

DESIGN: a redesign or retrofit of traditional city form that highlights and celebrates water would in a large proportion be centered around keeping runoff water on the ground where it falls, and letting its flow and be treated through naturalized channels, instead of putting it into pipes underground. We might also separate our water systems. These separate systems might include the drinking water delivery system, which would deliver pure and safe water to drinking taps, reclaimed water systems that run toilets and possibly showers, dishwashers, and so on, and waste water systems that capture grey and black water separately, and treat them differently, as needed. There are many alternative waste water treatment systems that we can use in our cities, or at smaller neighborhood or cluster scales, that use a variety of techniques to treat and capture nutrients from waste water. These include living machines (Worrell Water 2010), bio-digesters (Appropriate Infrastructure Development Group 2010), and sub-surface wetlands (Reed 1993). Each of these alternative technologies offer not only increased resource efficiency, but also hold out exciting opportunities for observation and kinesthetic learning.

Left to right from top left: latrine in the Marin Headlands Center for the Arts, Sausalito, California; fountain in Lyon, France; Heidelberg, Germany; temple pond in Chengdu, China; fishing boats in Essoiera, Morocco; snow in Prospect Park, Brooklyn, NY; rain in Provincetown, MA; women washing vegetables in a channelized stream, Dali, China.
Kinesthetic Experience

In Chapter Two I discussed the ways in which we can learn kinesthetically from the city, or from our own experience. Kinesthetic learning experiences tend to be more memorable and impactful than academic experience, and also encourage the establishment of a relationship to and feelings about what is being learned about (Kellert and Wilson 1993; Bell 2001; Clayton and Myers 2009). Kinesthetic experiences relating to the natural world have several benefits. One is that they engender care and compassion for the natural world, more than academic understanding does, and are as such key tools that we can employ to increase individuals’ desire to have a lighter impact on the natural world, and to behave more sustainably. Kinesthetic experiences in a city, or true physical engagement, may involve not only mental but also physical interaction, which often leads to physical change in the environment, and perhaps in the actor as well. The ability to change our environment, or to 'make a place our own,' has a profound effect on how we feel about and in a place, and can also effect our base level of happiness.

The ability to physically interact with a space makes the space significant, and it becomes a meaningful semantic place. The more we are able to interact with and be in a place, the more we feel that we belong to the place, and it belongs to us. This feeling of connection not only increases our care for the place, it also increases our sense of self. The opposite experience, one of being in a space that you cannot effect, and which does not respond or speak to you, like a blank corporate cubicle or sterile hospital ward, can be alienating and can disassociate one with one’s sense of place and self. Inability to personalize space is a significant detractor in worker satisfaction, for example.

In her essay, ‘The Poetics of City and Nature: Towards a New Aesthetic for Urban Design,’ (Spirn 1988) Anne Spirn argues that in order to feel at home in a place we must not only live there, we must also be able to influence and interact with our environment. In Environmental Psychology Bell posits that it is actually part of human nature to modify our surroundings (Bell 2001). Spirn goes on to describe how places that are responsive to the ecological cycles that surround and support them, like a small Italian hill town, are much richer and more evocative than those that do not, like Dubai, where buildings are fully sealed off from the desert environment, and everyone lives a boxed-in, air conditioned life. Spirn argues that without a sense of place we begin to loose a sense of self. This proposition is corroborated by research done by John Zeisel, an architect whose work lies at the confluence of Environmental Behavior, Neuroscience, and Planning. In Inquiry by Design: Environment/Behavior/Neuroscience in Architecture, Interiors, Landscape, and Planning (Zeisel 2006), Zeisel looks at the intersection of neuroscience/psychology and built city form as a designer and investigator into the effects of designs that have been developed using
environment/behavior techniques. His aim as an architect and consultant is to build environments that maximize our mental and physical functioning, which are deeply intertwined. He accomplishes this by using neuroscientific research on what makes us function more effectively to inform building design, which he then evaluates post-occupancy. He describes a number of cases, including an Alzheimer’s ward in a hospital and an assisted living home for healthy older folks, where personalization of space and basic physical space design are vital to the functioning and well-being of the inhabitants. In the Alzheimer’s ward patients often suffer from amnesia. This can be alleviated by their surroundings. Zeisel says, “Memories of our past largely define ourselves- who we believe we are. People with amnesia who cannot remember their pasts say that they do not know who they are, that they have lost their ‘selves’... Personalized environments that express who we are to the outside world also cue our memories and feeling about ourselves.” (p.357) In this case, the environments were personalized using pictures and objects from the patient’s past to trigger their memory. The place was made into ‘their place,’ which more able individuals may accomplish by themselves. The Alzheimer’s ward was also attached to a garden, where patients were free to walk. The garden was secure, so patients could not wander out of the facility and get lost, as often happens with Alzheimer’s patients, and it was designed using spatial signifiers that communicated to the patients where ‘home’ was. The garden was accessed from a porch, which looked homey and inviting, with rocking chairs to sit on. The walkway in the garden consisted largely of a looping path with small benches to the side of it. The absence of dead-ends decreased the likelihood of confusion for patients, and designers ensured that the porch was visible from every part of the path for easy orientation. In this way patients were given access to the outdoors, which has well-established health benefits, and they were given a way to understand the space and how to interact with it through its design language. In the case of the elder home, Zeisel describes how the space was designed to give residents a feeling of both community and individuality. The common spaces were central, and were approached gradually so that residents could decide if they wanted to join in communal activities or not. Each resident’s room was furnished with a small, interior, porch. The residents personalized these areas, and used them to communicate their desire to socialize or be alone by having their porch light on or off, or by having the top of their door open. They were communicating using space, and reported that this opportunity for personalization gave them a sense of belonging, value, and self.

Spirn (Spirn 1988) offers an example that is even more specific to this case. She describes an imaginary city, called Della, which, like many cities, lies along a river. There, the movement, management, and use of water is an integrated and visually accessible part of life. In just a few examples, their central park is also a floodplain, where the water’s varying edge is marked by
marble paths, the central square holds an interactive fountain where residents can control the flow and course of the water. Each year there is a water festival, during which musicians ride up a canal in shallow-bottomed boats to the central plaza where the mayor rededicates the fountain.

In her essay ‘The Poetics of City and Nature: Towards a New Aesthetic for Urban Design’ Spirn states that it is difficult to care for the city and one’s greater environment if one has no opportunity to positively and creatively interact with it, and that we are increasingly separated from ecological systems by technology. This claim is scientifically supported by those made by Clayton and Opotow, whose key finding in their investigation of Conservation Psychology was that kinesthetic education about natural systems was the most effective way to engender care for those systems (Clayton and Opotow 2003). As a solution for disregard of natural systems, Spirn argues for the creation of urban places that are established with a deep understanding of their physical contexts, over which inhabitants elaborate and create their own personally relevant forms. These kinds of places, she argues, must also be allowed to evolve and change, to respond to the passing of time and seasons. It is very difficult for planning as a discipline to account and allow for change. It is the nature of a plan to imagine an ideal future and to drive towards it, which drive has the potential to distrust and throw aside creativity and emergent forms which may come forth out of synch with the planning cycle.

Case Study: Village Homes, Davis, California

Village Homes is a suburban development in Davis, California, which is fourteen miles west of Sacramento. It was built in 1975, and is unique for a number of reasons, particularly related to sustainability. The development consists of 242 homes on 60 acres, located about two and a half miles from the center of Davis. It was designed and developed by Judy and Michael Corbett. Judy had a background, tellingly, in environmental psychology, and Michael was interested in architecture and ecology (Corbett and Corbett 2000). The Corbetts established eight principles of sustainable development, which they used in designing and building Village Homes. These principles spring from a variety of different concerns, which are primarily centered on ecological sustainability and creating a mutually beneficial relationship between humans and their environment.

Photos of Village Homes, left to right from top left: spinal walking and biking path, with community gardens running alongside; community vineyard; walking and biking path, note unfenced yards; walking and biking path, note the variation in how residents treat their yards; backyard chickens; one of two community greens; a cul-de-sac, which are actually safer roads for children to travel and play on; unexceptional architecture predominates, as does lack of fencing.
VILLAGE HOMES
environment. Many of these principles appear to spring straight from the pages of an environmental psychology text, particularly the last three, which detail the importance of living in physically and psychologically nurturing and natural conditions, which are directly related to physical space:

1. Every living thing survives by numerous and subtle relationships with all living things and with the inanimate environment.
2. Ecosystems and parts of ecosystems composed of a wide variety of species tend to adapt better to environmental changes or human tampering than do those composed of fewer species.
3. Part of the ecosystem is a complex system of energy transfers that depends, ultimately, on energy input.
4. In the long run, every one of the humanity’s physical needs must be satisfied either without the use of nonrenewable resources or through recovery and reuse of those resources.
5. Although humans seem to be the most adaptable of living things, we still have certain inherent physical and psychological needs that must be met by the ecosystem, the human-made physical environment, and the social environment.
6. Humans are for the most part genetically adapted to the environment that existed about 200 to 20,000 years ago. This adaptation involves not just the physical makeup but also the modes of
perception and behavior and relates to the social environment as well as the physical environment.

7. The relationship between people and the environment goes both ways: humanity shapes and is shaped by its environment.

8. Humans can adapt to a wide range of environmental conditions, but the results of the adaptation to inhospitable conditions is temporary or chronic stress. (Corbett and Corbett 2000)

The streets in Village Homes are narrow, curving cul-de-sacs, and are all less than twenty-five feet wide, with no sidewalks. The edges of the streets are planted with trees, which reduces the streets’ heating effect. The streets run largely east-west, so the lots are all oriented north-south, allowing for the use of passive solar heating, as well as providing ideal roof areas for photovoltaic panels. The streets alternate, as one moves north-south, with common areas connected by bike/pedestrian paths. All of the lots back onto the common areas, which are augmented by two parks and a community garden area that runs the length of the west side of the development and ties each of the communal paths together. These paths also allow access to the adjoining neighborhood. The common areas between the homes contain Village Homes’ natural drainage system, which involves a network of swales, streams, and ponds, and keeps runoff out of the sewer. There are several orchards and vineyards in the development, which supply produce to residents.

Residents are clearly passionate about edible landscapes. In addition to utilizing the extensive community garden

Figure 31. Drainage Swale, Village Homes

(Above) An example of a swale running through the common areas. The swale is quite noticeable here, but in other areas it’s simply a shallow, grassy depression.

Figure 32. Typical Village Homes facade.

Facades have no clear point of entry, and as such are unwelcoming, and don’t seem like the front of the building.
space, many residents grow crops and raise chickens in their back yards, adjoining the common pathways. The neighborhood has an exceptionally open feel because none of the back yards are fenced, although many residents have private fenced yards at the front or side of their houses. The buildings themselves are largely unremarkable, even plain, and reflect a rather boring, though solar-oriented, version of the kind of modern architecture in vogue during their development. Nevertheless, houses in the development consistently sell for more than do houses in adjoining developments because the environment is so pleasant. Homes there sell at a $10-$25 per square foot premium in 30% of the average market time. Village Homes is described as, “one of the most desirable and economically successful developments in California,” by Mark Francis, professor of landscape architecture at the University of California, Davis (Francis 2002).

Village Homes is held up in many cases to be an exemplar of sustainable development, and in many ways it is. But it is more interesting than that in relation to the topic at hand. In the course of my thesis research I interviewed Robin Moore, professor of Landscape Architecture in the College of Design at North Carolina State University. Moore studied the communication of cities with Kevin Lynch at the Massachusetts Institute of Technology, and has since become an expert in the design of play, learning, and educational environments. Moore is now largely involved in the design of educational parks and museum grounds because it is now widely deemed unsafe to allow children to wander around and play in the street. I asked him if he knew of any examples in which an urban environment was well designed to kinesthetically educate children about natural systems, and to give them a feeling of their place in them, and he mentioned Village Homes, so I went to see it.

Village Homes is indeed a very pleasant place to be. The weather is temperate, if a bit hot in the summer, and it doesn’t rain a lot. Residents of the Sacramento River Valley generally don’t let

Figure 33. Plan of Village Homes
Shown in Francis, 2002. One can clearly see the curvilinear streets and ample open spaces along the lower edge and in the lower right corner.
this stop them from using irrigation to grow tremendous amounts of food in the fantastically fertile soil. The land is generally flat, which encourages residents to walk and ride their bikes a lot, and the experience is enhanced by the pleasant and interesting walk/bike paths, which are separated from the street by rows of houses in Village Homes. Though the path doesn’t change, experience of walking it does on an almost daily basis because of changes in the gardens, plantings, and community plots around it, as well as whether or not the swales or ponds have any water in them. The separation of the paths from the streets, the fact that they can be visually monitored from each house, and the human engagement with ecosystems visible along their lengths make them very good places for children to wander together and learn about natural systems. Many of these positive qualities may be taken as proven design examples. Life is good in Village Homes in a number of ways beyond ecological connectedness. Residents have three times as many social contacts as in a comparable subdivision, and houses require one-third less energy than in other Davis neighborhoods (Francis 2002).

The primary negative aspects of Village Homes are its conformance to many of the stereotypes of traditional suburban development, and the deeply unexceptional architecture that features buildings that face neither the street nor the paths behind them. It is made up of cul-de-sacs lined with single family homes in a self-contained neighborhood that is in walking distance to very few destinations. Because it is a few miles from downtown Davis the development’s location and provision of two-car garages with each house encourages residents drive to destinations outside the development, despite the fact that the development itself is very walkable. Village Homes’ suburban nature and significant success make it an interesting counterpoint to the popular New Urbanist Development (Calthorpe 1993; Duany and Plater-Zyberk 1991) which generally avoids all cul-de-sacs, espouses connected, geometric grids, recommends that homes be directly facing the street (which is to be equipped with a sidewalk), and does not advocate the kind of transcet scrambling see in Village Homes, where open space, tiny farms, homes, and the community center area are all stirred in together. Corbett and Corbett were instrumental in developing the Awahnee Principles, a foundational text of New Urbanism, and they say in their book Designing Sustainable Communities: Learning from Village Homes that they agree with the New Urbanists on every issue except the primacy of the grid (Corbett and Corbett 2000).

As originally designed, the houses in Village Homes are solar oriented, which is positive, but the face that they present the street consists of ugly car ports and fences that contain small, private front yards. The overall effect is uninviting, but also gives the impression that the houses are facing another direction. The other logical direction for them to be facing is towards the shared paths. Unfortunately, the ‘backs’ of the houses, the sides that front the shared paths, look precisely like the backs of houses. It turns out that the front doors of the homes are on the side, of
the building, located on narrow shared walkways between the buildings. The entrances are often difficult to find. This design flaw significantly reduces the sense of place on the street, because you don’t feel like you could walk down the street and see your neighbor unless she was parking her car. This impression of separation does not translate to social separation, however. Village Homes is the kind of subdivision with very few connections to the outside grid or street pattern, a quality that is currently out of vogue, but does yield streets that are safer for children.

Although Village Homes is not a prefect development it does serve as an exceptional example of a place that is designed to promote and support engagement with ecosystems. This is accomplished through the key features listed below, which may be taken as positive design examples.

**Key features:**

- Surface treatment of water runoff
- Solar orientation
- Unfenced yards
- Many trees
- Integrated home-scale agriculture, community gardens, and communal farm
- Lots of shared space
- Walking/Biking paths separated from roads and located between houses, where there are eyes on the paths
- Child-friendly design

**Learning Journeys**

When the Sustainable Food Lab, an organization devoted to promoting cross sector collaboration towards creating a full scale sustainable food system, first established itself one of its first steps was to take members (all high level representatives of food companies, non-profits, and government) on a learning journey. As Peter Senge describes them, learning journeys are, “expeditions taken in search of a new understanding of an issue or set of issues (Senge 2008).” In this case participants went to rural Brazil, where they travelled for long hours with people from sectors entirely different from their own to see the kinds of places where non-profit workers were comfortable, in smallholder farming villages and coops, and places where the corporate guys were comfortable, in large sugar plantations. In this way they not only learned about aspects of their industry that they’d never seen before, but also did it in the company of the kinds of people they would have to work with if they are to create large scale sustainable agriculture systems. They learned to see reality through each other’s eyes.
The concept of learning journeys can also be used in urban design and education about natural systems. Field trips are one kind of learning journey, and the city can also be designed in such a way that it invites exploration into its functioning.

**Practice: Engagement with Ecosystems**

When we think of examples of ecological engagement and feeling of non-dualism with the ‘natural’ world two questions come to mind. First, what is natural? And second, aren’t farmers and fisherpeople and others who truly live off the land the only ones with real connections to the natural world. There are many different conceptions of what ‘natural’ means [Spirn 1998], but from a practical point of view humans are part of ecosystems and are indeed non-dual, or not separate, and cannot be accounted for separately [Berger 2006; Alberti 2008]. Therefore, strictly speaking, every human experience is an experience of engagement with ecosystems, though it might not feel that way. In this thesis the variety of ecosystem engagement that I am focusing on is that which makes one aware of non-human controlled or motivated processes. Though we might think of farming as human controlled and motivated it relies heavily on the farmed species controlling its own growth and fruiting because of its own built-in motivations for growth, life and survival of its species.

Ecological connections can come in many forms, from seeing a ray of sunlight coming through a window to living intimately off the land. There is a continuum of experiences of the natural world that vary in their intimacy with the natural world and in the degree of wildness encountered, and all of them can be called valid engagement with ecosystems, and all can be valuable in teaching or inviting people to care for ecosystems. People are often scared of the unfamiliar of uncomfortable, so it would be unreasonable to expect that someone who lives on the Upper East Side of Manhattan or the Bronx will be comfortable suddenly picking wild berries in the Himalayas or butchering their own game. That would probably be an abrupt and discomfitting experience unless they were introduced gradually to that kind of activity, starting simply, like with a guided nature walk through Central Park, or a deep connection with a poodle who wants to go hiking.

The degree to which our everyday employment and living situation put us close to ecosystems certainly has an impact on the availability of ecosystems to consciously engage with. If one is a farmer living in pre-industrial cottage living systems are constantly knocking at the door. The degree of societal and infrastructure development that we are surrounded with, where we live, and the degree to which our jobs require that we be inside [staring at computers] currently determine in a large part how frequently we will be able to reach out and interact physically with
our ecosystem, though this is mitigated somewhat by the accessibility of recreational activities, like sailing and horseback riding, that put city dwellers face to face with natural elements they might not really be able to control. If our cities are designed with the ecosystems and technologies that support us made more apparent, this daily separation will be less the case.

Design lessons

The simplest way to come face to face with natural systems would be to take off all of one’s clothes and walk into the wilderness, if you could find any that was intact enough to have all of the elements one needs for survival. Asking everyone who has a net negative environmental impact to do that is impractical for scores of reasons, not least of which is that very few people would be willing to do it. We cannot all be ascetics, and we probably won’t all go back to being farmers and herdsmen. The first and most obvious solution for accomplishing this is to bring ecosystems and ecosystem services back into the city, as we have seen in done in Village Homes, but this is not always practicable. Many cities are already built, and though a certain amount of retrofitting can be done we cannot turn them all into Village Homes; not even very dense versions thereof. We also do not want to sprinkle pocket parks all over the place and call the job of ecological connection done, because those parks are ecologically useless, have very little educational potential, are often irrelevant to the place where they are because they’re planted with generic non-native species, and lastly but most importantly they do not communicate that we are a part of an ecosystem. They are not connected to anything. They communicate that we are in control. What we need are ecosystems that communicate their own beauty and function, and our reliance thereon. In looking at each element and significant system that is expressed in the city, how we sense them, and how they can be highlighted in design, I have built up a body of recommendations for how natural systems can be more clearly communicated in city design. There are limits, however, to the ability of ecosystems to speak in ways that we understand. This does not reflect a failing on either side, but rather an opportunity for translation, feedback, and two-way conversation.

Engagement Meets Feedback

The next chapter addresses the ways that city dwellers can get feedback on their resource consumption, on the impacts of that consumption, and how this can serve to enable habit change towards more sustainable habits and behaviors. As in the case of awareness of systems and engagement with systems, there is some crossover between engagement with ecosystems and
behavioral feedback. For millennia our ancestors have gotten feedback on their actions from the natural world, and they got that feedback precisely by being deeply involved with and dependant on natural systems. This methodology has some margins of error in exactitude and possible interpretation, which are discussed in the next chapter, but if, for example, intensive farming leads to soil fertility loss, which leads to famine, the ecosystems is giving the farmers feedback, and the farmers, who are not stupid, understand the cause of the loss of fertility and may learn alternate farming methods, particularly if there is no more farmland available. In some cases, as in the US, farmland is plentiful and can be abandoned after its ruined (Dregne 1986), but this will not always be the case. The simplest kinds of feedback we get through engagements with the ecosystem come from activities like growing a plant, raising a pet, or opening a window and having wind brush against our skin. Let us now examine the case of feedback itself more fully.
The Bright Built Barn is equipped with a building management system that monitors temperatures in the spaces in the building and displays that information in a control closet or publishes it online.
The Difficulty Inherent in Learning about Natural Systems from Natural Systems

Natural systems are extremely complex. There are many academic disciplines dedicated to understanding them, like biology, physics, and medicine. The systems, though we are surrounded by them and they aren’t hiding anything, are not self evident to us. This has profound implications for our interactions with and participation in ecology, and for learning about natural systems. The most significant implication is that despite all our scientific knowledge we have very little idea of how “nature” works, or how we work as a part of it. We, ecologically, have no idea what we’re doing, though we’ve been looking at some signals from the natural world, and a lot of them are pointing to change and trouble.

It would be fantastic, and easy, if I could say that all we need to do to understand natural systems and build that knowledge into the city is to integrate each element and system in thoughtful ways. That is a wonderful thing to do, and would do a lot of good, but there would still be a great deal of error and generality in our understanding of how ecosystems work and we work within them, because we are not physiologically equipped to read ecosystems. We have yet to develop a network system that hooks us up to Gaia. Even people who rely directly on their own interactions with ecosystems for their livelihoods, like farmers and fishermen, are capable of and have brought about tremendous ecosystem damage. This is not only because of the pressures of globalization, but also because the systems they’re relying on are partially opaque. It is not in the interest of a fisherman or fishing village to cause the fish stock they rely on to collapse from overfishing, so they will not over fish if they can help it, but fish stocks do not announce themselves, so how can they know if they are over fishing? And if a village cannot understand their impact, how can one fisherman?

Natural systems respond to the activity of both individual humans and humans in aggregate, and with a time delay. When I drive my car I understand conceptually that CO$_2$ is being emitted, and that that’s bad for the environment, but I don’t see any effect. There is no tree that starts screaming, no poisoned bird that drops dead at my feet. Maybe in fifty years I will be a nomad...
in a desert in what’s now lush British Columbia, and I will kick myself for contributing to global warming, but because I don’t see any changes now it is difficult for me to understand the impacts of my actions, and to learn to change my habits. We are not biologically programmed to react to something we intellectually think might happen fifty years from now. We are much more likely to react to the present, and our present perceived needs and desires.

We need feedback

It would be very helpful if we, as organic creatures designed to have limited foresight, were provided with feedback on our actions and how they are affecting the systems that we depend on. We are of course getting feedback from natural systems now, but it is aggregate and time delayed, and as a result we don’t really understand it, and if we think that we do understand it we equally frequently don’t know what to do or feel so overwhelmed by the complexity and catastrophic nature of it all that we decide to just have a nice cocktail and think of something else. Either way, many of us are paralyzed and therefore making the whole situation worse. Lots of people are actually working on making us all ‘greener,’ but that does not represent the vast majority of people, and even people who are deeply involved in sustainability issues, could benefit from instantaneous, intuitive, individualized feedback. I want a tree that screams every time I forget to turn the bathroom light off, or possibly a tree that sings a nice reminder. The caveat is that the feedback must make me feel empowered and able to make a difference, not overwhelmed and impotent.

Another way to look at all of this is that we need to change our habits of action, which likely requires use of our stimulus response capacity. If we focus on changing our habits of action instead of necessarily changing habits of thought, the conclusions is the we need to be stimulated favorably when we behave sustainably, and we need to be uncomfortable when we’re behaving unsustainably. We need to make the unsustainable behavior harder than the sustainable behavior. The problem with this approach is that it is suspiciously like a ‘better mousetrap’ solution, and does not address the root of the unsustainable behavior.

Ways to get feedback

Let us look at the ways that we receive news and information about our relative sustainability, and the ways that we get feedback about our personal resource use.

As the Electronic Power Research Institute describes in their analysis of residential electricity
use feedback (Electric Power Research Institute 2009), types of feedback may be loosely grouped in to ‘indirect’ feedback, which we receive after consumption occurs, and ‘direct’ feedback, which is provided in real time. Below is a comparison of our current average state of feedback, indirect and direct ways that we may get feedback about natural systems through technology, or through biological systems and direct observation and engagement.

**Current**

Currently, much of the communication that we receive about the state of the environment is mediated. We receive it through the news media, blogs, reports, books, lectures, film and television, and the various social and peripheral medias that we spread around us. Very few of us gather data on ecological functioning, global warming, or resource efficiency. Personally, we are apprised of our resource use by the amount of money we are required to pay out for those resources. We pay for electricity, natural gas, food, fuel, transit, and commodities. In some cases there is also a social system that monitors and gives feedback about resource use, like the social sanction that convinced an MIT professor to give up his SUV, but this is spotty and badly documented.

One of the most detailed ways that many of us are given feedback about our resource use is through our electricity bill, which not only tells us how many kilowatt-hours we’ve used, but also shows a little graph of our past usage. This usage naturally varies with the seasons, which

Figure 35. Feedback Mechanism Delivery Spectrum

often require heating and cooling, which makes it difficult to tell if more voluntary usage is going up or down. Billing for utilities is indirect, because it takes place after usage. We do tend to pay for food, fuel, transit, and commodities at the time of usage, which implies that we are receiving direct feedback. The problem with this assessment is that the feedback we are receiving is purely financial, and does not give us any idea of the effects of our purchases on the ecosystem. Our current market economy does not account for the externalities of burning gasoline, strip mining, chemical production, power production, excessive tillage or fertilization, or any of the myriad ways that humans take shortsighted advantage of ‘freely’ available natural resources. As Paul Hawken describes in The Ecology of Commerce, economic systems can only give us the price of something, not the cost (Hawken 1994). Because the direct kind of financial feedback we receive at a gas pump is so heavily mediated (we never see the gas, it is not clear what taxation is for [Is it ecological restoration? No.] or what price variability is a result of), and tax is included in the cost of a gallon of gas, instead of added at the end of your purchase as with a sales tax, when one is more conscious of it, for the purposes of this inquiry I will consider it either indirect or irrelevant, unless it is increased dramatically enough to alter buying patterns.

Figure 36. Types of Feedback Available Through Technology and Biological Systems

<table>
<thead>
<tr>
<th>FEEDBACK TYPE</th>
<th>INDIRECT</th>
<th>DIRECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECHNOLOGICAL/</td>
<td>• News Reports</td>
<td>• The Energy Detective (TED)</td>
</tr>
<tr>
<td>MEDIATED</td>
<td>• Energy and gas bills</td>
<td>• Prius MPG reading, readout</td>
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<tr>
<td></td>
<td>• Enhanced bills with usage comparisons</td>
<td>• IDEO’s filling water shower display</td>
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<tr>
<td></td>
<td>• Delayed Taxation</td>
<td>• Lights that change color with usage</td>
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<tr>
<td></td>
<td>• Web tracking or estimates of your usage, requiring log-on or not</td>
<td>• Air quality reader</td>
</tr>
<tr>
<td></td>
<td>• Air quality reports</td>
<td>• Texts regarding current usage</td>
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<tr>
<td></td>
<td></td>
<td>• Augmented reality</td>
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<tr>
<td></td>
<td></td>
<td>• Congestion pricing</td>
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<tr>
<td></td>
<td></td>
<td>• Real time metering</td>
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<tr>
<td></td>
<td></td>
<td>• Immediate, highlighted taxation</td>
</tr>
<tr>
<td>BIOLOGICAL</td>
<td>• Ecosystem collapse and change</td>
<td>• Visual impacts and changes</td>
</tr>
<tr>
<td></td>
<td>• Smog</td>
<td>• Trash outside on the street</td>
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<tr>
<td></td>
<td>• Global Warming</td>
<td>• Canary in a coal mine</td>
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<td></td>
<td>• Droughts</td>
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<td></td>
<td>• Aquifer and reservoir levels</td>
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<td></td>
<td>• Salinization</td>
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<td>• Landfills</td>
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<td></td>
<td>• Increased fertilization needs</td>
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<tr>
<td></td>
<td>• Visual impacts and changes</td>
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<tr>
<td></td>
<td>• Windmills and hydroelectric facilities functioning</td>
<td></td>
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<tr>
<td></td>
<td>• Pollution sensitive plants and animals used as sensors</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>PERSONAL ENGAGEMENT</td>
<td>• Buying locally available food</td>
<td>• Visual assessment of environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Personal involvement in farming, gardening</td>
</tr>
</tbody>
</table>
Building Dashboard by Lucid Design for Oberlin College

This building resource use monitoring system, called the "Building Dashboard" is a product of Lucid Design that allows users to monitor their energy systems and water use in real time. It is currently being used by Oberlin College (Oberlin College 2010) to monitor the energy use in their dorms and to run a competition to see which dorm can use the least energy per person. The feedback is direct in that it’s real time, but it is also aggregate and mediated, so the experience of using it is not as personal and intuitive as it could be. Source: Oberlin College

This light, in the Bright Built Barn, changes color in real time with electricity usage. The light is green if the building is producing more electricity than its using, orange if net energy use is zero, and red when net energy use is negative. This is a perfect example of immediate, intuitive, unmediated feedback on personal usage. The barn is also equipped with electricity and hot water production and use sensors, which upload data in real time to the web in much the way that Lucid’s technology works, but in this case PowerDash provides the technology [Collins 2010].
Indirect technology

Indirect technological forms of feedback on resource use are the ones that we are largely familiar with today, as seen in monthly electrical billing, online usage estimates, and so on. News reports, books, videos, and the like are other ways that people gather information about the state of consumption and its impacts. Many of these reports are time delayed and necessarily report on aggregate impacts. If they are not delayed, like an air quality alert system, they reflect a state of the natural system that has already been reached because of aggregate action, and about which individuals can do little except take public transit and wear a gas mask. An ‘air quality approaching critical levels’ alert would be more actionable.

Direct technology

The concept behind direct technological feedback is to provide resource users with personalized, real-time feedback, at which point they can use that information to alter their behavior, and receive feedback detailing resulting usage and impacts of behavior change in an ongoing way. There are several examples of how this can be done, and there are infinite possibilities for design and implementation. In one simple example, a light or multiple lights can be installed in a building and connected to utility meters, and the light can change color with usage.

One version of this kind of light is installed in the Bright Built Barn (Collins 2010), and is described above. The light as installed in Bright Built has the disadvantage of only providing feedback on the direction of power in the building: into the building from the utility (red); out of the building to the utility (green); or neutral (orange). For this reason the owner and mastermind behind Bright Built, Keith Collins, said in an interview with the author [Collins April 9, 2010] that he isn’t really interested in the lights, because he knows whether or not he’s generating electricity by looking outside to see if the sun is out. He just keeps the lights off, except when guests want to see them. The fixtures employed are made up of red, green, and blue LEDs, however, which are capable of turning any color. This means that the light could be programmed to not only report on power direction but also the amount of wattage through

Figure 38. Direct Feedback Delivery, designed by IDEO

As the user showers a sensor monitors water usage and the digital bottle on the shower wall fills given usage. This product is still in the conceptal stage. Source: Dennis Frenchman
a more nuanced spectrum. For example, a red light could mean that lots of power was flowing into the building, a yellow light means that the building is at net zero energy consumption, and a blue (farther on the spectrum from red than green) light means that the building is supplying lot of energy to the utility. As the intensity of power flow moved from static to one end of the extreme of possibilities the light could follow the gradient of colors between, for example, yellow and red. The awareness of the amount of power flow could be quite interesting to Collins, and would partially obviate the need to look at the power readings that are constantly updated on his web site and home control device. For users without advanced photovoltaics like the ones on Bright Built the lighting system could simply display varying rates of usage. That kind of feedback system would be both extremely intuitive and information rich.

There are also digital monitors available that can display precise usage information, like ‘The Energy Detective,’ (Energy Detective 2009) which monitors electricity usage in real time and provides users with price and volume data on a small digital screen. These monitors are useful, but not particularly compelling or intuitive in their method of communication. Another popular concept for discouraging usage in real time is on-the-spot taxation or tolls, like gas, snack and tobacco taxes or congestion tolls. These measures are potentially useful, but they represent a ‘stick’ approach as opposed to a ‘carrot’ approach. Taxation does not invite consumers to become more educated about the impacts of the choices they are making, and to modify their choices freely. Instead taxation is the result of decisions that have already been made for the consumer by the government. I do not mean to imply that I don’t support European-level gas taxes. I do, but the difficulty with them (besides temporary political infeasibility) is that they do not change the root desire of the behavior they are trying to stop. They don’t change people’s minds, just their willingness to pay.

I have mentioned only a few examples of technologically derived direct feedback, and one of the reasons for that is that much of the technology for both sensing and data communication are still under development. For example, Shwetak Patel, a professor of computer science and electrical engineering at the University of Washington, has developed sensors that can be attached
to existing water, gas, and electricity lines (Greene 2009). These sensors, although plugged in to only one point in the system, can detect subtle fluctuations in the system caused by specific sources. For example, the water sensor can tell the differences in vibrations caused in the water system by a kitchen sink or a toilet flushing. It can even tell the difference between particular toilets in the house. The implication of this technology is that a single device can track the utility usage of every piece of equipment or outlet in the house, with an accuracy rate of 95.6%. For gas, water and electricity one would need three devices, which is extraordinarily simple. These devices could be routed through an analysis program that evaluated the resources used by piece of equipment, time of day, time of year, same time last year, and so forth. This data could be used to build up a resource use profile, which could be used as a baseline dataset to develop behavior change goals and guidelines, and it could be sent to a regional data collection center for regional analysis and display. The data could also be used to feed into intuitive feedback displays, like the changing lights mentioned above. I anticipate that sensing mechanisms will mature quickly, at which point high quality feedback will be simply a matter of developing well-designed user interfaces.

**Biological feedback mechanisms**

Biological systems, as discussed above and shown in Figure 36, do not generally respond to us individually, unless we are looking at a small part of a system, like a houseplant. Systems respond to us systematically, that is, in aggregate and with a time delay. We can see these responses in myriad ways, from aquifer salinization to habitat shifts and global climate change. These are indirect feedback mechanisms, and very few direct mechanisms are available, although there are a few natural sensors that we can rely on, just as miners did with canaries in coal mines. Canaries are more sensitive to air pollution than humans are, so miners used them as pollution sensing devices. If the canary died in the mine, the miners knew to get out.

It would be particularly interesting to look at developing biologically based or powered sensing and feedback mechanisms, like floating PH meters in polluted water or screens that changed colors with air quality. Perhaps the Biomimicry field will provide more of these solutions (Benyus 2002).

**Involvement and education**

One of the most interesting ways for us to receive feedback that speaks to us individually, even if it is aggregate feedback, is for us to observe the environment around us. For us to be able to read the environment effectively enough to glean meaning from it, we need to be educated about
its functioning, which will, hopefully, make us more interested in observing and preserving that functioning.

In aspiring towards more direct, intuitive feedback the distinction must be made between technological feedback methods and biological ones. For example, there is an intuitive difference between looking at dials, like those in a power station control room or even on private electricity meters, and watering a drooping plant and watching it perk up again. Both experiences can be categorized as immediate, direct, and fairly intuitive feedback, but the more physically engaged experience of watering the plant is more kinesthetic and leaves one with a feeling of connection to the plant, whereas adjusting some dials on a power station control board in response to dial readings could leave one feeling plugged into a machine instead of the physical world.

**The Live Building**

At Queen’s University, in Kingston, Canada, they have what they call a ‘live building.’ It is also known as Beamish-Munroe Hall, and was built in 2005. The building is built to be a living lab for students of engineering and sustainability in the built form (Queen’s University 2010). Its mechanical, electrical, and structural systems are embedded with sensors and are monitored in real time. They are also exposed in some cases so that, as I have been suggesting, the guts of the building and their functions in the building are plain to see. Data from the

![The Live Building, Queen’s University](image-url)

The building incorporates different kinds of facade glass for thermal transmission testing, a green wall that filters air through itself, and numerous cutaways that reveal the structure of the building. (Source: Queen’s University 2010)
sensors, which are embedded in walls to sense temperature and in many places in the electrical system, is available in real time online and in labs. The entire building is an exercise in communicating about itself visually, physically, and virtually. It not only informs students of the systems that it embodies and is a part of, it also provides rich feedback about aggregate and specific locational electricity uses. The data is not personal, and at times it is useful more for comparison and study, between different kinds of window construction, for example, than it is for behavior change in the moment. The intended behavior change, being a working engineer who has an in-depth appreciation of issues of sustainability as they relate to the built environment, would presumably be in evidence after students entered the workforce. The building is an extraordinary example of a built combination of educational structure and meaningful feedback. The feedback is not displayed in a particularly intuitive way to the outsider, but is available at a number of real-time graphs and available data downloads over the internet.

Scales of feedback

Thus far I have largely been discussing sensors and feedback mechanisms that measure individual resource usage and offer individual feedback, or feedback to a small group, like the group of people living on one floor of a college dorm, as in the Oberlin College case. The scale of both measurement and feedback discussed has been at the level of the individual. Individual feedback is clearly advantageous because it can help to inspire informed and targeted personal behavior change, and I have largely been discussing the ways that design can be used to facilitate individual knowledge, engagement, and feedback about the ecosystem’s functioning. As I have mentioned, aggregate feedback and feedback directly from the natural world can be difficult to understand and to translate into behavior change. This is not to say that aggregate feedback isn’t important, and can not provide us with a vital picture of our impacts. Feedback can happen and is valuable at a variety of scales, from the individual to the population of a bioregion.

One of the most adaptable and promising ways that data can be gathered on the health and functioning of many human built systems, like utilities and factories, and natural systems, like bird breeding colonies, is through distributed sensor networks (Olson and Rejeski 2005). The sensors designed by Shwetak Patel described above are one example of a distributed wireless sensor network. Such sensors are usually quite small, and are equipped with a radio frequency emitter and a power source, like a battery. Distributed sensors can be used for many things including sensing temperature, humidity, vibration, atmospheric pressure, light and pollution. For example, these sensors are being used to monitor endangered nesting birds in Maine. They are the size of matchbooks, and are placed in nests. They transmit occupancy data, deduced by
temperature sensing, back to scientists, who now no longer need to disturb the birds to get head counts (Olson and Rejeski 2005). This system is providing a translation of biological feedback/data to scientists, which could be the key to unraveling some of our difficulties in understanding the natural world. Distributed sensing systems have many possible applications, and can be used to provide data for individual or aggregate feedback, or simply data on the functioning of systems that we don’t yet understand our impact on. Easily accessible aggregate feedback on subjects like air quality or local water pollution has the potential to perform the same function for larger populations that I claim individual feedback has for individuals. Larger populations shifting to more sustainable behavior without very specific individual feedback would be wonderful, and is happening in many parts of the world as countries strive to lower their carbon footprints, and this process can be aided by supplementary individual and collective feedback.

If we are to design widespread ecological and resource use feedback mechanisms, one of the most important requirements of those systems will be that they do not overwhelm the end user. The feedback must be a way to make sustainable behavior easier and more pleasurable than unsustainable behavior. The feedback must not nag, depress, or cause existential collapse (leading to the user turning off the feedback supply) in the end user. I expect that steps towards sustainability and integrated feedback must be taken gradually so that they are not rejected outright. This might mean that a development is wired to give feedback on electricity use one year, and natural gas usage the next. Whatever the case, I don’t believe that houseplants that scream when you leave the bathroom light on are the answer for beginning feedback recipients.
CONCLUSION

One of the trickiest distinctions to make about this thesis is that the goal is to examine ways in which people can be encouraged to adopt more ecologically sustainable behaviors using city form as a communication tool, but it is not to discuss the ways in which city form can be made more sustainable. The subject of how cities can be structurally more sustainable is deeply important, and is focused largely on design solutions that make the behaviors of city users more sustainable by changing what they are using, not necessarily by changing them. I want to change the users. Though I am making the distinction between creating communicative environments and creating intact ecosystems, the nuance in the distinction lies in the fact that intact ecosystems have the potential to be excellent communicators, particularly if we can highlight certain functions so that we understand them, or if we can learn to understand them better as is.

There is also a difference between places that are clearly related to their ecosystems and places that are rich in feedback. Parts of this difference come from differences in technology, which can offer more intuitive (for humans) kinds of feedback, however the larger difference springs from the communicativeness of the place. Do we understand our relationship to our environment and to the resources we use every day? A street tree will not help clarify that relationship, nor will a beautifully designed and engineered, ecologically responsible sewer system if no one can see it, and no one understands how it works. We can build LEED buildings until the cows come home (or suffocate us with methane), but if the buildings don’t communicate the value of sustainable habits and the mechanisms behind how they work it will be impossible for us to effect the kind of massive societal behavior change that is imperative if we are not to severely damage the planet that we depend on, and ourselves in the process.

In Chapter One I discussed the importance of human behavior to sustainability, particularly the importance of individual behavior. Individual behavior, though it is certainly influenced by policy and legislation, and can be directly manipulated by physical design and technology, is also largely a product of personal choice, conviction, and training. Personal choice and commitment is therefore extremely important to the project of making humans a sustainable resident species of Earth, and I describe my model, derived from systems thinking and psychology as well as knowledge of design processes, which represents the possible paths from unsustainable to sustainable behavior, which are societal collapse, legislation, technology, and behavior...
change. These paths are all part of one system, however, and are not necessarily alternatives to one another, but are instead cofactors that may interact with one another. Voluntary behavior change, which is the focus of the thesis, due to its importance and the fact that it is often overlooked in many design solutions, is a product of ecosystem knowledge, engagement, and feedback. Fortunately, these three factors, which are separated here for the sake of clarity and discussion, but which also bend together and depend on each other, can be provided, at least partially, through skillful urban design and technology. I go on to describe the foundations of this model in system dynamics, environmental and conservation psychology, and to relate how, in my personal experience as well as scientific literature, kinesthetic experience in conjunction with knowledge can create trigger experiences that dramatically shape behavior, in this case due to a desire to foster sustainability. The following three chapter contain in-depth looks at each of the compounding factors in the choice to adopt sustainable behavior.

Chapter Two addresses knowledge of the ecosystem by looking at the ways that cities communicate using physical form, and how specifically they communicate about natural systems. I use a building in Cambridge, MA, and Boston, MA as examples. Because current communication about natural systems is inadequate and overwhelmingly conveys that humans are in charge of natural systems, I investigate how one might create a communication system that uses city form by examining how precisely we sense each element and system that we could be aware of in the city. This information can be used to craft new design solutions that appropriately trigger multiple senses to recognize and enjoy the presence of natural systems. Chapter Two includes a case study of Disney World and Celebration, FL, where largely artificial and arguably unsustainable environments are crafted in such a way that they are extremely evocative of natural systems, and are powerful examples of how designers could communicate non-verbally.

Chapter Three, in which I discuss engagement with ecosystems, details not only the importance of kinesthetic experience of nature, which leads to a non-dual conception of humans in relation to ecosystems, but also examines each element as it presents itself and is presented in cities and finally offers design suggestions for incorporating elements into city form. This is accomplished by drawing examples from photographs of cities around the world and through verbal analysis. Village Homes, in Davis, CA, provides a case study of a community where the ecosystem and engagement with it is around every turn, though it is only one example of such a community.

Chapter Four focuses on the importance of feedback when one is in relationship with the natural world, and on the difficulty that humans have in understanding and responding to the unmediated feedback that the natural world is constantly giving us. This difficulty springs primarily from
the fact that natural feedback is generally aggregate, not always localized, certainly not individualized, and appears with a time delay that makes it difficult for human brains and relatively short attention spans to comprehend as an actionable system that they are actors in. There are additional scientific breakthroughs that need to and will be made as part of our process of understanding our environment. In conjunction with that increased knowledge, but also independent of it, there are many existing and emerging technological solutions to how to provide direct, intuitive feedback on both individual and collective resource use and impact, as well as the general health and status of our ecosystems, whether or not we understand the factors leading to that status. It is also possible, perhaps through biomimicry, to develop naturally based feedback mechanisms, and to simply develop our own sensitivity to our local ecosystems and what we can learn from their changes.

The following two sections address the implications of this argument on the suburban form, and offer a vision projection of what cities might be like if they strive to promote voluntary sustainable behavior using my model.

Nature in the Suburbs

There is a slight uneasiness that can emerge from the application of the recommendations for creating spaces that provide education, connection and feedback with and about natural systems, and that is that if the best way to learn about nature is to be in nature, then the ideal form could be suburbs or exurbs. When one lives in a town like Concord, Massachusetts, one often has a large lot, and drinking water comes from a well out back. Everyone else has large lots, as well, so the overall effect is quite natural (in the sense of ‘nature without or unaffected by humans’). Residents have every opportunity to observe natural systems as work in their town and back yard, and wouldn’t dream of using artificial fertilizers or pesticides on their lots because they drink the water that comes from those lots. Many people move to the suburbs precisely because it gives them the opportunity to be surrounded by and perhaps feel a part of the ecosystem. Access to all of that green space also has innumerable health benefits and is a great stress reliever, which many people sense and are drawn to. So, a suburb is a great place to be aware of and connected to natural systems, and would therefore cover two of the three steps towards behavior change towards sustainability. However, suburbs also require that residents drive almost everywhere, which, given our current car fleet, is inherently unsustainable. So, suburbs are apparently not powerful enough in making people change their behaviors to discourage them from driving, so they could represent a flaw in my argument.

Suburbs also represent a conundrum because if they offer the very connections that change
behavior towards sustainability, and yet are not sustainable themselves (because of the driv-
ing; long roads and large patches of impermeable surfaces; habitat fragmentation, destruction
and alteration; large houses that require lots of heating and cooling; pets [especially cats] that
slaughter wildlife; long and inefficient utility lines; social and economic inequity; and invasive
species that they are associated with), then perhaps a suburb is the kind of place that, after you
live there and it teaches you to love the environment, makes you not want to live there any more.

I have two answers for these problems. One is that suburbs do not accurately portray the larger
ecosystem with humans incorporated into it, nor do they currently provide residents with feed-
back on the impact of their resource uses. They are like fairylands, where all the unpleasant-
ness of producing whatever the residents of the suburb need takes place far away and out of
sight. Shiny new BMWs or Priuses do not bring with them the mines, oil rigs (some exploding),
steel mills, cows for leather, refining, manufacturing, and labor housing that is necessary for
their creation. Roads are put in and covered with smooth pavement that does not some from
suburban land, and which covers utilities and electrical lines that lead to plants and power sta-
tions out of sight, and out of mind. This represents a gap in the communication of the suburb.
Residents then are not experiencing the whole reality of the ecosystem condition; instead, they
live in a beautiful urban design fairy tale, which gives the impression of living a simple life in the
woods, and somehow adds modern convenience. If the suburb presented the whole reality of the
system it is a part of, people might indeed not want to live there. Additional feedback on re-
source usage and overall ecosystem health might also deter people from moving to the suburbs.

I am not proposing that we erase all suburbs tomorrow. It isn’t possible or practical to do that. In
the near term I do believe that feedback mechanisms and all of the `better mousetrap` solutions
that we can think of, and which are actually effective, should be applied, not least important of
which is non-polluting transportation. In the longer term we might find that a gradual drawing
in of the boundaries of development in suburbs, with attendant densification and infilling of their
centers, might be an appropriate response to the increasing need to live sustainably. The kind
of significant behavior change that this would require of suburb dwellers is precisely what I am
developing the tools to facilitate.

In order to explore a variation on the theme of how one can reform suburbs I have examined
Stagecoach, Colorado, an unbuilt suburb near Steamboat Springs. A full project description,
site analysis, and design proposal are to be found in Appendix: Stagecoach, CO. The benefit of
this case is that it represents an holistic evaluation of the site and its ecosystem, and sculptures
development around that, while providing residents with access to wild areas. The disad-
vantage in the context of this paper is that, like any very specific plan, it does not represent an ideal
development or the whole answer to all of the design questions raised here. The following is a projection of how life might be, and what kinds of interventions might be made, if education about the ecosystem, engagement with it, and feedback from it, are truly built into urban form.

**Vision Projection: The Emerging Tomorrow**

We will not all become like the wild animals we once were and return to living in caves. Rome wasn’t built in a day, and we will not build, retrofit, or inhabit sustainable cities tomorrow, nor will we abandon the cities we have. We should not waste the energy we have already invested in our built forms. We can move quickly, but change towards sustainable behavior and cities that support and encourage it will be an incremental process nonetheless. We are very good at rapid technological change, so perhaps feedback delivered by technology will be one of the first of these recommendations to emerge. Of course this doesn’t represent a final solution, and as Judy and Michael Corbett, developers of Village Homes, reflect, “We have assumed our wealth, technology, and ‘problem-solving ability’ can bail us out of any new problem somewhere down the road. But technology and ingenuity have not bailed us out. In fact, we find ourselves deeper and deeper in a quagmire of environmental and social problems.” (Corbett and Corbett 2000)

First, I will begin to receive a weekly email from the companies supplying my water, gas, and electricity telling me, in plain English and with simple charts, what my usage has been that week, what my general trends of usage are, and possibly how they compare to my neighbors. If I’m doing well, I get a smiley face, and maybe even a star. If I’m doing badly, no comment will be made. Soon, a small panel of lights appears next to my front door and in the kitchen that updates me on my utility usage in real time. The lights are programmable, so I can have whatever colors I want, and with a push of the button they also display my weekly and monthly usage trends. I install a switch by the front door that shuts off everything in the house that doesn’t need to keep running, as the refrigerator does. The John Hancock Building in Boston installs beacons at each of the four corners of its roof that signal the aggregate level of carbon emissions produced in Boston. A similar light is placed at the top of Cambridge City Hall, and many other city halls across the country. Soon, news stations begin reporting on the day’s air and water quality and general habitat happenings with the morning weather. I can directly access the data being collected from the sensing networks that feed these news stories, along with analysis of the data, through the watershed website. Watersheds have become the new default planning areas, because planning by city and country just didn’t make sense as a way to plan for ecosystems health.

There is (in 2010) an overwhelming impression that is broadcast through the marketing,
accessible credit, and media that covers the rich and famous that yes, we can have everything. We can all have huge houses in the suburbs with pools and lots of cars to put into the multiple garages. We can all live alone. We can have virtually whatever food we want, whenever we want, wherever we want. Especially in New York. New York City is dense, so its per capita carbon footprint for transportation is relatively low, however, if one adds the carbon footprints of everything consumed in New York (like fresh Tropicana orange juice shipped up from Brazil and Florida), the picture changes. Gradually, life becomes more modest. Small is the new big [Cardwell 2010]. Products that last are the new high fashion. Fewer people live alone in the US, and more people have begun living with their families after they reach adulthood, as they still do in many countries. As the old, large style of fire engine gets retired new, smaller engines replace them. Roads have already begun to narrow. I step out of the front door of my row house onto a small porch. I scan a QR code [Denso Wave Inc. 2010] on the banister and learn that the wood is pine, and was recycled from an 1850 warehouse in Boston harbor in 2015. A small pot of herbs attracts bees that live a few blocks over. A baby swallow sticks its head out of a nest on a beam above the porch, considers the bee, and poops on the basil. The path leading to the sidewalk is made up of permeable pavers with little tufts of groundcover growing between them. The pavers are marked with a small ‘7,’ their permeability rating. They are 70% permeable. The path crosses a small swale to the road, which is embossed with a ‘5’ every twenty feet. Trees line the road and drink from the swale. When the road was retrofitted the ground underneath it was so compacted that in order to plant trees successfully the contractors brought a combine through to lighten it all up. We don’t use heavy machinery like Caterpillar D9s in construction any more. Once, after a rain storm, I followed a trickle of water from the overflow of my rain barrel as it ran into the swale. It was a weekend, so I followed the swale as it ran along my street. I followed the rain from my roof as it joined with other water, passing under streets and through swales on the way to a stream. The swales opened up in a few places to ponds, where water slows, pools, and absorbs into the soil. Some of these pools have water in them year-round, and they provide rich habitat areas, and are the focus of many neighborhood parks. Occasionally there is a micro-hydro dam at the end of one of these pools, with a little fish ladder next to it if the stream is year-round. I pass the local sewage treatment plant, a large greenhouse with subsurface wetlands outside of it, richly habitated by native water-loving plants. Much of our animal food is grown in that greenhouse, and in some places they also cultivate food for human consumption using nutrients from the sewer. I kept walking, and discovered that I could follow the water from my roof all the way to the sea. I could see and sense the natural water system, and the systems that were attached to it all along the way. My neighbor said that every year school children do a similar walk from their school garden to the sea.
The inside of my block, lined with row houses, has been converted into a common area, with space for sitting, and space for gardening. Everyone has a little rack to attach plants to on their back fire escape. There are laundry lines on the shiny roofs. An increasing number of buildings are fitted out with green roofs and harvest rainwater for garden irrigation and use in showers and so on. These green roofs, and sitting areas surrounded by native plantings, provide habitat for native bird species and flowers for bees to cultivate, which gives them a break from the feast-or-famine cycles that come with monocultures like fields of cherry and apple trees. The bird watching is great from my back porch, and local honey is collected and sold at farmer’s markets. Access to this local honey is very helpful for allergies, because it contains digested local pollen, a common allergen. Many buildings contract out with a local farmer for their roof garden care and cultivation. If the farmer can grow crops on the roof the fee for maintenance is decreased, and the farmer sells the crops to local residents and restaurants. All food now comes with recycled, biodegradable tags that allow eaters to track the food from seed to table. These tags are printed with QR codes as well as plain English, and if one wishes all personal food data can be aggregated to create maps of individual food sheds, as well as nutritional information.

Suburbs are increasingly densifying, and many houses are now subdivided, just as old houses are in larger cities, like the big Victorians in San Francisco. Suburban roads have been narrowed and the soil underneath, which was often rich farm soil to begin with, has been remediated for naturalized drainage, and for increased habitat and gardening area. The federal government has recently initiated a program that significantly subsidizes moving expenses for families who own houses that are over one thousand square feet per resident, and who are moving to houses with less than 800 feet per resident. It’s much like a ‘cash for clunkers’ program designed to take unfit and inefficient buildings out of the housing pool. The government is given the first option to buy the outsized house, and in many cases in which that house is a McMansion that wasn’t built to last the government simply takes the house down and landbanks the land or builds something modern on it. In other cases the government divides the house. The government also offers classes in sustainable living that mirror those taught in schools, and runs robust retrofitting programs which entail education of the occupants as well as improving physical structures. Because we have sensing nets that cover the utility use of most units we can see that utility use is dramatically lowered by the retrofitting programs and by education programs. The two together have the most benefit, of course.

New buildings are now built with separate taps with filters on them that ensure the water coming through the faucet is sterile. There’s no need to sterilize every drop of city water any more, we just drink the water from the drinking water tap, though it’s all filtered and perfectly safe. I
heard on the news that the fluoride level in our watershed was dropping, and salmon run numbers are up. All those chemicals really stupefied the salmon. In school we had two fish tanks filled with naturally filtered water. For two weeks we replaced the water in one tank with traditionally treated municipal water, filled with fluorides and chlorine, and the fish in that tank got really slow. The catfish died, and we cut the experiment short. This kind of action learning is increasingly common.

I live in an eastern temperate climate, where it gets quite hot in the summer, so the central staircases of many buildings have been adapted for use as central wind towers. Small towers with aerodynamic roofs are placed above the central space, and when the wind blows a vacuum is created that draws hot, stale air out of the building. New buildings are all built with this feature, as well as better solar orientation for winter heating. In hotter climates buildings are built closer to each other so that they give each other and the narrow roadways between them shade, and many buildings are built around small, densely planted courtyards with small fountains in them that cool the air through evaporation and cool the mind with their sound. Streets generally do not have non-native trees along them in the desert, because they waste irrigation water. We have taken the thoughtful, decorative, evocative, and climactically relevant aspects of native architecture from all over the globe and created patterns that work for specific localities. These patterns are used to update ancient buildings for modern living, and to build modern buildings that benefit from the knowledge of the past.

Everyone generally gets around by walking, riding their bikes or a shared bike, or by taking the tram or train. Busses were phased out years ago because everyone hated riding them. Some people have small personal cars that are stored in large car filing buildings, and many people use car share programs, especially if they need to move a couch or something. Cars contain graphic displays of minute-to-minute, trip, and aggregate energy per mile used, which helps to keep fuel costs low, as does the fact that they’re all plug-in hybrids or simply electric charged off of solar and biomass production units. Many cars also have solar roofs, and all of them are equipped with sensors that detect road beds, and objects in the road. They can communicate with other cars in the road travelling in both directions, which means that roadways can be much narrower and still quite safe, because cars can navigate around each other and pass within a fairly close distance to one another. Communication between vehicles, and with the centralized traffic tracking system, means that traffic moves much more smoothly than it used to, and jams can be easily avoided. All cars have GPS capabilities, so trips can be programmed in and don’t require much “driving” from the driver at all. It is possible to manually control the car, but seeing through the car’s information and performance tracking panel how inefficient that is compared to automation means that most people opt to simply enjoy the ride. For long distances
we take high speed trains, sometimes with our cars on board, and if we need to cross the ocean there are ships. Few people fly, and certainly never for short hauls, because ticket prices now include the cost of remediating the atmosphere after all that fuel is burned in it. Even flights on planes which run on switch-grass derived bio fuel are expensive.

After globalization hit and we began to realize the ecological ramifications of all of our trade and consumption, most city life has become more locally focused. Both QR codes on products and price let us know where items were produced, by whom, and what manufacturing methods were used. Everything in the developed world is produced using cradle to cradle (McDonough and Braungart 2002) methodologies. Humans are still basically the same. Our number has stabilized, but we still have kids, forget to do the dishes, and go to work. We are working towards a future of elegance, graceful integration with nature, and joy. We cultivate creativity and tasty heirloom turkeys (Carpenter 2009). Because everyone is often being gently reminded of their connections to our collective history, the state of the present, and our trajectory into tomorrow, society as a whole has developed an increased commitment to mindfulness, happiness and community. How much do I need, and what can I contribute to make the city richer and more alive?

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I have developed a behavior change model that details how urban designers, planners, architects, landscape architects, and indeed members of any discipline that has a hand in shaping urban form, can lend their expertise and creativity to the project of making human existence within the global ecosystem more sustainable, by increasing individual motivation to be personally, and collectively, more sustainable. As I have written, the three key elements are an intellectual understanding of ecosystems, a feeling of connection with ecosystems, and feedback from the ecosystems. I have offered some suggestions and frameworks for how this can be accomplished through design. Designers can look at specific elements, like the earth, understand how humans experience the earth and what might trigger an acknowledgement of the earth, and incorporate those triggers into the design. This can be done for any element or sense, and can include both intellectual and kinesthetic stimulation, thereby creating a multi-sensory experience of a living ecosystem that one is a delighted part of.

I do not claim to have created a fully formulated or complete design solution that answers the question of how to put this theory into practice, though each of the chapters on the key factors of behavior change offers some solutions. I do not believe that there is one answer to the question of how we should design cities what promote sustainable behavior, or even how we should
design interventions for each factor. Though I have detailed a specific theoretical solution for behavior change there are infinite design solutions and applications, and it is the role of designers to envision applications of the theory that are appropriate for the specific design problem they are addressing. I do not have every climate, city, or culture within my purview. I bow to the creativity of others and my future self in the hopes that we will come up with more solutions than those I have mentioned here.
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In this appendix I will describe some work that I have done, concurrently with writing the thesis, as part of an academic urban design and planning workshop. The workshop, focused on a largely undeveloped subdivision in Stagecoach, Colorado, has given me the opportunity to further investigate the ideas in the previous four chapters by applying them to an urban design project. I describe the context and process of the project, research and resulting physical plan, as well as the ways that this case relates to the ideas in the thesis.

**Geographical and historical context**

Stagecoach, Colorado is a small development 16 miles south of Steamboat Springs, which is a 25 minute drive. Stagecoach was originally established in 1972 as a ski resort. Developers cleared ski runs and roads, and platted out 1,500 lots, but within two years the resort failed and the developers went bankrupt. Stagecoach hasn’t changed a lot since then. The main entry road to Stagecoach brings you along a river to the bottom of a valley where there is a large reservoir (2.67 miles long) close to the ski run base. From there 2,000 platted lots run up a beautiful mountain valley for more than 6 miles. Only about 200 lots are developed and now contain single-family Colorado ranch/ski style homes, and a few condominiums at the base of the ski hill. Some landowners own large chunks of Stagecoach, and many lots are owned by individuals.

As one of a group of six students I developed an urban design and development plan for the town of
Stagecoach represents both a unique condition and the pervasive phenomenon of unbuilt subdivisions in the American west. Stagecoach has its own history, geography, economic context, and political climate. The site is dramatic in many of its features, including its scale, openness, and geological drama. However, unbuilt subdivisions are a problem throughout the intermountain west. They have dodged the worse fate of being built, foreclosed, and abandoned like many suburbs in California, Phoenix, Denver, and many other cities (Egan 2010). But they represent a dramatic over-entitling, which could lead to future overdevelopment. In Arizona’s Sun Corridor approximately one million lots have been entitled, and Teton County, Idaho has entitled enough land to quadruple their population (Lincoln Institute of Land Policy – Sonoran Institute Joint Venture 2009). It is not clear where all the residents (or fourth home owners) could come from, or how all these lots could be developed sustainably. Our assumption is that they simply can’t be built sustainably, and we set out to answer the question of what to do with them.

**Project Goals**

There were five goals that the team set forth on starting the project. In design terms, the overarching goal of the project was to create a plan that is both deeply sustainable and creative. Deep sustainability means that we did not focus solely on one aspect of sustainability, but strove to be ecologically, socially, and economically responsible. We also wanted to be creative and to look at proven but not widely implemented methodologies for arriving at sustainability. The site represents a cookie cutter pattern of development from the 1970s, and we wanted to not just break the mold but also reuse and recycle the best parts of it.

The five specific goals of the plan are to pursue ecological responsibility and the existing appeal and ecological functioning of the site, create locally relevant design, develop housing that is affordable for middle and lower income residents of Routt County, and to understand the issues inherent in addressing unbuilt subdivisions. The goals are described here in detail, and are followed by our plans for fulfilling them.

**Ecological responsibility**

Planning for ecological sustainability has different meanings and implications for different places, particularly when they are developed in different ways and to varying degrees. Understanding ecological sustainability in a given place requires understanding the past and present uses of the site as well as present and future development pressures. In the case of Stagecoach, the
site from the air looks almost pristine, with the exception of some winding dirt roads and a few houses scattered around. As a team we are disinclined to cover mountain greenfields with new single family housing, but if one looks at the legal designation of Stagecoach that is precisely what exists there, therefore we developed a plan that is as ecologically responsible as possible, given that the land is significantly entitled and more homes could legally spring up there at any time.

**Preservation the appeal of the site**

In preparing a plan for the development of Stagecoach the team decided that preserving the existing appeal of the site, which includes naturally functioning ecosystems and a plethora of recreational opportunities, was of paramount importance. Residents to not move to Stagecoach when they are looking for the business and nightlife of a city. They move to Stagecoach because it provides a strikingly beautiful mountain environment, with lots of open space to play in and look at, and a small town feeling. We set out to create a tight-knit town fabric that celebrates its location in the Front Range.

**Local design relevance**

As Duerkson and Van Hemert note in *True West* (Duerksen and Van Hemert 2003), the west, particularly the Intermountain West, presents a different kind of space and requires different design solutions than are found on the East Cost or in the Midwest. The West is generally very dry, and is characterized by wide-open spaces with unique, dramatic scenery, high altitudes, and geographic extremes. Almost half of the land is owned by the federal government, and the history and embedded culture is quite different than the East Coast. It is cowboy and Native American country. We determined that we would design a locally relevant and historically rooted town.

**Affordability by middle and lower income residents of Routt County**

One of the regional roles the Stagecoach plays now is as an area that is appropriate for affordable housing, broadly defined as housing that middle and lower-income residents of Routt County can afford. Steamboat Springs, the nearest significant city and locus of much of the regional employment, is deeply unaffordable, with average home sale prices at about one million dollars. Steamboat residents recently voted down a measure that would expand the developable area of the city (Lawrence 2010), so Steamboat isn’t going to begin growing or becoming more affordable in the near future, which leaves a strong market for housing for service and professional workers. We would like to provide those folks with reasonably priced housing.
Providing Green Transportation

Part of the difficulty inherent in housing workers in Stagecoach instead of Steamboat Springs is transportation. There is currently very limited public transportation between the two, and increased service isn’t currently viable. This means that workers will either work in Stagecoach or commute, probably by car, to Steamboat Springs. This fact is one of the major obstacles we face in creating an ecologically sustainable development. Our solution is to provide a $10,000 credit towards the purchase of one of a list of approved low-emission, hybrid, or electric cars with the purchase of each housing unit. Fortunately, Stagecoach is a great place for solar energy generation, so many cars may be charged using photovoltaics.

Method of analysis

Our initial step in forming our plan and recommendations was to begin to understand the site through analysis. We used a multi-faceted approach to analysis, and examined the site, and the region, if appropriate, from seven points of view, including: spatial & environmental; transportation; market and economy; building technology; political environment; and policy contexts. The method of inquiry for the spatial and environmental research is detailed below.

Spatial & Environmental

The goal of the spatial analysis was simply to understand the geography, ownership, dimensions, and physical improvements as thoroughly as possible. The analysis was conducted primarily using Geographic Information Systems (GIS). Data layers were obtained from the US Geological Survey (US Geographical Survey 2010), The State of Colorado (State of Colorado 2010), Routt County (Routt County 2010), the National Forest Service (US Forest Service 2010), and the Natural Diversity Information Source (NDIS) (Colorado Division of Wildlife 2010). We used Google Earth and Google Maps (Google 2010) to aid our understanding of the site, and we were able to get around 200 photos of the site as well.

The process of analysis involved opening many of the available map layers and placing them over one another simply to see if there were any interesting overlaps, as well as more targeted comparisons and combinations. The data that emerged as most relevant to the planning process was the orthographic photos of the site, parcel and ownership information, stream, street and watercourse data, and topography. The water body, watercourse, and street location information available from the national USGS server was much less accurate than that available for the county, so we used the former, and edited it slightly when necessary. For example, the county
data described a stream running all the way around the reservoir, which is not the case, as we could see from the ortho photos, so we deleted it. We also used our digital elevation model (DEM) to create contour lines and hillshade layers. Ownership data was obtained through the Routt County parcel data, which allowed us to determine precisely which lots were involved in the project, which were publicly owned or owned by the Stagecoach Home Owner’s Association, lot size, and development status.

**Environmental**

Environmental data was gathered and analyzed in much the same way as the spatial data, using the same data sources as above. Because Stagecoach is private land, and we could not to an in-depth, in person site analysis, we were not able to get very detailed vegetative cover information, or then to single out highly specific areas that represent particularly valuable or vulnerable habitats. We do know, however, that riparian areas and corridors and edge conditions in general are particularly important to many species and rich in biodiversity. We also have habitat data for endangered and sensitive species in Colorado, several of which are impacted by development in Stagecoach, including the endangered: Boreal Toad; Columbian Sharp-Tailed Grouse; and Cutthroat Trout. Other important species, or charismatic mega fauna (Feldhamer 2002), which are not endangered also live in Stagecoach: Black Bear; Elk; Moose; Mountain Lion; Mule Deer; Great Blue Heron; White Pelican; and Wild Turkey

Initial environmental and spatial analysis was done using the McHargian (McHarg 1992) methodology of layering datasets and exploring the relative importance and use types of spaces on the site. After this high-level analysis we created a detailed suitability analysis for the entire site that combines spatial, ecological, and design considerations to give us a map of the areas that it is most desirable to build on. This suitability model is dynamic and can be adjusted to account for different demands, weighting of particular variables, and new data.
Spatial Analysis

Stagecoach is a huge site, characterized by wide-open spaces. Entry to the development is from the West, the direction of Oak Creek. Visitors drive into town alongside the small river that feeds into the reservoir. Before reaching the reservoir, the road veers to the right towards a broad valley and the landmark Eagle’s Nest, a small, conical peak in the middle of the valley. Heading Southeast, the valley is wide as it begins alongside the 2.5 mile long reservoir, then narrows to the width of a two-lane road for slightly more than a mile, at which point it opens up again to become a broad, grassy expanse cut across by meandering streams and small patches of trees. This is Southern Stagecoach, where the majority of the lots were platted out in the 70’s. These lots are quite large, and mostly undeveloped. The lots that our client owns are in Southern Stagecoach. It is possible to keep driving from southern Stagecoach southwest, and

Figure 42. Stagecoach, with parcel lines.
Note that though a few parcels are clustered around the reservoir the majority are in southern Stagecoach
Figure 43. Lots in Southern Stagecoach

The current condition in the Southern portion of Stagecoach. Large lots are spread out across the landscape in an typical suburban form of cul-de-sacs and curvilinear streets. Very few of these lots are developed, but they are legally entitled and could theoretically be built on at any time.
to eventually meet up with the highway again, but it’s a fair distance and should not be considered a practical route.

The base of the ski resort is near the reservoir and the entrance to Stagecoach, as is the majority of existing development. Interestingly, there are very large parcels of privately owned land abutting and near the reservoir that have not been developed or subdivided. Several miles from the ski resort base and current center of town (judging by density, which is still low) there is another cluster of development towards the eastern end of the reservoir.

Stagecoach’s site is dramatic not only because of its sheer size, but also because of its geology. The valley is rimmed with beautiful peaks, and the combination of those and the reservoir to the northwest means that it’s difficult to find a location with a boring view. Residents enjoy a wide range of outdoor activities, including fishing, ice fishing, dog sledding, hiking, boating, horseback riding, and skiing (if they’re willing to climb the mountain). The site is ringed by public land, so ample recreational areas will remain, but the mountains just abutting the current center of Stagecoach are privately owned and could be developed, though not a great deal because of the steepness of their slopes.

**Habitats**

According to our habitat maps, although there are a significant number of animals who live in Stagecoach the majority depend on land that is not in the northern area of the town, where we are planning to develop. The exception to this is the Columbia Sharp-Tailed Grouse, whose habitat incorporates the reservoir and a significant area around it, including Northern Stagecoach. In order to plan for the continued existence of this endangered species a detailed study of the Grouse’s needs and the areas that would best fulfill those needs is called for, and cannot be
The peaks that surround Stagecoach Valley mean that dramatic views abound, and that plenty of unbuildable land is available for recreation.
This map shows ownership in Stagecoach. The pink areas are the Stagecoach Ski Hill. The blue areas are owned by the Stagecoach Homeowner’s association, and the green lots are owned by our client. Stagecoach is surrounded by wide swaths of public land, including the Routt County Forest to the east.

accomplished in the scope of this study. We also assumed that although the habitat maps that we have don’t specify the riparian corridors or the area around the reservoir as important for the animals that live in the area they are important, and we allowed a 90 foot barrier to development on either side of each stream and around the reservoir. Habitat maps for each of the species studies are in Appendix: Habitat Maps.

Beginning to Design

After we began to have a basic understanding of the site’s geography, ownership issues, occupancy, and so on we looked at how our goals could be accomplished on the site. We decided
Figure 47. Southern Stagecoach

This map shows the location of lots owned by our client in green, with topographic lines 1/10. The lots are all clearly arranged in a valley, but are still mostly unbuilt. The blue lots are developed.
that our primary recommendation would be to transfer development rights from Southern Stagecoach’s large, sprawling suburban area to Northern Stagecoach, where we would develop a much denser and more regionally relevant town. We began to develop basic typologies of western towns, and decided that a grid would be the appropriate form, because that is the traditional Western town layout, which is well accepted and occupied near Stagecoach in town of Oak Creek. The grid in Stagecoach would not be perfectly orthogonal, however, because there are existing roads and built lots in Northern Stagecoach, which we do not see the advantage of moving, nor could we, legally, if we were designating the area an area to be developed using transferred development rights (TDR). We also agreed that there is an appeal in irregular grids and roads that lead to interesting vistas.

I developed some sketch site maps which proposed a loose form and scope of development for the site, and which looked at where the center of town should be. We agreed that it should be moved from its current location near the base of the ski hill to a location on the main road into town with good access to the reservoir. Because there is no fully functioning ski hill in Stagecoach it doesn’t make sense to orient the town around it, and the reservoir is a much more important asset. The original town center is out of easy walking distance to the reservoir, and if there is further development in eastern Stagecoach a direct road there would bypass the town center in its existing location. These sketch plans can be seen below.

**GIS analysis and Suitability study**

As I have mentioned, the Stagecoach site is huge and topographically varied, and we wanted to make sure that certain sensitive areas were not built on. In order to accurately determine what land was and was not buildable, so that a more detailed design could be developed, we developed a suitability model in GIS. Essentially, this model looks at the data in the GIS file of Stagecoach and creates a mask that lets us know what areas are buildable according to the parameters of the model. The areas that we determined were unbuildable are:

- Riparian areas, with a buffer of 90 feet on each side
- The reservoir banks, with a buffer of 90 feet
- Slopes over 20%
- Landmark mountains and their bases
- Public land
- Built lots equal to or smaller than one acre
- The ski hill

Each of these constraints is then weighted according to importance. In this case all of the constraints were weighted equally. A diagram of the model can be seen below, along with the results of the suitability analysis.
Transferring Development Rights to Northern Stagecoach
Figure 48. Sketch site maps
With loose grid and new center near highway and reservoir [above], and an unmooved center [below]
Figure 49. Suitability Model

This GIS model shows the analysis process for arriving at a buildable areas map. Each of the geological and ecological features that we do not want to build on is added to the model, processed, and combined to produce a map that we can use on our map of the site. This tells us where we should and should not build, given the weighting of each feature. For example, we chose not to build within 90 feet of a riparian area or water body, or on slopes above 30%. We are positively weighting sites near the center of town and the ski resort base, whether or not it reopens.

We later added further nuance to the spatial analysis and developed a map that displays the most desirable building areas according to both the suitability analysis and proximity to amenities like streams, the reservoir, landmark peaks, and the base of the ski hill, which could become an amenity if it were to reopen. We used this model in the design process to determine which areas were more desirable, and should be designed for increased density. A map showing the results is below.
Figure 50. Suitability in Northern Stagecoach

(Above) Suitability maps of the town center area and the entire development, with existing roads. Buffers around watercourses and waterbodies, built lots smaller than one acre, landmark hills and mountains, and slopes above 30% are all excluded. This yields a map that details places where it is better to build, and places where building is prohibited.

Figure 51. Areas suitable for building in Stagecoach

(Right) Buildable areas, as defined by our suitability model, are represented in green. This map dramatizes the fact that Stagecoach is surrounded by steep mountains and large swaths of public land to the east and west.
Figure 52. Suitability and Desirability model

[Above] This model shows the most desirable buildable areas by combining the suitability analysis with known preferences of being near water bodies and streams, near the town center, and near the ski resort. The red areas are the most desirable, the green the least so. This model assumes that there will be a ski resort, or that it is an amenity whether or not it’s open. This image focuses on Northern Stagecoach.
Developing the Site Plan

After all the analysis was complete I developed a site plan, with input from the team. We determined that the plan should have a few very important characteristics, which are:

- Ecological responsibility
- Density and walkability
- Access to outdoor recreational areas
- Building and blocks aligned on a 23 degree north angle: the ideal angle for solar orientation in Colorado
- Walkable block sizes similar to those in Oak Creek, CO [and Berkeley, California]
- Space to incorporate biodigesters and subsurface wetlands as waste treatment areas (1 acre per 100 people)
- Plentiful parks
- A dock and marina
- Generally connected street grids, with allowances for a few cul-de-sacs
- Progressive phasing

Maps follow that document the design and design process.

The New Plan

One of the interesting aspects of this plan is that it represents what is in some ways the opposite process than the one that has occurred in many cites that were originally laid out on a Roman grid, but have over time become more idiosyncratic and less Euclidean [Rasmussen 1969] in different ways, according to the culture of the succeeding occupiers [Kostof 1991]. In this case the initial layout of the development is curving and suburban, while the new pattern of regularity is fit within and adapted to curvilinear development boundaries and landforms.

Developing Sustainably

Although it is not shown at site plan scale the intention for the development of Stagecoach is for the buildings to utilize the best proven technologies to shrink their ecological footprints. These techniques could include:

- Solar heat and hot water
- Real time energy and water usage sensing and date feedback
• Water saving appliances
• Energy efficient appliances
• Daylit spaces
• Passive heating and cooling
• Green roofs
• Permeable paving
• Recycled materials
• Locally sourced materials
• Water recycling and nutrient capture
• Effective insulation and HVAC systems
• Durable construction and timeless design
• Density
• Proximity to amenities and services (walkability)

... And so on

These techniques are generally designed to make existing patterns of human behavior more sustainable, by changing the impact on resource usage of the behavior, but not the behavior itself. With structural design adjustments that highlight these technologies, and integrated sensing and feedback mechanisms associated with them, these measures have the potential to inspire knowledge and care for the environment and I have discussed. Behavior change towards sustainable habits can result from this increased care, or could result from design constraints or considerations built into the devices that make sustainable choices easier to make than inefficient choices, like a dishwasher that defaults to an energy and water efficient cycle.

Stagecoach as Exemplar

Stagecoach is designed according to a utopian and practical vision. It is designed to make residents aware of the larger ecosystem that they find themselves within, to allow them to engage with their environment, and the give them feedback on their ecological impacts as well as the tools to lessen that impact. The vision, unlike many others, comes with a pro forma.

It would be difficult in a place like Stagecoach not to be aware of the immediate majesty of the site, which, through the power of its wildness and the occasional mountain lion and black bear in the back yard, must remind residents of the functioning of natural systems. Some of these systems can be made more apparent through the design of dwellings, and some more through site design. Dwellings that incorporate the various efficiencies and sustainable technologies mentioned above can make residents aware of their environment, particularly if they are visibly
Current Condition with Suitability Analysis

- Roads
- Paths
- Streams

Suitable to Develop
Existing Roads
Plan in Context: Overall Suitability and Northern Open Space
different than standard appliances, or alter the structure or orientation of the building in some way, like through the incorporation of a wind tower or solar orientation. In the site design, the preservation of natural habitat buffers and great swaths of open space are intended to provide residents with frequent experiences of active edge habitats where they can observe processes at work. The center of the development is located and oriented towards the reservoir on one side and Eagle’s Nest peak on the other, reinforcing the sense that Stagecoach is a town built within a larger natural context, and the extensive trail network will invite access to and experience of that space. The placement of parks and the use of biodigesters and subsurface wetlands in each neighborhood will also serve as a visible reminder of nutrient cycles. The fact that Stagecoach is located on a reservoir with a hydroelectric dam at one end means that evidence of power production isn’t far off, either. Stagecoach is an excellent place for photovoltaics, so solar panels can add their distinct presence to the neighborhood, too. The site also allows ample space for a large community garden, or several gardens. The gardens could perhaps be located next to a stream, which could irrigate them. Irrigation might not be legally possible, as Colorado law forbids water harvesting, even rainwater harvesting (Riccardi 2009) in many areas. Naturally irrigated or not, a central garden area could also serve as Steamboat’s composting center, where residents leave compostables and can observe them transforming into humus and being reused. Even if residents didn’t participate in gardening they could still observe the process of food production, and might end up eating the local food after purchasing it at a local farmer’s market or at a neighbor’s house.

Locally integrated community gardens, and the opportunity, designed into the site, to walk up and touch streams, mountains, and reservoirs, will provide residents with ample experiences that will begin to erode the cultural understanding of humans as being separate from the natural world, and superior to it. Residents will be able to get their hands and boots dirty. Individual houses will be designed so that residents can adjust the airflow, light exposure, and temperature of their homes using construction methods and technologies that treat the outside environment as an asset. For example, if it is hot inside a home, a resident can open louvers above a central space, where the outside wind can act as a vacuum and draw the hot air up and out of the house. Residents can also manipulate shading devices, windows, and partitions.

Feedback on resource consumption, the importance of which is discussed in Chapter Four, will be provided in both high and low-tech ways. One kind of feedback is provided by individual engagement with ecosystems that has an immediately observable effect. If you plant a plant, care for it, watch it grow, and harvest its fruit you are getting feedback on how your behavior impacts a microcosm of natural systems through many of your sensory apparatuses. This kind of feedback, the organic kind, will be available to residents, as will the results of sensors monitoring
their usages and usage patterns, and displaying the results through both intuitive and mediated channels. Collective feedback will also be available through aggregate use statistics, and possibly through lights in each neighborhood that display information about current and weekly utility usage. The practice of encouraging residents to drive electric or hybrid cars, which may be charged daily and can provide feedback on energy usage, will also bring the community together in an understanding of what it takes to move them, their goods, and their friends around on the planet. Stagecoach is clearly an example of the kind of place where different scales of feedback, particularly at the individual and community/watershed scale, are appropriate. In addition to individual in-home or in-car feedback, the community would benefit from learning about itself through distributed sensing networks, or perhaps an ongoing ecological survey and study by the school children of Stagecoach. Unlike many communities, the valley where Stagecoach is located represents two watersheds, and there are no other towns in those watersheds. This means that Stagecoach is in an excellent position to do watershed planning and impact studies. Watershed health could be used as an initial environmental focus for the town, which could unify residents around one comprehensible ecological cause. After working towards preserving watershed health is embraced by the community, additional ecological goals could be added, eventually resulting in a deeply ecologically aware and sustainably functioning community.

Stagecoach is designed to be both an eco-topia and a fantastic place to live. It is designed to enable residents to build and participate in a unique community in a reformed suburb, the vestiges of which will be visible on the outskirts of town. The town will be walkable, human scaled, and located in a fantastic, celebrated and preserved natural setting. Stagecoach is intended to serve as an inspiration for counties and municipalities who find themselves overwhelmed with overcommitted open land in their jurisdiction. Stagecoach is designed to offer an alternative to closing one’s eyes and building a generic, inefficient, locally irrelevant, isolated box (or series of boxes) for living in.

The plan for Stagecoach is locally relevant and unique, and if built the development will therefore have a strong sense of place rooted not only in the personal experiences and interpersonal relationships that residents will have, but also rooted in the landscape. This is the kind of place that will impress itself strongly on people who live and grow up here. It will become part of their sense of self, and because they love the environment, their home, they will be willing to behave in a way that protects that environment, which is the end goal of all the measures discussed in the larger thesis.
APPENDIX: HABITAT MAPS
Elk Habitat

Legend
- Streams
- roads
- ElkMigrationPatterns08202009
- ElkOverallRange08202009
- ElkCallvingArea08202009

0 0.25 0.5 1 1.5 2 Miles
Great Blue Heron Habitat

Legend
- Streams
- roads
- GBHeronForagingArea08202009

0 0.25 0.5 1 1.5 2 Miles