

# Outside In

Design Principles for Evoking a Sense  
of the Natural World in Indoor Spaces



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# Outside In: Design Principles for Evoking a Sense of the Natural World in Indoor Spaces

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## Abstract

Humans have a psychological and emotional need to feel connected to the outdoors. As people increasingly spend time in built environments using computational devices to perform their everyday work, it is essential that these indoor spaces consider the physical, mental and emotional well-being of their human occupants.

Channeling the tenets of ensoulment and slow technology, this paper outlines a series of principles to help guide the design of systems that amplify the presence of the outside world in indoor environments. These principles include a refined understanding of the differences between natural and built artifacts, and the qualities that characterize outdoor and indoor spaces. I propose five lenses of meaning, the biological, perceptual, temporal, spatial and sociocultural lenses, as a means to structure the different ways the natural world is rendered meaningful to us. I consider the use of light as a design medium through which to communicate the slow processes of the outside world, and evoke a sense of nature in indoor environments.

## 1. Introduction

### The Need for an Outdoor Connection

Humans are natural, biological creatures, and our continued health and well-being demands that we maintain a connection to the natural world. Many people spend numerous hours each day in a built work

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environment that alienates them from the outdoors, and it is essential that these indoor spaces be tuned to cater towards people's need to feel connected to something beyond themselves. Even something as simple as a window is an effective means to keep people aware of their place in their community, their region, and the world.

Our indoor environments must be designed so that they carry a reminder of the larger spaces in which we exist. There is a temporal disconnect between the immediacy of the workplace and the larger temporal unfolding of nature. There is little in the artificial life of the workplace that resembles the behaviors of natural world, leaving us feeling alienated from nature while we work indoors. This paper outlines a series of principles that can help designers amplify the presence of the outside, natural world in these indoor, built spaces.

### The Role of HCI

The field of human-computer interaction is increasingly concerned with addressing the full person, and considering the user as a dynamically thinking, feeling, emotional being, possessing unique needs, fears and desires that shape her intentionality and the meaning she ascribes to her world. The user is an interpretative powerhouse, and as a field we are beginning to deliberately craft experiences instead of interfaces and devices. As we make this transition towards designing for felt experience, we need to deliberately consider the design of the environments in which computing takes place, and craft them in a manner that addresses the complex needs of the whole person.

Computing technology mediates much of people's working lives, and so the welfare of people using our designs is of our utmost concern. It is our responsibility to consider not just the products or devices we produce, but to design the environments in which they are used. Existing at the intersection between humans and computers, HCI is uniquely outfitted to leverage itself as a tool that increases rather than decreases, improves rather than diminishes, our aware and perception of the outside world and our ongoing relationship with it. As computing technology migrates off the desktop and out of the workplace and into the environment around us, we must realign our field and our designs so they are not perceived as being at odds with the natural world. If computing is to become

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ubiquitous we must consider our own ecological humanity, and channel the design principles outlined by nature itself in the planning and creation of our computer-augmented environment. Our relationship with the earth and its natural processes offer a boundless resource for design inspiration and potential interactions, casting light on our interpretative skills, and our abilities to derive meaning from our surroundings. As the boundary between computational devices and the environments they occupy continues to blur, interaction designers will need to concern themselves with the design of the environments that play host to their products and systems.

Though computers are frequently implicated as being the opposite of nature, efforts from the field of HCI can help dissolve the boundary between the inside and outside worlds. Technology pervades our environments, from the inputs and outputs of control surfaces and displays, to the electromagnetic frequencies upon which our wireless communications ride. Recent trends in HCI, including those from ubiquitous computing, ambient displays and calm technology, aim to leverage our surroundings as a resource for communicating information, in much the same way that the natural, physical world does now. As technology continues its migration out of the workplace and into everyday life, our field is increasingly interested in addressing the needs of the whole person, and topics such as aesthetics, experience design, embodied interaction and reflection continue to gain traction. For all it has done to revolutionize the workplace, HCI is now tasked with improving the condition of the inside world that has become central to modern work life.

Through this project I hope to outline a series of design principles that help guide the designs of systems that not only inform people of the outdoors, but inspires them to reflect positively on their place in the natural world. It is imperative that we leverage the tenets of calm technology, slow technology and reflective design as a means to communicate natural systems and processes on a timescale that more closely relates to that of the outdoors. The tenets of ambient computing offer an effective way to communicate the slow processes that are typically rendered outdoors, including the passage of the sun, the changing phases of the moon, the growth of plants or the changing of the leaves. These changes happen at a timescale that we cannot perceive in real time, but we

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definitely notice over the timespan of hours, days, weeks and months. The slow processes of the natural world stand in sharp contrast to the workplace, where everything tends towards immediacy. The phone immediately rings, my inbox immediately receives a new message, and a document immediately comes off the printer. Little in the workplace possesses the emergent properties of the outdoors.

## My Contribution to the Field

My contribution is a series of design principles that aim to help interaction designers frame and understand the design of systems, solutions or devices that communicate a sense of the outdoors in an indoor space. These principles are outlined in two parts, the first of which attempts to cast light on people's complex relationship with the outdoors by disentangling our concepts of *natural* and *built* from our concepts of the *indoors* and *outdoors*. The second part outlines five lenses through which the natural world is rendered meaningful to people. These lenses include the biological, perceptual, temporal, spatial, and sociocultural lens, each offering a unique view as to how and why people interpret the outside, natural world as being meaningful. By considering these lenses of meaning, we are better outfitted to design systems that dissolve the boundary between the inside and outside worlds.

Channeling these lenses, I conducted a series of sketching exercises, design explorations and prototyping sessions, where I considered the use of light as a medium to introduce a sense of the outdoors in an indoor space. My work was guided by an intent to communicate the slow change of nature at a level below the threshold of active human perception, and to extend one's sense of space beyond their immediate, indoor locale.

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## 2. Approach and Methodology

### 2.1 Beliefs, Values and Motivations

In pursuing this project, I was interested in uncovering trends in HCI that would mesh well with my personal need to be outside. Research in HCI that specifically relates to the outdoors is limited, but I felt that trends such as ubiquitous computing, ambient computing and calm technologies, as well as an increasing focus on experience, felt-life and embodiment, would have a lot to offer a conflicted outdoor enthusiast technophile such as myself.

As this project is concerned with such messy, subjective topics as experience, meaning and emotion, the bulk of my research is largely qualitative in nature. In pursuing this design project, I conducted an extensive literature review to gain a better theoretical understanding of recent trends and thinking in regards to interaction. I scoured numerous sources in search of designs that encapsulate the goals of my project, and collected nearly two hundred compelling examples where people have attempted to bring the outdoors indoors. To gain a better understanding of the needs of my target user group, I communicated with a number of outdoor enthusiasts through forum threads and email, and conducted a telephone interview with the manager of an outdoor sports company. Throughout the project I continuously sketched ideas and concepts of potential designs, as a means to reveal to myself my own thinking and assumptions. Finally, I conducted a series of design activities with fellow designers, including conversations, sketching exhibitions and prototyping sessions.

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### 2.2 Methodology and Theoretical Approach

#### *Literature Review*

To gain a better understanding of how people create and construct meaning, and to discover techniques we as interaction designers can use to influence these meanings, I conducted an extensive literature review of trends in HCI. In studying ubiquitous computing I was interested in understanding what happens as computing becomes increasingly delocalized and permeates the space around us. In ambient media and threshold devices I was interested in the actual, physical media that might be used to render aspects of the outside world, and gaining a more sophisticated understanding about the different meanings that could be evoked therein. A number of trends in HCI consider computing interactions that extend beyond the cognitive concerns of task completion and efficiency, and so I studied ludic engagement, reflective design, ambiguity and enchantment as resources for allowing interpretation in the communication of meaning. In unremarkable computing, calm technology and slow technology I was able to dive deeper into ambient computing, better understand the threshold between central and peripheral attention, and learn ways to provide information to users in a manner that is not distracting. This extensive review of HCI trends helped frame the limited research in the field that directly relates to our relationship to the outside world.

#### *Exemplar Research*

In my exemplar research I conducted an extensive review of existing designs that, in varying fashions, attempt to introduce a sense of nature or the outdoors in an indoor space. These design ranged greatly in how they reinterpreted nature or the outdoors, some using literal materials from the natural world while others rendering natural forms in artificial materials. Some were ambitious and concerned the entire indoor built space, some attempted to introduce a literal high-resolution experience of the outdoors, while others offered more abstract views of nature in varying degrees of intensity. Throughout my review of existing designs I became interested in ways to display status information regarding the natural world, and how to communicate it in ways that were abstract and

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would leverage the sophisticated interpretative abilities of my audience.

### *User Interviews and Forum Posts*

Outdoor enthusiasts are a population who possess a strong passion for the outdoors. They tend to engage in outdoor activities such as running, cycling, hiking, skiing or camping, but may even enjoy the simple pleasure of gardening. These people have an intimate and meaningful relationship with the outdoors, and many define themselves by their favorite activities. Their passion resonates to the core of their being, and I count myself as one among their ranks. We love being outside, embracing the active challenge of existing in both beautiful and unforgiving environments, and the strong embodied experience that it seems only the physical, natural world can bring.

Indeed, despite their passion for being outdoors, many enthusiasts find themselves working indoors on a regular basis. Given economic realities, knowledge work typically pays more than physical labor, and it is difficult to sustain oneself on a means of outdoor employ for an extended period of time. Workplaces tend to be sheltered from the elements, necessarily climate-controlled to ensure both the comfort of their occupants as well as their sensitive technologies. The isolation that comes along with this protection from the outside world can negatively affect one's mental state, leading to poor well-being, decreased work productivity, and an overwhelmingly negative work environment.

In an effort to get outside my head and beyond my own thinking, I conducted a series of online conversations and interviews with outdoor enthusiasts, to see if they experience a similar tension between their indoor work life and their love for the outdoors. I chose outdoor enthusiasts as they are a user group that already has a personal interest in, and deep relationship with, the outside natural world. I believed this group would be able to offer an informed and critical perspective, given their intimate knowledge and familiarity with the outside world, and their personal investment in maintaining a relationship with it. I believed that these qualities granted them a uniquely informed perspective regarding their specific relationship with the outdoors, as well as humankind's relationship with the natural world in general. Additionally, I

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was interested in gaining insight into their working environments, and to learn about possible tactics they use to nurture their relationship with the outdoors in a potentially hostile indoor environment.

### *Design Research*

As this project has been a design exploration into ways to bring the outdoors indoors, I participated in many activities intended to push my conceptualization of the problem space, to challenge my own design thinking, and to generate new design ideas. Channeling the skills and knowledge of my fellow design peers, I held numerous conversations with other designers regarding this project, and led a series of active prototyping sessions to gain insight into new ways to think about the challenge of introducing a sense of the outdoors into an indoor environment.

### *Sketching Sessions*

Over the course of this project I conducted extensive sketching exercises, in an attempt to visualize and externalize my own thinking regarding this topic. In my exploratory sketching sessions I identified opportunities for intervention, considered existing means that people use to maintain a connection with the outdoors, and reflected extensively on my own thoughts and emotions regarding the conflict between the inside and outside worlds. In my generative sketching sessions I created and iterated on numerous design concepts that attempted to get to the core of this issue, and whose varying degrees of fidelity and practicality continued to give rise to further concepts. Finally, sketching proved an invaluable tool when it came time to assemble my design principles, helping me orient myself and organize my own thinking in a generative, freeform manner.

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## *Light Exploration Sessions*

Informed by insights gained from my user research, literature review and design research activities, I chose to focus specifically on light, and the nature of sunlight in particular, as a means to enrich indoor environments with a sense of the outdoors. I conducted a number of activities where I studied the movement of sunlight throughout an indoor space over the course of time, tracking its position and compiling time-lapse videos to better understand how computer-backed dynamic lighting might achieve a similar effect.

## *Light Prototypes*

To better understand how an artificial implementation of the natural movement of sunlight might work, I refined a concept called the ChronoCube and built a physical prototype of it. The ChronoCube would be a small device that resides on the user's desk, and casts a slowly moving beam of light across their workspace. The goal of this prototype was to consider the use of light as a medium to communicate a sense of the slow passage of time throughout the day.

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## 3. Literature Review

### The Psychological Need for an Outside Connection

Employees without windows near their workspace are significantly less positive than their windowed counterparts in regards to their opinion of their physical working conditions and satisfaction with their job [Finnegan and Solomon 1981]. In addition to light and sunshine, windows provide an extension of people's place in space and time, but in order to realize the full psychological benefits of a window people must be able to see some aspect of nature out of it [Kaplan 1993]. Windows with a view of nature enhance perceptions of self-productivity and interest in one's job, and reduce the recovery time for surgical patients [Farley and Veitch 2001]. The "quality" of the view of nature seems to have little bearing on the psychological effects of the window, as even a few trees in a parking lot make as much of a difference as a fully natural view [Kaplan 1993].

In *The Design Way* Nelson and Stolterman outline the importance for designers to consider the act of *ensoulment* when designing not just artifacts, but environments as well:

"We live in a world of designed, artificial environments. Within this artificial world, we have created organizations, work processes, procedures and rules. To live in such environments, especially if they are constantly changing, takes time and energy. If these environments are without soul, it makes people tired, it drains us of energy. An ensouled environment, on the other hand, evokes life. When we encounter ensouled designs, we are energized. We feel that our own souls are filled with splendor. To take part in the ongoing design of reality is therefore a task of ever-greater responsibility. Since it's not just a question of creating a functioning, ethical and aesthetic environment, but also involves creating a reality that can either give people energy and hope, or make their lives poorer in spirit."  
[Nelson and Stolterman, 2003]

I believe that one path towards ensuring that these indoor, built environments fill people with energy and splendor,

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rather than drain their spirit, is to ensoul them by evoking a sense of the natural world within their confines.

### CHI Literature Review

#### *Experience and Aesthetics*

Technology influences how people think, feel and ascribe value to their world, and Wright and McCarthy outline the importance of considering experience, felt life, emotion, desire and fulfillment, in addition to the more common topics of practices and tasks [Wright and McCarthy 2008]. Likewise, HCI is increasingly concerned with aesthetic experience, and the issues of reflection and awareness that accompany this ineffable subject [Boehner et al. 2008]. There is a considerable difference between simply making information available for users, and designing for an experience such that information becomes personally meaningful. It is a delicate balancing act, for an interface to communicate just enough information so that it can be actively interpreted by the user, without saying so much that it ceases to be interesting to interpret [Boehner et al. 2008].

Aesthetic interaction is concerned more with the aesthetics of use, rather than the aesthetics of appearance. Indeed, aesthetic interaction in HCI begins to move beyond efficiency and transparency, towards an agenda that considers emotion, mood and affect. A pragmatic approach to aesthetics, similar to that described by Dewey [Dewey 2005], claims that aesthetics are realized in a dialogue with the world, and are "tightly connected to context, use and instrumentality" [Petersen et al. 2004].

#### *Embodiment and Phenomenology*

Klemmer et al. discuss how our physical bodies play a central role in shaping human experience [Klemmer et al. 2006]. Dourish discusses embodiment, and how it is the property of our physical engagement and existence in the world that allows us to make it meaningful [Dourish 2001]. Indeed, meaning and embodiment are closely intertwined, and our bodies mediate how we come to encounter physical and social realities in the everyday world. Embodiment has its roots in phenomenology, a branch of philosophy that concerns itself with the nature of being,

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human existence and perception, as it is rendered in consciousness.

Phenomenology is not concerned so much with the objective realities of the physical world, but rather with how the properties of the world are processed, interpreted and made available in the mind. Indeed, the interpretative nature of understanding is the foundation of Heidegger's hermeneutical phenomenology, which since its inception has inspired all philosophical thought regarding phenomenology. Heidegger begins disentangling the properties of being-in-the-world, rendering explicit the properties of our lifeworld, which forms the mundane world of tacit understandings and experiences with which we operate on a daily basis. While uniquely situated in each individual, these "common sense" understandings tend to have similarities that are shared between people from a similar culture. These intersubjective understandings form a shared framework of mundane tacit knowledge that allow people to practically accomplish the acts of physical and social interaction.

Specifically related to ubiquitous computing, Dourish discusses Heidegger's concepts of an artifact being present-at-hand or ready-to-hand [Dourish 2001]. When an artifact or tool is present-at-hand the user is aware of it, and is consciously attending to its existence. Something that is present-at-hand exists at the center of one's attention, whereas an artifact that is ready-to-hand exists in one's peripheral awareness. When an artifact is ready-to-hand it is embodied, essentially acting as an extension of the user's own body in the accomplishment of a task.

### *Context*

Harrison and Dourish discuss the difference between space and place, and how it is actually place that frames our interactive behavior [Harrison and Dourish 1996]. While space relates to the spatial organization of our world, place is our cultural understanding of appropriate behaviors and interactions, which can be quite independent from the spatial features of our environment.

Space and place are necessarily intertwined, and Dourish claims that the context of an interaction, and its corresponding appropriateness, is not a detectable quality of the physical world, but rather a subtle and undetectable construction that is situated in sociocultural discourses

[Dourish 2004]. Context does not exist *a priori* but emerges from the act of individual and social interaction, formed in the mundane experiences of everyday life. In any interaction, context is continuously being constructed, defined, negotiated and shared among numerous social actors [Dourish 2004].

Williams et al. discuss the relationship between space and embodied action, and how the meaning of a space results from our encounters with it [Williams et al. 2005]. Space is not a passive container of objects and actions but is explicitly constructed, managed and negotiated. Activities and social interactions are embodied, and the spaces in which they are situated are produced through active interpretation. Similarly, Bidwell and Browning explore the personal experience of natural places, and the emotional and intellectual experience of being embodied in a place. They suggest that despite the ever-changing nature of a place, the fictive constancy of place that people hold in their minds is a result of their active construction of their own identity [Bidwell and Browning 2006].

### *Ambiguity*

Gaver et al. discuss the important role that ambiguity can play as a design resource, in asking that users actively interpret an interaction and form their own meanings about it [Gaver et al. 2003]. They discuss three different classes of ambiguity, including ambiguity of information, which is sourced in the artifact itself; ambiguity of context, which challenges the sociocultural discourses used to interpret the artifact; and ambiguity of relationship, which situates ambiguity in the interpretative stance of the individual. As a means towards introducing ambiguity into interactive systems, Gaver et al. offer a number of suggestions, including using imprecise representations and exposing inconsistencies in information to provoke interpretation, blocking expected interactions in favor of unexpected ones, and situating the user in awkward roles of responsibility or interpretation without explanation [Gaver et al. 2003].

Sengers and Gaver state that as computing moves into aspects of everyday life, it is important to address the complex notion of interpretation, and to design systems in such a way that they allow for multiple, even competing interpretations [Sengers and Gaver 2006]. Inspired by subjects such as art and other humanities, this effort

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encourages the need to design not just for efficiency and usability, but for curiosity, play, exploration and reflection. By downplaying the apparent authority of a system users would be able to actively interpret its meaning, helping evolve its interpretation over time and stimulating new meanings.

### *Enchantment*

McCarthy et al. discuss the concept of enchantment as a means to improve user experience with technology [McCarthy et al. 2006]. Enchantment is a rich experience that involves the engagement of the whole person, and the establishment of an affective attachment between person and artifact. In the creation of evocative artifacts and spaces, McCarthy et al. outline four primary means by which the designer can begin to encourage a sense of enchantment with her designs: by considering the unique sensuousness of an artifact; by engaging concepts of play; by encouraging paradox, multiple interpretations and ambiguity; and by allowing the potential for a user to be transformed by a design [McCarthy et al. 2006].

### *Ludic Engagement*

As we begin to consider the affective and emotional qualities of human life, ludic engagement is an increasingly popular subject in interaction design [Gaver et al. 2004, Sengers and Gaver 2006, Mathew and Taylor 2008]. The goals behind ludic design are to promote curiosity, exploration and reflection, deemphasize the pursuit of goals, and maintain ambiguity as a resource for interpretation and meaning [Gaver et al. 2004]. Focused on the human as a playful creature, ludic designs consider themselves as resources to be appropriated by the user, and implicated in their own meanings. As described by Gaver et al., ludic activities can be encouraged through technology by offering a range of explorative possibilities, presenting the familiar as strange or the strange as familiar, and in deliberately avoiding the appearance of a computer. Gaver et al.'s Drift Table is simultaneously an example of ubiquitous computing, calm technology, a tangible interface, an ambient display, and an information appliance [Gaver et al. 2004].

### *Reflective Design*

Technology shapes the texture of people's everyday experience, and by providing for interpretative flexibility

designers can help bring the unconscious aspects of experience to consciousness. As one of the tenets for reflective design, Sengers et al. outline the importance of considering emotion and felt life, and the role that technology can have in supporting users in reflecting on their own lives [Sengers et al. 2005].

### *Ubiquitous Computing*

Interactions with computers should be free-flowing and integrative, and should resemble our interactions with the physical world of people, places and artifacts [Abowd and Mynatt 2000]. Interactions in ubiquitous computing have no clear start or end, and so as designers we need to scale our interactions in respect to this lengthened timeline.

Much work in ubiquitous computing is concerned with transparency, invisibility, and eliminating friction between user, system and information. However, Sengers and Gaver discuss the strategy of seamful design, which rejects the notion of seamless design in favor of making seams between ubiquitous technologies visible and explicit [Sengers and Gaver 2006]. The goal of seamful design is to allow users to become aware of seams and appropriate them for their own uses, empowering users in a manner that would be impossible if the technology were seamless and invisible.

Ubiquitous computing should provide users with information without stripping control from them. People must be allowed to live in empowering environments, and so the task of interpreting information from a ubiquitous system should rest with the user. A lack of control over life diminishes one's health, and so technology should offer peripherally empowering information without being overwhelming [Intille et al. 2003]. Nelson and Stolterman address this issue as well, stressing the importance of designing ensouled environments that give people hope, life and energy [Nelson and Stolterman 2003].

### *Threshold Devices*

Gaver et al. discuss the concept of threshold devices, which seek to bridge the gap between a domestic space and its surrounding environment in an effort to elicit new views and understandings of one's place in a community [Gaver et al. 2008]. Blurring the line between the inside



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and the outside, threshold devices rely on individual interpretation by situating information in relation to the home and its surroundings, and offering opportunities for one to reflect on how the “here” is situated in and connected to the “there”. These devices are positioned not as tools, but as information appliances that offer a new way to look out from the home, and appreciate one’s position in a wider physical or social environment.

### *Ambient Systems and the ambientROOM*

In ambientROOM, Ishii et al. envision that the architectural spaces we inhabit can function as an interface between humans and digital information [Ishii et al. 1997, Ishii and Ullmer 1997]. These so-called ambient systems communicate information through the subtle usage of light, sound, color and movement, or even smell and temperature. Humans have a sophisticated capacity to process multiple information streams from their environment, and nature makes incredible use of this capacity. Typically we can only hold a few particular things in the foreground of our consciousness at any given time, but we are constantly monitoring other systems in the background. Ishii et al. seek to exploit this natural ability, by augmenting physical space with peripheral awareness of digital information. Indeed, ambient computing has its roots in natural phenomena, and Ishii et al. discuss wind and sunlight, the sounds of a forest, and the monitoring of weather through cues such as light, temperature sound and airflow, as prime examples of ambient monitoring of information. [Ishii et al. 1997, Ishii and Ullmer 1997, Ishii et al. 2001].

### *Evaluating Ambient Displays*

Given the differences between ambient systems and conventional interfaces, Mankoff et al. offer ten criteria for the heuristic evaluation of ambient displays [Mankoff et al. 2003]. These criteria include providing sufficient information design, offering the user consistent and intuitive mapping between information and controls, establishing a match between the ambient system and the real world, providing visibility of state, possessing an aesthetic and pleasing design, offering control and freedom to the user, providing an easy transition to more in-depth information, preventing errors, and emphasizing both flexibility and efficiency of use [Mankoff et al. 2003].

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### *Unremarkable Computing*

Tolmie et al. discuss the concept of unremarkable computing, which is closely related to ubiquitous computing, and focuses on recognizing the complex details of everyday routines as a resource for design [Tolmie et al. 2002]. Making technology “invisible in use” has long been a stated goal of ubiquitous computing, but it is important to deliberately consider what “invisible” actually means. When something is unremarkable it is not marked by consciousness, according to Tolmie et al., which is different than ignoring or not noticing something. Artifacts can be implicated as resources in a routine without their existence being consciously “marked out” by the user, and nowhere is this more evident than in routines themselves. Routines involve tacit knowledge and embodied knowledge, and the awareness of a routine can itself be implicated as a resource for action. In regards to computing, Tolmie et al. discuss the role of peripheral background processing, and how unremarkability in ambient technology is a very different goal than invisibility [Tolmie et al. 2002].

### *Calm Technology*

In *Designing Calm Technology*, Weiser and Brown discuss *LiveWire*, an information appliance designed by artist Natalie Jeremijenko to communicate network activity in the office through a dangling string [Weiser and Brown 1996]. Calm technology is a movement that aims to create designs that encalm and inform their users by existing in the periphery of consciousness. By leveraging the natural human ability to attend to multiple threads of peripheral information simultaneously, calm technology aims to extend our peripheral reach by informing us without overburdening us with demanding interfaces.

*LiveWire* is a clear example of ambient technology, which like calm technology leverages our ability to process background information. By moving an information source from the periphery to the center of our attention we are able to take control of it, and are empowered to act on it. Calm technology, according to Weiser and Brown, empowers us in that we are able to mark and unmark this ambient information by bringing it to the foreground and attending to it, or leaving it unattended in the background [Weiser and Brown 1996]. A key challenge with calm technology is figuring out the proper threshold between

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central and peripheral attention. An ambient background source that is too subtle will never get marked by a user, even when reflecting drastic changes in state, and thus its information is not empowering in that the user is unable to center it in her attention. An information source that is too demanding is not encalming, however, as it will not fade to the background and will always be in the center of attention for the user.

### *Slow Technology*

Initially relegated to the workplace, computing technology at one time involved tools that people would use for a limited time in particular situations. However, as technology increasingly surrounds us in every aspect of our lives, Hallnäs and Redström argue for a technology that likewise embraces a longer timescale [Hallnäs and Redström 2001]. Channeling the tenets of calm technology, slow technology is aimed at providing people with moments of mental rest and reflection. Similar to architecture, Hallnäs and Redström consider the impact of creating interactions that are not designed for periods of use, but rather are dwell-able interactions designed for prolonged engagement. Slow technology aims at creating a more reflective environment, taking inspiration from works of art, pieces of music, and other subjects that are designed for reflection. “Amplifying the presence of things” is a basic principle of slow technology, and one could extend this to include amplifying the presence of the natural world and its own slow processes [Hallnäs and Redström 2001].

### *Focusing on Appearance and Aesthetics in Slow Technology*

Focusing on the slowness of appearance and the aesthetics of material are two guidelines outlined by Hallnäs and Redström as key to designing slow technology. An artistic work by Arthur Ganson, *Machine With Concrete*<sup>1</sup> exemplifies the first guideline by using twelve gears to slow down a motor running at two hundred revolutions-per-minute to a final gear, embedded in concrete, that runs at one revolution per *two trillion years*. *Machine With Fabric*<sup>2</sup>, a second work by Ganson, exemplifies the aesthetics of material by glorifying the sensual nature of a simple piece of cloth.

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## CHI Literature Regarding Nature

### *Helping Humans Maintain a Connection with the Outdoors*

There are a number of examples in CHI literature that tie directly into helping humans maintain a connection with the outdoors, including *Aurascapes* [Mathew and Taylor 2008], *Wearable Forest* [Kobayahsi et al. 2008], and Kobayashi’s concept of *Human-Computer Biosphere Interaction* [Kobayashi et al. 2009]. Artistic works such as *MORI* seek to encourage reflection on how humans perceive, understand and construct the natural world [DiSalvo et al. 2009]. A number of authors have published on digital windows, including Gaver and his experience living with a video window [Gaver 2006], Friedman et al. and their high-definition video office window [Friedman et al. 2004], and the digital parallax window from Radikovic et al., which attempts to realistically simulate the visual effect of looking out from an actual window [Radikovic et al. 2005].

In *Threshold Devices* Gaver et al. introduce the concepts of *Local Barometer* and *Plane Tracker*, which in information about the outside world and encourage reflection on one’s physical and social locatedness [Gaver et al. 2008]. Gaver also introduced a number of conceptual information appliances to help open up new design spaces, and demonstrate design concepting as a legitimate research method to evoke design insights. One of these concepts was *Dawn Chorus*, a bird feeder that would use behavioral conditioning to teach birds to learn and sing the user’s favorite songs [Gaver and Martin 2000]. The *Drift Table* is a video screen embedded in a coffee table, that displays aerial photographs in a manner that is deliberately difficult and ambiguous to control [Gaver et al. 2004]. Mankoff et al. designed an indoor ambient appliance called *Daylight Display*, which used light to indicate to users the approximate time of day [Mankoff et al. 2003].

### *Aurascapes*

*Aurascapes* is a threshold device that uses microphones and speakers to reconnect users in a windowless indoor space with the outside environment [Mathew and Taylor 2008]. Microphones located outside the building pick up ambient outdoor sounds, and broadcast them in real-time

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to an inner room. The information conveyed in this configuration is deliberately unclear, and must be interpreted from one's own situated context. The sound started as an interruption for the users involved, but quickly faded to the background and moved to people's peripheral attention as they grew accustomed to it. With *Auralscapes* the value was not in the data, but the meaning of everything surrounding it. Users were required to incorporate their own imaginations, histories and experiences to interpret the sound, resulting in a poetic interaction filled with ludic ambiguity.

### *Wearable Forest and Human-Computer Biosphere Interaction*

*Wearable Forest* is a garment that allows the wearer to acoustically experience the sound of a distant forest, offering a sense of belonging to nature [Kobayashi et al. 2008]. Sounds are recorded by microphones located in the forest, and broadcast in real-time to speakers in the garment. Additionally, the soundscape of the remote location is visualized as a pattern in the LED array on the garment, growing in brightness and complexity as the sound level increases. *Wearable Forest* also allows the individual to remotely activate pre-recorded sounds of wildlife that will play back through speakers in the remote forest, offering one the opportunity to influence nature from afar. In *Human-Computer Biosphere Interaction*, Kobayashi et al. further their agenda from *Wearable Forest*, and theorize on the value of networked bio-acoustic streaming and recording systems, and using information technology to help one feel at one with nature [Kobayashi et al. 2009].

### *Gaver and the Video Window*

Gaver installed a video screen next to a window on his bedroom wall, connecting it to a camera mounted outside so that it would extend his view from that same window. His auto-ethnographic account of his experience with the video window offers some keen insights into the unique value of ludic systems [Gaver 2006]. He found that the video window offered aesthetic, utilitarian and practical value, and the ludic experience of it afforded curiosity, exploration and enjoyment. He concludes that new views of the existing environment could be fascinating, and that slight technologically-mediated distortions (such as lens flares and rain drops) could augment an experience without distracting from the "natural" view. Gaver

discusses how one's own viewpoint may engender strong feelings of engagement, and that the act of making meaning with a ludic system is highly situated with the individual. He found that practical uses of the system included using it as an ambient weather display, and that the video window was able to deliver this information in uncontrived, aesthetically-pleasing ways. Indeed, Gaver notes that based on his experience, systems designed for ludic engagement and aesthetic pleasure can also have a functional component without detracting from the overall experience [Gaver 2006].

### *Using Natural Substances as a Means to Communicate Information*

A number of research concepts have been designed that use nature, natural substances and the physical world as a means to communicate information. *Pinwheels* is a concept by Ishii et al. that uses pinwheels to simulate the movement of air and communicate traffic over a computer network [Ishii et al. 2001]. Furthermore, Ishii et al. state that such ambient displays may be effective for visualizing atmospheric or astronomical phenomena, which may align with the goals of this project. *Water Lamp* by Dahley et al. is an ambient fixture that projects the rippling surface of a small pool of water on the ceiling, as a means to display information [Dahley et al. 1998].

Both *Pinwheels* and *Water Lamp* were born from the ambientROOM, an ambitious effort to use sound, air, color, light and other natural phenomena as a subtle palette with which to communicate information [Ishii et al. 1998]. Similarly, as mentioned in Sengers and Gaver, Böhlen and Mateas offer an artificial plant that wilts or blooms in response to the emotional tenor of the user's email [Sengers and Gaver 2006, Böhlen and Mateas 1998]. Sawhney and Dodge designed a small ambient display that uses sand to communicate slowly emerging patterns of data [Sawhney and Dodge 1997]. *Interactive Poetic Garden* is a design by White and Small that projects words on the surface of a pond, giving users multiple ways to move, group and interact with the words [White and Small 1998].

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## *Connecting Local and Remote Locales in Interesting Ways*

Other literature discusses ways to connect local and remote locales in innovative ways, typically in the context of domestic technology. *Digital Selves* is a project where Grivas virtually overlaps the homes of two intimate partners, spatially mapping them in such a way that each participant could know generally what the other was doing [Grivas 2006]. Other research, such as that conducted by DiSalvo, is aimed entirely at blurring the boundary between natural and artificial, or between humans and nature [DiSalvo 2009].

### *Digital Selves*

In *Digital Selves*, Grivas argues that current approaches to ubiquitous computing undermine mankind's embodied and experiential way of occupying and interpreting space [Grivas 2006]. Technology should extend and reflect our own physicality, says Grivas, and workplace-oriented values of usability and efficiency need to give way to the evocative, poetic powers inherent in computing. Grivas designed a spatial system where the homes of two distant partners were overlapped and virtually merged together, and the physical locations of active hubs in each home (such as the sofa, desk or kitchen sink) were marked out in physical space by devices in the other home. A device would glow when the other person occupied its space in their home, giving the distant person a spatial sensation of the other person's presence [Grivas 2006].

### *MORI*

DiSalvo et al. mention an art installation called *MORI*, which uses low-frequency sounds to communicate real-time seismic data from a remote probe [DiSalvo 2009]. DiSalvo et al. argue that by placing a unique emphasis on the interpretative quality of the representation of environmental information, *MORI* questions how we perceive and understand the natural world, and explicitly demonstrates how this understanding is technologically mediated.

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## *Interesting Ways to Collect Information from the Outdoors*

Other work offered inspiration for ways to collect information from the outdoors, including Tolle et al.'s *Macroscopes* project, which used a dense network of sensors to detect the microclimates of a redwood tree [Tolle 2005]. While their implementation was geared towards collecting scientific data, this work has implications for how we collect, process and communicate information in design. The ability to collect dense temporal and spatial information about a particular object or location in nature is a powerful concept, but with it comes the challenge of visualizing the resulting data in a meaningful manner.

## **Insights from Literature Review**

Based on my literature review, some of the most compelling insights came from the tenets of slow technology, which aims to amplify the presence of things through subtle, long-term change. Additionally, recent work in ambient technology offers inspiration for ways to use alternative mediums to communicate information in a peripheral, non-intrusive manner. Indeed, communicating the slow changes and temporal patterns of the outside world in an indoor setting, and making information about those changes available to people in an ambiguous manner that allows opportunities for reflection and meaning-making, are all key concepts that helped guide the development of my design principles.

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## 4. Research

### 4.1 Exemplar research

In an effort to gain inspiration for my design concepts and to motivate my design space, I conducted an extensive survey of existing designs, systems and concepts that attempt to connect people with the outdoors. Many people use familiar means to maintain a connection to the outside world while they are at work, populating their workspace with reminders of a life beyond the office. Nature calendars, framed photos from vacations, and computer desktop backgrounds depicting natural settings are all common ways to personalize one's space and satisfy this need. Some outdoor enthusiasts during user research indicated that in the winter they regularly view webcams for nearby ski resorts, and access websites that offer weather reports, wind conditions and snow forecasts.

In surveying existing solutions and concepts, I collected nearly two hundred designs that exemplify unique and imaginative approaches to connecting people with the outdoors. Some of these exemplars are efforts to literally bring the outdoors indoors, while others use artificial materials to create a reasonable semblance of nature inside. Some integrate nature into the built environment, while others create cozy outdoor-eque spaces within a larger space. A number of examples attempt to recreate windows or skylights at varying levels of realism and fidelity.

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### *Exemplars by Medium*

A number of exemplars are difficult to categorize in regards to their implementation, but are more easily grouped on account of their medium. Many exemplars make use of light, especially dynamic lighting that changes throughout the day, in an effort to simulate natural light and improve well-being in spaces with limited access to the outdoors. A few exemplars use sound to communicate information about the outside world, or to create a sense of being outside. A limited number of concepts make use of air, either to engage the sense of smell or to stimulate airflow in an indoor setting.

### *Exemplars by Subject*

Weather is by far the most common type of information offered by systems that report on the status of the outdoors. From simple web browser plugins to dedicated weather websites, from simple outdoor thermometers to networked forecasting devices, the range of forms and formats through which one can access weather information is staggering. While less common, other systems offer information on daylight, sunspots, moon phases, tides, and even tectonic activity. Some designs communicate time in an innovative manner, while others encourage reflection on both time and materiality.

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## *Literally Bringing the Outdoors Indoors*

In my exemplar research, many of the designs I discovered are concerned with literally bringing a piece of the outdoors indoors. Designs like the *Grobal* from Grobal LLC., *Grass* from nine99, and even the lowly *Chia Pet* allow people to introduce a small bit of greenery to their workspace. Solutions like the *Wooly Pocket* allow people to hang plants on the wall, lending the ability to add greenery while conserving desk space. La Chanh Nguyen's *Moss Carpet* allows one to literally carpet an indoor space with nature. Other designs such as the BOSKKE *Sky Planter* do away with horizontal and vertical surfaces entirely, opting for a hanging solution.

Not all literal solutions were concerned with plant life. The *Compubeaver* is Kasey McMahon's effort to introduce wildlife to a workspace, by installing a computer inside a stuffed beaver.



*Grobal self-watering pot by Grobal LLC.* <sup>3</sup>



*Sky Planter by BOSKKE* <sup>4</sup>





*Moss Carpet by La Chanh Nguyen* <sup>5</sup>



*Wee Woolly Pocket by Woolly Pocket Garden Company* <sup>7</sup>



*Grass by nine99* <sup>6</sup>



*Wally Five by Woolly Pocket Garden Company* <sup>8</sup>



*Compubeaver by Kasey McMahon* <sup>9</sup>

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### *Bringing a Fake Outdoors Indoors*

The delicate nature of living things, as well as the responsibility that comes with caring for them, are factors that may discourage their use in systems that aim to evoke a sense of the outdoors. A number of designs attempt to introduce nature to an indoor space, but use artificial materials to do so. *2030* by Raphael Charles is a rug that looks like an uncomfortable jumble of sharp rocks, but is actually made out of foam. *Sonumbra* by Loop.pH is composed of light-emitting fabric that responds to sound and is clearly not a real tree, but its familiar form echoes its natural brethren.

### *Using Nature in the Built Environment*

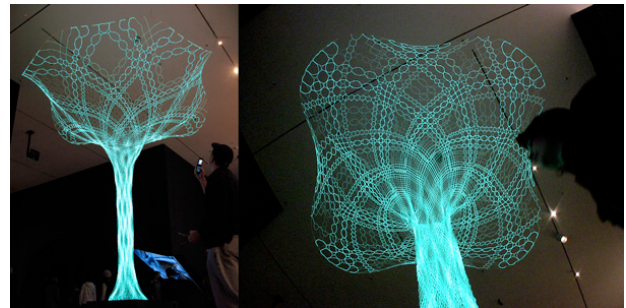
John Carson's residence in Margaretville, New York, located up in the Catskill Mountains, is deliberately built around a 250-ton bluestone boulder. The boulder is a dominating presence that takes up much of the living room, its rough-hewn natural form juxtaposed against the modern elegance of the residence. In a similar vein, Roald Gundersen constructed the indoor space of his Stoddard, Wisconsin residence using whole trees.

### *Built Environments Inspired by the Outdoors*

A number of architectural firms, including the Tumbleweed Tiny House Company and ALCHEMY, specialize in building tiny but finely-designed homes. These small structures, no larger than a potting shed, efficiently pack in the basic essentials for living, and inspire thoughts of a self-contained office in the wilderness. Similarly, Bob Tremain of Rochester, Minnesota turned a backyard treehouse into his home office. In reversing the flow on this concept, Pixar Animation Studios arranged one of their office spaces such that instead of cubicles, its employees work in a series of cozy houses. One can also find echoes of the tiny indoor house in Ishii's ambientROOM, a deliberately self-contained experiential space.



*2030* by Raphael Charles <sup>10</sup>



*Sonumbra* by Loop.pH <sup>11</sup>





*Residence by John Carson <sup>12</sup>*



*Pixar Animation Studio photo from Moses M <sup>14</sup>*



*Residence by Roald Gundersen <sup>13</sup>*



*Arado weeHouse by ALCHEMY <sup>15</sup>*



*Weebee by Tumbleweed Tiny House Company <sup>16</sup>*

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## Artificial Windows

While offering each employee their own indoor home may be beyond the budget of many organizations, there exist numerous efforts to simulate windows in windowless environments. These concepts range from detailed, high-fidelity attempts to recreate the experience of an actual window (from Friedman et al.'s HD office window to Radikovic et al.'s simulated parallax window) to Gaver's low-budget video window.

Mathew and Taylor's *Auralscapes*, which does not attempt to simulate a window but instead displays a real-time view of the sky, demonstrates the value of ambiguity and interpretation in the case of an artificial window. Daniel Rybakken's *Daylight Comes Sideways* uses thousands of LEDs hidden behind its canvas to simulate a foggy window, which animates to create the impression that one is watching a forest waving in the breeze. Makoto Hirahara's *Bright Blind* takes this abstraction one step further, with no movement at all. Each individual blind conceals a series of lights along the length its back, creating the impression that the blinds are backlit by a window that is not actually there.



*Daylight Comes Sideways* by Daniel Rybakken <sup>18</sup>



*Bright Blind* by Makoto Hirahara <sup>17</sup>

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## Simulating Outdoor Light Sources

Similar in some ways to *Daylight Comes Sideways*, Adam Frank's *Reveal* is a projector installation that simulates the appearance of light filtering in through a nearby window.

The image it casts depicts a tree swaying in the wind, framed by the shape and individual panes of the imaginary window. Daniel Rybakken's *Subconscious Effect of Daylight* is an end table outfitted with a hidden light source underneath, that projects a lighted shape on the floor. The resulting image appears as though the end table is casting a shadow from daylight filtering in through a nonexistent window.

## Artificial Skylights

While many concepts attempt to simulate windows, there are also a number of designs that consider skylights. *TESS Skylight Panels* are a ceiling installation for hospital settings, that offer a backlit image of blue sky and clouds. BioBrite offers a similar solution that attaches to standard office light fixtures. One of the outdoor enthusiasts we interviewed indicated that she saw these lights in her dentist's office, and was quite delighted by them.

Adam Frank's *Sunray* is a conceptual design for New York's Grand Central Terminal, that would project a moving image of the sun on the ceiling. The projected sun would represent the position of the actual sun were the ceiling transparent. There is no indication, however, how the design would overcome issues of auto-stereoscopy or parallax motion when determining where to render the sun or sky. A similarly fictional concept, from the Harry Potter series of books, is the ceiling in the Great Hall of Hogwarts School of Witchcraft and Wizardry. The ceiling is enchanted such that it mimics the sky outside, from day to night, from sun to stars, from clouds to rain to snow. This enchanted ceiling has been mentioned numerous times, unprompted, over the course of this project, in sketching exercises, design sessions, and conversations with others.



*Reveal* by Adam Frank <sup>19</sup>



*Subconscious Effect of Daylight* by Daniel Rybakken <sup>20</sup>



*Sunray* by Adam Frank <sup>21</sup>



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## Dynamic Lighting

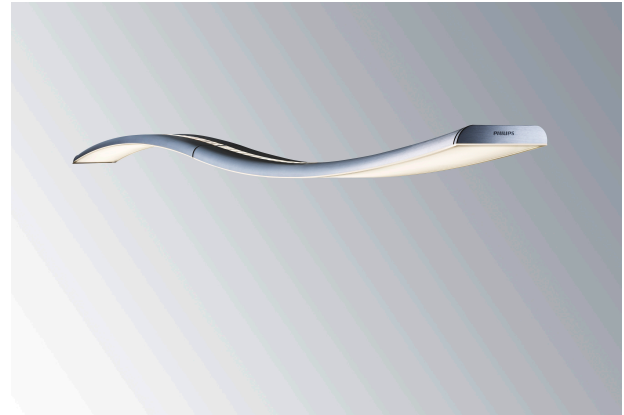
Philips has conducted extensive research into how lighting can be used in an office setting to boost productivity and improve the well-being of occupants. The Philips *Daywave* is a dynamic office lighting fixture that uses LEDs to offer different qualities of light, particularly different temperatures of white light, throughout the day. The *Daywave* operates under Philips' research claims that, for example, a cool bluish light can be refreshing and invigorating in the morning, while a warm orangish light in the evening can be cozy and comforting. These solutions show how one can adapt office lighting to accommodate the changing needs of office workers, or perhaps make it more closely mimic the changing qualities of light that one would experience outside.

The Philips *Living Colors* is a dynamic accent light that allows the user to choose from sixteen million different color options. Sharp's remote-controlled *DL-L60AV* LED light bulb offers seven different shades of white, and while offering a far more limited spectrum than the Philips *Living Colors*, puts a unique emphasis on the variety of colors of white light. SUCK UK LTD.'s *Sun and Moon Jars* are little more than colored solar-powered lights in frosted mason jars, but nevertheless evoke memories of collecting fireflies as a child. In making the intangible tangible, the notion of "collecting" sunlight or moonlight in a jar has a particularly ludic appeal to it.

## Sound

A number of designs and concepts use sound to communicate a sense of the outdoors. *Auralscapes*, mentioned above, uses an omnidirectional microphone on the roof of a building to introduce real-time outdoor sounds to a windowless interior room. Kobayashi describes a solution that uses a series of microphones in a forest to record and broadcast real-time nature sounds to a remote location [Kobayashi et al. 2009]. Further, with *Wearable Forest* Kobayashi weaves these sounds into reactive light patterns on a garment, and gives the wearer the ability to "communicate" by playing back pre-recorded sounds on remote speakers in the forest [Kobayashi et al. 2008].

There are numerous ambient sound systems, including alarm clocks and white noise devices, that allow people to listen to pre-recorded sounds. Often marketed because of



*Daywave by Philips* <sup>22</sup>



*Living Colors by Philips* <sup>23</sup>



*Sun and Moon Jars by SUCK UK LTD.* <sup>24</sup>

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their soothing qualities, these systems typically offer a collection of natural sounds, including crashing waves, babbling streams, chirping frogs and gentle rain. The sounds can be delivered in any number of forms, including CDs and bedside devices, and there are an increasing number of iPhone applications along the same theme, such as those offered by TMSOFT, LLC. and Naturespace Holographic Audio Theater.

One of the more imaginative uses of sound to communicate the goings-on of the outside world is *Space Weather Radio*, a website that allows visitors to listen to satellites and meteors pass over Lake Kickapoo, Texas. Similarly, Goldberg et al.'s *MORI* is an art installation that records the remote geological movements of the Hayward Fault in California, rendering them in real-time as low-frequency sounds that reverberate throughout the gallery space.

## Air

Compared to light and sound, air seems to be a relatively unexplored medium for influencing perception and experience within a built space. Humidifiers and dehumidifiers are familiar tools for influencing the amount of moisture in the air. A number of air purifiers and air “washers” are available on the market, that aim to cleanse the air of dust, mold and other particulates. The *ANDREA Plant Air Filter* by LaboGroup is a self-contained device that uses plants to purify and oxygenate the air in a room.

With the ambientROOM, Ishii et al. first mentioned the challenges of using air to communicate information. They found air difficult to control, and thus relied on using the spinning of pinwheels, not the air itself, to ambiently convey information. The Dyson *Air Multiplier* fan, however, is a radically different approach to moving air, and could hold the key to being able to precisely control airflow. This bladeless fan takes in air at its base, and releases it from an open aperture in a continuous stream of smooth air. With further advancement and miniaturization, technologies like the Dyson *Air Multiplier* may allow us laser-like precision in how we control the movement of air in built environments.

Despite our sense of smell being quite developed and so closely tied to memory, there seems to be reservation in using it to deliberately communicate information. There are



*ANDREA Plant Air Filter* by LaboGroup <sup>25</sup>



*Glade Sense & Spray Automatic Air Freshener* by Johnson & Son Inc. <sup>26</sup>

a few humidifiers on the market that include fragrances in their list of features, and the Glade line of products from Johnson & Johnson is dedicated to scent. Most interesting, at least from a computing perspective, is the Glade *Sense & Spray Automatic Freshener*, which automatically releases a burst of fragrance when it detects movement. While this particular solution is certainly primitive from a contextually-aware perspective, the idea of releasing scents based on context, rather than deliberate action on the part of the user, is certainly interesting.

*Soarin' Over California* is a ride at Disneyland that makes effective use of both airflow and scent, in an effort to provide an immersive multi-sensual experience. Visitors buckle into a simulated hang glider, which moves as a large theater screen plays flyover footage of famous California landmarks. Fans blow on the visitors to give the sensation of flying through the air, and different scents are added to the airflow depending on the scene depicted in the film. When visitors “fly” over an orange field, for example, they smell oranges, and similar scents accompany an evergreen forest and an ocean coast.

### Weather Applications

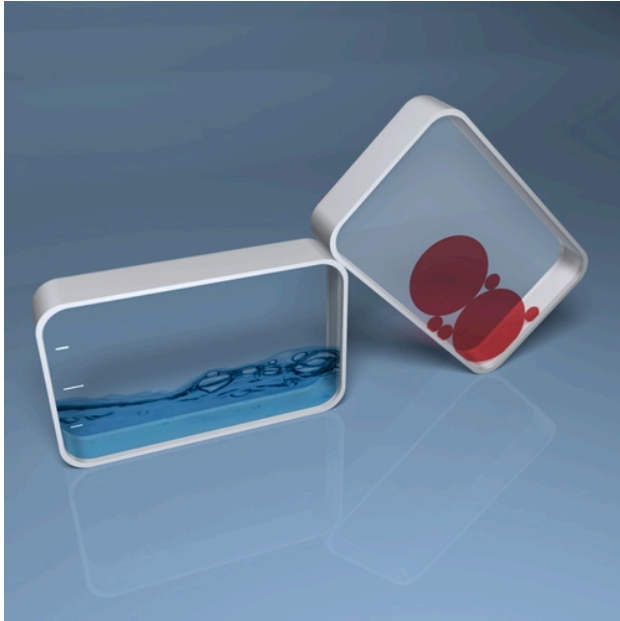
Solutions abound for accessing weather and forecast information. Webpages such as [weather.com](http://weather.com), [accuweather.com](http://accuweather.com) and [wunderground.com](http://wunderground.com) allow visitors access to current conditions, local forecasts and radar maps. Google includes local weather forecasts directly in search results, as well as on users' iGoogle home pages. Mac OS X has had a weather widget for years, and Windows has a weather gadget as well. Firefox has a number of browser plugins that can unobtrusively display weather information in toolbars and status bars, and a few outdoor enthusiasts indicated that they use these plugins to keep an eye on what's going on outside. The Apple iPhone has a default weather app, and the App Store is full of iPhone applications that deliver weather information.



Weather OS X Dashboard Widget by Apple <sup>27</sup>



Big Digit Indoor/Outdoor Thermometer by Extech Instruments Corporation <sup>28</sup>



*Interactive Desktop Hygrometer and Thermometer by Mac Funamizu <sup>29</sup>*

### *Weather Appliances*

Beyond the computing environment, our surroundings are filled with weather information, from simple thermometers to digital indoor/outdoor thermometers. While the digital thermometer industry has seen a proliferation of brands and enclosures, true innovation seems rare. Almost all devices feature grey segmented LCD digits, minimum and maximum temperatures, and measurements to the tenth-of-a-degree. Mac Funamizu's physical thermometer concept is a welcome reinterpretation, with a unique visual language that does not rely on segmented numerals. In his concept, each large dot represents ten degrees, and each small dot represents one. Also interesting is Funamizu's hygrometer, which would represent humidity by how much water is shown in the device.

Personal weather stations demonstrate a bit more diversity and attention to design. The *7-Day Forecaster* and the *Weather Caddie*, both from Ambient Devices, are networked weather devices that communicate wirelessly with AccuWeather.com to retrieve local forecast information. The *Internet Weather Station* by Sharper Image functions in a similar manner, but with a full-color LCD screen and graphical treatment that breaks away



*7-Day Forecaster by Ambient Devices <sup>30</sup>*



*The Internet Weather Station by Sharper Image <sup>31</sup>*



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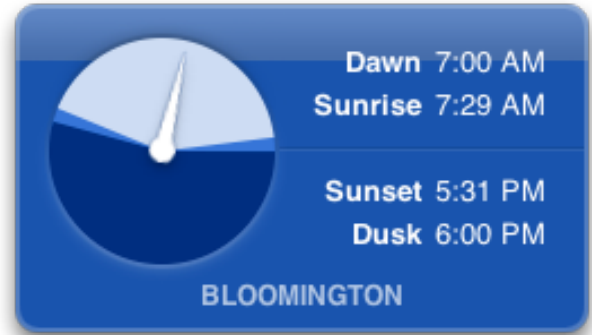
from the standard segmented digits.

Likewise, the Oregon Scientific *WeatherNow II* connects to the MSN Direct Weather Service to retrieve its extended forecast information. Additionally, the Oregon Scientific Complete Wireless Weather Station <sup>32</sup> is interesting from a sensing perspective, in that it comes with all the outdoor materials necessary to set up your own personal weather station. From wind speed to rainfall, humidity to barometric pressure, the *Complete Wireless Weather Station* collects local sensor data from the outdoors, and can broadcast it to multiple remote displays.

### *Communicating Outdoor Status*

A number of solutions communicate the status of a feature of the outdoors, without necessarily being concerned with weather. *Sol* is an elegant widget for OS X that shows how much daylight is left in the day for your particular location. The circle of the widget represents the current day, and the amount of lightness or darkness indicates the proportion of daylight and night for today. As the seasons progress and the days get shorter, you can actually see as the dark part of the circle get larger.

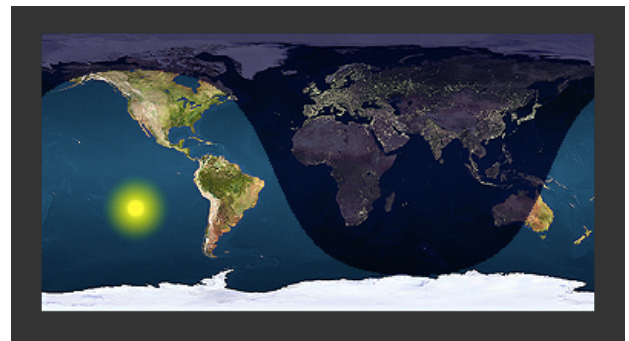
*Sunlit Earth* is another widget for OS X, which overlays the current extent of daylight and night on a flat satellite image of the Earth. Along with the boundaries between night and day, an image of the sun moves across the map, showing where the sun is directly overhead. Similar to *Sol*, as the seasons progress you can see how the boundary changes shape in the extreme northern and southern latitudes. Near the equinox the boundary between day and night takes on a very sharp angle at extreme latitudes, whereas near the solstice the boundary has a very gentle angle.



*Sol OS X Dashboard Widget by Captain Dan* <sup>33</sup>



*Sunlit Earth near the vernal equinox.*



*Sunlit Earth near the winter solstice.*

*Sunlit Earth OS X Dashboard Widget by Texas A&M Astronomical Observatory and Don Carona* <sup>32</sup>

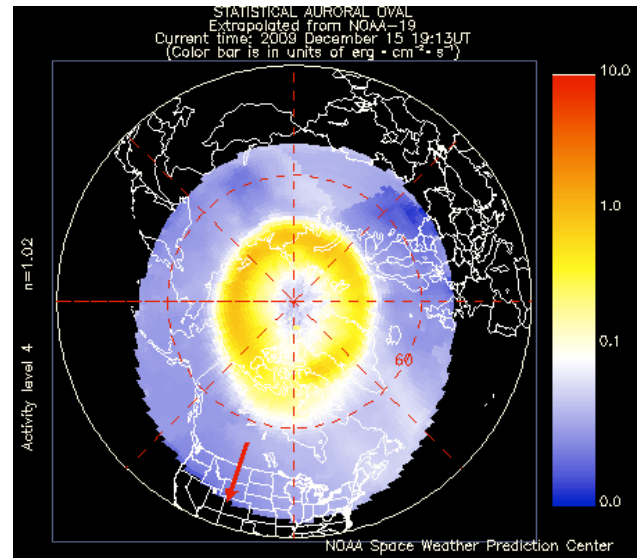


There are many other services that offer information about celestial activity. *Moon Phase* is a simple widget for OS X that depicts the current phase of the moon. The *Current Auroral Oval*, a service offered by NOAA, depicts activity in the northern hemisphere's magnetic field, which can be interpreted as the potential for viewing the northern lights. Spaceweather.com is a clearinghouse for information on auroral activity, as well as meteor showers, spaceship flyovers, sunspot counts and solar flares. *Spaceweather Phone* is a service that can alert you to upcoming meteor showers or planetary alignments.

In addition to the usual weather applications, there are a number of iPhone apps currently available in the App Store that are dedicated to tracking outdoor systems. *SunGPS* by Mark Hessburg tracks the position of the sun, including sunrise and sunset, as well as the current height and azimuth of the sun. *Oakley Surf Report* compiles data from Surflin.com to track tides, swell, surf height, wind and weather conditions at numerous beaches around the world. A number of snow report applications, including those from The North Face, REI and Clif Bar, allow users to access snow conditions at ski resorts across the globe.



*Moon Phase OS X Dashboard Widget by Jon Wiley* <sup>34</sup>



*Visualization of Current Auroral Oval by NOAA* <sup>35</sup>

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## Miscellaneous Exemplars

Many of the exemplar designs I have discovered in my research are undoubtedly influential on my thinking, but nonetheless defy categorization. Some are anachronistic, like the planting charts and weather predictions of the *Farmer's Almanac*. Others are modern technologies looking for problems, like netbooks and other internet appliances.

The *litl* is a small netbook with an interesting form factor that allows it to turn inside out and stand on its own, like a digital picture frame. The *Chumby*, recently redesigned, is an internet appliance that can access the news, display weather forecasts, stream music and share pictures, all independent from one's computer. The *Ambient Orb* is a tabletop device that can be programmed to change color according to stock prices or weather. Taking the weather theme a step forward, the *Weather Beacon*<sup>36</sup>, also by Ambient Devices, changes color depending on the forecasted high temperature for the day, and pulses if precipitation is predicted.



*The litl netbook by litl, LLC.* <sup>37</sup>



*The chumby one by Chumby Industries* <sup>38</sup>



*Ambient Orb by Ambient Devices Inc.* <sup>39</sup>

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Funamizu's snow globe concept is interesting from a form factor perspective, in that it projects an interactive three-dimensional photo browsing interface within the confines of a half dome. While this concept is beyond the scope of today's technology, the *Momento* digital video player concept from Philips shows that others are considering these alternative form factors as well. The *Momento* would be a seamless spherical device with an internal screen that plays videos over Bluetooth, and like a snow globe would be controlled through grasping and shaking.



*Snow Globe Screen by Mac Funamizu* <sup>40</sup>



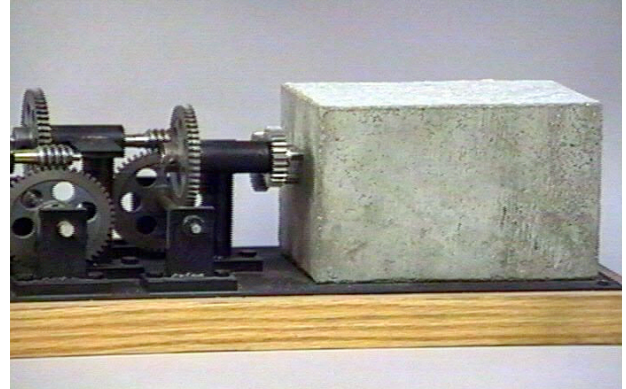
*Momento by Philips* <sup>41</sup>

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Other designs, including much of Arthur Ganson's Kinetic Sculpture work, are inspiring because of the emotions and states of reflection that they evoke. In particular, Ganson's *Machine With Fabric* slowly drops a piece of shiny blue fabric on a flat surface. The incredibly slow movement causes the viewer to carefully attend to the materiality of the fabric, its unique texture and how it reflects light in a particular way, lending meaning and significance to a simple blue scrap. Similarly, Ganson's *Machine With Concrete* uses a series of twelve pairs of gears to reduce the speed of an electric motor. While the motor spins at a rate of two hundred revolutions per minute, the final gear spins at an approximate rate of one revolution per *two trillion years*. Ganson has thusly embedded the last gear in an immovable block of concrete, leading the viewer to consider a timescale that operates at a vastly different scale than her own life. It is my hope that my design principles can aid in the design of systems that encourage a similar depth of reflection regarding one's own relationship with the outdoors, and the temporal and spatial scales therein.

### *Insights from Exemplar Research*

I cast a wide net during the course of my exemplar research, which exposed me to many unexpected mediums that could offer unique opportunities for evoking a sense of the outdoors in an indoor environment. In particular I was inspired by designs such as those by Arthur Ganson, which offer deliberately slow opportunities for reflection, or those by Daniel Rybakken, which creatively use light to communicate a sense of extended space.



*Machine with Concrete by Arthur Ganson* <sup>1</sup>



*Machine with Fabric by Arthur Ganson* <sup>2</sup>

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## 4.2 User research

As part of my user research, I posted questions to two public forums popular with windsports enthusiasts, asking members how they stay connected with the outdoors at work. These discussion threads resulted in more in-depth online conversations with a few participants, and some email correspondence as well. Additionally, I conducted a phone interview with the manager and owner of an outdoor sports company based in the Pacific Northwest, to learn how he manages a balance between work life and active life.

The goal of my user research was to gain insight into how people perceive and frame their relationship with the outdoors, particularly in the context of their working environment. I chose outdoor enthusiasts as my target user group based on my own personal familiarity and experiences with the challenges, annoyances and frustrations that these enthusiasts face when they work indoors. These are individuals who are intimately familiar with nature, and have a vested relationship with the outside world.

Additionally, I chose this group because it sets the bar unnaturally high for creating an authentic, if not necessarily realistic, solution to this problem. An outdoor enthusiast who is able to get outside on the weekend, and uniquely identifies with the activities she engages with while she is outdoors, is intimately familiar with the experience of being outside. She understands the subtle and complex qualities of nature, and thus will be extremely critical of anything but the best, most authentic solution. Because of her familiarity with the outdoors and ready ability to get outside, she will be able to compare any solution against the actual aesthetic experience of being outside. This critical and knowledgeable user group possesses a certain connoisseurship of outdoor experience, and as a result their input can help to inform more sophisticated design principles for building systems that evoke a sense of the natural world indoors.

### *Questions Posted to Outdoor Enthusiast Forums*

In response to the questions I posed on outdoor enthusiast forums, one person indicated that they would actually use an outdoor toilet in the back parking lot of

their work as an excuse to go outside. The fresh air from the walk outside was cited as a compelling motivation for this behavior. This person also compared their workplace to a cave, a rather negative comparison that evokes thoughts of a cramped and dimly lit space. Another person indicated a desire for some sort of device that would connect them to the Earth specifically. They also mentioned their love of the smell of leaves, and how it might be interesting to introduce that to a work setting.

One participant offered the value of having a plant on their desk. Another person mentioned nature almanac calendars, that communicate what is happening in the natural world in your area at a particular time. They suggested an almanac program that would communicate on a daily basis these natural and biological processes, such as the salmon returning to the Columbia River, birds migrating back to the area, or amphibian eggs hatching. This person also indicated that information too closely tied to their favorite outdoor activities (such as wind and water conditions for a watersports enthusiast) were actually harmful psychologically, as it made the person want to be somewhere besides work.

One person adamantly stated that the only technology necessary to maintain a connection to the outdoors is a window. In particular they suggested a south-facing window that would allow sunlight to filter into the workspace, and related their own positive experience of being able to glimpse a sunrise or sunset while at work. They also suggested the value of taking their lunch outside, even in cold weather, as this quick outdoor break helped them with their mental state.

This person also suggested creating a web page of shortcuts to local weather, astrological information, tides or web cams of places one might go after work or on the weekend, in an effort to maintain a connection with the outside world. However, they indicated the risk inherent in visiting these online resources too often, as it gives the impression that one is simply goofing off at work. Indeed, the social and cultural structure of the workplace was cited by many participants as being detrimental to their ability to engage with the outdoors at work. One person was pessimistic about the ability for a new device to strengthen one's connection to the outdoors, as technology and nature were perceived as mutually incompatible. To this

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participant, there was no substitute for actually being outdoors.

One participant vented their frustration with insensitive, contextually-agnostic systems that would issue “wind alerts” notifying them of excellent kiteboarding conditions while they were stuck at work and unable to leave. Similarly, this person indicated that for a brief period they used a digital picture frame on their desk to cycle local photographs of kiteboarding. They decided, however, that the time spent looking at the photos was wasted time that could have been spent finishing their work more quickly, and actually getting out on the water after work. What’s more, the rotating kiteboarding photos often became a topic of conversation with other coworkers, furthering a sense of lost productivity as a result of the digital picture frame. As a result this person now has only two (static, non-digital) framed photographs on their desk that depict kiteboarding, and says that they actually threw the digital picture frame away.

A number of individuals noted the importance of listening to music at work, in order to maintain a positive mood. One individual suggested the idea of an outdoor parklike workplace, where each person’s office would be an tiny individual house or potting shed. Daydreaming, they mused that being within walking distance of water would be an ideal arrangement. Referring to my “chainsaw” concept, which would allow users to “install” a window wherever they want, one person referred to architect Christopher Alexander, and his work in establishing a pattern language to empower people to design and build their own architectural spaces [Alexander 1977].

### *Detailed Responses from Outdoor Enthusiasts*

A few participants in the forum threads offered quite in-depth responses, and some communicated via private forum messaging.

#### *Detailed response from M.*

M. maintains a connection with the outdoors by actually getting outdoors, and deliberately crafting his worklife to make this possible on a regular basis. He cites five obstacles that prevent him from getting out, namely those of meetings, deadlines, bosses, knowing “when to act”, and securing vacation approval on short notice. An avid

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windsurfer, M. refers to these “perfect” days to get outside as “Windsdays”, and based on weather and wind forecasts will actually plan for and execute on them.

#### *Detailed response from T.*

T. works as a product manager at a software company, in an office with large windows, which he says is nice on sunny days, but dreary during the rainy, grey winters in the Northwest. He spends about a third of his time in meetings, and avoids the phone in favor of running up and down the stairs to chat with co-workers who work on another floor. He spends about a quarter of his time working remotely, in such places as the Columbia Gorge, Seattle or Maui.

He sees the outdoors throughout his workday, but is usually too busy to actually “see” it. For T., the outside world is regularly in the background of his perception. He regularly checks windsurfing webcams in Maui or the Columbia Gorge, and is constantly checking wind speeds throughout the west coast and Hawaii. At one point he had a screen saver with a photograph of a professional windsurfer, executing an enormous jump.

T. says that the importance of nature in his life has changed over time. Twenty-five years ago, for example, he was an active climber, and valued quiet, solitude, pristine wilderness, and challenging climbing terrain. He continues to value the quiet and solitude, and tries to avoid crowds when engaged in any outdoor activity, but is now more interested in the simpler pleasures of sun, blue skies and warm water.

#### *Detailed response from K.*

K.’s attitude towards working indoors can be summed up in one quote, which she offered unprompted via email: “I work inside and it blows. Big time.”

K. is the executive director at a small non-profit company in Oregon. She works alone in a small 15’ x 10’ office, which she says can get lonely, but fortunately she can bring her dog to work for company. She spends the bulk of her workday at her desk and in meetings, but once a week goes on a walk to get coffee and socialize. She has an office window and can see the Columbia River from her desk, which she says boosts her mental state, but not her work productivity.

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To stay connected with the outdoors during her workday, K. often opens her window, the fresh air from which helps prevent her from feeling nauseous. During the summer she sneaks in quick windsurfing sessions in the morning, under the guise of “networking” with the industry and community.

K. previously worked as a windsurfing instructor, and misses the active lifestyle that working an outdoor job would naturally bring. Often, she says, she spends all day sitting in front of her computer at work, only to be exhausted at the end of the day and waste her evening sitting around at home. Naturally, she says she loves the fact that being outside is almost always a more active pursuit than being inside, and often yearns for a release from her sedentary office life.

*Detailed response from E.*

E. works as a pharmacy technician at a mail-order pharmacy company in the Pacific Northwest. He spends his day working in the warehouse where there are no windows. His only contact with the outdoors is when the occasional delivery truck arrives and he gets to answer the door. The nearest windows are outside his workspace and are only seen in passing. They are blurred out for privacy, however, so they bring in little natural light and do not allow a view of the outside.

E.’s work and work location in the warehouse varies from day to day, and depends on staffing requirements and the sort of work that needs to be done. As a result he finds himself working on 10-20 different desktop computers throughout the warehouse, and has no permanent workspace. He has setup different surfing or kiteboarding pictures on the desktops of most of these computers, and while he used to visit forums and other sport-related websites during lulls in work activity, the company has since restricted web access to a few specific stations throughout the office, in a policy effort to prevent distractions among employees.

E.’s work requires that he print and scan numerous barcodes, and as a result most of his workspaces are dotted with label printers and barcode scanners with bright LED lights on them. These lights are annoying and useless, E. says, so he has actually covered them with tape.

E. listens to music on his iPod at work and keeps earbuds in his ears all day, and says that music is the only saving grace in his job. He keeps a miniature longboard skateboard at work, so he can get outside and skate on breaks or during lunch. E. says that any attempts to help himself maintain a better connection to the outdoors have always been undone by management, and he has even considered taking up smoking to get more frequent breaks.

When it comes to the outdoors, E. values a life in the sunshine and well-kept roads for skating, and dislikes car exhaust. He says he needs to find a way to spend more time outside, and is looking into jobs that would provide a better work environment given his interests and passions.

*Detailed response from N.*

N. is an administrator, who works in an open office where each individual’s workspace is separated by cubicle walls. She works at her desk all day, doesn’t move around much in her job, and is rarely involved in meetings. Employees are allowed to listen to music at work, so she’s typically plugged into headphones during the workday.

N.’s workspace is populated with photographs of family, as well as pictures from her favorite outdoor pursuits of kiteboarding, snowboarding and dirt biking. N. is lucky enough to have one of the only windows in the office, which offers an incredible view of the Columbia River and Mount Hood. N. hates artificial lighting, and on sunny days her officemates turn off the overhead lights to allow the space to be lit naturally.

Sometimes when she needs a quick mental break, N. will turn her chair to face the sun, close her eyes, and absorb the warm sun on her face for a few moments. When it is nice out N. will often go for a walk outside on her lunch break, though employees are not allowed to leave the office campus during the work day.

N. says she needs to live near a river or ocean, as she is never happy unless she lives close to water. She loves being outside and enjoying nice weather, and likes the smell when it first begins to rain, and the smell of flowers in the spring. She loves the way that snowboarding through fresh powder makes her feel like she is floating, and thrills in the feeling when she does a jump just right.



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She enjoys the anticipation of driving to have fun, loves days that are sunny but chilly, and says that she feels a deep, personal connection with the wooded trails and her dirt bike when she goes out riding.

### *Phone Interview with a Manager of an Outdoor Sporting Goods Store*

As part of my user research I conducted a thirty-minute phone interview with one participant, who owns and manages an outdoor sporting goods store in the Pacific Northwest.

#### *Interview with S.*

S. is a 59-year-old manager who enjoys windsurfing, kiteboarding, cycling and playing tennis, and operates an outdoor sporting goods store in the Pacific Northwest. He has a window in his workspace, from which he can see the sky and the tops of some trees. If he stands up and looks out the window, he can see an incredible view of the Columbia River Gorge, complete with cliffs and trees.

S. is happy that he can see, from his office window, people outside windsurfing and kiteboarding; that he can see the stuff he wants to do. He looks out the window often, and considers it an opportunity to stand up, stretch, and reconnect with the outside world. He describes the window as “prime real estate” and cannot imagine what it would feel like to work in a windowless setting.

Despite a rather ideal setup in his office, S. actually spends very little time at his desk. In running a retail store he is on his feet most of the day, helping customers on the sales floor, checking stock in the back room, and running up and down the office stairs. He often runs errands by foot in town, and occasionally goes out for exercise on his lunch break.

For S. interacting with fellow co-workers throughout the day is extremely important, and he believes strongly in maintaining a connection both with people as well as the outdoors. S. will talk with co-workers about what is going on outside, but beyond looking out the window he does not keep tabs on it during his workday. Outside of work he will often check news and websites, but for S. a separation between work life and non-work life is extremely important. When he is at work he is deliberate about focusing on

work-related tasks and minimizing distractions, so he can get everything done and leave early.

S. says he values the outdoors because he simply enjoys the innate satisfaction of being outside. Changes in weather and seasons do not affect S.’s mood that much, as he says he participates in enough sports, such as cycling and hiking, that allow him to stay active and get outside during transitional seasons.

#### *S.’s Recommendations*

S. describes his connection to the outdoors as very much a lifestyle choice, in that he will often take advantage of his lunch break to go windsurfing instead of, say, heading to an office cafeteria to eat a large plate of unhealthy food. S. clearly had an opinion about the manner in which I was tackling this design problem, and did not mince words about the realities of changing behavior in the workplace. He offered some suggestions that I continued to consider as I worked through my design exploration.

S. spoke of the importance of designing a solution not for an entrepreneurial-minded workaholic, who might be working extremely long hours indoors, but rather what he described as the more typical American worker, who “puts in his 40 hours.” He described his working situation as rather ideal, but recognized that people who are more cubicle-oriented in their line of work could greatly benefit from a better connection to the outdoors. According to S. the challenge is not in finding something that helps employees at an outdoor sports company be active, but in delivering a solution that improves the quality of indoor life for people who spend eight hours a day in front of a computer.

Additionally, S. mentioned the importance of “theatrical” performance and impressions at work, how employees do not want to get fired, and need to (or feel they need to) look like they are working so that they appear productive to others. Given this need for focused productivity at work, and the desire to not appear as though one is “goofing off”, a solution would need to be “almost subliminal” so that it could improve working conditions without being distracting. Indeed, S. mentioned studies that indicate certain combinations of lighting, sounds and colors can improve workplace mood.



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## *Insights from User Research*

Through my user research I discovered that the indoor workplace is filled with complex relationships, perhaps the *least* considered of which is the relationship between employees and the outdoors. Significant concerns tend to be managing impressions at work, and the theatrical performance of appearing productive. Systems that distract from productivity, including slideshows, digital picture frames or web cams, tend to be discouraged, as they give the impression that one could actually get more work done without them, and potentially enjoy more time outside as a result.

Additionally, systems that report on specifically meaningful information, including current wind conditions for windsports enthusiasts, can actually be harmful to individuals as it reminds them of the great outdoor experience they are missing. A final challenge is that bottom-up efforts led by employees to maintain a connection with the outdoors are often unraveled by management, so any solution would need to have organizational support in order to remain established in the long-term. Ultimately, users indicated that the best technology for maintaining a connection to the outdoors was a window, and that any use of technology beyond the qualities of experience that a window affords would be met with skepticism.

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## *Beyond Outdoor Enthusiasts*

The design principles outlined in this paper have implications for user groups beyond that of this target research population. Indeed, outdoor enthusiasts are a privileged group that is already willing and able to get outside whenever desired, an opportunity that many people currently lack. Hospital patients, elderly people and other vulnerable groups may not have the ability to regularly and willfully get outside, and for them these principles can help guide the design of systems that would not merely complement an already rich outdoor experience, but perhaps exist as their only connection with the outdoors. While this research focuses on outdoor enthusiasts, the uniquely critical demands of this population help inform principles that have implications for the design of solutions for disadvantaged populations.

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## 4.3 Design Research

As this project has been a design exploration, rather than a pure research project or a product-oriented design project, much of my work falls under the category of design research. I engaged in numerous design-related activities to jog my thinking, and to force myself to think about and reconsider my problem space in new ways. These activities included in-depth conversations with fellow design peers, prototyping activities where I asked designers to create systems that evoke a sense of the outdoors, and extensive sketching sessions, where I explored my opportunity space and generated numerous design concepts.

### *Design Conversations*

In a conversation with a number of fellow designers we discussed the circadian rhythm, and the challenges that new parents go through in helping their newborn children establish a rhythm with daylight, and sleep through the night. One designer related his own experience of how switching to and from Daylight Savings Time throws his body off-rhythm. Another designer shared his experience of sleeping in a dark, windowless bedroom, and that he needs a lighted clock that gradually gets brighter in the morning to help him get out of bed at a reasonable time. In another design session, a designer informed me that hospital patients who can see trees out of their room window heal faster than those who cannot, a theory I was able to confirm through secondary research [Ulrich 1984].

We also discussed the importance of weather, both as a topic of conversation, as well as a source of meaning. People often follow the weather of places they have lived, places they are going, or places where they have friends or loved ones. Additionally, we talked about “the sublime” as it relates to our experience of nature, and the importance of such a force that cannot be changed or influenced by human activity, and can only be met on its own terms.

One designer discussed his experience living in a hundred-year-old house, that was positioned on its lot and constructed in such a way that low-angled sunlight would stream in through windows during the winter and keep it warm, while during the summer high-angled sunlight would stay out, keeping the house cool. Additionally the house was made largely of brick, whose heavy thermal

mass held heat in the winter. Indeed, this designer mused that perhaps we have lost our connection with the outdoors simply because we have central air.

### *Conversation with Richard Hazlewood*

I had an extended conversation with Richard Hazlewood, a Ph.D. candidate at Indiana University who specializes in ambient computing. We discussed many potential concepts for connecting people with the outdoors, including a means to visualize salmon running up a river, and constructing a terrarium that reflects the weather of a remote location. He also mentioned a frosted ceiling light that resembles a skylight but is actually artificial, and a particularly imaginative artificial “natural” light window, that simulates a backlit window with closed blinds. Through my exemplar research I was able to find an example of the artificial window he described, namely Makoto Hirahara’s *Bright Blind* concept.

When discussing ambient technology in general, Hazlewood stressed that ambient information is never ambient at first; that it always calls attention to itself before it fades into the background of perception. He also suggested that evaluating proposed ambient devices based on whether they provide “useful” information or not is a meaningless endeavor. Indeed, his interests in establishing ambient systems are to make information, even “irrelevant” information, available to people, and see how they interpret and make use of it. He used the example of having the “worst superpower in the world”, where one could see and detect carbon dioxide in the air. Seemingly useless at first, such a skill would allow you to know, based on exhalations still hanging in the air, whether someone had recently stepped out of the room, or whether you just missed a large group meeting.

### *Meeting with Shaowen Bardzell*

I had a meeting with Shaowen Bardzell, where she stressed the importance of identifying pockets of opportunity to intervene in the user’s everyday activities. Especially when dealing ubiquitous computing, I need to know how people create meaning in their environment, both individually as well socially, and what elates and frustrates them in the context of work. She advised I look into domestic technologies as a way to gain insight into what people do indoors, in their natural habitat. We also discussed the ramifications of extending my problem

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space, which involves a privileged population that is already physically able to get outdoors, to a marginalized population of people who are confined indoors because of health or physical issues. Rather than simply enhancing the lives of people who can already get outside, Bardzell challenged me to consider the possibility of giving something very new to these people who cannot get outside even if they want to. Given my passion for addressing the needs of outdoor enthusiasts it is proper to continue on my charted path, but I continue to consider the implications of my design principles, and how they might be leveraged to benefit other user groups.

### *Conversation with Erik Stolterman*

In a conversation with Erik Stolterman, we discussed a recent exchange between two other faculty members. Since it is difficult to hear what is going on outside from the second floor faculty offices in the Informatics East building, one faculty member would often call over to the other to ask if it was still raining outside. Stolterman also kindly filled me in on the origin of the term “friggebod”, in that it is a play on the name of a Swedish politician who helped pass legislation allowing property owners to build tiny sheds on their property without needing to secure a permit. These small buildings, called “friggebods”, are often used as a tool shed, a place for children to play, or a miniature guest house.



*The design prototyping activity*

### *Design Prototyping Activities*

One evening I held a 20-minute design activity with three fellow Informatics graduate students, where they were each challenged to prototype a design, system or solution that helps people maintain a connection with the outdoors. I provided the designers with a variety of prototyping materials, including pens, pencils, scissors, tape, glue, construction paper, outdoor magazines, rocks, sticks, bones and Play-Doh. One designer, inspired by the *Enchanted Ceiling* in the Great Hall of Hogwarts, came up with a three-dimensional ceiling display that would show a live video feed of the current sky. In the case of rain or snow, in-air projection technology would be used to make it appear as though the precipitation is falling down around you. In the case of a clear night sky, the moon and stars would be in the actual locations that one would find them if they stepped outside.

Another designer came up with a solution called the *Edifice*, which would be a small building that consisted almost entirely of large exterior windows, located somewhere in the wilds of Alaska. He cited the *Weehouse*, as well as other trends in off-site pre-fabricated housing construction, as precedent and inspiration for his idea. The aim of his design would be to make its occupants intimately aware of their surroundings, putting their work in a completely different context. People working in this structure would feel like they are outside and connected with the natural world. Video cameras would be trained on

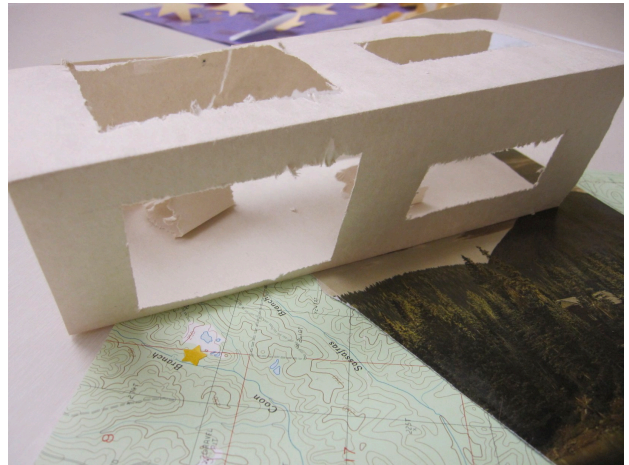
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the structure and the surrounding wilderness, so remote visitors could see what they were missing.

The third designer in our activity came up with no less than three concepts to help people maintain a connection to the outside world. Her first design was the *Moon Lamp*, a ceiling light whose shape and brightness would change depending on the current phase of the moon. Her second design was an artifact that would live on someone's desk, and would represent and follow the natural world. It consisted of a wooden stick with a small bud, that would blossom in the spring, fall off in autumn, and regrow the following spring. Finally, her third design was a map that would appear on the computer desktop, marked with a series of favorite locations. By selecting one of the locations, the user could bring up a real-time photograph depicting that place. If real-time imagery is not available, the system would use information about the time of day, weather, season and geo-location to select an appropriate picture from a shared photo pool.



*The Enchanted Ceiling prototype*



*The Edifice prototype*



*The Blossoming Stick prototype*



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### *LightScreen Prototyping Activity*

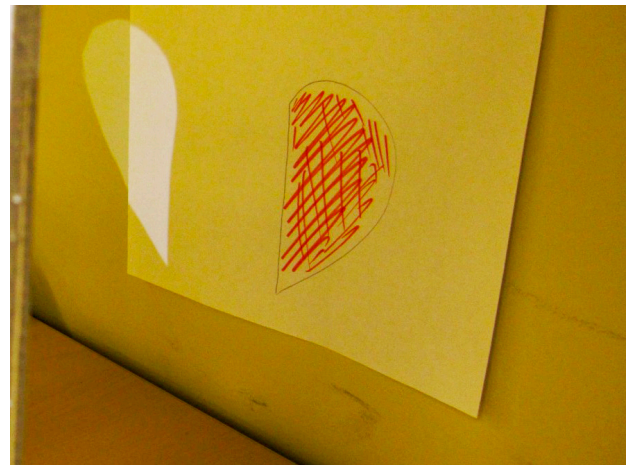
I held a second design prototyping activity, where three fellow design students were asked to create light prototypes that would help communicate a sense of the outdoors in an indoor space. I provided the designers with a wide array of prototyping materials, including construction paper, topographic maps, scissors, tape and glue sticks. In addition I created the LightScreen, a small frame designed to hold a regular-sized sheet of paper in front of a flashlight. The designers came up with a number of compelling prototypes, as well as some new ways of interacting with light that I had not considered. I had long been looking at ways to manipulate the shape and quality of light introduced into a space, but I had not yet thought of using a paper screen itself as a canvas upon which to cast light images. One of the designers shared examples of Chinese shadow play, a kind of theatrical puppetry that involves colorful characters pressed up against a thin, brightly back-lit sheet of rice paper.

Another designer cut random holes into a sheet of green construction paper, and held it in front of the flashlight to simulate the effect of cool, green light filtering through a lush forest canopy. The idea was that the angle and color of light would change throughout the day, and that the cast light itself would move as though filtering through leaves on a breezy day. This design resonated significantly with me, as the quality of light underneath a maple tree fiery with the colors of autumn has been a great source of personal motivation throughout the course of this project.

Finally, one of the designers produced a particularly imaginative prototype, where the shape cast by a beam of light would actually complete a physical shape. This particular example used a wall-mounted sketch of half a heart, and a half-heart-shaped screen in front of the flashlight. The idea is that as a significant date approaches, perhaps your anniversary or the birthday of a loved one, the lighted half of the heart would slowly, over the course of a few days, approach the physical half. On the day of the significant event the two halves would meet, forming a complete heart out of material and light. This concept is incredibly interesting, as it brings together the notions of ambient information, ambiguity, interpretation, interpersonal meaning, and human relationships in a deeply resonant manner.



*The Sunlight Through Leaves LightScreen prototype*



*The Anniversary Heart LightScreen prototype*

## Visit to J.L. Waters

In an effort to jog new ideas I took a trip to J.L. Waters, a local outdoor sporting goods store located Bloomington, Indiana. The retail space of the store maintains a strong aesthetic of the outdoors, using exposed wood, raw materials and other warm, natural accents to lend itself a rustic appearance. The store features a large flyfishing section, an unfamiliar sport whose appeal is rather mysterious to me, and so my visit offered an opportunity to defamiliarize myself with the pursuits I commonly associate with being outside. After my trip I took a moment to sketch my reflections, and account for the activities that J.L. Waters itself considers to be quintessential of the outdoor experience.

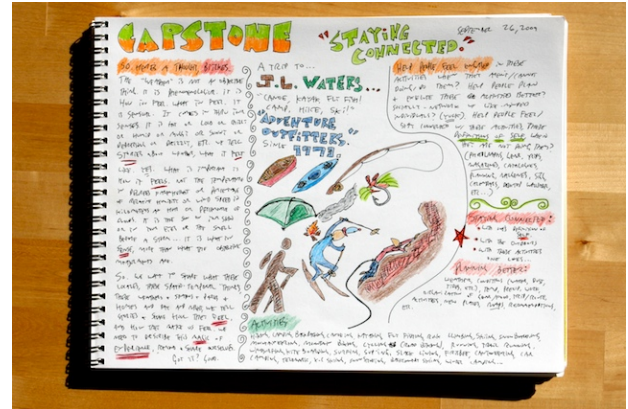
## Sketching

As part of my design process I conducted a number of sketching exercises, in an effort to better understand myself what it would mean to bring the outdoors indoors.

### Exploring the Problem Space in Sketching

I began by sketching existing techniques that people use to maintain a connection to the world outside, including computer desktop backgrounds, framed pictures from vacations, and nature calendars. Some of the ideas established quite literal connections, including windows, office plants, natural light lamps, and natural building materials such as wood. Others were more interpretative, such as a digital outdoor thermometer, coffee mugs from a favorite vacation spot, or music associated with a particular outdoor experience.

Some of my sketching sessions explored artificial materials that are made to appear and feel organic, such as Nicros' climbing handholds and playground boulders, or the use of natural materials, such as whole trees, to recreate the impression of a forest indoors. I also sketched more far-reaching techniques, such as the produce section at many grocery stores, which use strobe lights and recorded sounds to simulate a thunderstorm when they mist their produce. I also considered more multi-sensory experiences, such as the *Soarin' Over California* ride at Disneyland, which uses air currents, motion, scents, and immersive video footage to simulate the effect of flying in a hang glider.



Sketch reflections after my trip to J.L. Waters, a local sporting goods store



Sketching explorations of different ways people currently keep track of the outdoors while inside



Sketching explorations of potential opportunities of intervention

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In sketching I considered different objects and spaces in the workplace that might offer themselves as unique opportunities to intervene with people's established habits.

Objects such as the computer, monitor, keyboard and mouse, and spaces such as the office desk and cubicle, are fairly obvious. Less obvious opportunities, however, may reside in office lighting, task lights, chairs, the ceiling, the floor, and even the baseboard along office hallways.

Every spare electrical outlet in every hallway could be leveraged for some sort of natural system, as well as office art, the coffee machine, or the bathroom sink. Indeed, at first blush the bathroom would seem to be an off-limits space for intervention, but when you consider it as a unique place that is necessarily visited multiple times a day by every office worker, its advantages over other spaces become more apparent. Nevertheless, most of the concepts I have sketched so far are concerned with the user's workspace, as that seems to be where people spend most of their time at work.

### *Insights from Design Research*

The numerous research-related design activities I conducted helped immensely in getting out of my own head regarding this problem space. The natural world, and my relationship with the outdoors, is something that is immensely important to me, and my conversations with fellow designers helped me realize that not every person values the outdoors for the same reason. Some people appreciate hearing the sound of birds, even though they would never characterize themselves as outdoor enthusiasts. Nevertheless, it was through conversations with designers that I came to know about circadian rhythm, and the biological situatedness of human interpretation and meaning in regards to the outdoors.

While the influence of one's society and culture cannot be underestimated, there are certain inescapable qualities inherent in being a human that influence how we perceive the natural world, and how we interpret it as being meaningful in our lives.

What's more, as evidenced by my trip to J.L. Waters these innate biological predispositions can be evoked by human-created artifacts that are implicated in outdoor activities, feeding into the associations we have with those artifacts, in turn feeding into the associations we have with the natural world. It was these discoveries that led to the formation of my Lenses of Meaning, in particular the

sociocultural and biological lenses, as a means to frame our relationship with the outside, natural world.

## **4.5 Insights and Analysis from Research**

The design research phase of my project took me on an extensive journey into how and why people interpret the outside world as being meaningful, as well as the challenges we face in changing the established associations and hierarchies of the indoor workplace.

There are numerous designs and techniques that already exist for evoking a sense of the outdoors, from potted plants to digital windows, from stuffed beavers to tiny houses, from dynamic lights to widgets and internet appliances. Different parties in the workplace, from the manager to the employee to the human resources department, have different and often competing objectives, and navigating these relationships is a delicate process. In particular, the theatrical performance of work motivates the need for a system to appear as though it does not distract from work, or to make its benefit to productivity or workplace morale so apparent that its positive impact cannot be denied.

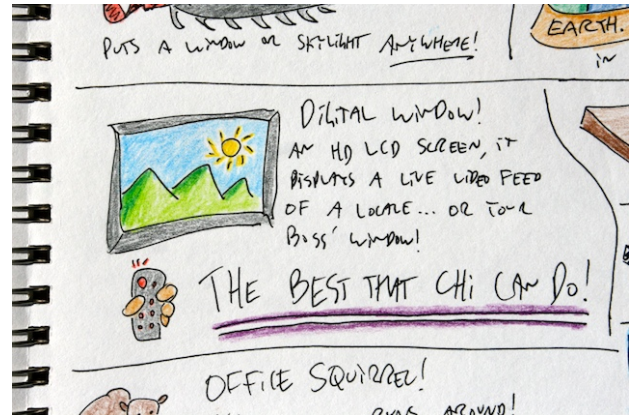
Indeed, it has become clear through my research that disentangling our relationship with the outdoors will be an essential phase in motivating any principles that argue for an increased sense of the outdoors in an indoor space. It is undeniable that humans are situated in nature as well as culture, but merely saying that nature is important to us does not offer any actionable insight into the design of an evocative system. It is clear that we need a better understanding of why the outdoors are meaningful to us, why indoor spaces damage the relationship we have with it, and how we can design systems that remedy the situation without conflicting with the needs of the workplace.



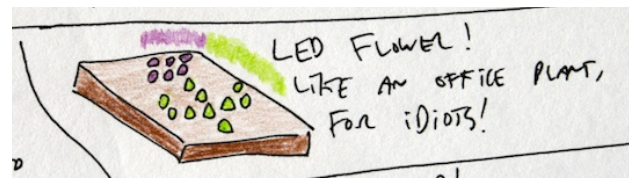
## 5. Design Process

### 5.1 Conceptual Development

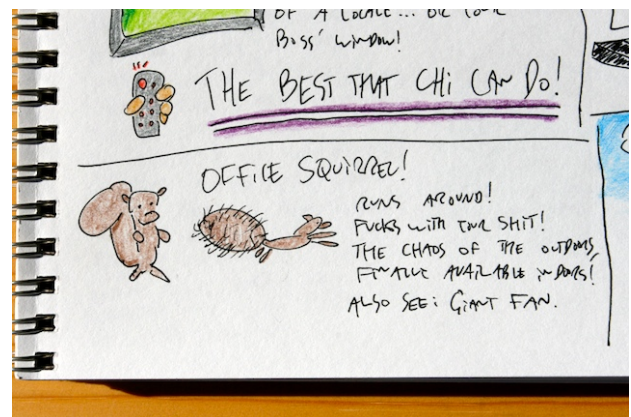
Through sketching I considered a number of initial concepts that might help evoke a sense of the outdoors in an indoor space. These concepts ranged from the practical, such as a wall-mounted LCD display that would act as a window or an LED flower that would reside on one's desk, to the impractical, such as a squirrel that would run around the office causing mayhem or a chainsaw that would allow users to "install" a window anywhere. Concepts such as the squirrel, or a giant fan that would occasionally turn on and blow papers around the office, are aimed at introducing the randomness and unpredictability of the outdoors to a work setting. Other concepts, such as the earth or solar system devices, seek to communicate statuses from the outside world, such as the phase of the moon, the current sunlight coverage of the earth, or the current locations of planets in the solar system.



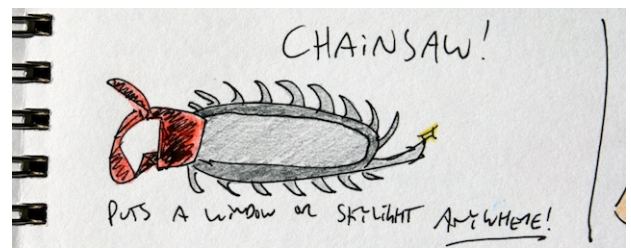
The Digital Window concept



The LED Flower concept



The Office Squirrel concept



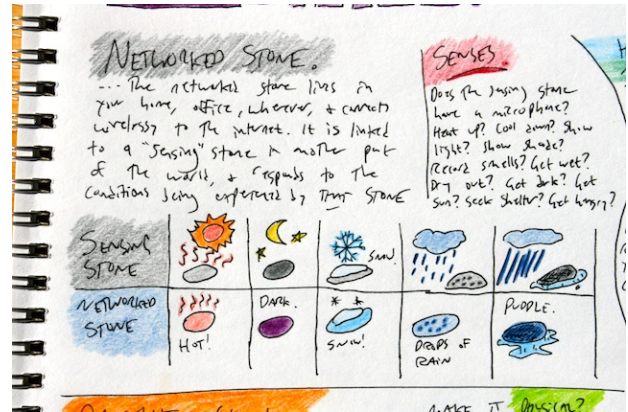
The Chainsaw concept



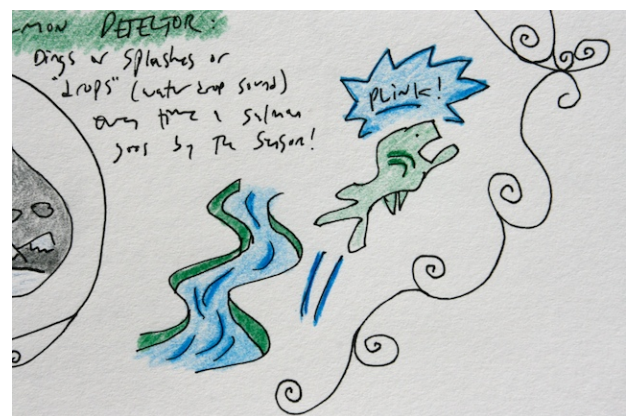
Further sketches explored such ideas as a networked terrarium, that would experience the same weather and climate as a remote locale, or a networked stone that would become hot, cold or wet in response to current weather conditions. I also considered a system called the *Salmon Detector*, which includes a sensor that would be placed in a fish ladder and would record every time a salmon swam upstream. The information from the *Salmon Detector* would be broadcast in realtime and picked up by a small device on a user's desk, which would make a subtle splashing sound every time a salmon was detected.

In a similar vein I also sketched the idea of a *Jealousy Engine*, which involves a sensor that would be installed on the user's favorite mountain bike trail. Every time a remote cyclist tripped the sensor, a cog and flywheel in the user's workspace would make a clicking sound, leaving the user to interpret the fun she might be missing by being stuck at work. While certainly not improving the mental condition of the outdoor enthusiast, this concept is a helpful reality check in illustrating how information about the outside world could trigger negative emotions, and actually be detrimental to one's quality of life indoors. In my user research, a number of users indicated that information about the outside world that was *too* relevant to their interests made them feel worse about working inside all day.

Inspired by *Berkeley Motes* and the concept of *Smart Dust*, I extended the concepts of the *Salmon Detector* and the *Jealousy Engine* into a concept that uses numerous self-deployable sensors. When the user visits a favorite outdoor space, she would toss tens or hundreds of these tiny sensors into the environment. Back in the office, the user could pick up the wireless signal broadcast by these sensors, and check in on the conditions of her favorite place. Similar to the work by Tolle et al. in *A Macroscope in the Redwoods*, the idea behind this concept is that the so-called macroscope generated by these numerous networked sensors could provide a very different representation of a space than a single dedicated sensor [Tolle et al. 2005]. At this conceptual stage, the impact of deploying these sensors into the environment has not been carefully considered.



The Networked Stone concept



The Salmon Detector concept



The Jealousy Engine concept

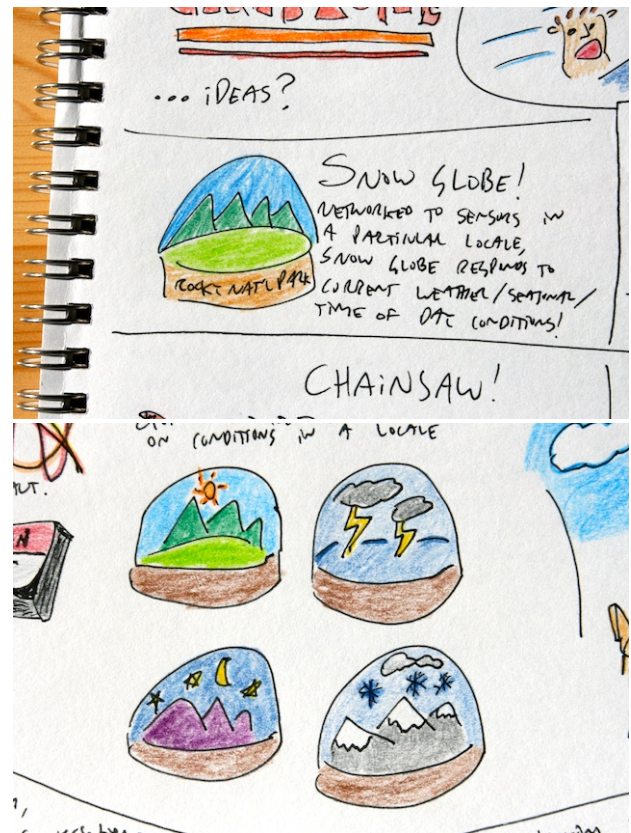
Inspired by the workspaces at Pixar and the Swedish concept of friggebods, I envisioned the office cubicle replaced by a series of tiny indoor sheds. Similar to the ambientROOM, each of these *Friggebods* would be wired with ambient information, to give the occupant the feeling that they are not at the office at all, but are working in a tiny house in the woods. Digital windows in the shed would depict images of a wild landscape, that would change throughout the day as the sun would travel its course. The *Friggebod* may be linked to a remote natural locale, and the image depicted in the windows may change depending on actual weather conditions. Speakers in the ceiling would generate the sound of rain in case of precipitation, and speakers in the walls would make creaking sounds on windy days.

In user research a number of participants indicated that listening to music during their workday is deeply important to them. Understanding that the space and expense necessary to outfit an office with *Friggebods* would certainly limit the rate of adoption of this concept, I considered the ambient sound elements as their own independent concept. A system would consider such factors such as time of day, wind speed, precipitation and temperature, while using outdoor microphones to record current sounds. Given the day's unique weather conditions and sounds, these inputs would be mixed together to produce an original electronic audio track that would be made available through the user's computer or music device. In addition to a local mix, different "stations" could offer unique mixes for a number of different locales, including popular national parks. Users mentioned their desire to listen to their own music at work, so perhaps the system could overlay real-time ambient outdoor sounds on their music, or generate smart playlists from the user's own music library based on conditions.

One concept in particular that kept recurring in my sketching was the *Enchanted Snow Globe*, which would contain a landscape that changes depending on the weather, cloud cover, season, or time of day for a particular locale. Indeed, I have been very interested in exploring these cycles of the earth, and figuring out ways to visually represent these natural systems that operate on vastly different timescales. On a partly cloudy day, cloud cover can change minute-to-minute, weather might change by the hour, and daylight of course changes



The Friggebod concept



The Enchanted Snow Globe concept

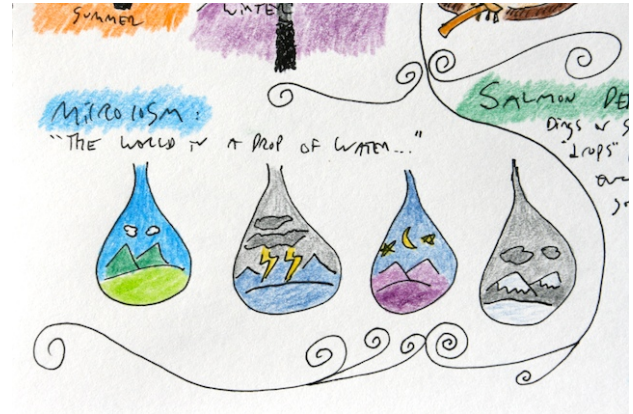


throughout day. Predominant weather systems change over the course of many days, while seasonal changes become apparent over the timespan of weeks and months. These notions consider the temporal aspect of my Lenses of Meaning, which seek to structure our understanding of our relationship with nature.

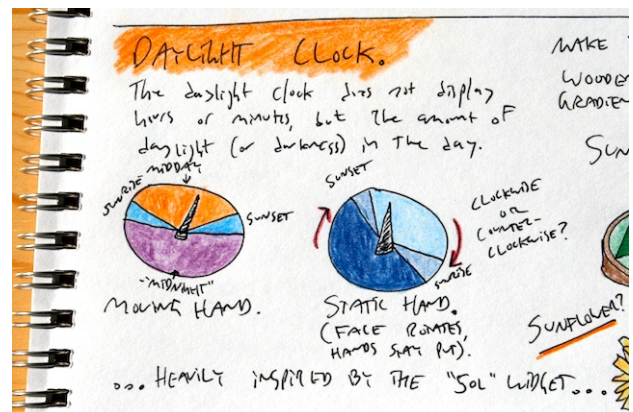
In exploring form factors for the *Enchanted Slow Globe*, I have also been developing a concept I call the *Microcosm*, which would contain a tiny world not in a globe but in a drop of water. Inspiration for this came from a number of flower photos, where the artist would photograph a hanging drop of water in such a way that it would appear to contain a small garden within its volume.

Another concept that I have continued to explore is the *Daylight Clock*, which is inspired by the *Sol* widget for OS X. Rather than assigning a precise and numerical value to time, the *Daylight Clock* would visually represent the amount of darkness and light for the current 24-hour day, along with an indicator for the current time relative to sunrise and sunset. As the seasons progress the visualization would change, depicting an increased amount of darkness in the winter, and increased sunlight in the summer. To that end I have also considered other natural means of tracking time and daylight, such as sundials and sunflowers.

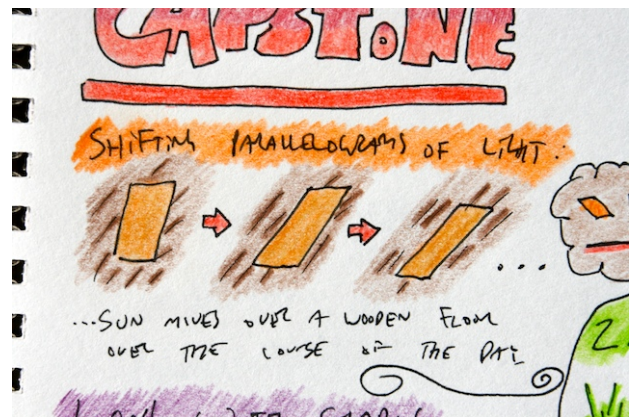
Additionally, after observing a square of sunlight move slowly across a wooden floor over the course of a day, I sketched a concept called *Shifting Parallelogram of Light*. Similar to the artistic work of Daniel Rybakken, this concept would project an image of sunlight on a surface, as though filtering through a nearby window. The projection would move throughout the day, and actually change shape depending on the time of year. During the summer months, for example, the sun would be far overhead, and so the projection would be rather short. During the winter, however, the sun sits closer to the horizon, and so the projection would become elongated.



The Microcosm concept



Daylight Clock explorations



The Shifting Parallelogram of Light concept

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## *Categorizing the Design Concepts*

As I developed my ideas through sketching, I realized that many of these solutions could be grouped according to three categories. The first category includes systems of self-identity, which are extremely important to outdoor enthusiasts as they often define themselves by the activities they pursue outside. Systems of self-identity include such things as bumper stickers, t-shirts, keychains, as well as artifacts one might use to decorate their workspace. The second category concerns systems of memory, which act as general reminders of a person's active life outside of work, or specific records of certain meaningful trips or experiences that person has had. These systems include photographs of family members on vacation, souvenir coffee mugs from favorite locales, or a desktop background featuring pictures from a favorite trip.

Finally, the third category concerns systems of natural processes. These solutions report on the goings-on outside, and include outdoor thermometers, weather information, lunar calendars, and nature almanacs. The concepts I have developed, including such examples as the *Enchanted Snow Globe* and the *Hogwarts Enchanted Ceiling*, seem to predominantly occupy this category. While systems that report on natural processes are easy to conceptualize, they are also extremely challenging to get "right". A solution that merely provides data or "status updates" of natural processes will do little to help people forge a meaningful connection to the outdoors. While I hold a keen interest in systems that communicate these natural processes and cycles, there is considerable work to be done to ensure that the information is presented in an aesthetic manner, allowing users the opportunity to interpret it and ultimately create their own meanings.

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## **5.2 Light Explorations**

As my project progressed I became increasingly interested in light, and how it could be used as a design medium to communicate a sense of the outdoors. In particular I wanted to better know how sunlight enters and plays with built spaces, and how the movement of the sun throughout the day changes the quality and shape of these natural light projections.

### *Time-Lapse Sunlight Explorations*

A number of my explorations in light involved shooting time-lapse photography of the shapes that light from the sun casts in indoor spaces. These inquiries were heavily inspired by Daniel Rybakken's *Subconscious Effect of Daylight*, an exemplar consisting of an end table that casts a small ray of light, as though the table is blocking light from a nearby window. In cultivating an intimate understanding of how natural light moves and behaves, it was important for me to interact with real sunlight in these explorations. When an opportunity presented itself I would setup a stage, simulating an office desktop workspace, and video record approximately thirty minutes of sunlight moving across this space. In post-production I would condense these long videos into two-minute clips, and review the results for inspiration.

The time-lapse explorations provided me with some surprising discoveries, including a better understanding of how the morning sun's vertical as well as horizontal movement across the sky affects the shape and direction of shadows. The video at <http://vimeo.com/9972262> shows an expected left-to-right movement the morning sun's rays against an indoor west-facing wall. However, the video at <http://vimeo.com/9972385>, recorded later in the morning on a different day but in the same location, shows a rather abrupt shift in the directional movement of the sun's rays. Rather than simply moving left to right the shapes begin moving quickly downward, to the point where the sun has completely left the scene by the end of the recording. Finally, the video at <http://vimeo.com/9972741> depicts the motion of the sun through a set of horizontal blinds, and shows how the cast shapes move in near-perfect parallel to the pattern of the blinds themselves.

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## *Sunlight Tracking Explorations*

Given the fussiness of weather as well as the difficulty of predicting where the sun will cast itself in a particular space at a particular time, opportunities to study the interaction of cast shapes of sunlight within indoor spaces often presented themselves at times where I was ill-outfitted to video record them. Nevertheless, I adopted a series of low-tech techniques, using paper and whatever writing tools were available, to engage in these “guerilla” sunlight-tracking activities whenever possible. Wherever a cast shape of sunlight presented itself, I would tape a piece of paper underneath it and trace the current position and shape of the cast image. At fairly regular intervals, I would retrace the shape, and eventually chart a vector showing the sun’s direction of movement. As I became more sophisticated in these studies I would date and timestamp each line, as well as record the latitude, longitude and compass bearing of the entire recording.

A key discovery from these light tracking studies was that sunlight travels *fast*. Incredibly fast. I frequently underestimated the speed at which the sun would move, and at times my five-minute intervals for measurement would record four inches or more of movement.

While I was conducting one of these studies, a fellow design student exclaimed that he had an “Ah ha!” moment while watching my activities. “That’s an interesting timepiece you have right there,” he said. A few of my previous studies had been scattered about the space, left over from the day before, and he remarked that he did not understand what they were for, and thus they did not mean anything to him. However, after watching me freshly outline a beam of sunlight, he looked around the room and suddenly realized the meaning behind all the other outlines. The designer remarked at the delight he experienced having “figured it out”, and how he began scanning the room for these new sources of meaning. The idea of the sun leaving a trace of its own path, and having that trace appear relative to paths cast in later days, weeks or months, seems to have merit.



*A Time-Lapse Sunlight Exploration*



### 5.3 Conceptual Development in Light

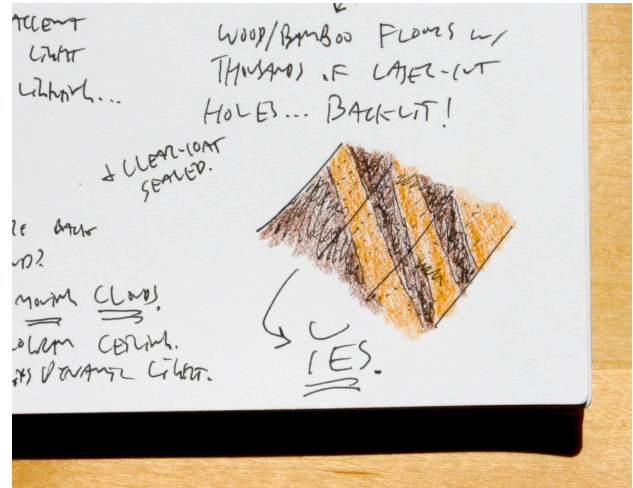
As I delved deeper into exploring light as a design medium, I conducted extensive sketching exercises to generate new concepts demonstrating ways that light could be used to communicate a sense of the outdoors.

#### *The Fiber Optic Floor Concept*

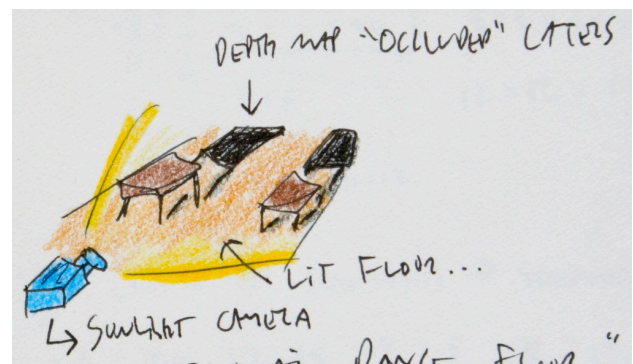
Daniel Rybakken's *Subconscious Effect of Daylight* led to numerous concepts around the idea of casting "reverse shadows", or shapes of light that simulate sunlight streaming in from a window. The limitation of Rybakken's design is that it requires an artifact from which the light to be cast, limiting the opportunities for the concept's deployment throughout a workspace. Each artifact intended to cast a "reverse shadow" would need to have a mechanism for producing light, with a shape, angle and position that makes sense given the layout of the space.

Reflecting on my *Shifting Parallelogram of Light* concept, I realized that the light does not necessarily need to have a source; rather, the surface upon which the light is cast merely needs to appear brighter than the rest of the surface. The status light on the late-2008 Apple Macbook laptop is actually comprised of dozens of tiny laser-drilled holes in the aluminum casing, such that the light's location is practically invisible when turned off. Similarly, I imagined a hardwood floor covered with millions of laser-drilled holes, backed by a fiber optic light network that would be able to light up certain portions of the floor in a computer-driven pattern.

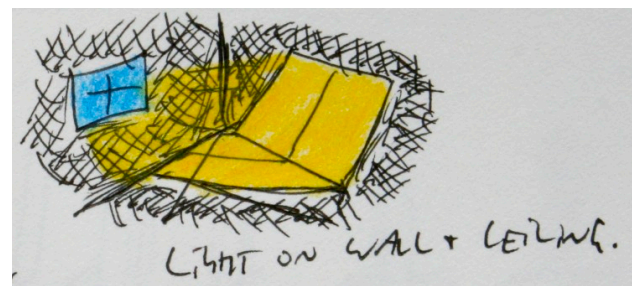
In this *Fiber Optic Floor* concept, the entire floor can invisibly act as a high-resolution pixel screen, appearing to be lit by external sunlight by emitting light from its surface. The patterns cast by furniture and people could be cast dynamically in real time, by positioning a special camera at the virtual source of light. Certain portions of the floor as seen from the camera's point of view would be occluded by objects, and the floor in those unseen spaces would not be lit by the fiber optic lights. Computing shadows through object occlusion is a standard approach for rendering depth-map shadows in 3D modeling software, and this concept brings a similar technique into the real world.



*The Fiber Optic Floor concept*



*The Virtual Light Source Camera concept*



*The Fiber Optic Floor and Walls concept*



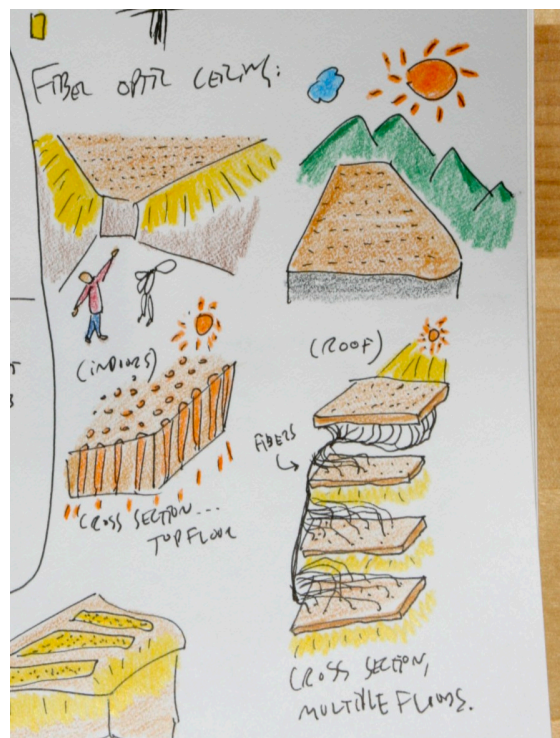
### The Fiber Optic Floor and Walls Concept

In my light studies I noted the way that sunlight slides across a room, effortlessly bending across walls and floors in a manner that would be difficult to achieve in a physical medium. Considering the *Fiber Optic Floor* concept, where the floor itself emits light to appear as though it is lit by sunlight from a window, one could extend this concept into a special kind of wall paint that emits light in a similar manner. By moving the camera's point of view throughout the course of the day, the occlusion shadows cast by objects would travel effortlessly across the walls and floors of the space.

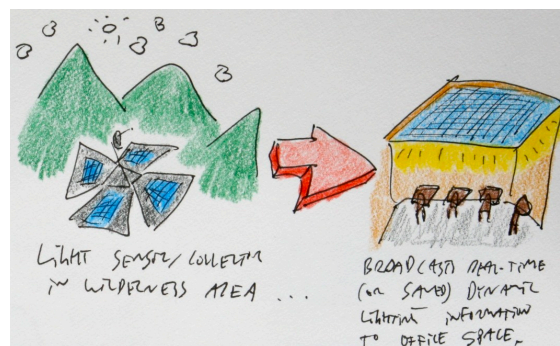
### The Permeable Ceiling Concept

The *Enchanted Ceiling* concept from Harry Potter continued to pop up throughout my light explorations, and despite its appeal there are considerable challenges that need to be overcome in order to make it a technical reality. A blue sky within a built space is a compelling idea, but the actual sky is blue because of Rayleigh scattering, which makes it *appear* blue. Unlike a screen depicting a blue sky, or even a blue-painted ceiling, the actual sky does not *emit* or *reflect* the color blue. One challenge, then, is how to display a blue surface without casting the entire space in a saturated blue-colored hue. Furthermore, unlike a ceiling the sky appears to stay in place as we move around, an effect known as parallax. Holography or head-tracking offer potential solutions to this problem, but at a high cost.

Instead of rendering a real-time auto-stereoscopic parallax-exhibiting image of a ceiling, the *Permeable Ceiling Concept* would collect sunlight from a large fiber optic matrix embedded in the roof of the building, and broadcast it in real-time to the ceiling of an indoor space. On a partly cloudy day, the indoor space would experience the same dynamic lighting effects of the outdoors, with shadows from clouds slowly passing throughout the workspace. Another permutation of the *Permeable Ceiling Concept* could leverage Philips' work on dynamic lighting, responding to sensors embedded in the ceiling by adjusting indoor light levels and colors according to real-time information.



The Permeable Ceiling concept



The Virtual Permeable Ceiling concept

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## The Hawaiian Light Concept

The *Permeable Ceiling Concept* collects and broadcasts local outdoor light, a feature that may be undesirable in places such as the Pacific Northwest, where it is gloomy much of the year, or at high latitudes, where the extreme lengths of night and day may be upsetting. The *Hawaiian Light Concept* is similar to the *Permeable Ceiling Concept*, except that it involves a remote probe that detects the light at a particular location. These readings would be broadcast to a space outfitted with dynamic lighting fixtures, where users would experience the real-time natural light of the remote location. If there is a significant difference in time zones between the two locations, it may make sense to time-shift the readings to be more in-sync with one's current location. That said, maintaining an absolute relationship with the real-time lighting of the remote location would certainly create an extended sense of space, and give users an opportunity to reflect on the truly relative nature of local time.



The Hawaiian Light concept

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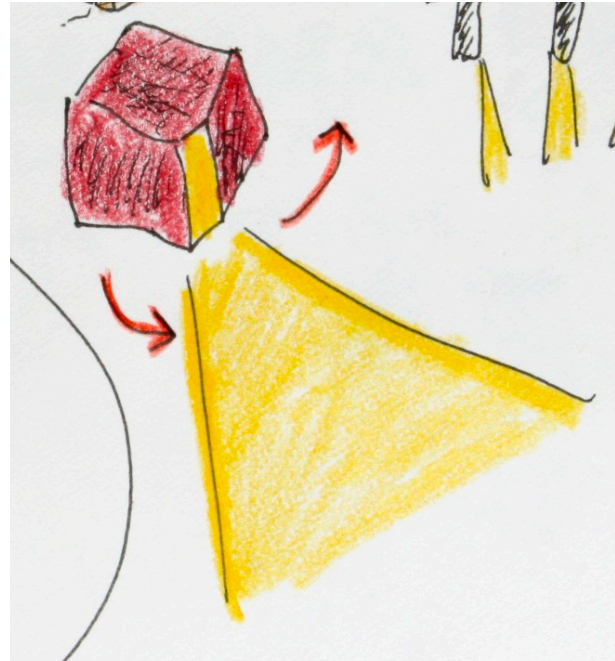
## 5.4 Design Prototypes in Light

### *The ChronoCube Concept*

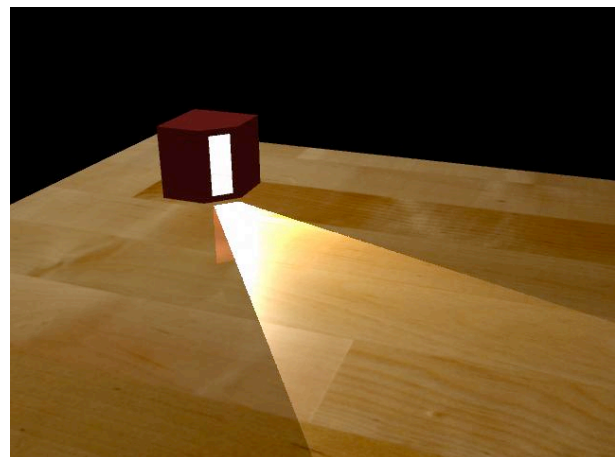
One of my main interests in this project has been the idea of using light to communicate the slow passage of time. The ChronoCube concept would be a small device that rests on the user's desk, and casts a narrow beam of light across her workspace. Just as the position, shape and angle of the sun's cast images change throughout the day in an indoor space, so would the ChronoCube simulate the dynamic movement of natural light. Its beam would move throughout the day in a relatively predictable cycle, and over the course of weeks and months its image would change shape in response to the time of the year. In the winter, for instance, the sun is lower in the sky and casts longer shadows, even at noon. Thus, the ChronoCube would cast a longer image in the winter, and a shorter image in the summer, representing the seasonal progression of the sun.

### *ChronoCube Maya Renderings*

Light is a tricky and ephemeral medium in which to design, so I triangulated my understanding of the ChronoCube concept by engaging in a series of explorations through sketching, 3D rendering and physical prototyping. Using Maya I created a series of 3D animations that depict a potential form factor for the ChronoCube, and its potential for casting a moving beam of light. These exercises were useful in establishing a computationally-precise understanding of how light behaves in the sterile environment of 3D modeling software, and inspired me to find more physical avenues to explore the experiential qualities of this design.



*The ChronoCube concept*

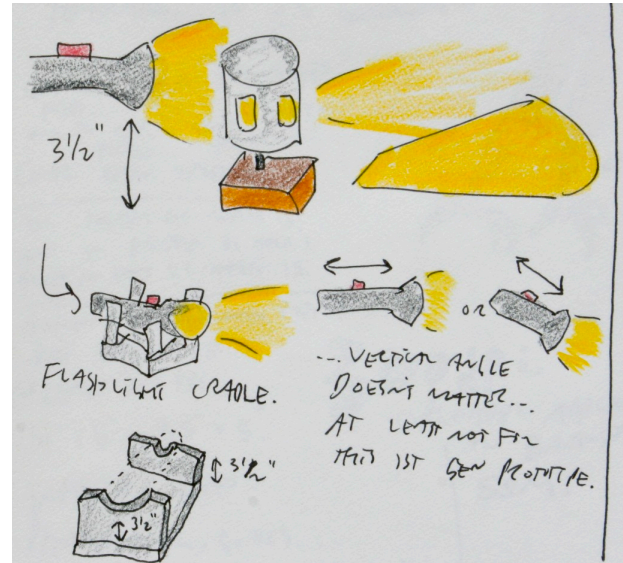


3D Rendering of ChronoCube concept



### ChronoCube Prototype

Using a quartz clock movement, a paper screen and a high-intensity flashlight, I built a physical prototype of the ChronoCube concept. I recorded a number of time-lapse videos of the ChronoCube prototype in action, staging it in an environment populated with artifacts that are commonly found in an indoor workplace. The video at <http://vimeo.com/9619638> shows the results from one of these time-lapse studies with the ChronoCube prototype. Reviewing these videos, and comparing them against my time-lapse studies of actual sunlight, helped reveal further opportunities for improvement. The ChronoCube prototype rotates on a single axis, while the sun moves not only across the sky, but up and down as well. Communicating the more subtle directional arc of the sun throughout the day, and the repositioning of that arc as the days grow longer or shorter, will require a more sophisticated mechanism than the current prototype provides, but its construction and demonstration helped reveal these subtle opportunities for meaning.



Sketches of the ChronoCube prototype



The ChronoCube prototype



The ChronoCube prototype in action

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## 6. Design Principles for Bringing the Outdoors Indoors

The result of my design exploration is a series of design principles intended to help interaction designers frame and understand the design of systems that communicate a sense of the outdoors in an indoor environment. These principles are presented in two parts, the first of which is a series of lenses, five in all, through which we can understand how and why the natural world is meaningful to us. These lenses include the biological, perceptual, temporal, spatial and sociocultural lens, and each attempts to frame one way in which we interpret nature as being meaningful in our lives. The second part of my design principles is a semantic differential that attempts to untangle our complex relationship with the outdoors, and present it in a manner that is more structured and actionable for designers.

### The Five Lenses of Meaning

#### *The Biological Lens*

As biological products of our natural world, many aspects of our humanity are irrevocably situated in the temporal rhythms of the planet. Having co-evolved with nature, our biology is an inescapable precondition that establishes the ways we perceive and make meaning from our surroundings. Our circadian rhythm governs our sleep/wake cycles, and even when deprived of sensory information regarding time our bodies maintain a day that is approximately 24 hours long. Certain wavelengths of light are perceptible to us, as determined by the spectrum of light emitted by our sun. Humans seem to be infinitely flexible, as demonstrated by our ability to adapt to the harshest climates on earth, or even our somewhat mundane ability to overcome jet lag. Nevertheless, we operate within a particularly narrow set of biological constraints, including demands for food, water and warmth. These constraints form a certain set of biological meanings, which no amount of self-discipline or sociocultural influence can escape. Thus, a system that aims to communicate a sense of the outside world would do well to consider the biological situatedness of human meaning and interpretation, and leverage it effectively.

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#### *The Perceptual Lens*

As shaped by evolutionary advantage and the unique qualities of our natural world, we are innately tuned to attend to particular perceptual inputs. We see certain wavelengths of light, hear sound at particular frequencies, and unconsciously prioritize certain inputs over others. Additionally, our ability to perceive something is closely tied to the amount of change it exhibits in a certain amount of time. In the case of natural processes, many changes occur below the threshold of active human perception; from one spring day to the next you may notice how much the plants in your garden have grown, but you cannot sit down and actually perceive them growing in real-time.

The temporal scale at which perceivable events unfold exists at numerous orders of magnitude in the natural world, but indoor spaces tend to lack this diversity of scale. What's more, perception is logarithmic, in that small objects can exhibit small changes that are still easy to perceive, but the same small change when applied to a larger object may be impossible to notice. The day-to-day change when a garden first starts to sprout is relatively astounding, but the same amount of change when applied to large plants is very difficult to discern.

#### *The Temporal Lens*

All our perceptions are situated in time, and thus can be considered through the temporal lens. As mentioned in the perceptual thread, processes in nature often unfold slowly, and exist in numerous cyclic layers. The amount of change noticed, and the type of change perceived, often depends on the length of time under consideration. While I cannot attend to the changes in my garden from minute-to-minute, I do notice its change from day-to-day, or certainly week-to-week. When considering natural processes, our unit of temporal measurement may be on the magnitude of seconds, minutes, hours, days, weeks, months, years, or more. The cyclic passage of a single day exists at a different temporal resolution than the phases of the moon, which are both simultaneously related to, but separate from, the cyclic progression of the seasons. These levels of perceivable change, existing at multiple temporal resolutions, can be communicated to an indoors environment in an effort enliven these built spaces, and raise our awareness of the natural world.

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## The Spatial Lens

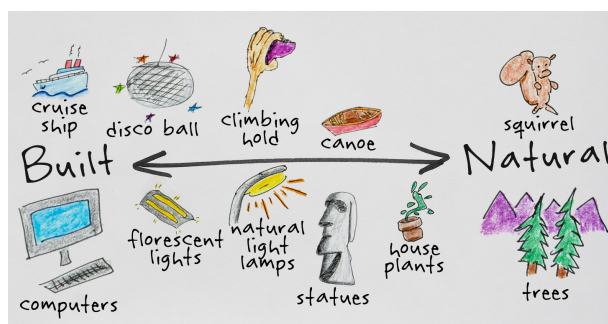
Humans are physical beings that exist in a physical world, and much of our perception of and orientation towards the world happens through our ability to perceive space. We attend to space across multiple senses, deriving meaning from the ambient sound of a space, or the sense of a space beyond the one we currently occupy. A window is an artificial creation that allows a clear view of a more distant space, extending our ability to see and perceive beyond the immediate. As outlined by Lakoff and Johnson, many of the metaphors we use to describe time are spatial in nature, so an extended sense of space also allows an extended sense of time [Lakoff and Johnson 1999].

Just as the indoor environment restricts our perception of time by depriving us of sensory information about the cyclic progressions of the natural world, so do these environments limit our ability to sense, and thereby make meaning from, spaces beyond our immediate. Additionally the natural world is filled with unique mechanisms, such as fog, crepuscular rays and atmospheric perspective, that heighten our awareness of space that is normally invisible to us. As with the temporal lens, computing technology can be leveraged to render visible these implicit properties of space, granting an enhanced sense of spatiality by communicating along these multi-scalar threads.

## The Sociocultural Lens

Our relationship with the natural world is necessarily situated in, and influenced by, our personal experiences, culture and society. These sociocultural relationships offer a unique and valuable resource that we can deliberately leverage in our designs, in order to responsibly evoke the rich meanings associated with them. When designing cross-cultural systems that aim to communicate a sense of the outdoors, it is important to realize that people with different values may align themselves differently with the outdoors, and will likely form radically different interpretations of the meanings behind your design. Even in the United States over the last hundred years, the meaning of nature has evolved from that of an inexhaustible resource to be pushed back and dominated, to that of something precious to be protected and preserved. The formation of meaning is an active accomplishment, continually being negotiated and renegotiated by us, and it is important to keep this fluidity

in mind when designing systems that attempt to evoke a sense of the natural world.



*The Natural and Built Semantic Differential*

## The Natural and Built Worlds — A Semantic Differential

As my research began coalescing around these five lenses, I realized that my operating definition of what constitutes the outside world, and what differentiates it from indoor spaces, required further study and elaboration. In an attempt to clarify the issue, I disentangled the opposing concepts of “inside” and “outside” from the concept of nature, and considered what defines something as being natural. Through reflection I realized that nature was not a strict category, but rather existed on a continuum against the human-created world. While many would argue that the antithesis of “natural” is “artificial”, I chose to eschew the word “artificial” given its rather negative connotations. As my research has shown, there is no innate goodness in the natural world, and likewise there is no evil inherent in the humanly-constructed world. Thus, I chose to oppose the word “natural”, characterizing artifacts that originate in nature, with the word “built”, which characterizes artifacts from human origin, or those that are shaped by human intentionality.

It is impossible to imagine something as being “natural” without having something against which to compare it, and so my operating definition of what constitutes an artifact as being natural or built is necessarily entwined with these two opposites:



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**“Whether something is considered natural or built is determined by the social and cultural connotations of the artifact, and its perceived origins.”**

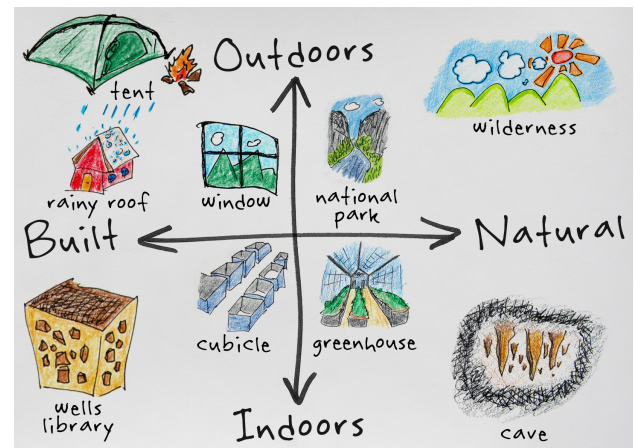
Thus, something like a tree is clearly natural, while a computer is clearly built. A tree originates in nature and is shaped by it, while a computer is shaped by human intention out of materials of rather unnatural origins.

Regarding materiality, it is extremely important to note that this definition concerns *perceived* origins. This definition does not attempt to arrive at an objective account of artifacts the world, but rather a phenomenological one. In this case, the truth of materiality is not as important as the subjective interpretation of an artifact by an individual. The truth is situated in the interpretation of the individual and the meaning they derive from it, whether it is objectively accurate or not. If I see a plant and am convinced it is fake, then by this definition it becomes part of the “built” world. If, however, I later learn that what I believed to be a fake plant is actually real, or I am later convinced, falsely, that a fake plant is real, then it becomes part of the “natural” world for me. Since the difference between the natural and built world is necessarily interpretative, it is subjective and thus practically accomplished by the individual.

Since the meaning of an artifact from the natural or built world is interpretative, its social and cultural connotations are actively interpreted as well. The natural and built worlds exist at two opposite ends of a differential, between which there exists a rich spectrum of artifacts that belong in both categories. A natural light lamp, for example, is a built artifact that attempts to simulate the effect of sunlight. A marble statue’s materiality originates from the natural world, but its ultimate form is strongly shaped by human intention. A house plant is clearly an artifact from the natural world, but again has been shaped by human action.

Social connotations of artifacts can become increasingly complex, too. Climbing holds, such as those from Nicros, are often installed in large numbers at indoor climbing gyms. These holds are shaped, to a point, like the rocky ledges that a climber might encounter in a natural outdoor setting, but are often cast in a textured plastic material in bright colors. The materiality of a climbing hold is clearly of

human origin, but its shape is inspired by natural forms. What’s more, the activity of climbing has sociocultural connotations than usually place it in an outdoor setting, despite the indoor nature of a climbing gym. In spite of its unnatural built origins, the climbing hold is implicated by the practice of climbing in the activity it affords and the natural associations of that activity, placing it closer to the “natural” end of the semantic differential than one might expect.



*The Natural and Built, Outdoor and Indoor Semantic Differential*

## The Outdoor and Indoor Worlds – Extending the Differential

By disentangling the difference between the natural and built worlds from the concepts of inside and outside, we are able to more effectively approach the qualities that differentiate these two different classifications of spaces. The spectrum between natural and built is decidedly subjective, organized according to individual meaning and interpretation. The difference between the outdoors and the indoors, however, allows us to establish a slightly more objective axis on our semantic differential.

**“Whether a space is indoors or outdoors is determined by the perceptual permeability of the space.”**

We see, feel and sense our surroundings with all our senses. Considering the spatial lens, the outdoors typically allow an extended sense of space, whereas the indoors

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tend to close us off in certain ways. In my research, indoor spaces that people positively relate to, such as those that let in natural light, or have windows that open, allow this extended sense of space normally allowed by outdoor spaces. Thus, a completely open outdoor space where all senses can perceive a multi-scalar sense of spatiality forms one extreme of the spectrum. Likewise, an indoor space completely cut off from the outside world, with no windows, no natural light and no external sounds, forms the other extreme.

It's important to point out that according to this definition, the difference between the indoors and outdoors is based on perceptual permeability, and is completely independent of whether a space is natural or built. That said, it's impossible to conceptualize a space that is indoors or outdoors, that possesses no qualities of either the natural or built worlds. Thus, the differential between the outdoors and indoors presupposes the differential between the natural and built. Against these two axes we can group spaces into one of four primary categories:

**Built and Indoors** – This category includes indoor built spaces that are completely cut off from the outside, natural world. Examples include windowless offices or underground parking garages.

**Natural and Outdoors** – This category includes outdoor natural spaces that engage our perceptions in a sense of extended space, and are largely independent of human intention. Examples include wilderness areas, forests and deserts.

**Natural and Indoors** – This category includes “indoor” natural spaces such as caves, as well as greenhouses, indoor zoos, or other “built” indoor spaces that contain natural elements, are implicated by activities associated with nature, or could otherwise be interpreted as having natural origins.

**Built and Outdoors** – This category includes outdoor spaces that have been clearly shaped by human intentionality, such as city streets and plazas. Additionally, it includes built artifacts that allow an extended sense of outdoor space, such as windows. Sight is not the only sense that can be engaged, however, as sound can communicate a sense of space as well. Windows often

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serve a dual-purpose in allowing the sound of the outdoors to permeate inside, and roofs often let in the sound of rain during a storm.

These are not strict categories. As this project is concerned with subjective experience, people will navigate this semantic differential and form associations in different ways. The purpose is not to establish an objective categorization mechanism for organizing artifacts and spaces, but to use this as a design tool to generate new ideas. By separating the outdoors from their familiar natural properties, and considering these two qualities independently, we are better outfitted to examine our relationship with the outside, natural world in a more orderly fashion.

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## 7. Conclusions

As we retreat further into built spaces for conducting our work, surrounding ourselves by products of human ingenuity, we risk losing our connection with nature. As creatures of biology we evolved within the unique qualities and constraints of our planet, such that the very characteristics of the natural world are an integral part of our humanity.

There is a temporal disconnect between the immediacy of the workplace and the larger temporal unfolding of nature. A thunderstorm, for all its violence, announces its approach with wind, dark clouds and distant rumblings. An email, which could be similarly implicated in its own violence of attention and focus, offers no such warning, and likewise there is an expectation of immediacy. It is no wonder that we feel alienated from nature while we work indoors, as there is little in the artificial life of the workplace that resembles the behaviors of natural world. Given the prominent role our devices play in mediating these environments, it is the responsibility of HCI to work toward remedying this dispiriting situation. By leveraging the tenets of calm technology, slow technology and reflective design, we can create designs that communicate natural systems and processes on a timescale that more closely relates to that of the outdoors, properly ensouling these indoor spaces with rich sources of meaning for their occupants.

## 8. Contribution to the Field

### How We Form Meaning

A large concern of this project has been getting to the root of how people make meaning from their environment. On account of my research I believe it has much to do with our own human embodiment, the strong physicality of the natural world, and the comfort and familiarity that we can derive from these natural surroundings. The multi-sensual experience of being in the outdoors is strongly phenomenological, bringing with it enormous quantities of information that we interpret in our minds and from which we form meaning. It is the dynamic range of the outdoors that makes it compelling, with its rich bouquet of smells, sounds and feelings, from the subtle sensation of the

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breeze on your skin to the roar in your ears from a massive waterfall.

The appeal of the outdoors is manifest in different people in different ways, from those who enjoy the sound of birdsong but don't care for thrill of mountain biking, or those who enjoy racing their dirt bikes through the logging trails of the Northwest. Meaning is constructed of things that, in one's mind, are connected to other things of value. It is through these value chains that we determine what is meaningful to us. These meanings are derived from people making sense of their surroundings, interpreting them in a manner that is embodied and necessarily situated in the world.

We derive all meaning from these connections, between our experiences and memories and intuitions collected over time, as physical beings in a physical world. Indeed, our own existence is an unshakable prerequisite for forming these meanings, and as biological creatures that exist in the world we do ourselves harm by ignoring the unique qualities of our humanness. Our connection to the outdoors, to the rhythms of the planets, is inescapably wired into our brains and blood. A parent of a newborn can attest to the importance of establishing a circadian rhythm, and thus synchronizing one's biological clock to the heavens, as early in life as possible.

### The Five Lenses of Meaning

It was these realizations that led to my five lenses of meaning. The Biological Lens accounts for our biological situatedness in the natural world, the ways in which we have evolved within the particular constraints of our planet. With the Biological Lens I aim to render explicit the tacit assumptions of our own humanity, to celebrate our unique physical nature as beings that exist not in general, not in abstract, but in specific, on a particular planet that possesses certain characteristics that inescapably determine how we perceive and come to know.

The Perceptual Lens aims to make clear the primary role that our senses play in mediating our experience, and how our own physical embodiment helps us interpret and make meaning from our surroundings. Our bodies are tuned to perceive particular qualities of our environment, attend to certain changes while ignoring others, to the point where it

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becomes foolish to believe that our senses allow us unfiltered, objective access to the world beyond ourselves.

All our perceptions are situated in time, and the Temporal Lens describes the important role that time plays in mediating our experiences. From the passage of days, to the phases of the moon, to the changing of seasons, our experience of time exists at multiple layers of temporal resolution, each one existing at a different level of perceptibility. I cannot sit and consciously attend to the sunlight moving across the floor, but the way the movement of the sun impacts my day is undeniable.

Additionally our perceptions all exist in space, and spatial reasoning plays a large role in how we come to know the world and form meaning about it. The Spatial Lens describes this relationship we hold with space, which like the Perceptual and Temporal exists at multiple resolutions. The joy derived from a window results from the way it extends the perceptual permeability of our space, allowing us to sense a world beyond the immediate.

None of this is to downplay the role that society, culture and personal experience play in determining the meanings we associate with the natural world. Rather than attempting to minimize their influence in the pursuit of a pure and idealized representation of nature, I believe designers should leverage cultural associations so that their designs can responsibly evoke their rich meanings. Thus, the Sociocultural Lens describes the meanings we form based on our society, culture and personal experiences. These are all factors within which a designer must create, and they offer an incredible meaning-rich resource that can be respectfully implicated by a design.

## The Semantic Differential

Inspired by these five lenses of meaning, I set to disentangle the meanings we associate with nature from those we associate with the outdoors. The natural world exists on a spectrum with the built world. Artifacts can then be placed on this spectrum according to their origins, whether they are from the natural world or the human-made world, as well as according to their social and cultural connotations. While there is some objectivity to this spectrum, these meanings are largely situated in consciousness, achieved through active human interpretation.

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A second spectrum exists, plotted against the natural and built worlds, describing the relationship between the outside world and the inside world. Again, deciding whether a space is “outside” or “inside” is not a binary categorization, but rather a gradient as determined by the perceptual permeability of a space. By considering our relationship towards the outside, natural world and the inside, built world in this manner, we as designers are better prepared to design systems that begin to dissolve the barrier between these spaces.

My design principles do not aim to bring the outdoors indoors in a superficial manner. I am not striving for an objective account of the outdoors, or a means to reproduce it precisely, but rather experientially. I hope that my efforts in disentangling our meanings into these five lenses can help designers realize the goals outlined herein, distilling the experience of nature down to its essence, the felt experience rather than the literal experience. Drawing on the mundane practical accomplishments of everyday life, the unpredictable ways in which we form meanings, connecting smells to songs and pictures to experiences, I seek a way to evoke the rich aesthetic experience of being outside, and the enchantment that results.

The earliest computers, including such devices as the sundial, compass and astrolabe, were used to derive humanly meaningful information from the movements of the heavens. Through these tools humans were able to determine the current time of day, the day of the year, or even the latitude of their position on earth. This information, derived through these computational devices, aided in human efforts to grow crops, navigate the seas, or schedule religious observances.

As we spend more time isolated from the outdoors in our built environments, we are deprived from our ability to use these processes to create meaning from the patterns of the natural world. What I am proposing, then, is that computing return to its roots, and use its powers to communicate, render and interpret the natural world in a manner that is humanly meaningful, and to broadcast these interpretations into indoor built spaces that are otherwise isolated from the outside, natural world. Computing must once again leverage its strengths to render the rhythms of our planet visible to human

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interpretation, allowing us to form new relationships with it, create new meanings, and ultimately create new knowledge from the extended sensing it enables.

## 9. Reflections

### Considering the Whole Person at Work

Computing beyond the workplace is becoming less concerned with utility and efficiency, and increasingly interested in creating evocative and poetic interactions. Extensive work in domestic computing addresses issues of meaning, intimacy and connection, but the workplace has largely been left cold in these efforts. The goal of not making domestic life mimic that of work life is an important one, but in holding our ground in the home we seem to cede defeat in the office. If people are to spend eight hours a day, five days a week of most of their adult lives in the workplace, and if they are to use computing technology for much of that time, we owe it to them to make those spaces emotional and affective as well. Issues of human well-being and happiness do not end after one leaves the home.

Therein lies the challenge of bridging the outside and inside worlds in a work environment. From user research I have learned that some people work in cubicles, some work in offices with windows, some move between multiple terminals throughout the day, some can take lunch breaks off-campus, some socialize, some run up and down the stairs, and others are strictly at their desks and are not even allowed to go for walks. Considering the number of waking hours spent at work and not at home, it seems sensible to leverage the efforts in domestic computing in treating the whole thinking, feeling, emotional person at work, while still respecting their unique work-life needs.

As evidenced by my research, there are very real issues in the workplace that are radically different than those in the domestic space, from maintaining appearances with managers and co-workers, to productivity, to the mere feeling of being productive, to the nuanced (yet incredibly important) difference between “good” and “bad” distractions. Nevertheless, the quality of one’s life at work is an important matter, and not merely for reasons of productivity. Increased worker satisfaction and improved

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work/life balances lead to better work and better business results. The path to business success is in treating employees as people, as thinking, feeling people, and respecting their needs. Indeed, human-centeredness is important not just in the design of computer interfaces, but in the design of the departments, offices and company cultures in which one’s work life is situated.

The people I have spoken with regarding this project are passionate about the outdoors, and are kind, intelligent, hard-working people. They have a love of the sun and sky and trees and water, care deeply about the experience and challenges of the outdoors, and yet they say their indoor work environment is making them physically ill, even killing them. From their perspective, it is clear their physical and emotional needs are not being met by their indoor built environments. As outdoor enthusiasts these people thrive on hard, physical challenge, go out on the water in extremely windy days with mast-high swell, and come back with bruises and injuries and ear-to-ear smiles. How is someone this strong bested by a chair and a desk? How can we translate their intense passion for the outdoors into a mentally and emotionally positive force at work?

It is a delicate question, especially when intervening at someone’s place of work, where there is already a culture loaded with hierarchies, social arrangements, personal habits, and accomplishments of one’s own self-presentation. As revealed in research, some employers will thwart any individual effort to change the workspace. In other cases, employees will bristle at change, any change, that is introduced without their consent. I hope that the design principles I have outlined here can help extend designers’ thinking on these issues, and that others can be better-suited for tackling these hierarchies with the arguments I have made herein.

### Ambiguity

Extensive work has been done by the HCI community in regards to ambiguity, interpretation and ludic engagement. By presenting users with something deliberately ambiguous, or by blocking expected interactions to encourage unexpected ones, we allow users an opportunity to draw their own conclusions and make their own meaning. Through ambiguity they are able to interpret information, rather than passively receive it.



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Ludic engagement and ambiguous design both encourage people to be reflective, and indeed perhaps the penultimate American example of reflection in an outdoor setting is Henry David Thoreau's Walden. While perhaps not the most authentic wilderness experience, as Thoreau had visitors and went into town on a regular basis, his experiment in self-sufficiency did encourage a great deal of reflection.

Is Walden an inauthentic example of simple outdoor living because Thoreau wasn't objectively, factually living in the woods, or is Walden an authentic example of something, namely that of Walden? As with the concept of "place" these categorizations are not fixed, and authenticity is likewise a practically constructed accomplishment. I feel Walden is a brilliant work of literature, but a dangerous one in that it encourages, nay demands, escapism as a mechanism for reflection.

My love for the outdoors, and that of many others, is based largely on the reflection and insight afforded by my time with it. These opportunities allow me to communicate with nature, and explore my place in the world, as a being that lives on the boundary between the natural and the artificial. With this project, a key question has been how one can encourage similarly reflective behavior, the ability to discover these unusual connections between, independent of the destructively escapist force of the transcendentalists. Indeed, how can an interaction help us shrug off this overwhelming need to escape the workplace, and instead offer an in-place opportunity to reflect on one's relationship with the outside world? How can we actively construct that meaning, forge those connections, independent of the physical place? How does a system help people bring their whole experience of the outdoors, their rich, passionate, uniquely embodied experience, and translate it in such a way that it becomes helpful, relevant and empowering in their everyday work?

Indeed, on the reflective side of these design principles, I aim to help people drill through their mental layers into a mineral-rich vein, thick with the meaning of their outdoor experiences. I would hope to aid them in making those embodied experiences meaningful to their everyday challenges in an authentic manner. Navigating this threshold is difficult, but not impossible. While living in San

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Francisco for the summer I discovered that commuting every day by bicycle stimulated the same rush of adrenaline that makes snowboarding so thrilling. How could one, then, make a similar connection between kiteboarding and fulfilling pharmacy orders? Perhaps the unification of the two is impossible without some form of physical effort, or without the aesthetic outdoor experience, but it demonstrates the importance of carrying one's passion into work, in an effort to make it more meaningful.

What I aim to demonstrate in my design principles, especially in the way they consider the difference between the inside and outside worlds, is that manmade spaces and artifacts do not necessarily need to be positioned in opposition to the natural world. The meanings we associate with the natural or built worlds are situated in consciousness, subjective, and actively accomplished. As a result they are open to change, and can be influenced by new ideas that challenge existing assumptions. I hope that my design principles, and the lenses of meaning that I have identified, help identify a way forward that does not exacerbate the painful tension between these two extremes, but rather identifies unexpected similarities that present opportunities for design intervention.

## Ubiquitous Computing

As technology becomes increasingly powerful, increasingly cheap, increasingly networked and increasingly miniaturized, the notion of ubiquitous computing posits that computing will seep into every crack of our lives. We are already witnessing this transition through portable media players, cell phones, mobile internet-connected devices, netbooks and tablets. The trend can continue, however, towards concepts such as smart dust and paintable computers, where the everyday environment can be embedded with thousands of imperceptible, invisible, networked computers.

Recent trends in the field of human-computer interaction design offer numerous opportunities to help increase one's awareness of the outdoors. Weiser established his agenda for ubiquitous computing nearly twenty years ago, and while we have made incredible inroads towards his future, deviating as necessary along the way, we still have room to grow. A solution that aims to connect people with the outdoors need not be a new application, or website, or

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widget, or information appliance, or computer peripheral, or even a mobile application.

## Ambient Computing

Ubiquitous computing need not mean another screen in the world, or even another touch screen, despite their current prevalence. Through ambient technology we can render communications and information in different media, such as sand, wind, light, water, air, scent, color or sound. Ambient displays offer one possibility, and yet they present challenges based on their very nature of being ambient. Nothing appears ambient at first, and information only becomes “ambient” after the user has grown accustomed to the display, allowing it to fade into the background of consciousness. Nevertheless, the ambient system cannot fade too far, as the user must be able to perceive changes in it, so that she can center the information in her consciousness should something grab her interest. In an ambient take on this problem space, a view of nature could exist at the edge of one’s periphery until something unusual happens. A sudden change in weather could trigger a change that would grab the user’s attention, such that she can mark out the system by consciously attending to it.

Additionally, ambient computing could be an effective way to communicate the slow processes that are typically rendered outdoors, including the passage of the sun, the changing phases of the moon, the growth of plants or the changing of the leaves. These changes happen at a timescale that we cannot perceive in real time, but we definitely notice over the timespan of hours, days, weeks and months. The slow processes of the natural world stand in sharp contrast to the workplace, where everything tends towards immediacy. Considering the temporal lens of meaning can open up many opportunities to communicate these slow changes that occur over hours and days, or even over longer temporal resolutions. My design exploration into using light as a design medium to evoke a sense of the natural world is one small push in this direction.

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## 10. Acknowledgements

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## 11. Biography

Dane Petersen grew up in Minnesota, where his passion for the outdoors was cultivated through numerous childhood camping and canoeing experiences. He has worked outside in jobs ranging from camp counselor to windsurfing technician, snowboard instructor to wilderness guide. His indoor ventures have included stuffing envelopes, grading essays, slinging lattes and finally building websites, where he discovered his love for designing delightful user experiences. Dane currently works as an experience designer at Adaptive Path, a leading experience design consultancy based in San Francisco.

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