## ABSTRACT

TYPHINA, ELIZABETH. Mobile Phones and Environmentalism. (Under the direction of Dr. Jason Swarts).

This dissertation explores uses of mobile phones for environmental activity and how mobile phone use influences perceptions of environmental problems. These findings are applied in the creation of a design methodology and recommendations for improving mobile phone interventions for understanding and acting on environmental problems. Due to the complexity and multidimensionality of these research goals, I integrated insights from multiple theoretical frameworks and disciplines.

The first set of frameworks approached the research questions from a historical perspective, reviewing three decades of mobile phone use and environmental activity. The second set of frameworks focused on the structural design and appropriation of mobile applications for environmental understanding and action. The third set of frameworks exposed the impact that design methodologies have on user perceptions, and the concluding framework coalesced findings, showing a complex array of activities and implications around mobile phone use.

The outcomes of this dissertation reveal that mobile phones have transformed how users recognize and address environmental problems. Outcomes also reveal a shift in cultural perceptions of who can solve environmental problems. The use of participatory design methodologies, such as an actor diagramming and tracing method, is recommended as a way to integrate both human and nonhuman stakeholders in finding problems and solutions. Other recommendations from this dissertation include the use of environmental mobile phone initiatives for: 1) collective and collaborative action, 2) culture jamming, and 3) connecting and awakening users to the nonhuman.

These recommendations aim to shift mobile developers and users from human-centric understandings, where humans dominate ecosystems, to eco-centric understandings, where humans are intricately connected to and reliant on ecosystems. Ultimately, this dissertation shows how the execution of technological features in mobile phones and their appropriation by users either reproduces the status quo or leads to changes in society, technology, and the environment.

Mobile Phones and Environmentalism

by
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## DEDICATION

To those who do what they can to care for our planet and the beings on it, may this inspire you as you inspire me.

## BIOGRAPHY

Since 2002, Eli Typhina has engaged in environmental education, communication, and activism in a range of contexts. While completing her bachelors in environmental studies and sculpture at St. John's University, Typhina ran several campus-wide environmental education weeks, an environmental living community, and taught outdoor education at the St. John's Arboretum, in Collegeville, MN. After graduation, in 2005, Typhina worked with government agencies and non-profits in the US and Ireland to develop educational programs, materials, and communications ranging in topics from ecology, wildlife, indigenous culture, history, community organizing, and water quality.

In 2010, Typhina decided to peruse graduate education in environmental communication as a way to bring the knowledge and skills of academia to the people and organizations looking to elicit environmental change. During her master's degree at Washington State University (Pullman, WA) and her doctoral degree at North Carolina State University (Raleigh, NC), Typhina examined theories, methods, and concepts from psychology, marketing, organizational change, communication, design, human-computer-interaction, environmental studies, and science, technology, and society. During her graduate career, Typhina published eight times in academic arenas, including a chapter in the book *Pedagogy of Environmental Communication*, and articles in the journals *Environmental Education Research* and *Applied Environmental Education and Communication.*

Drawing from her graduate research, Typhina continues to look for ways to design physical and digital environments to mediate environmentally friendly behavior, emotion, and cognition in individuals and organizations. She uses qualitative and quantitative research

methods to examine how the interactions among human systems, technology, and the environment lead to positive and negative outcomes. Typhina plans to share her research through book publications, workshops, and consulting with citizens and organizations interested in prompting environmentally friendly activity.

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I am grateful to my family, who sacrificed, supported me, and worked hard to bring me to the place I am now. I thank my friends and colleagues, who were always there encouraging me, brainstorming ideas, and offering a shoulder during the tough times. I appreciate the feedback and comradery of those I interviewed and who worked with me in creating this dissertation. I acknowledge the faculty who stimulated my ideas and agreed to learn with me, especially my committee. Finally, I recognize the important role my dyslexia played in my dissertation, both as a frustration and as a blessing to the way I approached, conducted, and wrote this dissertation.

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## Chapter 1 : Introduction: Rationale for Dissertation

The overarching goal of this dissertation is to find and refine a technological means to help humans identify and address environmental problems. Many means for addressing environmental problems exist, such as policy, community action, and science, but I chose to examine technology, specifically mobile phones, because mobiles can bring together multiple efforts through rapid coordination and communication features. I fully understand that technologies not only help to identify and solve environmental problems, but technologies also create them (Mulder, Ferrer, & van Lente, 2011). However, the aim here is to identify and understand how to use mobile phone features to address environmental problems.

When I write *environmental problems* or *complex problems* throughout this dissertation, I'm speaking about the way intersections of human and ecologic systems can negatively impact the health of these systems. I also use the term *complex* as a way to acknowledge the multifaceted and interconnected causes of environmental problems. An example of a complex environmental problem is climate change, which results from the multifaceted activity of people, technologies, and nature that are interconnected in such a way that greenhouse gasses in the atmosphere increase, lead to climate variability, and harm the functioning of human and ecological systems.

Scientists, politicians, and concerned citizens have held numerous local, national, and international gatherings to present alternative and often conflicting viewpoints on the causes and effects of climate change. Coyne (2005) explains that the complexity of environmental problems emerges through such gatherings where the problem is "subject to redefinition and resolution in different ways over time" (p.6). These gatherings include collaborative

governance, community resource planning, co-management, and citizen advisory boards, wherein participants present multiple interpretations of the problem and solution.

Even when the problem is agreed upon, reaching a solution requires agreement on what measurements constitute balance and what action must be taken to restore balance. For example, many consider rising sea levels and 'sinking' island nations as indicators of imbalance caused by climate change, yet the solutions to solving this imbalance remain contested. Jentoft and Chuenpagdee (2009) explain that contestation arises because one stakeholder's solution may be another stakeholder's problem. In the case of rising sea levels, reducing motor vehicle exhaust is one solution, yet this solution would require changing infrastructure, social customs, and production practices across the globe.

Recognizing the complexity inherent in identifying environmental problems and negotiating their solutions, I decided to explore the role technology, specifically mobile phones, plays in influencing people's perceptions of and action toward environmental problems and solutions. Mobile phones are an interactive medium through which users can quickly gather and share information in a nonlinear way, which is one of the underlying reasons for their rapid uptake. Through features of calling, texting, and data accessibility, a mobile phone mediates the understanding of reality by presenting the user with data that he might not otherwise have access to. Mediation occurs on the go and through diverse forms, such as audio, text, and graphical visualizations. These diverse presentations can enable an array of users with varying levels of motivation, experience, knowledge, and cognitive abilities to gain access to and address environmental problems in an individualized way.

Additionally, mobile communication scholars, such as Ling (2014), de Souza e Silva (2013) and Ling and Donner (2009), have found that the connectivity capabilities of mobiles have altered social interactions, power dynamics, and the spatial presence of users. For example, social media applications, like Twitter, enable users to microcoordinate and quasibroadcast content to thousands of people, as seen in the 2011 and 2013 *Twitter revolutions* in Egypt and Ukraine (Parmelee & Bichard, 2011). However, the ability to digitally annotate physical locations through mobile phones also gives users new understanding of each other and their environment (de Souza e Silva, 2013; Schwartz, 2015). The mobile app Yelp allows users to digitally pin images and ratings to physical restaurants, a process that has led to significant changes in where people choose to dine (Blanding, 2011).

Although examples abound of the ways mobiles have connected people and place, some scholars argue that mobiles also disconnect users from the world. Turkle (2011) highlights findings in her research of the ways mobile phones have negatively changed the way people relate to one another and their environment. She states that the technology has enabled users to retreat from their physical reality into the digital via their mobile phone, thereby avoiding the need to address emergent situations. Turkle (2011) also found that mobile users can garner numerous online friends who give the illusion of comradery without the time required to maintain close ties.

In the context of human-nature interactions, Louv (2008) argues that reliance on digital technology, such as mobile phones, results in nature deficit disorder, which he describes as a disconnect from nature that negatively impacts physical and emotional health.

Similarly, Glendinning (1995) argues that people's reliance on technology is akin to the addiction of substance abuse, wherein users believe that more technology is the answer to environmental problems, yet they never step away and ask how more technology might lead to more problems.

Many of the arguments for or against technology and human-nature interactions present binaries between the two, hailing technology as the solution or the downfall to human connectedness or disconnectedness to nature. However, I think that the relationship between people, nature, and technology is subtle, always shifting, and tends toward complexity rather than a binary of two distinct sides.

In this dissertation, I examine the way that technologies are designed and used to uncover how binaries of their use emerge. For example, the design of a mobile phone can engross a user so much that they are not encouraged to look up or experience the world around them and, as Louv (2008) stated, the user suffers a nature deficit. Yet, a mobile phone application could be designed in such a way so as to encourage users to explore nature in ways they had not considered before. #Litterati encourages users to seek out litter, creatively photograph it through Instagram, then dispose of the litter appropriately. The prompts of the app cause users of #Litterati become aware of new aspects of their environment because they are exploring it in a new way. Furthermore, the app prompts alternative understanding of human-nature interactions beyond the individual by encouraging users to present #Litterati data to local municipalities and work with them to place garbage bins near litter-prone areas.

The negative ecological footprint of a mobile phone and its ability to facilitate preservation of nature through its use is another binary. For example, the production practices of mobile phones, the electricity needed to charge them, and their eventual disposal in landfills lead to considerable amounts of damage to ecosystems and human health (The Ecologist, 2004). Yet, the use of mobile phones also enabled people to preserve nature, as in the case of Julia Butterfly Hill, who used her mobile phone to call into radio stations and raise awareness of the negative effect of logging old-growth forests. In 1999 Hill's calls were unique; she made them from her make-shift tree house in an old-growth redwood tree designated for logging. In an interview with Dateline NBC (aired 14 February, 1999), Hill stated she and others had attempted to bring attention to the destruction of the redwoods on the ground, but it was only when she started her tree sit that she was able to bring worldwide attention to the destruction of the redwoods. The mobile phone enabled Hill to bring global attention to the damage of logging in old-growth forests and ultimately protect the trees she had sat in.

The above examples show the complex and multi-dimensional interactions among people, technology, and nature. Using mobile phones to address environmental problems not only offers solutions and new perspectives, but also tensions and negative consequences. Because my aim was to understand the mediating capabilities of mobile phones to alter human understanding and interactions with nature as a way to improve ecosystem health, I focused mostly on the positive outcomes of their design and use. However, I interject, throughout this dissertation, the tensions and disagreements leading to negative outcomes in

the design and use of mobile phones as a tool to solve environmental problems. Following this line of inquiry, my overarching research questions for this dissertation are:

- What can we learn from uses of mobile phones to address environmental problems?
- How could this knowledge inform design and use of mobile phones for addressing environmental problems?

**My Approach**

As outlined in the previous section, human, technological, and nature interactions are complex and multi-dimensional; therefore, they require a multi-dimensional investigation that can reveal nuanced complexities as opposed to binaries. As a way to actualize investigation of my research questions, I used multiple theoretical, conceptual, and methodological frameworks from different fields. My approach in this dissertation is multidisciplinary, transdisciplinary, and integrative because I wanted to gain multiple disciplinary perspectives on the intersection and interaction of phenomena under study and merging frameworks to create a completely new understanding of phenomena (Choi & Pak, 2006; Wake, 2003). Furthermore, due to my training in an interdisciplinary doctoral program, I recognized that every theory, method, and framework reveals one perspective and, thus, has failings in its ability to show other perspectives of the same phenomena. I chose frameworks and methods that I thought complemented one another and applied them to different phenomena in each chapter. Therefore, each chapter is unique in the questions asked, frameworks used, and findings revealed, yet these questions, frameworks, and findings complement one another and offer a broader understanding of phenomena in my over-arching research questions (Table 1.1).

Table 1.1

*Dissertation research questions, frameworks, and associated disciplines*

| Chapter | Title & Research Question | Frameworks | Disciplines |
|---|---|---|---|
| 2 | The history of mobile phones and environmentalism<br>RQ: How have people used mobile phones to engage in environmental activity? | Media history | Communication, cultural studies, information theory |
| | | Mobile communication | Communication, sociology, linguistics, computer science |
| 3 | Eco-apps and environmental public participation<br>RQ: What are the technological structures and features that enable and constrain user participation in eco-apps? | Structuration theory | Sociology |
| | | Adaptive structuration theory | Business, organizational behavior, information systems |
| | | Environmental public participation | Environmental communication |
| 4 | Participatory techno-building: Actor diagramming and tracing method<br>RQ: How does a participatory design process and its outcomes differ from conventional development of a sustainable technology, such as an eco-app? | Deep ecology | Environmental studies |
| | | Sustainable persuasive technology | Psychology, human-computer-interaction, environmental studies |
| | | Participatory design | Design, human-computer-interaction |
| | | Actor network theory | Science and technology studies |
| | | Framing theory | Mass communication |
| 5 | Intersections of environmentalism and mobile telephony<br>RQ1: What can we learn from uses of mobile phones to address environmental problems?<br>RQ 2: How could this knowledge inform design and use of mobile phones for addressing environmental problems? | Activity theory | Educational psychology |

## Chapter Overview

In the second chapter of this dissertation, I take a media history approach to understand how people have used mobile phones to engage in environmental activity and the impact of that activity on power relations, discourse, and social outcomes. As a conceptual framework and methodology, media history is not meant to offer an all-encompassing historical account of the past. Instead, it affords scholars a way to gather a range of historical phenomena and question who, what, how, and why people used technology for specific activity (Packer, 2013). Furthermore, the approach helped me to identify how the use of mobile phones for environmental activities shifted power relations, discourse, and social outcomes.

Following Packer's (2013) media history methodology, I created a broad and diverse archive of 141 instances of mobile phone use for environmental activity. These instances included news articles, press releases, websites, and reports from 1993 to 2016; however, they did not include every instance in every time period because my goal was to get a broad view of activity. I analyzed the instances using Packer's (2013) "questions of enquiry" and the constant comparative method (Strauss & Corbin, 1990). The constant comparative method enabled me to find emergent themes pertaining to technology use; however, it did not offer me a structure within which to place the critical findings that emerged. Therefore, I decided to organize my findings following the research of mobile communication scholars Ling (2014), de Souza e Silva (2013) and Ling and Donner (2009), who discovered implications of mobile phones for the social interactions, spatial presence, and power dynamics of users.

By combining media history and the findings of mobile communication scholars, I was able to gather a broad view of the historical uses of mobile phones for environmental activity. These findings also provided insight to the ways that future mobile phone interventions could be designed. However, the theoretical frameworks that were applied in chapter two lacked the mechanisms to explain how the design of mobile phone interventions leads to their appropriation. Thus, I needed another theoretical framework, one that offered insight into design mechanisms. Additionally, the media history approach did not explain the mechanisms behind increased or decreased participation, which led me to seek another theoretical framework. Finally, such a broad review of all mobile phone uses for environmental activity did not offer a detailed understanding of the mechanisms supporting that activity, which led me to narrow my focus to mobile phone applications in the third chapter.

To fill in the gaps left by the media history approach, I chose to use DeSanctis and Poole's (1994) adaptive structuration theory and Norton's (2007) environmental public participation (EPP) framework in Chapter Three. I narrowed my study to mobile phone applications, called eco-apps, to achieve a clearer understanding of design mechanisms and appropriation process. I chose adaptive structuration theory (AST) because it offers a way to understand how a technology's intended and emergent features enable and constrain user agency. I coupled AST with the EPP framework because the EPP identifies the organizational mechanisms supporting agency. Agency is the ability of a stakeholder to access and use resources to act on and influence existing environmental practices and to create new practices (Norton, 2007). Without access to reports or data explicating how

environmental policy or contexts affect them and their family, stakeholders lack agency in the environmental context. Additionally, not having the ability to influence existing or to participate in creating new environmental practices means that the imposed practices can harm the livelihoods, health, and/or cultural rituals of non-participating stakeholders.

Following DeSanctis and Poole's (1994) methodology for applying AST, I chose 11 eco-apps to study and inferred their structural potential by looking at a range of resources, including news articles about the apps, the app creators' websites, content from app storefronts, and I downloaded and used the applications if the app was available. I documented the way that users appropriated the eco-apps' structures by reviewing news articles about the applications, user comments on the app store, and user activity within the applications. I used Miles and Huberman's (1994) cross-case techniques to code each application for objectively describable features and the types of goals, values, and activities those features promoted. Then, I reviewed my findings with the EPP framework to understanding how the design of the apps offered users agency and how users appropriated the eco-apps to exert their agency.

Application of AST and EPP frameworks allowed me to understand the types of designs and features that enabled users to attain, learn, and contribute to environmental activity and to build trust in one another and the software. Though these frameworks afforded insight into eco-app design and use, they did not explain why specific designs were chosen and developed over other designs. Nor did these frameworks offer perspective on how the development process influenced the design and appropriation of eco-apps. I decided that I needed another set of conceptual frameworks to help me understand how changes in

the development process of an environmental mobile phone intervention affected the technology's design and use.

In Chapter Four, I identify the problems with current development practices, as well as a set of conceptual frameworks through the recommendations of sustainable persuasive technologies (SPTs). SPT scholars found that developers of technologies who support environmental activity tended to create these technologies based on personal knowledge and experience, which led to designs that avoided underlying environmental problems (i.e. Brynjarsdóttir, Håkansson, Pierce, Baumer, & DiSalvo, 2012; Goodman, 2009; DiSalvo, Sengers, & Brynjarsdóttir, 2010). SPT scholars recommended conceptual frameworks from participatory design, actor network theory, and deep ecology as a way to incorporate user feedback and engage users in the creation of the technology.

Drawing inspiration from the recommended frameworks, I proposed a unique participatory development method that encourages developers to take an eco-centric approach to understanding and designing technologies. I show how a developer might use my method, called actor diagramming and tracing, through the development of an eco-app to support sustainable forestry practices on family owned land. At the same time, I present application of the conventional design method to the same environmental problem. By applying both design methods, I am able to reveal how choices in the development process influence structural design and, eventually, user appropriation.

The application of both development methods provides an important piece to understanding how we might design and use mobile phones to address environmental problems. Yet, the examples in this chapter only show one application, that of developing an

eco-app for sustainable forestry practices. To explore my two over-arching research questions, I needed to look across all three chapters and interpret how the activity within each affects a range of mobile phone uses (i.e. calling, texting, eco-apps, sensing systems), as well as environmental activity (i.e. citizen science, consumer behaviors, social justice). Therefore, I decided to include one last theoretical framework, activity theory.

Activity theory allowed me to reveal new understanding of the phenomena within my dissertation by uncovering contradictions between activity and desired outcomes and revealing the ways that activity changed the cognitions of those involved (Cole & Engeström, 1993). At the end of each chapter, I place my findings into an activity system (Figure 1.1), which allows me to pull apart the findings of that chapter and place them in a new configuration. An activity system includes seven components: 1) physical or psychological tools that mediate the activity, 2) a community that gives meaning to the activity, 3) a subject or subjects that initiate the activity, 4) rules that establish the nature of relationships in the activity, 5) the object or motivation of the activity, 6) a division of labor that implicitly or explicitly states the roles that each collaborator undertakes to develop the object, and 7) the overarching outcome or product of the activity (Kaptelinin & Nardi, 2009; Spinuzzi, 2008). By looking at the relationships between the components of an activity system, I am able to see a holistic picture of their interactions (Engeström, 1993).

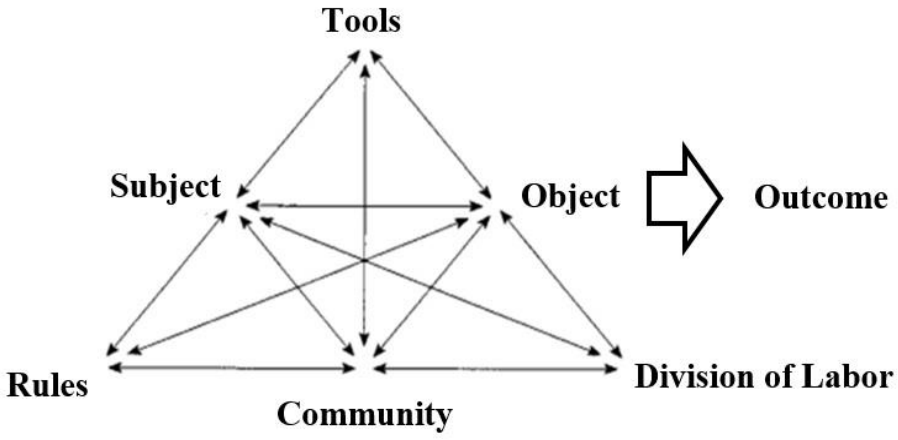


*Figure 1.1.* Activity system diagram.

After defining the activity system of each chapter, I present the contradictions within the system that hinder mobile users' ability to address environmental problems (Nardi, 1996). Contradictions are problems, breakdowns, or clashes that destabilize an activity system due to misalignment of activity components (Engeström, 2011; Nardi, 1996). By defining the activity system, I can also show how environmental awareness and knowledge develop through experiential and situated learning afforded by mobile technology. I then present options for improving the system and overcoming the contradictions (Engeström, 2011).

In Chapter Five, I bring together the analysis of the previous three chapters to offer a holistic interpretation of my findings that transcends and coalesces each chapter's approach (Choi & Pak, 2006). This final chapter shows how activity theory complements the other frameworks used in this dissertation through its dynamic view of activity, including the people, technology, and nature involved. Drawing on the findings of the activity system analysis of all three chapters, I propose four novel concepts to overcome contradictions in the activity system and increase environmental activity and understanding of the complexity of

environmental problems through the use of mobile phones. These novel concepts include: 1) use participatory methods for development and engagement, 2) use mobile phones for collaborative action, 3) use mobile phone interventions for culture jamming, 4): use mobile features to connect and awaken users to the nonhuman.

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## Chapter 2 : History of Mobile Phones and Environmentalism


### Abstract

In this chapter, I consider the historical uses of mobile phones to engage in environmental activity and the outcome of mobile's use, to offer recommendations for ways that people can use mobile phones to engage in environmental activity. To conduct this historical analysis, I used a media history approach that combines media archeology to reveal the technological affordances of mobile phones and media genealogy to highlight the outcomes of mobile phone use for environmental activity. Because the goal of media history is to gather a broad understanding of prevalent and diverse instances across time, I created an archive of 141 historical materials such as websites, manuals, and newspaper articles. These materials were not intended to present an all-encompassing view of historical events; they were intended to illustrate the prominent uses of mobile phones to support environmental activity. I organized my analysis following three affordances identified by mobile communication scholars, namely the mobile's ability to change social interactions, spatial presence, and power dynamics of users. The findings of this media history align closely with those of mobile communication scholars, yet they provide unique insight into the ways people have appropriated mobile phones to intervene in environmental problems. Appropriation practices included the use of mobiles to micro-coordinate, quasi-broadcast, crowdsource, and "sense" nature. These appropriation practices changed narratives of who addresses environmental problems and helped identify better ways to integrate human activity into the rhythms of nature.



Key words: mobile phones, media history, archive, environmentalism, activism

## History of Mobile Phones and Environmentalism

Mobile phones have a wide range of affordances that set them apart from other communication technologies, such as television and print. These affordances include the ability to connect users with individuals and collectives around the world via multi-media, to tag physical places with digital content, and to organize political action through quasi-broadcasting. When I examined mobile communication literature (de Souza e Silva, 2013; Ling, 2014; Ling & Donner, 2009), three affordances emerged across space and time: mobile's ability to change users' s*ocial interactions, spatial presence,* and *power dynamics*. Examples include the Twitter-influenced 2011 political uprising in Egypt and the competitive Foursquare battles to become digital Mayor of a physical place. Though mobile communication scholars have recorded uses of mobiles that point to their affordances across a range of contexts, little attention has been given to whether or how these affordances have supported environmental activity.

In this chapter, I created an assemblage of media artifacts to explore the ways that people have used mobile phones and the outcomes of their use in relation to environmental activity. Just as mobiles afforded protesters in Egypt the ability to influence politics, mobiles have also afforded new ways to make environmental problems more evident and solutions more attainable. Additionally, I identify successful mobile phone tactics for environmental activity and recommend ways to use historical tactics for future activity.

I chose to take a *media history* approach in this chapter because its aim is to uncover historical intersections of technology and human activity through application of archaeological and genealogical frameworks (Monea & Packer, 2016). Media archeology

highlights the affordances of technology, and media genealogy explores the social factors leading to and the outcomes of technology use. This approach requires an archive of historical materials, such as manuals and newspaper articles, which are meant to cover prominent and diverse uses of technology, not record every instance (Packer, 2010). Therefore, the framework provides a way of uncovering the historical relationships between mobile phone use, social activity, and environmental problems.

In application of the media history approach, I created an archive of 141 instances of mobile phone use related to environmental activity. I searched and included a diverse set of materials ranging in content from mobile phone app stores, development reports, press releases, newspaper articles, and websites of organizations producing and using mobile phones for environmental activism. Following Packer's (2010) suggestions, my goal was not to gather every instance of use, but to instead find prominent and diverse instances of use pointing to why some technical and social arrangements appeared over others and how those arrangements resulted in specific outcomes. I found instances of mobile phones and cellular infrastructure intersecting environmental activity dating back to 1993, and I continued my search up to 2016. Using questions of inquiry from Packer (2013) and the constant comparative method (Strauss & Corbin, 1990), I identified a range of relationships among mobile users, environmental problems, and development of mobile telecommunications. After describing each era of mobile phone use, I reflect on how mobile phone use impacted social narratives and activity addressing environmental problems. I conclude with a set of recommendations for ways that mobile phones can support environmental activity by way of calling, texting, mobile applications, and sensing systems.

## A Media History Approach

Numerous scholars (as cited in Monea & Packer, 2016) have used the research approaches of media archaeology and genealogy to interpret the effects of human-technology relationships over time. Media *archeology* reveals the enabling and inhibiting factors of technology to collect, process, store, and transmit data, and media *genealogy* explores how social interactions lead to the creation of technologies and how technological factors lead to specific social effects and power struggles (Monea & Packer, 2016). I used an archeological exploration in this chapter because it offered insights for why mobile phones enabled specific environmental activities and how those activities resulted in unique social outcomes (Parikka, 2012). For example, the mobile phone bird identification application *BirdsEye* enabled thousands of users to identify and document the location of bird species, which is information that contributes to conservation efforts and promotes environmental awareness among users.

I used a genealogical approach in this chapter because it offered questions toward social outcomes that can reveal the positive and negative results of shifts in who constructs, holds, and disseminates environmental data and prompts to action (Monea & Packer, 2016). A genealogical approach to the BirdsEye app might show how the ability for anyone, not just expert birders, to record and observe bird species affords new possibilities for collaboration and learning among novice and expert birders. Yet, increased data recording by novices can lead to misidentification of bird species, which can harm conservation efforts and reduce funding for detailed bird surveys because of the misguided belief that crowdsourced data is sufficient for understanding bird populations.

The glue that holds together archaeological and genealogical research is the presumption that technologies mediate interactions among individuals, society, and nature (Packer, 2013). Packer (2013) explains that the mediating effects of technologies come from their ability to, "organize what can be said, where and to whom it is said, and what can be made with such statements" (p. 9). Additionally, he states that the unique data collection, display, and transfer properties of technology can lead to new ways of knowing and acting in the world. Following Packer's (2013) argument, mobile technology has the ability to alter and extend environmental activity in ways not possible before, such as the BirdsEye app's ability to extend surveying capabilities to novice birders and also alter the control that experts have over data collection quality.

Most often, these two approaches, media archeology and genealogy, are brought together in a cyclical process of historical review called *media history*. In this chapter, I engage in a media history approach by first conducting a genealogy to understand why people designed environmental mobile phone interventions, then I conducted an archeology to understand the affordances of the technology. Following the cyclical process of historical review, I again conducted a genealogy to explore how technical constraints altered social structures, power relations, and the continued development of new mobile phone interventions.

I use media history in this chapter because it offers a way to delineate historical tensions in mobile phone use and environmental activity, tensions that can also point to new and unique uses of mobile phones for addressing environmental problems. Because the media history approach encourages broad and diverse findings of the most prevalent activity,

I thought it important to narrow and set boundaries for my research by organizing my findings according to the mediating affordances identified by mobile communication scholars.

## Mobile Phone Affordances

Drawing from mobile communication literature (de Souza e Silva, 2013; Katz & Lai, 2014; Ling, 2013; Ling & Donner, 2009), I recognized scholars highlighting three mediating properties of mobile phones, specifically the way they altered the *social interactions*, *spatial presence*, and *power dynamics* of users. Similar to arguments made by Packer (2013), mobile communication scholars point to the mediating properties of mobiles as key to altering interactions among society, individuals, and their environment. Because social interactions are fundamental to negotiating, defining, and altering environmental ideologies and beliefs (Cox, 2013; Milsten, 2009; Oravec, 2004), the mediating properties of mobile phones may lead to new environmental understanding and activity. Therefore, I decided to start this dissertation with a historical study that can offer perspective on the ways mobile phone affordances have mediated environmental activity. In the following paragraphs, I explicate the three affordances that I identified in mobile communication scholarship, and I suggest ways that these affordances mediate environmental activity.

First, when looking at the ways mobile phones have changed *social interaction*, mobile communication scholar Ling (2012) points to the technology's mediating presence in coordination, communication, and transportation. For example, mobiles have altered social interactions by allowing users to make meeting arrangements with others by micro-coordinating via text just minutes before meeting as opposed to calling far in advance (Ling,

2014). Mobiles have also allowed users to quasi-broadcast content to millions of other users via applications such as Instagram and Twitter (Ling, 2012). Additionally, users can gather pertinent information on the go without engaging in conversations with others (Katz & Lai, 2014). When applied to environmental activity, the above examples point to the mediation ability of mobiles to assist in faster and broader reaching coordination to identify and address environmental problems.

Second, mobile communication scholars have also recorded mobile devices extending users' *spatial presence* through locative media and constant contact. Campbell (2013) states that mobiles "introduce new dynamics…by connecting users to each other and to locations, possibly both at the same time, while physically in motion and/or engaged in everyday life activities" (p. 11). The ability to connect users to physical locations occurs through digital annotations that alter mobile users' movements, perceptions, and relationships with place (de Souza e Silva, 2013). Furthermore, mobile affordances extend the range of communication beyond a stable landline by moving with the user's body and connecting him to others around the globe (Ling & Donner, 2009). Changes in spatial presence are exemplified by the activities of the original Foursquare users whose lives were reordered and redefined through the ability to label locations, upload personal images, become 'mayor', and observe the movement of others through their mobile phone (Schwartz, 2014). The mediating properties of these affordances may offer new ways for users to collectively identify and digitally tag environmental problems and solutions.

Third, when it comes to challenging *power dynamics*, mobiles allow users to influence individuals through one-on-one messaging and organize protests through quasi-

broadcasting (Ling & Donner, 2009). Ling and Donner (2009) noted rifts in power structures caused by users engaging in citizen journalism and protests, such as the Ukraine Twitter revolution. Similarly, power dynamics can be altered by the surveillance capabilities of governments, businesses, and peers who have access to users' physical locations, contact lists, and other data collected via the mobiles' sensors and software (de Souza e Silva, 2013; Ling & Donner, 2009). When applying these mediating affordances to environmental activity, one might find that the surveillance mechanisms of mobiles reveal power disparities between users' exposure to pollution. Additionally, the influence of peer mobile users' activity (Typhina, 2016), in conjunction with surveillance data and patterns of mobility (de Souza e Silva, 2013), might lead mobile users to engage in new and unique forms of environmental activity that might have otherwise not occurred.

The remainder of this chapter couples the methodological attributes of media history with the mediating affordances of mobile phones, as identified by mobile communication scholars, as way to sort and discover how and why mobile phones supported specific forms of environmental activity over time. The activity identified in the body of this chapter is then used as exemplars in the conclusion of this chapter, exemplars with which mobile phone users might plan and execute future environmental activity.

## Methodology

Following media history methodology (Packer, 2010 & 2012), I created an archive of artifacts that presented instances of mobile phones governing and controlling environmental activity by capturing, orientating, or determining human behavior and thought. Since the aim of the media history archive is to uncover a range of instances and not record every instance,

I sought a range of sources that included a range of instances. My archive included content from mobile phone app stores, organization's reports of their apps, press releases, news articles, and websites describing environmental activity. Using the search engines *Newspaper Source Plus* and *ProQuest Historical Newspapers*, I searched the following terms individually and interchangeably: mobile, phone, cellular, infrastructure, environmentalist, nature, environmental, and activist. I started my searches at the year 1990 because companies offered mobile phones to the general public at that time (Wolpin, 2014), and individual users represented my focus population for this study (as opposed to companies or government agencies).

As I found articles, my search terms expanded to include terms used in those articles, which then lead me to find additional articles. I also used the terms that I found to search Google for instances of activity outside of news articles, such as mobile phone app stores, organization's reports of their apps, press releases, and websites describing environmental activity using mobile phones. Reports of people using mobile phones for environmental activity started surfacing around 1993; these initial reports, up to 2001, remained relatively sparse. Each decade after, I found increasing amounts of news coverage and web content describing the use of mobile phones for assisting users in environmental activity. Though coverage of mobile phone use increased in later decades, the content became repetitive. I also focused on initial uptake of specific mobile phone affordances, tapering my research efforts after people started using a new feature or affordance of the mobile phone for environmental activity.

When I started to see news articles covering topics, mobile phone uses, and mobile phone initiatives similar to what I already had in my archive, I moved on to a new search term, or if my terms were exhausted, a new year. Not including every article that ever existed on the topic of mobile phones and environmental activity limited the size of my archive and kept my search within the parameters of the media history approach. Additionally, focusing on the initial uptake of mobile phone features and affordances allowed me to zoom in on the many and diverse uses of mobiles over the years instead of getting bogged down in how many instances of that activity occurred over multiple decades.

I copied and pasted the text and images that I found into Microsoft OneNote and organized the content by year. Then, I read each article and looked for concepts and phrases pointing to the ways that mobile phones captured, controlled, and governed environmental activity. I used the constant comparative method recommended by Strauss and Corbin (1990) to identify and organize themes, which I then recorded in an excel spreadsheet. Initially, I identified 27 different themes, which crossed multiple articles and time frames. I sectioned my findings by eras, which represented initial and prevalent uptake of mobile phones for environmental activity.

I narrowed and refined the 27 themes to 12 (left column, Table 2.1) by first combining similar themes and then eliminating themes that only had one or two instances within that era. For example, in the first era, I had nine instances of actions against the building of cellular infrastructure due to the environmental damage they caused and three instances of cellular companies redesigning their infrastructure in response to these actions. Since these 12 instances covered the topic of environmental damage caused by cellular

infrastructure, I combined them into one theme (see first them in Table 2.1). In that same era, I had one instance of mobile phone use for environmental art; though interesting, I decided to remove this one instance because the lack of additional instances within that decade meant this use of the mobile phone during that time frame was not as prevalent as other uses. I acknowledge that by eliminating the single instances that I found within each era, this historical archive does not recount the complete history of mobile phones and environmental activity. However, an all-encompassing account of activity was not my intended goal. My goal was to use the media history approach to identify the prevalent ways that people used mobile phones to engage in environmental activity.

Table 2.1 shows the themes identified in my archive, the number of instances of those themes across time, and the eras I created. I created the eras as a way to break down activity occurring across time into more digestible and related chunks; the eras are not meant to represent rigid cut-off points. The first, third, and fourth eras are relatively distinct, showing the initial uptake of specific uses of mobile phones for environmental activity. However, I found limited discussion of recycling and greening of mobile handsets initially and then a dramatic increase in the topics in later years. I decided to start the second era where the increase in the topics occurred; though these themes did not fit as neatly into my chart as others, their placement in the second era served my needs for organizing and explaining activity.

Table 2.1

*Archive of Mobile Technology and Environment*

| | Mobile & Green Protests | | | | | | | | | Greening the Mobile Handset | | | | | | Mobiles as Extensions of Self | | | | Independent Advocacy and Action | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concepts/Themes | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Environmentally damaging cellular infrastructure | 1 | 1 | | 1 | 2 | 1 | 2 | 2 | 2 | | | 1 | | | | | 1 | | | | | | | |
| Improved coordination of environmental action and narratives | | | | 1 | 1 | 2 | 4 | 1 | | | | | | | | | | | | | | | | |
| Recycling of mobile handsets | | | 1 | | 1 | 1 | | | | 4 | 2 | 3 | 3 | 1 | 2 | 2 | | | | | 2 | 1 | | |
| Greening mobile handsets | | | | | 1 | | 2 | | 1 | 2 | | 3 | 1 | | 2 | 1 | 4 | 3 | 1 | 2 | | | | |
| Texting campaigns | | | | | | | | | | 2 | 1 | | | | 10 | | | | | | | | | |
| Sensing systems | | | | | | | | | | | | | | | | 3 | 3 | 1 | | 1 | 1 | | 1 | |
| Individual behavior applications | | | | | | | | | | | | | | | | 5 | 16 | 14 | 10 | 15 | 5 | 1 | 5 | |
| Citizen scientist applications | | | | | | | | | | | | | | | | | 2 | 2 | 1 | 2 | 2 | 1 | 1 | |
| Collective behavior applications | | | | | | | | | | | | | | | | 1 | 4 | | | 2 | | | 3 | |
| Apps developed by organizations | | | | | | | | | | | | | | | | 1 | 6 | 1 | 1 | | 1 | | | |
| Smart systems | | | | | | | | | | | | | | | | | | | | | 2 | 3 | 2 | 1 |
| Democratizing broadcasting | | | | | | | | | | | | | | | | | | | | | 1 | 2 | 1 | 3 |
| Apps developed by individuals | | | | | | | | | | | | | | | | | | | | 8 | 1 | | 6 | |

After creating this table, I used Packer's (2013) "questions of enquiry" to gather a media history of the artifacts in each era. Packer's (2013) questions of enquiry include:

- *Who* makes truth claims?
- *What claims* justify government, commercial, or other initiatives? Are there competing claims?
- *What narratives* exist that change a person into an object? (As in the objectification of a person by turning them into a classifiable object or data point.)
- *How do media technologies* work to organize people and things? Do they rearrange existing networks and alter the way phenomena are experienced,

presented, or known? How do they govern individuals and larger systems, such as politics, society, and economy?

After addressing each of Packer's questions, I organized and reflected upon my findings following the three mobile affordances discussed earlier; *social interactions, spatial presence*, and *power dynamics*. Finally, I reviewed each section to identify overarching findings of each era and their implications for environmental activity.

## Mobile Phones and Environmental Activity

The analysis of the archive resulted in the emergence of four eras (see *methods* Table 2.1), which included Mobile and green protests (1993-2001), Greening the mobile handset (2002-2007), Mobiles as extensions of self (2008-2011), and Independent advocacy and action (2012-2016). I attempt to highlight the affordances of mobile phones in each era by organizing examples according to how they altered social interactions, spatial presence, and power dynamics related to environmental activity. However, these three categories are not mutually exclusive, and often features that altered social interactions also affected users' spatial presence. Interwoven through each section is commentary on the ways that mobile phones mediated interactions among individuals, society, and nature (Packer, 2013). I offer examples from the archive to illustrate how the technology organized and delivered data and how this mediation affected environmental understanding and activity.

### Mobile & Green Protests: 1993-2001

The introduction of mobile phones and their associated infrastructure brought forth efforts to both counter the destructive nature of mobile infrastructure and use the technology to further environmental initiatives. I include an image of the Nokia 6110 (Figure 2.1;

MoDiP, 2016), a popular mobile phone of this era, to give context to the type of technology being used at this time.


*Figure 2.1.* Nokia 6110, released in 1995.

The themes of this era include 1) improved coordination of environmental action and narratives, and 2) the negative impact of cellular infrastructures on ecosystems. I separated these themes into the three categories of mobile affordances and then pulled examples from my archive to address Packer's (2013) questions. Important implications of this era based on Packer's questions include changes in:

- who communicated about nature and how;
- the narratives used to describe environmental actors;
- the speed and breadth of organized activity;
- the presentation of environmental problems.

Social interaction. News reports of the late 1990s and early 2000s revealed use of mobile phones to micro-coordinate ecotage and increase the number of activists involved in

environmental counter-actions. In 1998, 25 activists in Scotland conducted a raid on genetically-modified crops; over the course of two hours the activists uprooted plants and used mobile phone calling to evade security patrols (Daily Mail, 1998). The *Daily Mail* (1998) described how mobiles enabled activists to engage in "a summer of hide-and-seek" with police because they could move in and out of sites nearly undetected. Micro-coordination via mobile phone calling also enabled Canadian activists to successfully lock down a coke oven that was going to Fort McMurray's tar sands in 2000 (NikiForuk, 2000). Again, the reporter noted the highly evasive techniques enabled by mobile phones and compared the operation to "something out of a James Bond movie."

Besides helping activists to quickly coordinate actions, mobiles also helped broaden the environmental messages and actors. According to one news report, "police admit[ted] they were amazed by the sophisticated planning behind the storming of the City [London] by nearly 7,000 eco-warriors" (Blackman, Fraser, & Edwards, 1999, p. 14). The "eco-warriors" of the 1999 London riots against global capitalism were able to stealthily coordinate thousands of protesters via mobile phone calling and whistles. Also in 1999, mobile phone users coordinated one of the largest recorded direct action campaigns against city development in south London by calling important community decision makers (Minton, 1999). Minton (1999) noted the industry's concern over the increasingly "professional resistance" tactics enabled by mobile phone calling and the annoyance that it created for city officials. Minton (1999) documented that the nick-name "eco-dweebs" emerged as reference to the mobile phone users who made phone calls against the development.

Besides the nickname and catch phrase of *eco-dweebs* and *James Bond* activity, mobile phone users engaged in environmental activity were also called a "new breed" of activist who could nimbly outsmart and outpace global organizations with their tech savvy abilities (NikiForuk, 2000). Before mobile phones, the coordination of direct environmental actions had to occur through careful planning and, once initiated, the plans were hard to change (Wall, 1999). Through the use of mobile phones, environmental activists dramatically increased their efficiency in organizing large numbers of people for direct actions (Wall, 1999). In this era, social interactions between citizen, businesses, and government agencies in relation to environmental problems started changing because of the ability of citizens to micro-coordinate movement via mobile phone.

Spatial presence. For the first time in history, people could stay at remote sites of environmental concern while communicating their message to geographically dispersed listeners and negotiating solutions. Protesters in Ireland, the U.K., and the U.S. used mobile phone calling to communicate with family, radio stations, and press from their remote camps to explain the harm behind widening roads, building quarries, and clear-cutting trees (Cullen, 1997; Mcmahon, 1999; Murphy, 1998). In 1996, members of the Bad River Chippewa tribe blockaded railroad tracks to prevent the shipment of sulfuric acid to a mine in Wisconsin, U.S.A. (Morrison, 1996). Tribe members erected a camp on the train tracks and refused to move when police came to escort them off of the premises. In an effort to avoid conflict, protesters used mobile phones to coordinate communications between the Tribal Chairman and deputies, which resulted in police backing down and a reverberation of the tribe members' environmental message in news accounts of the event. One protester who was

stationed at the site of a planned quarry in Bristol, U.K., made the following statement about his use of mobile phone calling, “We're the techno-crusties. We have to be able to communicate effectively to get our message across, or it makes us less influential” (Murphy, 1998).

At the same time that mobile phone infrastructure enabled people to address environmental problems in remote locations, it also created more environmental problems. Starting in 1993, development of the cellular infrastructure created a new ‘spatial presence’ in sensitive ecosystems and heritage sites. During this time, a staggering 200% growth rate in wireless customers prompted government and industry to take any means necessary to keep up with demand (Farley, 2005); essentially, cell phone tower construction took priority over local ecosystems and communities. Construction of towers required the clearing of land, laying of roads, and erection of infrastructure that often destroyed fragile habitats and lead to illegal logging, activity that led to protests by residents against their construction (Dreazen, 2001; Wilson, 1994).

Once constructed, community members saw cellular towers as nuisances that ruined aesthetics, tourism, and the health and safety of people and animals (Chen, 1996; Dreazen, 2001; Ezard, 1997; Hollins, 2000; Watson, 2000). In Scotland, residents protested the construction of a tower next to a 5,000-year-old Bronze Age burial site, an act they called “environmental vandalism” (McSherry, 1993). Concerns about radiation and long-term health effects from towers triggered residents in Glasgow, U.K. to challenge Scottish Parliament’s cellular tower construction rulings (Drewry, 1999; Watson, 2000). Additionally, concerned citizens lobbied against cellular tower construction after

numerous birds and bats died because of collisions with newly erected towers (Chan, 1999; Dreazen, 2001).

In response to the aforementioned concerns, staff at mobile phone companies started paying more attention to design and construction of cellular towers. To address aesthetic concerns, staff at cellular companies designed and erected towers resembling trees (see Figure 2.2) (George, 2001; Nuki & McGinty, 1997; Pratt, 1999; Wilson, 1998). As a way to gain insight on how to minimize the effects of towers both aesthetically and environmentally, the cellular company Vodafone joined the Corporate Forum for National Parks (Vodafone, 1999). Additionally, One-2-One, a mobile phone operator, invested $15 million to improve the biodiversity at tower base stations and integration of towers with surroundings (Mechanical Engineering Publications, 1999).

*Figure 2.2.* Orange Cellular's tree base station in Somerset, UK, 1999.

Power dynamics. As discussed in the social interaction section earlier, people could now micro-coordinate environmental activity in real time, allowing individuals and grassroots groups to counter the communicative advantages that only large organizations once had. Reporters documented the shift in communicative power through quotes of business and government staff noting their 'surprise' and 'amazement' at the 'James Bond', 'sophisticated', 'professional', and 'tech savvy' environmental action of the 'new breed' of mobile toting 'eco-dweebs'. Through use of mobile phone calling, these 'eco-dweebs' now had strategic and tactical advantages over large organizations through their ability to engage in covert operations, real-time maneuvering, and surveillance. Through the use of mobile phone calling and whistles, London protesters against global capitalism shifted control of city streets in 1999, stopping traffic with the presence of over 7,000 protesters who were dubbed 'eco-warriors' (see Blackman, et al., 1999; Minton, 1999).

Besides increasing maneuverability, mobiles enabled users to alter environmental narratives in the media. Julia Butterfly Hill (Figure 2.3; Boje, 2000) used her mobile phone to communicate her message of anti-logging old-growth forests to thousands of listeners on radio talk shows, all while perched in a 200ft tall redwood tree in California (Mcmahon, 1999). While talking from her tree, which she called Luna, Hill explained to radio listeners what it felt like to be in the tree and the importance of saving her tree, and others, for future generations. She also fielded questions immediately and directly in her own words from radio announcers and interested callers. This example is one of many during this era that shows how users of mobile phones could 'bring' people to a site of environmental concern and offer a real-time narrative based on their experience. Previously, journalists would

mediate environmental narratives to the public through the stories they crafted while visiting a site of environmental concern, or concerned citizens would have to leave the site to take representations such as photographs and stories to the public. Using mobile phones, activists could, for the first time, communicate with news agencies and other outlets directly from the locations they aimed to protect.

*Figure 2.3.* Julia Butterfly Hill, day 729 of her continuous tree-sit, 1999.

In the *mobile and green protests* era, mobile phone calling opened a new set of opportunities for concerned citizens to renegotiate their place and power among organizations vying for use of the earth's resources. In the next era, *greening the mobile handset*, the feature of text messaging increased micro-coordination and information sharing beyond the one-to-one capabilities of phone calling. Though mobiles continued to help users protect the environment, they also continued to destroy it through pollution caused by the manufacturing and disposal of mobile phone handsets.

**Greening the Mobile Handset: 2002-2007**

A massive increase in mobile phone users during this time frame offered the potential for more people to engage in environmental activity and also increase the destruction and pollution of natural resources caused by mobiles' production, use, and disposal. The feature of text messaging afforded mobile users the ability to send short snippets of information to large numbers of people. I include an image of the Samsung SGH-T100, a popular phone during this era, to give context of the type of mobiles used in the examples presented (Figure 2.4; MoDiP, 2016).


*Figure 2.4.* Samsung SGH-T100, released in 2002.

The major themes of this era include 1) texting to promote environmental activism and awareness, 2) recycling mobile handsets, and 3) greening mobile handsets. These themes are explicated with examples under the three categories of mobile

affordances. Important implications of this era, based on Packer's (2013) questions, include changes in:

- accessibility to information on the environmental impact of consumer products;
- modes of environmental activism and;
- the production and disposal of mobile handset.

Social interaction. The ability to quasi-broadcast information via text messages offered a new mode for environmental activism supported by mobile phone text messaging, an activity that I call *textivism*. A number of organizations used textivism to engage supporters in environmental activism during this era. By soliciting mobile phone owners online and in-person, Greenpeace Argentina amassed contact details for 350,000 supporters (Kinkade & Verclas, 2008) and used text messaging to arrange a large, fast-functioning network of supporters. Through their textivism efforts, organizers of Greenpeace Argentina successfully coordinated demonstrations and lobbying efforts that lead to the passage of the Zero Waste law in 2005 and passage of the Forest Law in 2007 (Kinkade & Verclas, 2008). In 2007, citizens in Xiamen, China, engaged in textivism to pressure city staff to reevaluate the planned construction of a petrochemical plant. After citizens sent nearly one million text messages, government officials suspended construction of the petrochemical plant (Oster, Yang, & Zhang, 2007). Texting also played a role in prompting attendee pledges to take action to solve climate change during the Live Earth global music event in 2007 (Kinkade & Verclas, 2008), and in another environmental initiative called

Smokebelchers, Manila teens used texting to report black smoke emitting vehicles to curb air pollution (The Christian Science Monitor, 2002).

Texting allowed environmental organizations and citizens to coordinate initiatives faster and more efficiently than with traditional mechanisms of letter writing, phone calling, or email. Texting meant that large numbers of geographically dispersed supporters could receive information simultaneously. Instead of having to check a physical mailbox, landline phone, or computer, supporters could receive messages and send messages from wherever they stood. As seen in the Smokebelchers campaign, teens could immediately report, from the street, polluting vehicles as opposed to note the vehicle on paper or fill out computer form.

Spatial presence. Not only did texting change coordination of large numbers of supporters, but it also enabled mobile users to query for environmental information via text. In early 2000, *Infolines* (Kinkade & Verclas, 2008) emerged as a way for mobile users to send texts via a short series of numbers to receive 'just-in-time' information on an environmental topic of concern. For the first time, people had a way of requesting and receiving environmental information pertinent to their decision making and action wherever they happened to be. The Southern African Sustainable Seafood Initiative and the World Wildlife Fund's infoline, called FishMS, started in 2006. FishMS enabled South African mobile users to text the name of a fish, whether at the grocery store or market, and receive information on whether or not to purchase that species based on harvesting practices (World Wildlife Fund & The Southern African Sustainable Seafood Initiative, 2010). Two other point-of-purchase infolines emerged around 2007: the Climate Counts infoline, which

allowed mobile users to send text messages to query the sustainability ratings of a company and its product, and the Moms Rising infoline, which gave the chemical content of toys when users text a toy's name and company (Kinkade & Verclas, 2008). Infolines changed the product buying experience for consumers who now had a way to research environmental and health aspects of a product before they purchased it. Besides consumer products, mobile users also quarried infolines to learn about their surrounding environment. The U.K.'s airText campaign and the U.S.'s Ergo service sent mobile users air quality information when quarried via short code (European Space Agency, 2007; Paulos, 2007).

Before infolines, people *reacted* to information, often finding out after purchase of a product the negative environmental impact of their purchase and then taking steps to boycott or promote better products. Or, in the case of airText and Ergo, people would venture outside, unknowingly exposing themselves to high levels of air pollution, often inducing asthma attacks. The advent of infolines allowed mobile users to become *proactive*, comparing products to find the most environmentally friendly or checking air quality before venturing out for a bike ride. The instances mentioned above point to the ways that mobile phones started to alter what people knew about everyday phenomena.

Power dynamics. Though mobile phones influenced environmental activity, environmental activity also influenced mobile phone manufacturing, use, and disposal. While in use, mobiles needed to be charged daily, typically sucking energy from the grid powered by coal or nuclear plants (New Media Age, 2007). According to *The Ecologist* (2004), the effects of mobile handset production included but were not limited to illegal hunting of endangered animals during tantalum mining and arsenic poisoning from

copper mining. Similarly, the disposal of mobile handsets included pollution from the burning of plastic cases and the leaching of copper from circuit boards into groundwater when disposed in a landfill. In 2002, the U.S. Environmental Protection Agency estimated that by 2005, users would dispose of 130 million mobile phones per year and, if current trends persisted, that would result in 65,000 tons of waste (Natural Life, 2002a). One report noted that in 2004, less than 1% of mobiles were recycled or refurbished (The Christian Science Monitor, 2004).

Individuals and organizations began to challenge the production practices of mobile companies and ask for government policies to curb the pollution associated with mobile phone disposal. Environmental organizations partnered with mobile phone distributors to collect then recycle or refurbish old handsets. Some groups, such as Planet Ark, Australia, hoped that their efforts would lead to the recycling of half a million phones per year (Bawaba, 2007; Natural Life, 2002b; Plastics News International, 2003; Sydney Morning Herald, 2002). In 2002, Shields Environmental, U.K., aimed to curb the 15 million handsets entering British landfills per year via their Fonebak initiative, which diverted handsets from the landfill through interventions at retail stores across the U.K. (Europemedia, 2002).

In addition to recycling programs, government representatives and environmental organizations lobbied for bills and laws to improve recycling efforts (Inner-West Weekly, 2006; Knight Ridder, 2004; TreeHugger, 2005). In 2005, Assemblywoman Fran Pavley, from California, U.S., presented the first bill to require mobile providers to offer free recycling of handsets (Folmar, 2004). At the same time, Australia Environment Ministers and the Environment Victoria group advocated for state laws requiring that the mobile

industry increase handset recycling from 4% to 50% (Australian Financial Review, 2005a, 2005c; TreeHugger, 2005). These efforts led Australian mobile carriers and handset manufacturers to set up a recycling scheme that consisted of a levy on new phones to cover the cost of recycling, 1,600 recycling bins in stores across the country, and efforts to recover toxic and precious metals for recycling (Australian Financial Review, 2005b).

Mobile companies and entrepreneurs also took on the challenge to curb the polluting nature of mobiles. U.K. mobile companies opted to provide special offers, such as rewards for customers and donations to charities, if users kept their mobiles for an additional year instead of upgrading (The Independent, 2007; UK Newsquest, 2007). The mobile phone company Motorola created a biodegradable mobile phone case with an embedded sunflower seed that would grow when users placed the phone cover in soil (Figure 2.5; Dunn, 2004). To eliminate the pollution caused from charging phones, several entrepreneurs created the SideWinder, a device that enabled mobile users to charge their phone by winding a lever (The Straits Times, 2007).


*Figure 2.5* Biodegradable mobile phone cover, 2004.

In the Greening the Mobile Handset era, mobiles offered people ways to alter their environmental activity. At the same time, people altered the development, use, and disposal of mobile phones. Though this dissertation does not discuss this topic further, people continued to challenge companies and government agencies to reduce the pollution caused by mobiles in every era after this one. The next era, Mobiles as Extensions of Self, brought new opportunities for quasi-broadcasting of messages and new ways of understanding nature via smartphones and their associated applications.

**Mobiles as Extensions of Self: 2008-2011**

The Mobiles as Extensions of Self era included a broad range of communicative possibilities not offered through phone calling or texting of previous eras. The release of touchscreen smartphones in 2007, such as the iPhone (Figure 2.6; Gadgets 360, 2008), offered developers and users advanced computational power and a growing cellular infrastructure capable of transmitting high-speed data (Kalba, 2008; Karmakar & Dooley, 2008).


*Figure 2.6.* The iPhone 3G, released 2008.

Mobile users now had access to mobile phone applications capable of internet queries, playing MP3 files, utilizing Global Positioning Systems (GPS), and showing videos. These capabilities added a new dimension to environmental communication and personalization of environmental data. Initially, mobile phones did not include applications specifically designed for environmental activity; instead users promoting the creative use of general apps. For example, environmental journalists suggested that mobile users reduce paper waste using the Amazon Kindle, the Map + Compass, or the GreenCard business card app (Barz, 2009; Yoneda, 2009). As smartphones increased in popularity, so too did the development of mobile applications known as *eco-apps* designed to promote environmentally friendly behavior.

Mobile phone users of this era began to use a range of eco-apps to help them engage in environmental activity; these apps supported collective behavior, sensing systems, individual behavior, and citizen science efforts. Eco-apps offered a new level of personalization to entice, educate, and motivate mobile users toward environmental activity that was not possible with the texting initiatives of the Greening the Mobile Handset era. Personalization included connecting a user's location, interests, and property to environmental data. Due to the complexity, time, and resources needed to create the eco-apps of this era, most were created by government agencies, businesses, universities, and nonprofits. Implications of this era, based on Packer's (2013) questions, include changes in:

- who defined and enacted sustainability; and
- the recording and application of environmental phenomena.

Social interaction. *Collective behavior eco-apps* allowed like-minded mobile users to collaborate and play games toward achieving sustainability via social media. These apps coordinated geographically dispersed individuals in simultaneous learning and competition with one another. The JouleBug app encouraged users to complete sustainability tasks to receive badges and trophies; each task completed placed users either ahead or behind of their peers, thus encouraging competition among the network of players (Ohnesorge, 2012). Similarly, the carbon calculator game, Twavel (Figure 2.7; Copeland, 2011), helped users track their emissions, compete with others for the lowest emissions, and share tips on how to reduce their carbon footprint (Barz, 2009). Figure 2.7 shows a Twavel user's weekly emissions (left) and community tips (right).


*Figure 2.7.* Twavel eco-app, 2009.

Other collective behavior apps increased user sustainability efforts by offering a space for sharing tips and collaborating on projects. The GreenITers eco-app helped users to quasi-broadcast sustainability ideas and projects, which users could then comment on or participate in (Fullcircle Innovations, 2012). Mobile users gathered pertinent information about community problems using EcoSnoop, which helped them to geotag environmental problems in their community and discuss solutions (Heimbuch, 2009b). Collective behavior eco-apps provided space for mobile users to discuss and enact sustainability as it pertained to their lives instead of simply following guidelines set out by others.

Spatial presence. *Sensing systems* emerged via mobile phones and cellular infrastructure as way of connecting users to environmental conditions and physical locations. Sensing systems utilized sensing devices such as air monitors to collect data from users' mobile phone handsets or cellular towers. The Japanese mobile company DOCOMO attached air monitoring devices to their cellular towers to collect and relay surrounding air quality to local governments and healthcare providers (Heimbuch, 2009c). Google's map app complied mobile phone users' locations and speed of movement to notify users of congested areas and reduce traffic related pollution (Heimbuch, 2009c).

Several organizations developed embeddable chips and sensing attachments that detected chemicals in the air. These devices included NASA's Chemical sniffing app and silicon chips developed at the University of California with funding from the U.S. Department of Homeland Security (Brown, 2010; Yoneda, 2009). Extending beyond the handset, several companies developed wearable sensors, including Nokia and Sensaris (Figure 2.8; Videosfing, 2009). Both companies created wristwatch like devices, called

wristlets that collected and transmitted air pollution levels to the user's mobile phone (Heimbuch, 2009d; Kinkade, 2008). Figure 2.8 shows a Sensaris wristlet in use, collecting the surrounding air pollution levels and communicating the data to the user's mobile phone.

*Figure 2.8.* Sensaris wristlet, 2009.

Sensing systems altered the way that mobile users learned about environmental conditions. Instead of relying on data gathered by other people or at different locations, users could gather and analyze personalized data reflecting their environment. With such personalized and timely data, users could alter their movements within space, choosing to travel to or out of areas based on environmental data relayed via mobile phone.

Power dynamics. Individual behavior eco-apps and citizen science eco-apps, which I will describe shortly, offered new avenues through which environmental experts could

engage with novices and vice-versa. *Individual behavior eco-apps* presented content from sustainability experts to shape user behavior and knowledge. One type of individual behavior app included those that tracked user behavior and suggested ways to reduce the user's environmental footprint. Examples include greenMeter and Green Gas Saver, which monitored users' driving habits, then offered alternative driving habits to reduce fuel consumption (Hunter Research and Technology, 2009; Wauters, 2010).

Other tracking apps included carbon footprint trackers that correlated users' movements to carbon dioxide, methane, and nitrous oxide outputs. Carbon tracker apps included the European Commission's mobGAS app, Bike Your Drive, and the Carbon Tracker app (Aughton, 2007; Barz, 2009; Wauters, 2010). Some apps allowed users to track their gas meter and appliance use to identify ways to reduce energy intensive activities or replace energy draining appliances (Spinks, 2011; Wauters, 2010). Tracking apps revealed hidden dimensions of users' behavior to help users reduce their environmental impact.

Some individual behavior apps catered to shoppers through product guides that recommended some products over others based on a set of sustainability guidelines. Catch-all shopping guides included GoodGuide (Figure 2.9; Knoblauch, 2009), which enabled users to scan product barcodes, and Ethical Company Organisation, which offered a way for users to search 700 brands; both revealed environmental ratings and rankings of the products queried (Spinks, 2011; Wauters, 2010). The Environmental Working Group's DirtyProduce app outlined the most and least pesticide-laden fruits, and the Monterey Bay Aquarium's Seafood Watch app showed fish of most and least concern based on overfishing and pollution

(Barz, 2009; Rickstad, 2011). Find Green and 3rdWhale apps offered local purchasing recommendations and highlighted sustainable businesses (Heimbuch, 2009a; Wauters, 2010).

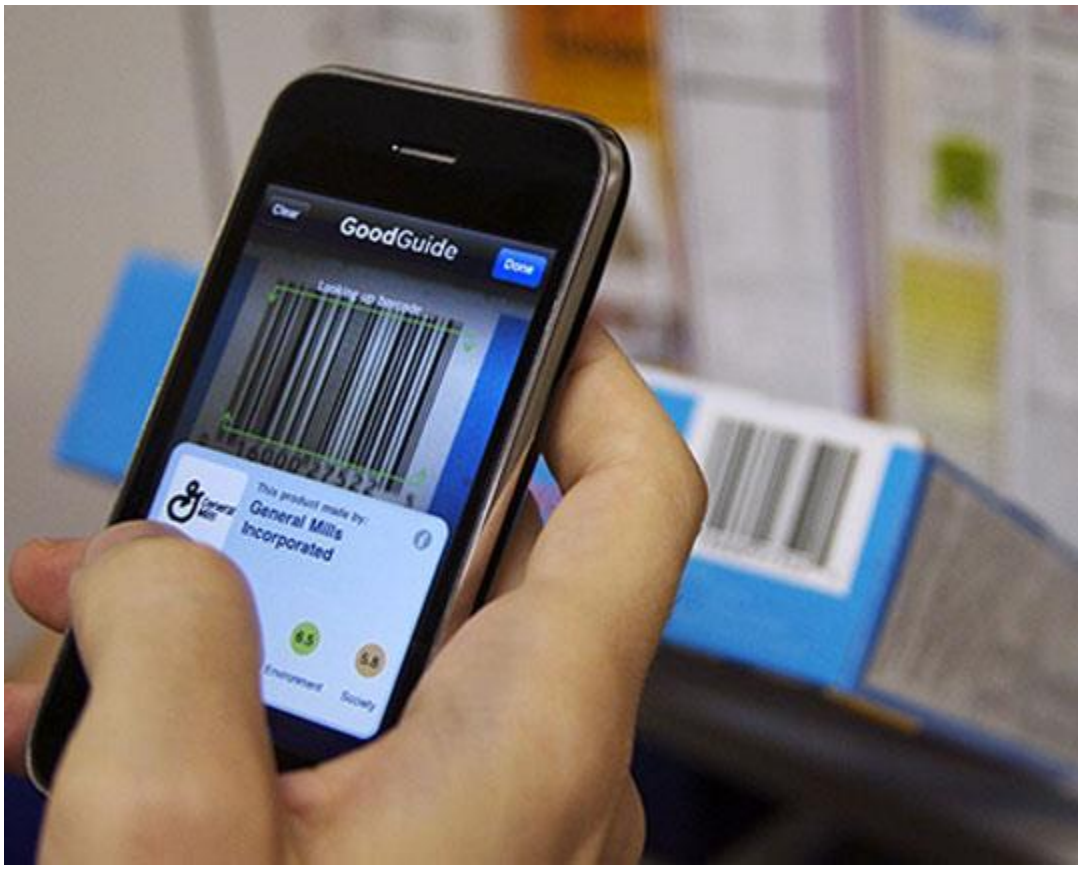


*Figure 2.9.* GoodGuide app, 2009.

Individual behavior eco-apps also offered individualized environmental content ranging from news articles to sustainability tips. GreenSpot and Green Living News offered mobile users environmentally focused articles from popular news sources such as *The New York Times* and *Associated Press* (Barz, 2009; RelaxNews, 2011). Get Green, Green Energy Now, and Green Genie apps helped users reduce their environmental footprint through suggested activities such as recycling office paper and composting coffee grounds (Barz,

2009; Graham, 2011). Users could also learn specific facts related to issues of their interest, such as facts about climate change through the Skeptical Science app, seasonal phenomena with ECOcal, or tree identification through Leafsnap (Barz, 2009; Hickman, 2011; Spinks, 2011).

Besides creating content for individual behavior apps, experts also participated in construction of *citizen science eco-apps.* As a way to crowdsource scientific data collection and investigation, experts from a range of environmental disciplines created citizen science apps. Citizen science apps asked mobile users to collect and upload data about the natural world through text, images, or video; data that was contributed was used to create databases used for conservation efforts. The application iBats, released in 2011, allowed bat enthusiasts to plug an ultrasonic bat detector into their iPhone and collect the bat's call and location. Scientists could then access iBat data via a database and monitor bat biodiversity. The organizations that created iBat included the Zoological Society of London, the Bat Conservation Trust, and Atomic Powered application developers (Atomic Powered, 2011; iBats, 2012).

Several apps, such as the Map the Spill app, opened space for the analysis of scientific data to non-scientists. Creators of Map the Spill designed the app to circumvent the restrictions placed on many news agencies during the Gulf Oil Spill in 2010. Map the Spill allowed mobile users to upload photos, videos, and notes of oiled shorelines and wildlife on an interactive map, resulting in a crowdsourced database of the spill available to anyone with the app (Heimbuch, 2010). The BirdsEye app (Figure 2.10; Slocum, 2010), created by Birds in the Hand, LLC, allowed users to record and submit bird sightings to the eBird database,

accessible to both citizens and avian research groups (Audubon & Cornell Lab of Ornithology, 2012; Cornell Lab of Ornithology, 2009).


*Figure 2.10.* BirdsEye app, 2009.

Citizen science apps opened the possibility for people who traditionally did not engage in scientific activities, to collect and analyze patterns and changes in their community's ecosystems. These apps offered a quick and easy way to engage beach goers, in the case of Map the Spill, and recreational birders in the case of BirdsEye. Eric Paulos, a computer scientist at Carnegie Mellon University, credits citizen science apps with allowing

users to “develop a relationship with and a sense of ownership over the data,” which he thought could change users’ understanding of science (The Economist, 2009).

Power dynamics shifted in this era because mobile phone users, no matter their education or background, could gain access to information and activity once privy to people with advanced degrees or with access to more resources. Instead of having to acquire a birding degree or pay for a subscription to *New York Times,* mobile users could download an eco-app to learn and engage in the environmental topics of their choice. The accessibility and participatory nature of individual behavior and citizen science eco-apps lead to new narratives in society regarding the abilities of non-experts to contribute to conservation efforts.

Many of the articles and reports of this era boasted the features of eco-apps as effective mechanisms for developing ‘environmentalists’ and ‘scientists’. For example, the features of collaborating on conservation projects, playing environmentally themed games, reading sustainability tips, purchasing environmentally friendly products, or monitoring and adjusting behavior according to sustainability prompts could develop users into environmentalists. Yet, others argued that eco-apps could not ‘make’ an environmentalist, because such a title should be bestowed to people who not only engage in environmentally friendly activity, but also embody a deep philosophical understanding of human-nature relationships. Similarly, discussion on citizen science eco-apps and sensing systems purported that users could become ‘scientists’ observing, identifying, recording, and analyzing patterns through the mobile phone. Yet, others argued that simply observing, recording, and musing over natural phenomena did not constitute a scientist; instead the title

of such a person should be reserved for people who received formal training and who were less likely to miss identify or miss interpret data. The use of mobile phones by novices to engage in environmental and scientific activity opened debates as to who and what constituted an environmentalist or scientist and exposed how sharing scientific data collection and analysis allowed for alternative understandings of conservation efforts.

Though eco-apps opened the door for novices to contribute to scientific data, large organizations and scientific experts remained in control of the eco-app development process. Organizations creating eco-apps in this era included government agencies, businesses, universities, and nonprofits. Because apps of this era required substantial knowledge of coding to design, financial resources to create, and took a considerable amount of time to build, only organizations who possessed monetary and intellectual assets could create apps. In the previous era, mostly small grassroots organizations initiated environmental activity; however, in this era, responsibility for initiating environmental activity shifted to large, established organizations.

The Mobiles as Extensions of Self era brought a new level of personalization to environmental communication through mobile phones that was not possible in earlier eras by calling or texting. The development of eco-apps such as collective behavior, sensing systems, individual behavior, and citizen science, offered new ways to record, understand, and apply environmental experiences and information. In the next era, Independent Advocacy and Action, technological capabilities became even more detailed at detecting and relaying information to users about their environment, thus adding another dimension to what

mobile phones could offer users. Additionally, a shift occurred between the two eras in who created mobile app initiatives, specifically from large organizations to individuals.

**Independent Advocacy and Action: 2012-2016**

The contributions of individuals through eco-apps that began in the Mobiles as Extensions of Self era, increased in the Independent Advocacy and Action era through the use of social media applications. The popularity of social media applications in this era enabled individuals to challenge larger organizations' environmental practices and broader social belief structures. Additionally, advancements in mobile technology offered a refinement of the sensing systems of the Mobiles as Extensions of Self era, paving the way for smart systems that offered fine grained detail of human-nature relationships. I present the Samsung Galaxy S5 (Figure 2.11; GSMArena, 2014) as an example of the type of mobile phone used during this era.


*Figure 2.11.* The Samsung Galaxy S5, released 2014.

Themes in the fourth era included 1) democratizing broadcasting, 2) smart systems, and 3) apps developed by individuals. Together these themes reveal how individuals engaged in environmental advocacy and action without involvement or support from environmental organizations, as was the case in previous eras. These themes are explicated with examples under the three categories of mobile affordances. Important implications of this era, based on Packer's (2013) questions, include changes in:

- who participated in environmental discussions and how;
- who created eco-apps; and
- how human-nature dynamics were understood.

Social interaction. With mobile social media applications reaching mainstream use, new forms of coordination and communication emerged. Instead of environmental groups with carefully planned messages communicating by mobile phones, individuals could find, create, and share their own messages. Individuals used social media platforms such as Twitter, Instagram, and Snapchat, to insert messages that challenged mainstream environmental propaganda. Once posted on social media, a message would attract the attention of supporters and opponents, spiraling into public discourse and igniting community action. For example, when the World Forum on Natural Capital (WFNC) occurred in May 2013, event organizers publicized the event on Twitter. Organizers highlighted the event's purpose to bring leaders together to apply economic logic to conservation practices. Brett Matulis (2015) countered the WFNC's Twitter post with his own, pointing out the lack of alternative voices and debate scheduled for an event advertised as open to discussion. The WFNC organizers responded to Matulis' Twitter posts by offering limited complimentary

tickets to lead members of oppositional activist organizations and scholarships for students. As the event neared, other activists joined Matulis on Twitter, flooding the WFNC Twitter handle #natcap13 with queries about the effects of the monetizing nature on social and environmental justice. As dissenting posts filled the event hashtag, Matulis (2015) recorded event organizers' anxiety that their message was "getting diluted" and "people [weren't] going to have a clue what [the WFNC was] all about" (p. 13). This example shows how individuals used social media through mobile phones to challenge prominent environmental messages in public discourse, even when they could not physically attend the main even.

A year later, several seal hunting supporters from Canada played off of the publicity generated by Ellen DeGeneres 'selfie' photo on Twitter (Hawkins & Silver, 2016). After DeGeneres took her selfie at the 2014 Academy Awards, numerous donations were made to organizations known for campaigning against seal hunting. Hawkins and Silver (2016) found two seal hunt supporters and decided to utilize the Twitter conversations around DeGeneres' #selfie to present counter seal hunting narratives using the hashtag #sealfie. The supporters posted personal images and stories of seal hunting's cultural significance.

Similar to the WFNC counter posts, the #sealfie posts attracted supporters who added their own images and stories to challenge dominant anti-sealing narratives. According to Hawkins and Silver (2016), the effects of #sealfie included more public debate on seal hunting and exposure to the counter narrative in the news. In both the WFNC and #sealfie examples the mobile phone offered ways for geographically dispersed individuals to stay abreast of discourse in the public realm and to offer instant counter narratives without the

need to move from their location or gather in one physical place. However, the affordance of social media for environmental activism only became possible in this era because of the increased popularity of both mobile phones and social media.

The work of Fenton Lutunatabua in broadcasting the 2014 efforts of the Pacific Climate Warriors is another example of the use of social media to present counter messages. The warriors consisted of an alliance of activists from over 12 island nations in the South Pacific (Cronin, 2016). Using Twitter, Instagram, Snapchat, and Flicker, Lutunatabua broadcast the Pacific Climate Warriors' canoe blockade of coal boats in the Port of Newcastle, Australia. As seen in the WFNC and #sealfie examples, the Lutunatabua utilized social media to circulate a counter narrative. Lutunatabua showed that the Warriors did not want the world to see them as climate change "victims," but as warriors ready to "fight" instead by holding people accountable for their actions. Lutunatabua stated, "Snapchat is real life, showing how things look without a filter…you can show the world what's really happening" (Cronin, 2016, par 10). Due to Lutunatabua's efforts, the islander's counter narrative made global headlines.

In another effort to broadcast counter narratives, the organizers of the Twitter and Instagram hashtag #climategame, encouraged individuals and groups to post images, videos, and stories of how they disrupted the 2015 Conference of Parties (COP21) convention on climate change. In this effort, environmentalists were encouraged to register on the Climate Games website and then use their mobile phones to record and post their activity. Participants received points for "playing," such as engaging in hilarious stunts of clownery at official COP21 meetings (Figure 2.12; Climategames, 2015) and initiating dance

movements in public squares, all in an effort to counter or mock the event. As with all forms of culture jamming, the ultimate purpose of #climategame activities was to disrupt the status quo by breaking routines, reassembling space, and inverting perspective to reveal new understanding of culture (Milstein & Pulos, 2015). Advertised as the world's largest disobedient action adventure game, #climategame generated 214 actions by 124 teams from around the world that included environmental artists, activists, coders, developers, and gamers. By culture jamming at the COP21 event, #climategame participants attempted to use the official event space to engage in alternative discussions and proposals for solving environmental problems.

*Figure 2.12.* "Clowning around" at an official COP21 meeting, 2015.

The impact of these counter messages often reached such acclaim that anti-environmentalists would quasibroadcast their own round of counter narratives through mobile social media. The term "astroturfing" came about as companies created fake

grassroots groups on social media to argue in the favor of the company's practices and against those of real grassroots groups (Cho, Martens, Kim, Rodrgue, 2011). Based on research by the advocacy organization DeSmog, the Midwest Alliance for Infrastructure Now (MAIN) appeared to have engaged in astroturfing when they created fake Twitter profiles to serve as "sock puppets" to support the Dakota Access Pipeline (DAPL) (Horn, 2016). DeSmog tracked down 16 questionable Twitter accounts that used the #NoDAPL hashtag to produce counter narratives; the #NoDAPL hashtag was commonly used by activists against the pipeline. The sock puppet accounts look like those of grassroots advocates, but the pro-pipeline messages echoed messages used by DAPL supporters. When users queried the sock puppet accounts and asked if they were generated by genuine people, the accounts immediately disappeared. Following a similar tactic but without use of fake accounts, anti-environmentalists often interjected counter narratives into the hash tags of environmentalists. For example, climate deniers utilized the same hashtags as climate change advocates to Tweet the alleged farcical nature of climate change (Swain, 2016).

The popularity of mobile social media in this era offered individuals a digital platform from which to freely interject counter narratives and reach a broad audience of people who may have otherwise ignored environmental concerns. As seen by the changes at WFNC, Matulis' (2015) and others' interjections in the #natcap13 Twitter feed brought new perspectives and uncovered new realities for event participants to discuss and act upon. Additionally, the impact of environmentalists' counter narratives within the broader arena of discourse lead to identification of specific Twitter users as 'sock puppets' and the dishonest tactics used by large businesses to silence pro-environmental initiatives.

Spatial presence. Moving beyond the sensing attachments and watches of the previous era, users of this era could monitor themselves and others in detail with wearable computing and embedded sensors, which I call *smart systems*. Wearable computing, including smart watches, smart clothes, smart glasses, and smart pet collars, allowed users to easily monitor and connect with their body, their pets, and the surrounding environment (Markham, 2013; Sung, 2015). Smart systems brought new dimensions of mobile users' environment through automated home systems and monitoring devices such as the Apple's HomeKit and Samsung's Smart Home. These smart systems enabled mobile users to connect digitally to the physical functions of their home. The Sense home energy monitoring system let users monitor every appliance, light, and device in their house via the mobile app by installing a device in their electrical box. By alerting users to how much TV they watched or when someone left an iron on, the Sense app, to conserve energy, helped users reorder and reorient how they interact with their home environment. The Sense system and others like it also offered a way for users to "hear" the functioning of home energy systems in relation to users' daily activities.

The miniaturization of electronics further enabled sensing and monitoring of things in ways not possible in earlier eras, such as Intel's Curie module, a low-power, wearable chip. Intel's advertisements sold the module as easy to use, so easy that any student or entrepreneur could create a wearable device. To support their claim and promote their product, Intel instigated a reality television show called *America's Greatest Makers* where students and entrepreneurs competed for prizes based on their Curie module creations. Several teams create sensors related to environmental efforts, which redefined

mobile locative media from locating the user to locating things. Team Tandm used the chip to create a module that attaches to a user's bike, making it possible to rent the bike to others who use the accompanying mobile app to locate and rent the bike. In addition to connecting users to the location of inanimate objects, the Curie module allowed Team Herddogg to connect mobile users to the location and statistics of cattle. The team created a system to help ranchers track health and proximity data of cattle herds by attaching the Curie module to a cow's ear. The module would then pick up ambient data, tabulate how much the cow walked, and record temperature then relay it back to the rancher's smartphone. In both of these examples, the users of the apps could reorganize their own movement, the movement of objects, and animals.

Another smart system, that used sensors and mobile technology to monitor animals was the $16 million shark tracking technologies of the Australian state of New South Wales (Treacy, 2015). These technologies included drones and helicopters to assist with shark-tagging and a smartphone app called SharkSmart that allowed swimmers to see the real time location of sharks. By identifying the location of sharks in relation to where people wished to swim, supporters of the project hoped to avoid shark attacks and the killing of sharks suspected of attacking swimmers. To ensure the system worked, New South Wales set aside an additional $7 million to monitor how well the technologies helped keep both swimmers and sharks safe.

Smartsystems helped monitor other aspects of nature during this era, including soil, water, and weather. Smart irrigation systems for homeowners, such as Blue Marble, The Eve, and Hydros irrigation systems, advertised that their sensors and apps could save

homeowners up to 60% of water compared to conventional timer-based watering systems (Markham, 2014a; 2014b; 2015). The smart irrigation systems combined information from historical and current weather forecasts, soil moisture sensors in the yard, temperature, and light conditions to produce personalized watering schedules. Homeowners could view garden sensors and watering schedules through their mobile app. These irrigation apps allowed users to monitor their yard from anywhere without the need to physically touch the soil or observe weather conditions.

The combination of sensors and mobile applications in this era afforded users connections to physical space, which allowed users to determine from any location the functioning state of themselves, objects, and nature. In a way, smart systems offered a digital voice to nature that afforded mobile users a new way of seeing the nuances between human-nature interactions and finding better ways to integrate human activities in the rhythms of nature. As seen in the SharkSmart app, swimmers could avoid specific locations, and as seen in the irrigations systems example, users could choose to water more or less depending on the feedback of sensors in their yard's biome. Yet, such detailed monitoring and feedback might also hinder deeper understanding of and action for the conservation of nature. The location of sharks provided by the SharkSmart app might lead to their demise because fishermen now have immediate access to shark's locations. Similarly, having data transmitted to one's smartphone about the health of his yard may reduce the amount of time spent in the yard. Thus, smart systems may confound the very problems they aim to solve by leading users to rely on digital understandings of nature through their mobile phones instead of physical connections with nature.

Power dynamics. During this era, app creators shifted from large organizations, as seen in the Mobiles as Extensions of Self era, to individuals who are passionate about nature. Instead of experts dictating which important and unimportant aspects of nature to focus on, individuals could interject their ideas into the environmental discourse of the app world. During this era, many eco-apps started as an idea of one or two people then evolved to include a diverse group of developers. These individuals included professionally trained environmentalists, expert programmers, and novices, who lacked formal training in ecology and/or programming. For example, a Stanford University professor in climate and energy initiated the creation of the Oroeco app to help users reduce their environmental impact. He had considerable experience in the climate field but needed a team to build and maintain the app. Once organized, the team called themselves a "crew of...scientists, engineers, sustainability junkies, and startup vets" (Bolluyt, 2015). The creator of another conservation app, Dropcountr, also described the team that he created to develop the water conservation app as a group of water, sustainability, and technology "enthusiasts" from Silicon Valley (Bolluyt, 2015).

Other solo developers entering the eco-app market during this era included Josh Felser, who identified as a serial entrepreneur with a passion for technology, innovation, and the environment. Felser created #climate, an app that helps users discover and share actions to combat climate change (Bolluyt, 2015). The self-described teen entrepreneur, Param Jaggi, created the app Ecoviate to spread social sustainability through a newsfeed with eco-friendly tips and products (Bolluyt, 2015). Seattle software developers, Brendan Ribera and

Sean Mortazavi, teamed up to develop their vision to stop paper junk mail and reduce associated waste through creation of the app PaperKarma (Mazzoni, 2014).

Besides individuals acting on their ideas, eco-app creation also occurred via organized events. The U.S. Environmental Protection Agency launched a developer challenge in the summer of 2011 called Apps for the Environment Challenge (available at: https://developer.epa.gov/apps-for-the-environment-lessons-learned/). The challenge asked developers to use the EPA's data to produce environmental and/or health apps. Individuals and teams worked to produce 38 apps, which the EPA recognized at a high-profile event. The following year, the U.S. Department of Energy ran their app challenge, called Apps for Energy (available at: http://appsforenergy.devpost.com/). Apps for Energy brought together individual and group developers, producing 56 different apps and awarding $100,000 in prizes for the apps that most effectively helped users reduce electricity consumption. That same year, several Brooklyn developers opened a technology incubator called Summer Camp, "to inspire web developers and designers to make something they love and to help remove any barriers that stand in the way" (Ford, 2013, par 3). One group of developers submitted their app, called Farmstand, and received $25,000 to develop and market the app as way of supporting local food producers (Bolluyt, 2015).

The classroom appeared as another location for gathering like-minded environmental enthusiasts to develop eco-apps. Four university students at Pontificia Universidad Católica de Chile created the carbon footprint tracker GiveO2 in 2011 as part of an engineering class (available at: http://www.giveo2.com/aboutus/). In Northern Ireland, students at Ulidia Integrated College received funding from local businesses for their mobile app KS3 (Key

Stage 3), aimed at helping students learn about science and conserve energy (Carrick Times, 2015). Even middle school students became involved in eco-app creation when students from Kyrene Aprende Middle School in Mesa, AZ, U.S. won Verizon's Innovative App Challenge Best in Region and Best in State (Figure 2.14) for their environmentally friendly mobile application (Ochoa, 2015).


*Figure 2.13.* Winners of Verizon's Innovative App Challenge, 2015.

The examples mentioned above show the diversity of eco-app developers that emerged during this era. These developers, known as *enthusiasts*, *entrepreneurs*, and *students,* have *passion* to bring together environmental concerns with technological innovation. This new set of developers created apps as a way to explore relationships

between technology, nature, and their lived experience, as opposed to reifying discipline specific environmental or technological ontology.

Looking across the eras, it is possible to see how changes in technological affordances and popularity of mobile phones impacted who communicated about the environment and how. In each era, news reports and press releases revealed how the developers and users of mobile phones defined themselves, a definition that became broader over time. In the first era, people using mobile phones for environmental activity defined themselves as activists, and in the last era, they defined themselves as entrepreneurs and students. Additionally, the types of communication used in each era enabled users to reach more people and gain a more detailed understanding of human-nature dynamics.

## Findings and Interventions

My findings align with mobile communication scholarship, such as Ling's (2012) research, in the ways that mobile phones mediated and changed communication, coordination, and transportation. Specifically, mobiles affected coordination by enabling users to rapidly organize environmental activity with people from disparate locations, an affordance not offered by landline phones, desktop computers, or paper mailings. I also found that mobiles changed communication and transportation in the way they connected users to each other and locations while physically in motion (Campbell, 2013) and altered users' movements, perceptions and relationships with space (de Souza e Silva, 2013). Most importantly, mobiles enabled and prompted users to identify better ways to integrate human activity into the rhythms of nature by presenting new perspectives of nature, as seen in the smart systems examples.

Additionally, mobiles altered the power dynamics related to environmental activity and information sharing by creating new narratives about who engaged in environmental activity and how. For example, in 1999 Julia Butterfly Hill telephoned radio stations from her tree house 200ft off the ground in a redwood. Instead of letting reporters speak for her, Hill explained her efforts, in her own words, creating a narrative that reached global recognition. Eco-apps gave novices access to environmental data and the ability to contribute to that data, while social media apps helped individuals challenge mainstream environmental propaganda.

The results of this media archaeology also aligned with Packer's (2013) argument, that technology can mediate what can be said, where, and to whom. Mobile phones generated new possibilities for mediating environmental messages and information between environmental organizations, businesses, government agencies, activists, interested individuals, and anti-environmentalists. This media history also revealed how mobiles mediated the ways in which people interacted with and impacted nature. As suggested by Packer (2013), the unique data collection, transfer, and display capabilities of mobile technology offered users new ways of knowing and interacting in the world. Following Packer's (2010; 2012) articles, I conclude my media history with take-away points summarizing the findings and arguments. The take-away points are located within four features of mobile phones, calling, texting, apps, and smart systems, and offer ideas and examples for how people can use those features to engage in environmental activity. The fifth grouping offers ideas and examples for how people can alter the environmental impact of the mobile phone infrastructure, including phone handsets and cellular towers.

What is important to take from these summaries is the many and diverse ways that people have used mobiles to organize, communicate, and instigate action. When considering whether to use a mobile phone for environmental action, the end goal and what mobile feature might work best to achieve that goal should be noted. If the goal is to coordinate direct action, phone calling or texting will allow for quick and seamless organization. If the goal is to meet users where they are, offering infolines and eco-apps can put knowledge and resources at users' fingers. Discussions of ethics and environmental concern may function best through popular social media platforms like Facebook and Twitter. Efforts to alter policy and environmental narratives in the media might work best through textavism and social media efforts like those of #climategame.

Scholars and practitioners can apply the findings of this media history by identifying which examples discussed below best apply to their situation and goals. On one hand, a phone call to media outlets from a remote and important environmental site may be all that is necessary to refocus environmental narratives in the public realm, and on the other hand texting alerts and locative eco-apps may help mobile users recognize where and when they can make the strongest environmental impact. Yet, the most detailed feedback between people and nature is still underway with the use of sensors and monitoring systems that allow people to gain new perspective toward their environmental footprint as seen with smart systems. The following will help generate ideas for future environmental activity through mobile phone use:

**Calling affords:**

- One-to-One communication to evade and observe others and negotiate and arrange activity. Examples: Mobiles helped activists evade police in a 1998 raid on genetically-modified crops in Scotland and quickly coordinate riots against global capitalism a year later in London.
- Freedom to speak *directly* from contested locations. Examples: In the late 90s protesters in Ireland, the U.K., and the U.S. used mobiles to communicate with family, radio stations, and press from their remote camps to explain the harm behind widening roads, building quarries, and clear-cutting trees.
- Renegotiation of narratives in the public sphere, such as who engaged in environmental activity and how. Examples: Julia Butterfly Hill's 1999 calls to radio stations from her tree house in a redwood and activists' efforts in the 90s that elicited the nickname of 'eco-dweebs' and reports of 'James Bond' like tactics.

**Texting affords:**

- One-to-Many communication for quick coordination and action, which I call *textivism*. Examples: Greenpeace Argentina's texting initiatives in early 2000 led to successful demonstrations and lobbying efforts and laws to protect the country's natural resources, and citizens of Xiamen, China used text messaging to pressure city government staff to suspend construction of a petrochemical plant in 2007.

- Contribution of environmental data to larger databases and datasets. Example: The Smokebelchers texting campaign in Manila allowed users to report polluting vehicles by texting the license plate number of a polluting car.
- The ability for mobile users to send texts to a short code and receive information, an initiative called *infolines* (Kinkade & Verclas, 2008). Examples: FishMS, initiated in 2006, enabled South African mobile users to text the name of a fish, whether at the grocery store or fish market, and receive information on how it was harvested, and the Climate Counts infoline, available in 2007, which allowed mobile users to send text messages to query the sustainability ratings of a company and their product.

**Applications afforded:**

- Collective behavior through combined activity and game play on social media. Examples: JouleBug encouraged users to complete sustainability tasks to receive badges and trophies, which they could use to compete with friends. GreenITers allowed users to quasi-broadcast sustainability ideas and projects, which users could then comment on or participate in.
- Individual behavior by offering specific pieces of information from sustainability experts for users to alter their behavior and learn about sustainability. Examples: GreenMeter, monitored users' driving habits, then offered alternative driving habits to reduce fuel consumption, while GoodGuide helped users understand a product's environmental impact after scanning the product's barcode.

- Crowdsourced scientific data by offering tools to identify and collect environmental data. Examples: The application iBats, released in 2011, allowed bat enthusiasts to plug an ultrasonic bat detector into their iPhone and collect the bat's call and location, data that contributed to the iBat database. Map the Spill app, created during the Gulf Oil Spill in 2010, enabled mobile users to upload photos, videos, and notes of oiled shorelines and wildlife on an interactive map.
- Critical reflection and culture jamming (Milstein & Pulos, 2015), where individuals and organizations challenged the ethics of others and attempt to create transitional space where the status quo is challenged. Examples: Brett Matulis' (2015) Tweets challenging assumptions of the organizers and attendees at the 2013 World Forum on Natural Capital (WFNC), and the #climategame activities prompted users to creatively disrupt the 2015 Conference of Parties (COP21) convention on climate change through in-person activities and posts on Twitter.

**Smart Systems afforded:**

- Personalized and detailed information of bodies and nature. Examples: Smart irrigation systems for homeowners, such as Blue Marble, combined information from historical and current weather forecasts, soil moisture sensors in the yard, temperature, and light conditions to produce personalized watering schedules.

**Environmental Impact of Mobile Phone Infrastructure Included…**

- Destruction caused by cellular base stations and mobile handset development, use, and disposal. Examples: Protests and news reports highlight the destructive nature of towers on ecosystems, such as the deaths of numerous birds and bats due to collisions with towers. News reports presented the effects of mobile handset production, such as poisoning from copper mining and pollution from disposal of handsets in landfills.
- Enactment of recycling laws. Examples: Assemblywoman Fran Pavley, from California, U.S., presented the first bill to require mobile providers to offer free recycling of handsets in 2005. At the same time Australia Environment Ministers, along with the Environment Victoria group, advocated for state laws requiring that the mobile industry increase handset recycling from 4% to 50%.
- Product innovations. Examples: Cellular companies redesigned towers, joined organizations to learn how to have less of an impact, and invested millions to improve biodiversity at tower base stations in late 90s. In early 2000, the non-profit Planet Ark, Australia partnered with mobile phone distributors to collect, then recycle or refurbish old handsets. In addition, Motorola created a biodegradable mobile phone case that could grow a flower.

## Conclusion

Some aspects of mobile phone use and development for environmental activity did not appear as prevalent as described in mobile communications literature. For example, mobile communications scholars (de Souza e Silva, 2013; Ling, 2014; Ling & Donner, 2009)

noted surveillance of mobile users as an important aspect of control and manipulation, including collateral surveillance, such as tracking and observing other members of a network, and Big Brother surveillance, where companies and government agencies track and use personal data without the knowledge of users (de Souza e Silva & Frith, 2012). Some collateral surveillance occurred in the eco-app games and the SharkSmart app, yet I did not find reports of Big Brother surveillance occurring in relation to environmental activity. This does not mean that there is no Big Brother surveillance occurring, just that my research method did not reveal any.

Additionally, I did not find any discussion of mobile phone initiatives addressing environmental social justice issues. According to Pezzullo and Sandler (2007), these issues include the marginalization of people of color and the poor in relation to the identification and remediation of environmental problems. Examples of the marginalization include livestock grazing on public lands, which harms indigenous peoples, and "debt-for-nature swaps" which harms citizens of Third World countries who are encouraged to exchange land rights for debt reduction. Another example is the focus of major environmental organizations on the protection of less populated areas as opposed to more populated areas where people of color live. It could be that my search terms did not uncover current activity in this area or it might be that projects are underway to address these concerns.

However, allegations of mobile phone jamming at the Dakota Access Pipeline protests in October 2016, highlight shifts in mobile phone surveillance and environmental social justice that are starting to emerge (Newcomb, Medina, Salibe, & Sottile, 2016). Protesters and journalist noted planes and helicopters circling the Standing Rock camp in

North Dakota, while at the same time their phones and equipment encountered connectivity problems. Phone jamming resulted in a considerable risk for protestors since much of their communication occurred through social media sites through mobile phones.

The missing pieces of surveillance and social justice issues point to the limitations of this media history, specifically that I did not conduct an all-encompassing review of events and that, as the Dakota Access Pipeline example shows, there are events that occurred that I did not capture. Additionally, there are hundreds of new eco-apps released every year, but I only reviewed a selection in this chapter.

Future research on this topic through interviews with mobile phone users and review of radio and television broadcasts could afford additional perspectives to the history of mobile phones and environmental activity. Future research on this topic could expand the archive that I created here by interviewing staff at environmental organizations (i.e. non-profits, government agencies, businesses, etc.), prominent environmental activists, and staff at mobile communications companies. Also, radio and television broadcasts could provide vivid details of mobile use by environmentalists, detail not possibly captured through text.

In conclusion, this chapter provides stories and examples explicating how people have used mobile phones and cellular infrastructure to launch campaigns, create new legislation, and encourage environmentally friendly behavior. With these examples, scholars and practitioners can more easily identify the types of mobile communications to study and apply in future environmental initiatives.

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**Activity Theory Analysis**

The activity system of chapter two (Figure 2.14) broadly addresses the ways that people have used mobile phones since 1993 to organize, create, and implement interventions in social and environmental contexts related to complex environmental problems.

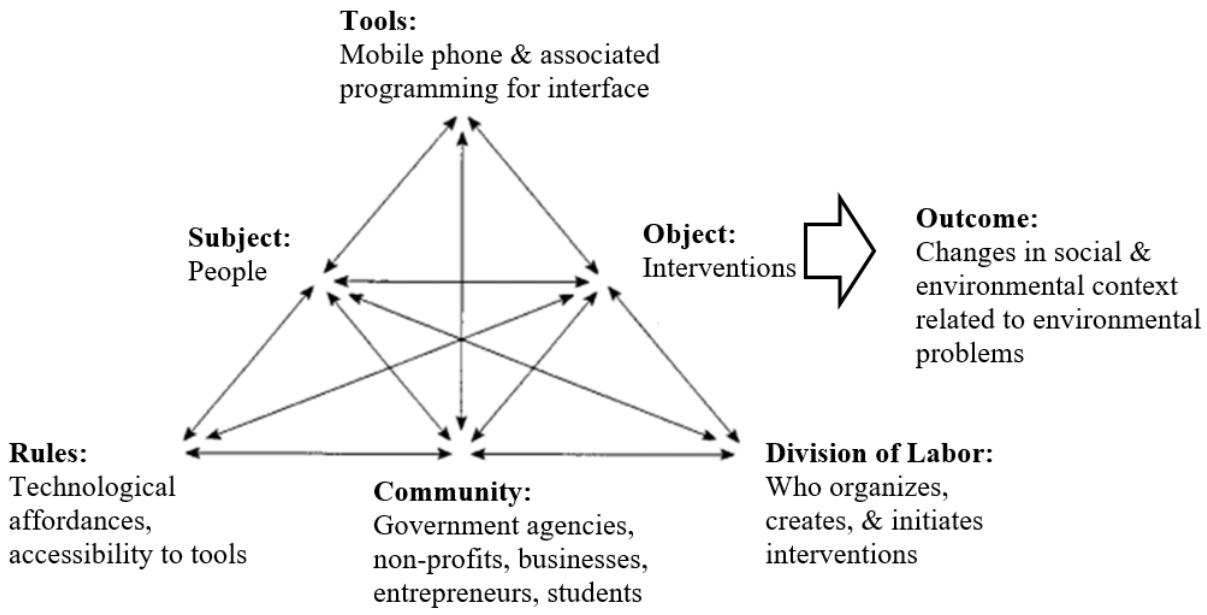


*Figure 2.14.* Chapter 2 activity system.

Chapter 2's historical review showed how the *subjects* or initiators of these interventions shifted over time in accordance with technological developments and accessibility to mobile phones. Starting in the late 90s, people utilized mobile phone calling to bring attention to problems in remote locations (such as Hill calling from her tree house in a redwood tree) and to micro-coordinate direct action (such as the genetically-modified crop raid in Scotland). These two examples show how mobiles shifted the consciousness of

environmental problems by enabling communication from remote sites of concern and activity on those sites, both of which presented new dimensions to environmental concerns.

By early 2000 texting became technologically and economically viable, a *tool* advancement that shifted the *subject* of the activity system to environmental organizations who amassed mobile phone numbers, such as Greenpeace Argentina, to coordinate lobbying efforts and demonstrations through quasi-broadcasting messages to thousands of supporters at one time. Additionally, the ability to text shifted the *rules* of communication between the *subject* and their *community*. During this time, infolines became a popular way for a mobile user to query an *environmental organization* (*subject*) for information related to a decision the user intended to make. For example, the FishMS infoline enabled South African mobile users to text the name of a fish, whether at the grocery store or market, and receive fish harvesting information. Through texting, mobile users could alter their consciousness of hard-to-see environmental problems and activity in crucial moments of decision making.

With the development of smartphones in 2007, the *tools* available to mobile users expanded the affordances possible and thus, completely altered the components of the activity system. The *tools* of mobile applications offered programming that changed the *rules* and *division of labor* as to who could contribute content and how these new contributors enacted interventions. For example, the collective behavior application Twavel *divided labor* among the developer and users by allowing users to share tips on how to reduce their carbon footprint. Twavel also changed how users engaged in *interventions* (*object*) to address environmental problems by helping users track and gamify their actions to reduce their carbon emissions. The citizen science application Map the Spill *distributed the*

*labor* of recording the 2010 Gulf Oil Spill among all users by allowing them to upload photos, videos, and notes of oiled shorelines and wildlife on an interactive map. In these examples, consciousness of environmental problems and solutions became more evenly distributed among the trained scientists creating the apps and users' personal knowledge and lived experience of the environmental problem.

By the 2010s the popularity of mobile phones and technological advancements shifted the *community* of creators and the *outcomes* of mobile phone use. During this time, the *community* involved in the activity system expanded to include environmental enthusiasts, entrepreneurs, and students. Since these new *community* members came from different backgrounds, they brought to the activity system different understandings leading to new forms of *interventions* (*object*). At the same time, the coupling of sensors with mobile phone applications shifted the types of *interventions* and *outcomes* possible. Previously mobile *interventions*, such as calling, texting, and applications, focused on coordinating information generated by developers and mobile users. New *tools*, such as sensors, gave nature a digital voice, altering the *division of labor* among human and nonhuman actors. For example, smart irrigation systems for homeowners utilized soil moisture sensors in the yard, temperature, and light conditions to produce personalized watering schedules appropriate for that yard's ecosystem. The expansion in voices contributing to the creation and content of mobile phone interventions broadened and diversified the consciousness possible related to environmental problems and their solutions. In addition, the broadening and inclusion of more voices may have also led to a disconnect between humans and nature, as the mediation capabilities of mobiles afforded users a way to know about nature without interacting with it.

Looking across the eras through the framework of activity theory, it appears the advancements in mobile telephony offered new affordances that users quickly adopted for intervening in environmental problems. As such, the *community* expanded and diversified, leading to *new divisions of labor* and types of *interventions*. As the *technology* (*tools*) and *community* shifted, user consciousness of and interaction with nature became more refined. Instead of speaking for nature, as Hill did from her tree, nature could "speak" for itself through sensors and mobile applications. Finally, environmental activity was not only influenced by *technology*, but environmental activity also influenced *technological* development. Consciousness of the ecological harm associated with the production, use, and disposal of mobile phones triggered numerous efforts to change manufacturing practices and create recycling programs and policies to prevent pollution from mobile phones.

Contradictions are problems, breakdowns, or clashes that destabilize an activity system due to misalignment of activity components. Several contradictions appeared in the activity system of this chapter that impacted the *outcomes* possible through mobile phone interventions, specifically among the *tool*, *subject*, and *object*. It appeared that the more diverse the *mobile phone* affordances became, from the development of calling to texting to apps, the more diverse the *subject* of mobile phones use for environmental interventions became. In turn, the diversity of *subjects* led to a diversity of *interventions*. Therefore, with each new type of *intervention* came the possibility to address another environmental problem.

Essentially, the contradiction in the activity system of this chapter occurred because the *tools* did not always afford the types of *interventions* needed to support the *outcomes*

desired. This occurred because the interventions could not fully account for the complexity of environmental problems and the social contexts in which they emerge. For example, the feature of *calling* enabled *users* to create *interventions* that changed environmental narratives, yet the one-to-one communication method limited users' ability to mass coordinate detailed and more complex interventions. Texting expanded the types of *users* involved in interventions, from activists who used *calling* to shoppers and concerned citizens who used *textivism* and *infolines.* Texting afforded people a way to coordinate more types of interventions, which enabled more ways to address environmental problems.

Yet, of these *tools,* few contradictions occurred between the *subject* and *object* with use of *applications*. Apps opened up both design and use of *interventions* to many types of *environmental actors* such as fathers, students, and environmental enthusiasts. The possibilities afforded by *applications* reduced contradictions within the activity system because more *subjects* became involved, resulting in increased diversity of *interventions* and possibilities at the desired *outcomes. Smart systems* provided another opportunity to expand the *subject* to include nature.

In summary, the activity system of chapter two shows how mobile phones helped to alter users' consciousness of and activity toward environmental problems and the consciousness and activity of other people. Through use of mobile phones, people could overcome the material challenges of quickly relaying environmental information from disparate and remote locations. Mobile phones helped people change social contexts by coordinating people and bringing social recognition to previously unseen environmental

problems. Thus, mobiles impacted people's efforts to address problems by providing a way to connect people, places, and information.

However, contradictions appeared between the *tool* and *subject* of this activity system, specifically with *calling, texting,* and *smart systems*, thereby reducing the possible *interventions* and, thus, possible solutions to *environmental problems. Applications* appeared promising in their ability to expand the *subject* of the activity system and the types of *interventions* and *outcomes* possible through use. Though the media history approach offered a way to understand the many uses of mobile phones for environmental activity, it did not offer a way to understand the nuances between mobile phone design and activity. Since my over-arching research questions are to understand the mechanisms behind mobile phone use to address environmental problems, I need a clear understanding of how the technology's design affects activity. Therefore, I applied another set of frameworks in Chapter Three.

In Chapter Three, I focus on eco-apps because of their potential for engaging a range of users in environmental issues, as discussed in the activity analysis above. To understand the relationship between the design of eco- apps and their appropriation by users, I coupled DeSanctis and Poole's (1994) adaptive structuration theory and Norton's (2007) environmental public participation (EPP) framework. Chapter Three explores in more detail the possibilities of *applications* to offer *mobile users* a diverse arena for expanding consciousness and activity related to *environmental problems.*

## Chapter 3 : Eco-apps and Environmental Public Participation


### Abstract

This chapter examines the possible affordances of mobile applications as environmental public participation (EPP) initiatives, specifically as a means for involving stakeholders in solving environmental problems. Eco-apps offer a unique alternative to traditional in-person EPP initiatives due to the technology's mobility, connectivity, and personalization. However, little is known about the organizational and technical mechanisms of eco-app design that might support stakeholder involvement. Thus, DeSanctis and Poole's (1994) adaptive structuration theory (AST) is applied to an analysis of 11 mobile applications to pinpoint technological features affecting stakeholder agency. AST is coupled with Norton's (2007) EPP framework to evaluate the affordances of these features for stakeholder involvement. Results show that features such as tagging, commenting, and posting support users' acquisition and distribution of environmental information through visualizations, community forums, games, data, and interactions with their environment. However, the results also show that eco-apps reflect one-dimensional views of complex environmental problems instead of offering a space for users to realize the multiple dimensions of problems stemming from social, political, and economic activities. Drawing from the analysis, the author offers recommendations to scholars and practitioners on ways to reconceptualize mobile applications to engage diverse stakeholders and address environmental problems.



Keywords: mobile phone, eco-apps, structuration theory, environmental public participation

## Eco-apps and Environmental Public Participation

Environmental public participation (EPP) initiatives such as citizen advisory boards, public hearings, and volunteer environmental monitoring, involve multiple stakeholders who affect and are affected by complex environmental problems. By involving multiple people in EPP initiatives, the solutions identified are more diverse than those without stakeholder involvement (Jentoft & Chuenpagdee, 2009). Jentoft and Chuenpagdee (2009) explain that the inclusion of stakeholders is particularly important to solving environmental problems because these problems impact multiple ecosystems and groups of people. However, traditional EPP initiatives require stakeholders to physically attend meetings or events, a requirement that environmental communication scholars have found limits stakeholder involvement (e.g. Smith & Norton, 2013 and others cited in their paper).

Efforts to increase stakeholder involvement have included use of Web 2.0 technologies like discussion forums because these technologies allow stakeholders to contribute during times and from locations that are convenient to their schedule. Additionally, Web 2.0 creates a new way of interacting with digital information where developers and users engage in an 'architecture of participation' instead of passive viewing (O'Reilly, 2005, para. 24). For example, local governments in Brisbane, Australia found that the use of Facebook, Twitter, blogs, and online forums afforded citizens access to more resources and discussion than in-person meetings (Fredericks & Foth, 2013). Therefore, the freedom to contribute when and where it is convenient leads many scholars to argue that Web 2.0 is democratic, empowering, and engaging for the individuals that use it (Castells, 2007; Reynolds, 2006; Shirky, 2008; Tapscott & Williams, 2006).

The affordances of Web 2.0 on mobile phones places the resources and connections needed to solve environmental problems in the hands of stakeholders. Mobile phone applications utilizing Web 2.0, such as social media applications, are well known for their ability to prompt co-creation of content. The original Foursquare application digitally connected friends, places, and information through gamification and features that reordered users' daily lives and changed their relationships with physical places (Schwartz, 2014). If the outcomes of Foursquare are possible in relation to environmental issues, stakeholders and experts might gain new perspectives and form new relationships through the use of mobile phone applications. Additionally, mobile applications, called eco-apps, that seek to engage people in environmental activity offer a unique alternative to traditional EPP initiatives because of the technology's mobility, connectivity, and personalization. However, little is known about the organizational and technological mechanisms behind eco-apps that might support EPP.

Therefore, in this chapter, I examine the possible affordances of eco-apps as EPP initiatives. Since I am interested in understanding the organizational mechanisms leading to participation, I utilize Norton's (2007) EPP framework. Norton (2007) adopted Anthony Giddens' structuration theory (1984) to develop a mid-level theoretical framework that identifies the organizational mechanisms supporting stakeholder *agency* in EPP initiatives. *Agency* is the ability of a stakeholder to access and use resources to act on and influence existing environmental practices and create new practices (Norton, 2007). Without agency, stakeholders do not have access to reports or data explicating how environmental policy or contexts affect them and their family. Additionally, not having the ability to

influence existing or participate in creating new environmental practices means that the imposed practices can harm the livelihoods, health, and/or cultural rituals of non-participating stakeholders. By withholding stakeholder participation and agency in EPP initiatives, initiative outcomes can miss opposing views and interests, incur implementation problems, lack support of stakeholders, and miss critical details related to better understanding of environmental problems and solutions (Bulkeley & Mol, 2003).

Though Norton's framework illuminates the organizational processes involved with designing and implementing EPP initiatives, it does not offer methodological considerations for identifying how technology, such as eco-apps, can increase stakeholder agency. However, DeSanctis and Poole's (1994) adaptive structuration theory (AST) offers methodological guidance to identifying the technological features that enable and constrain user agency. DeSanctis and Poole (1994) developed AST from Anthony Giddens's (1984) structuration theory as a way to highlight the influence of technological structure on user agency. Recognizing that DeSanctis and Poole developed AST to examine technology in businesses and organizations, I coupled AST with Norton's framework to position my examination of mobile apps within EPP.

Because user agency is crucial to effective EPP initiatives, I chose to focus on mobile applications that allow users the freedom to contribute to and retrieve information in real time. I also wanted to explore the affordances of uniquely mobile features, such as uploading locative content and taking photos with the mobile's camera. I identified 11 eco-apps with Web 2.0 and uniquely mobile features for analysis in this chapter. I used AST methodology to pinpoint technological features that affect stakeholder agency, and used Norton's

framework to evaluate the affordances of these features for stakeholder participation. At the end of this chapter, I summarize my findings and offer recommendations to scholars and practitioners for exploring and increasing the capabilities of eco-apps for EPP.

## Analytical Framework

I chose to use two theories grounded in Anthony Giddens' (1984) structuration theory because they provide means for analyzing the reciprocal influence of social structures and individual agency, a concept that Giddens (1984) calls *duality of structure*. Giddens (1984) explains the duality of structure as the process through which the rules and resources of social structures enable and constrain an individual's actions, yet an individual's ability to reciprocally influence social structures comes from their agency, or ability to act freely, within structures. Norton (2007) adapted this concept for EPP, calling it *duality of participation* and explaining it as the process whereby stakeholder agency influences the reproduction or alteration of EPP rules and resources. In addition, the rules and resources of EPP events constrain stakeholder agency (Norton, 2007). For example, the structure of EPP events concerning Colorado's public commentary on the Roadless Area Conservation Rule made it easy for revenue-focused groups to attend but harder for forest advocates to participate. Therefore, the structure of the event privileged reproduction of discourse on economic gain over forest preservation (Smith & Norton, 2013).

Web 2.0 technologies may offer a way to shift the duality of participation by offering stakeholders more agency in creation of EPP rules and resources. For example, stakeholders using Web 2.0 can create, co-author, and control data through portals such as social networking sites (e.g., Facebook), video sharing sites (i.e., YouTube), blogs (i.e., Pinterest),

and wikis (e.g., Wikipedia) (Stern, 2015). The co-creation process available via Web 2.0 is indicative of increased *discursive access*, which Norton (2007) describes as stakeholders' ability to exert agency by attaining and contributing to the environmental knowledge, materials, and procedures at EPP events. Depoe and Delicath (2004) outline specific mechanisms for increasing stakeholder agency, including the ability to decide which mechanisms through which stakeholders participate, when to access information, and the ability to meaningfully contributing to the final product.

The affordances of eco-apps utilizing social media platforms offer the mechanisms that Depoe and Delicath (2004) highlight by enabling stakeholders to contribute text, images, or video and to control when and from where they contribute. Research shows that increased discursive access for stakeholders results in better decision-making efforts and improved scientific understanding of environmental problems (Fischer, 2000; Kasemir, 2003; Phillips et al., 2012;). In the case of eco-apps, examining the duality of participation can reveal the ways in which human activity affects the mediating capabilities of the technology and vice versa.

Alternatively, limiting stakeholder participation and feedback results in decreased understanding of environmental problems, fewer solutions, and less stakeholder buy-in (Phillips et al., 2012). The groups that organizes EPP initiatives can restrict stakeholder agency by limiting the resources and discursive space available to stakeholders (Horsbøl & Lassen, 2012). Peterson's (1997) account of public participation efforts toward squelching the spread of brucellosis disease in Canadian bison populations described how agency staff organizing the event privileged their technological discourse over the creative discourse of

stakeholders through restricted meeting availability and verbally discrediting and leaving out alternative perspectives in management decisions.

Yet, increasing discursive access is not enough to ensure stakeholder participation in EPP initiatives. Norton (2007) raises Giddens (1984) concepts of ontological security and competence as crucial to stakeholders' willingness and ability to meaningfully participate in initiatives. Giddens (1984) argues that as people engage in daily routines they gain *ontological security* or trust in existing social structures, but to act within those structures people must also have *ontological competence* or understanding of how they can act. Norton (2007) appropriates these concepts for EPP initiatives, explaining that ontological competence and security can increase participant agency to solve environmental problems. Ontological competence is important for both EPP stakeholders and organizers because it ensures understanding and collaboration in processes to address environmental problems. Ontological security is established through processes and standards that build trust among EPP stakeholders and organizers, trust that other parties' intentions are for the good of all. Some stakeholders in Peterson's (1997) Canadian bison brucellosis disease EPP initiative could not gain ontological security because organizers placed their own interests at the forefront and limited stakeholder input. Additionally, the EPP organizers in Peterson's account lacked ontological competence in ways to accept and integrate the creative discourse of stakeholders as legitimate sources of knowledge on bison health.

Alternative ways of building ontological competence and security may occur through the features of co-production and real-time feedback afforded through mobile phone applications using Web 2.0 technologies. For example, the process of working with others to

solve environmental problems at times and in ways convenient for stakeholders may lead to increased ontological security and competence as a result of a more transparent structure and the contributions of others. Additionally, eco-apps may help overcome broader complications of in-person EPP initiatives such as the permeability of environmental problems across political borders, costs associated with time, setup, and transportation, and a lack of systems to support dialogue creation and incorporation (Depoe & Delicath, 2004; John, 2000; Savitz, 2000). Eco-app features of interest include the ability for stakeholders in any location to upload data, a minimal set-up cost, and transparent newsfeeds. By examining ontological competence and security, we might also see how these elements affect the mediation occurring through the apps' interfaces.

Research has shown that the personalization, collaboration, and location features afforded by mobiles have influenced the movements, contributions, and knowledge of EPP stakeholders (Büscher, 2014; Newman et al., 2012; Shaw, Surry, & Green, 2015). The term *hybrid ecology* adequately addresses the uniquely mobile affordances of eco-apps, specifically their ability to augment users' understanding and experience of space because of access to previously inaccessible information (Licoppe, 2013). These examples point to the possibilities for eco-apps to improve EPP initiatives; however, it is not clear how organizers and stakeholders might design and engage with eco-apps to support ontological competence and security.

To draw out the features of eco-apps that might lead to improved EPP initiatives, I coupled Norton's (2007) framework with DeSanctis and Poole's (1994) adaptive structuration theory (AST) to study 11 eco-apps. AST originates from Giddens's (1979)

structuration theory and Ollman's (1971) concept of appropriation and offers a methodological approach to understanding the way that technology influences social structure and agency. Similar to Giddens' duality of structure and Norton's duality of participation, DeSanctis and Poole (1994) offer the *duality of technological structure*, which they describe as the intersection of the social structure built into technology and the social structure that emerges from users' appropriation of the technology. For example, a government agency may design a mobile app to encourage users to collect scientific data on tree populations; however, once people start using the app, they may appropriate the app's structure to discuss the decline of various tree populations and the ethics of genetically modified tree species. This example shows how users can affect the ability of a technology to mediate certain types of behavior.

DeSanctis and Poole (1994) give specific concepts for analyzing each side of a technology's duality. One concept is *structural potential*, which is the idea that built technology offers specific social structures and action that users can potentially engage in. To analyze a technology's structural potential, a researcher first identifies the *structural features* that can enable or constrain user agency. These features must be objectively describable, such as the rules, resources, and capabilities afforded by the technology. Next, the researcher surmises the goals, values, and action these features promote, which DeSanctis and Poole (1994) call the *spirit* of a technology. Thus, by identifying the features and what those features might afford, it is possible to identify the potential of a technology to enable a specific social structure and user agency. Alternatively, once users interact with a technology, they may not engage in the potential social structures and action; they may

instead *appropriate* the technology's features for their own social structures and action. Thus, DeSanctis and Poole instruct researchers to also look for the ways that users appropriate the structural features identified and the goals, values, and actions that come from users' appropriation.

In this chapter, I couple AST with Norton's framework by identifying the structural potential of 11eco-apps to increase stakeholder agency (research question one). Next, I look at how users of these eco-apps appropriated the technology to act on and influence existing environmental practices and create new practices (research question two). I break down the components of user agency into those suggested by Norton: a) *discursive access*, which is the ability of stakeholders to attain and contribute environmental knowledge, materials, and procedures in an EPP initiative; b) *ontological competence*, which is the ability of stakeholders to gain alternative understandings of environmental problems and knowledge of how to collaborate to address those problems; and c) *ontological security*, which is the ability of stakeholders to use processes and standards to build trust in the goodness behind other participants' intentions.

## Methods

I reviewed over 100 eco-apps, both old and new, using newspaper articles, websites, and the iTunes and Google Play stores. I looked for applications that encouraged environmental public participation by prompting users to think, talk, or act for environmental change by using Web 2.0 features, specifically co-creation of content, and offering mobile specific features such as uploading locative content and taking pictures with the phone's camera. Of all of the apps reviewed, only eleven fit the criteria mentioned above (Table

3.1). These eleven apps fell into two structurally unique forms: 1) *native eco-apps*, which were designed specifically for environmental participation and require download from an app store, such as iTunes or Google Play, and 2) *embedded eco-apps*, which were eco-apps that were embedded in native apps not specifically designed for environmental participation.

Table 3.1

*Eco-apps reviewed in this study*

| Native Eco-Apps | Embedded Eco-Apps |
|---|---|
| 1. Joulebug | 8. 3R Actions Challenge: @RecycleManiacs embedded in *Twitter (event ended)* |
| 2. Marine Debris Tracker | 9. BART Public Transport Badge embedded in *Foursquare* (*event ended & app discontinued*) |
| 3. MyActions | 10. Litterati: #litterati embedded in *Instagram* |
| 4. Nature Near You (*discontinued)* | 11. Sydney photo walk: #sydearthhourpw embedded in *Instagram (event ended)* |
| 5. Project Noah | |
| 6. Tracking the Wild | |
| 7. WildLab Bird | |

Procedure

Following DeSanctis and Poole's (1994) methodology, I inferred the eco-apps' structural potential by looking at a range of resources, including news articles about the apps, the app creators' websites, content from app storefronts, and downloading and using the applications myself if the app was available. I manually explored all of the apps on my Android phone and Apple iPad except for the BART badge, which was not accessible because of changes in the Foursquare application. I used all of the downloaded apps to the best of my ability, which enabled me to observe and experience application features

directly. I could not directly use some of the apps such as Tracking the Wild, 3R Actions Challenge, and #sydearthhourpw because of my physical location or because the event had ended. Drawing from news articles, websites, and app store pages, I surmised the types of goals, values, and actions that the eco-app creators intended in the structural features of their app.

I documented the way users appropriated eco-app structure by reviewing news articles about the applications, user comments on the app store, and user activity within the applications. The biggest data set came from users posting their activity within the applications, which directly showed how users appropriated the applications. I did not collect interviews or directly communicate with users (which posed a limitation to this study) because they may have used the apps for other purposes without actually participating in the app interface through posting content. I included user comments from news articles and the app store to infer the goals, values, and actions that occurred as a result of app appropriation. The ephemeral nature of eco-app users (that the majority participate with aliases and came and went often from the app community) made it difficult to conduct interviews. Additionally, the number of supporting materials that I have reflects DeSanctis and Poole's (1994) recommendation that interviews with users are not required when the focus of the study is on the ways that features promote activity within and through the technology and user appropriation is evident through such activity in the technology.

Next, I followed DeSanctis and Poole's (1994) recommendation for qualitative analysis, specifically to use Miles and Huberman's (1994) cross-case techniques to code each application for objectively describable features and the types of goals, values, and activities

that these features promoted. I developed my codes by creating a table where I listed the application names, features, and comments by users and developers. The table includes information on the development of the eco-apps, structural potential of eco-app features, and data on how eco-app users appropriated those features. After downloading the apps on either an Android smartphone or Apple iPad (except for the expired Foursquare app), I documented my interactions with the apps listed in the table. I clicked on all available links in each app to explore where they went and the type of content available to the user. I registered and participated in any games or initiatives that were available, typically using them for about a month. As I reviewed the eco-apps, I refined and combined features and comments based on the relationships and patterns that I found. I also noted anomalies to preserve the uniqueness of each eco-app, their features, and user feedback. Categories included app content, personalization, locative features, image functions, gamified elements, social sharing, descriptions of who created the apps, their partnerships and funding sources, any statement as to the creators' purposes in making the app, and app reviewers.

Next, I engaged in a cyclical process of reviewing the table and my sources as way of understanding how the design of the apps offered users agency and the ways that users appropriated technology to exert their agency. First, I identified the eco-app features that offered *discursive access* to stakeholders such as the features that offered a route for users to attain and contribute environmental knowledge, materials, and procedures. Then, I noted how users appropriated those features to gather and post content. Second, I documented structural features that enabled the posting of multiple perspectives and collaborative opportunities, essentially any features that offered users a way to build *ontological*

*competence* in the environmental topic and ways to solve it. Third, I documented how users interacted with the aforementioned structural features to learn about environmental issues and take action to solve them. Fourth, I documented the eco-app processes and features that might help users build trust in one another and the software. To identify if users felt *ontological security* in the system, I recorded user comments posted in the apps and on the app store pages, specifically regarding their enjoyment and appreciation of the app or lack thereof. Finally, I brought the findings together to explain the features in eco-apps that afforded user agency (research question one) and how users engaged with these features to employ their agency (research question two).

## Analysis

Comparing the structural potential to the appropriation of eco-apps, I found congruency across the goals of app creators and the actual behaviors of end users. The eco-apps offered users agency in the EPP initiative through the structural features of visualizations, community forums, games, data, and interactions with their environment. Users commented on the ways that these structures increased their agency in and ontological competence of environmental problems and what they could do to solve them. Ontological security varied, with some users appreciating the app and even knowing the creators, while other users found numerous bugs and constant crashes challenging to their attempts to participate. It appeared that the mediating capabilities of the app were actualized through the users' behavior, as opposed to users ignoring app structure and engaging in alternative activity.

**Research Question One**

In addressing Research Question One, *what is the structural potential of specific eco-apps to increase stakeholder agency?,* I found that the following features helped to offer the structural potential to increase stakeholder agency: tagging, posting, commenting, liking, sharing, badges, points, missions, and location based prompts. These features offered the structural potential for users to exert agency by gathering, creating, and sharing environmental knowledge through the structural features of visualizations, community forums, games, data, and interactions with their environment. In the following paragraphs, I explain and offer examples of the structural potential offered by the apps examined.

All of the apps reviewed used *visualizations* to coalesce user-generated content on dashboards, newsfeeds, tables, and maps. Examples included a table in MyActions showing the total amount of water conserved by users and a world map in #Litterati showing locations of user collected litter. Creators of MyActions describe on their Google Play store page the importance of visualizations to users of their app, "Measure Your Impact – Visualize the real time impact of personal and campus actions." Tracking the Wild promoted *ontological competence* of African wildlife by offering a link to descriptions of animals on Wikipedia (Figure 3.1) in the same tab that allowed for uploading and identification of wildlife sightings (Figure 3.2). Users could also learn about wildlife from other users' posts (Figure 3.3) and posts' geo-tags (Figure 3.4). Apps reflected user competence and discursive access through personalized visualizations of their contributed content. In the Tracking the Wild app, users could see the parks that they visited and animals that they recorded (Figure 3.5), and in the

Joulebug app, users could see the total amount of money and CO2 that they saved from participating in sustainability challenges.

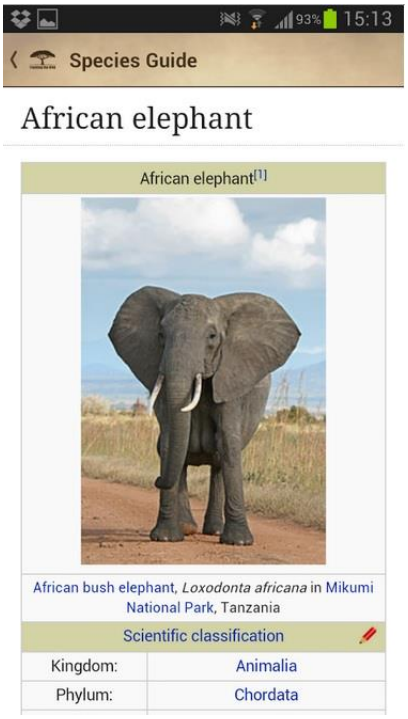


*Figure 3.1.* Tracking the Wild: Wikipedia description.


*Figure 3.2.* Tracking the Wild: New sightings tab.


*Figure 3.3.* Tracking the Wild: User's post.

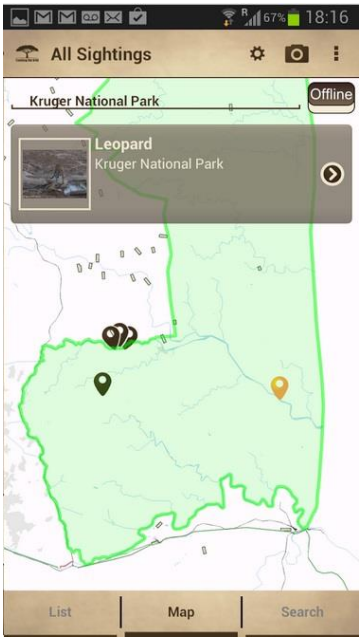


*Figure 3.4.* Tracking the Wild: Visualization of animal sightings.

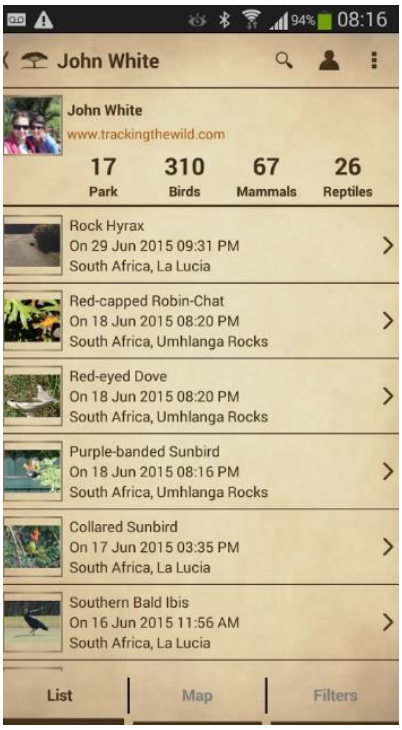


*Figure 3.5.* Tracking the Wild: User's posting history.

Visualizations appeared to offer both ontological competence, as described, and *ontological security* by showing the efforts of other users and highlighting the importance of each contribution. Creators of Tracking the Wild wrote on their iTunes page, "Tracking the Wild is a wildlife social media platform that is an easy way to explore Africa's parks & reserves, safely share your wildlife sightings and make a valuable contribution to conservation." To affirm the efforts of users, the Tracking the Wild page further states,

> Professor Les Underhill of the Animal Demography Unit at the University of Cape Town explains the value of the app: 'Imagine trying to motivate that a species is of conservation concern if you do not have an up-to-date distribution map for the species. Ideally, one would like to have a distribution map that is based on records

collected only in the past decade or less. This means that distribution data needs to be updated continuously. This is what this new app helps us to achieve.

*Community forums* included commenting, liking, and sharing features where participants posted ideas, made suggestions, shared content, and organized offline events. All the apps included some aspect of community forums, but Project Noah, WildLab Bird, MyActions, and JouleBug stood out because they offered a way for users to meet and converse in-person by creating, sharing, or participating in events or missions in their local community (Figure 3.6).


*Figure 3.6.* WildLab Bird: Event tab (circled in red).

*Data*, such as Wikipedia pages, bird sounds, nature news, and conservation tips, offered descriptions and information to build app users' ontological competence. Five of the

11 eco-apps offered environmental data, including Joulebug, MyActions, Nature Near You, Tracking the Wild, and WildLab Bird. Often, apps coupled data with *gamification* features, such as badges, points, actions, check-ins, missions, contests, and competitions. Five of the 11 eco-apps used features to gamify EPP, including Joulebug, MyActions, Project Noah, BART Badge, and @RecycleManiacs. To reduce CO2 emissions related to transportation, Bay Area Rapid Transit (BART) "gamified" check-ins by offering three $25 transit tickets to randomly selected Foursquare users who checked in at a BART station in January 2010. The Joulebug app (Figure 3.7) coupled game elements, such as competitions against one's social network for badges and points, with data about the impact of the user's actions towards reducing CO2 emissions.

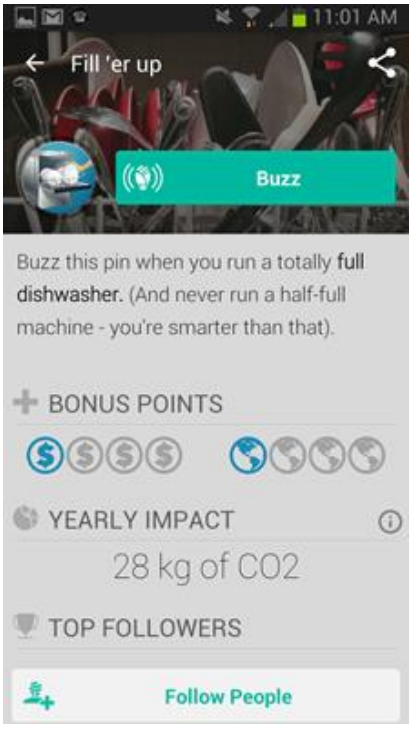


*Figure 3.7.* Joulebug: Fill 'er up pin.

The structural potential of apps offered another route for users to build *ontological competence* of nature and their actions by prompting *interactions with their environment*. These prompts included suggestions for engagement with users' homes, offices, and nature. The #Litterati app (Figure 3.8) encouraged users to find, photograph, and dispose of litter that they found in nature. The app accompanied the prompt with a *visualization* of the litter collected by others and the ability to like and comment on each post (Figure 3.9). The @RecycleManiacs, embedded in Twitter, encouraged university students to reduce, reuse, and recycle at home and at their universities through competitions with other universities.

Creators of WildLab Bird explain users' interactions with nature, specifically stewardship, as important to the purpose of their eco-app. They wrote on their webpage, "The WildLab leverages mobile technology to engage learners in citizen science activities that promote STEM learning and encourage local environmental stewardship. We envision a classroom framed by the sky, the earth, and everything in between." The MyActions app creators explained on their Google Play story the importance of any interaction or "experience" to inspire others to act, stating "Share Your Experiences - Photos, actions and stories from students, clubs and events inspire others to do more."

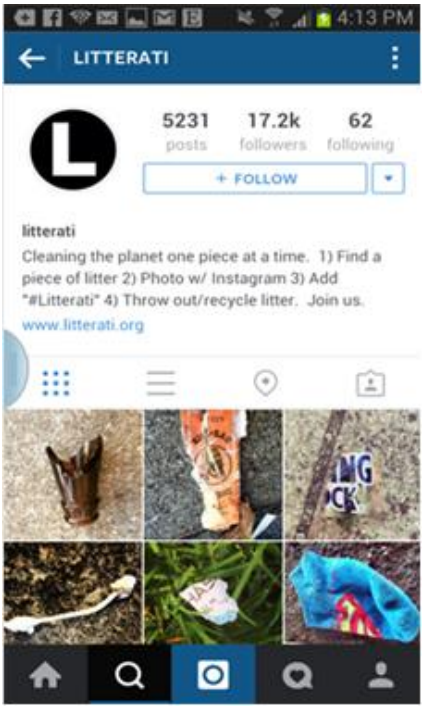


*Figure 3.8.* #Litterati: Litter collected visualization.


*Figure 3.9.* #Litterati: Post with 204 likes

**Research Question Two**

In addressing Research Question Two, *how did users of these eco-apps appropriate the technology to act on and influence existing environmental practices, as well as create new practices?*, I found that users appropriated the features of eco-apps in accordance with the structural potential as described under Research Question One. Users exerted agency by accessing and using apps to engage in the suggested environmental practices; however, few users utilized app features to create new practices or attend in-person events. Additionally, the differing structures of embedded and native apps affected how often and how much users appropriated the technology. Users' ontological competence and security appeared relatively high based on their comments; however, challenges with the app interface crashing and low user numbers appeared to damage users' access to knowledge and trust in eco-apps.

The *visualizations* of users' contributions offered a way to document appropriation and discursive access across users, with examples such as nearly 400,000 pieces of litter collected by users of Marine Debris Tracker (Figure 3.10), 32,000 items diverted from landfill by RecycleMania users reducing, reusing, and recycling (Figure 3.11), and 11,000 miles walked instead of driven by MyActions users. Additionally, the BART Foursquare app recorded increased ridership by 19% and frequency of rides by 14%. In addition, 38% of riders felt the app made BART more fun to ride (Mager, 2010). Some of the apps did not offer visualizations showing the exact quantity of contributions; instead, they showed user contributions through pins on a map, image newsfeeds, or comments. For example, in Tracking the Wild, I could see John White's (Figure 3.5 above) individual activity but not the activity of all of the other users except for their pins on a map, and in WildLab Bird, I could

only see the sighting pins of other users, but not anyone's individual profile. Even with the challenge of looking at broad ranging activity in all of the eco-apps, I could find and note appropriation in all of the eco-apps by users in one way or another.

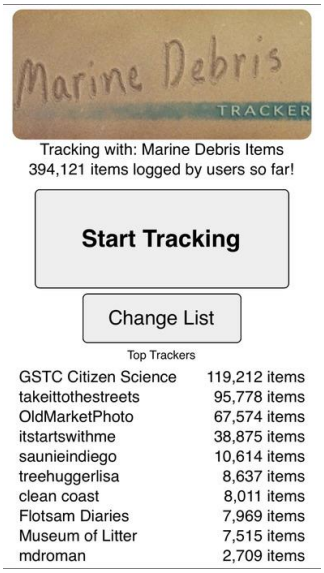


*Figure 3.10.* Marine Debris Tracker: Start screen.

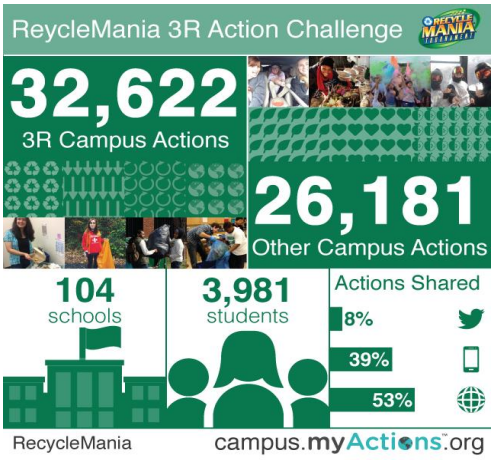


*Figure 3.11.* RecycleMania: Infographic of actions completed.

To understand appropriation even better, I noted the frequency and quantity of activity across apps while I used them, and by looking at older posts, I found a difference between embedded and native apps. The users of native apps appeared to post more content more often, and users of embedded apps appeared to post less content less often. Reflecting on fellow users' profiles over time, native app users appeared to appropriate the applications for a longer period of time or duration than embedded apps users. For example, the native app users of Joulebug and MyActions reported their daily and weekly activity, and users of Marine Debris Tracker, Nature Near You, Project Noah, and WildLab Bird posted 10 to 50 times within a one to two-hour time frame about once a month. The users of embedded apps posted about one to five times total, with the exception of #Litterati where users posted one to five times per month.

The difference in appropriation between the apps was most evident when I compared a native and embedded app requesting the same type of participation, litter collection. The native app Marine Debris Tracker requested that users record the type and quantity of litter, then dispose of it appropriately. The embedded app #Litterati requested that users photograph litter, then dispose of it appropriately. Marine Debris Tracker had a dedicated user base, recording litter collection of 10 to 50 articles weekly, while #Litterati users posted one to 5 times per month. Reflecting on how the structure of the apps may have affected user activity, on one hand the embedded app offered one simple feature, take a picture (Figure 3.12), within a native app, Instagram, that many people already used for other purposes. On the other hand, Marine Debris Tracker required that users search for the app in an app store,

download the app, fill in detailed information (Figure 3.13), and remember to use it, since it is not an app they use for other purposes.

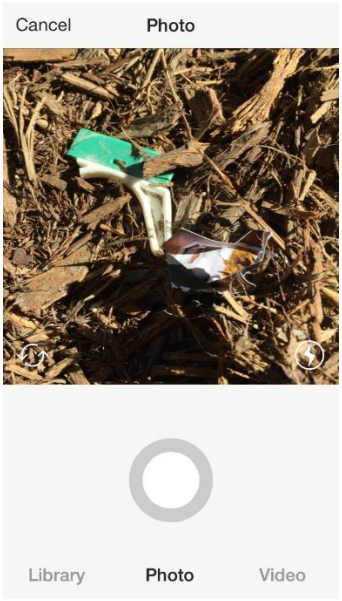


*Figure 3.12.* #Litterati: Upload screen.

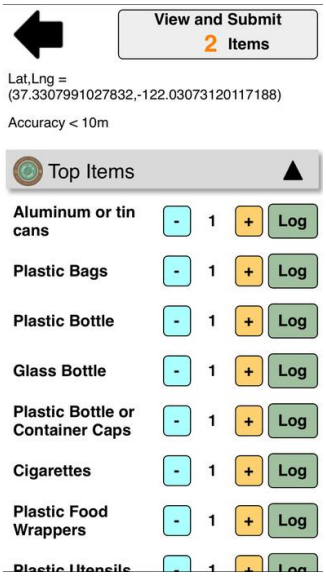


*Figure 3.13.* Marine Debris Tracker: Upload screen.

To get a sense of users' *ontological competence* and *security* I recorded user comments on app store pages and in the apps. In line with app creators' visions (see research question one), users wrote that they learned from and appreciated the features and design of eco-apps. On the Project Noah iTunes page, app-user Trailerville explained the importance of the app's locative features, community forums, gamification, and prompts for interaction with nature in his or her quest to document wildlife. Trailerville wrote:

> My in-field photo documentations are automatically GPS and date stamped and I was able to create a 'mission' for the group that has shared our reptile findings for the past 11 years. Now suddenly our work = a database, a shareable body of knowledge, available to the world.

On the Marine Debris Tracker GooglePlay store page, an anonymous user described their appreciation for the app and their relationship with the app creator:

> Love it! Big advocate of the app, its functionality and its creator! Jenna is easy to work with and this app has the potential to be used for cleanup groups to compile their data! Saves so much time and money! Spreading it on the West Coast! Contact her directly to help with edits and shes on it or she can tell you if it cannot be done ;)

Commenting specifically on gaining ontological competence and showing ability to exert agency in the EPP initiative, Hannah Maxwell wrote on the Joulebug GooglePlay Store app page, "Great way to learn. I love using this app to teach sustainability to my classes! It helps keep my bills low and the air clean." Project Noah user Irishpan explained on the app's iTunes page the importance of the app in building her son's ontological competence and discursive access,

> For the last year, I've been doing a leaf collection with my son to help him learn to notice, describe, and recognize things around him. But it really only worked for plants...Then we discovered Noah. Not only does it teach him the above, it has revitalized his interest. He loves knowing that he is helping real scientists and if Mommy can't find out what it is, someone else can help us figure it out. Earning patches offers a great set of goals. And best of all, we can surf other people's amazing sightings. Incredible project! Wonderful app!

WildLab Bird also noted on their webpage the contribution of children and appreciation of teachers toward their conservation efforts:

> Students enjoyed the WildLab program, found the iPhone app helpful, easy, and fun, demonstrated increased content knowledge, and had increased interest in studying science and pursuing careers in science after the 5-session program. Every teacher that participated said they would participate again if offered the opportunity. The program connected the students' environment to the global climate issues we all face, through data.

One structural design that users did not appropriate as anticipated was the use of community forums to develop new practices or meet in-person. Norton (2007) suggests the development of new practices as one of the key aspects of stakeholder *agency* in EPP initiatives. Eco-app users typically appropriated the commenting, liking, and sharing features of the apps to show their actions to the community and offer community support; however, they did not use these features often to post ideas, make suggestions, or organize offline events. Some exceptions include several users on MyActions who offered their community

creative sustainability practices and events to attend. JouleBug offered badges that people could complete in their community but did not specifically offer these as places for discussing ways to address problems. Finally, Project Noah and WildLab Bird garnered activity for in-person events through teachers who organized students for outings to document wildlife.

These examples point to an inadequacy in the current eco-app design and its appropriation by users, specifically in the area of stimulating new practices to solve environmental problems. Comparing eco-app community forums to in-person events, stakeholders appear to lack a sense of connection or deeper ontological competence and security to the issues and people that can elicit creative ideas and collaborative discussions. The comment boxes and visualizations on eco-apps may simply not compare to the essence of in-person events, such as seeing other people's reactions to ideas and 'speaking' without a word limit.

Complications with the interface further hampered users' *ontological security* and ability to engage in *discursive access*. On the MyActions Google Play store page Benjamin Leamon commented on the difficulty to get the app to work:

> Slow, Clunky, Buggy This app is barely more than a link to the myactions web site. I cannot upload photos (even after the update!), the site is prone to crashing, and many of the links just don't work on my device. If you want people to use the app, it needs to be more than this half-baked attempt.

On the Tracking the Wild Google Play store page, Sarien Lategan wrote about her frustrations with not being able to use the app, "Not working. I was extremely excited about

this app but can't get it to work properly. It keep force shutdown and not all the functionalities seem to be there."

The analysis above shows the great potential for eco-apps to serve as a digital space for increasing discursive access, ontological security and competence of environmental public participation stakeholders. Users of the eco-apps readily appropriated the app's structural features, yet some of the more crucial features that could lead to deeper understanding and problem solving were not well appropriated.

## Implications

Reflecting on my eco-app analysis, it appeared that the construction of eco-apps and user appropriation followed DeSanctis and Poole's (1994) ideal *duality of technological structure* because the social structure built into eco-apps closely mirrored the social structure that emerged from users' appropriation of the apps. When app structure offered users a way to gamify sustainable activities or visualize the amount of litter collected, users participated and rarely deviated to use the app for other purposes. Thus, from the perspective of DeSanctis and Poole (1994), the small deviation in the duality of structure afforded countless conservation efforts in accordance with eco-app creator's intentions.

Framing the eco-app analysis with Norton's (2007) *duality of participation* reveals relatively strong user agency. Stakeholders or users of the eco-apps acquired information and contributed content through a range of features, including tagging, posting, commenting, liking, sharing, badges, points, missions, and location based prompts. These features offered various structures within which users could engage in EPP, including visualizations, community forums, games, data, and interactions with their environment. Users affected the

overall structure of the app through the types of content and how often they uploaded content. Conversely, defects in the app structure, specifically bugs, crashes, and lack of functionality across different mobile devices, constrained stakeholder agency.

Though the outcomes of this study reflect relatively ideal scenarios from DeSanctis and Poole's (1994) and Norton's (2007) perspectives, they do not mediate the type of EPP that needs to occur to solve complex environmental problems. The features and structure of these eco-apps mediated *one-dimensional environmental public participation*. In one-dimensional EPP, the structure of the initiative is advantageous to user agency, but only to reveal one dimension of problems and their solutions. One-dimensional EPP does not offer connections to other resources or information pertaining to the multiple dimensions that constitute environmental problems.

One-dimensional EPP leads to a false sense of ontological competence because stakeholders' discursive access is limited to a narrow set of solutions that omit social, political, and economic structures underlying environmental problems. I do not advocate that eco-apps or other media show every aspect of an environmental problem, as that would be far too complicated. Instead, we need to find ways to show multiple dimensions of environmental problems through networked media. For example, the Joulebug app instructed users to "kill the lights when you leave a room" to conserve 200 kg of CO2 per year. Yet, this one-dimensional 'solution' to CO2 leaves out the myriad factors contributing to the problem, such as leaving lights on to deter home intruders, government subsidies to polluting power sources, and the relative cheapness of electricity. Joulebug might move to a *multi-dimensional* EPP by providing links to our information about the aforementioned

alternative situations. Similarly, Tracking the Wild instructed African wildlife tourists to photograph and identify animals to assist conservation efforts but neglected the social, political, and economic factors creating the need to protect African wildlife from poachers and habitat destruction. If at least one or two of these broader structures were included in the apps, the users could start to understand how they could alter these structures and change the environmental problem in more ways than just one.

Additionally, the features of one-dimensional EPP initiatives hold the potential for stakeholder collaboration, yet developer execution and stakeholder appropriation of these features results in collective affirmation of the status quo. For example, MyActions includes options for liking, commenting, thanking, and sharing user content while on the go, which offers the structural potential for users to gain new perspectives and form new relationships by using the apps. The app's Google Play site explains, "MyActions is the leading social platform to engage users and deliver real world impact of green, caring, and healthy actions!" Yet, the users of MyActions stuck to the suggested actions of taking public transit, recycling, and conserving water instead of offering ways to address why public transit does not reach everyone, the pollution caused by recycling, or the reason behind water shortages, thus affirming the status quo. Additionally, the app offered ways for users to meet in-person to start dialogues that could lead to multi-dimensional understanding, yet this was a seldom used feature of the app.

Though the features of these apps offered the potential for dialogue and meeting in-person to address environmental problems, their integration into the apps' interface did not result in appropriation. This may be due to the fact that some of the actions appeared more

clearly than others. Examining the app design, the user 'tasks,' as described in the MyActions example above, appeared foremost as opposed to 'discussion' space for questioning whether the 'tasks' were the only things needed to address environmental problems. In the appropriation process, users likely focused on the most evident features and the tasks and then set to work completing those, thus perpetuating the one-dimensional understanding of environmental problems and solutions.

This summation is similar to Büscher and Igoe's (2013), who argue that features of Web 2.0 do little to transform real environmental problems because users believe the simple acts of liking and sharing are effective forms of environmental participation, which leads to an artificial understanding of relationships that cause environmental problems. Contrary to Buscher and Igoe (2013), I do not think the features of Web 2.0, such as liking and sharing, are to blame for a lack of understanding or that they inherently lead to one-dimensional EPP. Instead, the execution of these features in the design of technological interfaces segue users into specific paths of appropriation and, thus, either limit or broaden user understanding.

My contribution to the discussions of EPP and technology is the need to reconceptualize Web 2.0 technologies, such as eco-apps, as pathways to *multi-dimensional EPP*. If EPP organizers and technology developers start with the intention to capture, connect, and explore the multi-faceted aspects of problems, the structural potential and appropriation of technology may look radically different. My recommendations focus on collaborating with diverse stakeholders because thus far the results of Chapters Two and Three show that most activity through eco-apps occurs individually. Though there are benefits to individual initiatives such as the success seen with Julia Butterfly Hill's work and

the work of the developers mentioned here, there is something to learn and discover through collaborative technology development and use.

I offer the following four recommendations as points of discussion and exploration for scholars and practitioners to reconceptualize the structural potential of eco-apps as modes for addressing environmental problems:

- Include and support diverse stakeholders in the development of eco-apps

The execution of features into specific structures and appropriation by users relies directly on the people developing the technology. The more diverse stakeholders are who participate in the development of the technology, the higher the chance that technology will include more than one dimension of a problem. This could mean opening brainstorming sessions for the design of eco-apps to stakeholders or assisting stakeholders to create their own apps that work to show different dimensions of the issue. By assisting stakeholders in development of their own apps, it is possible to both respect individual voices and connect these voices to a spectrum of positions and possibilities.

Though I did not cover developer inputs as part of my formal analysis in this chapter, I dedicated several columns in my spreadsheet to tracking the types of developers and development processes. I reserved these columns out of curiosity stemming from Norton's (2007) argument that for an EPP event to be successful, organizers must also hold some ontological competence in organizing these events. Drawing information from developer's websites, app store pages, and news articles, I found the that resources needed to develop native and embedded eco-apps shaped the structural potential of the app. Native apps were developed in partnership with non-profits, government agencies, and/or the private sector and

required people who were proficient in coding and design. The structural potential of the resulting native apps focused on continuous, long-term use by relatively dedicated users.

For example, on the one hand, Joulebug, created by a team of entrepreneurs and programmers, aimed to help users live a sustainable lifestyle by providing badges and pins that coincided with the time of year or current events. On the other hand, embedded apps were developed by one organization or one person and required no knowledge of coding or design, only that the developer know how to create and publicize a hashtag within the native app and their offline community. The structural potential of the resulting embedded apps focused on spontaneous, short term use by casual users. For example, the #sydearthhourpw app, created by the World Wildlife Fund, ran for one day and asked users to snap a photo of a street scenes exemplifying what a sustainable Sydney might look like.

The two types of apps, native and embedded, offered a range of possibilities for integration of stakeholders in the development processes. The first step of integration might entail bringing diverse stakeholders together to discuss the many facets of an environmental problem. Upon identifying these facets, the second step might entail stakeholders deciding how technology can address the problem. One possibility is for all stakeholders to contribute time, money, and knowledge to the development of a native app that reveals many of the facets identified. Another possibility is for all stakeholders to agree to create and maintain their own embedded app, which would reflect one or two of the facets identified and connect to the other embedded apps to bring users to a fuller understanding of the problem. Either way, the process of bringing stakeholders together to discuss the social, economic, and political causes of the problem will serve as an EPP initiative within itself, further solidifying

ontological security in the participants and widening stakeholder's ontological competence in the topic. Therefore, incorporating multiple stakeholders in the planning of an eco-app might lead to multi-dimensional understanding of the problem and a technological structure that supports mediation of that understanding to diverse users.

- **Incorporate diverse stakeholders as users of eco-apps**

Because Web 2.0 features offer a way for users to co-create content, the more diverse the stakeholders are who use the technology, the more likely users will identify and address multiple dimensions of the environmental problem. Following the first suggestion, the inclusion of stakeholders in the development of an eco-app gives the opportunity to identify possible roles and contributions of a range of stakeholders. With a range of contributors, an eco-app developer could then integrate their offerings into the structure of the app, which might lead to better appropriation by users. Therefore, the design of the app offers ways for multiple stakeholders to become involved, such as stakeholders from government agencies, non-profits, universities, business, etc.

Drawing from my analysis, several apps aimed to incorporate other stakeholders as an outcome of the app's use. #Litterati's creator, Jeff Kirschner, said:

> [T]he idea [of #Litterati] is to build this grassroots campaign, then using that who, what, where, and when data, go top-down and work with cities to be more strategic about the placement of trash cans and recycling bins; or work *with* brands to be more strategic about the type of packaging that they create in *hopes of* eventually reaching a litter free planet. [emphasis in original] (Litterati, 2015).

This quote shows that Kirschner does not assume the only purpose of his embedded eco-app is to collect and document litter; instead, he describes user data as a way to start a dialogue with the organizations that have power to change production practices and the agencies that can influence citizen behavior. Similarly, the World Wildlife Fund, creators of #sydearthhourpw embedded eco-app, asked users to upload images "to re-imagine the modern sustainable city" and, with such success from the first, they created a second embedded eco-app, #abettersydney that asked users to photograph the possibilities for a car-free street through Sydney. These images were then taken to a Sydney city council meeting to challenge council members to build a sustainable Sydney (Myers, 2011).

The creators of both #Litterati and #sydearthhourpw aimed to integrate other stakeholders to solve environmental problems, but neither invited these other stakeholders to literally participate and become users of their embedded apps. The outcomes of the apps may have been different had the creator of #Litterati invited businesses to participate, especially those whose products ended up as litter or if the developers of #sydearthhourpw invited local businesses to participate, showing that local businesses had the capacity and interested to contribute to the effort. The successful integration of other stakeholders in the interface relies heavily on their involvement in the development stage, which offers a chance for all parties to build ontological security among one another and competence in ways to solve the problem. Simply offering a place for stakeholders after the development of the app will not ensure their appropriation of the app, nor that the app will mediate behavior to encourage environmentally friendly behavior.

- **Record lived experience and live new experiences through eco-apps**

Designing eco-apps to enable the recording of experiences and prompt new experience in nature can open the door to multi-dimensional understanding of environmental problems. Nothing is static in human-nature interaction; mobiles offer an easy way to uncover, document, and share the user's constantly changing interactions with their environment. Users can develop ontological competence of place by reporting what they observe and going on missions to discover that which they have not yet seen or experienced. Additionally, the recordings and posts of users can also mediate the experiences of other users as they begin to see the world through the eyes of others.

The eco-apps in this study offered ways for users to record their lived experience. The Nature Near You eco-app encouraged users to take photos and mark noteworthy locations and wildlife in parks, and users of the #sydearthhourpw were asked to explore Sydney and post images of what a sustainable city might look like. In the process of exploration, users can develop ontological security by reflecting on their contributions in relation to the contributions of other users. For example, the WildLab Bird app allowed users to reflect on their location in relation to bird sightings and neighborhood events posted by other users, while also projecting their bird sightings on a map.

Connecting location and temporality (such as seasonal changes) with the ability to co-create content allows users to pin new meaning to places by digitally labeling or tagging places with descriptions and images of wildlife or geographic features. The discursive access offered by uploading one's own experience can lead to development of place meanings, which are a person's beliefs, feelings, memories, and knowledge about a place (Cheng et al.,

2003). By helping users develop place meanings within their communities, mobiles can influence stakeholders' attitudes towards changes, both positive and negative, at that place (Jacobs & Buijs, 2011).

When designing eco-apps, developers should consider ways to support the five types of place meanings through user experience: beauty (esthetic judgments), functionality (ways of use), attachment (feelings of belonging), biodiversity (meanings pertaining to nature), and risk (worries about current or future events) (Jacobs & Buijs, 2011). As users explore and develop place meanings, they have the opportunity to learn how social, political, and economic structures influence conservation and sustainability practices. Additionally, they can learn from their network new ways of seeing and experiencing the world.

- **Supplement and support offline relationships through eco-apps**

By supplementing and supporting stakeholders' offline relationships, eco-apps might help stakeholders recognize the human dimensions assisting and hindering solutions to environmental problems. This might mean using eco-apps as a tool to coordinate in-person meetings, offering resources to supplement in-person meetings, and supporting activity that addresses emergent aspects of problems. As a support tool, eco-apps could help to build ontological competency in the ways communities can address problems and increase users' ontological security in other stakeholders.

Some of the eco-apps in this study attempted to physically bring users together, such as WildLab Bird's events tab and MyActions' request for users to post community events that they planned to host or attend; however, not many users appropriated these features. For example, during the time that I used the apps, I could not find any events for my area on the

WildLab Bird app, a handful of MyActions users posted events, and the missions on Project Noah's were geared toward elementary students. Using the data that I collected for this study, I could not determine explicitly why users failed to appropriate these features, though I think that it had to do with the presentation of the features (as I discussed earlier). If developers placed more emphasis on in-person events within the interface instead of the tasks to be completed, the apps might function like this:

- Events on WildLab Bird might connect users with biologists at a community outing to discuss what local activities threaten the survival of birds. This event might lead to new experiences for users and new relationships with community members.
- #Litterati might incorporate monthly litter clean-ups at specific locations where users could meet city staff and discuss the challenges of acquiring, locating, and collecting new trash bins for reducing litter in the community.

However, challenges arise in the infrastructure of such planning, considering who will organize the meeting space, and how to ensure attendance and participation.

Besides holding events, eco-app developers could connect users in-person through *gamification*. Gamification is the process of applying game design elements, such as points, badges, avatars, and leaderboards, to ordinary tasks to make these tasks more engaging and game-like (Liu & Santhanam, 2015). Gamification offers an alternative way for users to meet other stakeholders through competitions for badges, missions, and points. From this study, Joulebug gamified opportunities to meet other stakeholders by offering missions within the user's community such as volunteering in the community. The creators of

Joulebug developed a version of the app called "Joulebug shine" specifically for use by employees within companies. The app offered a way for employees to compete against one another to improve their individual sustainability efforts. The pre-existing relationship of employees may offer more incentive for action, yet the app creators may have elicited more creativity and relationship building by asking users to solve sustainability problems within the company instead of in each user's individual life. Other ideas for gamification include:

- mayorship titles for those who perform the most environmental actions at one location
- increased points for people who attend in-person events
- a swarm badge (like that used on the original Foursquare) to award points only to users after a set number of diverse stakeholders arrives at a specific location

The benefit of prompting in-person interactions is the chance that through meeting, the dialogue of diverse stakeholders could result in redefining and addressing the social, economic, and political practices causing environmental problems.

The recommendation above brings full circle the emphasis on diverse stakeholder involvement from development to use as a way to increase stakeholder agency in EPP eco-app initiatives. I recommend exploring collaboration and participation because these approaches are not the standard mode for eco-app development and use. I acknowledge that the individual approach to mobile app development does lead to environmentally friendly activity (as outlined earlier), but it is worth exploring how this activity might change with new technology practices. Furthermore, the process of bringing diverse stakeholders

together is not easy nor does it always result in ideal outcomes. Stakeholders may not be willing to engage in collaboration due to a lack of ontological security in the intentions of organizers and other stakeholders. Additionally, if stakeholders do come together, divergent values, goals, and perspectives may lead to conflicts among participants, making it difficult, if not impossible, to reach agreed upon goals for how an eco-app might mediate environmental activity.

## Conclusion

To document the reciprocal influence of social structures and individual agency through eco-apps, I utilized two frameworks derived from Anthony Giddens' (1984) structuration theory. The first framework, Norton's Environmental Public Participation (EPP) framework, offered mid-level theoretical grounding in the ways that organizational mechanisms either supported or hindered stakeholder involvement in eco-app EPP initiatives. The second framework, DeSanctis and Poole's (1994) adaptive structuration theory (AST), offered methodological guidance to identify the technological features that enabled and constrained user activity in the apps.

By coupling the two frameworks, I situated my analysis of eco-apps within the context of EPP initiatives to understand their affordances for user agency and solving environmental problems. My analysis revealed that eco-apps increase stakeholder agency by offering opportunities for discursive access, such as the ability to quickly and easily attain and contribute to environmental knowledge and action. Users could build ontological competence in an environmental problem by following prompts in the app to explore their community and by observing the contributions of others. Additionally, the process of

observing and commenting on other users' posts offered a chance to build ontological security in the intentions of other users.

Though users readily appropriated the eco-apps in this study, resulting in numerous activities for a sustainable planet, there is still room for improvement. If the goal of scholars and practitioners is to get at the root of environmental problems, they need to reconsider how technologies can facilitate exploration of the multiple dimensions of those problems. The results of this study show that the current structure of eco-apps offers one-dimensional solutions that maintain the status quo instead of solutions that challenge the social, political, and economic mechanisms behind environmental problems. Based on the results of this study, I encourage EPP organizers to incorporate more and diverse stakeholders in the development and use of eco-apps.

Scholars and practitioners can build on these findings by studying the structure and appropriation of new eco-apps, especially those that incorporate diverse stakeholders. Additional research on other apps will address the limitation of a small sample size in this study, which occurred due to the limited number of eco-apps with Web 2.0 capabilities available at the time the study occurred. Another limitation of this study included a lack of quantitative longitudinal data, which if collected by future researchers could improve understanding of user appropriation. Using interview and shadowing methods for data collection would also increase understanding of the appropriation process. The lack of interview data in this study posed a limitation for understanding some of the appropriation mechanisms. Finally, creating eco-apps following the recommendations in this study offers another way of determining whether Web 2.0 features inherently disconnect users from

environmental problems, or whether these features simply need placement within a more broad and diverse array of stakeholders.

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**Activity Theory Analysis**

The activity system of chapter three (Figure 3.14) looks at the ways that mobile phone users appropriated the features of applications to address environmental problems.

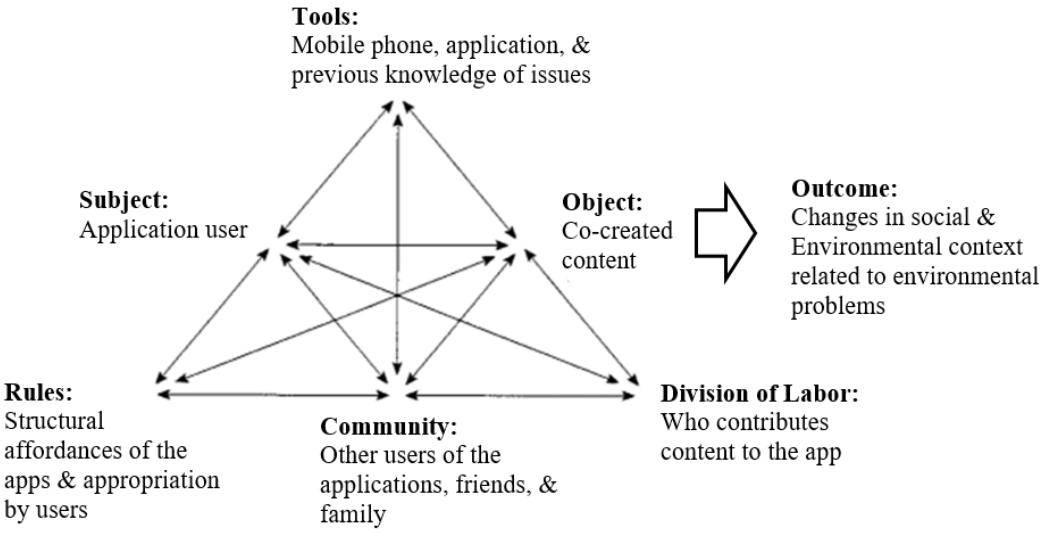


*Figure 3.14.* Chapter three activity system.

The structural analysis performed in Chapter Three showed how the potential and appropriation of *tools* can alter the activity system and its outcomes. The *tools* in this activity system consisted of mobile phone applications offering environmental public participation opportunities called eco-apps. The *rules* of the activity system included the structural potential of the eco-apps, essentially all of the possible ways that users could interact with the technology given the features that the technology offered. The features included tagging, posting, commenting, liking, sharing, badges, points, missions, and location based prompts. The developers of the apps utilized these features to create the following technological structures: visualizations, community forums, games, data, and

interactions with the user's environment. The features and structures worked together to offer users a way of seeing and recording their experiences with nature and each other, a process that altered user consciousness of environmental problems and their solutions.

The *subjects* were eco-app users whom appropriated the features of the apps in accordance with developers' goals by using the apps to monitor environmental conditions and learn about the environment. Developers' goals and the *outcomes* mentioned by *subjects* overlapped; specifically, they both aimed to create *content in the app* (*object)* to address environmental problems. However, bugs and crashes in the eco-apps sometimes hindered the ability of *users* (*subject*) to contribute content and engage in *sustainability or conservation efforts* (*outcomes*). Therefore, developers and users could develop their consciousness of environmental problems through eco-apps so far as the apps could function without technical difficulties.

The *division of labor* consisted of community members who co-created content on the app by uploading data and completing missions or badges. Though the structural features of the app remained consistent, the process of co-creating content changed the overall structure of the app. The types of images and information uploaded by *subjects* and their *community* completely altered the *outcomes* and consciousness possible through app use. For example, in the mobile eco-app called Tracking the Wild, users referenced the geo-located pins of other users to find animals and then contributed their own pins to the app's map. Without seeing the location of previously sited animals, users of Tracking the Wild were less likely to experience an animal siting themselves. In the Joulebug eco-app, users participated in competitions against one another to see who could garner the most points and badges; the

contributions of other users gave motive to activity within the app and supported the perception that individual user activity really made a difference. Therefore, the placement of structural features within the *tool* and the contributions of the *community* affected the *object* and *outcomes* of eco-app use.

Looking at the structural potential and appropriation of the 11 eco-apps in Chapter Three, it appears that eco-apps offered a *tool* through which *subjects* could quickly and easily learn and engage in environmental issues. Yet examination of the *outcomes* of the activity system shows little to alter the social, political, and economic causes underlying environmental problems. To understand why the *outcomes* were not fully achieved, I traced the interactions between elements in the activity system and found contradictions between the *rules* and the *subject* and *community*. Contradictions are problems, breakdowns, or clashes that destabilize an activity system due to misalignment of activity components. Though *application developers* designed apps to *divide the labor* of creating app content among the themselves and the *community* of users, a contradiction in the activity system arose in the *appropriation* (*rules*) of important features, such as discussions and meeting in-person, did not manifest successfully. This contradiction occurred because without discussion from diverse stakeholders, users could likely not gain consciousness of the multiple dimensions of an environmental problem. The breakdown between these activity elements may have occurred because the design of the interface did not make these features as evident as other features and/or because these features did not offer a convenient mode of achieving the desired outcomes.

In summary, the activity system of Chapter Three shows how peoples' use of eco-apps supported understanding of and activity to address environmental problems; however, current eco-app design did not support consciousness of the social, economic, or political underpinnings of environmental problems. The eco-apps reviewed in this chapter altered the material contexts of users by prompting users to explore, record, and try specific activities in the home, office, and community. The apps altered users' social contexts through structural features of community forums and gamification, allowing users to interact with one another on and offline. Therefore, the eco-apps examined in this chapter offered digital spaces for gathering and reflecting on environmental problems, yet contradictions exist between what the *developer* created and the *community's* engagement.

DeSanctis and Poole's (1994) adaptive structuration theory and Norton's (2007) environmental public participation (EPP) framework afforded ways to see the impact of technological design on user activity and vice versa; however, these frameworks did not explain why specific designs were chosen and developed over other designs. Nor did these frameworks offer perspective for how the development process influenced the design and appropriation of eco-apps. To fully understand my research questions, I needed another set of frameworks that would help explore how the development process of an environmental mobile phone intervention might affect the technology's design and use. Therefore, I take a closer look at the activity system of designing mobile phone applications in Chapter Four as way of uncovering why the contradictions of this chapter's activity system occurred.

## Chapter 4 : Actor Diagramming and Tracing Method


### Abstract

To assist in the creation of technologies that engage users to question, explore, and address environmental problems, this chapter proposes and applies an actor diagramming and tracing method. Inspired by concepts from participatory design, actor network theory, and deep ecology, the diagramming method aims to shift the development process of sustainable persuasive technologies from human-centric to more eco-centric. The method does this by guiding technology developers to survey both human and nonhuman actors in an environmental situation then translate the needs and relationships actors describe into a technological interface. The method involves identifying, then interviewing, observing, and interacting with actors to elicit human-nature-technology relationships. The method recommends developers collaboratively build technologies with actors through participatory mechanisms. To illustrate the method, I use it to develop a prototype mobile phone application for sustainable forestry. As reference, I also develop a mobile phone application for sustainable forestry following a conventional development method. I compare the outcomes of both development processes, showing how use of the diagraming method affords a more nuanced understanding of an environmental situation and leads to a very different technological interface than with use of the conventional method. This chapter provides a method for scholars and practitioners to continue to explore and reflect on how technological development and design impacts the types of environmental activity engaged by users.



Keywords: mobile apps, design, public participation, sustainability, behavior change

## Actor Diagramming and Tracing Method

Scanning the environmental public participation literature, one can find numerous benefits to using participatory practices when developing environmental policy, making scientific decisions, and running community initiatives. Yet, little is written on the possible benefits of using participatory approaches to develop information and communication technologies (ICTs) that engage users in environmentally friendly or sustainable behaviors. Even less exists on how one might use a participatory approach to capture and transform the complex human-nature relationships that cause an environmental problem into a technological interface that can help address the problem.

I propose the use of participatory methods as a way to improve the design of sustainable persuasive technologies (SPTs), which includes any technological interface encouraging users to engage in sustainable and environmentally friendly activities. Participatory design requires developers to integrate users in the design process so that the needs and values of users serve as the crux of design decisions (Schuler & Namioka, 1993). The approach assumes that: 1) users are the experts in deciding how a technology could improve their work and, 2) a technology functions as part of a workplace, not in isolation (Schuler & Namioka, 1993).

The methods offered by participatory design reflect similar methods used in environmental public participation initiatives; however, neither of these methods offers a way to account for the complex and dynamic nature of ecosystems in the development of SPTs (Brynjarsdóttir, Håkansson, Pierce, Baumer, & DiSalvo, 2012; DiSalvo, Sengers, & Brynjarsdóttir, 2010; Goodman, 2009). Currently, most SPT developers rely on personal

knowledge and experience, instead of incorporating user feedback or engaging users in collaboration (Brynjarsdóttir et al., 2012). I call the current method of development the *conventional method,* and it starts with an idea, which is developed based on the strength of the developer's personal knowledge and typically does not follow popular or mainstream development methods like Agile, Scrum, and Waterfall. Though the conventional method has its benefits, as shown by the examples in earlier chapters, alternative methods should be explored to generate different types of human-nature-technology relationships.

Because SPT developers come from a range of backgrounds and organizations, such as environmental science, communication, social justice, psychology, and computer science, they typically are not trained in or even aware of participatory design methods. When I reference developers in this chapters, I'm specifically speaking about the people who initiate, organize, facilitate, and finalize the development of a technology that is intended to alter human behavior in relation to environmental issues. Because of the diverse backgrounds of SPT developers, any solution to alter or improve SPT development methods must account for a broad range of skills and understanding in relation to both environmental situations and technological development.

Scholars of SPT caution against the conventional method because it affords a narrow understanding of the environmental problem, which then leads to overly simplistic framing in the design of a technological interface. Frames, as I use the term in this chapter, are language, images, and design features used to communicate one reality over another to end users. The way that environmental problems and solutions are framed within a technological interface mediates the way that users understand and act in relation to environmental

situations. When frames are narrow, as those found in most conventionally developed SPTs, users miss the complex sociocultural dynamics underpinning environmental problems (Brynjarsdóttir, et al., 2012; DiSalvo, Sengers, & Brynjarsdóttir, 2010; Goodman, 2009).

The aforementioned SPT scholars argue that without understanding the complex nature of environmental problems and solutions, users of SPTs incorrectly believe that taking one or two actions suggested by the technology will remedy the environmental problem. Additionally, the role cast for users of SPTs is typically one that requires users to follow directions outlined by app creators, as opposed to question, interpret, or attempt to address environmental problems on their own. If we are to avoid shallow understanding and minimally effective action, we need to consider how development methods impact the way technology mediates human-nature relationships. SPT scholars recommend the use of participatory design as a way to capture alternative perspectives on environmental problems, which can reveal sociocultural dynamics and improve applicability of technological frames to mediate environmental situations.

Therefore, I explore how to create a participatory development method for SPTs, as well as the types of frames that emerge using such a method. I acknowledge that there are many participatory development methods available, yet these typically do not encompass all actors within an environmental situation, and they can include complicated steps that are difficult for an untrained developer to implement. In this chapter, I draw inspiration from a range of frameworks to develop a new method called the *actor diagramming and tracing method.* The aim of the method is to shift developers' focus from a narrow, human focused set of actors and activity to a broader, ecosystem focused set of actors and activity.

To illustrate how my method works in practice, I apply it to the development of an eco-app to support sustainability practices on family owned land in North Carolina, U.S.A. Although one can apply the method to a range of SPTs, I chose eco-apps since that is the focus of this dissertation, and understanding the development process will help to address my overarching research questions. Additionally, though there are many environmental topics to pick from, I chose sustainable forestry because it is a relatively complex environmental situation that could afford numerous technological solutions. I also decided to develop an eco-app for sustainable forestry practices following the conventional development method as way to gauge how different development methods change the mediation process of technology. I do not claim that the comparison of the two methods and their outcomes is empirical or generalizable because being the sole developer in both situations likely influenced their outcomes. Moreover, my application of both methods in this chapter is not to prove one method better than the other, but instead to show the differences in using such methods.

I start this chapter by first exploring what is currently known about the development process of sustainable persuasive technologies. Second, I explicate the actor diagramming and tracing method, and third, I illustrate my method and the conventional method through development of an eco-app. Finally, I reflect on the implications of my findings for future SPT development.

## Sustainable Persuasive Technology and Participatory Design

The research area of sustainable persuasive technology (SPT) is grounded in the tradition of persuasive technologies founded by Fogg (2003), who describes technologies as

persuasive because of their ability to intervene in decision making at times, places, and with information that can influence user behavior. From Fogg's (2003) definition, it would appear that technology can play an influential role in encouraging people to engage in environmentally friendly behaviors, which is why so many people and organizations have attempted to use technology to do so.

Several meta-analyses on sustainable persuasive technologies (e.g. personal computers, stand-alone machines, and mobile devices) designed to help users understand and participate in sustainable activities revealed that most interfaces inform users if they are acting environmentally by comparing their behavior to metrics predetermined by the developer and/or sustainability experts (Brynjarsdóttir et al., 2012; DiSalvo et al., 2010; Goodman, 2009). The problem with using predetermined metrics is that developers assume that all factors have been accounted for, and when new problems arise, the interface cannot account for them (Brynjarsdóttir et al., 2012). Brynjarsdóttir et al. (2012) further explain that "while this narrowing of vision makes possible a wide range of technical solutions, those solutions tend to break down in the face of ecological issues outside of the 'selective reality' constructed through the problem framing" (p. 951).

This chapter focuses on the ways that environmental problems are framed through interfaces because the tools provided and reality presented to the user can influence how she thinks and engages with physical space, people, and objects (Bødker, 1987; Nardi, 1996; Vygotsky, 1978). Goffmann (1974) proposed the concept of framing as a communicative way of presenting reality by showing certain symbols, such as images and text, to influence a viewer's perception toward one reality over another. The creator of the frame imbues the

content with their understanding of the environmental problem and solution to influence the user toward the creator's interpretation of reality and influence audience's behaviors and attitudes (Scheufele & Iyengar, 2014; Schreiber, Matthews, & Elliott, 2003). On the other hand, the user also views technology with his or her own cognitive frames, which further impacts how messages are understood and acted upon (Goffmann, 1974).

Therefore, when trying to understand how technology mediates human interactions with nature, it is important to recognize both the frames designed in the technology and the frames perceived by users. The interaction of technological and cognitive frames can create dissonances in the mind of the users and lessen the mediation capabilities of the technology, or frames may align, making the technology an effective tool. Alternatively, dissonance cause by frames can lead to productive questioning of current practices, while easy alignment may inhibit learning by not offering new challenges. By incorporating users in the development of a technology, developers can gain insight into the cognitive frames of users and align technological frames with cognitive frames.

I employ activity theory in this chapter to record how incorporation of users in the development process changes the frames presented. The core concept of activity theory is *activity*, which is a process by which tools and signs connect an individual's mind to culture and society, while also allowing the individual to control behavior outside of the body (Engeström, 1991). By examining activity, one can understand how technological development unfolds among designers, artifacts, and society (Nardi, 1996, p.69). For example, it is possible to see how a tool or inclusion of specific resources in the design activity (such as a participatory method) influences the developer's understanding of the

problem and, thus, influences the type of technology produced (Nardi, 1996). Tools or methods can influence a developer because their consciousness or understanding is not just 'in the head', it is developed through daily interactions with materials and society (Nardi, 1996). As such, reflection on the material and social interactions that a developer has during the design process can reveal how they acquire understanding of environmental situations and how they choose some frames over others.

Activity theory breaks down activity into seven components: 1) physical or psychological tools; 2) the community that gives meaning to the activity; 3) rules that establish the nature of the relationship among participants; 4) division of labor among participants in transforming the object; 5) the object or focus of the activity; 6) the outcome or product of the activity; and 7) the subject, either individual or collective, who determines the object of the activity (Spinuzzi, 2008). In relation to studying the activity of SPT design, the subject is the developer and her object is to facilitate sustainable behaviors; her tools include design software and sustainability metrics, her community may be an environmental non-profit, and the division of labor may include sharing of knowledge among the subject and community with the final outcome being an SPT (Figure 4.1).

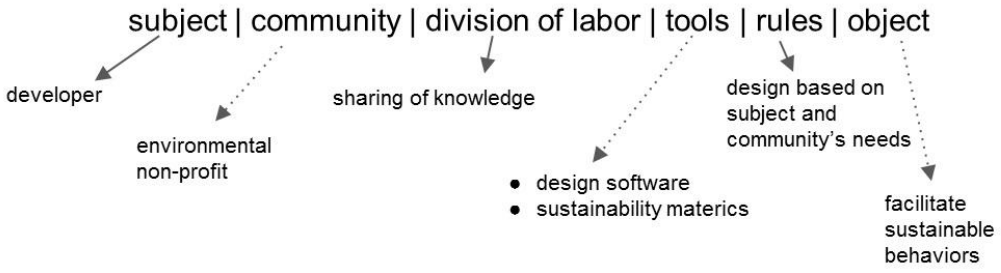


*Figure 4.1.* Activity components of sustainable persuasive technology.

Current SPT development does not avail of user feedback; instead, the activity of development is grounded in expert derived metrics containing specific numbers and parameters of what constitutes 'good' and 'bad' behavior (Brynjarsdóttir et al., 2012). Many SPT developers think that because they have data points related to specific conditions, they do not need any other forms of input and immediately start creating their SPT. In Valentinov's (2014) complexity-sustainability tradeoff, internal complexity is reduced to improve integration of individual systems to respond to complex environments. By using metrics, SPTs and users can quickly integrate with current economic systems; however, this also means that users are not sufficiently able to recognize or integrate into the complex political, social, and economic systems that underlie environmental problems.

Besides metrics, developers of SPTs often falsely assume that they understand their audience's needs, especially if they feel that they are part of the audience. Developers then speculate about the types of designs that will accommodate the needs of their audience, further fictionalizing their audience as people 'out there' waiting to be informed (Johnson, 1997). However, the technology never fully addresses the audience's needs or the complexity of their situation because the developer's understanding is based on layers of assumption about what the user's reality is. And, as mentioned earlier, most SPT developers do not come from a design background; instead, they are hobbyists who lack training in technology development methods but feel that they make up for that lack through their passion on the topic. The evident lack of user feedback in development of SPTs points to a contradiction in the activity system between the *community* of users and the *division of labor*.

The contradictions found broadly in SPT development are also apparent in the development of eco-apps. Upon review of numerous development methods used for eco-apps, I have found that the majority of developers describe the design activity as one where an environmental issue catches their attention; then, drawing on their personal knowledge of technology and/or of the environmental issue, the developer creates an eco-app. For example, Litterati encourages users to take an artistic photograph of litter, then dispose of the litter appropriately. The app creator, Jeff Kirschner, explained on his website that he developed the app on his own to help reduce litter in his community and around the world (Litterati, 2015). Similarly, the nonprofit World Wildlife Fund created the app 'Together' with a private design company to save endangered animals by helping users learn about endangered animals through images and videos (AKQA, 2013; Macleod, 2013; Vanhemert, 2013). Users were not involved in the Together app design process, and the narrow focus on building user knowledge missed possibilities for prompting user action toward changing the plight of endangered animals. The aforementioned examples reflect SPT development trends, specifically reliance on the developer's personal knowledge to design an eco-app.

To overcome contradictions between the community of users and division of labor in the technology development process, Bellamy (1996) encourages designers to collaborate with multiple parties to reveal how technology might mediate a range of human activity. As the developer interacts with others, contradictions between his assumptions and the reality of user needs appear (Spinuzzi, 2008). These contradictions are an example of productive dissonance in frames that can lead to improved environmental outcomes. To address contradictions, developers can discuss alternative perspectives with users, which can lead to

innovative technological solutions (Engeström, 1993). SPT scholars also advocate for discussions with users in the SPT development process through participatory mechanisms (Brynjarsdóttir et al., 2012; DiSalvo et al., 2010; Goodman, 2009). Through participatory approaches, the user becomes the identifier of environmental problems and solutions instead of being just a receiver of this information. Davis (2009) explained that through participatory design, users become experts in sustainability as it relates to their lives. As such, public participation in the development of SPTs can lead to the development of *public expertise*, a concept Kinsella (2004) explains as the ability of people to have enough understanding of science to productively engage with technical experts. However, not all users may want to discuss or become involved in the development of the technology due to a lack of trust in the developer or other users involved. Additionally, disagreement about what the problem is or outcomes desired can also hinder true participatory or collaborative technological development.

Considering the challenges and benefits of participatory design, I decided to persist in developing a participatory method for SPTs. SPT scholars, Goodman (2009) and DiSalvo et al. (2010) recommend pulling conceptual theories and frameworks from the fields of environmental studies and science and technology studies to expand development beyond the developer. Upon examination of frameworks within the field of science and technology studies, I found actor network theory (ANT). ANT offers insight to participatory development methods in the way it conceptualizes human and nonhuman actors as equally influential in creating the world we know (Latour, 2005) such that developers value feedback from end users and consider the role of nature and technology. Additionally, ANT

encourages scholars to document and follow actors to reveal the associations and alliances formed among human and nonhuman actors (Latour, 2005). If a developer were to follow actors, he could ask 'who interacts with what and how?' to understand the broader network of actors (Latour, 2005).

An examination of frameworks from environmental studies revealed deep ecology. Deep ecology proposes that all life on earth, human and nonhuman, has intrinsic value beyond the needs of humans (Devall & Sessions, 1985; Naess, 1973). Furthermore, it asks people to consider how humans and nature can equally benefit from social action or inaction by endowing nature with the same rights as humans, such as the rights to live, consume resources, and have representation in decision-making processes (Devall & Sessions, 1985). This conceptual framework is helpful to consider because it encourages thought about the value of nature beyond its usefulness to human needs. It also champions diversity of ecosystems and the need to reconsider the effect of current economic, technological, and ideological structures on the health of people and the planet.

Though SPT scholars did not mention the field of participatory design, it is important to consider the field's conceptual frameworks to improve SPT development methods. A core principle of participatory design is creating technology in a democratic way such that a person who is "affected by a decision or event should have an opportunity to influence it" (Schuler & Namioka, 1993, p. xii). Participatory design methods include involvement of end users in workshops, interviews, and observations of their current use of technology and discussion on ways to improve technology (Kensing & Blomberg, 1998). Several important points to consider from the field of participatory design for application to development of

SPTs include the importance of collaboration and transparency during the development process.

As the conceptual frameworks mentioned above demonstrate, there are many possible ways to instigate participatory development in the creation of SPTs. Any one of these approaches would afford developers and users more insight to complex human-nature-technology relationships than following the conventional development method. However, the aforementioned approaches and many others either require training in the use of the method or do not provide clear steps to apply the method in the context of environmental activity. Therefore, I created a method that is simple and flexible, enabling a range of people from diverse backgrounds to apply it. The method is unique in its request for developers to focus on humans and nature through a more eco-centric lens.

**Actor Diagramming and Tracing Method**

I call my method *actor diagramming and tracing* because it involves both drawing out and following human and nonhuman actors within an environmental situation as way to understand how technology can mediate their relationships. Human actors may include the end users, staff at various environmental organizations, representatives from businesses, and other community members. Nonhuman actors may include animals, weather, computers, and educational materials. The developer then traces actors in his diagram by interviewing, observing, and interacting with them and researching their relationships through publications or websites. Simultaneously, the developer works in a cyclical process of data collection, analysis, and the construction of a diagram of actors. The diagram can range from models and illustrations to maps as long as the developer is translating the words and actors he

encounters to a visual representation. The process of developing a visual representation of data leads to improved learning and creativity (Wesson, 2011), elements that are important to understand complex environmental problems and possible solutions. I present Figure 4.2 and the following steps detailing how a developer can apply the diagramming method:

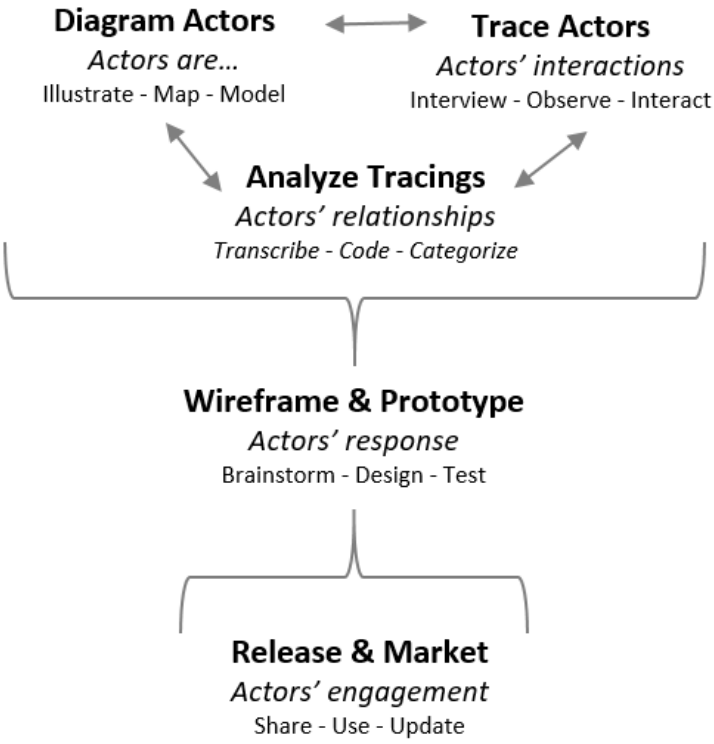


*Figure 4.2* Actor Diagram and Tracing Method

1) **Diagram actors.** Create a diagram, map, illustration, or model of the human and nonhuman actors you think might be involved in the environmental problem that you aim to address. The purpose of this diagram is to help you make present the actors involved in the environmental situation so that you do not focus on only end users or a select set of human actors. Do not try to describe relationships, interactions, or

process of actors because the diagram becomes unwieldy, and that information will emerge through the tracing process. Acknowledge that how you create your diagram influences your conceptualization of the problem and if you show it to actors it will influence their conceptualization as well. For example, creating separate groups of human and nonhuman actors may reinforce their differences but make it easier to distinguish the actors involved. Grouping human and nonhuman actors together may reveal their relationships but may make it harder to distinguish the actors. Use the initial diagram to research the environmental problem and actors involved and update the diagram with your findings.

*Ask:* Who are the actors involved?

2) **Trace actors.** Engage with human and nonhuman actors at multiple levels. Ask exploratory questions to expose interactions among actors, their motivations and behavior, and the ways that technology can mediate environmental situations. Use a range of recording devices, such as video, audio, image, and text, to capture the many possible facets of reality in vivo (Law, 2004). Invite human actors to participate in data collection through methods such as photovoice (Bulla & Steelman, 2016) and by keeping personal journals.

*Ask*: The five W's: who, what, when, where, why, and how.

Tracing human actors. Contact the human actors on your initial diagram and ask to interview, observe, and interact with them in the environment where the problem occurs and the solution is possible. Prepare a set of questions but also devise questions during observations to explore relationships that you did

not anticipate. For example, questions for tracing a homeowner's activity in relation to stormwater pollution might include:

- Show me *how* you [homeowner] maintain your yard.
- *Why* do you [homeowner] engage in this maintenance behavior?
- *What* ways might technology help you [homeowner] to prevent stormwater pollution?

Tracing nonhuman actors. Make a concerted effort to look beyond the value of nonhuman actors for human ends, to elicit and make present the intrinsic value of nonhuman actors. Seek sensory experiences, such as taste, touch, sight, sound, and vision, as way to understand the perceptions, memories, desires, and reasoning of multiple actors (Pink, 2009). Ask questions to reveal the reciprocal relationship between human and nonhuman actors. For example, questions for tracing a nonhuman actors' activity in relation to stormwater pollution might include:

- Show me *where* the path of stormwater flows from this street.
- *What* does stormwater pollution look, smell, and feel like?
- Can I see *how* the health of a fish from a polluted lake appears versus the health of a fish from non-polluted lake?

At the end of the observation:

- Ask them to either review the diagram you made or create their own diagram of actors and denote which actors are missing and which are most influential in the activity under study. If actors review your diagram, acknowledge that

your diagram may influence their perception of the problem, but it will make it easier to build one coherent diagram. If you ask actors to create their own diagram, you may find similarities and differences that reveal new relationships among actors, but you and the actors may find it difficult to bring the diagrams together for a coherent representation of actors.

- Ask the actors in what ways they think technology might assist them to change the environmental problem. Ask them to give examples of current technologies and ones they envision.
- Ask if they would like to participate to create or test the wireframe and prototype developed from your observations. Ask if they have ideas for how to promote the technology and if they would advocate for its use with their connections (i.e. organization, social networks, colleagues, etc.).

3) **Analyze tracings**. After each observation, write a brief reflection on your experience. Transcribe the actor's responses to your questions, code for themes, patterns, and suggestions, and update the main diagram with that given by the actor interviewed. I recommend using a grounded theory approach (see Glaser & Strauss, 2009) to data analysis, where each line or phrase is given a name or code to represent the meaning behind a sentence or paragraph of data in their transcript (Saldaña, 2013). The goal is to extrapolate meaning from data, which the coder can then use to find patterns, create broader categories, or build theory (Saldaña, 2013). By analyzing tracings, you are trying to understand how the actors perceive and engage with the environmental situation instead of basing your understanding of the situation

on your own assumptions. Using the earlier example of yard maintenance practices, analysis of tracings might reveal that yard care store clerks recommend using chemical herbicides, which then influences the homeowner's choice in yard maintenance practices. Interviews with store clerks may reveal a lack of training and resources on alternative yard maintenance practices. Observations of store clerk and homeowner interactions might reveal the need for a mobile phone application that the store clerk can use to walk customers through a series of questions to identify alternative, chemical free practices suited to the homeowner's soil composition and water use.

*Ask:* What are the actors' relationships?

4) **Repeat steps 1, 2, & 3**. Continue exploring the environmental situation and actors until redundant patterns emerge, such that additional interviews and observations do not provide dramatically new perspectives on the topic (similar to *sample saturation* in Strauss & Corbin, 1990). Realistically, the developer may have to stop tracing after depleting willing participants or when time and funding run out. Additionally, some actors may not want to participate, the developer should acknowledge and record these actors and their lack of participation. Before moving to the next step, make sure that prominent actors are denoted and that clear patterns of activity have emerged. Write a summary of the codes and themes that emerged and finalize the diagram.
5) **Wireframe and Prototype**. Contact the actors who wished to participate in the wireframe and prototyping of the technology. Present the summary and diagram

developed from your tracings. Engage the actors in workshops, storytelling, role-playing, design games, low-tech models, and cooperative prototyping as a way to generate new ideas, test the effectiveness of the technology, and invest actors in the technology's success (Davis, 2009).

*Ask:* What are the actors' response to this technology?

6) **Release and Promote.** After developing a prototype of the technology, connect with the actors who agreed to promote the technology with their connections. Arrange for dedicated staff to routinely:

   - collect user feedback, ranging from surveys to observations of the technology's use
   - Stimulate engagement with new and existing users
   - update the app according to user needs and software requirements

*Ask:* How can we engage actors in use of this technology?

In summary, the actor diagramming and tracing method offers an alternative process to understand environmental situations and devise ways that technology can mediate their solution. Compared to similar descriptive theories (i.e. distributed cognition, social network analysis, activity theory, knowledge mapping) the diagramming method offers simple steps with which actors can identify the relationships that they perceive and experience among human and nonhuman actors in an environmental situation. The method also encourages participatory involvement of actors through all stages of a technology's development, which can reveal the reciprocal influence of human and nonhuman actors to enact solutions to environmental problems.

## Applying a New Method

To illustrate my method, the following sections describe my application of the method to create a mobile phone application prototype aimed to assist family forest owners in North Carolina, U.S.A., in sustainable forestry practices on their land (*second intervention*). I also developed a second prototype following the conventional method of SPT development (*first intervention*). I describe both prototype development processes to show how application of each method changes the description of the environmental situation and the types of frames used in the technology's design.

To show the differences between the two methods, I ask the following research questions:

RQ 1: How do the elements of the development *activity* differ between the first and second intervention?

RQ 2: How do the *problems/solutions* identified during the development activity differ between the first and second intervention?

RQ 3: What differences emerge in the *frames* developed in the first and second interventions?

## Methods

As my key contact for the development of the prototypes, the North Carolina Cooperative Extension Forestry provided supplementary funding for supplies and gave feedback on the study procedures, which the North Carolina State University Institutional Review Board (IRB) deemed exempt from review (Exemption #5424). Following the conventional development method, the first intervention consisted of several facilitated

meetings with staff from two environmental organizations, which lead to creation of the intervention one prototype. Following my proposed method, the second intervention included a series of interviews and observations with a range of actors, the data from which I coded and used to construct the intervention two prototype. The remainder of this methods section is organized following my research questions.

**Research Question One**

To address Research Question One, I needed to identify the activity system of each intervention and describe how the development activity differed between the two. For intervention one, I created a facilitation agenda for each meeting. As each meeting progressed, I collected data on the meeting activity by recording my thoughts on the development process in real time through quick notes in the margins of my agenda. Immediately after each meeting, I reviewed and reduced my notes into a summary that brought together key words, materials, and activities, which were then mapped onto an activity system diagram.

After each interview and observation for intervention two, I collected data by either making notes or creating an audio recording describing key words, materials, and activities. I combined my notes into summaries, which I then mapped onto an activity system diagram. In the results section, I show and describe the differences in activity between the two interventions.

**Research Question Two**

To address Research Question Two, I needed to identify how and why different problems and solutions emerged with and without use of the proposed method. To do this

for intervention one, which followed the conventional method, I created an agenda (Table 4.1) that would help me to facilitate a discussion among two staff members from the North Carolina Cooperative Extension Forestry and one staff member from the American Forest Foundation. The combined experience of the staff at these meetings equated to decades of experience in forestry education; thus, staff had a very good sense of the challenges and needs of the target audience for the mobile app.

The discussion with the three staff members occurred on November 5, 2014, and lasted for one hour. The purpose of the meeting was for the three staff to identify and discuss the problems and solutions to promote sustainable family forestry in North Carolina. To build my initial diagram for intervention two, I asked staff to list human and nonhuman actors involved with family forestry and to provide contact information for people whom I could interview and observe. I audio-recorded the meeting and took notes on what staff said during the meeting; my intern, Tarang Malaviya, assisted with note taking. In preparation for the second meeting, which focused on developing the mobile app frame, I asked staff to research and bring example eco-apps. Because staff identified the primary problems and solutions during the first meeting, I address Research Question Two with summaries of their statements.

Table 4.1

*Excerpts of facilitation agenda.*

| Time | Excerpt |
|---|---|
| 9:30am | Introductions and review of goals for the meeting |
| 9:40am | Create diagram of human and nonhuman actors. Facilitator questions: Who is involved in land management? What tools do they use? (who, what, when, where, why, how) |
| 10:00am | Envision the end user and topic. Facilitator prompts: Start with role-playing how landowners manage or interact with their land. What are the problems they encounter? How might they solve these problems? |
| 10:20am | Review IRB forms |
| 10:30am | Discuss next steps |

To identify the problems and solutions through use of an actor diagram and tracing method (intervention two), I needed to start with a preliminary diagram. I created the preliminary diagram on November 1, 2014, using the suggestions of the staff from the first intervention (Figure 4.3). I chose to separate the human and nonhuman actors to make it easier to find and reference actors during interviews; however, I acknowledge that separating actors in this way influenced understanding of the actors involved. I showed the diagram to actors at the end of each interview to avoid influencing their responses to questions about actors' relationships.

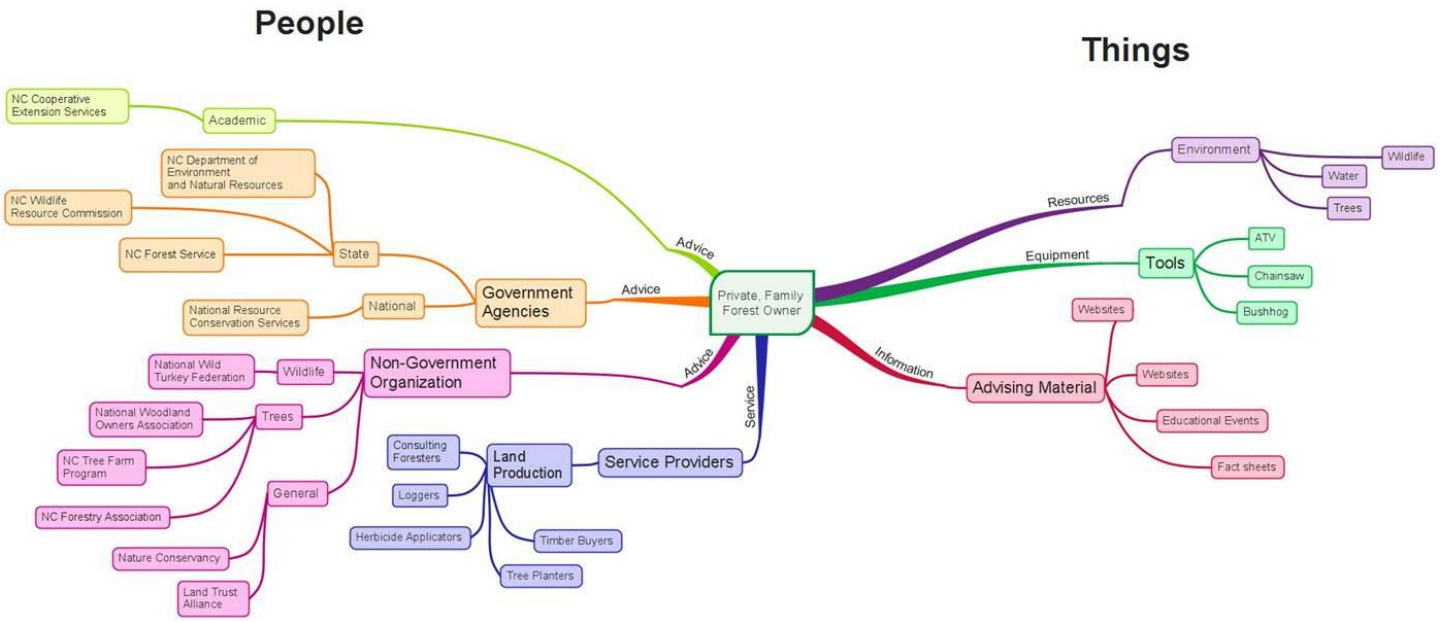


*Figure 4.3.* Preliminary diagram.

I started by tracing actors for whom I had contact details, mostly agency, non-profit, and business staff. I needed access to the end user (family forest owners), so after conducting research online, I found the North Carolina Tree Farm Program. Staff at the Tree Farm Program provided contact information for landowners. After setting up interviews, I started tracing the actors in my preliminary diagram on November 1, 2014. As my tracings progressed, I used the input from interviewees and added actors to the diagram. I finished observations and interviews on May 19, 2015.

During my tracings, I used audio recording equipment, a paper notebook, and my camera phone. I conducted one to two hour interviews with eight forestry professionals from industry, government, and the nonprofit sector specializing in a range of areas such as education, consulting, timber buying, timber selling, land accrual, and soil and water ecology. I conducted interviews and observations with five landowners from five different counties in North Carolina for two to three hours each (Figure 4.4). Landowner demographics were representative of landowners across North Carolina: male, Caucasian, and age approximately 55 to 65 years old. My sample included owners who inherited their land and those who purchased it, those who resided on their land and those who lived in cities away from their land. Though I had hoped to include participants with a range of demographics, but I either could not get their contact details or they did not respond to my inquiries. If I had had more resources, I might have been able to expand my demographic base, which would have led to more insight concerning the environmental situation. In total, I conducted approximately 25 hours of interviews and observations from November to May with the actors in my diagram.

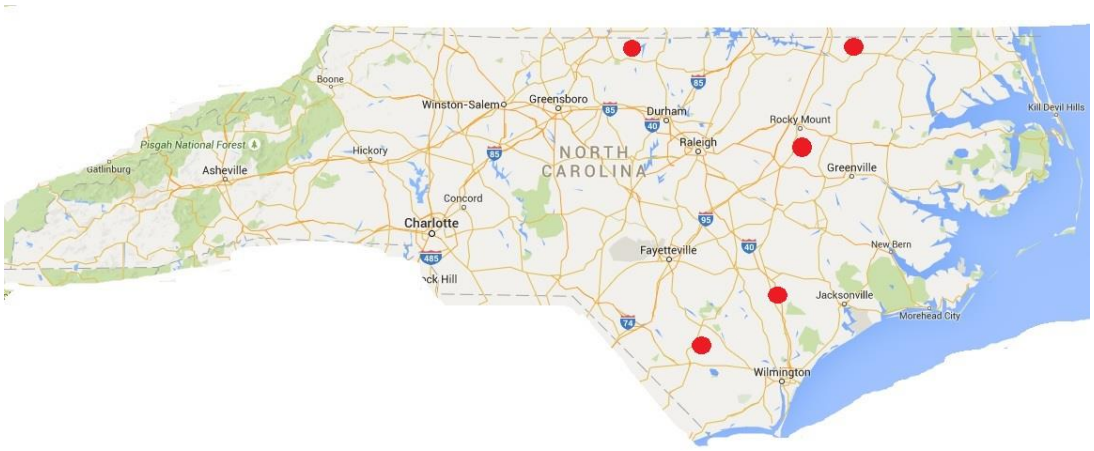


*Figure 4.4.* Red dots represent the locations of landowner observations.

My interviews, observations, and interactions consisted of an initial set of questions (excerpts, Table 4.2) and expanded on site with follow-up questions, all of which traced actors using who, what, when, where, why, and how prompts. As I interviewed and observed human actors, I inquired about nonhuman actors, such as equipment, trees, computers, and animals, through touch, sight, smell, and hearing. For example, one forest owner showed me beetle damage to a tree, and a forestry educator recommended that I become a member of an online landowner support program to see the types of materials offered to landowners. I recorded these experiences through my audio recordings of interviews and on a notepad, data that was included in my coding process.

Table 4.2 *Excerpts of interview and observation questions*

| |
|---|
| Forestry Professionals<br>1. *What* did you do on your most recent trip to advise a family forest owner?<br>i.Follow-up: *Why* did you say… while talking with the forest owner?<br>2. Show me *what* educational materials you use to help family forest owners.<br>.Follow-up: *When* do you present these materials to forest owners?<br>3. *What* do you think is the most important thing to tell family foresters about managing their forest?<br>4. *What* do you think are the concerns and aspirations of family forest owners?<br>5. Please draw on this diagram people and things *whom* you think influence family forest owners.<br>6. If you could design a mobile app to help landowners manage their land, *what* would it look like and do? |
| Family Foresters<br>1. Show me *what* you do while managing your forest.<br>Follow-up: Can I touch, hear, and/or smell that plant, animal, tool, etc.?<br>2. *Where* or from *whom* have you learned the most about forest management practices?<br>3. *How* did you first get started in managing your forested land?<br>4. *What* are your concerns and aspirations toward managing your forested land?<br>Follow-up: Show me the things or places in the forest that concern and inspire you.<br>5. Please draw on this diagram people and things *whom* you think influence your management practices.<br>6. If you could design a mobile app to help you manage your land, *what* would it look like and do? |

At the end of the interview, I showed the diagram and asked for suggestions as to the human and nonhuman actors involved and the actors they thought were most influential in promoting sustainable forestry practices. After each interview, I updated the diagram to reflect what the most recent interviewee had said. The final diagram (Figure 4.5), shows how the tracing process expanded the diagram to nearly twice its original size, with "key" actors identified by interviewees bolded in red. After several interviews, the responses to questions

that I asked included the same type of information that I had heard in several previous interviews. Since interviewees were no longer giving any new information to the same questions, I recognized that I had achieved sample saturation (see Strauss & Corbin, 1990).

To make analysis simple, I transcribed my field notes and reviewed the photos that I took and then added these materials at the end of the interview transcriptions. The interview transcription process included typing out participants' words, including mispronounced words and slang words; however, the transcriptions did not include nonverbal sounds (e.g. laughing or sighing) and long pauses or filler words (e.g. ah or um). I performed the initial transcription of 25% of the interviews, and my intern conducted the remainder of the transcriptions, which I cross-checked for accuracy.

To identify the dominant problems and solutions discussed by actors in my tracings, I utilized a grounded theory approach to code my notes, audio recordings, and photographs (Glaser & Strauss, 2009). I wanted to find emergent categories instead of relying on predetermined categories offered by the forestry sector. I trained my intern in the process of constant comparative analysis and how to create codes and categories in the MAXQDA analysis software. Using MAXQDA, we individually created codes based on the data, including codes for behavioral processes and in-vivo statements that summarized stories and events. We also made memos of our codes individually and then met to compare the accuracy of our codes and memos with an inter-coder reliability of 91.7% agreement and a Scott's Pi of -0.043. The data to address Research Question Two comes from the dominant codes and memos that we created related to problems and solutions of sustainable forestry.

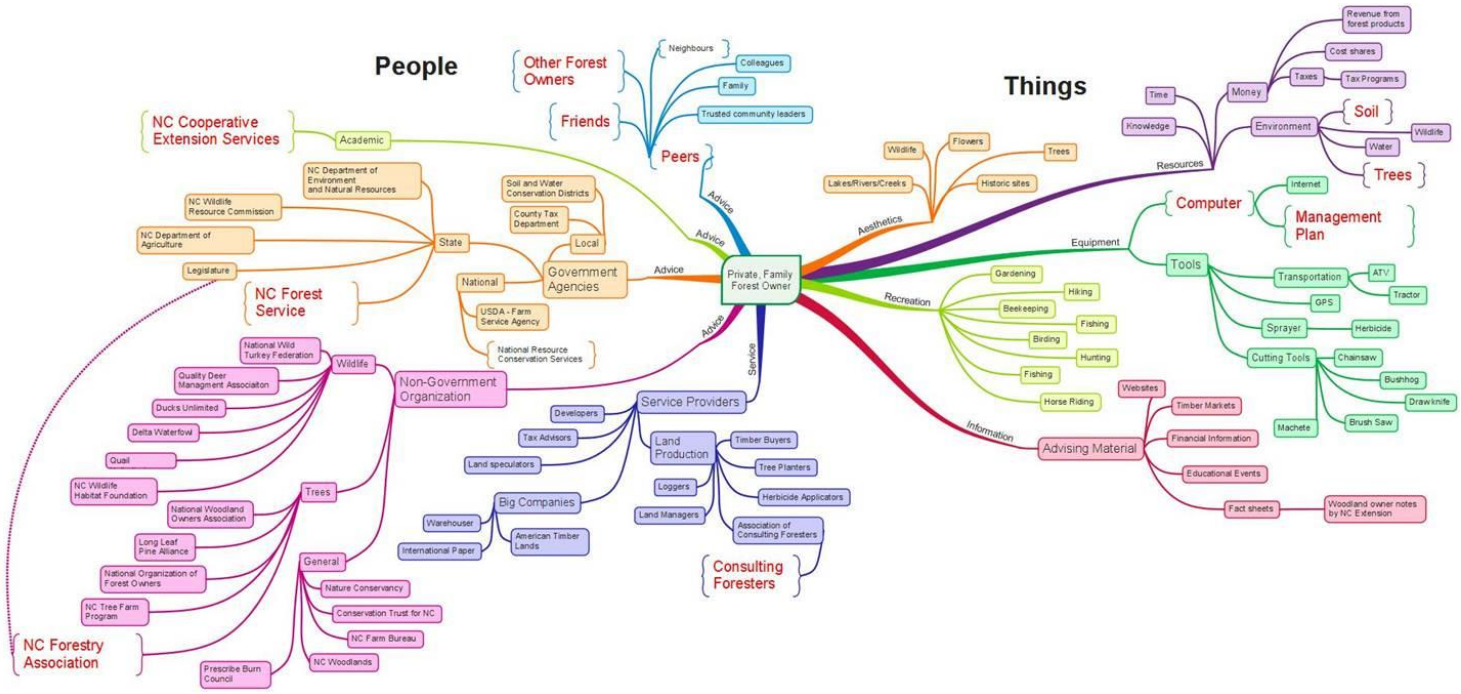


*Figure 4.5.* Final diagram.

**Research Question Three**

To address Research Question Three, I needed to identify how to visualize and animate the solutions and suggestions from Research Question Two into prototypes. To do this for intervention one, I conducted a second meeting, on January 6, 2015, with the same staff members as the first meeting following a facilitation agenda that I created (Table 4.3).

Table 4.3

*Second meeting agenda*

| Time | Excerpt/Agenda Item |
|---|---|
| 9:00am | Discuss the agenda for the meeting |
| 9:10am | Review items from the first meeting: the three groups of users identified (unengaged landowner, semi-engaged, and highly engaged) and the diagram created. Which user group should the app focus on? Based on the target end user, what behavior and factors should the app account for? Facilitator: Provide paper, markers, and clay to participants to help with visualization and discussion. Draw on poster paper visual representation of the key elements participants offer for the app. |
| 10:00am | Participants present their mobile app examples, discuss what features they liked and how those might apply to the app they want to create |
| 10:10am | Reflecting on the visualization and apps, participants draw on the blank wireframe paper their ideas for the app |
| 10:25am | As a group, staff show and explain their wireframe. Facilitator: Guide a discussion with the group on what aspects of the wireframes to keep, drawing on a poster paper an overarching wireframe encompassing those presented by the participants. |

I audio recorded the second meeting and took notes while we reviewed and honed findings from the first meeting toward creation of an eco-app wireframe. Staff also presented the eco-apps that they found and, after a short discussion, they sketched wireframe drawings depicting how they wanted the final app to look. We discussed the wireframes as a group to confirm the overarching design vision. I did not impose a requirement for the group to reach consensus on the app; instead, the participants themselves saw the goal of the meeting to

discuss, deliberate, and combine their ideas into a single vision. However, not all staff were able to complete their wireframes during the meeting, so these had to be combined with the overarching vision a few days after the meeting. With assistance from my intern, I combined the remaining wireframes from staff into a singular wireframe drawing representing the group's vision of the app.

Using the prototyping software, Proto.io, I created an animated prototype of the wireframe drawing. I chose Proto.io because the design interface allows: 1) the developer to import their own images, which meant I could use images from interviews and observations, 2) users to engage in simulations with the prototype on their phone, which would allow for testing of the prototype in the future, and 3) use by industry leaders in design, such as IDEO. Staff approved the prototype as representative of their vision on May 19, 2015, during a one-hour presentation of the prototype. Research Question Three, in the results section, includes a description of the prototype frame and animation used and several images of what the interface looked like.

For intervention two, my intern and I reviewed the codes pertaining to interviewee's suggested eco-app design and the overarching themes that we found in our memos of the coded data. Using these findings, we brainstormed a way to visualize the data into a wireframe drawing. I then used this wireframe to create an animated prototype using the prototyping software, Proto.io. The images and description of the prototype can be found in the results section under Research Question Three.

## Results

The results of Research Question One provided qualitative and quantitative evidence about differences at the activity level when using and not using a participatory design approach. Albeit simple, an increase in community resources stimulated exploration of the nuances in sustainable forestry practices on family owned land in North Carolina, U.S.A. The results to the second research question explicate how and what types of nuances appeared due to the diagramming method, such that the problem and solution to fostering sustainable forestry practices expanded in complexity from those identified without the method. Finally, the frames produced in each of the interventions included similar themes, such as the use of GPS to locate things and the use of place-based memories to develop sustainability practices. However, the frames differed in their design, with the first intervention using a gamified process that focused on expert advice, while the second intervention's frame used a social networking process to encourage collaboration among experts and novices.

### Research Question One

Research Question One asked, "How do the elements of the development activity system differ between the first and second intervention?" As presumed by SPT scholars (Brynjarsdóttir et al., 2012; DiSalvo et al., 2010; Goodman, 2009) the use of a participatory design approach altered the development activity by making new resources, both human and nonhuman, available.

The activity system using the conventional development method (Figure 4.6) included a limited number of community members, tools, and rules. This meant that the

perspectives available during the brainstorming meetings limited conceptualization of the environmental problem and solution. Additionally, since the end users were not present during the meetings, assumptions had to be made about their relationships with nature and technology.

The activity system using the diagramming method (Figure 4.7) included a range of community members, which led to increased tools and rules to the development activity. For example, after interviewing a timber buyer, the relationships between family forest owners, sustainability practices, and selling timber became evident. Also, chance encounters with snakes and huge ant hills during my observations of family forest owners brought new stories and understanding of the interconnectedness of the ecosystem and landowner. Additionally, through direct interactions and inquiry with end users, their relationships with nature and technology were made apparent.

Reflecting on the differences afforded by each method, I found the diagramming method resulted in a snowball effect of meanings and perspectives that informed subsequent tracings. In the first intervention, the community was limited, thus limiting the division of labor. However, the second intervention expanded the *community* and *division of labor*, which changed the outcomes of the activity system to better accommodate the complexity of the environmental problem and solution.

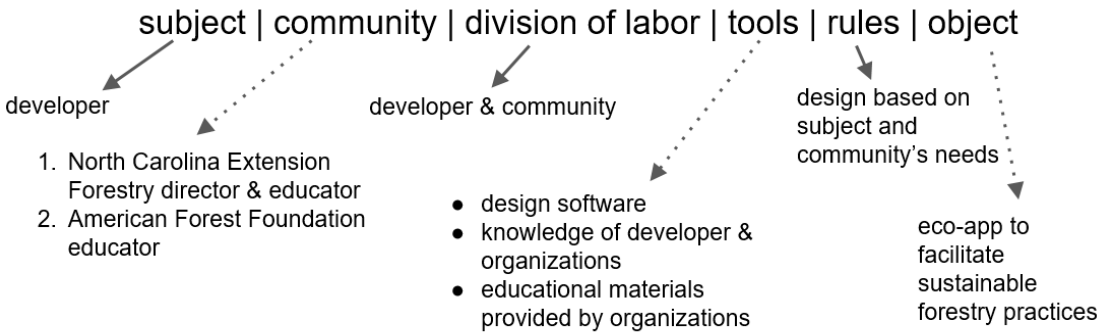


*Figure 4.6.* Conventional activity system


*Figure 4.7.* Diagram activity system, new components in black font.

**Research Question Two**

Research Question Two asked, "How do the *problems/solutions* identified during the development activity differ between the first and second intervention?" In the first intervention, staff from the North Carolina Cooperative Extension Forestry and the American Forest Foundation described family forest owners as interested in sustainability but unable to implement practices because of difficulty in documenting management practices and gaining new knowledge (Figure 4.8).

Staff gave the example of a forest owner who wanted to treat an overgrown invasive plant but did not know how. Staff explained that the owner would seek out education and assistance through workshops, Extension contacts, or the internet to identify what she could do on her land. She would also document on a paper map parts of the land with the invasive plant and the types of management practices used over time. Paper documentation often became tricky over the 30-year or more life span of a tree stand because of the many land management practices enacted during that time. To improve the recording and implementation activities of landowners, organization staff of the first intervention proposed a journaling eco-app that would allow forest owners to use GPS to document various tracts of land, record activity in the forest, receive suggestions for sustainable practices, and connect with educational organizations through websites, phone, and email (see Results RQ 3 for visualization of the solution).

In the second intervention, problems and solutions emerged through the questions and interactions that I had with actors. I identified the most often discussed and displayed problems and solutions by analyzing the interviews, observations, and interactions that I had

with human and nonhuman actors. The overarching problem for landowners to implement sustainable forestry practices occurred because of the complexity of land management as a whole, which required landowners to account for physical, cultural, and social factors (Figure 4.9).

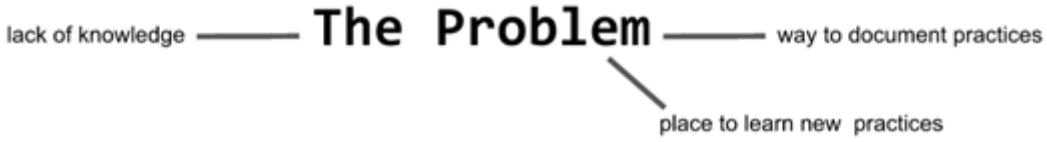


*Figure 4.8.* Problems identified in the conventional method.

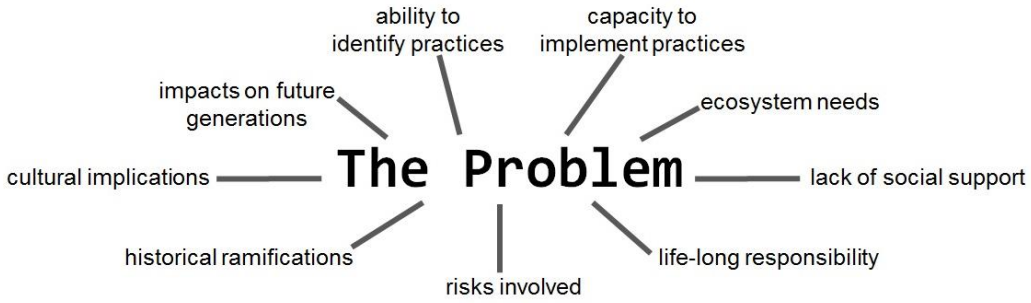


*Figure 4.9.* Problems identified with the diagraming method.

Actors of the second intervention brought forth the complexity inherent with managing a forest, which included the challenge of developing and maintaining a large network of supporters who could facilitate thoughtful management decisions. The analysis of my tracings repeatedly brought forth the following statement, forestry and timber harvests are a "once in a lifetime chance." Both forest owners and organization representatives noted that most forest owners start managing their land in their 40s or 50s and, since it takes 30 years to grow a tree stand, the owner would only get one chance to see their forest reach

maturity. In that statement, participants stressed the word *chance*, explaining that every decision that a landowner made carried considerable risk that compounded over the years, impacting the health of their forest and the benefit possible to future generations. Landowners explained future generations as their family and people in general.

Very experienced landowners also discussed the 'once in a lifetime' statement; however, they dismissed it, explaining that they could sustainably manage their forest and harvest timber multiple times in their lifetime because of suggestions from their strong and wide social network (Figure 4.10, one strategy for multiple harvests). Seasoned landowners described the important role that their social network played in assisting them during difficult and complex stages of the forest's and land owner's life.

*Figure 4.10.* Multi-age tree stand, six to 20 years old, on a landowner's parcel.

Staff from forestry related organizations and landowners emphasized and demonstrated how every decision they made needed to account for the complex cultural,

social, and physical composition of the land and people on it. The physical composition of the land determined much of what a landowner could do, a key to understanding the complexity of enacting sustainable forestry practices on one's land. For example, the management practices that worked for a neighbor may not work for the landowner because the ecosystem on her parcel(s) differed by tree variety, soil type, water quality, and wildlife.

While moving through landowners' forests, the intricate role of trees became evident. Often the landowner would stop and point out tree damage from beetles, fire, and lightning, which would bring forth stories of the risks involved with living on the land. One landowner pointed to a young tree stand in his forest and explained the irreparable damage that a hurricane had done a few years back. He explained how trees were snapped in half, making it nearly impossible for the forest owner to generate enough income from the fallen trees to replant them. He also lamented the loss of a 'snag' where a pileated woodpecker had made its home. The owner explained how he leaves standing dead trees in the forest for birds to make their snags, even though the practice does not increase his income. This example, along with others I heard from landowners, brought to life the intrinsic value that the forest ecosystem had.

During another observation, a landowner showed me a culvert overpass that he had constructed to gain access to his land. As we stomped through poison ivy and swampy waters, he explained how the yearly floods of "mother nature" kept destroying the overpass. He explained that mother nature did not stop until he learned how to work with the watershed instead of against it. Though it took considerable time and money for him to rebuild the overpass multiple years in a row, he said that it was his "first lesson in learning to

listen to the land". This example illustrates a biocentric approach to land management that other interviewees shared and that I looked for during the interviews. This landowner's statement highlights similar statements that I heard throughout the tracing process, which was the importance of working with the land instead of imposing one's personal will upon it.

While keeping in mind the ecology of the land, owners also needed to consider the impact of historical and cultural legacies. Landowners emphasized how their management would affect the ecosystem of their children and grandchildren, by telling stories of historical management practices that impacted the ecosystem that they experienced (such as using pine tree tar for sealing shipping vessels in the 1700's, see Figure 4.11). One landowner explained how his family had owned a significant stretch of land in the area since the 1700s, but because of hard times during the great depression, his grandparents had to sell off most of the land. Over the years, he had learned from his family, mentors, and the land how to make the most of it, which allowed him to slowly buy former pieces of his family's land. For example, by increasing wildlife habitat and offering hunting leases for a price, the landowner acquired additional income (see Figure 4.12).

For this landowner, along with nearly all of the others that I interviewed, building a diverse and healthy forest was an important legacy to pass to their children and future generations. Just as income from tree harvests was important to the families' budgets, the experience of being in a vibrant forest ecosystem was important to building bonds between familial generations by watching birds, tending beehives, or simply walking in the woods. Participants were greatly aware of the future that they were planting for themselves and their children through each decision that they made on their land.

A forest professional aptly summed up the complexity of parcel management:

When we get calls we try to not get too detailed because everybody's property is a little bit different. It's hard to give a good response to a landowner without seeing their property, or their timber, without having to really sit down and kind of tease out what's their real motivation, what's their real objective.

*Figure 4.11.* A tree cut to demonstrate the tar collection process of the 1700 and 1800s.

Figure 4.12. *Landowner points to tree species planted to provide food for wildlife.*

Participants explained that the most important component to their management was their social network, which consisted of supporters whom they could trust to help them make complex management decisions throughout their life. Mentors played an influential role in identification and implementation of sustainable practices and included staff at non-profits, educational institutions, government agencies, businesses, neighbors, family, and friends. Mentors had physically visited the land, built a relationship with the landowner, understood the cultural and ecological relationships formed over time and suggested management activities that achieved both human and ecological balance.

Additionally, I observed, interacted with, and asked landowners questions pertaining to the nonhuman actors in the forest and those with whom they engaged outside of the forest. By asking about nonhuman actors such as plants, animals, computer programs, and equipment, I was able to elicit relationships between the actors that would have gone unnoticed. Often the forest owner would explain their management practices at a site and prepare to move on, but when I would inquire further about the role of nonhuman actors, taken-for-granted connections emerged, and a much richer understanding of the human-forest relationship appeared. Spontaneous interactions also provided rich opportunities for exploration. For example, when a snake passed in front of the vehicle a landowner and I were in, the landowner stopped and pointed to the snake and excitedly told the story of the snake's importance in the forest ecosystem. Through experiences and stories such as this, I was able to make present nonhuman actors in the forest and their influence on human actors.

Drawing together the codes and categories from the interviews and observations, along with interviewee's suggestions for their 'ideal' forestry app, my intern and I came to

the solution of a social networking eco-app. The eco-app would allow the user to connect with other landowners and organizations to build a trusting relationship, glean valuable information, and support each other (see Results RQ 3 for visualization of the solution).

Comparing the problems and solutions identified between the two interventions, the diagramming method allowed for a much more nuanced description of the environmental situation to emerge. The nuances of the environmental situation revealed the relationships among actors, including nonhuman actors, which are important to the practice of sustainable forestry.

**Research Question Three**

Research Question Three asked, "What differences emerge in the *frames* developed in the first and second interventions?" In the first intervention, the frames for the eco-app materialized through wireframes drawn by staff of the North Carolina Cooperative Extension Forestry and the American Forest Foundation during the last meeting I facilitated (Figure 4.13).

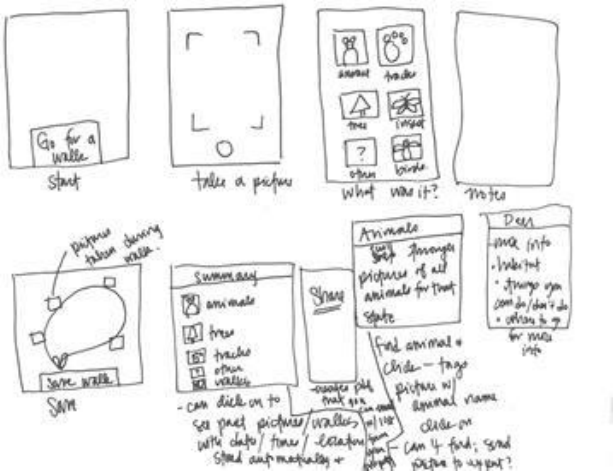


*Figure 4.13.* An NC Extension staff's wireframes.

During discussion of the wireframes, the staff agreed that they wanted a gamified journaling app that would allow users to map routes and tag locations with images and notes and learn new forestry practices. As the developer, I materialized staff descriptions and wireframes into a working prototype (Figures 4.14-4.16). The staff envisioned users tagging locations as a way of recording and learning new sustainability practices.

First, users would make a note on the map of a new item, and they would be prompted to photograph it and then identify it (Figure 4.14). After identifying the item of interest, users were provided with suggested management practices with links to images, videos, and contact details for experts in the area (Figure 4.15). Users could also see their expertise level (Figure 4.15), such as junior and deputy, which was linked to the number of forestry practices completed. Eventually, users would end up with several management maps that they could title to identify points of interest such as historic sites, honey bee colonies, trail damage, invasive species, bird nests, equipment, etc. (see Figure 4.16).


*Figure 4.14.* Tree species identification.


*Figure 4.15.* Management tips and goals.


*Figure 4.16.* Mapping edibles.

The app that was designed using the diagramming method required more work from me, as the developer, because I needed to bring together interviews and observations through coding and analysis and not simply do what a select group of forestry experts told me (as was the case with intervention one). Using grounded theory, I found that the frame most

representative of the human and nonhuman actors involved in forestry was a social networking app similar to Facebook. Forest owners and forestry professionals who were interviewed said that they wanted an app that connected them to forestry organizations, neighbors, and users, which I think is a big part of their ability to build the lifelong relationships on and offline that are needed to engage in sustainable forestry.

The human actors who were interviewed explained the importance of getting to know other people and their forestry interests to building relationships and collaborations. The manifestation of this need came in the form of a biographical page (Figure 4.17, *note: stock image and factious name used for example page*) where users could note their role in forestry (i.e. landowner, non-profit, government agency, business, etc.), document their goals for land management (current and future management practices), their experience in forestry practices, tools/skills they could share with the community, recommendations by others, latest news, contact information, and, if desired, their picture.

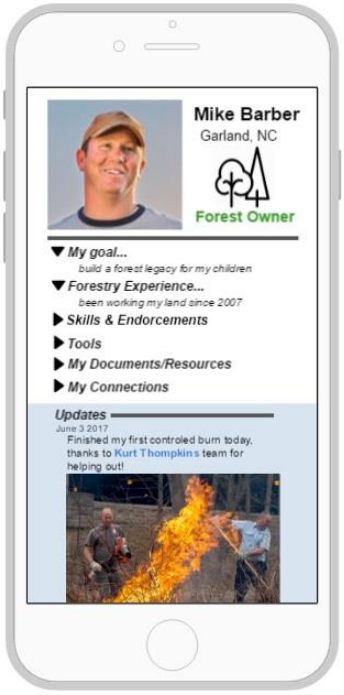


*Figure 4.17.* Biographical page.

Bringing to the forefront the diverse ecological systems at each site, the frame offers ways to find mentors geographically nearby who could physically visit users. Similar to Yelp! features, users could search people, organizations, skills, tools, and other resources based on their location (Figure 4.18, *note: stock images used with factious names*). By focusing the app on locating people who could visit the land, the users of the app could more readily incorporate management practices that would also support diverse ecosystems on their land.

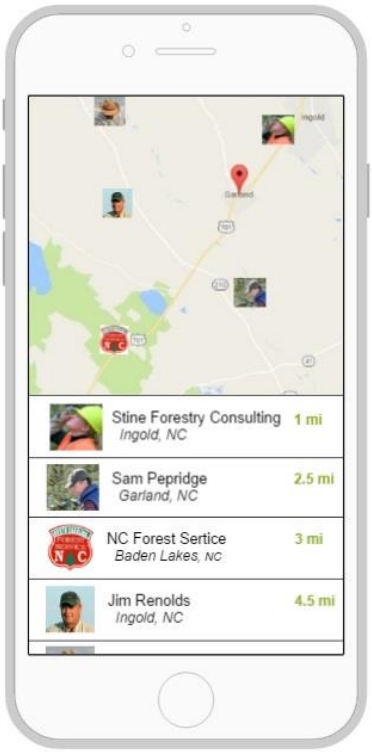


*Figure 4.18.* Biographies locatable via map.

Finally, landowners mentioned the importance of keeping up with the management practices of neighbors such as hiring and sharing a burning crew, to learn new practices and conserve resources and to learn about changes in regulations and invasive species in their area. Additionally, organization staff mentioned the need to keep tabs on landowners to know when to offer appropriate support and recommendations. To address this, I developed a news tab that would allow users to keep up with the latest news of those they followed (Figure 4.19, *note: stock images used with factious names*). The news tab also benefits nonhuman actors in the way that it allows experts and nonexperts to share stories of ecological changes within their forest and gain deeper appreciation for the intrinsic value of plants and animals. For example, an experienced landowner might post a picture of a snag

on his land and explain its importance in his forest's ecosystem. A novice landowner can see the image and inquire to meet with the landowner to learn more.

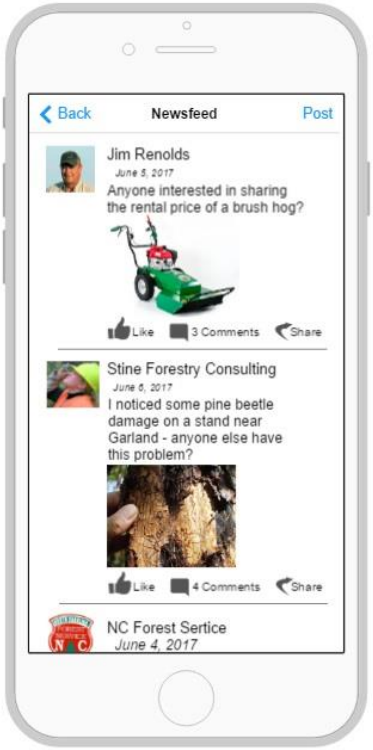


*Figure 4.19.* Newsfeed for sharing tools, skills, and management practices.

Several similarities and differences arose between the frames created with each method. Both methods produced frames focused on geography with features pulling data from the user's GPS and placing content on a map for the user to access. However, in the first intervention geography was used to bring together the tasks and resources of the landowner by tagging where invasive plants needed to be removed or by recording the location of food bearing plants. These tasks were then connected to generic sustainability suggestions from forestry professionals, which the landowner could choose to implement.

The frame produced by the second intervention used geography to bring together the many actors involved in sustainable forestry by offering ways to share machinery, learn about plants of the area, or meet neighbors. Through the newsfeed and ability to connect in-person, the tasks offered were more personal and less generic.

Both methods produced frames that were focused on memory of sustainability practices on the land. The app frame in the first intervention provided users with a linear way of recording their practices on the land. For example, a landowner could note what practices he did, when, and where through the app, which he could use to remember his practices at a later date. On the other hand, the app frame of the second intervention offered users a way to produce cyclical, living memories. These memories were produced through continual interaction on the newsfeed and through in-person meetings with people and things. These 'living' memories could occur through the interactions of actors at various times of the year. These interactions could also change from year to year, due to changes in social, cultural, and ecological factors, in a much less linear way than the first intervention.

Finally, the app frames differed in the way that they prompted sustainability tasks. The first intervention offered users a gamified frame where users would advance through various levels by completing the tasks in the app. The tasks in the app were written by forestry professionals, meaning that the ability for a user to advance required acceptance of an expert's knowledge over the user's own experience and knowledge.

The app in the second intervention offered users a social networking frame where users moved through the app by creating connections and sharing information with a range of users, both expert and novice. Instead of encouraging users to follow an 'expert's' advice,

the app asked users to interact with one another and the environment to generate appropriate action.

## Discussion

The overarching question of this research was, *How does a participatory design process and its outcomes differ from conventional development of a sustainable technology in the way the processes frame understanding and interaction with environmental problems?* Reflecting on this question, I found that a participatory design process, specifically the actor diagramming and tracing method, changed the framing of the environmental problem and user role.

Two problem frames emerged through the conventional method. The first frame focused on the difficulty that end users encountered when trying to maintain location based records of management practices over consecutive years. The second frame recognized the challenge that landowners had in gaining knowledge of new management practices that appropriately fit their needs.

The use of the actor diagramming and tracing method brought forth a more nuanced set of problem frames in relation to land owner behavior and forestry practices. These frames included the difficulty that landowners had in identifying and implementing sustainability practices that appropriately fit their ecosystem's needs but also took into consideration historical and cultural ramifications. Additionally, a lack of social support throughout the lifetime of the landowner and forest made it difficult for the landowner to accurately account for the risks related to implementation of specific land management practices and the impacts of practices on future generations.

Therefore, the problem frame of access to new and appropriate management practices emerged as a common theme in both design processes, yet the reasons why differed, mainly between a lack of documentation versus a lack of social support. Additionally, both problem frames recognized the complexity inherent in managing land over a number of years, yet the nuances of this frame differed, with the standard design frame focusing on recording of practices and the diagramming frame focusing on negotiating a careful balance between human-nature needs. Finally, both problem frames included a locative component; however, the conventional frame focused on the problem of pinning parts of the forest to a map, and the diagramming frame identified the challenge of locating mentors.

The frames that were used to communicate the user's role in sustainable forestry practices also shared overlap between the two design processes but differed in the details. The user frame generated in the standard design process focused on user acquisition and achievement of knowledge levels, moving from novice to expert. Users became experts by tagging and identifying elements of their forest through the app's guidance. Then, following the practices suggested by forestry experts, the user could advance to the next knowledge level. The user frame generated through the use of the diagramming method focused on the user networking and discussing forestry practices with other users. Networking and discussions occurred by way of a social networking interface where users could post status updates of their current projects, make suggestions on others' pages, inquire about tool sharing, and use a map to locate and meet users in-person.

The user frames generated in both processes intersected in their focus on the user as a learner, yet learner took on different connotations in both. In the frame derived with the

standard design procedure, users were subjugated to the knowledge outlined by experts in the prompts. On the other hand, the diagramming method framed the user as a learner who is also a teacher, making the user role one of sharing knowledge and negotiating sustainable practices with others. Additionally, the diagramming method led to expansion of the end user from a landowner to include people at government agencies, business, nonprofits, neighbors, friends, and relatives.

Comparison of the activity elements within each development process provided insight into how similar yet distinctly different frames emerged. The activity elements in play with the standard design process created a closed loop system where the organization staff described the behaviors of landowners and offered specific designs for the prototype without input from users or other organizations. Though the staff had decades of experience with landowners in North Carolina, they still had to draw assumptions about the problems that landowners faced and how a technology could mediate new solutions.

The activity elements of the diagramming method led to a divergent yet intersecting system. The perspectives of staff from non-profits, government agencies, and business, along with family forest owners opened new understandings of the problem and possible technological solutions. Following the diagramming method, I did not have to make assumptions about the end users or their relationships with nature and technology.

Overall, the standard development process brought forth the understanding and creation of a technology that addressed generally applicable sustainability practices, which any landowner could implement. However, the diagramming method brought forth the complexities inherent in applying general practices on land with unique ecosystems,

historical, and cultural heritages. The diagramming method required additional effort on my part to organize into a problem and technological solution. Instead of following the wireframe of experts, as I had done following the conventional method, I had to interpret the needs of actors into a wireframe drawing. I could have made the development process even more participatory by involving actors in the data collection, coding, and development of wireframe drawing, but I was unable to do so during this study because of money and time constraints.

The results of this study reflect broader findings in environmental public participation literature of the importance and value of incorporating stakeholder feedback to gain unique insights and expand understanding of the influential relationships between human and nonhuman actors (Fischer, 2000). This presentation of findings shows how a participatory method involving human and nonhuman actors results in deeper, more nuanced understandings of the relationships among actors constituting complex environmental problems and technology design that considers the activity of nonhuman actors as part of the activity of human actors.

Thus, the diagramming method reflects crucial aspects of participatory democracy such as the ability of actors to discuss topics affecting their lives, decide how they will participate in the final technology, and gain input throughout the development process (Depoe & Delicath, 2004). However, the method does require a considerable amount of time and money to connect with, interview, and observe a wide range of actors. The investment in this effort though, is not without its payoff. If technology developers truly aim to intervene in specific relationships of specific actors to improve environmental outcomes, only a

method that reveals the nuances of these relationships will be able to offer solutions that will effectively intervene in and alter these relationships.

**Implications and Future Research**

The two illustrations that I present in this chapter show how the development process of sustainable persuasive technology (SPT) can lead to different framing of environmental problems and solutions. This is an important finding because the framing of an environmental situation impacts the roles that users take to identify and solve these problems. Often, users are blamed for not appropriating technology in ways that lead to more sustainable outcomes. Yet these illustrations point to technology as a mediator of perspectives and roles that guide user behavior. Therefore, part of the problem lies in the way that SPTs are developed. If the current SPT development process is a closed loop cycle, there is little space to account for the nuances of environmental situations. As the illustrations of this chapter showed, if the SPT development process expands to encompass human and nonhuman actors as equally important to understanding environmental situations, then it is possible to account for the ways in which human-nature relationships continually evolve over time.

The diagramming method also elicited perspectives pointing to the complex sociocultural dynamics needed to enact sustainable forestry practices on family owned land. As SPT scholars (Brynjarsdóttir et al., 2012; DiSalvo et al., 2010; Goodman, 2009) pointed out, frames that are too simplistic can blind users to the challenging behavioral changes that need to occur. The illustrations in this chapter showed how following the conventional development method a relatively simple frame emerged, one that outlined sustainability tasks

and advanced users through knowledge levels. Though the SPT that was developed with the diagramming method did not provide any specific tasks, it did create the space to allow users to negotiate and discuss what sustainable forestry meant on their land, for their family, and for future generations.

The illustrations and examples offered in this chapter are just a start to the work that we have yet to do to improve the development of SPTs. First, most SPTs are not developed by a trained social scientist like myself, which means that applications of the diagramming method may not look the same when applied by others. Additionally, most developers do not create two applications on the same topic consecutively, as I did in this chapter. Therefore, my role and experience across the development of the two prototypes may have influenced the outcomes reported here. A diverse range of developers including environmental scientists, policy makers, concerned citizens, and computer programmers should test the application of the diagramming method. Additionally, testing of the method with different software development methods, such as Agile, Scrum, and Waterfall, would also prove insightful.

Second, the technology produced using the diagramming method may look different if more human and nonhuman actors are recruited and incorporated in the data collection, analysis and prototyping stages. In this chapter, I took the role of collecting, analyzing, and visualizing the data provided by actors. However, incorporation of human actors through workshops and focus groups may have led to alternative problem framing and design solutions.

Third, I only applied the diagramming method to one environmental situation. Application of the method to other situations, such as engaging communities to reduce water pollution, encourage sustainable building practices, or improve access to public transportation may reveal other contingencies related to application of the method.

Fourth, distribution practices and testing of these and other prototypes developed would provide additional insight regarding the effectiveness of the SPTs while in use. Many challenges exist to distribute and entice people to use SPTs, especially when people are already inundated with prompts to use technology for other communication and coordination needs.

Finally, the long term uses of SPTs developed with and without the diagramming method may take different paths. At this point, it is unknown which development process leads to effective, long term use of a technology.

## Conclusion

When developing sustainable persuasive technology, it is easy to assume the workings of an environmental situation and role of end users. Of course, using assumptions to develop sustainable technologies is much easier and faster than using a participatory method like the actor diagramming and tracing method. However, as this comparison study showed, developing a technology based on assumptions can miss the nuances of the environmental situation and potentially new and more engaging roles for end users.

The findings of this chapter point to the importance of careful consideration to the development method before jumping into a technology's creation. Future developers and policy makers wishing to fund SPTs need to consider the time, effort, and cost associated

with a highly participatory technology design and the considerable advantages that the method provides.

Finally, this chapter points to an ever more pressing need in the development of SPTs, that of reflecting on where things are and how they got that way. Constantly producing SPTs without reflecting on what worked and did not work does not contribute to the development of truly effective technology on either an environmental change or participatory front. The efforts of SPT scholars (Brynjarsdóttir et al., 2012; DiSalvo et al., 2010; Goodman, 2009), provided a starting place for reflection, yet new SPTs are being produced every year with little thought as to how development methods might impact the technology produced and the outcomes possible. It is my hope that the actor diagramming and tracing method provides a tool with which developers can test, build, and reflect on the future of sustainable technologies and their mediating affordances.

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**Activity Theory Analysis**

The activity system of Chapter Four (Figure 4.21) explores the ways that eco-app development affects the types of eco-apps produced and subsequent outcomes.

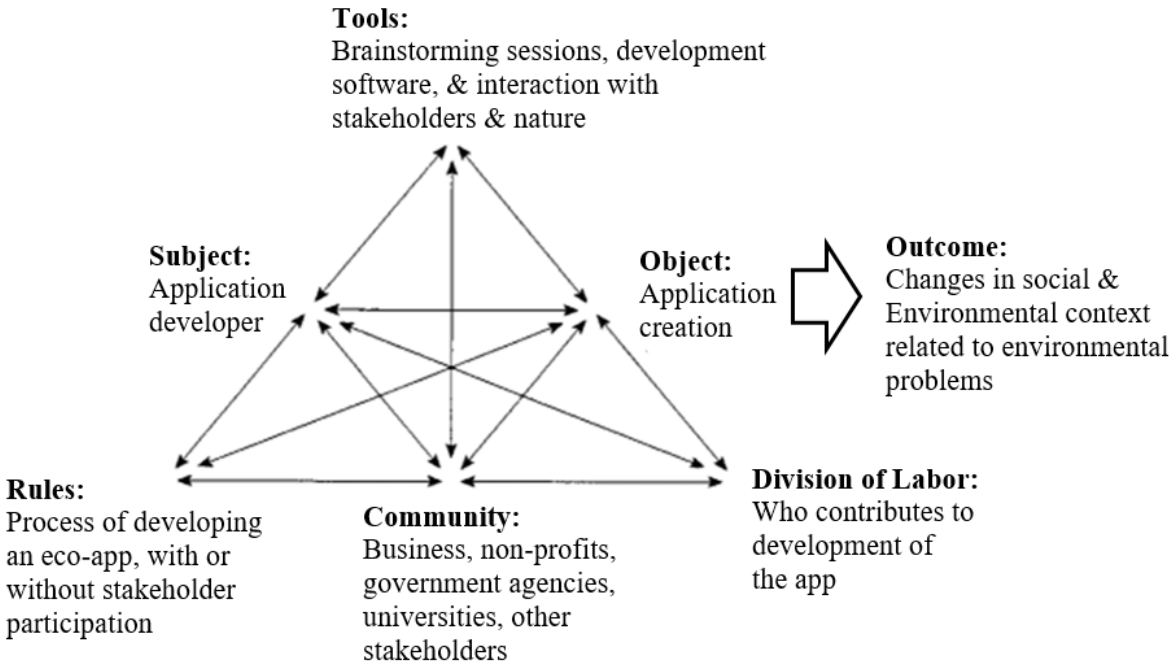


*Figure 4.20.* Chapter four activity system.

Of all of the components in Chapter Four's activity system, the *tools* of the development process, such as brainstorming sessions and interactions with stakeholders and nature, appeared most influential as they directly affected the *subject*, *community*, and *object*, and in turn, the remainder of the activity components. I applied two development methods as *tools* to construct two *eco-apps* (*object*) to support sustainable forestry practices with North Carolina family forest owners.

I used the *conventional development method* (*tool*) to develop the first eco-app, and this process included brainstorming sessions with a small *community* of educational forestry

staff with decades of experience in family forestry. Therefore, the consciousness of the environmental problem and its solution was confined to the knowledge of the three participating *community* members. This knowledge included the belief that landowners had difficulties in recognizing and implementing sustainability practices that fit their ecosystem's needs. The *division of labor* consisted of suggestions by the *community* about the design of the *app* (*object*), while *I* (*subject*) recorded the *community's* design ideas. I then developed the *community's* ideas into a *prototype eco-app* (*object*).

The second *tool* that I used to construct the second *eco-app* was the actor diagramming and tracing method; this method changed the *rules* of the activity to include interviews and observations with diverse *stakeholders* (*community)*. Therefore, the consciousness of the environmental problem and its solution was expanded to include the knowledge of a range of stakeholders. *Stakeholders* included human and nonhuman actors such as staff at non-profits, government agencies, and business, landowners, trees, computers, and wildlife connected to family forestry. The knowledge brought forth by *stakeholders* included the nuances of the environmental problem, specifically the importance of social support in negotiating ecological, familial, and cultural needs to implement sustainable forestry practices. The information that the *community* brought forth further enlarged the *tool* base that *I* (*subject*) had available to construct the second *eco-app prototype*. I then developed a combination of *stakeholder* ideas into a *prototype eco-app* (*object*).

Each method showed how contradictions arise within the eco-app development activity system among the *subject* and *community* depending on the *tools* and *rules* used to

develop the app. Contradictions are problems, breakdowns, or clashes that destabilize an activity system due to misalignment of activity components. When the *rules* and *tools* of the development process lessen the contribution of the *community*, gaps are created in the understanding of how to design the *eco-app* (*object)* to promote the desired *outcomes.* Subsequently, the *tools* and *rules* led to different *divisions of labor* and two different types of *eco-apps.* The first *eco-app* focused on user acquisition and advancement of knowledge in a gamified interface where users moved from novice to expert as they completed sustainability tasks. The second *eco-app* focused on users networking and discussing forestry practices with other users through a social networking interface.

Though both *eco-apps* focused on the *users as learners* (*outcome*), they did so in subtly different ways. In the first *eco-app,* the users needed to learn the knowledge offered by app prompts, and the users of the second *eco-app* needed to serve as both learners and teachers by sharing sustainable practices on- and offline. Additionally, the *actor diagramming and tracing method* not only expanded the *community* of contributors during the development of the *eco-app,* but it also led to the expansion of the end-users from landowners to people at government agencies, business, nonprofits, neighbors, friends, and relatives. By opening up the development process to a broader *community* and using *tools* and *rules* to support exploration of the desired *outcomes,* developers could bridge the gap between the *object* and *outcomes* as identified in the Chapter Three Activity System Analysis.

In summary, the activity system of Chapter Four shows how a participatory development method influenced developers and stakeholders' consciousness of

environmental problems and their technological solutions. By increasing the developer's interactions with a diverse community of stakeholders, the consciousness of complexities and nuances to environmental situations increased for both the developer and community. However, this one application of my participatory development method is not enough on its own to address my overarching dissertation research questions. To fully explore my two over-arching research questions, I need to look across all three chapters and interpret how the activity within each affects a range of mobile phone uses (i.e. calling, texting, eco-apps, sensing systems), and environmental activity (i.e. citizen science, consumer behaviors, social justice). Therefore, I decided to include one last theoretical framework, activity theory. I chose to use activity theory to analyze the activity of all three chapters because it can give a holistic interpretation of my findings relative to the activity of using mobile phones to engage people in environmental activity.

## Chapter 5 : Conclusion: Novel Approaches to Mobile Interventions

Environmental problems involve of the intersections of multiple people, technologies, and ecosystems leading to a network of possible problems and solutions. The previous three chapters show how the networked nature of mobile phones offers unique affordances to address these problems, such as the ability to connect people and nature in real time. My findings show how mobile phones also created environmental problems, through their production, use, and disposal.

My overarching goal with this dissertation was to address:

- What can we learn from uses of mobile phones to address environmental problems?
- How could this knowledge inform design and use of mobile phones for addressing environmental problems?

To understand the complex and multi-dimensional relationships among people, nature, and the technology emergent in my research questions, I took multidisciplinary, transdisciplinary, and integrative approaches. I purposely designed each chapter to be unique from the others, applying multiple theoretical, conceptual, and methodological frameworks to gain multiple disciplinary perspectives to my phenomena (Choi & Pak, 2006). After each chapter, I described the unique perspectives that the chapter's frameworks afforded in exploring my overarching research questions. I also described the ways in which that chapter's frameworks could not account for all of the variables needed to address my overarching research questions. To account for the missing perspectives, I offered new frameworks and a new set of data for the subsequent chapters. Through application of

multiple frameworks, theories, and concepts, I had enough perspectives to address my research questions, which I do in this final chapter.

To summarize (Table 5.1), I took a media history approach (Packer, 2013) in Chapter Two, which showed how a range of historical phenomena related to mobile phone use shifted power relations, discourse, and social outcomes of environmental activity. This perspective afforded insight to the ways that future mobile phone interventions could be designed to facilitate environmental activity. However, the approaches that I used in Chapter Two did not explain how the design of mobile phone interventions led to their appropriation, which is why I needed to apply other theoretical frameworks to answer my overarching research questions. Therefore, I used DeSanctis and Poole's (1994) adaptive structuration theory and Norton's (2007) environmental public participation (EPP) framework in Chapter Three. I also narrowed my study from all environmental activity using mobile phones to only mobile phone applications because eco-apps appeared as the primary means by which new human-nature relationships were developing. The frameworks that I used in Chapter Three revealed how various designs and features enabled users to attain, learn, and contribute to environmental activity and build trust in one another and the software. Yet, these frameworks did not explain why specific designs were chosen and developed over other designs and how those choices affected appropriation of the technology. For Chapter Four, I laid out the findings of sustainable persuasive technology (SPTs) scholars, mainly that current development methods lead to designs that avoided the underlying causes of environmental problems (Brynjarsdóttir, Håkansson, Pierce, Baumer, & DiSalvo, 2012; DiSalvo, Sengers, & Brynjarsdóttir, 2010; Goodman, 2009). I then described my unique

participatory development method that encourages developers to take a more eco-centric approach to understanding and designing technologies. I explained my method, called actor diagramming and tracing, through development of an eco-app to support sustainable forestry practices on family owned land. To show how development methods change the understanding of the environmental situation and technology produced, I created a second eco-app prototype, also supporting sustainable forestry practices, that followed the conventional development method. Though insightful, my illustrations only compared one form of mobile phone intervention and only one environmental situation. With so many ways to design interventions and with so many situations, I needed one more theory to more fully explore my overarching research questions. Thus, in Chapter Five, I apply activity theory to bring together the findings of the previous chapters and address my overarching research questions.

In this concluding chapter, I offer a summary of the activity systems in my dissertation following the recommendations of activity theory scholars. Penuel (2014) recommends using activity theory to bring attention to the history, institutions, and context afforded by a technology's use. Cole and Engeström (1993) encourage use of the theory as a way to understand how distribution of cognition among people, culture, artifacts, and time leads to specific understandings, such as the understanding of environmental problems afforded by mobile phones. I also point out several misalignments, that of the subject's and community's goals and the resources available and labor division, lead to contradictions in the activity systems, contradictions that limit people's ability to use mobile phones to support environmentally friendly activity.

Table 5.1

*Frameworks used in this dissertation.*

| Chapter | Title & Research Question | Frameworks | Disciplines |
|---|---|---|---|
| 2 | The history of mobile phones and environmentalism<br>RQ: How have people used mobile phones to engage in environmental activity? | Media history<br><br><br>Mobile communication | Communication, cultural studies, information theory<br><br>Communication, sociology, linguistics, computer science |
| 3 | Eco-apps and environmental public participation<br>RQ: What are the technological structures and features that enable and constrain user participation in eco-apps? | Structuration theory<br>Adaptive structuration theory<br><br>Environmental public participation | Sociology<br>Business, organizational behavior, information systems<br>Environmental communication |
| 4 | Participatory techno-building: Actor diagramming and tracing method<br>RQ: How does a participatory design process and its outcomes differ from conventional development of a sustainable technology, such as an eco-app? | Deep ecology<br>Sustainable persuasive technology<br>Participatory design<br>Actor network theory<br>Framing theory | Environmental studies<br>Psychology, human-computer-interaction, environmental studies<br>Design, human-computer-interaction<br>Science and technology studies<br>Mass communication |
| 5 | Intersections of environmentalism and mobile telephony<br>RQ1: What can we learn from uses of mobile phones to address environmental problems?<br>RQ 2: How could this knowledge inform design and use of mobile phones for addressing environmental problems? | Activity theory | Educational psychology |

Then, I propose new arrangements of people and uses of technology to overcome the contradictions that I found in the activity systems of my dissertation (Penuel, 2014). I

envision those within the activity system using my suggestions to enact transformative agency, which Engeström, Sannino, and Virkkunen (2014) define as the ability to recognize, envision, and implement new activity that overcomes activity system contradictions. The four new practices that I propose include: use of participatory methods, collaboration, culture jamming, and recognition of nonhuman actors as influential to environmental activity.

Finally, I discuss the implications of this dissertation for conceptualizing the mediation capabilities of mobile phones and the outcomes of using a diagramming method, like the one that I suggested in Chapter Four. I discuss how using the lens of technology in this dissertation to understand environmental situations revealed some perspectives of situations but missed others. Then, I conclude with how we can recognize and move forward productively and deal with tensions in collaborative, collective, and individual action for instigating environmental change.

## Juxtaposition of Chapters

Looking across the activity systems of the three core chapters (2-4) reveals the distribution of cognition among people, culture, artifacts, and time in the use of mobile phones to intervene in environmental problems. Since 1993, people have used mobile phones to intervene in social, political, and economic practices to address environmental problems. Using the latest features offered by the mobile phone, people called, texted, and used applications and sensing systems to disrupt the status quo and offer alternative, more eco-friendly ways of living. However, mobile phones also brought contradictions and challenges to people whose efforts in designing and using them did not always result in the

outcomes desired. Contradictions are problems, breakdowns, or clashes that destabilize an activity system due to misalignment of activity components.

People used mobile phones as means to transform consciousness of environmental problems. Starting with phone calls from the field, activists like Julia Butterfly Hill used mobile phones to bring consciousness of remote environmental problems to the forefront of people's minds. Mobile phones enabled distribution of cognition related to environmental problems through the features of texting and applications, which afforded changes in Argentinian forest policy and led to renegotiation of the ethics of seal hunting (under the Twitter hashtag #sealfie).

The distribution of cognition afforded via mobiles enabled a range of people to engage in environmental activity that they otherwise might not have. For example, the FishMS texting campaign offered information to concerned shoppers looking for sustainably harvested fish, and texting also afforded Chinese citizens a way to block the building of a chemical plant in their city in 2007. Similarly, the simplicity of developing mobile phone technology gave a range of people the power to promote environmental activity, such as the father who created #Litterati, the students who created the carbon footprint tracker GiveO2, and the entrepreneurs who used the Curie module to show the location and activity of cattle.

Contradictions in the activity systems included breakdowns in software, barriers to instigating activity, and design challenges. For example, in Chapter Three, a number of eco-app users reported the inability to engage in environmental activity because of bugs in the software or the app crashing; these crashes created barriers to further distribution of

cognition. Barriers to instigating environmental activity also came with calling, texting, and applications. For example, without engaging in dramatic acts, such as living in a tree, as Hill did, it was difficult for mobile users to bring attention to environmental problems through phone calling. If users wanted to coordinate activity by text, they needed access to numerous phone numbers, a feat that was much easier to accomplish for an organization than for an individual. Also, the complexity of programing early mobile applications made it difficult for a range of people to develop apps until software became simpler to use.

In Chapters Three and Four, contradictions in mobile application development became evident with differences between environmental problems, tools available, and the activity mobiles afforded. The problem appeared to originate between the development rules and division of labor during the design process. As shown in Chapter Four, changing the development rules to expand the division of labor among a diverse community led to changes in consciousness related to the complexity of the environmental situation.

In summary, the application of activity theory across chapters addressed my first overarching research question, "What can we learn from uses of mobile phones to address environmental problems?" by showing how mobile phones provided alternative means to gather, visualize, and enact new forms of environmental understanding and activity. In response to the second research question, "How could this knowledge inform design and use of mobile phones for addressing environmental problems?" the contradictions of the activity systems showed the need to change the ways that mobile phone interventions are created and executed to more effectively address the relationships between human behavior, technology, and environmental problems. The next section, *New Practices*, offers suggestions for how

we can overcome contradictions through new arrangements of people and uses of technology.

## New Practices

In this section, I address my second overarching research question by offering ways that people can exert transformative agency to alter the contradictions in current activity systems. Each suggestion presents ways to recognize, envision, and implement new activity with mobile phones for environmental change, through calling, texting, apps, and sensors. When using these suggestions, one should consider how use of mobiles can best connect people to their environment and to each other to reveal networks of environmental activity.

**Suggestion 1:** Use participatory methods, like the actor diagramming and tracing method described in Chapter Four, to elicit stakeholder perspectives, technological capabilities, and environmental relationships that may otherwise go unseen. This recommendation addresses the contradictions in the activity systems of mobile application development, specifically between the elements of rules, subject, and community. As seen in Chapters Three and Four, limited stakeholder participation leads to degraded environmental consciousness and limited access to tools that can reveal the social, economic, and political systems' underlying environmental problems. To engage in participatory methods, developers of mobile interventions should speak with, shadow, and, if possible, include a range of actors in the development of mobile interventions. This might include inviting stakeholders to brainstorming sessions, teaching stakeholders how to code, or encouraging stakeholders to share their stories with developers. By using a participatory method,

developers can avoid assuming the perspectives and technological needs of stakeholders in relation to environmental challenges.

**Suggestion 2:** Conceptualize mobile phones as devices for collaborative action, not just for collective and individual action. Many of the examples throughout this dissertation attest to the effectiveness of individual action through use of mobile phones. For example, the work of Hill in 2009 and Matulis in 2015 in Chapter Two showed how individuals challenging the status quo can bring about change. Additionally, Chapter Two contained examples of collective action and its effectiveness, such as the texting initiatives of Greenpeace and citizen science apps. However, little attention has been given to developing mobile phone initiatives fostering collaborative efforts. This suggestion comes from the contradictions that arose between the developer's understanding of users' roles and a lack of activity to address broader social, economic, and political practices that underlie environmental problems. As shown in Chapter Four, when developers recognize the contribution of a range of actors, it is possible to collaboratively challenge and bring awareness to larger social patterns and environmental concerns. Collaborative interventions request that users gather (online or in person) to define problems and discuss solutions, which leads to the co-creation of environmental consciousness and problem solving. Participatory design methods provide one avenue for starting collaborative discussions about collaborative environmental solutions.

**Suggestion 3**: Use mobile phone interventions for culture jamming, essentially, reframing and raising awareness of current social structures through creative acts of resistance. Milstein and Pulos (2015) argue that culture jammers disrupt the status quo by

breaking routines, reassembling space, and inverting perspective to reveal new understanding of culture. They explain that through street art and flashmobs, jammers attempt to foster "transitional spaces" (Sandlin & Milam, 2008) where viewers can reflect, discuss, and enact alternative social structures. One example from Chapter Two was the #climategame participants who posted images, videos, and stories on Twitter and Instagram of their disobedience, art, and music at the 2015 Conference of Parties (COP21) convention on climate change. By enacting culture jamming at COP21, these activists created transitional spaces where alternative discussions could occur by asking questions and challenging status quo environmental activity. Additionally, the practice of culture jamming can lead to changes in environmental consciousness in the activity system of understanding and addressing environmental problems. Other examples include using mobiles to organize events at local parks, intervening at conferences, or taking advantage of popular trends, just as the #sealfie creators did with DeGeneres' #selfie in 2014.

This recommendation arose because of contradictions in the outcomes desired and those possible through current activity systems. Many of the interventions surveyed in this dissertation encouraged mobile users to engage in activity that followed social, political, and economic paradigms that perpetuate environmental problems. Finding ways to break out of these paradigms is challenging but also something that mobile phones can assist with. People can use mobiles to engage in culture jamming by coordinating, broadcasting, and recording art, music, and discussions at locations and times where community members can deliberate alternative environmental practices.

**Suggestion 4:** Use mobile features to connect and awaken users to the nonhuman. Nonhuman includes both manmade and natural elements that construct the environment in which we live. Again, contradictions between intended outcomes and current activity brought about this recommendation. Current outcomes of mobile phone use take a *human centric* approach, focusing on the user's activity at the expense of the reciprocal relationship between humans and nonhumans. By encouraging mobile users to see and experience their role within an ecosystem, it may be possible for them to also see how political, economic, and social structures lead to the environmental problems. To make this shift happen, mobile users need to experience nature, which might include physically exploring and documenting nature, as users of the iBat app did in Chapter Two, or understanding detailed aspects of nature's functioning, as users of the smart irrigation apps did in the context of their yard's soil humidity, also in Chapter Two. Another way to connect and awaken users to the nonhuman is by using mobiles to invite users to seek a deeper, visceral understanding of nature through meditations or sensory adventures where users are prompted to smell, taste, touch, see, and hear aspects of their environment. Also, locative features, sensors, and real-time feedback offer a means through which mobile users can connect with nature.

## Implications

Over the years, I have spoken with a number of scientists, government officials, and activists who think that by creating a technology, such as an eco-app, then putting that technology in people's hands, that users will change their behavior and, thus, change environmental problems. However, my findings show that the mediation process of mobile

technology is much more complex and requires forethought. As Packer (2013) argued, technology can mediate what can be said, where, and to whom. Mediation characteristics of mobile phones include new ways of saying things, to a range of people, from anywhere the user happens to be.

Though mobiles mediate extended communication capabilities with other people, they also mediate new understandings and interactions with nature. Mobile phones mediate through the duality of the technology's structure and users' participation, as seen in Chapter Three, where the features of tagging, posting, and commenting can lead to understanding and appreciation of human-nature relationships. Thus, it is important that people who are planning to develop mobile phone interventions for environmental activity consider how the technology frames environmental problems to the user and how the user cognitively frames environmental problems. Essentially, how the relationship between humans and technology alters the consciousness of users and their community.

In Chapter Four, I offered the diagramming method as a way to expand cognitive frames in relation to an environmental situation. By creating the diagram, I attempted to identify the actors within the environmental situation and create a representation of the actors involved. Through each observation and interview, I added actors to the diagram and developed a more complex representation of the environmental situation. Though it was not my goal to use the diagram as a complete representation of all actors' cognitive frames, the process brought forth dynamic relationships that a linear list would not have afforded.

Another implication to consider is how the introduction of mobile phones into an environmental situation may lead to negative outcomes. I mostly discussed positive

outcomes of mobile phone mediation, yet negative outcomes of their use can transpire. For example, the transparency of human-nature interactions affords improved interactions with nature, yet it can also lead to problems. The location coordinates of sharks provided via the SharkSmart app helped swimmers avoid sharks, but this transparency can also lead shark hunters straight to a shark's location. Similarly, the transparency that enabled people to miccrocordinate and quasibroadcast successful environmental initiatives could damage these efforts. For example, protestors against the building of the Dakota Access Pipeline successfully organized their efforts via social media, yet the transparency of their organizing tactics led to suspicious mobile phone jamming by aircraft (Newcomb, Medina, Salibe, & Sottile, 2016).

Another negative outcome is the way in which novel information afforded through mobile phones can also lead to a disconnect with nature. For example, the smart irrigation apps afford users information on soil moisture, yet having this information meant that users could rely on digital representations of nature instead of physical interactions. Similarly, Büscher and Igoe (2013) found that users of social media who engage in online activism, such as liking and sharing environmental content, believe that their digital presence is sufficient for solving environmental problems, when in reality, the best solutions must be enacted through on-the-ground activism that requires physical presence. Thus, it is important for developers to consider how the use of a mobile phone might change relationships among actors in their diagram and to reflect on the effects of mobile phone use after an intervention is released.

Some of the aforementioned examples point to the missing pieces of the environmental movement that were not possible to capture through the approach that I took in this dissertation, for example, the challenges to enact policy and develop individual affect that must take place on the ground and in person. Through my research lens, I could show how mobiles assisted protestors at the site of the Dakota Access Pipeline in coordination of supporters and information. Although my approach did not reveal the challenge of convincing people who did not believe in indigenous rights or agree with the importance of water quality for that remote region to join the movement, it does offer ways to alter the consciousness of people. Additionally, my approach did not show the challenge of getting President Obama to block the pipeline or how the change to the Trump administration led to reversal of Obama's block. These are just a few examples of the elements of activity that I could not capture through the approaches that I took in this dissertation; however, these examples show the importance of other approaches and lenses to study how we can enact environmental change with or without the use of technology.

These examples segue me to my final point, which is the use of collaborative, collective, and individual tactics for instigating environmental change. As we move forward to explore how to enact changes in the social, political, and economic structures that cause environmental problems, we must consider how a range of approaches complement one another. Working collaboratively on solutions brings a shared understanding to problems, yet this process requires compromise, which does not always move forward the dramatic policy or social change needed. Working collectively affords many different people acting in different places to create broad environmental change, but may also mean following blindly

in preexisting environmental paradigms. When people work independently, they can challenge the status quo, as seen with the culture jamming examples, yet by pushing people beyond their comfort zones, an oppositional message can get muddled or disregarded. When devising a mobile phone intervention for environmental activity, we should consider these tensions and acknowledge that each approach nudges us closer to environmental change.

In conclusion, mobile phones offer unique affordances that can help us overcome the problems inherent with current approaches, such as a lack of diverse voices, vocabulary, and tactics (Crompton, 2008). Yet, we must also acknowledge the limitations of mobile phones and their impact when introduced into an environmental situation. Moving forward, developers and users of mobile phones must recognize that the way technological features are executed and appropriated either opens doors to dialogue and change, funnels users toward reproduction of the status quo, and in most cases, probably does some of both.

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