A SOCIAL EVALUATION OF LANDSCAPE SOIL MOISTURE SENSORS FROM THE PERSPECTIVE OF HOMEOWNERS

By

LYNDALL CHRISTINE BREZINA

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2014

To my family and my great friends in Gainesville

ACKNOWLEDGMENTS

I thank Gainesville Regional Utilities for the opportunity to work on this project, specifically the cooperation of Jennifer McElroy and Shelby Hughes. I thank also the Agricultural Education and Communication Department for supporting this work, Dr. Tracy Irani, and I especially thank Dr. Paul Monaghan, and Emily Ott for their patience and assistance.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science

A SOCIAL EVALUATION OF LANDSCAPE SOIL MOISTURE SENSORS
FROM THE PERSPECTIVE OF HOMEOWNERS

By

Lyndall Christine Brezina

May 2014

Chair: Paul Monaghan
Major: Agricultural Education and Communication

Limited research has been devoted to understanding how "smart irrigation technology", such as soil moisture sensors may be adopted by homeowners for water conservation. The water saving technology has been tested in pilot studies to evaluate how it functions and saves water, but the factors that influence adoption of new landscaping technologies by homeowners has yet to be examined. The soil moisture sensor (SMS) is a device that has the potential to save 20-60% of household water commonly used on landscape irrigation. A municipal water utility evaluated the effectiveness of SMS by installing them for free in the yards of customers who were high water users. These are households that value their lawn but often do not know how to maintain it and they apply more water than is needed. A technology which can automatically apply or shut off water as needed could be a valuable addition to irrigation systems, providing the technology would be accepted by homeowners. This Masters' thesis examines the adoption potential for soil moisture sensors among homeowners using a community based social marketing approach.

CHAPTER 1
INTRODUCTION

The Study

As development in Florida has increased, water demand has also increased. The resulting changes to the natural landscape have affected the sustainability of water resources. One challenge for water managers is the overuse of water on lawns by many small private landowners: the suburban homeowner. A possible solution to the problem of overwatering may be automated devices that make adjustments to the irrigation timer without homeowner input. Soil moisture sensors (SMS) are one type of automatic shutoff device for residential irrigation systems that are set for a designated threshold for water use, specific to the needs of each lawn; they measure actual soil moisture before activating the irrigation system. While the technology has proven successful at lowering household water use, its dissemination still depends on understanding how it fits in with homeowner landscape practices and the factors that encourage them to overwater in the first place. Technological solutions to limit the application of water on landscapes will not have success unless the homeowner becomes more interested, knowledgeable, and motivated to adopt and maintain new water conservation technologies. This thesis offers an alternative approach to technology adoption called community based social marketing (CBSM) in order to identify key target audiences, their barriers to acceptance and the potential incentives and normative factors that would improve dissemination of the SMS.

This chapter will outline the study, showing the significance of water conservation programs and the difficulties of motivating behavior change. I will present background information on the state's water resources, and the governance over its use. Then I will discuss the phenomenon of suburban development in Florida, the growth of lawns and the social factors that sustain them. The overconsumption of water resources in the state caused by homeowner landscaping practices is then detailed. An alternative for saving water, the soil moisture sensor, is offered as a potential solution to water waste. The chapter concludes with an outline of the goals of the thesis which answer four questions:

- Is SMS technology seen as useful by homeowners?
- Does an environmental ethic play a role in adoption?
- Do homeowners need to understand the technology to accept it?
- How can the results be used in a social marketing campaign?

Florida's Water

In Florida, increased development is both a benefit to the economy and a concern to the environment. While development is necessary for Florida's economic growth, it permanently alters water resources while continually increasing water demand. Whether the development is housing, industry, or agriculture, increased population and infrastructure create their own unique problems within the landscape (Pickett et al., 2008). Situated within an ancient limestone and shale reef, the underground water sources in Florida are trapped in aquifers and in some places, water is pressured into upwelling springs like those found in North Central Florida (Carriker & Borisova, 2013). The karst landscape, with a stratum of both impermeable and permeable rock, is covered by Myakka soil type, which consists largely of sand (Allen & Main, 2011). When impermeable concrete is poured and storm water drainage systems divert rain water away from structures in cities, the water does not run through the sandy soil and return to recharge the aquifers and other water bodies (Carriker & Borisova, 2013). Drainage systems and other municipal systems take water in all its forms and sequester it into areas where it is temporarily or permanently cut off from the rest of the natural system (Carriker & Borisova, 2013). Evaporation and transfer into agricultural or manufactured products are some other ways in which water is removed and made unavailable to seep through the ground into aquifers (Carriker & Borisova, 2013).

Loss of water from the aquifers does more than just diminish water supply. It also interferes with the natural flow and constitution of the landscape. Confined aquifers, surface aquifers, and springs require large amounts of water to create the pressure that maintains their natural flow and excludes the saltwater from the Peninsula's surrounding ocean (Carriker & Borisova, 2013). The damage that has been caused by water withdrawal without sufficient recharge, also called groundwater depletion, includes sinkholes, decreased ground water supply, decreased river flow, and decreased water levels in springs, lakes and wetlands, and saltwater intrusion into the aquifer (Custodio, 2002). West-Central Florida, for example, has reported saltwater intrusion, appearance of sinkholes, and surface water depletion, as a result of ground-water use and increased development (Spechler, 1994).

There is a distinction between water consumption and water withdrawal. Water withdrawal is the water that is pumped from Florida's water sources such as lakes or aquifers while water consumption is water that is pumped but held unavailable for source recharge. Both water withdrawal and water consumption remove the water needed for ecological purposes such river and stream flow, and for Florida's overall water supply (Borisova & Carriker, 2009). The following is a consideration of water demand in Florida for various sectors and its effects.

Water Demand

Water withdrawal in Florida is driven by six main, overlapping purposes: agricultural irrigation, commercial use, power generation, domestic self-supplied use, recreational irrigation, and public supply (Borisova & Carriker, 2009). Water withdrawal fluctuates monthly due to variation in temperature, precipitation, crop production and tourism (Marella, 2009). Total water withdrawal in 2005 amounted to 18,369 million gallons per day (Mgal/d), groundwater withdrawals providing 60% of that total (Marella, 2009).

Agriculture

In 2005, agricultural production accounted for 2,766.18 Mg/d (million gallons per day), which is 40% of the state's total freshwater withdrawn in a year. Roughly half of the water is from ground sources and the other half from surface waters (Marella, 2009). Other than public supply, agriculture is the leading purpose for freshwater withdrawals in Florida. One example of the impact of agriculture can be seen in the Florida Everglades, once covering 11,000 square miles, but now less than 2,000 square miles. Much of the land was first drained for crop production, and through construction of canals, levees, and pump stations built in the 1950s and 60s, more surface water became available for thousands of acres of sugarcane and vegetables (Grunwald, 2006; Marella, 2009). Each day, 1.7 billion gallons of water are channeled from the Everglades into the ocean (DEP, 2011).

Commercial-Industrial Self-Supplied

Seven percent of total freshwater utilized by Florida in 2005 was in commercial-industrial self-supplied use (488.33 mg/d). Facilities included in this category are prisons, schools, hospitals and non-manufacturing facilities. The Floridan aquifer supplied 78% of the water for this category. The remaining water came from surface waters from creeks, catchments in unnamed mining pits and from rivers. Mining accounted for the largest water use (40%), followed by paper and pulp manufacturers (28%) (Marella, 2009; pg 20) and then other facilities (32%).

Power Generation

During the 1950s and 1960s, freshwater withdrawals fluctuated due to construction of new power facilities. In 2005, there were a total of 66 active power generation facilities and an additional 4 power plants for standby use while one is shut down for maintenance. More than 12,042 Mgal/d of water were reportedly withdrawn for power-generation in 2005—freshwater making up 5% (558 Mgal/d), and saline amounting to 95% (11,484 Mgal/d) of the total water. The saline waters came from surface waters, which may include brackish, salt, or fresh water, in accordance with tidal patterns. Eighty-two percent of the freshwater withdrawals came from the Floridan Aquifer. Since the peak of water withdrawals for power plants in 1985, total yearly withdrawals have decreased or are nearly constant. Power generation accounts for nearly all (99.9%) saline water withdrawals. Between 1990 and 2005, withdrawals for saline water increased 12% but freshwater decreased 29% while the total amount of gross power generated statewide increased 59% between 1990 and 2005 (Marella, 2009).

The purpose for most of the total water (98%) used by power generating companies is once-through cooling purposes, and the water used is returned to its source immediately after use (Marella, 2009). More freshwater is consumed during the hot season, due to the need for its use in cooling and increased public power demand; the highest withdrawals are from June through October (Marella, 2009).

Although electric utilities are efficient in their use of water (Marella, 2009), they, along with bottling companies, are exempt from needing consumptive permits to withdraw waters from aquifers, lakes, or rivers in Florida (Holt, 2005).

Recreational Irrigation

Recreational irrigation is water application generally for commercial or public lands like golf courses athletic fields, cemeteries, common public or highway areas, parks, playgrounds, and lawns (primarily nonresidential, but may include some residential lawns that are measured with a separate irrigation meter. Recreational irrigation accounted for 4% of total fresh groundwater withdrawals in 2005, and 6% of total fresh surface water withdrawals. Water withdrawal for recreational irrigation in 2005 totaled 330 Mgal/d of freshwater, 52% (171 Mgal/d) being from groundwater, and 48% (159 Mgal/d) from surface water. In many cases, surface water sources for recreational irrigation are supplemented either with ground water or reclaimed water. Reclaimed wastewater from treated domestic wastewater facilities amounted to an additional 321 Mgal/d, and the Florida aquifer system supplied more than one half (nearly 55%) of withdrawals.

Aesthetic uses for this category include water used to fill or maintain nonagricultural ponds. Swimming pools may be found in this category, but according to

Ozan and Alsharif, (2012), swimming pools were not found to be a significantly greater water consumer for comparable homes.

In 1985, data was differentiated for use on golf courses. Golf course irrigation was the largest user for the recreational use category in 2005, amounting to 225 Mgal/d (69% of water withdrawals and 110 Mgal/d (34%) of reclaimed wastewater. Seventy percent of land in this category is golf courses, while the remaining is for turf grass for public lands or other landscape uses. The total water withdrawn for recreational irrigation increased 82% between 1985 and 2005, and golf course acreage increased 62%.

Withdrawals for recreational irrigation see large seasonal fluctuations, because water is largely dependent first on rainfall. Withdrawals increased during March, April and May (36% of the yearly water used), and were at the lowest in 2005 during months June through September (Marella, 2009).

Domestic Self-Supplied

Domestic water use includes indoor and outdoor residential use, and all withdrawals are assumed to be from groundwater sources, accounting for well-water use. Populations for this category are obtained by subtracting the populations served by public supply systems from total county population. Withdrawals are calculated by multiplying the year’s statewide domestic per capita use by the self-supplied population served for each county. Amounts in water withdrawal ranged between 190 and 300 Mgal/d in years between 1975 and 2005 (Marella, 2009).

Public Supply

Public suppliers are utility companies and managers that provide water delivery for residential, commercial, industrial, public use and other uses. Florida ranked first in the nation in groundwater withdrawals for public supply. Nearly 90% (16.13 million) of the State's 17.92 million residents obtained their drinking water form a public-supply system. Of those residents, 89% (14.40 million) relied on groundwater sources and the remaining relied on surface-water. Alachua County, where the study took place, withdrew 60.56 mg/d, almost 99% of which is from groundwater sources (Marella, 2009).

Water Governance

The Florida Water Resources Act of 1972 established authority for management of the State's water resources through five Water Management Districts (WMDs). They operate under the general supervision of the Florida Department of Environmental Protection (Marella, 2009; Fernald & Patton, 1984). The five WMDs have been charged with maintaining and protecting the water supply for the citizens of Florida, in partnership with utility companies and local and state governments. See Figure 1-1. WMDs have alerted citizens to problems in supply and have helped plan for sustainable use of resources. They are also responsible for the management of all competing uses.

Water Resource Caution Areas: Signs of Stress on the Resource

All Florida WMDs have reported areas with critical water supply problems or areas projected to have problems within 20 years. These Water Resource Caution Areas (WRCAs) are declarations of an looming problem in the projected future supply of clean water given current development trends. The Northwest Florida Water Management District (NFWMD) designated the southern portion of Okaloosa, and Santa Rose Counties and the Telogia Creek Basin in Gadsden County to be the WRCAs in the district. The Southwest Florida Water Management District (SWFWMD) designated four areas as WRCAs; the South Florida Water Management District

(SFWMD) designated 90% of its district as a caution area, and the St. Johns River Water Management District (SJRWMD) designated its entire district as a WRCA (FDEP, 2012). The Suwannee District was the final one to report a WRCA: in 2010, four of its river water basins are expected to have problems within the next 20 years.

The city of Gainesville, Florida, falls under both SJRWMD and SRWMD jurisdiction, with a majority belonging to SJRWMD. The soil moisture sensor study with homeowners was sponsored by the SJRWMD in an attempt to evaluate the effectiveness of this technology for saving water. It was administered through the local utility company, Gainesville Regional Utilities. A map of SJRWMD jurisdiction is provided in Figure 1-2. The SJRWMD has the second largest population with about 25% of total Florida residents (about 4.46 million). It also has the largest self- supplied population (0.6 million people), and accounts for the second largest total freshwater withdrawals in the state (19%) (Marella, 2009).

Setting Minimum Flows and Levels to Limit Future Withdrawals

By Florida Law, (Section 373.042, F.S.) WMDs must establish Minimum Flow and Levels (MFLs). These are water quantity limits for lakes, streams, rivers and aquifers and when measures go below the MFL, it signifies danger for ecologically important fish populations and for recreation (Annear & Conder, 1984). Also established are minimum water levels at which further ground or surface withdrawal would be significantly harmful to water resources in the area (Silk et al. 2000). MFLs are constructed by utilizing elevation transects extending from open water to its surrounding uplands (Neubauer et al. 2008).

MFLs are decided in a process that begins with public workshops. The decisions reached in these workshops are reviewed by the Florida Department of Environmental

Protection, and then the MFLs are adopted as rules and are published in the *Florida Administrative Weekly*. MFLs are to be reviewed periodically and revised as necessary under Florida law (Subsection 373.0421(3), F.S.). This information, as well as historical record, help guide conservation and regulation strategies and decisions on permitting and water restrictions.

Governance Efforts to Encourage Residential Conservation

Florida statutes encourage conservation as a water demand limiting strategy. Shut-off devices for irrigation systems (§373.62), water-conserving landscape choices (§373.185) and reclaimed water systems (§373.250) are supported by Florida Statutes. In response to these directives, Water Management Districts and utilities impose timing restrictions, rationing, price schemes and encourage the use of water saving technology (Lund, 1995; Renwick & Archibald, 1998; Ozan & Alsharif, 2012). Many municipalities have instituted one day a week watering restrictions, especially during the winter season when most lawns go dormant. In addition, management authorities advocate landscape design that uniquely caters to local soil and climate conditions. Both mandatory and voluntary water restrictions have been issued according to the amounts of rainfall and water use for Gainesville, Florida by the water management districts covering Alachua County. Under normal conditions, WMDs have restricted watering lawns to certain days of the week and times of day. Utility companies use incentives and rebates for water conservation technology adoption.

The Barriers to Conservation: Development Patterns and Lawns

Between 2000 and 2010, total housing units increased in Alachua County by 18.56% (112,766) (U.S. Census Bureau, 2010). Urban sprawl has claimed land for residences while lawns have replaced farmland (Milesi, et al, 2009). Water management districts scramble to plan for potable water sources for an increasing population of consumers. Meanwhile, many Florida homeowners with in-ground irrigation systems use approximately 60% of household water from public supply to preserve their landscape (Mayer et al., 1999; Haley et al., 2007; Haley & Dukes, 2012). Further landscape change is expected with an increasing population and higher demand for water (Milesi, et al. 2005) making lawns a focus of water conservation efforts by management authorities. (Russell & Fielding, 2010)

Lawns and History

Since the late 1800s residential lawns have been widely marketed and advertised in the United States (Jenkins, 1994). Upwardly mobile Americans during the post WWII housing boom had increased access to a turfgrass lawn and it became a status symbol for affluent homeowners (Skardon, 1962; Jenkins, 1994). The lawn ideal, a thick, uniform expanse of grass, has been symbolically tied to patriotism, unity, and the retention of social and moral order (Feagan and Ripmeester, 1999; Dorsey, 2010; Ozan & Alsharif, 2012). Through media and advertising, the lawn took root in the American psyche, where acceptable yards were associated with a socially accepted lifestyle. Within neighborhoods, “the successful lawn maker became the turf evangelist for his neighborhood” (Jenkins, 1994, pg 103;). The normative belief was that lawn cultivation was the mark of a good citizen and neighbors encouraged that behavior with each other (Feagan and Ripmeester, 1999; Dorsey, 2010; Ozan & Alsharif, 2012).

Turfgrass species have been developed for Florida’s climate and soil. However, the sandy Myakka soil does not hold applied moisture, and multiple water applications have been necessary to keep lawn quality. St. Augustine grass and Bermuda grass have required irrigation twice or three times weekly for acceptable quality during the summer (Trenholm et al., 2002). St. Augustine and Bermuda grass have often been selected by homeowner’s associations for lawns in Florida suburb developments. These types of grass and their maintenance are incorporated into homeowner deed restrictions.

Landscape Design for Conservation

Xeriscaping has been recommended as an alternative to turfgrass lawns in landscaping. Xeriscaping is a water conservation planning methodology that involves seven practices that would ideally maintain and nurture healthy landscapes: 1) adequate planting and design, 2) soil amendments, 3) drought-tolerant plant selection, 4) smaller turf areas, 5) efficient irrigation, 6) use of mulching, and 7) appropriate maintenance (Welsch et al., 1998).

These themes were adapted by University of Florida researchers and the resulting program to encourage best landscaping practices for Florida was called Florida-Friendly Landscape™(Gamer, et al., 1996). The FFL Program has nine principles:

1. Right plant, right place. This principle advocates the best plant for the area based on soil, water tolerance under the most natural occurring circumstances requiring the lowest inputs of water, pesticides, or fertilizers.

2. Water efficiently. Irrigating the yard only when it needs water can cut down on withdrawals from the aquifer and potentially damaging the plants by overwatering.

3. Fertilize appropriately. Fertilizing plants too much is a waste of money and can lead to runoff into stormwater systems.

4. Mulch. Mulching the soil cuts down on weeds, and also holds moisture in the soil, saving the need to water.

5. Attract wildlife. Plants that would attract wildlife lend to the health of your yard, as well as some aesthetically pleasing encounters.

6. Manage pests responsibly. Using pesticides in an incorrect manner can harm pets and family members. Pesticides must be used as directed and only when needed.

7. Recycle yard waste. Grass clippings and other substances can add to nitrogen in water bodies if not disposed of responsibly. In this case, the grass can be used as fertilizer right back on the grass instead of falling into storm drains and contributing to algal growth in water bodies.

8. Reduce stormwater runoff. Because of the vulnerability of Florida's water resources, pesticides and fertilizer from lawns can leach and run off and cause non-point source pollution. The university recommends keeping water on the property by limiting impermeable surfaces and building rain gardens to let rainwater soak into the ground.

9. Protect the waterfront. Buffer zones of 10 feet should be established around waterbodies to reduce pollution runoff. Invasive aquatics should be eliminated while natural plants should be maintained carefully.

These nine principles are a design-inspired solution to water waste and they depend on behavior changes among residents., In contrast the Soil Moisture Sensor is a technological solution, emphasizing efficiency of water use while still maintaining a healthy lawn. WMDs have worked alongside utility companies and policy makers to encourage adherence to the FFL conservation practices and have also encouraged the use of rebates for water conservation technology purchase and Installation.

Social Challenges to Conservation Efforts

Enlisting the public in water conservation programs has met with mixed results in many cities, rarely resulting in significant water savings (Harlan et al., 2009; Eden & Megdal, 2006). The turfgrass lawn continues to be a dominant landscape despite the financial and environmental cost. This social phenomenon of costly lawn maintenance was described by Jenkins (1994), who noted the paradox of homeowner concern for the environment and the wasteful actions taken to maintain their lawns.

In opposition to serious conservation efforts is the reality that turfgrass lawns raise property values and have been found to contribute to social order in a neighborhood (Byrne, 2005; Pickett et al., 2008; Nash, 1982; Feagan & Ripmeester, 1999; Dorsey, 2010). Accordingly, many homeowner's associations carry clauses in their housing agreements that set standards for lawns in their neighborhoods (Ozan & Alsharif, 2012). Acceptable grass species, uniformity in species, grass height and thickness, and the use of irrigation systems have been some requirements listed in neighborhood housing deeds or agreements. Deviation from the standard can result in penalties such as warnings or even fines. In 1998, for example, a homeowner's association successfully sued a man for his lawn's appearance, despite the fact that the design saved 5,000 gallons of water per month (Robbins, 2007).

Florida law now defends water efficient lawns, providing they follow the standards of the Florida Friendly landscapes™ program (§ 720.3075 (4)). Increasingly strict irrigation ordinances are believed to be one reason homeowners are changing their landscapes to low-maintenance, low energy designs that would still be aesthetically pleasing while using fewer resources (Hansen, et al., 2012). However, despite the encouragement of best practices in lawn maintenance, the lawn continues to be viewed as a social and financial investment, and a status symbol of the affluent. Despite water supply concerns, and despite higher utility prices for higher users, the lawn is still a source of excessive household water use (Kurz et al., 2005; Dorsey, 2009).

Can Environmental Theory Help Us Understand Landscaping Behavior?

What is the answer to changing behaviors to conserve more water among homeowners with turfgrass landscapes? Environmental theory has shown that portions of the population are more likely to adopt certain water conservation technologies and behaviors than others. This has been observed by Gilg and Barr (2006) and Corral-

Verdugo and Frias-Armenta (2006). Gilg and Barr (2006) identified four different groups based on environmental behavior: the committed environmentalists, mainstream environmentalists, occasional environmentalists and non-environmentalists. Corral-Verdugo & Frias-Armenta, (2006) wrote that, on an individual level, antisocial or less involved persons are less altruistic and tend to act against the environment, which coincides with the non-environmentalist group in Gilg and Barr (2006).

Ajzen and Fishbein (1993) created a theoretical model (the Theory of Reasoned Action) that attempts to predict behavioral intention- that is, the attitudes and beliefs toward a behavior that can impact whether a new behavior is performed. Despite its popular use in research, the Theory of Reasoned Action has been criticized for assuming that people make reasonable decisions, its emphasis on attitude change affecting behavior change, and limited attention to barriers or the means by which the actor has control over the behavior. The other categories described in the model, normative behavior and attitudes, are popularly applied toward lawn maintenance behavior to account for group pressure in landscaping (Jenkins, 1994).

The Technology Acceptance Model is a variant on Ajzen and Fishbein's Theory of Reasoned Action, targeting technology acceptance as the final behavior change, and was used primarily with Information technology. It provided for a directive toward evaluating a device's usability and ease of use for adopters. This has some relevance to SMS because it is seen as an easy technology for adopters.

Grob's model of Environmental Behavior (1995) also is a variant on Fishebein and Ajzen's model, expanding it with the addition of emotions and personal philosophical values as factors leading to a behavior, and directs it more toward an environmental behavior. There are five components of this model: personal philosophical values, environmental awareness, emotions, perceived control, and environmental behavior. Personal Philosophical values are found to be the most influential of the five categories on an environmental behavior in Grob's 1995 study and emotion directly affects behavior, although the causes of the emotion may be more complex than the model implies. The five components were described by Grob as motivations that lead to environmental behavior.

Different paradigms have been described by some authors regarding the interface of people with their environment. The Human Exception Paradigm is that which is anthropocentric and technology reliant confidence that humans can change and adapt the environment to their wishes. Dunlap and Van Liere (1978) developed an environmental paradigm in opposition to that where the interface is more eco-centric and human beings are thought to be just a component of the larger environment or system. The most recent paradigm described by Corral-Verdugo and others (2008), the New Human Interdependence Paradigm (NHIP), is a compromise between the two extremes. These paradigms can be studied to further categorize individuals into segments of the population that can be targeted.

Although not specifically designed for environmental behaviors, Everett Rogers' (1995) model of technological diffusion lends itself to understanding the process of the social acceptance of a technology. For Rogers, the population that is faced with a new technology can be split into five groups: innovators, early adopters, early majority, late majority, and laggards. As a population begins to adopt a new technology they form a bell curve with the majority in the middle. The initial innovators lead the diffusion process and the curve begins to decline with the few laggards who the last to adopt. Rogers also provided an ideal model for extension services to disseminate new technologies as well as a description of the individual adoption decision process.

Community Based Social Marketing (CBSM) is an alternative to the above theories and paradigms. The field of CBSM draws on marketing theory by emphasizing target audiences for change, and the active lowering of barriers to a specific target behavior. It identifies Rogers' opinion leaders as partners in campaigns to influence individual behavior change for the benefit of the public. More information on environmental theory and CBSM and they role they play in SMS adoption will be provided in the literature review in Chapter 2.

Problem

The purpose of the study is to evaluate the beliefs, attitudes and experience of households using Soil Moisture Sensor (SMS) in order to understand the factors that influence the adoption of water conservation technologies and behaviors. Understanding this process may assist in marketing the device to a larger scale audience. Despite much effort devoted to water conservation campaigns, lawn-loving homeowners have continued to overwater their lawns, wasting resources. Understanding the perspective of the homeowner is the first step to achieving a technological solution to the problem of water waste on lawns.

Soil Moisture Sensors (SMS) are devices attached to the irrigation system that override regularly timed watering if the moisture content of the soil is above a set threshold (Olmstead & Dukes, 2008). An SMS controller is an irrigation shut-off device that is similar to a rain sensor but is placed underneath the mat of turf instead of on a rain gutter or roof. The SMS reads the moisture levels in the soil directly while a Rain

Sensor (RS) determines whether the system should irrigate based on rainfall (Haley & Dukes, 2012). Both innovations provide water to a thirsty landscape but sense the need for water by different means. The rain sensor technology has several limitations such as deteriorating parts and problems if it is not located properly, while the SMS is seen as a more precise means of providing feedback to the irrigation system because of its direct reading of soil moisture content (Haley & Dukes, 2012).

While rain sensors have been studied and accepted by industry, SMS controllers have yet to become accepted by many landscape professionals and homeowners. Field tests for SMS technology have been performed for agricultural crops in Florida. In one study, SMS use increased irrigation water use efficiency 2-3 times compared to timing treatments for tomato and pepper crops (Zotarelli, et al. 2006). Multiple agricultural field tests of SMS devices resulted in increased water use efficiency, diminishing fertilizer leaching and run-off, and thereby contributing to money savings in fertilizer and increased crop productivity. (Dukes, Zotarelli & Morgan, 2010). One controlled study of SMS with residential landscapes reduced water demand between 69 and 92% during normal wet weather conditions and between 28 and 83% during dry weather conditions (Cardenas-Lailhacar, et al., 2008). In another study conducted over 9 months, homes with SMS used 51% less water than homes using only irrigation timers (Haley et al., 2007). These savings occurred without any loss in turf grass health. Justification for the present study is found in Florida Statute §373.62 which requires all new automatic sprinkler devices to “install a rain sensor device or switch to override the irrigation cycle of the sprinkler system when adequate rainfall has occurred” (Florida Statutes, Part VI;1).

Objectives

This study's objectives were to 1) evaluate homeowner opinion of the SMS device, 2) examine homeowner environmental beliefs, 3) compare the "black box" approach to an informed approach for advancement of SMS adoption, and 4) tailor the results to a Community Based Social Marketing campaign for SMS adoption. The objectives of the study are expounded below.

Homeowner opinions of SMS. The homeowners involved in the pilot study were asked a series of questions, either in focus groups or in personal interviews, such as their interaction with the device, and their perceptions on its usefulness and whether it filled some need in their landscape practices or their desire to conserve water. Knowing these answers helped to understand the barriers to interaction with the technology, and helped evaluate potential market perceptions of the device.

Environmental and technological beliefs. In order to evaluate the usefulness of different paradigms of environmental beliefs, and whether they motivated behavior, questions were asked of the study participants on their beliefs about conservation. Exploring the beliefs surrounding SMS use and the environment might illuminate a common phenomenon or tendency linking beliefs and specific behaviors.

Black box vs. informed approach. In effort to understand how the message and adoption of the device may be received, the answers to two different interventions were compared utilizing the approach to introducing the SMS device. One was a "black box" approach where the homeowner had the technology installed without much explanation. The other was an informed approach where educational materials were provided in addition to online support and a follow-up to installation. In adoption of a technology, homeowners may enjoy the freedom that comes from automation and function of the device and not desire more information, or they may require information and desire more control over its functioning.

Tailor the results to a Community Based Social Marketing campaign. Finally, the principles of CBSM were applied to prepare for planning in adoption of SMS devices to benefit the environment, but tailored to the audience and situation. This evaluation from the pilot study is essential for developing a socially targeted action plan.

Significance of the Study

The utility company which instituted the pilot study wanted to document the opinions of high water users targeted for the study. An addition to accounting for the water saved during the pilot study—the technological advantage of a functioning SMS in terms of gallons per day saved—the utility company also wanted to evaluate the opinions of their clients and explore the most efficient and effective means to SMS adoption by households. In contrast to the first round of installment using the “black box” approach, in which the SMS device was provided with little explanation, an informed approach was also used in which clients were provided education and training with the device. A survey instrument was created to incorporated functional opinions of the device with the effects of the black box approach and the informed approach to the adoption, as well as the benefits and barriers associated with the device’s adoption and use.

There has been little published research as to SMS technology’s acceptance by homeowners. Most studies focus on the efficiency of the Soil Moisture Sensor as a water-saving device. However, to the applied nature of this research, this study was most useful for utilities and water managers for the development of future campaigns, as well as for the manufacturers and installers of soil moisture sensor technology.

Recommendations were lastly given on how high water consumers may be effectively engaged in the future.

Limitations and Assumptions

The use of SMS as a tool for the focus of conservation motivations may be limited due to the specificity of the technology and its application, that is, each brand may be slightly different and installed or maintain if different ways. In addition, the choice of using Alachua County residents implies that the results may not be transferable to a greater population although similarities may exist between the participants and other Florida residents. Validity was ensured with multiple researcher oversight and outside information from the local utility.

Chapter Summary

The State of Florida's water resources are governed by five water management districts charged with ensuring the future of water resources. Past drainage projects supported the agricultural boom of the south and have cleared the way for population increase and urban sprawl. As climate change limits predictability of weather and saltwater intrusion threatens, groundwater depletion is a concern in providing water to an increasing population in Florida. The challenge water managers and utilities prepare to meet is with efficient water use. Since 1991, power companies have decreased their dependency on freshwater withdrawals in favor of saline waters, and power generated has increased 59%, much of this returned immediately to the source after cooling use. Public supply in Florida is the deliverer of potable household water through utilities, with the source of 99% coming from groundwater. Five WMDs were directed by the legislature to maintain and protect water sources, and lowering water demand through efficient water use is a common strategy. Conservation is an effort to lower water demand in Florida by providing more efficiency in water use.

Through government policy and programs, water managers have sought to change people's behavior toward conservation. As a possible technical solution for water waste on residential lawns, Gainesville Regional Utilities partnered with St. Johns River Water Management District to pilot test a SMS technology through a pilot test with 35 households. Using behavior change theory and environmental paradigms, a survey instrument was created to evaluate the homeowner's perspective regarding the SMS. The impact of the SMS device will depend on widespread successful adoption. Objectives of this evaluation were to 1) evaluate the perspective of the homeowner in regards to the usefulness and ease of use of the Soil Moisture Sensor, 2) examine the beliefs surrounding SMS use and environmental attitudes for indicators of a tendency to link beliefs and specific behaviors, 3) compare the use of a "black box" approach where the homeowner does not understand the technology to an informed approach, and 4) to utilize results in recommending a Community Based Social Marketing campaign.

Table 1-1. Total water withdrawals in Florida by category, 2005. U.S. Geological Survey, Florida Water Science Center - Tallahassee; all values in million gallons per day.

Florida 2005	Freshwater			Saline water			All water
	Ground	Surface	Total	Ground	Surface	Total	Total
Public supply	2,201.26	339.26	2,540.52	0.00	0.00	0.00	2,540.52
Domestic self-supplied	190.38	0.00	190.38	0.00	0.00	0.00	190.38
Commercial-industrial self-supplied	365.56	122.77	488.33	0.00	1.19	1.19	489.52
Agricultural self-supplied	1,301.57	1,464.61	2,766.18	0.00	0.00	0.00	2,766.18
Recreational irrigation	171.03	158.61	329.64	0.00	0.00	0.00	329.64
Power generation	17.56	540.52	558.08	3.26	11,481.10	11,484.36	12,042.44
State totals:	4,247.36	2,625.77	6,873.13	3.26	11,482.29	11,485.55	18,358.68

Figure 1-1. Map of Florida' s five Water Management Districts. (Neubauer et al. 2008)

Figure 1-2. Map of the jurisdiction of St. John's River Water Management District in Florida. Alachua County is divided between The Suwannee River Water Management District to the northwest, and the St. John's River Water Management District to the southeast. Gainesville, the setting of this study is within the boundaries of SJRWMD, although some participants of the study may be located on the border or in SRWMD jurisdiction. (SJRWMD, 2012)

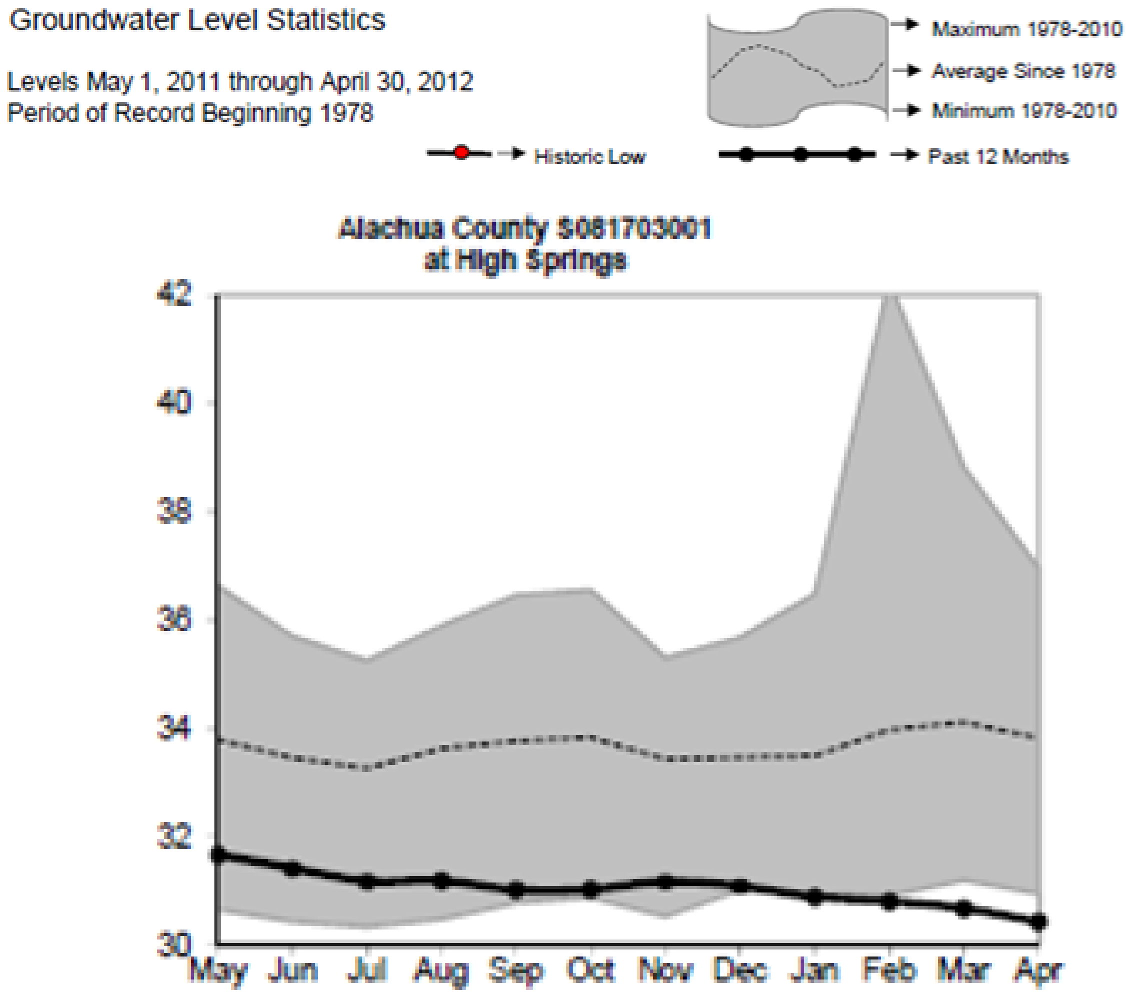

Figure 1-3. Groundwater level statistics for a point in High Springs,Suwannee River Water Management District. This shows the variation in water levels along with historic lows and highs and minimum recorded level for this point. (SRWMD, 2012)

CHAPTER 2
USING THEORY, POLICY AND SOCIAL MARKETING TO PROMOTE CONSERVATION

The purpose of the study is to evaluate the beliefs, attitudes and experience of households using Soil Moisture Sensor (SMS) for the purpose of forming a well-informed marketing campaign. The stated objectives were 1) to evaluate homeowner opinion of the SMS device, 2) examine homeowner environmental and technological beliefs, 3) compare the “black box” approach to an informed approach for advancement of SMS adoption, and 4) to tailor the results to a Community Based Social Marketing campaign for SMS adoption. This study can contribute to the body of research on diffusion of innovations (Rogers, 1995), and the wider body of action research concerning technology adoption. An alternative approach to encouraging adoption of SMS technology is community based social marketing and this study illustrates how that approach could be applied.

Environmental Theory

Environmentalism is a concept based on the limits to resources and the need to conserve them (Hardin1977; Cahn & O’Brien, 1996). Conservation behavior results whenever individuals take on a personal responsibility for environmental stewardship. A number of studies have sought to predict conservation behavior by linking it to demographic and situational factors (Corral-Verdugo, 2003, Gilg and Barr 2006; Corral-Verdugo & Frias-Armenta, 2006). Environmental paradigms are often based on the understanding that beliefs lead to behavior. Attitudes and beliefs are the main focus of the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 2010). Both the Technology Acceptance Models (TAM) and Environmental Beliefs (EB) model are two of the many variants on the TRA model. In addition, Everett Rogers’ model on diffusion of innovations is a good descriptor of how an innovation is adopted among individuals and through a population on a larger scale (Rogers 1995).

Demographic Predictors of Behavior

A number of studies have sought to predict conservation behavior by linking it to demographic and situational factors (Corral-Verdugo et al., 2003). Gilg and Barr (2006) identified four different groups based on environmental behavior: the committed environmentalists, mainstream environmentalists, occasional environmentalists and non-environmentalists. Those that were non-environmentalists were young males with lower income, with a focus on luxuries rather than frugality, while committed environmentalists, on the other side of the ordinal grouping, were older and had membership in a community organization, owned their own home, had smaller household sizes and terraced properties, and were more likely to vote Green or Liberal Democrat. The committed and mainstream environmentalists were those most likely to state that their neighbors and friends usually helped the environment, with non-environmentalists the least likely to state that commitment. Antisocial or less involved persons were less altruistic and tended to act against the environment (Gilg and Barr 2006; Corral-Verdugo & Frias-Armenta, 2006). However, research shows it is difficult to establish a significant relationship between environmental beliefs and water conservation (Mainieri et al., 1997; Corral-Verdugo & Armendariz, 2000). This may be because measurement involved only general environmental beliefs. Corral-Verdugo et al. (2003) made an assessment more directly focused on water resource beliefs, resulting in a significant link mediating between general environmental beliefs and the more specific beliefs about water. General beliefs were not found to be specifically influencing water consumption, and the researchers concluded that general environmental beliefs were not good direct predictors of specific water-consumption behavior. Instead, the relation was found to be mediated between a specific behavior by a specific related belief. A scale indicating specific beliefs was given to participants in the study, and compared with household observations of water use. Those participants who admit a need for setting a limit on human growth and exploitation are those that see water as a resource to save, indicated by conservation activities such as re-using sink or tub water for irrigation or limiting the rinse cycle to once while washing clothes.

One segment of the population is known to have both concern for natural resource sustainability and they utilize resources responsibly. A consistent percentage of people who report going above and beyond recommended behaviors have been the “observable exceptions” to conservation campaigns (Pascale et al., 2010). Pascale and others (2010) call this phenomena “positive deviance.” This segment may be important actors in the diffusion process of adoption. These may be the opinion leaders who are more likely to be the voluntary innovators that catalyze diffusion.

Environmental Paradigms

The field of environmental sociology has produced research linking beliefs to the motivations for environmental behavior. One of the first scales to measure general environmental beliefs is the New Environmental Paradigm (NEP), developed by Dunlap and Van Liere (1978). These beliefs are narrowed down to the individual assumptions of balance and limits on the human impact on the environment. If there is a balance in nature, and humans are a part of that balance, humans must be wary of their effects on the whole. If resources are limited, then the use of them must also be limited. Alternatively, the Human Exception Paradigm (HEP) concludes that humanity is the exception and humans have the power to manipulate the environment and utilize resources how they see fit. These two paradigms form a dichotomy where a person or people could view the environment either anthropocentrically (HEP) or eco-centrically (NEP).

Another model combines anthropocentric-ecocentric views into the New Human Interdependence Paradigm (NHIP) (Corral- Verdugo, Carrus, Bonnes, Moser and Sinha 2008). The NHIP corresponds to beliefs commonly affiliated with the sustainability movement by linking the "well-being of current and future human societies to the ability to care for a proper renewal and restoration of natural resources" (pg. 718). The scale used to measure this paradigm takes into account a mixture of views regarding environmentalism, without a sharp dichotomy of eco-centric versus anthropocentric environmental beliefs. One limitation of the study is that participant samples from the New Human Interdependence Paradigm were not from the United States. They were from four countries: India, Mexico, Italy and France. Geographically, each of these would have unique settings and cultures which would provide for different attitudes and barriers to behavior.

Attitudes and Beliefs and Their Impact on Water Conservation

In the Theory of Reasoned Action (TRA), Ajzen and Fishbein (1980) have found that personal attitude has a great effect on behavior but that is has been confounded by normative beliefs toward the environment. The Theory of Reasoned Action model accounts for actual behavior based on the following main factors: Behavioral Beliefs, Normative Beliefs, and Control Beliefs. Utilizing the TRA model has been advocated to help encourage adoption of a behavior, either by affecting behavioral beliefs or normative beliefs by increasing knowledge and by eliminating barriers to the behavior by influencing the personal control one has over that behavior. Health research has been performed using this model regarding condom use (Albarracin, Johnson, Fishbein, and Muellerlleile, 2001) and breastfeeding (Manstead, Proffitt & Smart, 1983), as well as AIDS risk-related behaviors (Fishbein & Middlestadt, 1989).

Behavioral beliefs are beliefs by individuals surrounding the specific target behavior. Normative beliefs are beliefs about the behavior by others, and the extent to which these beliefs of others would influence the individuals, and control beliefs are the beliefs surrounding the ability or inability to change ones behavior. Ajzen and Fishbein constructed Likert- type questions for their study participants and graded the answers on a scale, comparing the scores to actual behavior. The model describes influence on behavior but apart from knowledge gained does not aid in planning interventions.

Norms and Neighborhood Behaviors

Utilizing the TRA model, homeowner landscaping behavior is influenced by pervasive social norms that are reinforced through media and through communities and neighborhoods. These normative pressures encourage homeowners to maintain a landscape that is prone to consumes more water than it needs (Jenkins, 1994; Haley et al., 2007).

In the case of irrigating turf, the TRA model shows that beliefs form an attitude toward the current behavior by the individual, and a wide scale normative understanding of the acceptability of the behavior (Fishbein & Ajzen, 2010). Fishbein and Yzer (2003) write that “an intervention can change attitude toward a particular behavior by persuading someone to believe differently about the behavior and by augmenting the association between the belief and attitude.” (Fishbein & Yzer, 2003, pg 177) Convincing households to change their irrigation behavior might depend on their actual ability to perform the task.

Grob's Environmental Behavior (1995)

Fishbein (1979) wrote that the Theory of Reasoned Action does not include factors of personality or values because they do not add to the goal of behavior prediction. Grob (1995), in contrast, integrated emotion and personal philosophical values into his model. The main categories for this model are: Personal Philosophical Values, Environmental Awareness, Emotions, Perceived control, and Environmental Behavior.

When speaking of Environmental Awareness, Grob states that this involves two factors: 1) Factual knowledge of the environment, and 2) recognition of environmental problems. However, researchers described a gap between knowledge of the environment and recognition of the problems. Grob also highlighted the importance of Perceived Control, which include the efficacy of science and technology, and self-efficacy. The idea of Perceived Control applies to the SMS project, with homeowner beliefs about technology, trust of technology, and self-efficacy. The extent to which the participant trusts technology and is comfortable with its use may motivate or discourage acceptance of the device.

Personal Philosophical Values presents a case for involving self-identification questions in the study, and those which can identify environmental paradigms of thought that could be commonly seen in Environmental Psychology research. This category for motivation is directly related to segmentation of the population based on what values participants ascribe to, or the environmental paradigm of belief they can be identified with. How do they describe themselves? Do they value conservation or do they value the opinions of their neighbors or friends? These values feed directly into the emotions toward behavior and into the other categories of Environmental Awareness and Perceived control, as well as directly affecting the behavior itself. Grob therefore labels this category as the most influential toward behavior (Grob, 1995)

Emotion is the last category in Grob’s model that can influence behavior. According to Verhage (1978), marked behavior change sometimes only comes about when there is an identifiable crisis. Emotion is influenced primarily by Personal Philosophical Values, and directly affects the Environmental Behavior, according to Grob’s model. Emotion may take the form as pressures or fear to approach others about their water use or fear of consequences from Homeowner Associations or other authority.

Specificity in Environmental Behavior Research

Research shows it is difficult to establish a significant relationship between environmental beliefs and water conservation behavior (Mainieri et al., 1997; Corral-Verdugo & Armendariz, 2000). This may be because measurement involved general environmental beliefs. Corral-Verdugo et al. (2003) made an assessment singularly focused on water resource beliefs, resulting in a significant link between general environmental beliefs and the more specific beliefs about water. General beliefs were not found to specifically influence water consumption, and the researchers concluded that general environmental beliefs were not good direct predictors of specific water-consumption behavior. Instead, the relation was found to be mediated between a specific behavior by a specific related belief. One of the admitted limitations of the TRA model was a “lack of specificity” (Sheppard, Hartwick & Warshaw 1988) In their meta-analysis, the reliability of the TRA model to predict behavior change was questioned as well as the ability to direct the researcher to a point where an intervention can be performed. They assert that the generality of the model makes it insufficient for use in behavioral change. In fact, many variants on TRA have been created to specifically tailor the behavior change model to a prescribed behavior- one of which deals specifically with technology acceptance, the Technology Acceptance Model (TAM) (Moore & Benbasat, 1996). This model created and tested by Davis (1985) deals almost exclusively with Information Systems research, or adoption of a technology product or service as in Information Technologies.

Corral-Verdugo (2003) tested a scale indicating specific beliefs to participants and compared it with household observations of water use. Those participants who admit a need for setting a limit on human growth and exploitation are those that see water as a resource to save, and practiced conservation activities such as re-using sink or tub water for irrigation or limiting the rinse cycle to once while washing clothes. By targeting the adoption of a water conservation device, other beliefs and understanding concerning water, irrigation, and conservation can be explored, but the definition of the prescribed behavior is extremely important in that it directs action research and diminishes ambiguity that may inhibit study.

Rogers and the Diffusion of Innovation

Rogers' Diffusion curve describes a wide scale movement of an idea or innovation within a population. The specific behavior researched in this study was the adoption of a SMS for use in residential landscapes. In the case of this pilot study, the successful adoption of a soil moisture sensor might be described with Rogers' adoption curve. In order to be successful, the new innovation has to have a relative advantage over the old practice (Rogers, 1995). It also has to be consistent with existing cultural patterns (Barnett, 1953).

Rogers' model for adoption of an innovation forms a bell curve where five characterized population segments sequentially adopt the innovation. The five population categories indicated by adoption behavior are: innovators, early adopters, early majority, late majority and late adopters. Innovators are those who adopt the innovation readily and can possibly be opinion leaders who sustain the impetus to diffuse the technology across communication to the early adopters. Then the late adopters and finally a few laggards follow suit.

Rogers (1995) provided for the kinds of perceptions an individual would have toward the innovation and how this would benefit adoption. The first is relative advantage, which is the degree to which an innovation is perceived to be better than another similar option. Is the SMS a better choice than using a rain sensor? How is it relative to using only an irrigation timer? Compatibility is another perceived attribute of innovation, which is the degree to which the SMS is consistent with the values and past experience of the adopters. The complexity of the innovation is a third attribute, whether it is easy to use and understood. The concept of "Trialability" is the fourth attribute of a new technology and it allows participants to test it subjectively. Observability is the last attribute of an innovation perceived by an adopter, and this is the degree to which the results of an innovation are observed by other (Rogers, 1995). If others view benefits first-hand, they are more likely to adopt the innovation.

Black Box Approach to Disseminating Conservation Technology

The term, "black box" is used to describe a technology that is described solely based on its inputs and outputs, with no attention to understanding the object by those that adopt them (Winner, 1993). Before the 1980s, much of technology was delivered and tested using a "black box" approach. The approach to technology adoption was often from an economic or logic-driven hard science lens, devoid of sociological influence or understanding (Pinch & Bijker, 1984; Kallinikos, 2002; Feenburg, 2004). The black box approach is a top-down authoritative approach where authority comes from the utility company, the water management district and public policy regarding automatic shut-off devices.

This approach could be effective where simple technology has been added to a previously accepted device for the purpose of conserving water. For example, aerators in faucets and flow restrictors installed in showers of college dormitories have been shown to save water (Sharpe & Fletcher, 1977). Seen as a technological extension of an in-ground irrigation system, the approach assumes that full understanding of the function or use of the devices is unnecessary. However, Hoff (2009) encouraged water management to be integrated vertically across all levels with particular decisions as close to individual citizens as possible, citing the ideal to be close cooperation and networks for benefit sharing.

Educational Approaches for Promoting Conservation

Extension Services are employed by water managers to plan and implement programs. A program could be defined as either activities, such as field days, demonstrations, or presentations, or a comprehensive set of activities where education is a component (Israel, Harder & Brodeur, 2010). Conservation education/awareness programs are one leading strategy advocated by managers and utilities (Raibhandary, et al. 2010). However, education alone does not lead to conservation practices (Geller, et al., 1983).

Programs conducted by the University of Florida Extension Service have had some limited success in participant adoption of best practices for irrigation and landscape choices. Florida Friendly landscaping ™ is a program based on Environmental Landscape Management practices, and was developed in 1992 by the University of Florida, Sarasota Bay, and Tampa Bay National Estuary programs, EPA, FDEP, and SWFWMD. Its goal is to educate the public on creating and maintaining a landscape that impacts the surrounding environment as little as possible. It provides consultations and workshops to demonstrate best practices developed by field research and further adapted with continued social research.

Another Extension program is the Program for Resource Efficient Communities (PREC) that promotes the adoption of best design, construction and management practices in new residential community developments to reduce energy and water consumption and environmental degradation. Professionals work in partnership with utilities for research and aid in the creation of extension programs which largely emphasize an education component.

Evaluative surveys given after educational interventions claim a difference in attitude, but fall short when these attitudes are tested with choice in action (Bickman, 1972, Geller, 1981; Geller, Erickson, & Buttram, 1983; Finger, 1994). A portion of the population not responding or accessed in a volunteer program can yield low returns for funds spent on the programs (McKenzie-Mohr, 2000(2).

Policy Approaches to Water Conservation

Policy approaches to water conservation are by nature, top-down adoption decisions directed by Florida law. Florida Statutes are passed by legislature as directives that can be specific but are too technical and minute to address in implementation. Florida Statute §373.185 appointed Water Management Districts to plan and implement strategies in partnership with utility companies in effort to meet directives set by law (Olexa, Borisova & Broome, 2011). Water managers, scientists and policy makers are relied upon to augment water resources through creating more supply or diminishing water resource demand. Increasing supply can be done by using more water from traditional water sources (ground water or surface water), or by using alternative sources such as desalination, water storage, or reclaimed water.

Overuse of traditional sources is problematic, and the infrastructure needed for increasing water supply with alternative sources is costly. Therefore water managers pursue efforts to reduce the demand for water (Rawls & Borisova, 2009). Reducing demand for water, considered “demand management,” is achieved through increasing water use efficiency and water conservation. (Baumann & Boland, 1997; Rawls & Borisova, 2009)

Some examples of demand management strategies are: educational programs, financial incentives for voluntary water use reduction or conservation water pricing, mandatory restrictions, and leak detection. (Rawls & Borisova, 2009) Other conservation strategies include irrigation design and installation standards and cost-share incentives (e.g., rebates) (FDEP 2002).

Under normal conditions, WMDs have commonly used mandatory watering restrictions (Raibhandary, et al. 2010) on watering lawns to certain days of the week and at specific times of the day, lowering water demand. Unfortunately, water restrictions are often ignored (Haley & Dukes, 2007).

A technological strategy pursued to decrease the demand of water with the use of an automatic shut-off device is supported in Florida Statute §373.62, which specifically directed that water efficiency should be attained with the use of a technological device:

> Any person who purchases and installs an automatic sprinkler system after May 1, 1991, shall install, and must maintain and operate a rain sensor device or switch that will override the irrigation cycle of the sprinkler system when adequate rainfall has occurred. (Florida Statutes, 1991)

Strategies used by utilities to encourage conservation can be categorized as either financial, through certification programs and rebates, or ensuring appropriate use of technology. One popular strategy used by utilities is conservation pricing (Borisova, Unel and Rawls, 2013). Based on consumption rates, customers are placed in price brackets that would discourage heavy resource use, also called “inclining block rate structures.” (Rajbhandary, Borisova, Adams, Haynes, & Boyer, 2010) Raibhandary et. al (2010) found that rate block structures are an economic incentive for high water users to conserve, while there is no difference between uniform rate structures for low water users, and therefore no economic incentive to conserve for these low-use households.

Ensuring that technology is properly used is extremely important. Olmstead and Dukes (2011) found that in an evaluation of 3,416 residential irrigation systems, there were five main problems: unmatched, varying application rates in the same zone, vegetation blocked water stream, overlap of two types of vegetation (turf and landscape) within the same zone, operating time too frequent, and operating time too long. These are problems with both irrigation design and homeonwer operation.

Certificate Programs such as Florida Water Star^{SM} are recognition programs that have also showed some success by both incentivizing water conserving practices and adoption of water conservation technology. Florida Water Star^{SM} was a program developed by the SJRWMD in 2006 that went statewide in 2012 and allows a home to be recognized as efficient both outdoors and indoors. Developers can base their design on the Florida Water Star^{SM} criteria and be designated gold or silver and are given rebates for certification by various companies (Florida Water Star, 2012).

The utility in partnership in this study uses rate block structures to discourage high use and uses rebates to encourage purchase and use of water conservation technology. The installation of an SMS would serve the purpose of following the directive instituted by Florida law, and would increase efficiency of irrigation, depending on proper installation and use.

Social Marketing as an Alternative Approach

Social Marketing is an approach to behavior change that has gained more influence in the arena of action research in public health. Kotler and Zaltman (1971) describe it as a framework that applies knowledge from fields such as psychology, sociology, anthropology and communications theory to solve social and health problems. Proponents for the approach cite the many instances when an educational workshop or intervention was given that did not lead to participants' change in behavior (Bickman, 1972; Geller, 1981; Geller, Erickson, & Buttram, 1983; Finger, 1994). While attitude has been one focal point of behavior change research, another has been economic incentives. One study in energy research achieved very little change- a program where money that has been spent on media messages and programs resulted in only 2-3% energy change, amounting to very little in return for money spent on the campaign. (Hirst, 1984; Hirst, Berry,&Soderstrom, 1981; U.S. Department of Energy, 1984; McKenzie-Mohr, 2000(2)) Behavior change is much more complex than what would be guided by the TRA model or Rogers' models. Information-intensive campaigns fall short of creating a new behavior (McKenzie-Mohr, 2000(2)) and fall short in catering to the audience to ensure greater success.

McDermott, Stead and Hastings (2005) reviewed social marketing literature and developed a set of six benchmarks common to Social Marketing research. These were adapted from Andreasan (2002) that described social marketing application. These benchmarks are described below.

- Behavior change. In any directed study, the target behavior must be identified and there must be specific and measurable behavioral objectives.
- Audience research. Formative research is produced that identifies the traits and needs of the audience, and a pilot study is conducted with the intervention.
- Segmentation. The intervention target group is selected out as a segment of the population with certain characteristics.
- Exchange. There must be an exchange where return benefits for participation or change would motivate people to voluntarily engage.
- Marketing mix. Product, price, and promotion and place are a part of the marketing strategy for the behavior.
- Competition. Minimizing the chance of competing behaviors is necessary by accounting for and eliminating barriers to target behavior.

These are recommended portions of a successful social marketing campaign, and not all were involved in the SMS pilot study, but will be discussed in Chapter 5.

There are four main steps emphasized in social marketing: discovering barriers to behavior and selecting behavior to promote, designing a program to overcome barriers toward the behavior, piloting the program, and then evaluating it (McKenzie-Mohr, 2000(2)). The behavior sought to be corrected with the use of an SMS device was reducing the use of water on lawns. In researching the barriers to adoption the approach first identifies differences between individuals who engage in the activity, and those who do not (Andreasan, 1995; McKenzie-Mohr, 2000(2)). Like Rogers' Theory, this prepares the agent to identify a target audience or segment based on certain characteristics or traits.

Identifying barriers to adoption of a behavior is a key feature of CBSM, whether these barriers are cultural normative beliefs, information or knowledge gaps, or physical ability to adopt a change (McKenzie-Mohr, 2000(2)). An effective strategy can only be developed if there is a detailed knowledge of barriers, either internal (knowledge or skill gap) or external (limits on accessibility to product). (McKenzie-Mohr, 2000(2)) Education is useful if it eliminates a barrier and does not cause additional barriers to emerge (McKenzie-Mohr, 2000(2)).

In the case of this study, the adoption of a Soil Moisture Sensor may or may not be a new behavior, depending on the participant's previous experience. It may be an alternative product for one already in use, such as an alternative to the rain sensor. In addition it is important to consider whether the behavior is repetitive or a one-time event. In the case of a SMS, adoption is a one-time event, although the device must also be maintained with subsequent routine checks.

Chapter Summary

Adoption of SMS for lawn and landscape maintenance is the specific behavior researched in this study. There can be many motivators either to reject or accept the SMS device. Literature that aided this study came from descriptive and applied research. Studies have been conducted on technology adoption: segments of the population are more likely to adopt water conservation technologies and behaviors than others (Gilg & Barr, Corral-Verdugo & Frias-Armenta, 2006). Studies have also been performed that emphasize the importance of marketing information for technology adoption. Everett Rogers identified and described the characteristics of critical components in the adoption-diffusion process. Research on the rate of adoption of an innovation, types of decisions based on adoption approaches, social system impacts, and the influence of change agents are some of the important models provided by Rogers for both small scale or individual innovation decision making (Rogers, 1995).

The instrument created and used for this research was guided by the above theories and literature to meet the following objectives: 1) to evaluate homeowner opinion of the SMS device, 2) examine homeowner environmental and technological beliefs, 3) compare the “black box” approach to an informed approach for advancement of SMS adoption, and 4) to tailor the results to a Community Based Social Marketing campaign for SMS adoption.

The adoption of any water-conserving innovation is dependent upon the understanding and beliefs by those who are targeted for behavior change. The motivations behind adopting this water conservation device were uncovered through this evaluative study. High outdoor water consumers who already display a propensity to waste water on the landscape can limit their resource use with the use of an SMS. The pilot study attempts to ease transition to conservation with SMS technology by having participating households answer questions on their opinion of the SMS device. A program is effective if the difficulty to change behavior is not underestimated and if the barriers to that behavior are addressed (McKenzie-Mohr, 2000(2)). Extension approaches that rely heavily on media messages and education may change attitudes, but often the behavior does not follow. McKenzie-Mohr (2000(2)) cites studies in which education and the lure of incentives is not enough to change a behavior.

Table 2-1. List of theories and their descriptions regarding adoption behavior. (Fishbein & Ajzen, 1975; Davis, 1986; Rogers, 1995; Grob, 1995)

Theory	Applies To	Main dependent constructs/factors	Main independent constructs/factors
TRA- Fishbein & Ajzen's Theory of Reasoned Action, 1975	Individual behavior is driven by intentions which are a function of beliefs and feeling about the behavior and its consequences	Behavioral intention, Behavior	Attitude toward behavior, Subjective norm
TAM- Technology Acceptance Model, 1986	Information technologies usually, but can be applicable to other technology adoption situations	Behavioral intention to use (leads to use)	Perceived usefulness, perceived ease of use
DOI- Rogers' Adoption of Innovations (Diffusion of Innovations Theory), 1995	Channels of influence and communication leading to adoption of an innovation	Implementation Success or Technology Adoption	Compatibility of Technology, Complexity of technology, Relative advantage
Grob- Grob's Model of Environmental Behavior, 1995	Environmental behavior is correlated mostly to Personal Philosophical Values which affects Environmental Awareness, Perceived Control, and Emotions.	Correlations and Motivations for Environmental behavior	Personal Philosophical Values, Perceived Control, Environmental Awareness, Emotions, and Environmental Behavior

CHAPTER 3
METHODS

This chapter describes the process in which qualitative research data was collected and analyzed. The purpose of this research was to explore the conservation motivations, behaviors and potential adoption of SMS by high outdoor water use households. The research was also designed to produce results useful for the development of a future social marketing campaign to promote SMS adoption.

A local utility company provided the SMS technologies to selected households in order to test their use in a real-world setting. Quantitative data on water use was recorded by the utility and a social evaluation was conducted with participants. Since the SMS is a tool directly concerned with water conservation, attitudes toward the environment and water conservation were considered in addition to attitudes toward the device itself. The instrument was tested and evaluated by an expert panel before being implemented. Data analysis was performed with the use of MAXQDA and Glaser's Constant Comparative method. This chapter described the methodology for recruitment of participants to the SMS trial, contrasts the interventions used for Phase A and B, the recruitment for the evaluation and the methods used in qualitative data collection and analysis.

Background: SMS Interventions Phase A and Phase B

The pilot study to test SMS use in homeowners landscapes underwent two different interventions with two different sets of participants. The selection of the technology used in the program was influenced by the research conducted by University of Florida researchers and the successful track record of Acclima Closed Loop Irrigation Systems. Phase A was characterized by having a black box approach with Acclima's model SC-X, and Phase A occupied a different timeline for installation than the later Phase B.

A different model, the SC-6/12, was used for Phase B, and was installed by a different contractor. Knowledge was provided to homeowners in Phase B by means of an information packet given during installation. A follow-up visit was made to the homes and some training provided with an educational approach. What follows is a description of the recruitment for participants in the SMS interventions for Phase A and Phase B, and description of differences between the interventions. These differences are also recorded in Table 3-1.

Recruitment Phase A

In the fall of 2008, letters were sent to 323 customers of Gainesville Regional Utilities who consumed more than thirty thousand gallons of water per month (>30 kgal/mo). These letters informed residents of their high water usage compared to their neighbors, and invited them to participate in a free SMS pilot study to help lower their water bill. Of these, one hundred people responded (30%). The utility then called these households and narrowed them down to thirty-eight qualified participants.

By the time a contractor installed the SMS, the final number was 22 households. Selection bias of these participants includes the fact that the study is composed primarily of participants who use excessive amounts of water on their lawn. No educational materials or guidance were provided to homeowners with SMS installation in Phase A. With each installation, a new control panel was spliced into the existing irrigation timer. There were no follow-up appointments and very little contact before recruitment for evaluation approximately one year later.

Recruitment Phase B

Phase B of the installations took place approximately one year after Phase A with a similar letter sent to 300 high water using households. This time only sixty-three people responded (21%). They were interviewed and screened by the utility company. Thirty four people met the qualification criteria for the study. At the time of installation, contractors were given a checklist (see APPENDIX A), to guide their installation and to create a baseline. This ensured that the irrigation system and timer were in good working order before the study, to record the zones and their settings, and to ensure that there was a back-flow preventer present. Participants of Phase A and Phase B had a separate meter for outdoor irrigation, which is a factor that aided accuracy in water savings during the study.

A new model of SMS devices were installed which required that the existing irrigation control panel in each home was replaced with the model's control panel that functioned both as an irrigation timer and SMS interface. Phase B participants were presented with a rebate form at installation where they would be receiving $25 in return for the installation. Participants also agreed that they would participate in a final evaluation.

Extension services were employed to create an informational packet and a website for the program with step-by-step instruction videos for the use of Phase B households. The informational packet contained an overview of the SMS pilot study, the instructional manual for the SMS control panel, information on its function, irrigation tracking sheets, and contact information for contractors and program staff. A follow-up appointment was conducted in many cases by the utility to provide access to some training on the use of the new control panel and to make adjustments to the SMS thresholds. See Table 3-1 for comparison of Phase A and Phase B.

Quantitative Comparison

The Program for Resource Efficient Communities (PREC) at the University of Florida was responsible for the quantitative data analysis involved in this study. Homeowner use of water was tracked before, during and after the utility sent the invitation letter for the study. For each household, PREC established a baseline for expected water consumption based on irrigable area of lawn. Then pre- and post-irrigation periods were compared within the intervention periods for the SMS groups and also between those households that received the recruitment letter.

Evaluation Stage Recruitment

The research participant list of 37 households (18 participants from Phase A, and 19 participants for Phase B) was provided to the evaluators by the local utility. Focus groups were the most reasonable data collection method for evaluation, due to the propensity to gain richer data through discussion. Possible venues for focus groups were mapped according to proximity and convenience for participants, and participants were called on the telephone and given multiple choices of location and dates. A $50 dollar gift card was offered as incentive for focus group participation. However, many participants opted to be interviewed over the phone which garnered no financial return. Through focus groups and interviews, data were collected from 24 out of the original 37 contacts provided. Out of the 24 that participated in the research, 15 agreed to the phone survey and five came to a focus group, two were involved in a small group interview.

Instrument

The preliminary questions created for the study, and the subsequent semi-structured interview guide draft can both be found in APPENDIX B. The interview guide draft was tested in the first interview on November 2, 2012, and was then re-examined by an expert panel of social science researchers. They concluded that the information gained could achieve better quality with some additional interview questions and prompts added to the interview guide. That became the instrument for the evaluation along with the accompanying demographic questionnaire. The IRB document was submitted for these changes.

The final Interview/Focus Group guide contained questions on motivations, acceptability and experience of the device, level of awareness and control over the SMS device, assistance with the device including training and education, normative beliefs about landscaping, and evaluation of their environmental beliefs regarding risk and the future of water resources. Below is a description on the instrument's construction guided by different theory and their components. APPENDIX B and APPENDIX C have preliminary and final versions, respectively.

Input From Theory of Reasoned Action (TRA)

The construction of the survey borrowed from understanding of attitude, norms and control which would impact the setting of the study. Setting a couple of distinctions dealing according to the behavior, attitudes were explored. Some aspects of attitude are presented as follows:

- Attitudes toward technology. Do participants consider technology to be a trusted and reliable solution to problems? What is their comfort level when dealing with technology?

- Attitudes toward installation contractors. What amount of trust or distrust is there for those installing the technology? Who do people turn to when a problem arises concerning the technology?

- Attitudes toward water managers. Do participants display trust or distrust toward regulating organizations, and for what reasons?

- Attitudes toward conservation of water itself. Do participants perceive problems regarding the water supply and its future? Which problems are these and how would they combat them?

Normative beliefs can impact behavior as well and the norms of lawn care were explored.

- Normative beliefs toward lawn cultivation. What level of importance do participants give lawns in contrast to their neighbors?

- Normative beliefs toward "lawn culture." What kind of vernacular is used concerning lawn maintenance and does it signify an awareness of the problem?

- Normative beliefs toward interaction with their neighbors. What is acceptable behavior with neighbors? Do participants speak to others in their neighborhood? Are lawns or landscaping acceptable topics of conversation?

Control beliefs are extremely important for behavior change. If participants do not believe the new behavior is within their abilities, there is a low chance it will be performed, or the possibility even explored. Some control beliefs are considered in the following.

- Control beliefs toward the environment. Do participants believe their individual choices can influence water supply or the health of the environment? What connection to participants perceive between their actions and environmental consequences?

- Control beliefs over policy. Do participants believe they have influence over policy or management decisions?

- Control beliefs over irrigation. Can participants utilize what is necessary to manage their lawn irrigation?

- Control beliefs over SMS device use. Do people feel confident in their use of the device?

- Control beliefs over similar equipment. Do participants feel confident in their use of similar equipment?

Exploration on these control beliefs would enlighten researchers to barriers present for SMS adoption and a variety of other similar issues.

Input from Grob's Environmental Behavior Model

The objectives for the study and components from theory and research lend themselves to organization in Grob's Model of Environmental Behavior (1995). From the model, the motivations for adoption of the SMS can be laid out clearly. As written by Grob, the main categories for this model are: Personal Philosophical Values, Environmental Awareness, Emotions, Perceived control, and Environmental Behavior. Other Models include some of these factors, which can fit into the diagram. These were explored in preparation for the instrument as well.

- Personal Philosophical Values. This category for motivation is directly related to segmentation of the population based on what values participants ascribe to, or the environmental paradigm of belief they can be identified with. How do participants describe themselves? Do they value conservation or do they value the opinions of their neighbors or friends? This feeds into the emotions toward SMS adoption. Cultural changes that value conservation create a cognitive dissonance in those who knowingly invest in the opulence of a lawn using the common's resources.

- Environmental Awareness. When speaking of Environmental Awareness, Grob states that this involves two sections: 1) Factual knowledge of the environment, and 2) recognition of environmental problems. Participants of the study revealed knowledge gaps when it came to the environment, while some demonstrated knowledge of source waters and homeowner impact on them. What knowledge does a participant have concerning water sources in Florida, the hydrologic cycle and possibilities of augmenting water supply? Does a participant notice or draw a connection between regulations and rain? Have they observed infractions by neighbors and can relate it to environmental problems?

- Emotions. Guilt and self-justification has been a focal point for the study, and may be a good motivator. Fear is also a motivator through social norms and the threat of being fined, or getting a letter from the Homeowners Association. Emotion leads directly to adopting behavior along with the other motivations.

What emotions do participants have toward their own water waste or that of their neighbors? Do they show guilt? Are they inspired to address problems they see?

- Perceived Control. The two factors involved in Perceived Control, according to Grob are: 1) the efficacy of science and technology, and 2) self-efficacy. These can be translated through the TAM model to be usefulness, and ease of use. The price would also be a factor in control- do they have the ability to pay for the device and its maintenance? Do participants see avenues by which they can be part of the solution to environmental problems? In particular, do they feel that they can make an informed decision on lawn care or lawn design and take action? What limits them? The desire for more control can be a proponent for SMS adoption signified by interest in technological solutions and hands-on use of technology.

Input from Rogers' Perceptions Toward the Innovation

Questions were constructed based on Rogers' perceptions toward an innovation that related to: Relative advantage, compatibility, complexity, trialability, and observability. With these categories, individual perceptions toward the SMS were explored.

- Relative advantage. To what degree do participants perceive this to be a better choice than using a timer alone or a rain sensor, and under what conditions? How does its use compare?

- Compatibility. How is the degree to which the SMS is consistent with the values and past experience of the adopters? Does the culture and setting lend itself to acceptance?

- Complexity. Is the SMS easy to use and is the use understood?

- Trialability. Are participants allowed to test it subjectively?

- Observability. To what degree are the effects of its use observable?

Relative advantage was explored regarding the SMS comparison to use of the timer or rain sensor. Compatibility was investigated in regards to past experience with the devices and the perceived acceptability of its use and landscape. Usability and ease of use was tested according to knowledge about the device and configured in trialability.

Guidance from Social Marketing

McDermott et al. (2005) established benchmarks for social marketing using a systematic literature analysis of studies. Below were the benchmarks put forth by McDermott, Stead and Hastings (2005), common to social marketing research application.

Behavior change. In any directed study, the target behavior must be identified and there must be specific and measurable behavioral objectives.

Audience research. The research performed provided for a list of homes with high comparative outdoor irrigation—outdoor irrigation amounting to more than 30 kgal/month. The traits and needs of this audience merit more exploration. An evaluation is conducted on both black box and informed approaches regarding SMS. The evaluation of this is integral to understanding the audience by its response to the intervention.

Segmentation. The intervention target group is selected out as a segment of the population due to its high outdoor water use, but segments within that group can help researchers find different avenues to affect behavior. Identifying opinion leaders that can be recruited in product diffusion is one outcome of segmentation.

Exchange. There must be an exchange where return benefits for participation or change would motivate people to voluntarily engage. What incentives or accompanying interventions would influence adoption?

Marketing mix. Product, price, and promotion and place (the 4Ps) are a part of the marketing strategy for promoting behavior adoption. Does the product fit the need of the segment of the population? Is the price or cost worth its adoption? What would be an acceptable price for the device? Are participants willing to take necessary actions to ensure its proper function and use? With what media and through which channels should the device be promoted? Is their ease of access to the purchase of the device and its installation?

Competition. Minimizing the chance of competing behaviors is necessary by accounting for and eliminating barriers to target behavior. What competing devices or factors can limit SMS adoption?

According to McDermott, et al. 2005, at least two of these six benchmarks were found in any one study analyzed. These benchmarks that should be useful in planning were evaluated as to how and if they functioned during the study.

Data Collection

Data collection for the evaluation was gained through interviews and focus group discussions. What follows are descriptions of Phase A and Phase B data collection and then description of data collection for both interviews and focus groups. Table 3-2 is a timeline is provided for the recruitment and data collection.

Phase A Overview

Out of the 18 participants in Phase A, data was collected from only seven. Two of these were residents who agreed to participate but had no knowledge of the study or the device itself. They had recently moved to their residence and one of these had installed a well for irrigation. The remaining five participants had lived in their residence long enough to take part in the SMS pilot study, but the memories were unclear due to the lengthy period before this follow-up. These five participants were professionals or retired, between the ages of 38 and 80, four males and one female. Three of these participants were interviewed via telephone while one participant came to the group interview. All participants of Phase A had similar stories of how the device either did not function, or only functioned for a short time.

Phase B Overview

The contact information for nineteen participants was provided and fifteen participants (fourteen households) were successfully recruited for evaluation. There was a total of six women and ten men. The age of these participants was between 37 and 75. All but two participants had graduated college. Five of the participants were retired. Almost all participants were white, with one Hispanic. Phone interviews were conducted with eight of the Phase B participant households and seven participants (representing six households) were present at the focus group.

Interviews

A total of fourteen telephone interviews were conducted. The interviews were performed by two researchers, from October 2012 to December 2013. Each participant was called and invited first to a focus group, and if refused, asked to participate immediately in a telephone interview. If another time was more convenient, the interview would be scheduled for a later time. If there was no answer, the researcher left messages with the intent of the call and a return contact. Telephone interviews were recorded with a digital audio recorder after recording permission was granted by the participant. The participant was first read the informed consent information, and with verbal agreement, the interview questions were asked, followed by demographic questions. The length of the interviews varied from 15 to 40 minutes.

Focus Groups

Focus group design was guided by Krueger & Casey (2000). This particular method of data collection was emphasized due to the rich data provided by group discussion. The survey instrument was used to guide a that discussion and encourage participation. The number sought for participation was between 6 and 12, which was reached in the first focus group, but not in the second. Segmentation, that is, multiple focus groups divided according to characteristics, or even according to Phase intervention, was beyond the resources and scope of this project due to low recruitment numbers.

Use of focus groups allowed for the generation of ideas and gave participants a venue to express themselves regarding their SMS experience. Some benefits of focus group use, according to Krueger and Casey (2000) to gather data are: discovery of specific issues of interest, identification of language and terminology used by the population of interest, and new ideas that may have never been discovered. The vernacular used can help create marketing messages that would resonate with possible adopters.

The one focus group (FG1) was held at a local library on November 14, 2012, while a second group interview of two individuals (FG2) was held at another local library on December 11, 2012. Participants were first asked to read and sign IRB informed consent verification forms and then given a questionnaire that collected data on demographics and landscaping practices. These sessions were facilitated discussions lasting about 45-90 minutes, using the same guide used for telephone interviews (See Table 3-1). The sessions were audio-recorded, transcribed and coded similarly to the interviews.

Those present for the focus group were all from Phase B and had different experiences using the SMS. Only two participant household in the first focus group had problems with the SMS, one discontinuing use and the other requesting adjustment from the SMS contractors. In the second group interview, one participant who participated in Phase A discontinued use of the SMS after six months and the other, who had been involved in Phase B, had no problems with the device.

Variance between participants and the mix of Phase A and Phase B participants in the intervention caused the focus of data analysis to be on topics rather than the questions asked. Some topics were overarching themes not unique to the intervention, and these provided insight into the personal values of the participants. Data gained from the focus groups and interviews were transcribed by the researchers, and each recording was listened to at least twice, while transcripts were read. Notes were taken based on content, to organize responses according to topics. Categories were labeled and coded based on the observed trends, general themes, patterns, ideas, self-reported behaviors, and terminology exhibited in the audio recordings and transcripts. Further explanation for analysis is in the next section.

Data Analysis

An appropriate technique for analyzing qualitative data is Glaser's constant comparative method. The data collection took the form of numerous transcripts of raw data guided by the researcher's survey. Transcripts from the focus groups and interviews were coded three times into smaller categories. Starting with the 4 broad objectives of the study, five main themes were created. Then an open coding system was used to get the subcategories. A third round of coding produced the individual quotes chosen to highlight the themes. Data from the demographics questionnaire was compiled into an excel spreadsheet according to participant for ease of comparison.

Coding was performed using MAXQDA programming with Glaser's constant comparative method, described below.

Glaser's Constant Comparative Method

Glaser's constant comparative method combines both the analytic method used in theories such as TRA with the broad exploration used in transcript analysis. It is not testing a theory but rather is a means of creating new hypotheses or theory. The constant comparative method follows 4 steps: 1) comparing incidents applicable to each category, 2) integrating categories and their properties, 3) delimiting the theory, and 4) writing the theory (Glaser, 1967) Theory is directly accountable to the researcher. Below is an outline of the steps taken in data analysis.

Comparing incidents applicable to each category. The researcher started with transcripts from the audio recordings of focus groups and interviews. The researcher listened to the recordings and read the transcripts multiple times, creating a memo for each one of these separately that describes first impressions of the participants and their perspectives. Using MaxQDA, a qualitative analysis program, the researcher created coding segments or incidents. Each incident was compared with the next incident. Segments linked together created five broad categories: discussion of water use, audience descriptions, benefits to SMS use, barriers, and knowledge or understanding of the technology.

Integrating categories and their properties. Each new incident or segment was compared to a code with its unique definition. A total of 213 segments were categorized into the five codes. For "discussions of water use," 103 segments were coded, "audience descriptions" had 29 segments, "benefits to the SMS" had 16, “barriers” had 24 and “knowledge or understanding of the technology” had 41 segments coded.

Delimiting the theory. Exclusion (or delimiting) occurred three times from the greater categories by creating subcodes. Theory took shape within subcodes, identified and defined with the use of the “comment function” in MaxQDA. The second round of coding revealed subcodes for “discussions of water use” such as awareness, commenting on others’ use of water and seeing water wasted in their neighborhood, water politics, and reasons for the program. The subcodes for “audience descriptions” were: self-description, unconcerned about water resources, views about restrictions, and communication with neighbors. The subcodes for “SMS benefits” were: efficacy (ease of to use), less worry, benefits when travelling and savings. The subocdes for “barriers” included any mention of problems or negative comments about the SMS device. The subcodes for “knowledge” dealt with how the participants viewed the SMS device and understanding of it. These subcodes were broken down even further in some cases, the results of which are presented in the next chapter.

Chapter Summary

A qualitative approach was used to determine the methods of data acquisition and analysis. Starting with the original behavior target as curtailing over-irrigation on lawns, the pilot study utilized the SMS as a technological solution. The subsequent evaluation of the pilot study is the focus of this Master’s thesis.

Recruitment for the pilot study targeted a section of the population with similar behavior: they were all high consumers of outdoor water. Differences between the two Phases of the pilot study were: the use of a new SMS model and control panel availability of education and training given to the homeowners, and the time elapsing between invitation and installation in Phase B. The interventions also differed in that Phase A participants had separate water meters and most of Phase B participants did not have separate water meters (Table 3-1). The municipal water utility provided evaluators with a contact list of 37 names, telephone numbers and addresses. The participants were contacted by the evaluators and invited to a focus group or were asked to complete a telephone interview. Seven participants were evaluated for Phase A, and seventeen total participants from Phase B. Total participants in the study numbered 24.

The instrument, found in APPENDIX C, was constructed and evaluated by a panel of experts. Questions for the instrument were based on Ajzen's research into attitudes norms and control beliefs, Grob's categories in environmental behavior model, and Rogers' description of an innovation decision.

Transcripts were made from the audio-recordings of the interviews and focus groups, and these were coded to broad categories, and then three times into smaller categories, finally ending with representative quotes for the themes regarding theory. These results can be found in the next chapter. Translation of findings into a potential social marketing strategy was discussed in Chapter 6.

Table 3-1. Comparison of Phase A and Phase B interventions.

Phase	Education	Training	Contractor	Device	Invitation	Installation
Phase A	No Education materials provided.	No training was provided, no rep present.	Company 1	Acclima Closed Loop Irrigation System, SC-X, Separate water meter	June 2009	Fall 2009
Phase B	Informational packet with contact information for contractors and utility project workers. Website for reference, additional material.	Utility rep explained packet. Follow-up appointment and training.	Company 2	Acclima Closed Loop Irrigation System, SC-6/12, No separate water meter	May 2012	Fall 2012

Phase A and Phase B had differences in the treatments for participants regarding education, training, installation contractors, the SMS device, and the timing of the invitation to study and the installation.

Table 3-2. Timeline for the study.

Aug.- Oct., 2008	High-use water notification invitations were sent to 323 high-use residences, volunteers interested in the pilot study called GRU. Follow-up with phone interviews, screening criteria for SMS installation.
Jul., 2009	Phase A installation of SMS device model SC-X.
May-June, 2012	300 Letters sent for Phase B recruitment and volunteer response, second contractor hired and trained. Phase B installation of SMS device model SC-6/12.
Jul. 5, 2012	IRB approved for the thesis focus of study.
Aug. 2012	Postcards sent by GRU to all Phase A and Phase B participants informing them to anticipate contact regarding Pilot Study evaluation.
Oct. 16, 2012	Evaluation recruitment started; confirmation e-mails sent after receiving agreement to participate in Focus Groups.
Nov. 2, 2012	First interview
Nov. 14, 2012	Focus Group 1 (FG1) performed at Tower Road Branch Library.
Dec. 11, 2012	Small group interview (FG2) performed at Millhopper Branch Library.
Dec. 12,2012	Last interview

CHAPTER 4
RESULTS

Transcripts were made from the audio-recordings of interviews and focus groups, and these were coded three times into smaller categories- starting with the 5 broad objectives of the study, then an open coding system to get the subcategories, then a third coding as individual quotes are chosen to highlight the themes. Responses of participants helped document the homeowner perspective as to the usefulness and ease of use of the SMS. Responses also revealed environmental attitudes and beliefs and their link to specific behaviors. The data also provided some comparison of the "black box" approach to the new technology versus a more informed one. And finally, the data contribute to the design of a community based social marketing campaign.

Overview of the Phases and Data

Of the 24 study participants, seven were retired, four were homemakers and the rest were professionals. There were nine women and 15 men in our sample. All were married; nearly all were white and had a college education, many with advanced degrees. There were several professors, as well as physicians, dentists and lawyers. All of the households used some type of lawn care service and only one used well water for irrigation. All but two had lived in Gainesville for more than 10 years. Only three had lived in their current home for a year or less, with most having lived in their present home for six years or more. Of the 23, three had removed or disconnected their SMS. (GRU, 2012)

Quantitative Results

Quantitative data provided by the utility and analyzed by the Program for Resource Efficient Communities (PREC) at the University of Florida revealed the efficacy of using SMS devices in residential landscapes. Multiple regression tests were performed to generate the baselines of expected water consumption based on irrigable area, year of construction and home size. A comparison was made between pre- and post- irrigation intervention periods for the SMS groups and also between those who received the letter as an intervention and those who did not.

The group that received a letter but not the SMS saw an average water savings of 33.5% (32.4 kgal/season) across the study period. Total savings per mail recipient was 226.8 kgal over the 42 months of the study. The act of receiving a letter was enough to change the behavior, at least during the period of the study. The SMS participant group averaged savings of 52.5% (44.6 kgal/season) across the study period. These savings were statistically significant from Winter 2010 through Winter 2011. Total savings per SMS participant was 315 kgal over the 36 months that were measured. (GRU, 2012). The difference in savings between the SMS participant and mail recipient groups showed that the SMS participant group saved 22.3% (11.5 kgal/season) more than the group that just received the letter (GRU, 2012)

Results From Coding: Five Themes and Sub-themes

Coding was started with the five broad categories from the five themes from the research: discussions about water use, audience descriptions, SMS benefits, barriers, and knowledge. These five themes originated from several objectives of the study: the need to determine the barriers to adoption of Soil Moisture Sensors by the targeted audiences; discover the perceived benefits from the participants viewpoint and finally, gain insight into how the program can be disseminated more effectively. Below is an outline of how they were broken down into subthemes, with explanation.

Theme 1: Discussions on Water Use

Individuals' perceptions on their own water use, the water use of neighbors, their knowledge of water politics, understanding of the purpose of the program, and other segments related to the topic of water use were coded in this category. The need to examine the participant's experience of water in relation to their own use, and the uses around them helps characterize their beliefs as well as their accompanying actual behavior, according to Objective 2 of the study: Determine the link between expressions of environmental attitudes and conservation behavior.

Subtheme 1: Awareness of personal use

Many participants had little awareness of how much water they were using previous to receiving the invitation letter, while others had seen the water reports on their household use in their GRU bill and had taken measures to fix potential leaks or other problems. In general, there was little concern about their excessive use.

> I haven't seen the bills, or I haven't just analyzed the volume of water since we put the sensor in. I know the system runs less and we haven't seen the spikes in the water usage since then, so I think it's positively affecting the amount of water usage that we have. I haven't compared that. (16B, 37, male, FG2)

> I don't know, when GRU sends out my bill, probably, I'm on the… higher end of water usage but I have a lot more sod and a lot more vegetation than they do… they have, their yard is mulched and they have natural areas where they haven't done any type of landscaping. (10B, 62, male, interview)

> You know what? I don't know. I'm thinking I probably irrigate too much because I got the letter. I know a lot of people have a whole yard irrigation system. I mean, some do—I'd say 50% do. Others just watch the rain water or have a manual sprinkler system like the old-school hook it to the hose sprinkler system. So I would say I was probably an aggressive irrigation person. (12B, 37, female, interview)

Subtheme 2: Opinions about neighbor's use

In contrast to their lack of concern about their own water use, participants were more likely to point out the neighbors' excessive use of irrigation water.

> I want to criticize them because they- I think they water their lawn too much, anyways. (17B, 40, male, interview)

> I happen to work in South America in the world's largest desert. And so you know, I come back up here and see the way we use water and I think it's uh, foolish. . . .Water on lawns and things like that is a waste. (14a, 71, male, interview)

Subtheme 3: Water and politics

Some participants acknowledged the stresses placed on population growth, but they more often emphasized the allocation of water to companies and industries. Some particular entities mentioned to be at fault were:

- Agriculture
- Cattle or livestock
- Quarries
- Golf courses
- Developers who get "breaks."
- Water bottling companies

> If I were a management officer or a county commissioner I would look at the entities that are using the most amount of water. And, you know, and I think most people- well, hopefully most people know it's not the individual family or family unit. (17B, 40, male, interview)

> We're a drop in the bucket compared to these big decisions that are very negative for long term management of this important resource. (11A, 59, male, interview)

Subtheme 4: Reasons for the SMS program

Some participants did not see the need for water conservation technology. While others felt the conservation efforts are misdirected, and should be focused on larger entities rather than homeowners.

> I think Florida's got a good supply compared to most of the other states… If you look at the overall cycles, you know, dry spells and wet spells it evens out. You know wastewater's different from drinking water. The bottom line is no matter if you drink the water or use it as wastewater, it's not like the water disappears. You know, it still gets recycled. It goes into the ground. It goes into the water treatment plant but it still gets recycled. It doesn't get consumed like gas or oil. (9B, Interview, 40, male, Phase B)

> I'm sure it's helping out, you know, the people- with the sensors, but it's not—it doesn't seem to be doing anything for our environment. (18A, interview, 37, female, Phase A)

> I am opposed to the present heavy . . . restrictions on homeowner's use and wide open, take all you want to people that's bottling water and doin' industry and plants and so forth. (2A, 80, male, FG2)

Theme 2: Audience Profile

This theme also relates to Objective 2: Evaluating homeowner environmental beliefs, and contributes to Objective 4 by providing insight for a social marketing campaign.

Subtheme 1: Self-description

Participants described themselves according to their values; they volunteered that they were trying to be "green" or that they participated in other conservation programs, and most mentioned the cost of water as a strong motivator or one of the motivations to conserve water. In contrast, other participants admitted that water was wasted, they were motivated by neighborhood norms, and cost was not a strong enough motivator to dissuade use. One participant was a good representative of a "lawn person" in that he would have a lawn despite high cost. Another participant gives the excuse that their home is already landscaped, and changing it would decrease property value.

> I like that I am being green- and that's two-fold. I'm saving money and helping the environment. (12B, 37, female, interview)

> I'm not lawn proud or anything like that- I just want it to look nice. (7A, male, 53, interview)

> Well, I can . . . think a minute and my lawn is probably a lot greener than the rest of my neighbors so you know they all have a sprinkler system and irrigation system, but I don't know . . . the one with the well they have to manually turn it on when they want to. The others obviously don't water as heavily as I do . . . You can't live-- without irrigation, you've got to have—I mean, to have a lawn, you got to have irrigation. I mean, the people on my street, their back yards are not grassed in. It's natural woody with the leaves and all. And the previous owners to my house cleaned it out and put a big lawn in the back yard. My neighbors come and look at my yard for the first—oh my! What a big lawn! And you know, well that takes water! (2A, 80, male, FG2)

> We're kind of enforcing a status quo at present. I mean, we have a lot of square footage in these gardens [wife] has, but she spends a lot of time out there and the maintenance on those is really time consuming. You know, and I think right now, and this might change in the future, but this part of the country, homes that are built on large lots are somehow already landscaped and to take out lawns and go native is not a value enhancing decision. (11A, 59, male, interview)

Subtheme 2: Talking to neighbors

A Willingness or unwillingness to talk to neighbors about their water use can help evaluate how likely adopters may be in the diffusion process, and could identify key actors who may aid in the process.

> Hm, um, well, I suppose talking to people about it is probably not a great way to build a friendly neighborhood. (11A, 59, male, interview)

> I can't tell you how many times I saw that thing running when it was pouring rain. But I couldn't talk to the guy about it. Didn't feel it was my duty to do that. (19B, 68, male, FG1)

> To think about my neighbor overusing water- it just doesn’t- it doesn’t motivate me. You know. Probably if I uh, if we were out in the yard I might say something. (15A, 69, male, interview)

> If there was educational material or something, I could—I wouldn't mind passing that along to the association because we do pay association dues and that covers the water cost in our neighborhood. I think it would be beneficial to them to have a water—you know, some kind of sensor or some way to not water when we don't need to. (16B, 37, male, FG2)

Theme 3: Benefits of SMS

The theme of benefits coincides with Objective 1: evaluating the perspective of the homeowner regarding the usefulness of the SMS. These segments can help to understand what residents like about the technology and creating suitable marketing messages.

Subtheme 1: Effectiveness

Most participants in the study were pleased that the SMS worked so well. They had little interaction with the technology but their lawns were still acceptable and they had noticed a savings in their water bills. From this standpoint, the intervention was effective.

> Well, in my opinion, if it rains, it prevents you from using that extra water time. Like, it will cut off—it overrides the regular system. So, if you don't have any type of way to monitor the water, then the system is gonna go on and it will sprinkle while it's raining, or right after it rained. And with the sensor, whether it be a water sensor or a moisture sensor, it's gonna save water. (16B, 37, male, FG2)

Subtheme 2: Efficiency/Accuracy

Some participants seemed to view the efficiency of the sensor with a means of having more control over lawn maintenance.

> Um, I- I think what I like the most is that it appeals to my need to be more scientific about my lawn. So I—I’m in medicine and science, so having more uh, accuracy and precision appeals to me. It enables me to use the professional side of my mind into my personal life. (17B, 40, male, interview)

> Um, I wanted to use the minimum amount but I have no way of gauging how much my lawn really needed. And this gave me an automated way to find out. (11B, 59, male, FG1)

Subtheme 3: Makes travel easier

A couple of program participants provided insight into the fact that the SMS technology allowed them to leave home on vacations and not have to worry about the lawn.

> Our landscaping is basically designed for us to be able to go away. I mean, we pick types of plants and flowers that especially blooms in the winter time instead of the summer, because we spend our springs, summers, and early fall typically in Colorado, and so we don’t want a whole lot of blooming stuff that blooms in the summer while we’re gone and needs to be taken care of. That’s why we designed it so we could be gone. And that’s why that Moisture sensor is so great because if uh, if we’re gone that amount of time, there are many days where we don’t have to pay to have it irrigated and overwater. (15A, 69, male, interview)

> Well you don't have to worry- if it's raining, it doesn't go on. If you go out of town you don't have to worry. My neighbors are jealous. (2b, 68, female, FG1)

Subtheme 4: Water savings

The savings noticed by program participants was a clear benefit to those households that had a positive experience with the SMS technology.

> I think there's so much water we could save just on a residential basis. If it was enforced, we would save lots of water just on a residential basis. (16B, 37, male, FG2)

> Well, in my opinion, if it rains, it prevents you from using that extra water time. Like, it will cut off – it overrides the regular system. So, if you don't have any type of way to monitor the water, then the system is gonna go on and it will sprinkle while it's raining, or right after it rained. And with the sensor, whether it be a water sensor or a moisture sensor, it's gonna save water. (16B, 37, male, FG2)

Theme 4: Barriers to Effectiveness

Investigating barriers is extremely important when developing marketing strategies. Understanding the barriers to adoption of the SMS meets Objective 1 of the study: evaluate homeowner opinion of the SMS device. The actual or perceived capabilities of the device itself can provide insight into what barriers need to be addressed to market the device successfully. Many of the devices failed, or only worked for a short time, and some did not function ideally for the landscape. Characteristics of the sensor, either perceived or real, were based on the limited knowledge of the participants and are recorded in subthemes.

Subtheme 1: SMS did not work

There were several participants whose SMS failed or they had it removed. When technological solutions are proposed to conservation issues, this is always a risk. This can lead to potential adopters being discouraged to try the technology again and they may also talk to their neighbors about their negative experience.

> It was great when it worked. (14A, 71, male, interview)

> Well I was hoping it would save me a lot of money on my water bill and it really did when it wasn't working. (15B, 75, male, FG1)

> There's no way that placing one sensor in one spot could give an accurate reading as it relates to how much water the different parts of my yard needed. (10B, 62, male, interview)

> Different parts of my yard requires different amounts of water so when it goes through the cycle, if it's reading that part of the yard where the sensor is has enough water, it's going to cut off and not feed the rest. (10B, 62, male, interview)

> I had a rain sensor that was attached to my wall not to the soil itself and when it rained that would turn off my system. And when the sensor dried out it would call for the system to come back on the day that I needed it to be watered. But I didn't see any difference in the amount of money that I

> was spending on my utility bill as it relates to the system that you guys installed. (10B, 62, male, interview)

Subtheme 2: Confusion over setting the threshold

Some participants had a problem with what threshold setting was appropriate for their lawns. An improper setting could cause the SMS to turn the water on too soon or not often enough. The threshold setting issues originate in the installation stage by the contractors.

> Well, you know my groundskeeper told me that the manufacturer ships them set at 24 or 25 and yet the installers pulled them down to 16 or so. I don't know why they did that. (19b, 68, male, FG1)

Theme 5: Knowledge of the Device

Knowledge of the device was coded by how they interacted with the SMS. Participants generally treated it as a “black box” device that ran automatically and did not need recalibration after installation. These quotes demonstrate how little participants knew of the device.

> I’ve never seen it. Um, they came and installed it, and uh, then it—So it automatically did everything and then once a year it has to be inspected so they come out and inspect it so I—I don’t—I’ve never seen it, actually. [So you’ve never had to reprogram it, or . . .] No, I’ve never had to do any of that. They um, they you know, they make you pay for an, uh, upkeep, but um, it’s never broken in between that I know of. (18A, 37, female, interview)

> [Ever reprogram it?] This is a tricky answer because I’ve been told for a long period of time to not really touch it. To let it go. And so, you mean post being told not to touch it like in the last month since it’s been recalibrated? (14B, 49, female, interview)

> We think we got a little booklet or something. We had some questions and someone came out once, but we had really very little follow up. Um, and we didn’t get a lot of information, it was kind of I think you know, like a plug and play. The thing gets plugged in and it would take care of itself and you don’t have to worry about it. That was how we understood it and we were sold on it. That was our expectation. (11a, 59, male, Interview)

> I don't think it's as easy as the rain bird we had initially. All you had to do is off-on, set the date and the time, and that's it. Whereas this, you gotta go in, and push this and change that and ok—It's just getting used to it, that's all. (2B, 68, female, FG1)

> It may not need the water that it normally would and therefore that magical trigger-point could be and should be changed. But I wouldn't know how to do that, and I don't . . . (19B, 68, male, FG1)

> It is done automatically and I don't look at it, so… we just have it set to water twice a week in the summer and once a week in the winter, and if the sensors say it doesn't need to be watered, the system doesn't come on. (1B, 44, female, interview)

> To best of my knowledge, the—what are you calling your thing again? The moisture system or something, to the best of my knowledge that was something they went out there and buried in the ground wired some wires to my valves so it would cut on and cut off when it told it to. (2A, 80, male, FG2)

> I can call the plumber that will come out and look at it that I was given that number. Or I'll just look in the manual first. Because if at this point I'm allowed to you know, play with that, I can see if I can increase the percentage myself. (14B, 49, female, interview)

Recommendations from Participants

Participants were eager to offer recommendations for the improvement of the project or for the device itself. The following are some topics they brought up. Participants suggested having more than one SMS in order to account for variations in soil and to have more accurate readings and control over each zone. However, multiple sensors aren't needed, provided that people have adequate knowledge as to just how much water different plants or zones need. Perhaps education or training will help people understand the water needs of the plants in their yard and they might become more aware of the impact lawn has on their water consumption. Another participant wanted increased control, perhaps with satellite and use of a smart phone application.

Chapter Summary

The quantitative savings recorded by the SMS installation showed that the device was effective for water conservation. While the savings were significant, the households remained in the upper level of water users. The social evaluation showed why this occurred. The audience for the trial could be described as mostly white, upper income with a large number of retirees. All used a lawncare service and lived in a neighborhood with homeowners association. The coding process yielded five broad themes with subthemes within each.

The first broad theme that emerged was coded into participant discussions of water. Within this category, they recounted their awareness of their own use of water, and expressed opinions about how much their neighbors were using (or wasting). Participants had strong opinions about what they saw as the real issues about use of water resources and hinted that it was political decisions that led to the wasteful use of water in bottling plants, agricultural operations, and large developments. A second broad category was created to capture a description of the SMS audience. This category included quotes about their lawns and how often they talked to their neighbors when they saw them wasting water. A third broad category focused on participant's opinions about their perceived benefits of the SMS. This depended on whether it was effective at saving water but also how it made travel easier. A fourth category revealed the barriers to effectiveness, such as when the device failed to work properly or when there was confusion about the threshold settings. A final category showed that some residents did have knowledge of how the SMS worked and how to set it. Finally, participants offered many recommendations for improving the program. The next chapter will discuss these data results in terms of developing a social marketing campaign for adoption of SMS.

CHAPTER 5
DISCUSSION

The results for the pilot study indicate that integration of Soil Moisture Sensors into a real-life residential setting can be more complicated than just installing the technology. For this chapter, the themes and coding resulting from the qualitative data analysis were applied to the principles of social marketing. An approach for more successful adoption by homeowners must address the target audience, the particular behavior, and a mix of factors to be used for marketing: the characteristics of the product, its price, placement, and its promotion. Recommendations from participants were considered along with their beliefs, calling to attention gaps in communication and possible barriers to behavior change.

Social Marketing Benchmarks

Using McDermott et al (2005) as a guide, the data were arranged into social marketing benchmarks. These are useful for structuring the discussion of the data results from the interviews and focus groups.

Behavior change

In any directed study, the target behavior must be identified and there must be specific and measurable behavioral objectives. Behavior change in this case is the acceptance and adoption of use of the Soil Moisture Sensor in a homeowner’s personal landscape. This is a narrow scope for behavior change and only involves purchasing a technology. It does not ask homeowners to become involved in the hands on management of their landscapes or to actively save water. Participants admitted not realizing they were over watering their lawn until they were invited to participate in the study. Others are not aware that their use of water is over-watering and harming their lawn. Others have no knowledge of the dormant period grass undergoes during the winter, and merely describe it as being “brown.” Some participants refuse to acknowledge there being a problem in the water supply at all, describing the hydrologic process. This lack of awareness can inhibit the recognition of a need to curtail water usage.

Audience research

Research on the participants drew characteristics and vernacular that can be used to create relatable marketing messages. The segment of the population was chosen based on rate of water consumption on lawns. These participants used enormous amounts of water regardless of the high payment required. However, some information gathered indicated that ultimate control of the irrigation systems and practices was often in the hands of contractors and lawn care professionals. This provides for a new direction in targeting another segment involved in the communication process for the purposes of diffusion- the professional sector. Participants reported that groundskeepers and lawn care professionals were responsible for setting and utilizing the irrigation system. In addition, most other lawn care needs were contracted out: thirteen participants hired a mowing/trimming company to handle those needs, while 20 hired fertilizing/pest control companies. Advice concerning products and services is routinely through the lawn care professionals rather than any other avenue. The partnership with these professionals is integral to the success of SMS adoption.

Segmentation

The intervention target group is selected out as a segment of the population due to its high outdoor water use, but segments within that group can help researchers find different avenues to affect behavior, such as identifying opinion leaders that can be recruited in product diffusion. As a group, the participating households had some similar characteristics. They were mostly white, upperclass and retired. They had large irrigation demands every month. There were potential segments that could be further defined with research. There were individuals who fully understood the SMS technology and were not afraid of adjusting the settings. Participants approved of the idea of having a “SMART” sensor, and were excited by the prospect of owning a device that exhibited unique and progressive new features. One participant in particular was very interested in the technology and essentially micromanaged the installation. Another participant merely liked using the SMS controller because he felt that it afforded him more control over his lawn and gave him a way to test out different thresholds on the grass. Two more participants appeared to be more knowledgeable of electronics and recommended new features, such as satellite linkage, or linkage to mobile devices. These participants may be the “innovators” described by Rogers and would be more likely to adopt the sensor the quickest, aided by lawn care professionals or promotion. Most participants however were more likely to avoid checking on the technology, which is typical of many households and their irrigation timer.

The influence of spouses brings in another potential audience segment. In some cases, the spouse that received the intervention or parts of the intervention, such as training, was not accessible for data collection but this highlights that not everyone in the household was familiar with the technology. Greater attention could be given for gender in future research.

Exchange

There must be an exchange where the target audience voluntarily accepts the new behavior in anticipation of some future benefits. One result of this study may be to highlight the incentives that would influence adoption. Benefits in return for adoption of the device have traditionally been rebates. In this case, $25.00 was offered in rebates to participants in Phase B. Other financial exchanges for its use were water savings and a decrease in the monthly water bill. Still other benefits perceived in return for the use of the SMS could be relief from worry. The fear of penalty for lack of lawn upkeep was very real for some participants, and some may find relief from the worry of infringing on neighborhood norms. On this same front, worry can be eliminated during travel with the automation provided by the SMS. It could lessen worries based on these conflicts, and it could reliably maintain a landscape during travel away.

The “plug and play” characteristic of the device was a benefit for those who did not want to worry about their lawns. They also saved water and money, which may have been a benefit they didn’t know was important to them until they received the initial letter from the utility. Some participants enjoyed the control that the device afforded them over water use on their lawns, for the purpose of exploring their lawn’s ideal water threshold. The SMS device afforded a worry free travel time to those often or seasonally out of town. Seasonal travel is common to Florida, and this point is particularly significant for Florida homeowners. One other benefit participants indicated may be important was the feeling of environmental responsibility such as being “sustainable,” or “green.” A commonly stated motivation for enrollment in the study was “conservation” even though these were high water using households that were not initially concerned about their use.

Marketing mix

Product, price, and promotion and place are a part of the marketing strategy for the behavior. Does the product fit the need of the segment of the population? Is the price or cost worth its adoption? What would be an acceptable price for the device? Are participants willing to take necessary actions to ensure its proper function and use? What media and channels should be used to promote the device? Is there ease of access to the purchase of the device and its installation? These are points to consider where the device interacts directly with potential adopters, considering messages to use for marketing and how they may be used.

Product

The SMS's intended use is a sensor relaying information to an automatic system. Essentially the device was a "black box" that only required installation, and no interaction with the homeowner. However, the black box approach gave participants a false sense of the trialability of the device, and this confused the participants. Further confusion occurred with the look of the control panel splicing at installation in Phase A, and then the panel/timer replacement in Phase B.

As the black box experiment indicated, homeowners need to have an accessible and clear source of information as well, perhaps from a third party, so that they may have the option to learn all the information about the device they would purchase. The fact that participants received an obvious avenue to gain information helped them feel secure in the project. Participant involvement is necessary for any future endeavor. Control beliefs and a sense of trialability are extremely important for SMS acceptance by stakeholders.

The SMS device is similar in concept to the rain sensor- a device that overrides the irrigation system timer if it measures moisture according to rain fall. Participants who were familiar with their rain sensor device have more of an understanding of the technology of the SMS. Otherwise, despite incentives, participants need to know what part they play in the interaction with the device. How does it fit into their lives? Those who were familiar with similar products like the rain sensor were more likely to understand their role and accept the product, and follow the directive not to touch.

Price

The price of the product includes the time to contact an installer, the total price of installation and maintenance, and the potential costs if the technology does not function as advertised. These prices may be lowered through a rebate program offered by the utility and the risks of failure may be mitigated by support from the local Extension office.

Product placement

The SMS is probably best suited to new home construction projects where the irrigation system is undergoing installation. If SMS is part of the irrigation system, it could be promoted as a technological asset to the new home. If it is to become an item for retro-fitting projects, it should be made available to the landscaping companies that do the installation.

Promotion

Because communication regarding landscapes came through lawn care professionals, the device would most likely be promoted and disseminated by lawn care professionals. These are the people best suited to the knowledge of the device and the setting where it would be used, as well as the network in which it can be adopted. Acting as opinion leaders, in many cases, these professionals were relied upon for advice concerning the lawn and setting of the irrigation system. Training more irrigation installers, who work as opinion leaders, and ensuring their understanding and acceptance of the device should be the focus of future residential study, as points of promotion via Rogers' diffusion model.

Other than promotion through specialty magazines and through distributors, SMS devices would be promoted through marked signs on lawns that have them in use, which is a practice already advocated by Florida statute 373.62, and which would influence neighborhood normative beliefs about the use of SMS devices.

Promotion messages for homeowners could be:

- Travel ease of lawn maintenance
- Lower water bill
- Environmental savings
- Greater control over how much water is applied to the lawn

Promotion for lawn care professionals could be incentives in the form of free products or commissions based on adoption by their customers.

Competition

What competing actions, or products interfere with the adoption of a Soil Moisture Sensor for residential use? This portion of the discussion addresses the barriers discovered in the research. Among the competing devices or factors that may limit SMS adoption are the rain sensors and the low price for water. As an alternative to buying and installing an SMS, many households may prefer to maintain their rain sensor or keep using large amounts of water each month. Few participants knew they were in the overwatering category until they received the initial letter from the utility. Participants were somewhat concerned with prices, and in fact, the motivation to participate in the study commonly was to lower irrigation costs once they had been pointed out.

Some appropriately linked their water use with the characteristics of their landscape. The degree to which a participant would perceive the lawn as a necessity would drive their maintenance and overuse of water, although many are uninformed just how much water their yard needs. Some reasons given concerning the benefit of cultivating a lawn were to avoid getting letters or fines from the homeowners' association (HOA): "And we do have restrictions, and you will get a letter if you're not maintaining your lawn." (7A, male, 53, interview) The influence of personal loved ones and attention received for the lawn does inspire more feelings of community than would otherwise be accessible. If the SMS places the lawn at risk, participants will not invest in its use and this represents a competitive behavior (maintaining the status quo).

One potential cost of any new technology is the chance of malfunction or incorrect installation. Participant 2A claimed that the Soil Moisture Sensor shorted out the electronics of the irrigation system 6 months after SMS installation.

> Didn't stop my system from working, until it shorted out… [The plumber] traced it down to uh, shortages at the valve switches due to the- whoever installed the sensor running his wires in there and causin' shorts. It was killin' my sprinkler system so [the plumber] disconnected all of that sensor junk. (2A, 80, male, FG2)

Some technical problems were due to lack of calibration at time of installation.

> Well, I had a problem with mine- it was put in on July 20th and until this last Sunday, it had never come on automatically. It was okay at first because there was a lot of rain, but then the plants were starting to show signs of stress (15B, 75, male, FG1).

In this case the threshold was set too low, and the sensor was reading that the soil moisture content was sufficient due to its setting, and therefore the irrigation system was perpetually turned off. Another participant in the same focus group had the opposite problem in that the SMS did not function to control the irrigation system at all, and so the system, “never failed to irrigate” on the days for which the timer was set. (19B, 68, male, FG1) If the device does not function, it fails to achieve the original promise of full-automation.

The factory settings were the settings used for most installations, and then the follow-up and training session from the technician were the opportunity to change the settings. If the threshold for factory setting is high for Florida soils, lawns can be overwatered with the SMS. After the follow-up session, many participants had their SMS thresholds lowered to water less. In this case, particular attention should be given to greater training of plumbers and irrigation experts.

Chapter Summary

The discussion for the evaluation results indicate that integration of SMS into a real-life residential setting can be more complicated than just installing the technology. For this chapter, the themes and coding resulting from the qualitative data analysis were applied to a social marketing framework. Its benchmarks and marketing variables were discussed. An approach for more successful adoption by homeowners considers addressing the target audience, the particular behavior, and a mix of factors to be used for marketing: the characteristics of the product, its price, placement, and its promotion.

CHAPTER 6
CONCLUSIONS

The conservation of water is a powerful issue in the face of increasing population and threats to aquifer health in Florida. To address the problem, the St. John's Water Management District partnered with Gainesville Regional Utilities to pilot test a conservation device, a Soil Moisture Sensor, in homes around Gainesville, Florida. Phase A of the project was characterized primarily by installing the technology in homes using a "black box" approach with little information provided to homeowners. Unfortunately, many of the SMS failed to work properly. The second phase involved a partnership with cooperative Extension which provided information to the homeowners, with more positive results.

This thesis is an evaluation of both phases of the pilot study, prepared from the perspective of homeowners and with the following objectives:

- To evaluate homeowner opinion of the SMS device
- To examine homeowner environmental and technological beliefs
- To compare the "black box" approach to an informed approach
- To tailor the results to a Community Based Social Marketing campaign

The results in Chapter Five summarized each of these objectives. This chapter will make final recommendations for a future campaign to promote adoption of SMS technology by homeowners.

The specific behavior to be promoted is the purchase of SMS technology and the installation of it in the landscape. Associated behaviors include the maintenance of the technology and confirmation that it is working properly. The target audience includes those households most likely to adopt the innovation, such as those who are comfortable with new technologies or who would like technological solutions that remove hands on management of landscape irrigation. Homeowners that tend to “set it and forget it” when it comes to irrigating, would find the SMS useful. Many participants in the research admitted that they did not adjust their irrigation system themselves and left it up to their lawn care professionals. If their lawn care contractor was capable of setting and using the SMS technology, they would be a secondary audience.

Normative beliefs play a large role in landscaping behaviors. These are beliefs enforced by family or community members to support the norm of a lush green landscape. Personal environmental beliefs may be in conflict with this ideology; several participants said they thought their landscaping actions were harmful to the environment but they would do it anyway or look the other way when a neighbor did them. For example, one woman, when asked about hiring a pesticide and fertilizer company, said, “I know it’s probably wrong”. Another participant, after admitting that he hates the thought of water being wasted, pointed out a neighbor’s irrigation: “I can't tell you how many times I saw that thing running when it was pouring rain. But I couldn't talk to the guy about it. I didn't feel it was my duty to do that.” Having homeowner associations (HOAs) play more of a role in setting the standards for behavior could eventually translate into normative changes in the neighborhood.

The information needed to support adoption of SMS, even if the household just wants to “set it and forget it,” must be easily accessible for homeowners. A website that is provided through Extension that clearly differentiates the choices in technological care for the lawn, with links to the operation manuals of different SMS models can help homeowners make clear choices, and encourage greater responsibility. Plumbing, irrigation, or lawn care companies may also be a target for marketing and information delivery, and also a good source for gaining feedback about SMS.

Partnerships are extremely important to a social marketing campaign. Multiple partners can address barriers from different directions, through different communication channels. The cooperative Extension service should partner with utilities to lower the barriers to adoption of SMS. The lack of knowledge by homeowners concerning their lawn's needs as well as watering restrictions shows the need for better informed citizens. Utility companies and Extension can do the following:

- Address the personal disconnect between landscaping and water resources
- Address the barriers due to convenience
- Address normative barriers in neighborhoods and HOAs
- Utilize communication channels
- Utilize change agents and opinion leaders

Rogers (1995) has indicated that the most influential sources are opinion leaders in the community. Indeed, the results have pointed to the fact that most residents rely on their irrigation contractors or landscapers for their information. Participants in the study demonstrate a propensity to rely on lawn care professionals and are a trusted source of information. Housing developments with landscaped common areas can also employ the use of SMS devices to save on water costs. Conservation rules could potentially be adopted in codes and deed restrictions, and the use of SMS on residential properties could be encouraged. Recruiting lawn care professionals as partners to disseminate the technology is a very clear avenue for growth. Training can be provided in partnership with Extension as well.

The results for the pilot study indicate that integration of Soil Moisture Sensors into a real-life residential setting can be more complicated than just installing the technology. Water conservation behavior is remarkably different from other conservation behaviors. The public does not have strong understanding of water as a threatened resource and they often blame others for using more than they do. They also do not understand the water needs of their landscape. While education is important in behavior change, it will not change behavior alone. Neither would technological advances alone be enough to promote change, because it does little to bridge the gap between understanding the problem of water and the homeowner's role in that problem. The results of this study provide policy makers, utility providers, and researchers a view of the possible barriers, complexities and avenues through which the Soil Moisture Sensor may be marketed.

People are more likely to change their behavior when they have multiple motivations for doing so. These motivations must also speak to a person's sense of risk or danger, and the messages should increase over time, through multiple avenues, especially from opinion leaders in the community. In this way, social marketing has proven effective by taking into account different factors of the setting, the perspective of possible adopters, and identifying the barriers to behavior change. In this case, the best approach would be addressing a particular target audience, focusing on a specific behavior, and using the mix of product, its price, placement, and its promotion. Finally, creating partnerships to plan and implement tailored strategies for adoption will produce the best chances for behavior change.

APPENDIX A
UTILITY CHECKLIST AND REBATE FORM

The following are example pages used to aid SMS installation and record-keeping for the utility company. Markings from the installer are there to visualize how they were used. The first page is a baseline checklist for installers that provides space to record previous settings, what actions were performed (e.g. installation of an irrigation system backflow preventer, or SMS device) and pre and post threshold settings for each irrigation zone. The second page is a rebate form. Homeowners had a $25 rebate available to them in return for the installation of the SMS device. All names and personal information on the form were eliminated to ensure confidentiality.

Irrigation Maintenance Checklist

✓ Condition of yard (Excellent Good Fair Poor)

✓ Inspect back-flow preventer for presence and proper function

 0 Install if not present

✓ Inspect system for proper function

 ✓ Irrigation heads inspected and adjust as needed

 ✓ Checked the irrigation lines for leaks, including from line (or meter) to system

0 Inspect system's rain gauge and/or moisture sensor

 0 Install or replace if malfunctioning or missing

 ✓ Field Capacity of soil for SMS installation 25 % Date Set: ____

✓ Check the system control settings and set to proper timer based on address, GRU, SJRWMD & IFAS recommendations for current season (e.g. in summer, address 1059 would water on Wed & Sat at 4:00 AM)

Start Time	Odd Addresses		Even Addresses		Non-Residential
	Potable	Reclaimed	Potable	Reclaimed	
2:00 AM	1, 3, 5		0, 2, 4		Potable
4:00 AM	7, 9		6, 8		
6:00-10:00 AM 4PM-Midnight		1, 3, 5, 7, 9		0, 2, 4, 6, 8	Reclaimed

Summer (April – September) Odd – Wed & Sat Even - Thurs & Sun
Winter (October – March) Odd – Saturday Even - Sunday

Current Settings

Zone 1 10 Zone 2 15 Zone 3 10 Zone 4 15 Zone 5 20

Zone 6 ____ Zone 7 ____ Zone 8 ____ Zone 9 ____ Zone 10 ____

New Settings - Recommended watering amounts/time based on vegetation & soil type

Zone 1 10 Zone 2 15 Zone 3 10 Zone 4 15 Zone 5 20

Zone 6 ____ Zone 7 ____ Zone 8 ____ Zone 9 ____ Zone 10 ____

Comments: ____

Irrigation Technician: [redacted] Date: [redacted]

BILLED BY: [handwritten initials]
DATE [handwritten]

FOR GRU USE ONLY

GRU Account #: [redacted]
Amount to be Paid: ______
Rebate Rate#: [redacted]
GL Account #: [redacted]
Invoice #: ______
Invoice Date: ______
Supplier #: ______

Irrigation Rebate Form

Effective March 1, 2010

Mail to:
Gainesville Regional Utilities
Conservation Services
PO Box 147117, Station A114
Gainesville, FL 32614-7117

Questions?
Phone: 352-393-1460
Fax: 352-334-2731

GRU Customer Information

Customer Name: [redacted]

Billing Address: [redacted]

Phone: [redacted]

Email: ______

GRU Account #: ______

Address where installed: ______

Contractor: [redacted]

Complete all that apply: ☑ Residential Structure ☐ Commercial Structure ☐ Owner Occupied ☐ Renter Occupied

Irrigation System Maintenance Rebate Up to $50 per system	# Zones checked/system System 1 ______ System 2 ______ System 3 ______	Back Flow Preventer ☐ Existing ☐ Installed Last Serviced: ______	Back Flow Information Make: ______ Model: ______ Serial: ______	Date System Serviced RP PVB
Rain Activated Shut-off Device Rebate $25 per device	Existing Device ☑ None ☐ Rain Sensor ☐ Soil Moisture Sensor	Installed Device ☐ None ☐ Rain Sensor ☑ Soil Moisture Sensor	SMS Field Capacity 35 %	Date Rain Shut-Off Device Installed

This rebate is to encourage the proper use and maintenance of an in-ground irrigation system and rain activated shut-off device. Rebate applies only to locations with GRU's water service and an existing in-ground irrigation system. Rain activated shut-off device must be installed and in working order, repaired or a new one installed. Irrigation system must have an existing or newly installed back flow preventer per Florida Plumbing Code. Irrigation System maintenance does not require or include testing of the system's back flow preventer. Customer must use current Irrigation Partnering Irrigation Contractor.

Restrictions - Limit one Irrigation Maintenance Rebate per system, limit one Rain Activated Shut-off Device per system

Rebate not available for GRU water customers using reclaimed water or a well for irrigation

Rebate form must be complete and turned in to GRU along with a copy of the receipt for maintenance and GRU's Irrigation Maintenance Checklist. Random on-site verification of installed/repaired measures may be performed prior to issuing rebate. A BILL CREDIT will be issued at the address of service (unless otherwise noted.) Please allow 2-4 weeks for processing.

I hereby affirm that I am a GRU Customer using GRU water service and have an existing in-ground irrigation system.

[redacted] Date: [redacted]
Customer [redacted]

☐ I prefer to receive the rebate in the form of a check

______ Date: ______
GRU – Confirmation of Program Manager

______ Date: ______
GRU – Conservation Services Manager
Revised 2/10 AC

APPENDIX B
DRAFTS FOR INSTRUMENT

Below are the preliminary questions formed for the study by researchers, and then following is the first draft of the instrument that was tested on participant 18A on November 2, 2012.

Preliminary Questions

1. What should Floridians do to conserve water?
2. Does it ever bother you how much water your neighbors use in their yards?
3. What motivated you to get involved in the GRU soil moisture sensor program?
4. What do you like best about having the soil moisture sensor?
5. What is the biggest drawback?
6. What were you expecting when it was installed?
7. How has it changed the way you water your lawn?
8. Have you talked to your family or neighbors about the soil moisture sensor? What did you say to them?
9. How could GRU convince more people to install SMS in their yards?
10. Do you think any of your neighbors would be interested in this? Why or why not?
11. Is there anything else you would like to add?

First Instrument

Thank you for agreeing to participate in the interview. Before we begin, can you confirm on the recording that I have your permission to audio-record our conversation today?

The University of Florida Institutional Review Board requires me to inform you that there are no foreseeable risks to your participation in this interview today. You will not be compensated for your participation and it is completely voluntary-- you may withdraw without penalty at any time. If at any time you want me to stop audio recording our conversation, let me know and I will do so. Your name will never be associated with your responses, and I hope by maintaining this confidentiality you will speak openly and honestly. Your perceptions and those of others who participated in the SMS program will be used as part of the data for my master's thesis and I really appreciate your time. This interview should take about 25 minutes. Thanks, again, let's get started.

1. What were your reasons for being involved in this pilot study?

2. What were you expecting when the Soil Moisture Sensor was installed?

3. How has the SMS changed the way you water your lawn?

4. What do you like most about having the soil moisture sensor?

5. How easy is it to use? Have you ever had to reprogram it? When? Why? Tell us more about that?

6. How do you know it works properly? Do you think it works properly all the time? What makes you say that?

7. Did you previously rely on the Timer? How does the SMS compare to using a timer?

8. Do you think your yard needs more water? Why? What do you do if/when you think that?

9. What do you dislike about your SMS?

10. Would you recommend an SMS to a friend or neighbor?

    Probe: Have you already? Were they interested?

[Switching gears]

11. Are you happy with your landscaping? Why or why not?

12. What would you change about your landscaping?

13. Have you made changes to your landscape since SMS installation?

[Switching gears]

14. How do you feel about water restrictions?

15. Do you ever worry that water use will be restricted even more than it is?

16. Have water restrictions had an effect on your yard? What makes you say that?

17. Have you ever seen water being wasted? Where/when? How does that make you feel?

18. Do you anticipate water shortages in Florida that would impact you personally?

19. What is the best way to increase water supply for Florida's future?/ What should Floridians do to secure enough water for the future?

20. Anything else you would like to add? Do you have any questions?

21. Is it ok for me to contact you in the future with further questions or feedback?

APPENDIX C
FULL INSTRUMENT FOR DATA COLLECTION

Below is the interview guide or the qualitative instrument in use for the study. This instrument starts with an introduction and informed consent, and is designed to be said aloud to participants in either a recorded interview setting or a focus group setting. The survey and questionnaires were given in a semi-structured interview, where the researcher, at his or her own discretion probes for more information or decides to omit question based on a previous response. The demographics questionnaire and the environmental paradigm questionnaire was given aloud in personal telephone interviews after the survey questions were asked, and was completed by Focus Group participants on paper prior to the discussion.

Interview/Focus Group Guide

Thank you for taking the time to join this discussion about soil moisture sensors and water use. My name is Lyndall Brezina and I am from the University of Florida. (If focus group: Assisting me is _______________.) My purpose today is to learn more about your opinions about the soil moisture sensors and water conservation in general. I am interested to know your opinions so that we can better understand SMS use and water management through conservation technology programs. Your perceptions will be used as data for my master's thesis so I want to thank you again for taking the time to speak with me today.

(If interview: Thank you for agreeing to participate in the interview.) Before we begin, can you confirm on the recording that I have your permission to audio record our conversation today?
Great, thanks.
The University of Florida Institutional Review Board requires me to inform you that there are no foreseeable risks to your participation in this interview today. You will not be compensated for your participation is completely voluntary-- you may withdraw without penalty at any time. If at any time you want me to stop audio recording our conversation, let me know and I will do so. Your name will never be associated with your responses, and I hope by maintaining this confidentiality you will speak openly and honestly. Your perceptions and those of others who participated in the SMS program will be used as part of the data for my master's thesis and I really appreciate your time. This interview should take between 20 and 30 minutes. Thanks, again, let's get started.

1. What were your reasons for being involved in this pilot study? – had you ever noticed how much water your used on your yard before? Were you surprised at how much water you were using on your yard?

2. What have you noticed about your water use since the SMS was installed?

3. How has the SMS changed the way you water your lawn?

4. What do you like most about having the soil moisture sensor?

5. How easy is it to use? Have you ever had to reprogram it? When? Why? Tell us more about that?

6. Did you receive any training on how to use it? IF YES: From whom? How was the training for you- What can you tell me about your training experience? Have you used information you learned in the training? How could the training be improved?

[Back to SMS itself:]

7. How do you know it works properly? Do you think it works properly all the time? Do you look to see if it is working? What signs do you see that let you know it is

working? What makes you say that?

8. What do you do if/when you think your SMS is not working properly? (What if it wasn't? what would you do?) Ex: Do you contact anyone? Who? Has the information provided by the manufacturer or GRU been helpful?

9. How do you know how much water your yard needs? Do you think your yard needs more water? Why?

10. Did you previously use an irrigation timer? How does the SMS compare to using a timer?

11. What do you dislike about your SMS?

12. Would you recommend an SMS to a friend or neighbor?

13. Have you talked to neighbors about your SMS? Why/ how did that come up? What did you say about your SMS?

14. How do your irrigation practices compare to your neighbors? How do you know? How do you know your neighbors use more/less irrigation water? How does that make you feel?

15. Have you ever seen water being wasted? Where/when? How does that make you feel?

16. What would you be willing to do to help your neighbors use less water? Ex:

- Talk to them about SMS, deficit irrigation, springs health, problems with overwatering grass- shallow roots, fungus etc.
- Refer their address to GRU and/or the county so they can receive a letter about their water use and information to lower it
- Talk about Reduce turf, remove turf, add natives
- Talk to your HOA about native plants, etc.

17. Do you talk to your neighbors about your yard? Do your neighbors talk with you about your yard? About what?

18. Are you happy with your landscaping? Why or why not?

19. What would you change about your landscaping?

20. Have you made changes to your landscape since SMS installation?

21. Could you live without an irrigation system?

[Switching gears]

22. How do you feel about water restrictions?

23. Do you ever worry that water use will be restricted even more than it is?

24. Have water restrictions had an effect on your yard? What makes you say that?

25. Do you anticipate water shortages in Florida that would impact you personally?

26. What is the best way to increase water supply for Florida’s future?/ What should Floridians do to secure enough water for the future?

27. Anything else you would like to add? Do you have any questions?

28. Is it ok for me to contact you in the future with further questions or feedback?

[Now I have some demographic questions to ask you.]

Demographics Questionnaire

1. What is your occupation?
____

2. What is your age? ___________

3. What is your gender? Female ❑ Male ❑

4. How long have you lived in the Gainesville area? ___________ years

5. How long have you lived at your current residence? ___________ years

6. How many live in your household? ___________

7. What are their ages and sexes?

___________ ___________ ___________ ___________

8. On average, how many days a week do you water your lawn? (circle your answer)

Don't know Rain is the source of water

1 2 3 4 5 6 7

9. What is your current marital status?

- Divorced
- Living with another
- Married
- Separated
- Single
- Widowed

10. What is the highest level of education you have completed?

- Grammar school
- High school or equivalent
- Vocational/technical school (2 year)
- Some college
- Bachelor's degree
- Master's degree

- Doctoral degree
- Professional degree (MD, JD, etc.)

11. How would you classify yourself?

- Caucasian/White
- Asian/Pacific Islander
- Black
- Arab
- Hispanic
- Indigenous or Aboriginal
- Latino
- Multiracial
- Would rather not say
- Other ______________________

12. Do you hire a contractor to (circle your answer):
Apply Fertilizer Apply Pesticides Apply Herbicides Mowing Trimming

13. What is/are the name(s) of your contractor(s)?

____

14. Do you have a well?
Yes No
If yes, what do you use it for? (I.E. household use or irrigation only)

____

Finally, if you are willing we have an optional ten-question inventory to assess your worldview. Would you like to answer eleven more questions or do you need to hang up?

Participant code ________

New Environmental Paradigm Questionnaire

We are curious as to your opinion on a wide range of environmental issues. For each of the following statements please indicate the extent to which you agree or disagree.

1	2	3	4	5
Strongly Disagree	Mildly Disagree	Neutral	Mildly Agree	Strongly Agree

_____1. We are approaching the limit of the number of people the earth can support

_____2. The balance of nature is very delicate and easily upset.

_____3. Mankind was created to rule over the rest of nature

_____4. When humans interfere with nature it often produces disastrous consequence

_____5. Plants and animals exist primarily to be used by humans

_____6. To maintain a healthy economy we will have to develop a "steady-state" economy where industrial growth is controlled

_____7. Humans must live in harmony with nature in order to survive

_____8. The earth is like a spaceship with only limited room and resources

_____9. Humans need not adapt to the natural environment because they can remake it to suit their needs

_____10. There are limits to growth beyond which our industrialized society cannot expand.

_____11. Mankind is severely abusing the environment

Adapted from Dunlap & Van Liere (1978). The new environmental paradigm: A proposed measuring instrument and preliminary results. *Journal of Environmental Education, 9,* 10-1

LIST OF REFERENCES

Ajzen, I., Fishbein, M. (1980) *Understanding Attitudes and Predicting Social Behavior.* (Englewood Cliffs, NJ, Prentice Hall).

Allen, G. M., Main, M. B. (2011) Florida's Geologic History. (WEC189). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved March 5, 2013, from http://edis.ifas.ufl.edu/uw208.

Andreasen, A. R. (1994). Social marketing: its definition and domain. *Journal of public policy and marketing* 13(1),108-114.

Annear, T. C., Conder, A. L. (1984) Relative bias of several fisheries instream flows methods. *North American Journal of Fisheries Management* 4, 531–539

Barnett, H. G. (1953). *Innovation: the basis of cultural change*. (McGraw-Hill: New York, NY, US)

Brookshire, D. S., Thayer, M. A., Schulze, W. D., D'Arge, R. C. (1982). Valuing public goods: a comparison of survey and hedonic approaches. *The American Economic Review* 72(1),165-177.

Byrne, L. B. (2005). Of looks, laws and lawns: how human aesthetic preferences influence landscape management, public policies and urban ecosystems. In Emerging issues along urban-rural interfaces: linking science and society conference proceedings. (Auburn University, Auburn 42-46).

Fishbein, M., Yzer, M. C. (2003). Using Theory to Design Effective Health Behavior Interventions. *Communication Theory*, 13,164–183.

Milesi, C., Elvidge, R., Nemani (2009). *Assessing the extent of urban irrigated areas in the United States. Remote sensing of global croplands for food security*. (NASA Ames Ecological Forecasting Lab, San Francisco, CA) Retrieved from http://ecocast.arc.nasa.gov/pubs/pdfs/2009/Milesi_Urban_BookChapter.pdf

Cahn, M. A., O'Brien, R. (Eds.). (1996). *Thinking about the environment: Readings on politics, property, and the physical world*. (ME Sharpe. Armong, NY)

Cardenas-Lailhacar, B., Dukes, M. D., Miller, G. L. (2008). Sensor-based automation of irrigation on bermudagrass, during wet weather conditions. *Journal of Irrigation and Drainage Engineering* 134(2), 120-128.

Carriker, R. R., Borisova, T. (2009). Public Policy and Water in Florida. (FE799). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved October 22, 2013 from http://edis.ifas.ufl.edu/fe799/.

Carriker, R. R., Borisova, T. (2013). Florida’s Water Resources. (FE757). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved October 22, 2013 from http://edis.ifas.ufl.edu/fe757.

Corral-Verdugo, V. (2002). A structural model of pro-environmental competency. *Environment and Behavior* 34(4), 531-549.

Corral-Verdugo, V., Armendáriz, L. I. (2000). The new environmental paradigm in a Mexican community. *The Journal of Environmental Education* 31(3), 25-31.

Corral-Verdugo, V., Bechtel, R. B., Fraijo-Sing, B. (2003). Environmental beliefs and water conservation: An empirical study. *Journal of Environmental Psychology* 23(3), 247-257.

Corral-Verdugo, V., Carrus, G., Bonnes, M., Moser, G., Sinha, J. B. (2008). Environmental beliefs and endorsement of sustainable development principles in water conservation toward a new human interdependence paradigm scale. *Environment and Behavior* 40(5), 703-725.

Corral-Verdugo, V., Frías-Armenta, M. (2006). Personal normative beliefs, antisocial behavior, and residential water conservation. *Environment and Behavior* 38(3), 406-421.

Custodio, E. (2002). Aquifer overexploitation: what does it mean?. Hydrogeology Journal 10(2), 254-277.

Dandy, N., Davies, A. (1997). Estimating Residential Water Demand in the Presence of Free Allowances. *Land Economics* 73(1).

Davis, F. D. (1986). *A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results.* (Doctoral dissertation, MIT Sloan School of Management, Cambridge, MA)

Dorsey, J. W. (2010). Lawn control, lawn culture, and the social marketing of sustainable behaviors. *Ecopsychology* 2(2), 91-103. doi:10.1089/eco.2009.0041.

Dukes, M. D., Shedd, M., Cardenas-Lailhacar, B. (2010). Smart Irrigation Controllers: How Do Soil Moisture Sensor (SMS) Irrigation Controllers Work? (AE437). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved October 20, 2013, from http://edis.ifas.ufl.edu/ae437

Dukes, M. D., Zotarelli, L., Morgan, K. T. (2010). Use of irrigation technologies for vegetable crops in Florida. HortTechnology 20(1), 133-142.

Dukes, M. D., Zotarelli, L., Scholberg, J. M., Muñoz-Carpena, R. (2006). Irrigation and nitrogen best management practices under drip irrigated vegetable production. In ‘Proceedings of the World Environmental and Water Resources Congress.’ (Omaha, NE)

Dunlap, R. E., Van Liere, K. D. (1978). The “New Environmental Paradigm”: A proposed measuring instrument and preliminary results. *Journal of Environmental Education* 9, 10–19.

Eden, S., Megdal, S. (2006). Water and growth. In ‘Arizona’s rapid growth and development: Natural resources and infrastructure’ chap. 4. (Background report prepared for the 88th Arizona Town Hall, April) Retrieved March, 12, 2013, from http://ag.arizona.edu/azwater/files/finalathchapter4.pdf

FDEP Florida Department of Environmental Protection. (2013). *Water Management District Reuse Programs.* Retrieved October 20, 2013, from http://www.dep.state.fl.us/water/reuse/wmdprog.htm

Feagan, R.B., Ripmeester M. (1999). Contesting naturalized lawns: A geography of private green space in the Niagra region. *Urban Geography* 20 (7), 617‐634

Feenberg, A. (2004). Democratic rationalization: Technology, power, and freedom. *Readings in the Philosophy of Technology* 209-226.

Fernald, E.A., Patton, D.J. (1984). Water Resources Atlas of Florida, Library of Congress Catalog No. 84-081758, (Institute of Science and Public Affairs, Tallahassee, Florida)

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior : An introduction to theory and research.* (Reading, Mass; Don Mills, Ontario: Addison-Wesley Pub. Co.)

Fishbein, M., Ajzen, I. (2010). *Predicting and Changing Behavior: The reasoned action approach*. (New York: Psychology Press, Taylor and Francis Group, LLC.)

Florida Department of Environmental Protection (FDEP). 2002. *Florida Water Conservation Initiative.* Florida Department of Environmental Protection, Tallahassee, FL. http://www.dep.state.fl.us/water/waterpolicy/docs/WCI_2002_Final_Report.pdf

Florida Statutes. § 720.3075. (Part I). Prohibited clauses in association documents. (4b) Retrieved October 22, 2013, from http://www.leg.state.fl.us/statutes/index.cfm?App_Mode=Display_Statute&URL=Ch0720/Sec3075.htm&StatuteYear=2001.

Florida Water Resources. West’s Florida Statutes Annotated §373.62 (2011). Retrieved 21 April, 2012, from http://www.lawserver.com/law/state/florida/statutes/florida_statutes_373-62

Florida Water Star SM (2012). SJRWMD. Retrieved February 11, 2014, from http://floridawaterstar.com/

Garner, A., Stevely, H., Smith, M., Hoppe, M., Floyd, T., Hinchcliff, P. (1996). *A Guide to Environmentally Friendly Landscaping: Florida Yards and Neighborhoods Handbook.* (SP191). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved October 22, 2013, from http://edis.ifas.ufl.edu/ep079.

Geller, E. S., Erickson, J. B., Buttram, B. A. (1983). Attempts to promote residential water conservation with educational, behavioral and engineering strategies. *Population and Environment* 6(2), 96-112.

Gilg, A., Barr, S. (2006). Behavioural attitudes towards water saving? Evidence from a study of environmental actions. *Ecological Economics* 57(3), 400-414.

Glaser, B. G., Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for qualitative research*. (New York: Aldine DeGruyter)

Grafton, R. Q., Ward, M. B. (2008). Prices versus rationing: Marshallian surplus and mandatory water restrictions. *Economic Record* 84:S57–S65. doi:10.1111/j.1475-4932.2008.00483.x

Grob, A. (1995). A structural model of environmental attitudes and behaviour. *Journal of Environmental Psychology* 15(3), 209–220.

GRU. (2012). *Soil Moisture Sensor Pilot Program*. Final report draft prepared for St. Johns River Water Management District, in coordination with the University of Florida.

Grunwald, M. (2006). *The swamp: The Everglades, Florida, and the politics of paradise*. (New York, NY: Simon and Schuster)

Haley, M. B., Dukes, M. D. (2012). Validation of landscape irrigation reduction with soil moisture sensor irrigation controllers. *Journal of Irrigation and Drainage Engineering* 138(2), 135-144. Retrieved February 2, 2014, from http://ascelibrary.org/doi/abs/10.1061/(ASCE)0733-9437(2008)134:2(120)

Haley, M. B., Dukes, M. D., Miller, G. L. (2007). Residential irrigation water use in Central Florida. *Journal of Irrigation and Drainage Engineering* 133(5), 427-434.

Hansen, G., Ramos, J., Felter, E. A., White, C. (2012). *Adopting a Florida-Friendly landscape: Steps for converting a typical development landscape to a Florida-Friendly Landscape.* (ENH1134). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved March 5, 2013, from https://edis.ifas.ufl.edu/ep396.

Harlan, S. L., Yabiku, S. T., Larsen, L., Brazel, A. J. (2009). Household water consumption in an arid city: affluence, affordance, and attitudes. *Society and Natural Resources* 22(8), 691-709. doi:10.1080/08941920802064679

Hayes, S.C., Cone, J.D. (1977). Reducing residential electrical energy use: Payments, information and feedback. *Journal of Applied Behavior Analysis* 10(3), 425-435.

Holt, L. (2005). Avoiding a Water Crisis in Florida–How Should Florida's Water Supply be Managed in Response to Growth? In 'How should Florida's water supply be managed in response to growth?' (Reubin O'D. Askew Institute, Vol. 18)

Jenkins, V. S. (1994). *The Lawn: A History of an American obsession*. (Washington, D.C.: Smithsonian Institution Press)

Kallinikos, J. (2002). Reopening the black box of technology artifacts and human agency. In 'Galliers, R. and Markus, L. (eds) 23rd International Conference on Information Systems.' (Barcelona, December 14-16, 287-94)

King, J.L., Gurbaxani, V., Kraemer, K.L., McFarlan, F.W., Raman, K.S., Yap, C.S. (1994). Institutional factors in information technology innovation. *Information systems Research* 5(2), 139-169.

Kohlenberg, R., Phillips, T., Proctor, W. (1976). A behavioral analysis of peaking in residential electrical-energy consumers. *Journal of Applied Behavior Analysis* 9(1),13-18. doi: 10.1901/jaba.1976.9-13.

Kotler, P., Zaltman, G. (1971). Social marketing: an approach to planned social change. *Journal of marketing,* 35(3).

Krueger, R.A., Casey, M.A. (2000). *Focus Groups.* 3rd ed. (Thousand Oaks, CA: Sage)

Kurz, T., Donaghue, N., Rapley, M. and Walker, I. (2005). The ways that people talk about natural resources: Discursive strategies as barriers to environmentally sustainable practices. *British Journal of Social Psychology* 44, 603–620. doi:10.1348/014466604X18064

Lund, J., Reed, R. (1995). Drought water rationing and transferable rations. *Journal of Water Resource Planning and Management* 121(6), 429–437.

Mainieri, T., Barnett, E. G., Valdero, T. R., Unipan, J. B., Oskamp, S. (1997). Green buying: The influence of environmental concern on consumer behavior. *The Journal of Social Psychology* 137(2), 189-204.

Maintenance Problems.Florida Statutes § 373.62 (Part VI; 1). *Water conservation; Automatic Sprinkler Systems*. (Current as of 2012).

Marella, R.L. (2009) Water withdrawals, use, and trends in Florida, 2005: U.S. *Geological Survey Scientific Investigations.* Report 2009-5125, 49.

Mayer, P. W., DeOreo, W. B., Opitz, E. M., Kiefer, J. C., Davis, W. Y., Dziegielewski, B., and Nelson, J. O. (1999). *Residential end uses of water.* (American Water Works Association Research Foundation, Final Report. Denver, Colorado)

McCready, M., Dukes, M., Miller, G. (2009). Water conservation potential of smart irrigation controllers on St. Augustinegrass. *Agricultural Water Management* 96(11), 1623-1632. Retrieved October 22, 2013, from http://ascelibrary.org/doi/abs/10.1061/.

McDermott, L., Stead, M., Hastings, G. (2005). What is and what is not social marketing: the challenge of reviewing the evidence*. Journal of Marketing Management* 21(5-6), 545-553.

McKenzie-Mohr, D. (2000) (2). New ways to promote proenvironmental behavior: Promoting sustainable behavior: An introduction to community-based social marketing. *Journal of social issues* 56(3), 543-554.

McKenzie-Mohr, D. (2000). Fostering sustainable behavior through community-based social marketing. *American Psychologist* 55(5), 531.

Milesi, C., Running, S. W., Elvidge, C. D., Dietz, J. B., Tuttle, B. T., Nemani, R. R. (2005). Mapping and modeling the biogeochemical cycling of turf grasses in the United States. *Environmental Management* 36(3), 426-438.

Moore, G. C., Benbasat, I. (1996). Integrating diffusion of innovations and theory of reasoned action models to predict utilization of information technology by end-users. In ‘Diffusion and adoption of information technology’ 132-146. (Springer US)

Nash, R. (1982). *Wilderness and the American Mind.* 3rd ed. (New Haven, CT: Yale University Press)

Neubauer, C. P., Hall, G. B., Lowe, E. F., Robison, C. P., Hupalo, R. B., Keenan, L. W. (2008). Minimum flows and levels method of the St. Johns River water management district, Florida, USA. *Environmental Management* 42(6), 1101-1114.

Olexa, M. T., Borisova, T., Broome, Z. (2011) *Handbook of Florida Water Regulation: State Regulatory Powers* (FE581). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved February 10, 2014, from http://edis.ifas.ufl.edu/pdffiles/FE/FE58100.pdf.

Olmsted, T. R., Dukes, M. D. (2011). Frequency of Residential IrrigationOzan, L. A., Alsharif, K. A. (2012). The effectiveness of water irrigation policies for residential turfgrass. *Land Use Policy* (31), 378-384.

Pascale, R. T., Sternin, J., Sternin,M. (2010). *The Power of Positive Deviance*. (Boston, MA: Harvard Business Press)

Pickett, S. T. A., Cadenasso, M. L., Grove, J. M., Groffman, P. M., Band, L. E., Boone, C. G., Burch . . . Wilson, M. (2008). Beyond urban legends: an emerging framework of urban ecology, as illustrated by the Baltimore ecosystem study. *Bioscience* 58:139-150.

Pinch, T. J., Bijker, W. E. (1984). The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science* 399-441.

Post, A. (2012) Florida-Friendly Landscaping™ Program Annual Report. Newport: UF/IFAS Sarasota County Extension. Retrieved February 10, 2014, from http://www.cityofnorthport.com/Modules/ShowDocument.aspx?documentid=6516

Rajbhandary, S., Borisova, T., Adams, D., Haynes, D., Boyer, C. (2010). *Use, perceptions, and barriers to water conservation strategies for Florida water utilities* (FE851). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved February 10, 2014, from http://edis.ifas.ufl.edu/pdffiles/FE/FE85100.pdf.

Rawls, C., Borisova, T. (2009). *Conservation and drought water rates: State-of-the-art practices and their application.* Conserve Florida Water Clearinghouse Research, Gainesville: University of Florida Water Institute, UF Public Utilities Research Center (PURC). Retrieved February 2, 2014, from http://warrington.ufl.edu/purc/purcdocs/papers/0910_Rawls_Conservation_and Drought.pdf

Renwick, M. E., Archibald, S. O. (1998). Demand side management policies for residential water use: Who bears the conservation burden? *Land Economics* 74: 343-359.

Robbins, P. (2007). *Lawn people: How grasses, weeds, and chemicals make us who we are.* (Philadelphia, PA: Temple University Press)

Rogers, E. M. (1995). *Diffusion of Innovations.* (4th ed.). (New York, NY: The Free Press)

Russell, S., Fielding, K. (2010). Water demand management research: A psychological perspective. *Water Resources Research* 46(5), W05302.

Sharpe, W. E., Fletcher, P. W. (1997). *The impact of water saving device installation on resource conservation*. (University Park, Pennsylvania: Pennsylvania State University, Institute for Research on Land and Water Resources, July)

Silk, N., McDonald, J., Wigington, R. (2000). Turning instream flow water rights upside down. *Rivers* 7(4), 298–313

Skardon, J. A. (1962). *The Grass Craze*, In 'Saturday Evening Post,' 17 March, 1962, 30-33.

Spechler, R. M. (1994). Saltwater intrusion and quality of water in the Floridan aquifer system, northeastern Florida: *Water Resources Investigations* 92-4174. http://fl.water.usgs.gov/Abstracts/wri92_4174_spechler.html

Spechler, R. M. (2001). The relation between structure and saltwater intrusion in the Floridan aquifer system, southeastern Florida; U.S. Geological Survey Karst Interest Group proceedings; *Water-Resources Investigations* 01-4011, 25-29. http://water.usgs.gov/ogw/karst/kigconference/rms_relationintrusion.htm

Trenholm, L. E., Gilman, E. F., Knox, G. W., Black, R. J. (2002). *Fertilization and Irrigation Needs for Florida Lawns and Landscapes*. (ENH860). Gainesville: University of Florida Institute of Food and Agricultural Sciences. Retrieved October 22, 2013, from http://edis.ifas.ufl.edu/ep070.

U.S. Census Bureau. (2010). *Quickfacts: Search Housing Alachua County*. Accessed February 2, 2014.

Verhage, B. J. (1978). Energy saving as a social marketing strategy: Implication for the government policy. *Economisch-Statistiche Berichten*, 28 November, 1978, 1248-53.

Welsh, D. F., Welch, W. C., Duble, R. L. (2007). *Xeriscape…Landscape Water Conservation.* Electronic Document: Texas A&M University. Retrieved February 2, 2014, from http : / /hdl .handle .net /1969 .1 /87749.

Winner, L. (1993). Upon opening the black box and finding it empty: Social constructivism and the philosophy of technology. *Science, Technology, and Human Values* 18(3), 362-378.

BIOGRAPHICAL SKETCH

Lyndall Brezina is a graduate of Agricultural Education and Communication from the University of Florida, focusing on Extension and received her certificate in Tropical Conservation and Development. She received her Bachelor degree in Entomology, focusing on ecotourism. Her primary interests are water conservation, food security and food systems, and international sustainable development in agriculture.