DETERMINANTS OF WATER CONSERVATION IRRIGATION PRACTICES: A STUDY OF PARK AND GOLF TURFGRASS MANAGEMENT IN OKLAHOMA

By

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CHAPTER I

INTRODUCTION

Approximately 50 million acres of land are managed as turf in the form of residential lawns, athletic fields, golf courses, highway roadsides, cemeteries, and parks with an annual estimated value of $57.9 billion (Haydu et al., 2006). Golf courses located near municipalities can be a significant competitor for urban water supplies. U.S. golf course irrigation is estimated to use more than 476 billion gallons of water each year (Zoldoske, 2003). In the more arid regions of the West and Southwest, watering withdrawals for irrigation practices and landscaping are highest (EPA Water Sense, 2008). A reported average of 88 million gallons of water per course can be consumed each year in the Southwest United States. According to The Irrigation Association (2003), of all fresh water used in the U.S. for the purpose of irrigation, 79.6 % is in agriculture, 2.9% is in landscape, 1.5% is in golf courses, and 16% is consumed by humans, animals, and industry (Zoldoske, 2003). Even though 1.5% may seem insignificant, a majority of golf courses are located within urban areas and use highly treated potable water supplies. Therefore, reducing consumption of water through improved irrigation practices and water conservation can provide substantial benefits in reducing costs to treat water and reducing seasonal strain on water supplies (Zoldoske, 2003).

Proper landscape water use and irrigation management, which produces appealing landscapes, can increase property values, provide a safe and natural recreational surface, and can contribute to social harmony and mental health. Turfgrass and landscape plants provide several functional uses such as erosion control, dust prevention, heat dissipation, glare reduction, and serve as environmental buffers and filters (Beard and Green, 1994).

Over the years, Oklahoma's most populous cities have experienced continued population growth. From 1990 to 2006, Oklahoma City, Broken Arrow, and Edmond experienced population growth of 20.9%, 52.2%, 46.5% respectively (United States Census Bureau, 2008). With urban and suburban sprawl increasing throughout Oklahoma, areas of previously non-irrigated pasture and/or croplands are being converted to homeowner and commercial landscapes generally composed of turfgrass. In order for the expanded area of lawn cover to remain appealing to property owners without increased total demand, conserving irrigation practices must be employed by landscape managers. As can be expected, continued increase in irrigated landscapes across the state will result in increased residential water demand. Not only is municipally treated water costly to treat and deliver, when supplies such as reservoirs, treatment facilities, and sewage facilities need to be expanded, infrastructure development may be at a greater cost than demand side management. Therefore, it is important to determine current landscape irrigation practices and to assess the willingness to adopt turfgrass management practices, such as selection of more drought tolerant turfgrass, use of alternative or reused "gray" water, and irrigation systems which conserve Oklahoma's water supply. The objective of this study is to identify determinants of current irrigation practices used by Oklahoma turfgrass managers of golf and park land.

CHAPTER II

REVIEW OF LITERATURE

Little research has been conducted on the adoption of water conservation by recreational turfgrass managers and other large scale users of turfgrass outside of the residential setting. Munoz-Carpena et al. (2004) found that in the 11 years prior, managers adopted water conservation measures to save water, time, and money while increasing soil moisture monitoring. However, the sample size was only 8 out of 29 targeted managers, underscoring the difficulty of obtaining adequate response rates from this particular turf industry.

Carrow (2006) addresses the question of whether or not turfgrass can be maintained yet still satisfy customers' preferences and standards when water conservation measures and strategies are implemented. The author presents four main points pertaining to this question: in many situations sound water conservation strategies can result in decreased water usage on turf sites; turf quality can be affected in such a way that will diminish its value to customers; some customers receive benefits from turfgrass; water conservation could have environmental, economical, or recreational costs (Carrow, 2006). Shmanske (1999) found that both beauty and the condition of the course increased golf course revenue. Therefore, managers may be risk averse in adopting conservation measures that they perceive as potentially reducing the quality of course.

Effective and successful water conservation strategies should be site-specific, and can include: use of non-potable water sources for irrigation-alternative water sources (water reuse), selection of turfgrass species/cultivars and landscape plants for water conservation (drought/heat resistance), landscape design for water conservation (xeriscape), efficient irrigation system design (spatial variability), improved irrigation scheduling, and modifying management practices to enhance water-use efficiency. Over-watering can occur on irrigated sites because managers may not irrigate according to plant needs, making it necessary for irrigation applications to be paired with the true water needs of plants. Education about water conservation techniques is key for their adoption. Turf managers may be more accepting of new water conservation technology if quality educational opportunities from trained specialists and consultants are made readily available and easily accessible (Carrow, 2006).

Higher mowing heights encourage deeper rooting, increasing turf survival during droughts and reducing water loss through evaporation (Biran et al., 1981). Improved cultivars can replace high water use grasses on golf fairways and roughs in a large geographic area of the Midwest resulting in water savings of 50% or more (United States Golf Association, 2009). A variety of cultivars may be available for drought tolerance, depending on the climate zones in Oklahoma (Martin, 2009). Zoned irrigation systems can be used to control the amount of water used on different plant materials. During establishment, plants require larger amounts of water than established plants. Water use zones should be run on schedules that suit the needs of the plant material for each zone (Moss, 2011). Irrigation scheduling involves scheduling the time and amount of water applied to a crop based on the amount of water present in the crop root zone, the amount of water consumed by the crop since the last irrigation, and other management considerations such as salt leaching requirements, deficit irrigation, and crop yield relationships. This water conservation practice reduces the chance of too much or too little water being applied to an irrigated crop (Texas Water Development Board, 2005).

Outdoor watering is changing dramatically, and as a result, so must water saving strategies and standards for efficiency. With increasing demand on this limited resource, it is important for water managers and officials to develop innovative rules and implement water saving strategies to limit water depletion caused by excessive irrigation. Much of the irrigation water is often treated to a needlessly high standard, unavailable for alternative uses, and increases in supply may be obtained at a higher marginal cost than the marginal cost of water conservation. In order to accomplish increased efficiency, Vickers (2006) provides several actions including: limiting the number of watering days per week or even month, reducing the area allowed for irrigation, and upgrading to xeriscape principles, i.e. natural lawns and landscapes that only require minimal irrigation or natural rainwater to thrive. Rules which limit outdoor water consumption should not only be reinforced, but also improved. For example, it may be beneficial for the size of irrigation systems to be decreased and for new standards for landscape design to be set (Vickers, 2006).

In another study relating to water conservation, Michelson et al. (1999) examined the effectiveness of different types of non price conservation programs that have been implemented in the Southwestern United States in residential settings. Many water providers across the United States have developed and implemented non-price conservation measures to reduce residential water consumption in response to anticipated growth in demand. A residential water demand model was utilized which included parameters to account for variation in water price, temperature, precipitation, and other factors. The authors found that non-price conservation measures, such as education, public information, appliance retrofit, and ordinances, induced reductions in water demand by 1.1 to 4.0 % per conservation program. The results of this study reinforce the notion that non-price water conservation programs will be effective in reducing residential water demand and consumption (Michelsen et al., 1999). Since no equivalents exist in the recreational industry, we assume that similar results will occur for municipal recreational turf users.

Over the years, golf has proven to be a popular pastime with the public. Even though approximately 800 golf courses (18-hole equivalents) have closed during the past decade, the U.S. golf course supply has actually increased by more than 500 net 18-hole equivalents (NGF, 2009). For these golf courses, playing surface quality is an important factor which attracts players. During construction, the selection of turfgrass varieties is an investment decision affecting both construction cost and the course characteristics. Replacement of a turfgrass variety will result in renovation costs and loss revenue resulting from suspended use of the course. When choosing a turfgrass variety, the decision is based on the bundle of attributes such as physiological requirements, appearance, and playability given the constraints related to the climate, soil, and the budgeted expenses of management (Florkowski and He, 2008).

A survey of fourteen southern states by Florkowski and He (2008) provided information about the opinions of golf course operators regarding the need for new turf varieties, preferred turfgrass attributes, and performance of varieties available on the market. Disease control, turf agronomics, insect control, and training of maintenance personnel in proper turf care were viewed as “very important” turfgrass issues by respondents. Turf density was the most important attribute to golf-course operators affecting turfgrass appearance. For plant stress resistance, drought resistance was determined to be the most important among respondents (Florkowski and He, 2008).

In a survey of golf course superintendents in the Southwestern U.S., researchers determined attitudes toward using reuse water for irrigation needs (Devitt et al., 2004). Of respondents, a majority 36% indicated using well water for irrigation while 27% utilize reuse water. Researchers found reasons for switching to reuse water varied by state. In Arizona, 40% of respondents switched because of mandates, while in Nevada, cost incentives were responsible for 47% switching to reuse water. In California, 47% of respondents switched to reuse water because it is considered to be a more reliable source of water (Devitt et al., 2004). Less than 20% of respondents indicated concern for negative impacts on the operations of the golf course due to using a reuse water source with pond and irrigation maintenance having the greatest negative impact. Of the respondents who already use reuse water for irrigation needs, changes in a wide range of landscape and turfgrass management practices have been deemed necessary. Results showed that adoption of reuse water for irrigation is not opposed in the Southwestern U.S. but it is recognized that employing reused water can have a negative impact on golf course operations (Devitt et al., 2004).

The focus of Klein and Green (2002) was to assess current perceptions and implementations of selected turfgrass best management practices (BMPs) among professional turfgrass managers in Southern California. Turfgrass BMPs include fertilization, irrigation, mowing, pest control, and soil management. The authors discovered that 86% of respondents consistently check irrigation systems for proper function. Approximately half of the respondents consistently cycle irrigation on slopes to prevent runoff and irrigate according to weather station or soil moisture sensor data. More turfgrass managers than sports turfgrass managers indicated they adjust irrigation clocks at least every three months. However, more sports turfgrass managers than general turfgrass managers specified they irrigate according to weather station or soil moisture sensor data. Turfgrass managers, especially sports turfgrass managers, were the most likely to be committed to the BMPs included in the survey. Any specified limitations to BMP implementation result from concerns of lack of financial backing, employee education, and necessary time (Klein and Green, 2002).

Through a survey of U.S. golf courses the total annual water use for all golf facilities nationwide averaged over 2003, 2004, and 2005, was estimated at 2,312,701 acre-feet with the greatest amount being used in the Southeast (Throssell et al., 2009). The data obtained from Throssell et al. (2009) has been determined to provide an accurate portrayal of golf course water use. Private golf courses indicated spending significantly more for water than public golf courses. Golf courses with higher annual maintenance budgets also spend significantly more for water than golf courses with smaller budgets. On average nationally, open water of lakes or ponds and wells are the most common sources for irrigation water. Only 12% of U.S. golf facilities use recycled water as a source for irrigation water. Nine hole public golf facilities with a maintenance budget of less than $500,000 are significantly more likely to have a manual irrigation system than other types of golf facilities. Eighteen to 27 hole private golf facilities with a maintenance budget greater than $1,000,000 are significantly more likely to have fully automated irrigation systems. Almost all 18 hole golf facilities use at least one technique to assist in scheduling irrigation (Throssell et al., 2009). These techniques include (in order from most used to least used): observations of turf, soil moisture observation, short-term weather forecasts, evapotranspiration rate from a weather service, evapotranspiration rate from an on-site weather station, long-term weather records, soil sensors, other, and none. Results show a need for improvement in the use of evapotranspiration estimates and soil sensors to schedule irrigation, and use of irrigation audits to improve irrigation distribution uniformity (Throssell et al., 2009).

The literature on conservation technology adoption has largely been conducted on agricultural adoption of irrigation in the United States and abroad (Schuck et al., 2005, Caswell and Zilberman, 1985, Shrestha and Gopalakrishnan, 1993, Dinar and Yaron, 1992). Land tenure (ownership), acreage, soil type, crop, water price, and cost of technology are found to affect the probability of adoption. Caswell and Zilberman (1985) calculate the log odds of adoption of sprinkler and drip irrigation in California as a function of water cost saving, groundwater, and crop type. In general, higher water costs have led to increasingly efficient irrigation systems in agriculture, using price as an indicator of scarcity (Schuck et al., 2005).

CHAPTER III

METHODOLOGY

On November 16 and 17, 2010, willing participants of the 65th Annual Turf Conference Trade Show held in Stillwater, Oklahoma completed a survey entitled, "Survey of Water Use in Recreational Turfgrass Management." The survey was designed to determine what current water conservation practices are being utilized on Oklahoma's golf courses, recreational fields, and parks and how individual characteristics of the facility and the facility's management influence their adoption.

The survey not only solicited information on facility characteristics and management, but also the characteristics of the managers. The information collected included: the type of facility, facility location, the annual budget for maintenance, watering methods currently being utilized, type of water source used for irrigation water, motivation and barriers to adopting water conservation methods, education, certifications, age, and the water conservation practices which have been adopted.

Rankings were utilized to determine the most important motivations and barriers to adopting water conservation methods. Respondents were asked to rank five motivations for adopting water conservation strategies in order of importance. These motivations included: lowering costs of water used, environmental conservation, reducing labor costs in irrigation, response to price increases by municipal water supply, and reducing mowing or weeding costs. In a separate question, respondents were asked to rank three barriers to adopting water conservation strategies in order of importance. Barriers included: need for knowledge of strategies to reduce water use, concern over performance and appearance of turf for users, and funding for implementing strategies.

Participants were given two opportunities to complete our survey, one while in attendance at the conference, and another two weeks later via either online at Surveymonkey.com or through the U.S. mail. In an attempt to increase the response rate, a financial incentive was offered in the form of three random drawings for $100. Of the 219 attendees on the conference's participant list, 72 completed the survey. Five of these 219 attendees were excluded due to their employment affiliation with Oklahoma State University, giving us a response rate of 33.64%. Additional conference attendees provided 52 more completed surveys. In the second opportunity, 119 emails and 37 mailers were sent out using a mailing list of turfgrass managers provided by conference leaders out of which 21 surveys were completed via internet survey (surveymonkey.com, 1999-2011) and 4 completed surveys were returned via the U.S. mail. The final response rate for the second contact was 17.6% for the internet survey and 10.8% for the U.S. mail. Including all attempts to contact Oklahoma professional turfgrass managers, a total of 149 responses were collected. Due to inconsistent responses, one respondent was omitted from data collection.

After collecting the data from 148 completed surveys, general statistics were generated and included: the percentages of how many respondents chose a multiple choice answer in a particular question, means, modes, and standard deviations.

Cross tabulations were developed for all completed surveys to demonstrate which of a respondent's/facility's characteristics were mostly associated with either choosing to adopt a particular water conservation practice or choosing not to adopt. These characteristics included: facility type, watering methods currently being used, irrigation water source, education level of the respondent, type of college degree held by the respondent, respondent's certifications, number of acres of turfgrass at the facility, and age of the respondent. For the top 5 most used conservation practices, every characteristic selected by a respondent was categorized as either "conservation method adopted" or "conservation method not adopted," depending on whether or not the individual had adopted the water conservation practice. After all chosen characteristics were categorized, they were then summed or averaged across all responses for each group.

Since our dependent variables have a discrete outcome (have adopted or have not adopted) the logistic procedure was chosen for the regression analysis of the data to predict the likelihood of adoption of users on average, given the facility and individual's characteristics. The logistic model is as follows:

$$\text{Prob}\ (Y=1) = F(\beta' x) \qquad \Rightarrow \text{ have adopted}$$

$$\text{Prob}\ (Y=0) = 1 - F(\beta x) \qquad \Rightarrow \text{ have not adopted}$$

The set of parameters (β) reflect the impact changes in x on the probability (Greene, 1992).

Logistic models were generated using the SAS 9.2 Program (2011 SAS Institute Inc) to analyze the effects of certain respondent/facility characteristics, such as facility type, current watering methods, education and certifications, and facility location, on the adoption of a certain water conservation technique. Five logit models were estimated, one for each of the top 5 most used conservation practices. In these models, the probability that a respondent/facility will adopt a certain water conservation technique is dependent on certain characteristics of the respondent or facility. The water conservation techniques chosen to be analyzed in this study include: reduced watering, reduced percentage of area irrigated, limited irrigation, zoned irrigation, irrigation scheduling, reuse water, irrigation audit, improved cultivars, greens modified, higher mowing heights, switch to alternative, adoption of xeriscaping, and adoption of conservation indoors.

For this study, the following conceptual model was created:

(1) Probability of adopting water conservation technique = f (type of facility, current watering methods, current source for irrigation water, respondent's education level, certification of respondent, number of individuals on maintenance staff, acres of turfgrass at facility, age of respondent, regional location of facility)

A linear probability model would not be efficient in analyzing the data because of the discrete nature of the dependent variables. Since $\beta x + \varepsilon$ must equal either zero or one, the variance of the errors depends on β which would result in a problem with heteroscedasticity (Greene, 1992). Therefore, the empirical model for this study is:

(2) $Y^* = \beta' x + \varepsilon$

Where: Y^* = 1 if the practice is chosen, 0 if not chosen
$\varepsilon \sim N(0,1)$, a random error term

For this model all estimated β coefficients are for the x variables. All x variables are dummy variables (1 => characteristic chosen, 0 => characteristic not chosen), except turfgrass acres, staff, and age. Y^* is the dependent variable or conservation technique, which is either one if adopted or zero if not. Regional information was not directly asked in the survey. Instead, respondents were asked to indicate the ZIP code in which their facility is located. Using Geographic Information software (ArcInfo/ArcGIS10, 1995–2011), these ZIP codes were plotted in four Oklahoma regions in which Interstate 35 and Interstate 40 served as boundary lines dividing the state into Southeast, Northwest, Southwest, and Northeast regions (Center for Spatial Analysis, 2004-07).

The model in less formal terms is as follows:

(3) $$Y^* = \beta_1 + \beta_2 Golf + \beta_3 Rec + \beta_4 Sports + \beta_5 Sod + \beta_6 OF + \beta_7 MS + \beta_8 AS + \beta_9 ZS + \beta_{10} MCS + \beta_{11} DI + \beta_{12} SH + \beta_{13} SBH + \beta_{14} OWM + \beta_{15} NoIrr + \beta_{16} City + \beta_{17} Private + \beta_{18} Reten + \beta_{19} OWS + \beta_{20} College + \beta_{21} Cert + \beta_{22} Staff + \beta_{23} Acres + \beta_{24} Age + \beta_{25} SE + \beta_{26} NW + \beta_{27} SW + \beta_{28} OS + \varepsilon$$

Table 1, Logistic Model Independent Variable Abbreviations, provides independent variable definitions, and Table 2, Logistic Model Dependent Variable Abbreviations, provides explanations of the dependent variables used for the different models.

The overall hypothesis of this study is that certain turfgrass facility and manager characteristics will influence the likelihood of water conservation adoption. It is hypothesized that recreational turfgrass managers who have received some form of higher education are expected to adopt water conservation strategies. Turfgrass facilities which have a greater number of turfgrass acres are likely to adopt water conservation techniques. Turfgrass facilities which utilize municipal water connections as their primary water source are expected to conserve water. Turfgrass facilities located in the Southern parts of Oklahoma are more likely to adopt water conservation techniques than the Northern parts because of potential shortfalls in supply due to historic rainfall differences.

CHAPTER IV

FINDINGS

Table 3, Simple Statistics of Determinants of Adoption of Water Conservation at Recreational Turfgrass Facilities in Oklahoma, presents simple statistics of some of the determinants of water conservation adoption. For facility type, golf courses comprised 47% of responses; recreational parks were 15% and sports fields 14%. In regard to watering methods, automated above ground automatic sprinklers comprised 75% of responses. City water connection was used as the primary water source for 58% of respondents, whereas 26% used private wells, 20% retention, and 14% other sources. Respondents were able to check multiple facility types, water sources, and watering methods, so no variables were omitted to avoid the dummy variable trap. Forty-six percent of respondents indicated obtaining a B.S. or higher degree as their highest level of education. Of respondents, 46% indicated working in facilities located in the Northeast region of Oklahoma.

In addition, 86% of respondents indicated being certified in the turfgrass management field. On average respondents were about 43 years old and their facilities had an average of 116 acres in turfgrass. One facility managing 3,000 acres was omitted as an outlier. Lead managers made up 63% of respondents. Of facilities, 59% were designated as public, while 41% were private. On average, facilities had an annual operating budget for maintenance of $430,400 per facility and approximately 12 individuals on their facility's maintenance staff. Respondents who apply pesticides to facility turfgrass acres comprised 80% of the total responses and 82% of respondents apply fertilizers. A majority of respondents were Caucasian males. Thirty-nine percent ranked "lowering cost of water used" as the most important motivation for adopting water conservation strategies, while 39% ranked "response to price increase by municipal water supply" as having the least affect on their motivation for adopting water conservation strategies. Economically, water users in the short term may have an inelastic demand for water making a facility's short term demand un-responsive to price increases. In fact, many smaller communities in Oklahoma have decreasing rates with greater consumption which discourages conservation adoption (Adams et al, 2009). Although rates had on average changed from 2002-2008 in Oklahoma, our respondents did not see increasing prices as the reason to conserve, potentially because the facility was not in a region of increasing water prices or appearance of turf was simply to important. For instance, fifty-two percent ranked "concern over performance and appearance of turf for users" as the pinnacle barrier to adopting water conservation strategies, while 43% ranked "the need for knowledge of strategies to reduce water use" as having the least effect on prohibiting the adoption of water conservation strategies.

Figure 1 illustrates which water conservation practices have been utilized and what percent of respondents are implementing them. The data collected shows the top five most used water conservation practices to be: reduced watering (64%), higher mowing heights of grass (64%), zoned irrigation systems (53%), selection of improved cultivars for drought tolerance (47%), and irrigation scheduling based on plant water requirements as estimated by site-specific weather data (43%). Options in facility types included: golf course, recreational park, sports field, and sod farm. In Figure 2, we see golf course (47%) was the most common facility type followed by other facility type (31%), recreational park (15%), sports field (14%), and sod farm (2%). A majority of the other facility types specified by respondents included lawn care services and educational institutes. A majority of respondents chose automated above ground automatic sprinkler systems as the facility's current watering method (75%), followed by spraying the turfgrass area by hand as needed (50%). Only 5% indicated not utilizing any irrigation methods at their facility (Figure 3). Figure 4 exhibits the division of water source usage. The large majority obtain water for irrigation from city water connections (58%) and private wells (26%). A majority of other water sources specified by respondents included lakes and rivers. The distribution of regional location can be observed in Figures 5 and 6. Most facilities (46%) reside in the Northeast region of Oklahoma. With only 6%, the Southwest has considerably fewer turfgrass facilities than the other three Oklahoma regions. This uneven distribution of turfgrass facilities may be due to differences in the amount of precipitation received or population. Having less rainfall than the other regions, may prohibit the Southwest region's ability to sustain turfgrass acres.

For the most part, survey participants have attained some college education. Approximately 39% have obtained some college education, while 46% have received a college degree, leaving only around 15% that have no college education (Figure 7). As seen in Figure 8, for those who have obtained a college degree, the majority received degrees in Turfgrass Management (31%). Nearly all survey participants (86%) have received certifications relating to turfgrass management. The two prevailing certifications (Figure 9) acquired by respondents are the certified pesticide applicator and the licensed pesticide applicator; both are state requirements (Oklahoma Department of Agriculture, Food & Forestry Plant Industry & Consumer Services Division, 2004). Table 4 presents certification definitions for all certifications acquired about in the survey.

Tables 5 through 9 present the findings of the cross tabulations for the most used water conservation methods beginning with the most adopted: determinants of reduced watering adoption (Table 5), determinants of higher mowing heights adoption (Table 6), determinants of zoned irrigation adoption (Table 7), determinants of improved cultivars adoption (Table 8), and determinants of irrigation scheduling adoption (Table 9). The determinants of water conservation adoption examined in this section of the study are: facility type, watering methods, water source, education, certification, age, and turfgrass acres. Each of the determinants has a characteristic which was indicated by a majority of respondents. These predominant characteristics found upon examination of the data include: golf course for facility type, automated above ground automatic sprinkler systems for watering method, city water connection for primary water source, B.S./B.A. or higher graduate for highest level of education, turfgrass management degree for type of degree acquired, and certified pesticide applicator for certification.

For the reduced watering conservation method, all predominant characteristics yielded higher percentages of respondents adopting the water conservation strategy than not adopting. Of all the golf course facilities, 74% have adopted reduced watering as a strategy, while 26% have not. For facilities using automated sprinklers as current watering methods, 70% have adopted reduced watering. A majority 62% of respondents who use city water connections for irrigation water have also chosen to utilize this method to conserve water. Sixty-six percent of college graduates partake in reducing water, as do 65% of turfgrass management degree holders. Of the 104 certified pesticide applicators, 68% have reduced watering at their facilities. For respondents using reduced watering, facility size averages 116 acres; non-adopters also average 116 acres.

For the higher mowing heights of grass strategy, again all predominant characteristics produced greater percentages of respondents adopting the water conservation strategy than not adopting. Of golf course facilities, 73% have adopted the strategy. For facilities using automated sprinklers, 68% have adopted higher mowing heights. A majority 65% of respondents who use city water connections for irrigation water have also chosen to utilize this method to conserve water. Approximately 69% of managers who are college graduates partake in higher mowing heights, as do 67% of turfgrass management degree holders. Of the certified pesticide applicators, 69% implement higher mowing heights at their facilities. On average adopters have 112 acres of turfgrass whereas, non-adopters average 123 acres.

For the zoned irrigation strategy, all predominant characteristics, with the exception of golf course facilities, produced greater percentages of respondents adopting the water conservation strategy than not adopting. Of golf course facilities, only 50% have adopted the strategy. For facilities using automated sprinklers, 57% have adopted zoned irrigation. A majority 64% of respondents who use city water connections for irrigation water have also chosen to utilize this method to conserve water. For zoned irrigation, 54% of college graduates and 54% of turfgrass management degree holders have adopted. Of the 104 certified pesticide applicators, 56% implement zoned irrigation at their facilities. On average adopters have 112 acres of turfgrass whereas, non-adopters average 121 acres.

For the selection of improved cultivars for drought tolerance strategy, most of the predominant characteristics were associated with producing greater percentages of respondents not adopting the water conservation strategy. Of golf course facilities, only 44% have adopted the strategy, while 56% have not. For facilities using automated sprinklers, 50% have adopted selection of improved cultivars for drought tolerance. A majority 55% of respondents who use city water connections for irrigation water have not chosen to utilize this method to conserve water. Of college graduates, 51% participate in selection of improved cultivars for drought tolerance, but 54% of turfgrass management degree holders do not. Of the 104 certified pesticide applicators, only 44% implement selection of improved cultivars for drought tolerance at their facilities. For respondents using improved cultivars, facility size averages 127 acres whereas non-adopters average only 107 acres.

For the irrigation scheduling strategy, all predominant characteristics, with the exception of city water connection, produced greater percentages of respondents not adopting the water conservation strategy. Of golf course facilities, 61% have not adopted the strategy while only 39% have. For facilities using automated sprinklers, 55% have not adopted an irrigation scheduling strategy. A majority 52% of respondents who use city water connections for irrigation water have chosen to utilize this method to conserve water. Only 44% of college graduates participate in irrigation scheduling as do only 39% of turfgrass management degree holders. Of the certified pesticide applicators, 59% do not implement irrigation scheduling at their facilities. On average adopters have 128 acres of turfgrass whereas, non-adopters average 107 acres. Even though there does not appear to be any substantial difference in facility size between reduced water, higher mowing heights, and zoned irrigation users and non users, the cross tabulation results show that facilities with a greater amount of turfgrass acres have adopted improved cultivars and irrigation scheduling as water conservation methods. Assuming larger facilities have a greater maintenance budget than smaller facilities, supplying the initial investment and upkeep costs of these water conservation techniques may only be an option for the larger facilities.

Table 10, Determinants of Conservation Adoption at Recreational Turfgrass Facilities in Oklahoma – Parameter Estimates, summarizes the logistic model information for the five most used water conservation methods. The models are as follows: Model 1 - reduced watering, Model 2 - higher mowing heights of grass, Model 3 - zoned irrigation systems, Model 4 - selection of improved cultivars for drought tolerance, and Model 5 - irrigation scheduling based on plant water requirements as estimated by site-specific weather data.

Model 1, predicting the likelihood of adopting reduced watering, produced a likelihood ratio of 46.0431 with two coefficients significant at a 95% confidence level and one additional coefficient significant at the 90% confidence level. The utilization of manual connection sprinklers at a facility positively affects the probability of adopting reduced watering as a water conservation strategy. Adversely, use of soaker hoses as a watering method has a negative impact on the probability of adopting reduced watering. Facilities which rely mainly on a private water source for irrigation water have a decreased likelihood for adoption.

Model 2, predicting the likelihood of adopting higher mowing heights, produced a likelihood ratio of 31.6399 with two coefficients significant at a 95% confidence level. Utilization of soaker hoses for irrigation has a positive effect on the probability of adopting higher mowing heights of grass as a water conservation strategy. Facilities which do not engage in any irrigation practices have an increased likelihood for adoption of higher mowing heights. Leaving the grass at higher heights might be the only way to keep the turf looking greener as they do not have any irrigation, in addition when grass is cut short it requires greater amounts of water.

Model 3, predicting the likelihood of adopting zoned irrigation sprinklers, produced a likelihood ratio of 30.4380 with one significant coefficient at a 95% confidence level. As expected, utilization of zoned sprinklers for irrigation needs has a significant decreasing effect on the probability of adopting zoned irrigation. Because respondents were able to and did choose multiple watering methods, all methods had to remain in the regression analysis to produce a parallel model. A reason for few predictors may be that zoned irrigation is used less as a conservation practice for tailoring different slopes and grass types and more to control water pressure to sprinkler heights.

Model 4, predicting the likelihood of adopting improved cultivars, produced a likelihood ratio of 38.3822 with four coefficients significant at a 95% confidence level. Use of other watering methods and having no current irrigation practices both have a significant influence on probability of adoption of improved cultivars. Facilities utilizing other watering methods have a decreased likelihood of conserving water using improved cultivars, while facilities that choose to not irrigate at all have an increased likelihood of using improved cultivars. Use of an on-site water retention as the primary irrigation water source increases the probability of adoption of improved cultivars. In Oklahoma, retention ponds are a newer requirement for golf course runoff control and thus these courses are more likely to have been established with newer drought tolerant cultivars. Out of state facilities are less likely to adopt this conservation measure than facilities located in Northeast Oklahoma, our comparison region and omitted dummy variable.

Model 5, predicting the likelihood of adopting irrigation scheduling, produced a likelihood ratio of 50.2419 with four significant coefficients at a 95% confidence level and two additional coefficients significant at the 90% confidence level. In this model, facilities using drip irrigation have an increased probability of adoption of irrigation scheduling. Facilities which rely on city water connections and private wells for irrigation water are less likely to adopt this water conservation technique. Cities such as Oklahoma City have adopted odd-even day watering to reduce low pressure problems in face of drought during July, 2011 (The Daily Oklahoman, 2011). Since actual supply is not short, but the delivery lines cannot meet volume, cities might benefit from instituting peak water pricing to shift demand away from problematic hours. Large volume users such as golf courses could also be nudged to change watering to lessen peak demand. Individuals who either have some college education of received a degree are less likely to adopt irrigation scheduling than individuals who do not have any college education. An increase in the number of individuals who are on the maintenance staff decreases the likelihood of irrigation scheduling adoption. Given that irrigation scheduling practices are less labor intensive relying mainly on one or two highly trained individuals, an increase in staff would not be necessary or efficient. However, irrigation practices such as use of soaker hoses would be expected to require more individuals on the maintenance staff resulting in a positive relationship between increases in staff and soaker hose adoption Facilities located in the Northwest region of Oklahoma are more likely to adopt irrigation scheduling than facilities in the Northeast.

Table 11, Determinants of Conservation Adoption at Recreational Turfgrass Facilities in Oklahoma – Odds Ratio Estimates, summarizes the odds ratio estimates for the five most used water conservation methods: Model 1 - reduced watering, Model 2 - higher mowing heights of grass, Model 3 - zoned irrigation systems, Model 4 - selection of improved cultivars for drought tolerance, and Model 5 - irrigation scheduling based on plant water requirements as estimated by site-specific weather data. The odds ratio illustrates the strength of the relationship between the predictor variable and the response variable. If the odds ratio estimate is 1, there is no association between the two variables (SAS, 2005).

For reduced watering, sports field facilities are 2.124 times more likely to conserve water using this technique than a facility that is not a sports field. Facilities not utilizing automated sprinklers for irrigation are 2.18 times more likely to use reduced watering than facilities which do use automated sprinklers. Manual connection sprinkler users are 6.786 times more likely to employ reduced watering than non users. Facilities which do not use soaker hoses for irrigation are 5.68 times more likely to adopt than soaker hose users. Facilities that do not use a private well as a primary water source are 5.49 times more likely to adopt than private well users. Water cost to private well users only includes the cost of extraction whereas municipal users are required to pay more for treated water delivery; as a result, municipal water users are more likely to consider reduced watering than private well users to reduce total water cost. Facilities located in

Northwestern Oklahoma are 2.327 times more likely to adopt than facilities in Northeastern Oklahoma.

For higher mowing heights, sod farm facilities are 2.473 times more likely to adopt than a facility that is not a sod farm. Soaker hose users are 5.996 times more likely to adopt higher mowing heights than non soaker hose users. The soaker hose irrigation practice requires intensive labor, and is one of the lowest levels of irrigation. With less water being used for irrigation, it may be necessary to leave the grass at higher heights to keep the turf looking greener. Facilities which do not irrigate at all are 17.825 times more likely to use this water conservation method than facilities that do irrigate. Facilities which do not use a private well as a primary water use are 2.4 times more likely to adopt than private well users. Facilities located in Northwestern Oklahoma are 2.21 times more likely to adopt than facilities in Northeastern Oklahoma.

For zoned irrigation, facilities which do not use zoned sprinklers for irrigation are 3.66 times more likely to adopt than zoned sprinkler users. Facilities which do not irrigate at all are 6.108 times more likely to use this water conservation method than facilities that do irrigate. Facilities which do not use a city water connection as a primary water use are 2.42 times more likely to adopt than city water users.

For improved cultivars, golf course facilities are 4.111 times more likely to adopt than a facility that is not a golf course. Facilities which do not irrigate at all are 22.305 times more likely to use this water conservation method than facilities that do irrigate. On-site water retention users are 4.625 times more likely to adopt improved cultivars than facilities which do not rely on on-site water retentions for irrigation water. Facilities in Northeast Oklahoma are 18.87 times more likely to adopt than out of state facilities.

For irrigation scheduling, sod farm facilities are 6.420 times more likely to adopt than a facility that is not a sod farm. Drip irrigation users are 3.313 times more likely to adopt irrigation scheduling than facilities which do not use drip irrigation. Facilities which do not use a city water connection as a primary water use are 4.52 times more likely to adopt than city water users. Facilities which do not use a private well as a primary water use are 4.13 times more likely to adopt than private well users. Individuals who do not have at least some college education are 3.22 times more likely to adopt than individuals with college education. Facilities located in Northwestern Oklahoma are 3.819 times more likely to adopt than facilities in Northeastern Oklahoma.

CHAPTER V

CONCLUSIONS

Because adoption exceeded 50% of respondents for only three types of water conservation strategies, higher mowing heights, reduced watering, and zoned irrigation systems, there appears to be a lack of motivation or incentive on the part of Oklahoma turfgrass managers to participate in water conservation. Even though respondents consider lowering facility watering costs to be an important motivation for adopting water conservation strategies, concern for maintaining performance and appearance of turfgrass for users overshadows those concerns as the most cited barrier to adoption. Thus, no one technique is likely to meet managers' needs given the concerns of appearance and performance.

Significant determinants which increased the probability of adoption of the top five most used water conservation strategies included: facilities located in the Northwest region of Oklahoma, facilities which utilize manual connection sprinklers, drip irrigation, or do not irrigate at all, and facilities which rely on on-site water retention for irrigation water. Significant determinants that decreased the likelihood of adopting the top five most used water conservation techniques included: utilization of zoned sprinklers and other watering methods for irrigation such as in-ground automatic sprinklers and pivots, facilities which rely on city water connections and private wells for irrigation water, an increase in the number of individuals on the maintenance staff, having at least some college education, and having a facility located outside of Oklahoma. Sod farm facilities tend to be more water conscious and are more likely to adopt water conservation techniques than golf, sports, and recreational managers. Facilities which do not use automatic sprinklers are more likely to conserve water than automatic sprinkler users. Quite simply, these conditions of non-adoption are not random; facilities with automated sprinklers are more likely to have invested in them to ensure turf aesthetics, city water connections indicate likelihood of higher returns to use from urban location and clientele and/or turf managers have already switched to private wells to avoid higher costs of treated water. Turfgrass facilities relying on municipal connections are in proximity to large populations therefore they strive to uphold landscape appeal with green, lush grasses. Sod farm employees are more likely to be aware of how much water turfgrass varieties require allowing the maximization of profits by producing healthy grasses at the least cost.

Results suggest that because automatic sprinkler users are less likely to adopt water conservation methods, extension efforts should be directed at aiding managers in the continuation of sprinkler auditing training programs. Automation users can afford a larger opportunity to reduce potential overwatering or increase scheduling to times where there is least evapotranspiration. In the case of golf courses, golf course managers strive to preserve turfgrass appeal in order to maintain clientele resulting in overwatering. These managers would benefit from the availability of more tools aiding in producing green, lush grasses at the lowest water use. An additional approach, such as that taken in Georgia (Carrow et al, 2005), would involve aiding golf and parks managers in development of best management plans for water conservation as a long term conservation tool, rather than a short term emergency response to seasonal or prolonged drought. Interestingly, Limehouse et al. (2010) found an entry price premium for golf courses that had obtained the environmental Audubon International certification, suggesting that early adopters of water conservation practices might also seek certification or use water conservation in their marketing literature.

Further research should be aimed at determining if smaller turfgrass facilities are prohibited from increasing the use of water conservation practices due to unsustainable increases in labor costs. Even though the data used in this study did not contain sufficient information regarding facility maintenance budget, we assume there is a positive relationship between the number of individuals on a facility's maintenance staff and the facility's maintenance budget. The relationship between increased staff and adoption of water conservation techniques is unclear in this study's models except for irrigation scheduling. After the initial investment of time and money, irrigation scheduling is a labor replacing technique that only requires one or two higher paid and better trained individuals. Another matter worthy of continued investigation is an inquiry as to why the use of on-site water retention ponds as an irrigation water source increases the probability of implementing improved cultivars as a means to conserve water. As a more recent requirement for irrigation practices, on-site water retentions reduce runoff of pesticides and fertilizers. In times of water scarcity, rather than finding a new source of water or expanding treatment facilities, it may be cheaper for a city to provide incentives for turfgrass operations to switch to improved cultivars which are more drought tolerant. These incentives should be helpful in covering large investment costs for the switch.

Cities may also consider paying individuals to use gray or recycled water or increasing water rates for high-water users during peak hours.

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TABLES

Table 1 Logistic Model Independent Variable Abbreviations

Golf	Golf course	**SH**	Soaker hose	**Staff**	Maintenance staff
Rec	Recreational park	**SBH**	Spray by hand	**Acres**	Turfgrass acres
Sports	Sports field	**OWM**	Other watering method	**Age**	Age
Sod	Sod farm	**NoIrr**	Do not irrigate	**SE**	Southeast
OF	Other facility	**City**	City water connection	**NW**	Northwest
MS	Manual sprinkler	**Private**	Private well water	**SW**	Southwest
AS	Automated sprinkler	**Reten**	On site water retention	**NE**	Northeast
ZS	Zoned sprinkler	**OWS**	Other water source	**OS**	Out of state
MCS	Manual connection	**HS**	$<12^{th}$ grade, H.S. diploma		
	Sprinkler	**College**	At least some college		
DI	Drip irrigation	**Cert**	Certified		

Table 2 Logistic Model Dependent Variable Abbreviations

Reduced watering	Reduced watering
Reduced % of area irr	Reduce percentage of area irrigated alone
Limited irr	Limited or nonexistent irrigation
Zoned irr	Zoned irrigation systems
Irrigation scheduling	Irrigation scheduling based on plant water requirements as estimated by site-specific weather data
Reuse water	Reuse or gray water for irrigation
Irr audit	Irrigation audit
Improved cultivars	Selection of improved turfgrass cultivars for drought tolerance
Greens modified	Greens or high use areas modified to improve water percolation and deeper rooting, avoidance of excessive slopes
Higher mowing heights	Higher mowing heights of grass
Switch to alt	Switch to alternative, non-municipal supply
Adopt of xeriscaping	Adoption of xeriscaping or drought tolerant plants where turfgrass is not necessary
Adopt of cons indoors	Adoption of conservation indoors in clubhouse, park structures, etc

Table 3 Simple Statistics of Determinants of Adoption of Water Conservation at Recreational Turfgrass Facilities in Oklahoma (2010, N=148)

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
Golf	148	0.47	0.50	70.00	0	1
Rec	148	0.15	0.36	22.00	0	1
Sports	148	0.14	0.35	21.00	0	1
Sod	148	0.02	0.14	3.00	0	1
OF	148	0.31	0.46	46.00	0	1
MS	148	0.23	0.42	34.00	0	1
AS	148	0.75	0.43	111.00	0	1
ZS	148	0.39	0.49	57.00	0	1
MCS	148	0.25	0.43	37.00	0	1
DI	148	0.25	0.43	37.00	0	1
SH	148	0.13	0.34	19.00	0	1
SBH	148	0.50	0.50	74.00	0	1
OWM	148	0.07	0.26	11.00	0	1
NoIrr	148	0.05	0.23	8.00	0	1
City	148	0.58	0.50	86.00	0	1
Private	148	0.26	0.44	39.00	0	1
Reten	148	0.20	0.40	29.00	0	1
OWS	148	0.16	0.36	23.00	0	1
HS	148	0.16	0.36	23.00	0	1
College	148	0.84	0.36	125.00	0	1
Cert	148	0.86	0.34	128.00	0	1
Staff	148	11.95	13.25	1769	0	100.00
Acres	148	116.09	97.32	17182	0	600.00
Age	148	42.82	11.51	6337	20	76.00
NE	148	0.46	0.50	68.00	0	1
SE	148	0.18	0.39	27.00	0	1
NW	148	0.22	0.42	33.00	0	1
SW	148	0.06	0.24	9.00	0	1
OS	148	0.05	0.23	8.00	0	1

Table 4 Certifications Cited by Recreational Turfgrass Managers in Oklahoma (2010)

CGCS	Certified Golf Course Superintendent (CGCS)
Cert Irr Auditor	Certified Irrigation Auditor
CSFM	Certified Sports Field Manager (CSFM)
Cert Pesticide App	Certified Pesticide Applicator
Licensed Pesticide App	Licensed Pesticide Applicator
Cert Horticulturist	Certified Horticulturist
Cert Arborist	Certified Arborist
Landscape Cert Manager	Landscape Industry Certified Manager
Landscape Cert Technician	Landscape Industry Certified Technician
Other	Other

Table 5 Determinants of Reduced Watering Adoption at Recreational Turfgrass Facilities in Oklahoma - Cross Tabulations (2010)

	Never Used	%	Used	%	Total
All Respondents	53	36%	95	64%	148
Golf Course	18	26%	52	74%	70
Recreational Park	10	45%	12	55%	22
Sports Field	11	52%	10	48%	21
Sod Farm	0	0%	3	100%	3
Other	21	46%	25	54%	46
Manual Sprinkler	11	32%	23	68%	34
Automated Sprinkler	33	30%	78	70%	111
Zoned Sprinkler	20	35%	37	65%	57
Manual Connection Sprinkler	18	49%	19	51%	37
Drip Irrigation	14	38%	23	62%	37
Soaker Hose	7	37%	12	63%	19
Spray by Hand	24	32%	50	68%	74
Other Watering Method	5	45%	6	55%	11
We do not irrigate	8	100%	0	0%	8
City	33	38%	53	62%	86
Private Well	10	26%	29	74%	39
Water Retention	7	24%	22	76%	29
Other	9	39%	14	61%	23
<12th Grade	6	43%	8	57%	14
H.S. Diploma	4	44%	5	56%	9
Some College	20	35%	37	65%	57
B.S./B.A.	23	34%	45	66%	68
Turfgrass Management	16	35%	30	65%	46
Landscape Architecture	3	60%	2	40%	5
Plant & Soil Science	4	67%	2	33%	6
Horticulture	7	39%	11	61%	18
Other	10	33%	20	67%	30
Certified Golf Course Superintendent (CGCS)	3	38%	5	63%	8
Certified Irrigation Auditor	1	50%	1	50%	2
Certified Sports Field Manager (CSFM)	4	67%	2	33%	6
Certified Pesticide Applicator	33	32%	71	68%	104
Licensed Pesticide Applicator	19	37%	32	63%	51
Certified Horticulturist	0	0%	1	100%	1
Certified Arborist	1	50%	1	50%	2
Landscape Industry Certified Manager	0	0%	1	100%	1
Landscape Industry Certified Technician	2	40%	3	60%	5
Other	4	44%	5	56%	9
Turfgrass Acres	116.42		115.91		
Age	41.92		43.32		

Table 6 Determinants of Higher Mowing Heights Adoption at Recreational Turfgrass Facilities in Oklahoma - Cross Tabulations (2010)

	Never Used	%	Used	%	Total
All Respondents	53	36%	95	64%	148
Golf Course	19	27%	51	73%	70
Recreational Park	10	45%	12	55%	22
Sports Field	11	52%	10	48%	21
Sod Farm	2	67%	1	33%	3
Other	18	39%	28	61%	46
Manual Sprinkler	13	38%	21	62%	34
Automated Sprinkler	35	32%	76	68%	111
Zoned Sprinkler	18	32%	39	68%	57
Manual Connection Sprinkler	13	35%	24	65%	37
Drip Irrigation	15	41%	22	59%	37
Soaker Hose	10	53%	9	47%	19
Spray by Hand	23	31%	51	69%	74
Other Watering Method	5	45%	6	55%	11
We do not irrigate	7	88%	1	13%	8
City	30	35%	56	65%	86
Private Well	12	31%	27	69%	39
Water Retention	9	31%	20	69%	29
Other	7	30%	16	70%	23
<12th Grade	8	57%	6	43%	14
H.S. Diploma	4	44%	5	56%	9
Some College	20	35%	37	65%	57
B.S./B.A.	21	31%	47	69%	68
Turfgrass Management	15	33%	31	67%	46
Landscape Architecture	3	60%	2	40%	5
Plant & Soil Science	3	50%	3	50%	6
Horticulture	5	28%	13	72%	18
Other	10	33%	20	67%	30
Certified Golf Course Superintendent (CGCS)	4	50%	4	50%	8
Certified Irrigation Auditor	1	50%	1	50%	2
Certified Sports Field Manager (CSFM)	2	33%	4	67%	6
Certified Pesticide Applicator	32	31%	72	69%	104
Licensed Pesticide Applicator	23	45%	28	55%	51
Certified Horticulturist	0	0%	1	100%	1
Certified Arborist	1	50%	1	50%	2
Landscape Industry Certified Manager	0	0%	1	100%	1
Landscape Industry Certified Technician	2	40%	3	60%	5
Other	4	44%	5	56%	9
Turfgrass Acres	122.85		112.32		
Age	42.69		42.89		

Table 7 Determinants of Zoned Irrigation Adoption at Recreational Turfgrass Facilities in Oklahoma - Cross Tabulations (2010)

	Never Used	%	Used	%	Total
All Respondents	69	47%	79	53%	148
Golf Course	35	50%	35	50%	70
Recreational Park	7	32%	15	68%	22
Sports Field	7	33%	14	67%	21
Sod Farm	2	67%	1	33%	3
Other	22	48%	24	52%	46
Manual Sprinkler	14	41%	20	59%	34
Automated Sprinkler	48	43%	63	57%	111
Zoned Sprinkler	18	32%	39	68%	57
Manual Connection Sprinkler	14	38%	23	62%	37
Drip Irrigation	15	41%	22	59%	37
Soaker Hose	9	47%	10	53%	19
Spray by Hand	32	43%	42	57%	74
Other Watering Method	7	64%	4	36%	11
We do not irrigate	7	88%	1	13%	8
City	31	36%	55	64%	86
Private Well	21	54%	18	46%	39
Water Retention	13	45%	16	55%	29
Other	15	65%	8	35%	23
<12th Grade	7	50%	7	50%	14
H.S. Diploma	3	33%	6	67%	9
Some College	28	49%	29	51%	57
B.S./B.A.	31	46%	37	54%	68
Turfgrass Management	21	46%	25	54%	46
Landscape Architecture	5	100%	0	0%	5
Plant & Soil Science	3	50%	3	50%	6
Horticulture	9	50%	9	50%	18
Other	10	33%	20	67%	30
Certified Golf Course Superintendent (CGCS)	6	75%	2	25%	8
Certified Irrigation Auditor	0	0%	2	100%	2
Certified Sports Field Manager (CSFM)	6	100%	0	0%	6
Certified Pesticide Applicator	46	44%	58	56%	104
Licensed Pesticide Applicator	24	47%	27	53%	51
Certified Horticulturist	1	100%	0	0%	1
Certified Arborist	1	50%	1	50%	2
Landscape Industry Certified Manager	1	100%	0	0%	1
Landscape Industry Certified Technician	1	20%	4	80%	5
Other	4	44%	5	56%	9
Turfgrass Acres	120.70		112.07		
Age	42.91		42.74		

Table 8 Determinants of Improved Cultivars Adoption at Recreational Turfgrass Facilities in Oklahoma - Cross Tabulations (2010)

	Never Used	%	Used	%	Total
All Respondents	79	53%	69	47%	148
Golf Course	39	56%	31	44%	70
Recreational Park	13	59%	9	41%	22
Sports Field	9	43%	12	57%	21
Sod Farm	2	67%	1	33%	3
Other	24	52%	22	48%	46
Manual Sprinkler	20	59%	14	41%	34
Automated Sprinkler	55	50%	56	50%	111
Zoned Sprinkler	31	54%	26	46%	57
Manual Connection Sprinkler	19	51%	18	49%	37
Drip Irrigation	16	43%	21	57%	37
Soaker Hose	9	47%	10	53%	19
Spray by Hand	40	54%	34	46%	74
Other Watering Method	4	36%	7	64%	11
We do not irrigate	7	88%	1	13%	8
City	47	55%	39	45%	86
Private Well	16	41%	23	59%	39
Water Retention	19	66%	10	34%	29
Other	11	48%	12	52%	23
<12th Grade	10	71%	4	29%	14
H.S. Diploma	5	56%	4	44%	9
Some College	31	54%	26	46%	57
B.S./B.A.	33	49%	35	51%	68
Turfgrass Management	25	54%	21	46%	46
Landscape Architecture	4	80%	1	20%	5
Plant & Soil Science	1	17%	5	83%	6
Horticulture	13	72%	5	28%	18
Other	10	33%	20	67%	30
Certified Golf Course Superintendent (CGCS)	5	63%	3	38%	8
Certified Irrigation Auditor	0	0%	2	100%	2
Certified Sports Field Manager (CSFM)	4	67%	2	33%	6
Certified Pesticide Applicator	58	56%	46	44%	104
Licensed Pesticide Applicator	27	53%	24	47%	51
Certified Horticulturist	1	100%	0	0%	1
Certified Arborist	1	50%	1	50%	2
Landscape Industry Certified Manager	0	0%	1	100%	1
Landscape Industry Certified Technician	4	80%	1	20%	5
Other	2	22%	7	78%	9
Turfgrass Acres	106.64		126.92		
Age	43.45		42.10		

Table 9 Determinants of Irrigation Scheduling Adoption at Recreational Turfgrass Facilities in Oklahoma - Cross Tabulations (2010)

	Never Used	%	Used	%	Total
All Respondents	85	57%	63	43%	148
Golf Course	43	61%	27	39%	70
Recreational Park	11	50%	11	50%	22
Sports Field	7	33%	14	67%	21
Sod Farm	2	67%	1	33%	3
Other	28	61%	18	39%	46
Manual Sprinkler	22	65%	12	35%	34
Automated Sprinkler	61	55%	50	45%	111
Zoned Sprinkler	32	56%	25	44%	57
Manual Connection Sprinkler	23	62%	14	38%	37
Drip Irrigation	21	57%	16	43%	37
Soaker Hose	11	58%	8	42%	19
Spray by Hand	47	64%	27	36%	74
Other Watering Method	5	45%	6	55%	11
We do not irrigate	8	100%	0	0%	8
City	41	48%	45	52%	86
Private Well	21	54%	18	46%	39
Water Retention	18	62%	11	38%	29
Other	17	74%	6	26%	23
<12th Grade	10	71%	4	29%	14
H.S. Diploma	6	67%	3	33%	9
Some College	31	54%	26	46%	57
B.S./B.A.	38	56%	30	44%	68
Turfgrass Management	28	61%	18	39%	46
Landscape Architecture	4	80%	1	20%	5
Plant & Soil Science	3	50%	3	50%	6
Horticulture	10	56%	8	44%	18
Other	13	43%	17	57%	30
Certified Golf Course Superintendent (CGCS)	6	75%	2	25%	8
Certified Irrigation Auditor	0	0%	2	100%	2
Certified Sports Field Manager (CSFM)	4	67%	2	33%	6
Certified Pesticide Applicator	61	59%	43	41%	104
Licensed Pesticide Applicator	27	53%	24	47%	51
Certified Horticulturist	1	100%	0	0%	1
Certified Arborist	0	0%	2	100%	2
Landscape Industry Certified Manager	0	0%	1	100%	1
Landscape Industry Certified Technician	2	40%	3	60%	5
Other	5	56%	4	44%	9
Turfgrass Acres	107.16		128.15		
Age	42.63		43.07		

Table 10 Determinants of Conservation Adoption at Recreational Turfgrass Facilities in Oklahoma – Parameter Estimates (2010, N=148)

The Logistic Procedure

	Model 1 - Reduced	Model 2 - Higher Mowing	Model 3 - Zoned Irrigation	Model 4 - Improved Cultivars	Model 5 - Irrigation Scheduling
Likelihood Ratio	46.0431	31.6399	30.4380	38.3822	50.2419
N	148	148	148	148	148
Intercept	0.7679 (1.7408)	0.6981 (1.6183)	1.2533 (1.5802)	-0.1519 (1.6184)	2.2667 (1.8467)
Golf	0.1444 (0.9642)	0.1191 (0.9134)	0.0782 (0.9137)	1.4136 (0.9505)	0.8552 (0.9813)
Rec	0.00425 (0.7930)	-0.0906 (0.7530)	-0.4870 (0.7814)	0.8192 (0.7714)	-0.5631 (0.7768)
Sports	0.7533 (0.8124)	0.7059 (0.7866)	-0.0965 (0.8091)	0.2687 (0.8089)	-0.8966 (0.8375)
Sod	-12.3092 (721.9)	0.9055 (1.7764)	0.8803 (1.7956)	3.1239 (1.9884)	1.8594 (1.9277)
OF	0.5699 (0.8783)	-0.0952 (0.8523)	0.0510 (0.8772)	0.8171 (0.8765)	0.7076 (0.9084)
MS	-0.4165 (0.5737)	0.4990 (0.5497)	0.3142 (0.5410)	0.8103 (0.5415)	0.6322 (0.5997)
AS	-0.7777 (0.5898)	-0.6993 (0.5745)	-0.6991 (0.5783)	-0.9703 (0.5967)	-0.9319 (0.6815)
ZS	0.1788 (0.5505)	-0.7198 (0.5469)	-1.2994* (0.5271)	-0.3857 (0.5321)	-0.0832 (0.5909)
MCS	1.9148* (0.6828)	-0.5999 (0.6702)	-0.3238 (0.5888)	-0.3049 (0.5857)	1.0385 (0.6376)
DI	0.1725 (0.6580)	0.7451 (0.6300)	0.6270 (0.6122)	-0.3070 (0.6110)	1.1979** (0.6823)
SH	-1.7382** (0.9340)	1.7911* (0.7991)	0.7256 (0.7458)	-0.2266 (0.7463)	-0.9241 (0.7941)
SBH	-0.6006 (0.5193)	-0.4588 (0.4954)	-0.5144 (0.4754)	0.0111 (0.4869)	0.4983 (0.5118)
OWM	-0.3437 (0.9941)	-0.5625 (0.9164)	-0.0755 (0.9080)	-2.5096* (1.0186)	-1.6056 (0.9948)
NoIrr	16.3746 (375.1)	2.8806* (1.3355)	1.8096 (1.2381)	3.1048* (1.4638)	14.7683 (362.8)
City	-0.9776 (0.7600)	-0.6203 (0.6598)	-0.8853 (0.5982)	0.4746 (0.6156)	-1.5101* (0.7167)
Private	-1.7060* (0.7646)	-0.8749 (0.6617)	-0.2294 (0.5845)	-0.9578 (0.6105)	-1.4209* (0.6942)
Reten	-1.0398 (0.8401)	0.0294 (0.6709)	0.2803 (0.6203)	1.5315* (0.6855)	-0.4169 (0.6994)
OWS	-0.4513 (0.8255)	-1.1244 (0.8037)	0.2838 (0.6828)	-0.4791 (0.6898)	-0.5300 (0.7869)

College	-0.3296	-0.5333	0.3871	-0.1608	-1.1689**
	(0.6625)	(0.6047)	(0.6184)	(0.6343)	(0.6807)
Cert	0.0376	-0.2195	-0.3959	-0.3571	0.2334
	(0.7194)	(0.6973)	(0.6460)	(0.6647)	(0.6918)
Staff	0.0163	-0.0116	0.00978	0.0123	-0.0453*
	(0.0168)	(0.0177)	(0.0158)	(0.0166)	(0.0210)
Acres	0.00288	0.00194	-0.00106	-0.00253	-0.00015
	(0.00243)	(0.00226)	(0.00220)	(0.00263)	(0.00235)
Age	-0.00741	0.00254	0.00363	0.0114	0.000589
	(0.0195)	(0.0194)	(0.0182)	(0.0184)	(0.0207)
SE	-0.4053	0.1847	-0.6088	-0.3883	0.1637
	(0.6379)	(0.6109)	(0.5753)	(0.5674)	(0.6088)
NW	0.8444	0.7930	0.3912	0.4088	1.3401*
	(0.5941)	(0.5797)	(0.5341)	(0.5461)	(0.5997)
SW	-1.0318	0.2077	-0.2352	1.0181	0.4243
	(1.2043)	(0.8983)	(0.8421)	(1.0621)	(0.9590)
OS	-1.7097	0.2292	-0.6587	-2.9448*	-0.2219
	(1.3039)	(1.0049)	(0.9452)	(1.2846)	(1.1587)

* Denotes significance at a 95% confidence level
** Denotes significance at a 90% confidence level

Table 11 Determinants of Conservation Adoption at Recreational Turfgrass Facilities in Oklahoma – Odds Ratio Estimates (2010, N=148)

The Logistic Procedure

	Model 1 - Reduced	Model 2 - Higher Mowing	Model 3 - Zoned Irrigation	Model 4 - Improved Cultivars	Model 5 - Irrigation Scheduling
Golf	1.155*	1.126*	1.081*	4.111*	2.352*
Rec	1.004*	0.913*	0.614*	2.269*	0.569*
Sports	2.124*	2.026*	0.908*	1.308*	0.408*
Sod	<0.001	2.473*	2.412*	22.735*	6.420*
OF	1.768*	0.909*	1.052*	2.264*	2.029*
MS	0.659*	1.647*	1.369*	2.248*	1.882*
AS	0.459*	0.497*	0.497*	0.379*	0.394*
ZS	1.196*	0.487*	0.273*	0.680*	0.920*
MCS	6.786*	0.549*	0.723*	0.737*	2.825*
DI	1.188*	2.107*	1.872*	0.736*	3.313*
SH	0.176*	5.996*	2.066*	0.797*	0.397*
SBH	0.548*	0.632*	0.598*	1.011*	1.646*
OWM	0.709*	0.570*	0.927*	0.081*	0.201*
NoIrr	>999.999	17.825*	6.108*	22.305*	>999.999
City	0.376*	0.538*	0.413*	1.607*	0.221*
Private	0.182*	0.417*	0.795*	0.384*	0.242*
Reten	0.354*	1.030*	1.324*	4.625*	0.659*
OWS	0.637*	0.325*	1.328*	0.619*	0.589*
College	0.719*	0.587*	1.473*	0.851*	0.311*
Cert	1.038*	0.803*	0.673*	0.700*	1.263*
Staff	1.016*	0.988*	1.010*	1.012*	0.956*
Acres	1.003*	1.002*	0.999*	0.997*	1.000*
Age	0.993*	1.003*	1.004*	1.011*	1.001*
SE	0.667*	1.203*	0.544*	0.678*	1.178*
NW	2.327*	2.210*	1.479*	1.505*	3.819*
SW	0.356*	1.231*	0.790*	2.768*	1.529*
OS	0.181*	1.258*	0.518*	0.053*	0.801*

* Denotes significance at a 95% confidence level

FIGURES

Figure 1   Water Conservation Practice Adoption in Oklahoma on Recreational Turfgrass Facilities (2010, N=148)

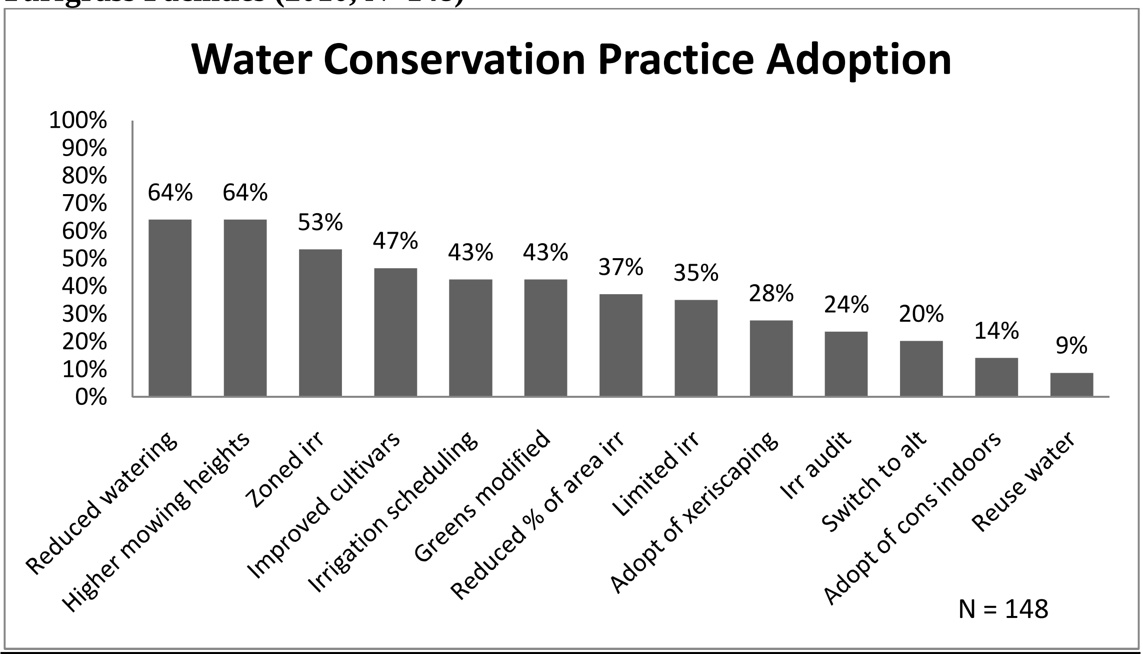
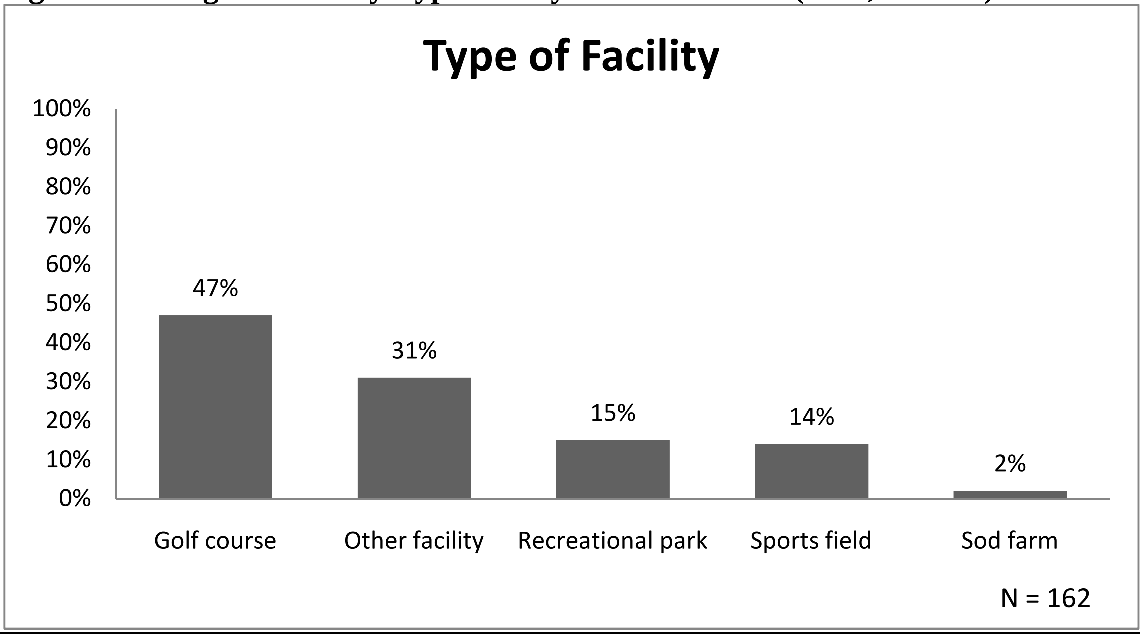
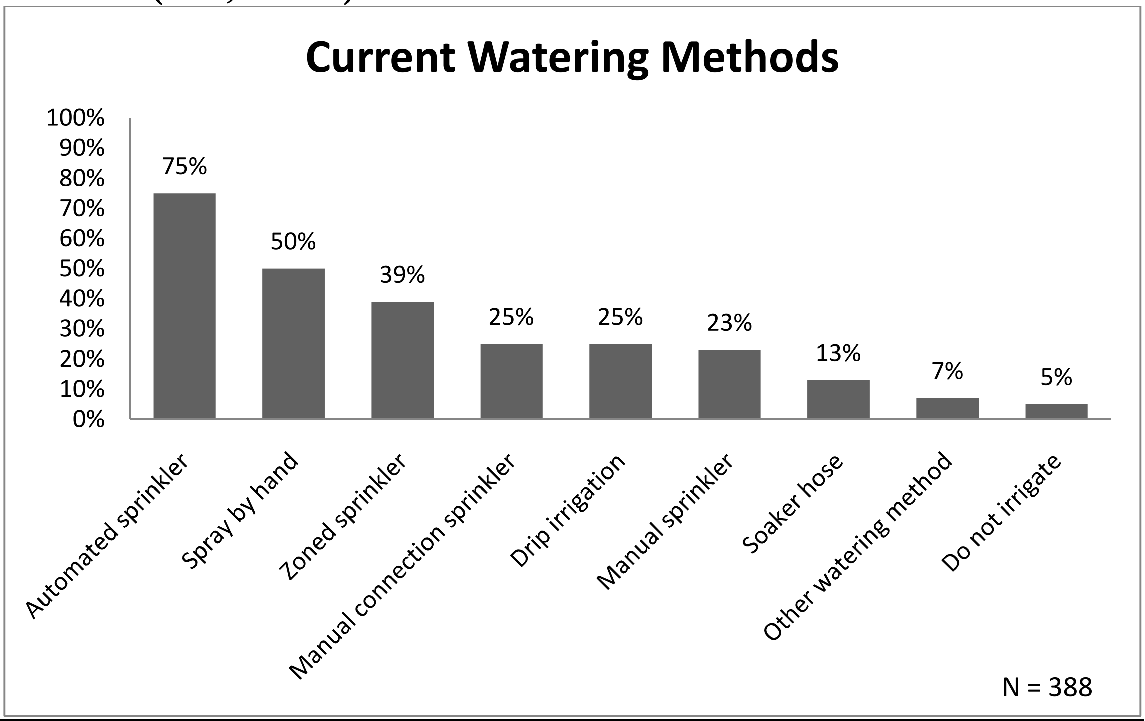


Figure 2 Turfgrass Facility Type Surveyed in Oklahoma (2010, N=162[1])



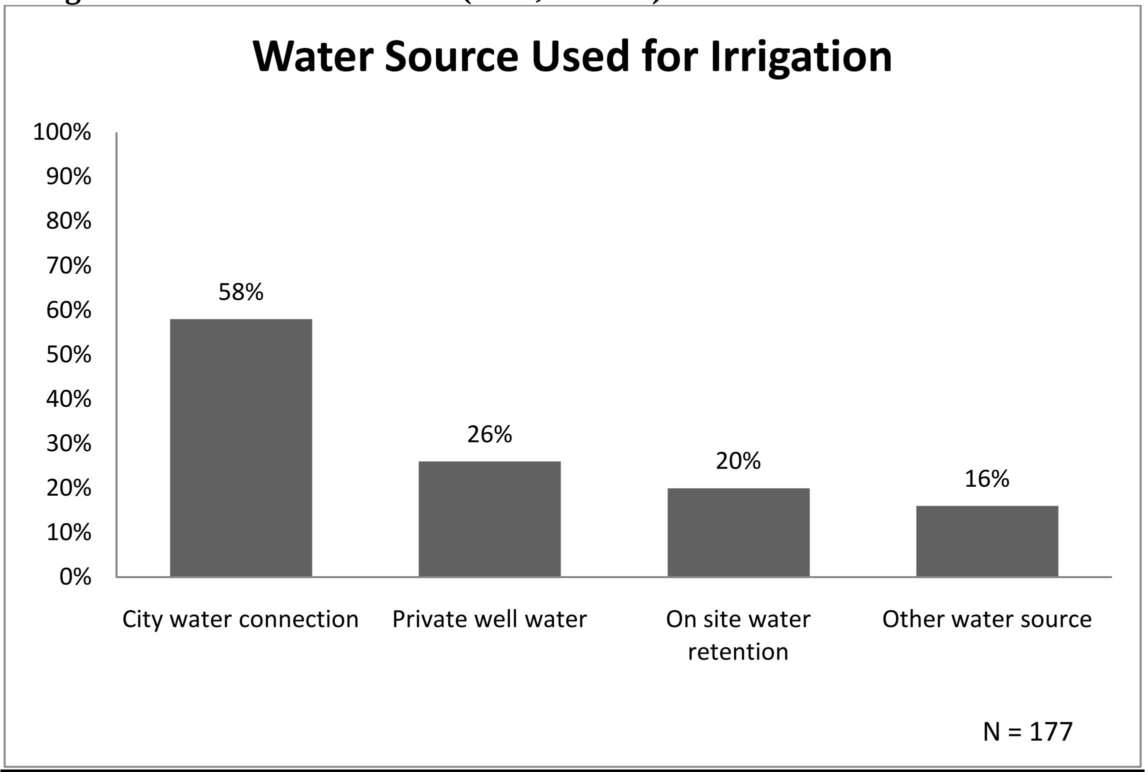
[1] **Respondents were not limited to choosing only one facility type**

Figure 3 Current Watering Methods for Recreational Turfgrass Facilities in Oklahoma (2010, N=388[1])



[1] **Respondents were not limited to choosing only one current watering method**

Figure 4 Current Primary Water Source Used for Irrigation for Recreational Turfgrass Facilities in Oklahoma (2010, N=177[1])



[1] Respondents were not limited to choosing only one water source

Figure 5 Regional Location of Recreational Turfgrass Facilities in Oklahoma (2010, N=148)

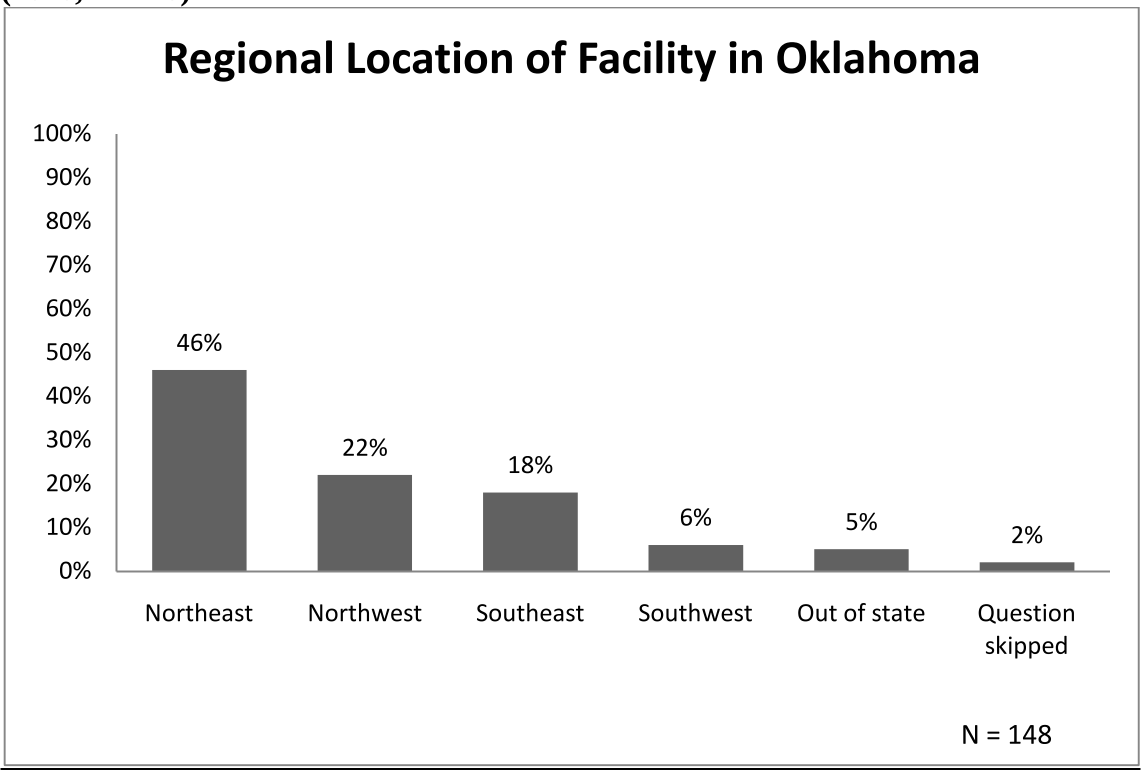
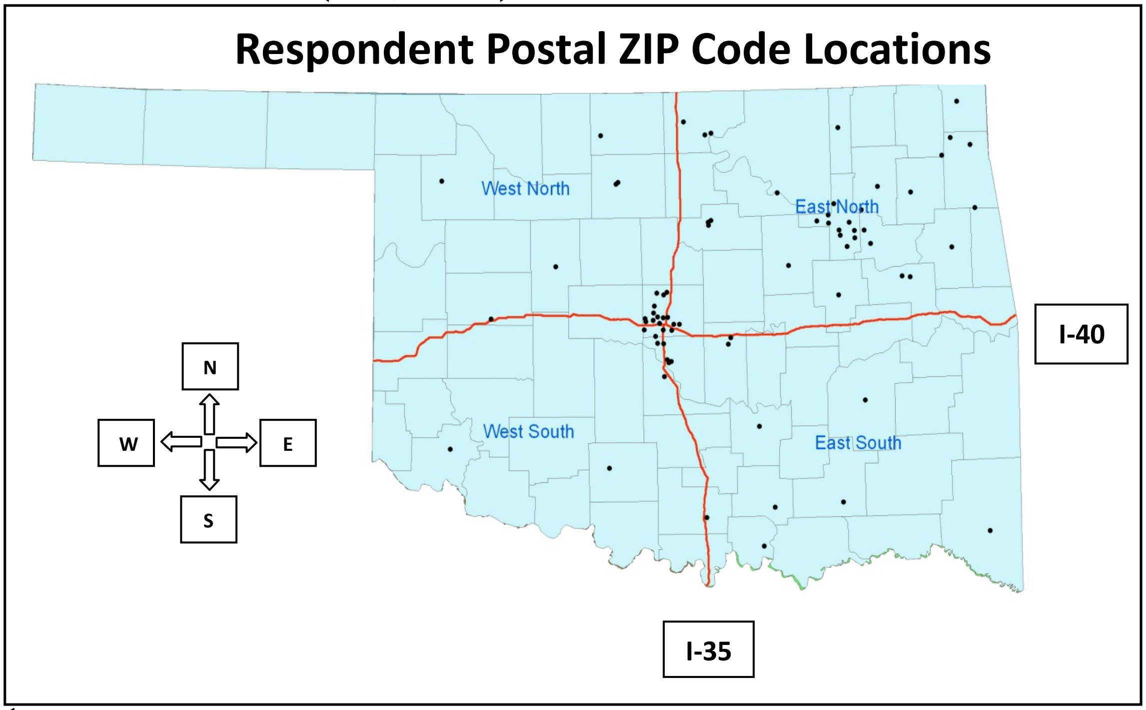


Figure 6 Respondent Postal ZIP Code Locations of Recreational Turfgrass Facilities in Oklahoma (2010, N=148)



[1] Dots indicate one or more responses were received from that ZIP code

Figure 7   Highest Level of Education of Recreational Turfgrass Managers in Oklahoma (2010, N=148)

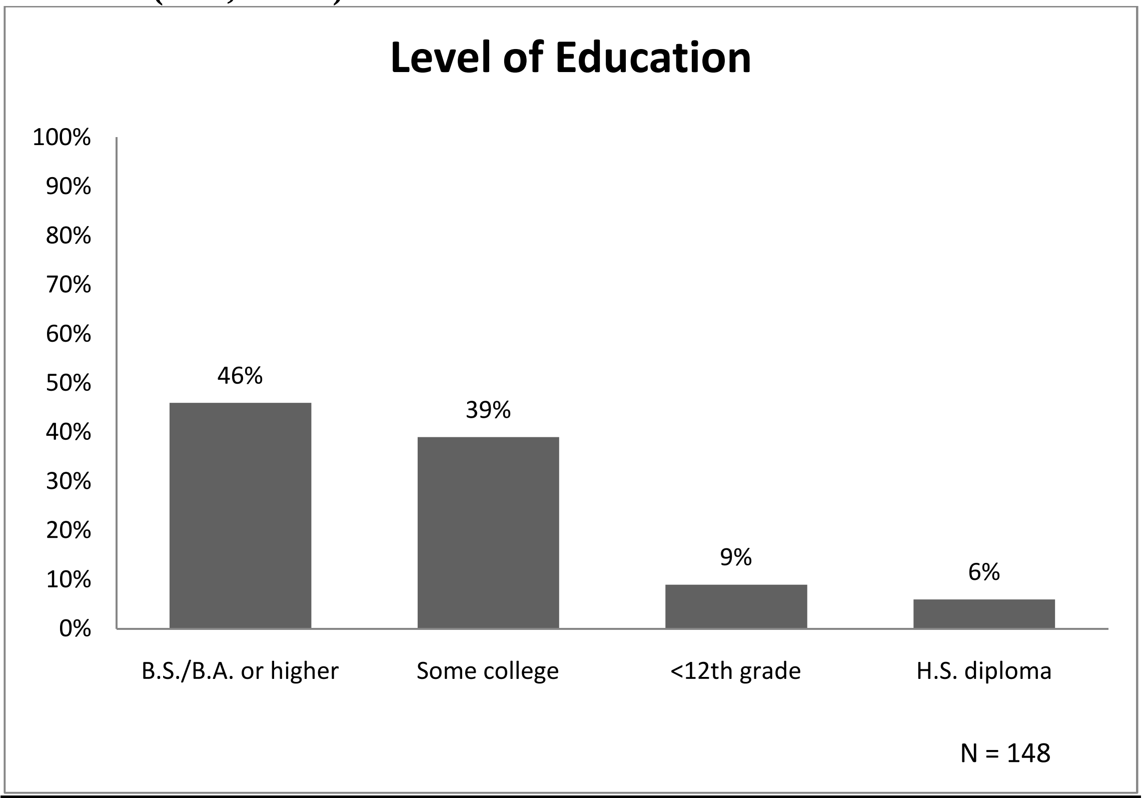
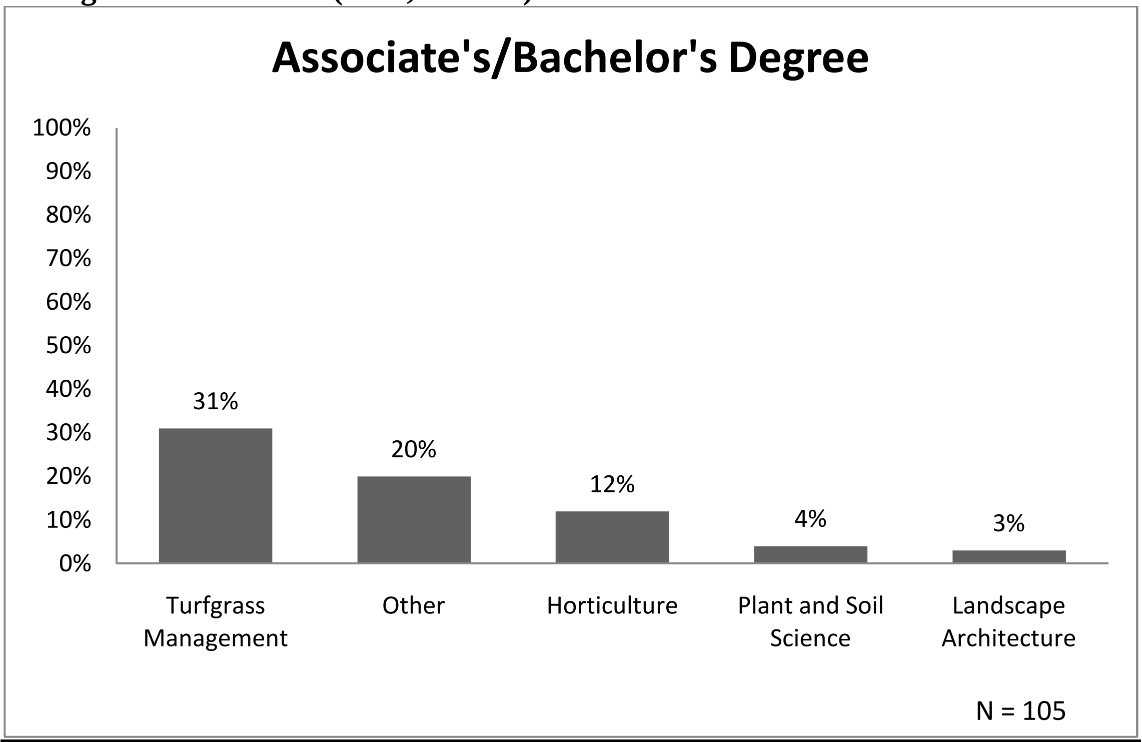
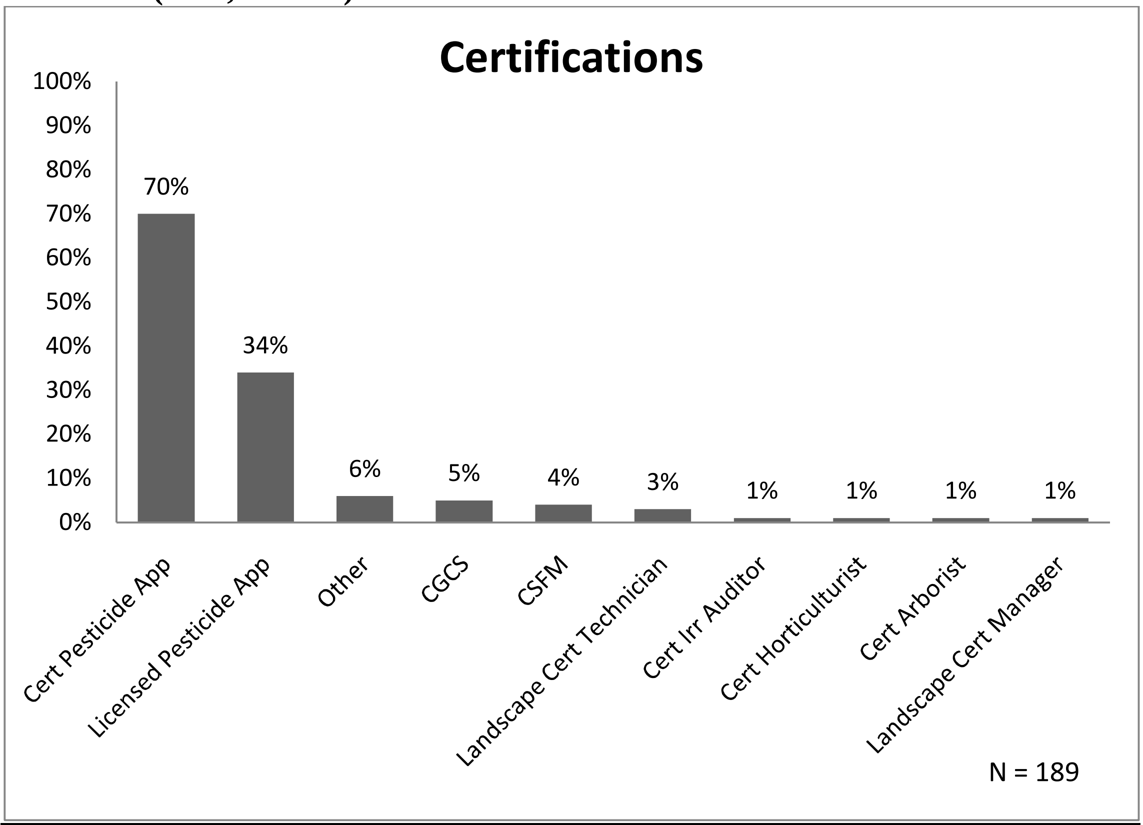


Figure 8 Type of Associate's or Bachelor's Degree Held by Recreational Turfgrass Managers in Oklahoma (2010, N=105[1])



[1] **Respondents were not required to indicate a college degree**

Figure 9 Current Certifications held by Recreational Turfgrass Managers in Oklahoma (2010, N=189[1])



[1] **Respondents were not limited to choosing only one certification**
[2] **Certification abbreviations:**

CGCS	Certified Golf Course Superintendent (CGCS)
Cert Irr Auditor	Certified Irrigation Auditor
CSFM	Certified Sports Field Manager (CSFM)
Cert Pesticide App	Certified Pesticide Applicator
Licensed Pesticide App	Licensed Pesticide Applicator
Cert Horticulturist	Certified Horticulturist
Cert Arborist	Certified Arborist
Landscape Cert Manager	Landscape Industry Certified Manager
Landscape Cert Technician	Landscape Industry Certified Technician
Other	Other

APPENDICES

Appendix A

Water Use in Recreational Turfgrass Management

This survey is being conducted by researchers in the Department of Agricultural Economics at Oklahoma State University to determine water conservation in turfgrass management. Your participation will greatly benefit future water conservation practices in Oklahoma.

Informed consent: Please **check this box** ☐ to indicate that you are aware that your answers will remain *confidential* and your participation in this survey is completely *voluntary*.

Section I:
Please answer the following questions pertaining to the park/golf course/sports field/sod farm or other facility in which you are employed.

1) At what kind of facility are you employed?
   - ☐ Golf Course
   - ☐ Recreational Park
   - ☐ Sports Field
   - ☐ Sod Farm
   - ☐ Other (please specify) ________________

2) Are you the lead manager? ☐ Yes ☐ No

3) Are you one of several employees? ☐ Yes ☐ No
   If yes, how many employees are at your facility? ___________ people

4) Is your facility ☐ private or ☐ public?

5) How many individuals are on your facility's maintenance staff? _______ people

6) What is the zip code for your facility? ______________

7) What is the annual operating budget for maintenance at your facility?
___________ $/year

8) Which of the following watering methods are used on the area you manage (please check all that apply)?
- ☐ Above ground automatic sprinkler (manual)
- ☐ Above ground automatic sprinkler (automated)
- ☐ Above ground automatic sprinkler (zoned)
- ☐ Manual connection sprinkler
- ☐ Drip irrigation
- ☐ Soaker hose or flood irrigation (leave hose on ground)
- ☐ Spray by hand as needed
- ☐ Other watering method (please specify) ____________________
- ☐ We do not irrigate

9) What source do you get your water from for your facility's irrigation?
- ☐ City water connection
- ☐ Private well water
- ☐ On site water retention (untreated water)
- ☐ Other (please specify) _______________________

10) Do you or a contracted maintenance firm apply **pesticides** to the area you manage?
☐ Yes ☐ No

11) Do you or a contracted maintenance firm apply **fertilizer** to the area you manage?
☐ Yes ☐ No

12) How much of your facility is in turfgrass? ____________ acres

13) Have you adopted any of the following water conservation approaches on the area you manage? For each water conservation strategy your facility has adopted, please check **when** it was adopted and also indicate the **percentage of area** in which it applies.

Irrigation practices	Never	Within the last 2 years	In the last 2-5 years	Already used prior to 5 years ago	% of area in turf practice
• Reduced watering	☐	☐	☐	☐	____
• Reduce percentage of area irrigated alone	☐	☐	☐	☐	____
• Limited or nonexistent Irrigation	☐	☐	☐	☐	____
• Zoned irrigation systems	☐	☐	☐	☐	____
• Irrigation scheduling based on plant water requirements as estimated by site-specific weather data (Mesonet/SIPS/Evapotranspiration)	☐	☐	☐	☐	____
• Reuse or gray water for irrigation	☐	☐	☐	☐	____
• Irrigation audit	☐	☐	☐	☐	____

Other Water Conservation Strategies	Never	Within the last 2 years	In the last 2-5 years	Already used prior to 5 years ago	% of area in turf practice
• Selection of improved turfgrass cultivars for drought tolerance	☐	☐	☐	☐	____
• Greens or high use areas modified to improve water percolation and deeper rooting, avoidance of excessive slopes	☐	☐	☐	☐	____
• Higher mowing heights of grass	☐	☐	☐	☐	____
• Switch to alternative, non-municipal supply	☐	☐	☐	☐	____
• Adoption of xeriscaping or drought tolerant plants where turfgrass is not necessary	☐	☐	☐	☐	____
• Adoption of conservation indoors in clubhouse, park structures, etc	☐	☐	☐	☐	____

14) Would your facility be interested in receiving training on your irrigation needs?

☐ Strongly agree
☐ Somewhat agree
☐ Neither agree nor disagree
☐ Somewhat disagree
☐ Strongly disagree

15) What is your predominant motivation for adopting water conservation strategies (please rank choices 1 – 5 with 1 being the most important)?

____ Lowering costs of water used
____ Environmental conservation
____ Reducing labor costs in irrigation
____ Response to price increase by municipal water supply
____ Reducing mowing or weeding costs

16) What are your concerns or barriers to adopting water conservation strategies (please rank choices 1 – 3 with 1 being the most important)?

____ Need for knowledge of strategies to reduce water use
____ Concern over performance and appearance of turf for users
____ Funding for implementing strategies

Section II:

In this section, you will be asked for demographic and household information. Please remember this survey is confidential and none of you answers will be revealed as an individual.

17) What is your highest level of education?

☐ <12th grade ☐ Some college
☐ H.S. diploma ☐ B.S./B.A. or higher graduate

18) Do you have an associate's/bachelor's degree in any of the following (please select all that apply)?

☐ Turfgrass Management ☐ Horticulture
☐ Landscape Architecture ☐ Other (please specify) ___________
☐ Plant and Soil Science

19) What certifications have you obtained (please select all that apply)?

☐ Certified Golf Course Superintendent (CGCS)
☐ Certified Irrigation Auditor
☐ Certified Sports Field Manager (CSFM)
☐ Certified Pesticide Applicator
☐ Licensed Pesticide Applicator
☐ Certified Horticulturist
☐ Certified Arborist
☐ Landscape Industry Certified Manager
☐ Landscape Industry Certified Technician
☐ Other (please specify) ____________________

20) What is your gender? ☐ Male ☐ Female

21) What is your age? ____________ years

22) Which category best describes your race?

☐ White ☐ Black, African American ☐ Native American
☐ Asian ☐ Other (please specify) ____________________

Are there any additional comments that you would like to share with the researchers about turfgrass water use and conservation in Oklahoma?

____
____
____

Thank you for completing our survey.

Please return your survey to the OSU booth in the lobby in order to enter the random drawing for THREE chances to win $100!

If you have any additional questions or comments about this survey, please contact:

Tracy Boyer, Assistant Professor
Department of Agricultural Economics
Oklahoma State University
321 Agricultural Economics
Stillwater, OK 74078
tracy.boyer@okstate.edu
Fax: 405-744-8120
Telephone: (405) 744-6169

Please mail or fax any late surveys to Tracy Boyer at the address above!

Appendix B

Oklahoma State University Institutional Review Board

Date:	Wednesday, November 10, 2010
IRB Application No	AG1045
Proposal Title:	Water Use in Recreational Turfgrass Management
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 11/9/2011

Principal Investigator(s):

Tracy Boyer
321 Ag Hall
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

[X] The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia M. Kennison

Shelia Kennison, Chair
Institutional Review Board

VITA

JoDee Lynn Schmidt

Candidate for the Degree of

Master of Science

Thesis: DETERMINANTS OF WATER CONSERVATION IRRIGATION PRACTICES: A STUDY OF PARK AND GOLF TURFGRASS MANAGEMENT IN OKLAHOMA

Major Field: Agricultural Economics

Biographical:

Education:

Completed the requirements for the Master of Science in Agricultural Economics at Oklahoma State University, Stillwater, Oklahoma in July, 2011.

Completed the requirements for the Bachelor of Science in Agricultural Economics at Oklahoma State University, Stillwater, Oklahoma in 2009.

Experience:

USDA Natural Resources Conservation Service
Earth Team Volunteer
Guthrie Field Office, Guthrie, Oklahoma
2004 – present

Professional Memberships:

Oklahoma State University Graduate Student Association	2009 - present
National Watershed Coalition	2006 - present
Oklahoma Association of Conservation Districts	2006 - present
Sigma Alpha Lambda, National Leadership and Honors	2008 - 2009
The National Scholars' Honor Society	2008 - 2009

Name: JoDee Lynn Schmidt   Date of Degree: July, 2011

Institution: Oklahoma State University   Location: Stillwater, Oklahoma

Title of Study: DETERMINANTS OF WATER CONSERVATION IRRIGATION PRACTICES: A STUDY OF PARK AND GOLF TURFGRASS MANAGEMENT IN OKLAHOMA

Pages in Study: 60   Candidate for the Degree of Master of Science

Major Field: Agricultural Economics

Scope and Method of Study: With urban and suburban sprawl increasing throughout Oklahoma, areas of previously non-irrigated pasture and/or croplands are being converted to homeowner and commercial landscapes generally composed of turfgrass. Continued increase in irrigated landscapes across the state will result in increased residential water demand making it important to determine current landscape irrigation practices and identify determinants of current irrigation practices used by Oklahoma turfgrass managers of athletic, golf, and park land.

A survey of 148 Oklahoma professional turfgrass managers solicited information on facility characteristics and management and also the characteristics of the managers. The logit procedure was utilized for the regression analysis of the data to predict the likelihood of adoption of conservation practices, given the facility and individual manager's characteristics.

Findings and Conclusions: Because adoption exceeded 50% of respondents for only three types of water conservation strategies, there appears to be a lack of motivation or incentive on the part of Oklahoma turfgrass managers to participate in water conservation. Even though respondents consider lowering facility watering costs to be an important motivation for adopting water conservation strategies, concern for maintaining performance and appearance of turfgrass for users overshadows those concerns as the most cited barrier to adoption. Conditions of non-adoption are not random, facilities with automated sprinklers are more likely to have invested in them to ensure turf aesthetics, city water connections indicate likelihood of higher returns to use from urban location and clientele and/or turf managers have already switched to private wells to avoid higher costs of treated water. Turfgrass facilities relying on municipal connections are in proximity to large populations therefore they strive to uphold landscape appeal with green, lush turf. Sod farm employees are more likely to be aware of how much water turfgrass varieties require allowing the maximization of profits by producing healthy grasses at the least cost.

ADVISER'S APPROVAL: Dr. Tracy Boyer