In-ground Irrigation Systems Affect Lawn-watering Behaviors of Residential Homeowners

Dale J. Bremer[1,3], Steven J. Keeley[1], Abigail Jager[2], Jack D. Fry[1], and Cathie Lavis[1]

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Summary. **Urbanization is increasing the land area covered with turfgrasses, which may have implications for water quantity and quality. The largest sector of turfgrass is residential lawns. Our objectives were to compare lawn-irrigation perceptions, knowledge, and behaviors of residential homeowners with and without in-ground sprinkler systems (IGS and NIGS, respectively); homeowners were surveyed in three Kansas cities, each with distinctive water quantity and quality issues. Surveys were mailed to 15,500 homeowners in Wichita, 10,000 in Olathe, and 5000 in Salina; the return rate was 11% to 13%. Homeowners with IGS watered more frequently than NIGS; 67% to 90% of IGS and 19% to 31% of NIGS homeowners watered two to three times per week or more. More IGS homeowners watered routinely and applied the same amount of water each time than NIGS homeowners, who mostly watered and adjusted watering amounts based on lawn dryness. More IGS than NIGS homeowners wanted their lawn green all the time, followed lawn-care guidelines, and considered their neighborhood appearance important. Among IGS homeowners, 41% to 54% claimed to know how much water their lawns required compared with only 29% to 33% of NIGS homeowners. However, 65% to 83% in both groups did not know how much water they applied when they irrigated. About 7% to 9% of homeowners swept or blew clippings or lawn-care products into streets or storm drains; this percentage was unaffected by whether they had IGS or not. All homeowners' lawn irrigation knowledge and habits must be improved to help conserve water and protect water quality, but educational efforts should concentrate on IGS homeowners because they water more frequently.**

With urbanization, significant tracts of natural ecosystem and agricultural land are being replaced with turfgrass [Alig et al., 2004; U.S. Geological Survey (USGS), 1999]. In the United States, turfgrasses are estimated to cover 16 to 20 million hectares of urbanized land, or up to 18% of the land area in some regions [Morris, 2003; U.S. Department of Agriculture (USDA), 2004, 2006]; this represents an area three times larger than any irrigated crop (Milesi et al., 2005). Furthermore, urbanization in the United States and elsewhere is projected to continue to increase rapidly (Alig et al., 2004), indicating a continued expansion of land area covered with turfgrasses.

The rapid increase of turfgrass in the landscape may have significant implications for water quality and quantity. A number of studies have linked urbanization with declining water quality in surface and groundwater reservoirs because of increased concentrations of nutrients and pesticides, some of which are used in lawns (Hamilton et al., 2004; King and Balogh, 2001; Petrovic and Easton, 2005; USGS, 2001). Irrigation of turfgrass is typical in many urban areas, which increases demand for water resources. Water scarcity is most critical in arid or semiarid regions experiencing rapid urban growth (Reisner, 1993).

Water quality in urban areas may be affected by runoff or leaching of fertilizer nutrients and pesticides from lawns, but runoff from impervious surfaces is the greatest concern. Runoff from lawns or impervious surfaces may happen during intense rainstorms, when turfgrass is over irrigated, or when irrigation systems are improperly adjusted (Brezonik and Stadelmann, 2002; Morton et al., 1988; Petrovic, 1990). The extent of excessively irrigated turfgrass is not known, but apparently over irrigation has altered the hydrologic system of the Las Vegas Valley such that historically ephemeral washes have become perennial streams in urbanized areas (Mizell and French, 1995). This indicates a critical need to change the behavior of urbanites to reduce their irrigation inputs and thus, conserve water and improve water quality.

The greatest opportunity for conserving water and minimizing runoff and leaching in urban areas may be in residential lawns. From 50% to as much as 80% of all land area covered with turfgrass in the United States is composed of residential lawns (Grounds Maintenance, 1996; USDA, 2004, 2006), and up to 75% of residential water use may be for "outdoor" purposes (Vickers, 2001). The use of automatic irrigation systems by homeowners, which increasingly are installed during construction of new single-family homes in urbanizing watersheds in some regions, may be both problematic and advantageous to water conservation efforts. On a per-area basis, in-ground irrigation systems may use twice the amount of water as manual irrigation if the systems are improperly adjusted (Vickers, 2001). However, these systems also may present opportunities for more accurate irrigation (e.g., match the minimal or actual water needs of the turfgrass) if residents are given proper education.

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[1]Department of Horticulture, Forestry and Recreation Resources, Kansas State University, 2021 Throckmorton Hall, Manhattan, KS 66506

[2]Department of Statistics, 101 Dickens Hall, Kansas State University, Manhattan, KS 66506

[3]Corresponding author. E-mail: bremer@ksu.edu.

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
25.4	inch(es)	mm	0.0394
1.6093	mile(s)	km	0.6214
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

Inaccurate perceptions about water requirements for turfgrass or embellished expectations about lawn appearance (e.g., maintaining perfectly green lawns even during drought) may result in over-irrigation. However, data are lacking to quantify the prevalence of such perceptions, including how they affect lawn-watering practices. Presumably, the perceptions and practices of homeowners about lawn watering may be influenced by a number of factors including demographics, local climate, water costs, water shortages, and whether homeowners have an in-ground irrigation system or not. Consequently, a first step toward improving water quality and conservation in urban watersheds is to carefully evaluate fundamental perceptions and practices of homeowners in watering their lawns.

Our objective was to determine how owning an in-ground irrigation sprinkler system affected the perceptions, knowledge, and behaviors of residential homeowners about the irrigation of their lawns during summer months. To that end, survey responses were compared between those with and without in-ground irrigation sprinkler systems in three separate urban areas of Kansas, each with distinct combinations of climate, demographics, and water issues.

Materials and methods

Study locations. Surveys were mailed to residents in Wichita, Olathe, and Salina, KS. Each city has related, but also distinctive concerns about water quantity and quality. The first is Olathe, which is located in the Lower Kansas River Watershed and is a suburb of the larger Kansas City metropolitan area that straddles the Kansas and Missouri state borders; Kansas City ranked 29th in the United States in 2010 for the amount of land area covered by urban landscapes (U.S. Census Bureau, 2012). Olathe grew by 35% from 2000 to 2010, was ranked 24th in the list of fastest growing cities in the nation in 2008, and is also an affluent suburb whose residents typically maintain high-input lawns; median annual household income from 2006 to 2010 was $75,228. In Olathe, water is generally plentiful except during peak water usage in summer months. A review of water use in Olathe and neighboring suburbs in the Kansas City, KS area; however, indicated that many residents were over-watering their lawns and that significant reductions in water use were possible by targeting lawn irrigation by homeowners (N.G. Scott, personal communication).

The second city is Wichita, which is 160 miles to the west-southwest of Olathe and located in the Middle Arkansas-Slate Watershed. Wichita is the 49th largest city in the United States and grew by 11% from 2000 to 2010 (U.S. Census Bureau, 2012). The median annual household income from 2006 to 2010 was $44,360, which was 41% lower than in Olathe. On an annual basis, Wichita receives nearly 9.2 inches less precipitation and averages 2.4 °F higher than Olathe, resulting in greater irrigation demands for lawns in Wichita (i.e., greater potential evapotranspiration and less rainfall). Unfortunately, Wichita's water sources, which include nearby Cheney Reservoir and the Equus Beds aquifer, are not expected to meet projected needs into the 21st century (K. Drennen, personal communication). Therefore, in 1995, Wichita implemented an innovative plan to recharge the Equus Beds aquifer with overflow from the Little Arkansas River after rain, when the river had risen to a predetermined level (USGS, 2012). In this way, the city hopes to store water for later recovery of the groundwater by the city although water conservation by residents will be crucial to ensure the adequacy of this water supply.

The third city is Salina, which lies in the Lower Saline Watershed. Salina is 150 miles west of Olathe and 80 miles north of Wichita and its climate is more similar to Wichita's than Olathe's. The median annual household income from 2006 to 2010 was $42,027 in Salina, which was also similar to Wichita and substantially less (i.e., by 44%) than Olathe (U.S. Census Bureau, 2012). Salina declared its first water emergency in 2006 because its main source of water, the Smoky Hill River, nearly ran dry for the first time in recorded history despite only slightly less than normal precipitation in recent years. Although the growth of Salina between 2000 and 2010 (4.4%) was not as rapid as Wichita or Olathe, its concern over water conservation and quality is critical. In particular, water quality is a concern because Salina's increased reliance on groundwater supplies has increased the rate of flow of an underground pollution plume (trichloroethylene) from a nearby former U.S. Air Force base toward city wells. Therefore, reductions in water use by Salina residents are crucial. This combination of factors makes Olathe, Wichita, and Salina ideal locations from which to investigate perceptions and irrigation behaviors of homeowners about their lawns.

Survey development. A survey was developed to determine how residential homeowners make decisions about watering their lawns, including the frequency of and amount of water applied during irrigation in the summer months of June, July, and August. Homeowners were asked if they knew how much water their lawn required per week and if so, to specify how much. Similarly, they were asked if they knew what type of grass they had in their lawns and if so, to specify what type. Inquiries were made as to how important it was to keep their lawns green and their neighborhoods looking nice, prevent their water bill from getting too high, keep their lawns alive during hot and dry periods, conserve water, and follow lawn-care guidelines. Surveyees were asked whether they swept or blew their driveways after mowing or applying lawn-care products and if they did, whether they swept or blew them back into their lawns or into the street or storm drains. Homeowners were asked whether they had an in-ground lawn sprinkler system and if so, the frequency with which they adjusted it.

The survey consisted of five-point Likert-scaled items and multiple choice questions. The Likert-scaled items were ranked from 1 to 5 with 1 = not important and 5 = very important. For multiple choice questions, participants were asked to select one answer out of two to six options to represent their response to a given question. Where only two options were offered, the question called for either a yes or no response.

Because the targeted population was residential homeowners, all respondents were asked whether they actually owned their homes. In addition, they were asked whether they watered and maintained their lawn themselves. If any respondent did not own their own home or water and maintain their own lawn, their surveys were discarded from the final analysis.

As an incentive to participate in the survey, all respondents were entered into a drawing for a $100 gift card from Lowe's® (Mooresville, NC), which is a home-improvement department store; separate drawings were held for each city, with one $100 gift card per city.

Population and sample. Surveys were mailed to more than 30,000 residential homeowners in three cities in Kansas—Wichita, Olathe, and Salina. Lists of residential homeowner addresses were obtained from the municipal utility in each city. The total population of residential homeowners was 98,708 in Wichita, 26,333 in Olathe, and 14,971 in Salina. To ensure that sampling was uniform geographically across each city, a stratified design was employed. This involved dividing each city arbitrarily into sections. Addresses were then selected randomly from within each section, based on its population proportionate to the total population of the city. Accordingly, Wichita was divided by zip codes into 23 sections, Olathe was divided into 13 sections, and Salina was divided into 54 sections based on route numbers assigned by the municipality.

Each selected address received a one-page, trifold survey mailer. Homeowners were asked to complete the survey and return it postage paid. The total number of surveys mailed to residential homeowners included 4992 in Salina on 28 Apr.; 9992 in Olathe on 27 May; and 15,534 in Wichita on 2 July; all in 2009. In total, the number of surveys returned by residents included 1772 from Wichita, 1110 from Olathe, and 652 from Salina. Thus, the total return rate was 11.4% for Wichita, 13.1% for Olathe, and 11.1% for Salina, or an overall return rate of 11.6%.

Although this survey did not have a high response rate, a survey with a low response rate can provide meaningful conclusions about the population. For this to be true, we assumed that the homeowners that responded to the survey were a random subgroup of the homeowners who were mailed surveys. In other words, respondents and non-respondents would have provided similar answers to the survey questions. In this case, this assumption seems plausible. Furthermore, when no information is available regarding characteristics of the non-respondents, we cannot quantify the amount of potential non-response bias present. In this case, since no follow-up surveys were attempted, we do not have information on non-respondents (Dey, 1997).

Data analysis. Responses were evaluated across the whole sample population of each urban area. Data were analyzed using the statistical program R version 2.13 (R Development Core Team, 2011). For each urban area, proportions (and standard errors) of respondents in each category for each survey question were computed using the stratified sampling design of the survey. Additional adjustments were made for sampling from finite populations (Scheaffer et al., 1979). Some questions on the survey were only intended to be answered by respondents who watered their lawns during the summer. To estimate proportions and SE for these subpopulations, we used ratio estimation methods for stratified sampling (Lohr, 2010).

Results and discussion

Lawn-watering behavior. Responses to the question "How often do you water your lawn during dry periods of the summer?" indicated that homeowners who had in-ground sprinkler systems watered much more frequently than those who did not have in-ground sprinkler systems (Fig. 1). In Wichita and Olathe, a total of 90% of homeowners with IGS watered two to three times per week or more, while only 30% of NIGS homeowners watered that frequently. Increased watering frequency by IGS homeowners is likely due to both

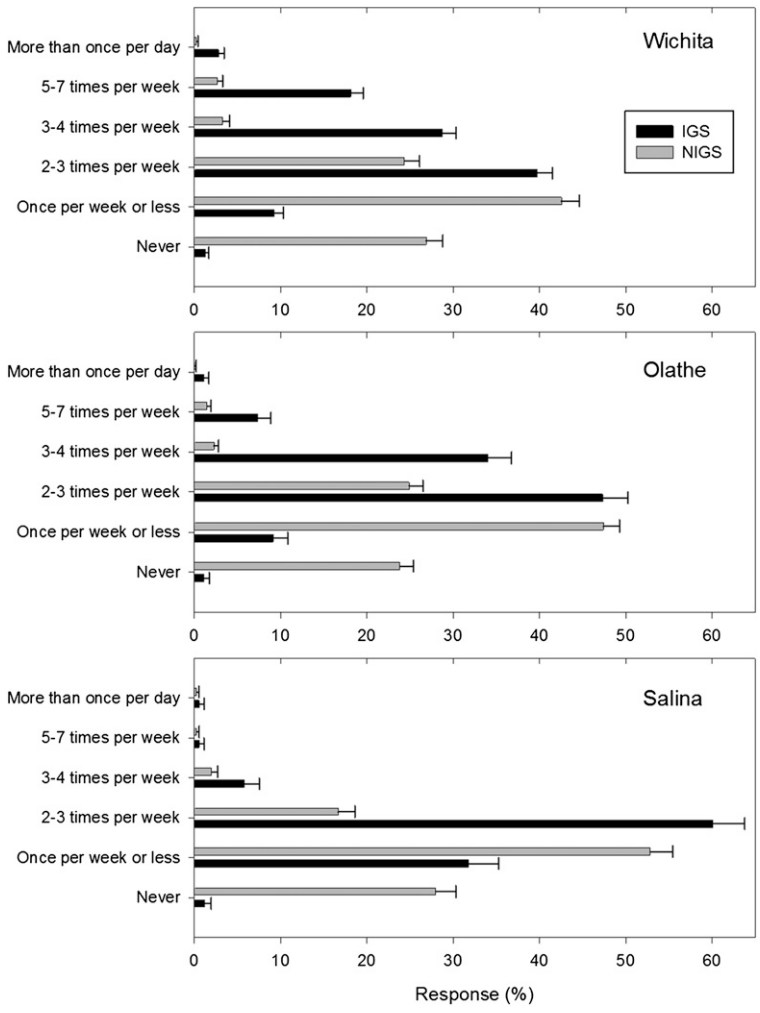

Fig. 1. Responses of residential homeowners with and without in-ground irrigation systems (IGS and NIGS, respectively) in three urban areas in Kansas to the survey question "How often do you water your lawn during dry periods of the summer?" Error bars denote SE.

convenience, and to a desire for a higher-quality lawn implied by their investment in an IGS. In Salina, while more IGS homeowners watered frequently (67% watering two to three times per week or more) than NIGS homeowners (19%), it is notable that 32% of Salina IGS homeowners still watered once per week or less compared with only 10% to 11% of IGS homeowners in that category in Olathe and Wichita. It was also notable that many more IGS homeowners in Wichita watered very frequently, with 21% watering five to seven times per week or more, compared with only 1% and 8% of IGS homeowners in Salina and Olathe, respectively.

The generally lower frequency with which Salina residents water their lawns may be related to a heightened perception of water shortages related to the water shortage of 2006 when the Smoky Hill River nearly ran dry. In support of this, residential homeowners in the U.S. desert southwest ranked water shortages as the main factor that would cause them to reduce irrigation of their landscapes; water shortages were even more important to them than high water bills (Spinti et al., 2004; St. Hilaire et al., 2010). An analysis of water costs for landscape irrigation (assuming water for landscape irrigation was charged at "second-tier" rates) in the three cities also revealed that Salina was roughly 40% more expensive than Wichita, and 55% more expensive than Olathe (personal communication with water municipalities in each city). Thus, higher water costs may also have contributed to less water use by IGS and NIGS homeowners in Salina among cities.

By contrast, the higher frequency with which Wichita IGS homeowners watered their lawns could be due to the warmer summers, leading to higher evaporative demand in that city. For example, the evaporative demand among cities as estimated by Penman potential evapotranspiration during June, July, and August is 27.97 inches in Wichita, 27.78 inches in Salina, and 24.16 inches in Olathe (Sophocleous, 1998); comparatively, precipitation during June, July, and August is 12.23 inches in Wichita, 12.35 inches in Salina, and 14.26 inches in Olathe. Although the evaporative demand is only slightly greater in Wichita than in Salina, Wichita residents may have less concern or awareness about water shortages than Salina residents.

In response to the question "How do you decide when it is time to water your lawn?," IGS homeowners were much more likely to water on a routine schedule (Fig. 2). By city, the percentage of IGS compared with NIGS homeowners watering on a routine schedule was 60:12 in Wichita, 56:5 in Olathe, and 45:15 in Salina. This discrepancy was likely due to the convenience afforded by the automatic timer, which may have led to a "set it and forget it" mentality in IGS homeowners. By contrast, NIGS homeowners were much more likely to water when the lawn looked dry; the percentage of NIGS compared with IGS homeowners using this strategy was 56:19 in Wichita, 60:24 in Olathe, and 52:26 in Salina. It seems likely that significant water savings could be achieved in all cities if IGS homeowners in particular were better educated about "plant-based" irrigation.

In response to the question "How do you decide how much to water your lawn?," IGS homeowners were much more likely than NIGS homeowners to apply the same amount at each irrigation (Fig. 3). Homeowners with IGS who applied the same amount every time ranged from 56% to 59% across cities, while NIGS homeowners in this category ranged from 34% to 38%. The "set it and forget it" mentality is probably at least partially responsible for this discrepancy. If homeowners apply the same amount every time and also irrigate on a routine schedule, their lawns will usually be under- or overwatered; our data suggest IGS homeowners are more likely than NIGS

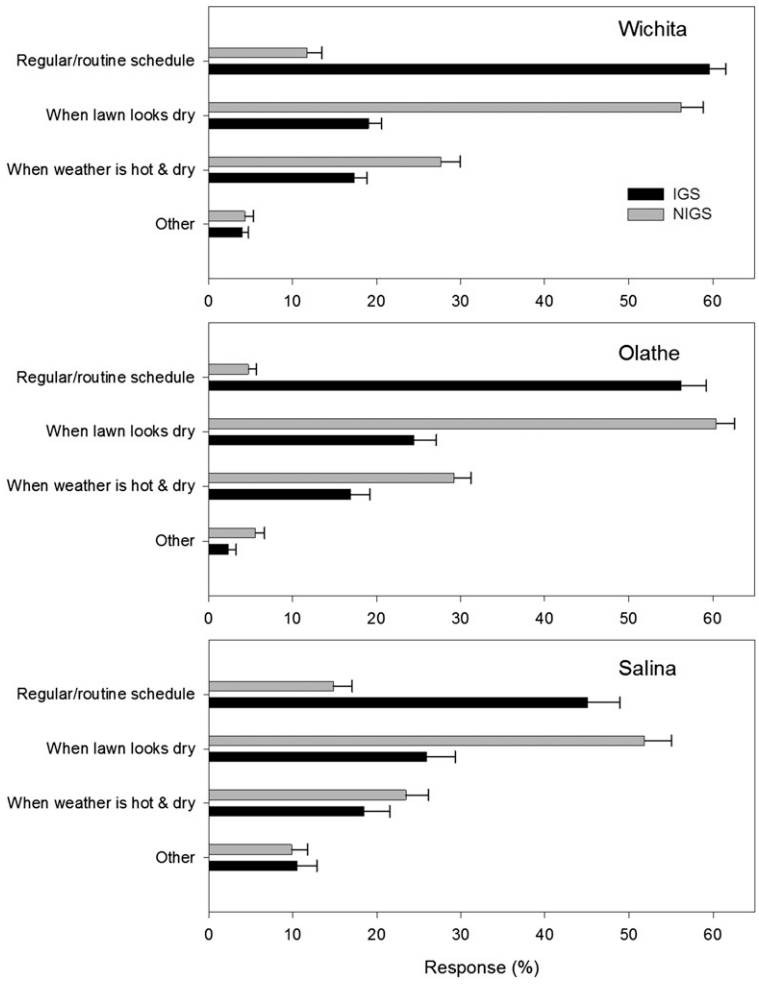

Fig. 2. Responses of residential homeowners with and without in-ground irrigation systems (IGS and NIGS, respectively) in three urban areas in Kansas to the survey question "How do you decide when it is time to water your lawn?" Error bars denote SE.

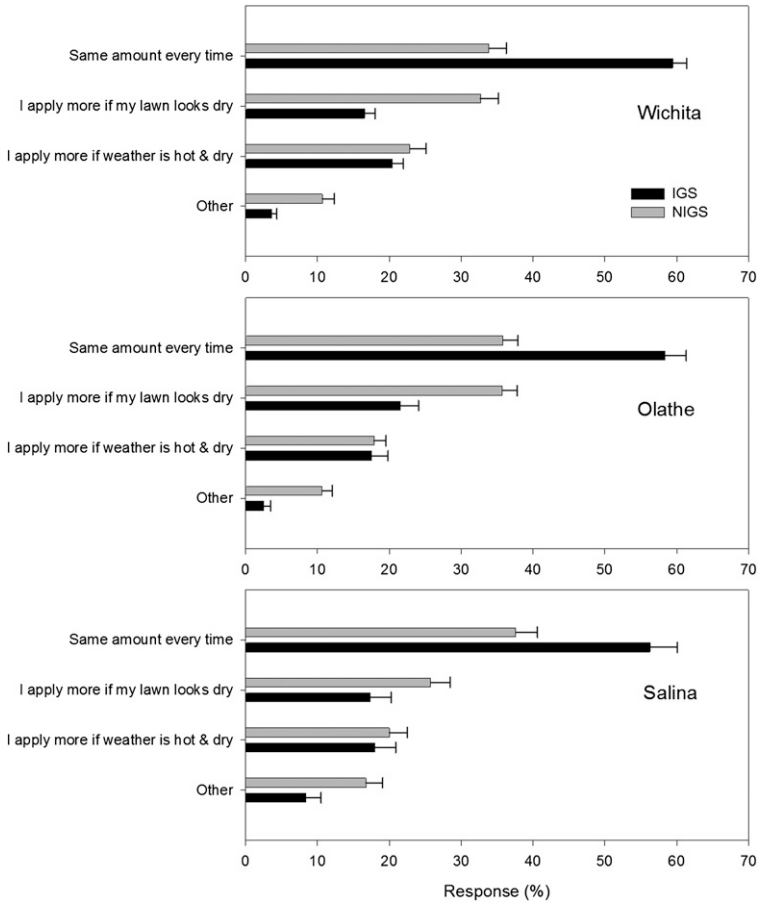

Fig. 3. Responses of residential homeowners with and without in-ground irrigation systems (IGS and NIGS, respectively) in three urban areas in Kansas to the survey question "How do you decide how much to water your lawn?" Error bars denote SE.

homeowners to fall in this category (Figs. 2 and 3).

Although fewer NIGS than IGS homeowners applied the same amount each time, in Wichita and Olathe, NIGS homeowners were still just as likely to apply the same amount every time vs. adjusting irrigation amounts based on the lawn's appearance (i.e., "I apply more if the lawn looks dry"), and in Salina, they were more likely to do so. This may be desirable if NIGS homeowners were adjusting frequency based on their lawns needs. Nevertheless, NIGS homeowners in each city were much more likely than IGS homeowners to adjust irrigation amounts based on the lawn's appearance. The percentage ratio of NIGS homeowners to IGS homeowners using this strategy was 33:16 in Wichita, 36:22 in Olathe, and 26:17 in Salina. In all three cities, a substantial number (18% to 23%) also said they applied more if weather was hot and dry, with no differences between IGS and NIGS homeowners.

Knowledge about lawns. In all three cities, 79% to 83% of NIGS homeowners indicated they did not know how much water they were applying when they watered their lawns. Similarly, 83% of IGS homeowners in Wichita and Olathe were in that category. However, the number of IGS homeowners in Salina who did not know how much water they applied to their lawns was less (65%). Encouraging IGS homeowners to conduct a home water audit on their irrigation systems could help fill this knowledge gap and perhaps conserve water (Nelson, 1992).

In all three cities, 67% to 71% of NIGS homeowners said they did not know how much their lawn required per week. That number was less for IGS homeowners among the three cities but was even less in Salina (46%) than in Wichita (59%) and Olathe (58%). It is possible that IGS homeowners in Salina were more conscious about how much water they applied and about the water requirements of their lawns, possibly because of the recent water shortage or greater water costs. It also appears that IGS homeowners in all three cities had greater awareness about how much water their lawn required, although it is less certain whether they actually knew or not. For example, when homeowners who indicated they did know were asked to specify the amount of water their lawns needed, 13% to 22% reported 2 inches/week or more, which is substantially greater than the recommended 1 inch/week (1.5 inches/week during dry summer conditions) (Fagerness, 2001). Nevertheless, in general the vast majority of NIGS and IGS homeowners did not know how much water they applied when they watered or the water requirements of their lawns. Clearly, there is much room for improvement in homeowners' general knowledge about lawn irrigation, which could translate to more efficient use of landscape irrigation water.

When asked "Do you know what type of grass you have in your lawn?" 63% to 73% indicated "Yes" among the cities. Among those who answered "Yes," 74% to 84% indicated their lawns contained tall fescue (*Festuca arundincea*). In Olathe, 56% of lawns also contained kentucky bluegrass (*Poa pratensis*), and 10% contained perennial ryegrass (*Lolium perenne*), while in Wichita and Salina, only 6% to 9% of lawns contained kentucky bluegrass and 1% to 4% contained perennial ryegrass. In Wichita and Salina, 26% to 35% of lawns also contained bermudagrass (*Cynodon dactylon*) compared with only 1% in Olathe. In Wichita, 8% of lawns also contained zoysiagrass (*Zoysia japonica*) compared with only 2% in Salina and Olathe. All other species of turfgrasses were in 3% or fewer lawns among cities.

Perceptions about lawns. Homeowners with IGS were much more likely than NIGS homeowners to consider a green lawn important or very important [i.e., rating of 4 or 5 (Fig. 4)], with percentage ratios of IGS to NIGS homeowners in this category at 78:44 in Wichita, 79:45 in Olathe, and 60:42 in Salina. By contrast, NIGS homeowners were much more likely than IGS homeowners to indicate a green lawn was of little to no importance (i.e., rating of 1 or 2) with ratios of NIGS to IGS homeowners in

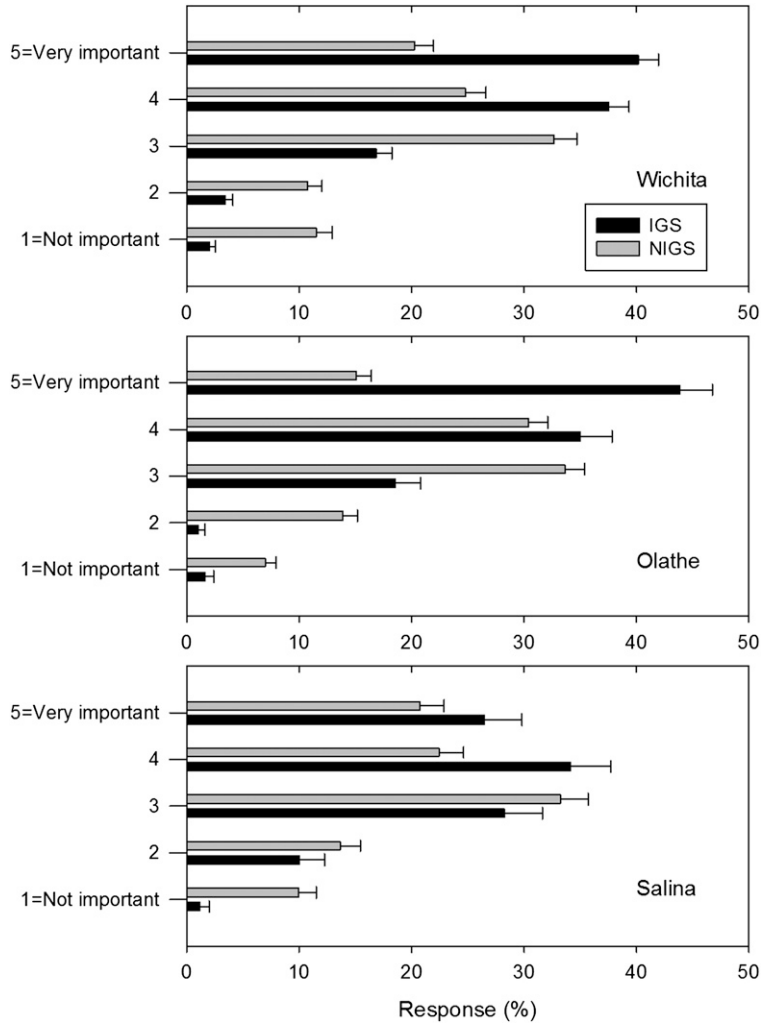

Fig. 4. Responses of residential homeowners with and without in-ground irrigation systems (IGS and NIGS, respectively) in three urban areas in Kansas to the statement "I like my lawn to look green all the time." Error bars denote SE.

this category at 23:5 in Wichita, 21:3 in Olathe, and 24:11 in Salina. This is not surprising since IGS homeowners apparently consider a green lawn important enough to make the substantial investment required to install an automatic system. Homeowners with IGS may also feel that keeping their lawn green increases their property values. For example, in a Nebraska survey, 85% of homeowners felt a well-kept lawn increased property values (Sewell et al., 2010).

Homeowners without in-ground systems were more likely than IGS homeowners to consider it very important to keep their water bill from getting too high (i.e., rating of 5), but differences between the two groups were greater in Wichita and Olathe than in Salina; percentage ratios of NIGS to IGS were 49:33 in Wichita, 47:30 in Olathe, and 59:49 in Salina. Because IGS homeowners have invested in their automatic system, they may feel that making use of their investment for aesthetic purposes and to maintain property values is more important than saving money on their monthly water bill. The higher percentage of IGS homeowners in Salina concerned about their water bill getting too high likely reflects their higher water costs compared with Wichita and Olathe.

Homeowners with IGS in all cities were also much more likely than NIGS homeowners to feel that keeping their lawn alive during hot and dry weather was very important (rating of 5), with percentage ratios of 68:38 in Wichita, 61:34 in Olathe, and 59:37 in Salina. This also may be related to IGS homeowners' interest in making use of their IGS to maintain the appearance of their lawns and their property values. Although NIGS were less likely than IGS homeowners to rank keeping their lawns alive as very important (rating of 5), the majority of NIGS homeowners (60% to 64%) nevertheless considered it more important than not (rating of 4 or 5).

Overall, 89% to 95% of IGS and NIGS homeowners in all three cities considered water conservation to be at least "somewhat important" (rating of 3 or higher). Homeowners without in-ground systems in Wichita and Olathe were only slightly more likely than IGS homeowners to say concerns about water conservation were "very important" (rating of 5), and there was no difference between the groups in Salina.

Concerns about neighborhood appearance were much more likely to be "very important" to IGS homeowners than to NIGS homeowners in Wichita (40% to 26%) and Olathe (39% to 19%), but not in Salina (25% to 23%). Nevertheless, neighborhood-appearance concerns were at least "somewhat important" (rating of 3 or higher) to 90% to 95% of IGS and 83% to 85% of NIGS homeowners in all three cities.

Homeowners with IGS in all cities were more likely than NIGS homeowners to say it was very important to follow guidelines and recommendations, with percentage ratios of 46:34 in Salina, 36:19 in Wichita, and 35:17 in Olathe (Fig. 5). Significantly, 16% to 30% of NIGS homeowners among cities indicated it was not particularly important (rating of 1 or 2) to follow lawn-care guidelines, which was greater than the 4% to 11% of IGS homeowners who felt it was not important.

QUESTIONS RELATING TO WATER QUALITY. Homeowners with IGS were much more likely than NIGS homeowners to say they swept after applying lawn-care products, with ratios of 48:28 in Wichita, 58:38 in Olathe, and 50:31 in Salina. Since IGS homeowners are more likely to follow current lawn-care guidelines and recommendations, it follows that a higher percentage of them sweep/blow after applying lawn-care products. It is desirable to sweep or blow lawn-care products back onto lawns because these products are otherwise carried by runoff from impervious surfaces (e.g.,

driveways and streets) directly into local streams or reservoirs (Petrovic and Easton, 2005). Other researchers reported that 92% of all homeowners fertilized their lawns (Dietz and Abraham, 2011), suggesting there is a large number of homeowners in all three cities who may be inadvertently applying lawn-care products to impervious surfaces and leaving them there.

Of the homeowners who sweep or blow, the vast majority (87% to 93%) in all cities did so back into the lawn (as they should), while 7% to 9% said they did so directly into the street or storm drains. While the latter numbers seem low at first glance, 9% of homeowners in Wichita, Olathe, and Salina equates to a substantial number in each city (e.g., ≈9000 residential homeowners in Wichita) sweeping directly into streets/storm drains, which would have a negative impact on water quality. Interestingly, there were no differences between IGS and NIGS homeowners with respect to whether they swept/blew back into the lawn or into the street.

Percentages of homeowners by city with in-ground sprinklers and the frequency that they adjust their watering timers. Wichita had the highest percentage of IGS homeowners, with a percentage ratio of IGS to NIGS homeowners of 46:54, while Olathe had 28:72 and Salina had 24:75. Wichita residents are probably more likely than Olathe residents to invest in an IGS because of the higher evaporative demand in Wichita, which would lead to higher irrigation requirements. Conversely, the lower percentage of IGS homeowners in Salina despite the similar evaporative demand as Wichita may be a result of Salina residents' heightened concern about potential water shortages and the higher water costs in Salina; these factors may have reduced their interest in investing in an IGS.

In all cities, most IGS homeowners adjusted their sprinkler timer seasonally (39% to 51%) (Fig. 6), while 32% to 40% adjusted more actively (i.e., when the lawn looks dry, weekly, biweekly, monthly, or daily,), and 16% to 24% said they never or rarely adjusted their timer. Clearly, the latter group is under- or over-irrigating most of the time, and undoubtedly, gains in irrigation efficiency and perhaps water conservation would be

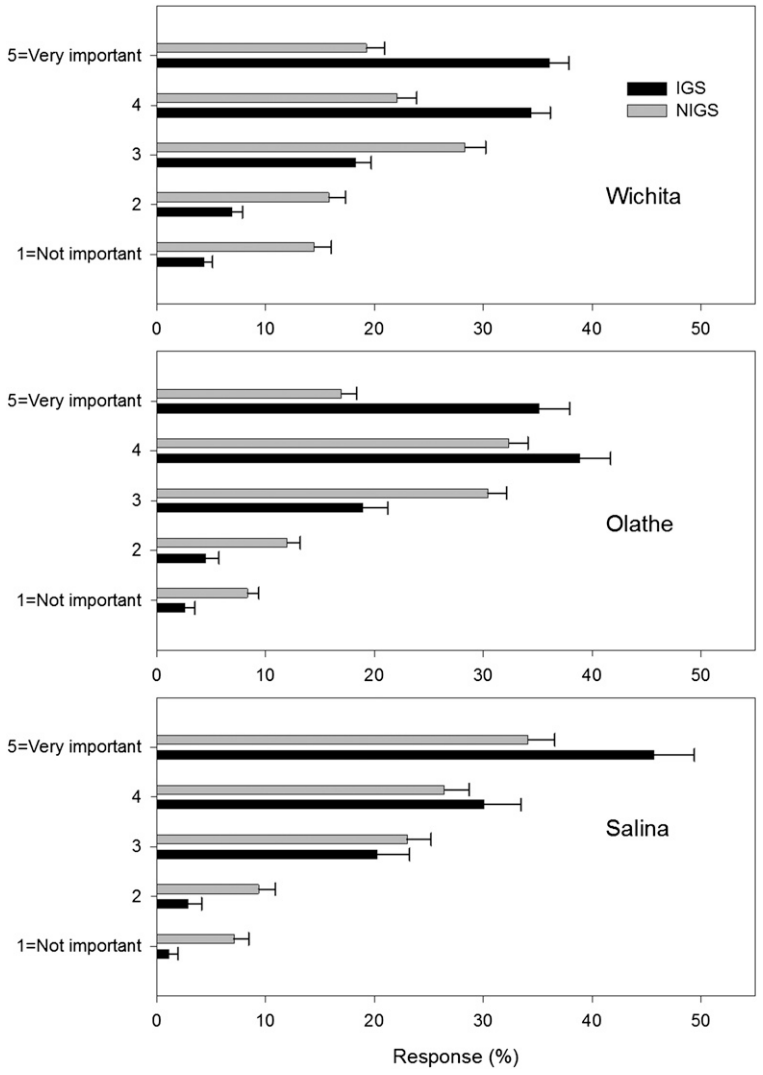

Fig. 5. Responses of residential homeowners with and without in-ground irrigation systems (IGS and NIGS, respectively) in three urban areas in Kansas to the statement "I try to follow current lawn-care guidelines and recommendations." Error bars denote SE.

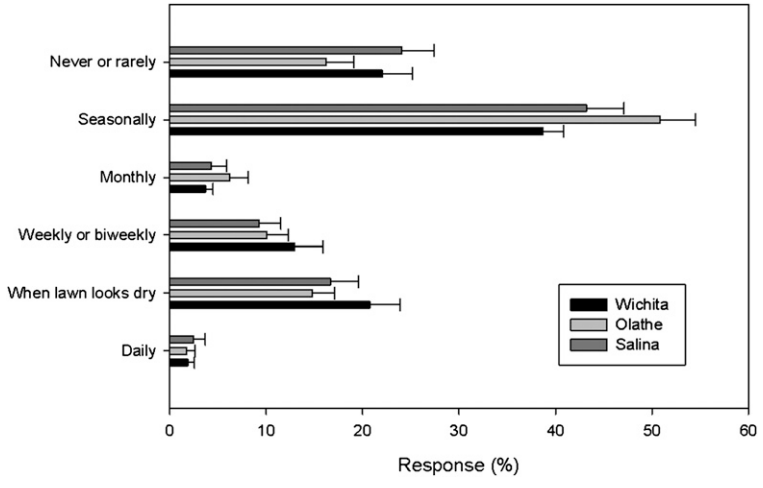

Fig. 6. Responses of residential homeowners in three cities in Kansas who had in-ground sprinklers to the question "How actively do you adjust your sprinkler timer?" Error bars denote SE.

possible if "smart controllers" were used, e.g., where irrigation scheduling is based on soil-moisture sensors or evaporative demand.

Conclusions

There appears to be a significant need to increase homeowners' knowledge about lawn irrigation. A majority of IGS and NIGS homeowners in all cities did not know how much water they were applying when they watered their lawns, nor did they know how much water their lawn required per week. Furthermore, a small but significant number of IGS and NIGS homeowners swept lawn-care products directly into streets or storm drains. Because IGS homeowners water much more frequently and are less likely to base irrigation decisions on how dry their lawn looks (i.e., lawn water requirements) than NIGS homeowners, educational efforts should be focused on IGS homeowners. Because 16% to 24% of IGS homeowners said they never adjust their sprinkler timer, it appears that gains in irrigation efficiency and perhaps water conservation would be possible if properly installed and operated "smart controllers" were used, e.g., where irrigation scheduling is based on soil-moisture sensors or evaporative demand; including a rain sensor is also a simple, inexpensive method of conserving water. Finally, there is a need to identify effective ways to fill this knowledge gap among residential homeowners. Applying lawn-irrigation amounts to match the actual needs of the turfgrass, and encouraging homeowners to follow proper lawn-care guidelines (e.g., sweeping or blowing lawn-care products back into the lawn), should help conserve water and protect water quality in urban watersheds.

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