Water conservation for Rhode Island lawns

Computer modeling helped Rhode Island water professionals choose the best way to educate consumers about lawn irrigation.

Alyson McCann, Arthur J. Gold, Kathleen Mallon, and Josef Gorres

This article presents results from a program for water conservation on home lawns in Rhode Island. The objectives of the program were twofold: (1) to adapt a computerized agricultural irrigation scheduling program for home lawns and (2) to develop an educational outreach program to promote the appropriate timing and application rates of irrigation water by homeowners.

In 1989, water professionals in Rhode Island developed a program for home lawn irrigation scheduling that adapted an agricultural soil moisture model for use on home lawns. The key to the program, which emphasized supplemental watering only, was a "water factor" that was developed from daily simulation models for lawns on two soil textures. The program was pilot-tested in 1990 and ran statewide in the 1991 growing season. The simulation model relied on a single weather station for moisture data. Analysis of rainfall amounts suggested that computerized irrigation scheduling for home lawns requires spatially explicit data. Variability in factors such as rooting depth and soil composition caused additional concern about the accuracy of the recommendations. It was concluded the computerized farm-based irrigation scheduling programs for the Northeast cannot be easily adapted to home lawn water management over a broad area. Instead, emphasis should be placed on linking sprinkler calibration rates to soil types. Low-maintenance landscaping also should be encouraged in suburban areas.
Lawn irrigation can constitute a major component of residential use, but often homeowners do not know how to water effectively and economically.

A lawn water conservation program would clearly generate great benefits to the state by optimizing existing sources of water supplies and potentially minimizing the need to develop new sources. Lawns of drought-sensitive species such as Kentucky bluegrass dominate the residential areas of southern New England. Much educational effort is now directed at promoting low-maintenance landscaping principles (i.e., landscaping with native or drought-tolerant plant species) to homeowners who are developing or renovating a landscape.

Although southern New England has a humid climate with an average annual rainfall of 40–50 in. per year, a precipitation deficit occurs during most summers. Home lawns are particularly sensitive to drought stress because their shallow root systems can use only a limited portion of the available water stored in the soil. Long-term computer simulations by Palmer and Gold et al. have shown that shallow-root crops such as lawns require an annual average of 9–11 in. of supplemental irrigation water to avoid drought stress. Over the past several years, Rhode Island communities have experienced watering restrictions or bans on outdoor water use as a result of decreased resource supplies. However, restrictions can cause an increase in outdoor water use if more water than needed is applied on the homeowners’ assigned day.

Irrigation schedule modified from agricultural approach

Agricultural irrigation schedules are increasingly being used to save both water and energy. In response to limited water supplies and increasing water costs, these types of programs have been modified for use on home lawns. Irrigation scheduling programs for home lawns have been developed to meet the water requirements of suburban and urban areas in arid climates. For example, programs in

Home lawns are particularly sensitive to drought stress because their shallow root systems can use only a limited portion of the available water stored in the soil.

Lawns are an integral part of the urban and suburban landscape. They have a positive influence on these environments because they modify heat adsorption from impervious areas, minimize overland runoff, reduce flooding, and provide recreational opportunities. However, irrigation of home lawns can constitute a major component of residential water use. Homeowners are motivated to water their lawns to prevent the lawn from turning brown, going dormant, or dying. However, people have little or no information on such factors as application rate of water, root depth, water holding capacity of soil, evaporative demand, or grass drought resistance on which to base a watering schedule. Where automated watering devices are in use, homeowners commonly apply fixed amounts of water to their lawns weekly regardless of weather conditions. As a result, most homeowners do not know if they are overwatering or under watering their lawns. What is known, however, is that during the summer, water use at least doubles in Rhode Island as well as in other areas of the United States.

Programs in other areas of the country have demonstrated the opportunities for water savings in home lawn irrigation. A water conservation program in California found that the most savings in the conservation program had to come from lawn watering and commercial irrigators. A survey of home lawn water application rates at the University of Wyoming found that more than 50 percent of the homeowners questioned overwatered their lawns. Saving even 0.25 in. of water per week on 1,000 acres of suburban development (half-acre lots with 10,000 sq ft of lawn per home) represents approximately 450,000 gal per day.

Suburban developments of quarter-acre to one-acre lots constitute about 50,000 acres in Rhode Island.
Phoenix, Ariz., and Los Angeles, Calif., involve calculating sprinkler output and applying water on a preset schedule throughout the summer season.

Using these programs as templates, a home lawn water conservation program entitled "When to Water" was developed in Rhode Island. The Rhode Island program differed from those in the arid climates in that it stressed only supplemental watering. The intent was to take advantage of precipitation and current soil moisture status, recommending watering only when there was a critical soil moisture deficit.

Everyone recognized the potential danger of a flawed program and a state full of brown lawns.

During the winter of 1989, a subcommittee of the Rhode Island Governor's Water Conservation Program laid the groundwork for a statewide homeowner irrigation and educational program that would help Rhode Islanders reduce the pressures on drinking water supplies without eliminating lawn watering. All those involved in the development of the program, including bureaucrats, educators, scientists, environmentalists, and turf industry professionals, agreed that for the program to be effective it had to reach a large audience, it had to be widely promoted and easy to understand, and it had to work. Everyone recognized the potential danger of a flawed program and a state full of brown lawns.

Soil moisture model developed

To determine how much and when to apply water to Rhode Island lawns, a computerized daily soil moisture model was adapted from the US Department of Agriculture Soil Conservation Service SCHEDULER model, which was developed to schedule irrigation for agricultural crops. The daily moisture status of the root zone was computed by a "capacity-type" hydrologic balance based on daily precipitation and irrigation as the inputs, evapotranspiration and percolation from the root zone as the outputs, and selected soil water characteristics of the root zone. Specifically, the daily soil moisture was computed as:

\[ SM(i) = SM(i-1) + PPT(i) + IRR(i) - ET(i) - PERC(i) \]

in which \( SM(i) = \) soil moisture within the root zone in inches on day \( i \), \( SM(i-1) = \) soil moisture within the root zone on day \( i-1 \), \( PPT(i) = \) precipitation in inches on day \( i \), \( IRR(i) = \) irrigation in inches on day \( i \), \( ET(i) = \) actual evapotranspiration in inches on day \( i \), and \( PERC(i) = \) percolation from the root zone in inches on day \( i \).

Based on observations by turfgrass scientists at the University of Rhode Island (URI), the root zone was set at a depth of 6 in. in the home lawn watering model. The model required that four soil water "constants" be input for a given soil type to control water storage within the root zone. The soil water constants (expressed in inches of water) were (1) saturation level, (2) field capacity level, (3) threshold water stress level, and (4) a postirrigation level. The field capacity level (FC) describes the moisture status of a soil two or three days after it has been saturated and free drainage has ceased. When the soil water content exceeds FC, the model assumes the excess will leach from the root zone and be unavailable for evapotranspiration. As described by Gold et al., the threshold water stress level was set midway between FC and the permanent wilting point of a given soil type. When the soil moisture status falls below the threshold water stress level, turfgrass quality is expected to decline.

It was assumed that no overland runoff occurred from the lawns, so all daily precipitation was added to the soil. Once the saturation moisture level was reached, excess precipitation was modeled as percolation from the root zone on the date of precipitation. If the soil moisture of the root zone was greater than FC, it was assumed to remain in the root zone for one day before percolating to the groundwater. When the soil moisture status was at or below FC, evapotranspiration (ET) was the only source of water loss from the root zone. Actual ET was set equal to the potential ET calculated by the modified Penman method. The modified Penman method has been found to closely estimate actual ET from well-watered
turfgrass in southern New England.\textsuperscript{12} Inputs for the calculation of ET included mean daily temperature (degrees Centigrade), mean relative humidity (calculated from the dewpoint temperature, degrees Centigrade), wind speed (kilometres/day), and percentage of available sunshine.

To maximize the usefulness of the random precipitation that occurred, the model only recognized a soil moisture deficit and recommended irrigation when the soil moisture was below the threshold water stress level. Irrigation depths were then calculated to bring the soil moisture level up to a postirrigation level of 80 percent of the difference between FC and the permanent wilting point. By not filling the soil profile to field capacity, the soil profile was maintained with enough available water to store precipitation and minimize percolation from the root zone.

Irrigation depths were rounded upward to the nearest 0.125 in. The computer-generated soil moisture deficit was converted from a fraction of an inch to a whole number from 0 to 10, making it easier to communicate the soil moisture deficit to the public (one unit equaled 0.125 in. of deficit). These whole numbers were labeled the weekly water factor. The basic hydrologic balance and ET computations were taken directly from the SCHEDULER model. The creation of a water factor and the decision to apply water to maintain a storage reservoir were unique to this program.

Two types of soil were modeled: a silt loam and a loamy sand. These are the most common soil textures found in suburban areas of Rhode Island and have markedly different characteristics.\textsuperscript{13} For the same soil depth, silt loam soils can hold two to three times as much plant-available water as sandy loam soils, which increases the capability of plants in silt loam soils to avoid water stress. Meteorological information was obtained from a single location, the National Weather Service at Green Airport in Warwick, R.I. This weather station was within 15 mi of most of the suburban area targeted by the program. All meteorological information was obtained by telephone and entered manually into the computer program.

**Brochure, TV weather show supplement program**

Because irrigation schedules can be difficult for homeowners to understand, a brochure was developed to help people use the program effectively. The brochure contained information on how to calculate sprinkler output, determine soil type, and water lawns properly using the irrigation schedule. The brochure also listed water-conserving lawn maintenance tips, such as optimal watering times, mowing height, and sprinkler positioning. Additionally, the brochure recommended planting grass varieties that are locally adapted and drought-tolerant.

Tests were conducted on a variety of sprinklers to develop an easy and accurate way to measure output and determine a realistic range of sprinkler appli-
The weekly water factor was announced as a regular feature on channel 10’s weather forecasts. Channel 10 (WJAR-TV) in Providence, R.I., reaches a 500-sq-mi area that includes most of the suburban areas in Rhode Island. In addition, the television station produced and aired public service announcements promoting the program and the URI’s Cooperative Extension toll-free consumer hotline as a source of information on how to use the weekly water factor and as the place to obtain a free program brochure.

**1990 Pilot program precedes full-scale trial**

A pilot program was conducted in August and September 1990. It was jointly sponsored by URI, Save The Bay, (a non-profit environmental organization), the Governor’s Water Conservation Program, and WJAR-TV, channel 10. During the pilot year, the weekly water factor was announced as a regular feature of WJAR’s Wednesday and Friday weather forecasts. At the end of the season, 168 people who sent a self-addressed stamped envelope and requested a brochure received an evaluation survey. Seventy-three respondents (44 percent) returned the evaluations and provided input as to the program’s ease of use and effectiveness. The questions asked and the results are listed in Table 2. Roughly two thirds of the respondents used the program. More respondents calibrated their sprinkler and determined their soil type than fully participated in the complete program (which included obtaining the water factor from television broadcasts). Based on Student’s t-test, these differences were significant at a confidence level of <0.05.

Each day, two weekly water factors had to be calculated—one for the loamy sands and another for the silt loams.

All four sponsors remained with the program for the 1991 outdoor watering season, which ran from May through September. Each organization’s role was clearly defined at a meeting before the start of the lawn-watering season. The URI would generate a watering factor four days a week and communicate it by phone to channel 10. The television station would air the weekly water factor as part of its weather broadcasts Tuesday through Friday. The typical weekly media campaign consisted of the announcement of the weekly water factor on the Tuesday and Thursday noon weather broadcasts, each

**TABLE 3** Weekly precipitation data—June 1–Aug. 16, 1993

<table>
<thead>
<tr>
<th>Week Ending</th>
<th>Kingston</th>
<th>Newport</th>
<th>North Foster</th>
<th>Woonsocket</th>
<th>Warwick†</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 7</td>
<td>0.50</td>
<td>0.38</td>
<td>0.23</td>
<td>0.98</td>
<td>0.28</td>
</tr>
<tr>
<td>June 14</td>
<td>0.22</td>
<td>0.10</td>
<td>0.29</td>
<td>0.40</td>
<td>0.11</td>
</tr>
<tr>
<td>June 21</td>
<td>0.10</td>
<td>0.03</td>
<td>0.00</td>
<td>0.18</td>
<td>0.50</td>
</tr>
<tr>
<td>June 28</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.11</td>
<td>0.02</td>
</tr>
<tr>
<td>July 5</td>
<td>0.03</td>
<td>0.14</td>
<td>0.19</td>
<td>0.46</td>
<td>0.25</td>
</tr>
<tr>
<td>July 12</td>
<td>0.08</td>
<td>0.08</td>
<td>0.30</td>
<td>0.60</td>
<td>0.18</td>
</tr>
<tr>
<td>July 19</td>
<td>0.20</td>
<td>0.27</td>
<td>0.32</td>
<td>0.38</td>
<td>0.39</td>
</tr>
<tr>
<td>July 26</td>
<td>0.74</td>
<td>0.25</td>
<td>3.38</td>
<td>0.51</td>
<td>1.91</td>
</tr>
<tr>
<td>August 2</td>
<td>0.61</td>
<td>0.26</td>
<td>0.18</td>
<td>3.01</td>
<td>0.05</td>
</tr>
<tr>
<td>August 9</td>
<td>2.01</td>
<td>1.54</td>
<td>1.70</td>
<td>0.39</td>
<td>1.19</td>
</tr>
<tr>
<td>August 16</td>
<td>3.16</td>
<td>2.09</td>
<td>1.58</td>
<td>1.33</td>
<td>1.69</td>
</tr>
</tbody>
</table>

*Data from five National Weather Service stations in Rhode Island within area targeted by the When to Water program.†Warwick was used as the input station for When to Water program.
of which had a viewing audience of about 35,000 households. Wednesday and Friday the weekly water factor was announced on the evening weather forecast, which reached 75,000 households nightly.

Specific promotional efforts during the 1991 season were increased. They included the production of a 90-second news feature on WJAR-TV, the coordination of two public service announcements that were produced and aired throughout the day and evening program hours, preparation of a news release to media throughout the state announcing the start of the program, and promotion and distribution of brochures at local events and to a variety of civic organizations. All of the originally printed 10,000 brochures were distributed.

Whenever there were known differences in the rainfall in certain localities or when watering bans went into effect, the station’s meteorologist and URI personnel collaborated on the information given out in support of the weekly water factor. For example, broadcast of the weekly water factor—with special cautions to those affected—was continued even when watering bans were in effect in some communities.

The program ran for 18 weeks during 1991. For the 1991 growing season, When to Water recommended that lawns on loamy sand soils be watered 14 of the 18 weeks and lawns on silt loam soils be watered 11 of the 18 weeks. The total amount of irrigation suggested for the 1991 season on loamy sands was 14.5 in.; for silt loams the total suggested was 13.5 in. The relatively small difference between total irrigation for the two soil types is attributed to drought conditions, which lasted for about eight weeks.

**Rainfall varies widely over area**

The irrigation program from which this program was adapted had found that the accuracy of the model was dependent on differences in rainfall between the site selected for input data and the site where scheduling occurs. To minimize this source of error, the program recommends that rainfall inputs to the model originate from the exact location where scheduling is to occur. Dunne and Leopold suggest that the rainfall depth observed at a single location is not representative of areas greater than several square miles. Brief, high-intensity precipitation, such as summer convective storms, often yields highly variable rainfall depth over an area. To gain insight into the adequacy of characterizing rainfall and soil moisture for the target area of 500 sq mi from a single rainfall collection station at Warwick, R.I., the weekly rainfall depth at Warwick was compared with the weekly rainfall at four neighboring weather stations that are also part of the National Weather Service system. These stations are all within 15 mi of the Warwick station and surround the target area of the program. Assuming that mean weekly

summer ET is equal to 1.10 in. per week, if rainfall for a particular week was greater than or equal to 1.10 in. at all sites, then discrepancies among the sites were not a problem. The primary interest was in deficit differences among stations when rainfall was less than 1.10 in.

Rainfall patterns varied widely within the target area (Table 3), and the use of a single weather station was totally inadequate for irrigation scheduling over a broad area. In some cases, on the basis of precipi-

**The authors believe that the best approach to irrigation water management is to educate homeowners on lawn-watering requirements.**
understand drought stress and lawn dormancy. Selecting grass species and cultivars that have a higher drought tolerance and properly fertilizing home lawns will become part of the program, because fertilizer use and application rates can affect plant growth and water requirements. The program will also move toward educating homeowners on

**Alternatives such as low-maintenance landscaping will be promoted.**

the principles of lawn watering based on determining sprinkler output and soil type and keeping track of rainfall.

Alternatives such as low-maintenance landscaping, which have the potential to reduce outdoor water use in the Northeast, will be promoted, particularly because these landscapes also utilize plant species that require minimal amounts of fertilizers and pesticides.17

**Acknowledgment**

The authors thank Tony Mallilo for assistance with statistics work, members of the Rhode Island Governor's Water Conservation Program, WJAR-TV Channel 10, and Save The Bay for their work on this program. This article, supported in part by the Rhode Island Cooperative Extension Water Quality Program, is contribution 2937 of the College of Resource Development, University of Rhode Island, with support from the Rhode Island Agricultural Experiment Station.

**References**


---

**About the authors:** Alyson McCann is a water resources specialist in the Department of Natural Resources Science, University of Rhode Island (URI), Room 210-B Woodward Hall, Kingston, RI 02881. She has worked for Cooperative Extension as a water resources specialist since 1989 in Rhode Island and Hawaii. In 1989 McCann was among recipients of the President's Environmental Youth Award, USEPA, for the “You and Your Environment Island Fresh Waters Program.” In 1991 she was named Cooperative Extension Educator of the Year in the College of Resource Development. McCann has a BA from the University of Vermont in Burlington and an MS from the University of Rhode Island in Kingston. She is a member of the Soil and Water Conservation Society. Arthur J. Gold* is professor and Josef Gorres is lecturer in the Department of Natural Resources Science, URI. Kathleen Malloy is director of URI's Cooperative Extension Education Center.

*To whom correspondence should be addressed*