TURFGRASS TRENDS

AQUATIC ECOSYSTEMS

Researchers Study Impact of Golf Courses on Stream-Water Temperature

By Kevin Ashman and Weston Dripps

Golf courses have become a prominent feature within urban and rural landscapes. The environmental impacts that golf courses have on the surrounding aquatic ecosystem have been heavily debated and discussed. Some studies (Moss et al., 2006; King et al., 2007) have found that golf courses negatively affect the aquatic environment, primarily through excess nutrient loading, while others (Kenn and Snow, 1992; Beard, 2000) found that golf courses actually serve as a green space in an otherwise urban environment. The bulk of the previous work has focused on course runoff and potential non-point source pollution; significantly less research has been done on the impacts to physical parameters like stream temperature.

In this study, a comparative analysis of stream-water temperature was conducted at five different golf courses in Greenville, S.C. Courses were selected that had continuous, tributary-free, lake-free reaches that passed through the golf course grounds. (See chart on page 49.)

At each course, stream water temperature was measured at five-minute intervals from June 2008 through November 2008 at sites upstream and downstream of the course. An Onset Water Temp Pro V2 temperature logger secured to the stream bottom was used to measure water temperature. In addition to stream temperature, a number of other parameters were assessed along the golf course stream reach, including stream discharge measurements under base-flow conditions, stream length between sampling sites and the extent of riparian cover along the stream banks. Any human alterations to the stream's channel morphology were observed and noted in the field.

Stream-water temperatures exhibit a distinct daily cycle, which mimics and is a subdued replica of air temperature. Stream-water temperatures peak in the late-afternoon and early-evening hours (5 to 6 p.m.) and trough in the early morning hours (7 to 9 a.m.). At all five courses, the average daily stream-water temperatures downstream of the course were higher than those upstream of the course. Temperature differences between the upstream and downstream sites were consistently variable, exhibiting a distinct daily cycle with the biggest differences routinely occurring during the mid-late afternoon hours (3 to 6 p.m.) and the smallest differences during the early morning hours (6 to 8 a.m.). In many instances,

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Stream-water temperatures peak in the late-afternoon and early-evening hours and trough in the early-morning hours.

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the downstream temperatures were actually lower than the upstream sites during early morning hours.

Although golf courses can often serve as green space in an otherwise urban or residential environment, they can still negatively impact local streams that pass through their grounds. This study found that stream-water temperatures downstream of golf courses can often be elevated as much as 6 degrees Fahrenheit to 8 degrees F higher during the day than those temperatures just upstream of the course.

Observed upstream versus downstream temperature differences among the five courses are attributed to differences in:

(a) actual stream length within each course;
(b) discharge of the streams; and
(c) extent of riparian cover along each course reach.

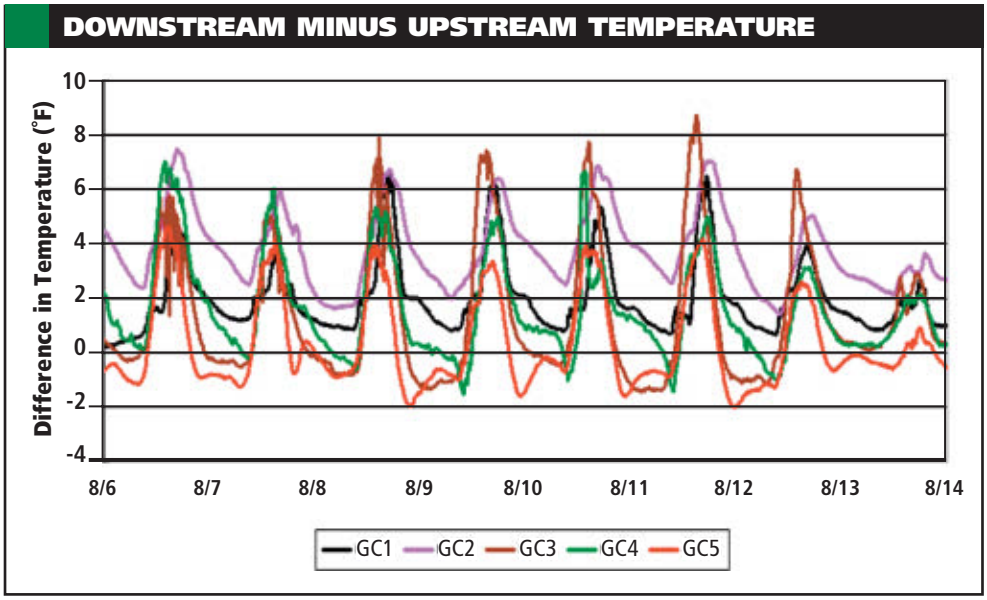
The lack of riparian cover along golf course stream reaches allows the sun to actively beat down on the stream water during the daylight hours. The increased sun exposure during the day causes the water in the streams to warm up as the water slowly makes its away across the course, leading to warmer stream temperatures and greater diurnal variability. The impacts are most pronounced during the peak solar hours. All stream reaches just upstream of the courses exhibited extensive riparian cover. This cover acts to insulate the stream, providing shade during the heat of the day and trapping heat during the evening. The reaches within each course were fully exposed.

Golf courses have a measurable impact on the stream-water temperature, primarily due to the removal of riparian cover.

The magnitude of the warming varied among the golf course sites, even after the data were normalized based on stream length. The remaining differences appear to be influenced by stream discharge, the extent of the riparian cover and the stream's geomorphology. Golf course streams with smaller discharge are more greatly impacted by the lack of riparian cover and the associated increase in sun exposure.

Water has the ability to absorb solar radiation. The larger the volume of water in the stream and the faster the flow, the longer it takes to heat the stream water and the less time it spends in the course fully exposed to the sun's rays. Those streams with larger discharge were less impacted with respect to changes in temperature than those with less flow.

At all five golf course sites, the streams exhibited a lack of riparian cover along the



stream reach, although the extent of riparian removal did slightly vary among the sites. These small differences in the degree of riparian removal, although certainly noticeable, didn't seem to account for observed differences in the temperature response. Furthermore, many of the courses intentionally altered the stream morphology in an effort to stabilize the stream's banks and/or fit within the course design. It was difficult to quantify the degree of alteration, but changes in the stream's cross-sectional area will impact flow rates and the addition of riprap in some cases may impact the local thermal properties, both of which could influence the stream temperature. More study is needed to quantify these impacts.

Golf courses have a measurable impact on the stream-water temperature, primarily due to removal of riparian cover.

A comparative analysis of stream-water temperature at the five courses showed that under base-flow conditions sites downstream of the courses exhibited consistently higher stream-water temperatures (on the order of 4 degrees to 10 degrees F during the afternoon hours), and significantly larger diurnal temperature ranges (typically two to three times larger) compared to their upstream counterparts.

Golf courses have a measurable impact on the stream-water temperature, primarily due to the removal of riparian cover along the stream banks. The impact that these temperature changes have on a stream's aquatic ecosystem are not fully known but should be considered in future course design. Providing good riparian cover and ensuring sustained flow within the stream reaches should help minimize impacts to stream temperature.

Kevin C. Ashman is a recent graduate from Georgia Southern University in Statesboro, Ga., with a major in geology. Weston Dripps is associate professor in the department of earth and environmental sciences at Furman University in Greenville, S.C.

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