

BY JAMES WALWORTH

Soil sampling and analysis

Analytical methods provide quantitative estimates of plant-available nutrients

Soil sampling and analysis are vital for golf course superintendents to help determine effective and efficient turfgrass management programs. Soils are sampled to determine physical conditions, fertility (nutrient) status and chemical properties that affect their suitability as plant growing media.

Through a combination of field and laboratory research, analytical methods have been developed that provide quantitative estimates of plant-available nutrients. Field research determines the optimum soil test levels for various nutrients for specific soil and crop combinations. Optimum fertilizer practices can be determined by knowing the optimum test level of each nutrient for a specific crop and soil, and by knowing how much fertilizer is required to change soil-test values.

Soil testing is comprised of four steps:

- Collection of a representative soil sample;
- Laboratory analyses of the soil sample;
- Interpretation of analytical results; and
- Management recommendations based on interpreted analytical results.

Focusing on the first two steps, one should gain an understanding of the proper methods for collecting soil samples and of the potentials and limitations of soil testing.

SOIL SAMPLING

Soil testing begins with soil sampling. A soil analysis can be only as good as the sample sent to the laboratory. It's important to realize only a tiny portion of a field is analyzed in the laboratory. For example, a one-pound soil sample collected from a five-acre field

represents just 1/10,000,000 of the field. Therefore, it's critical a soil sample be representative of the entire field.

The most common and economical method for sampling an area is composite sampling, where subsamples are collected from randomly selected locations in the field, and the subsamples are composited for analysis. The analytical results from composite sampling provide average values for the sampled area. The number of subsamples depends on field size and uniformity. Generally, a larger field or a less uniform field should be sampled more intensively than one that's small and uniform. No less than five subsamples should be taken – 15 to 25 are preferred.

Alternatively, areas can be grid-sampled in a regular pattern. Each sample is analyzed separately so variability of soil properties can be determined. With data provided by grid sampling, maps of soil test values can be constructed from the results. This information can be entered into a geographical information system and combined with additional geospatial data, such as soil texture, crop yields and leaf analyses, and used in precision agriculture systems for variable application of fertilizers and other crop inputs. This is a much more expensive method of soil analysis because of the number of analyses required, although it provides valuable information about geospatial uniformity that can be used in precision agriculture.

Ideally, samples should be collected with a soil probe or auger, to the depth of tillage (usually 6 to 8 inches) or to the effective rooting depth of plants. Deeper samples might be collected for evaluation of subsoil properties,



A soil analysis can be only as good as the sample sent to the laboratory. Photo: David Wolff

such as salt or nitrate accumulation. It's helpful to sample to the same depth each time a soil is sampled so that year-to-year samples can be compared directly to monitor changes throughout time. A small shovel or trowel can be used if a probe isn't available. Each subsample should be equal in size. The subsamples should be placed in a clean, plastic bucket and mixed thoroughly. Then the desired sample amount is removed from the bucket, and the remainder is discarded. Check with your testing laboratory to find out how large a sample it requires.

The area or size of the field sampled depends on management practices. Sample the smallest unit that will be managed separately. For example, if a field has two distinctly different halves, perhaps one half level and the other sloped, then sample the two areas separately, and fertilize each half separately to obtain optimum results. However, if each half of the area won't be fertilized or managed individually, there's no need for separate sampling. A single, representative sample will be less expensive and just as useful. Sample the smallest management unit.

Soil samples should be air-dried or taken to a test laboratory as soon as possible. To dry a soil sample, spread the soil out in a clean, warm, dry area, and let it dry for two to three days. It's best not to heat or dry soil samples in an oven because soil chemical properties might be altered. Bag the sample and send it to a laboratory for analysis. Soil samples can be refrigerated for several days if they can't be dried immediately.

Soil test values change slightly during the year, but the primary consideration for timing of soil sample collection is convenience. Collect samples early enough in the cropping cycle to allow results to be used to adjust management practices.

Soil-sample frequency depends on the specific soil test, environmental conditions and value of the crop. Status of some soil nutrients can change quickly, whereas others don't. For

example, phosphorus levels in soil are unlikely to change rapidly and annual testing might be unnecessary. Nitrogen levels, on the other hand, change quickly, and frequent tests are required to obtain accurate determinations of plant-available levels. A new soil analysis might be necessary after heavy rains or after a prolonged period of water-logging if one needs an accurate soil nitrogen level estimate.

When making substantial changes to soil fertility levels, it's a good idea to make the change during a period of two to three years, retesting the soil annually. If a crop doesn't have a high economic value, then occasional soil testing (once every three to four years) might be considered adequate in the absence of any noticeable nutritional problems. In contrast, commercial production of high-value crops might warrant annual testing to ensure maximum yields.

SOIL ANALYSES

After soil samples are received at a laboratory, a number of tests can be performed. A general understanding of soil testing will help you know how the results can be interpreted and appreciate the accuracy of the analytical results.

Soil supplies most of the mineral nutrition for higher plants through the plant's root system. The root system extracts nutrients from the soil throughout a long period of time – two to three months for most annual crops, years for perennial crops. In contrast, a soil test determines the soil's nutrient supplying capacity by mixing soil for only a few minutes with a strong extracting solution (often an acid or a combination of acids). The soil reacts with the extracting solution, releasing some of the nutrients. The solution is filtered and assayed for the concentration of each nutrient. The nutrient concentration then is related to field calibration research that indicates the yield level reached with varying soil nutrient concentrations. This method works well for some nutrients, but is less accurate for others, like those nutrients supplied largely from



Soil-sample frequency depends on the specific soil test, environmental conditions and value of the crop.
Photo: David Wolff

organic matter decomposition such as nitrogen and sulfur. This is primarily because of the difficulty of estimating or predicting the rate at which organic matter will decompose and release nutrients into plant-available forms.

Standard or routine soil tests vary from laboratory to laboratory, but generally include soil pH and available phosphorus (P) and potassium (K). They sometimes also include available calcium (Ca) and magnesium (Mg), salinity, and often include an analysis of organic matter content and soil texture. Most laboratories offer nitrogen (N), sulfur (S), and micronutrient analyses for additional cost.

The methods used to test soils vary depending on chemical properties of the soil. For example, tests used for measuring soil P are quite different in the acidic soils common in the southeastern U.S. than those used in the alkaline soils of the southwest. Analysis of southwestern soils with methods tailored for acidic soils will provide erroneous results. Therefore, it's important to be aware of the methods used by test labs, and to select

methods that are regionally appropriate. Local laboratories generally will use methods appropriate for your soils. A listing of local soil test laboratories might be found in the University of Arizona publication, "Laboratories Conducting Soil, Plant, Feed or Water Testing," <http://cals.arizona.edu/pubs/garden/az1111.pdf>.

SOIL ACIDITY

Soil pH is a measure of the acidity or alkalinity of a soil. The term pH technically only applies to solutions so the analysis must be conducted on a solution. Usually a soil sample is mixed with water, allowed to equilibrate for at least an hour, and the pH measured. Several factors affect pH measurement. Primary among these is the salt concentration of a soil (a salt is any molecule that, when placed in water, separates into positively and negatively charged components or ions). The salt concentration of a soil might vary with the season or with fertilizer application. The salt concentration of a soil generally is greater immediately following fertilizer application than before. The result might be an apparent pH decline as much as one-half a pH unit.

When samples are collected frequently or at various times of the year, it might be noted pH values tend to increase and decrease, seemingly at random. This leads to questions regarding the reliability of soil pH measurements, but the fluctuations might be because of changes in soil salt levels. It doesn't usually present a serious problem in the use of the analysis. Some laboratories measure pH in a dilute salt solution to mask salt-induced variations. This method gives lower pH values and the laboratory should provide interpretation guidelines.

Arizona soils generally are alkaline (high

pH), and pH adjustment isn't a common practice. In many other parts of the country, ground limestone is added routinely to soil to raise soil pH. In those parts of the country, lime requirement (amount of lime required to adjust the soil pH to a desired level) is determined. This test isn't needed for alkaline Arizona soils.

ELECTRICAL CONDUCTIVITY

Electrical conductivity of a soil extract is used to estimate the level of soluble salts. The standard method is to saturate the soil sample with water, vacuum filter to separate water from soil and then measure electrical conductivity of the saturated paste extract. The result is referred to as ECe and is expressed in units of deciSiemens per meter (dS/m). Test laboratories might use differing soil-to-water ratios and use a multiplication factor to convert results to an ECe equivalent.

Electrical conductivity is a reliable test for soil salinity, and this is a routine test in the arid southwest. However, in wetter climates, electrical conductivity isn't a standard test so, if soil samples are sent to a laboratory in another part of the country, electrical conductivity might have to be specifically requested.

NITROGEN

Nitrogen analyses aren't difficult to conduct, but interpreting results can be problematic. This is because a considerable portion of soil nitrogen might be contained in the soil organic matter. Plant availability of organic nitrogen is dependent on organic matter breakdown, which is difficult to estimate. Therefore analyses of "total N", a sum of all forms of soil nitrogen or organic nitrogen, aren't routinely conducted. Instead, nitrogen in the nitrate form (NO₃-N) is assayed. Nitrate is directly

available to plants, so this test provides an indication of short term nitrogen availability. However, NO₃-N can be lost quickly from soil, either leached past the rooting zone or lost to the atmosphere in gaseous forms.

The extractant used to remove NO₃-N from the soil isn't particularly important. Some laboratories extract NO₃-N from soil with a salt solution, such as potassium chloride (KCl). However, other laboratories in the southwestern U.S. measure NO₃-N in the same extract used to measure soil P (see below) to reduce analysis costs. Results from these two kinds of extractants are directly comparable.

Nitrate analyses can provide an accurate determination of the nitrogen available to plants at the time of soil sampling, although this might not provide reliable information concerning nitrogen availability later in the growing season. If soil nitrogen analysis is to be used for making fertilizer recommendations, it's important the sampling be done shortly before planting time or during the growing season.

PHOSPHORUS

Most soil phosphorus is tightly bound to soil particles or contained in relatively insoluble complexes. The phosphorus-containing complexes in alkaline soils are different than those in neutral or acidic soils. The amount of phosphorus removed during soil extraction is dependent on the nature of phosphorus complexes and on the specific extractant used, so it's critical phosphorus extractants be matched to soil properties.

The Olsen or bicarbonate extractant, a dilute sodium bicarbonate solution, is used to extract phosphorus from calcareous, alkaline and neutral soils and is appropriate for Arizona



Soil test values change slightly during the year. Photos: David Wolff

Research

soils. In contrast, most other phosphorus extractants, such as the Mehlich extractants, are suited for acidic soils and aren't acceptable for arid-region soils. If an appropriate extractant is selected, phosphorus analysis is a reliable and useful soil test. On a soil test report, the analysis might be reported as PO₄-P.

MAJOR EXCHANGEABLE CATIONS

The four major exchangeable cations in arid-region soils are potassium, calcium, magnesium, and sodium. All except sodium are essential plant nutrients; however, sodium is included because it plays an important role in soil physical properties. Soil sodium level also is needed for calculations of cation exchange capacity and exchangeable sodium percentage.

An ammonium acetate extractant is used to extract only exchangeable potassium, calcium, magnesium, and sodium from arid-region soils but not less plant-available forms. Some difficulty might be encountered in soils containing calcium or magnesium carbonates

(calcareous soils) because the ammonium acetate extraction might remove some calcium or magnesium from these minerals along with the exchangeable forms. In these situations, the analytical results might indicate slightly elevated levels of these nutrients. This isn't usually a large problem and potassium, calcium and magnesium tests generally provide excellent estimates of plant available levels of these nutrients.

CATION EXCHANGE CAPACITY

Cation exchange capacity might be estimated as the sum of the major exchangeable cations (potassium, calcium, magnesium, and sodium). Most laboratories don't routinely conduct a separate analysis for cation exchange capacity but use the ammonium acetate extractable levels of these elements (discussed above) for this calculation.

ESP AND SAR

Exchangeable sodium percentage and

sodium adsorption ratio are measures of soil sodium content relative to other soil cations. Exchangeable sodium percentage is the concentration of sodium divided by the cation exchange capacity. As described above, the cation exchange capacity often is estimated as the sum of the major exchangeable cations, so exchangeable sodium percentage equals $\text{Na}/(\text{K}+\text{Ca}+\text{Mg}+\text{Na})$. Sodium adsorption ratio is roughly comparable to exchangeable sodium percentage but is a ratio of sodium to calcium plus magnesium. For this calculation, concentrations of sodium, calcium and magnesium are measured in a saturated paste extract (see discussion of electrical conductivity above). The equation used for calculation of sodium adsorption ratio is: Na^+ divided by the square root of Ca^{2+} plus Mg^{2+} where concentrations are in units of mmol/L. Sodium adsorption ratio and exchangeable sodium percentage are useful measures of the influence of sodium on soil properties. The choice between the two is based largely on the type

Sorting through soil testing

BY PAT JONES

The phrase comes out of the mouth of turf consultants, extension personnel, researchers and colleagues all the time: "The first thing to do is get a soil test."

Easy to say ... not so easy to define.

For the past few decades, golf course superintendents increasingly have understood that what's underneath the playing surface dictates the health of the turf perhaps more than other factors. Soil tests, done properly, allow superintendents to balance nutrients, manage inputs and withstand stress better.

The problem is that soil testing comes in many shapes and sizes and, more importantly, usually doesn't provide a roadmap for fixing the problems they uncover. A soil test is like a medical diagnosis; it outlines the

problem but doesn't necessarily tell you what treatment is needed. That's where superintendents' knowledge or the use of soil consultants and other experts comes in to play.

The cost of soil testing for golf courses can range from "free" (basic tests provided by chemical manufacturers or other vendors) to several thousand dollars a year for an ongoing program with an independent lab.

Owners and clubs need to view soil testing as a necessary investment, not a luxury. To go back to the medical analogy, you can spend a lot of money treating the symptoms of the disease, or you can figure out the real problem and treat it. Soil testing sets a baseline for the entire agronomic program.

Virtually every golf course superintendent has a file or a

binder titled "soil tests" on his shelf. It's no different than a corporation that spends a lot of time and money to create a strategic plan. Once all that effort is put into the process, the plan can sit on the shelf and gather dust or be a guide to implementing a program to succeed.

Soils might be too acidic, too alkaline, nutrient-poor or nutrient rich. Or, there might be issues with the quality of the irrigation water on the site. The test is merely a first step in determining what fixes should be attempted to create a medium that supports turf grown at extremely low cutting heights.

It could be necessary to add tons of solid minerals through topdressing or simply employ a different foliar nutrition program. It also might show that

the program needs to incorporate more calcium, silica or magnesium in the mix. Every soil is different and every solution for the individual soil problem will be different. That's the value of an ongoing testing program.

Chances are good that two of the largest expenses in any golf course maintenance budget are fungicides and plant nutrition. Quite simply, healthy turf withstands stress better under warm, wet summer conditions and is less likely to need a heavy fungicide program. As a corollary, well-balanced soil provides many of the nutrients golf course turf needs. Instead of a shotgun approach to nutrition, superintendents can use a rifle.

Start your soil testing program now and act on the results, and you and your turf will be less stressed out in the future. **GCI**

of extraction used for cation analyses. Sodium adsorption ratio can be used with either soil or water samples, whereas exchangeable sodium percentage is applicable only with soils.

FREE LIME

Free lime is a measure of soil carbonates (salts of CO_3^{2-}). When combined with an acid, carbonates release gaseous carbon dioxide. The test usually performed for soil carbonates is semiquantitative. A weak acid solution is applied to the soil sample, and the degree of fizzing or release of carbon dioxide gas is determined visually and categorized as none, low, medium or high.

SULFUR

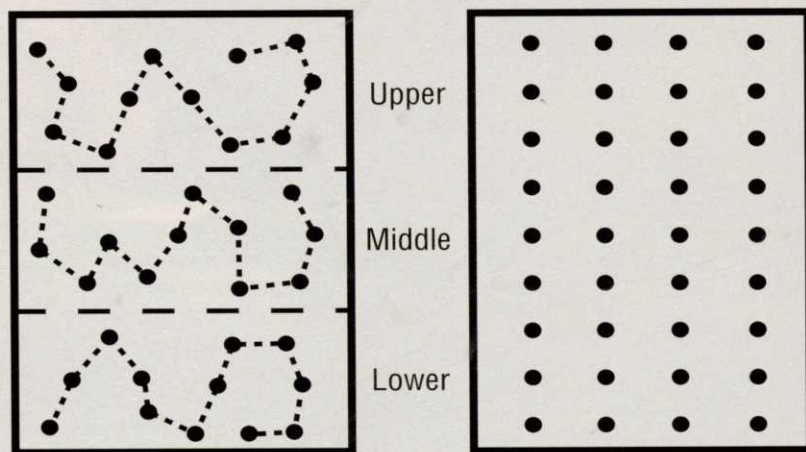
Sulfur, like nitrogen, might be contained primarily in the soil organic matter, but plants absorb only the inorganic sulfate (SO_4^{2-}) form. Measuring total soil sulfur doesn't provide a good estimate of sulfur plant availability because rates of release from organic matter can't be accurately predicted. Instead, sulfur in the sulfate form is a more common measure. Sulfate can be extracted from the soil with several extractants, including water or weak salt solutions. Analysis of SO_4^{2-} is relatively easy, but it provides a measure of immediately available sulfur, and not the soil's long-term ability to supply sulfur to a growing plant.

MICRONUTRIENTS

Micronutrient analysis is optional at most laboratories. Most laboratories in the southwest region use a DTPA-TEA (diethylenetriamine pentaacetic acid-triethanolamine) extractant, which uses the chelating agent DTPA that's tailored to extract available iron (Fe), copper (Cu), manganese (Mn), and zinc (Zn) from calcareous soils.

Analyses of these micronutrients probably are less accurate for predicting the likelihood of plant deficiencies or of crop responses to supplemental application of these nutrients than analyses of macronutrients such as potassium, calcium and magnesium because of the influence of dynamic soil conditions. For example, manganese availability can change substantially if the soil drainage status is altered, becoming more available in waterlogged soils and less available in dry soils. Iron availability also is affected by soil moisture and irrigation practices. Furthermore,

Figure 1. On the left is a dividing and sampling scheme for a sloped field with distinct upper, middle, and lower areas. Circles represent subsample locations that are composited for each of the three areas. On the right is a grid-sampling a field. Each sample is analyzed separately to evaluate field variability.



availability of copper, iron, manganese, and zinc are greatly affected by soil pH, so soils might need to be retested if soil pH is significantly altered. Soil testing can't predict the effects of altering management practices on availability of these nutrients reliably.

The most common method of extracting boron (B) from soils is with hot water. The plant availability and level of extractable boron in a soil might be influenced by soil pH. Boron also might be leached from the rooting zone. Therefore, extractable soil boron provides estimates of plant availability that are less reliable than those of many other nutrients.

Few laboratories conduct soil molybdenum (Mo) analysis. Molybdenum is present at low levels in most soils, much lower than most of the other nutrients, making an accurate determination difficult. Most plants have a low requirement for molybdenum, and slight differences in soil molybdenum levels can impact plant performance. Also, seeds might contain enough molybdenum to supply a crop's entire molybdenum requirement. For these reasons soil tests for molybdenum are of limited use and are seldom conducted.

ORGANIC MATTER

The organic matter level of a soil can be determined by several analytical techniques, all of which are accurate. All measure the amount of soil organic matter, but most don't determine its nature or how it will contribute

to soil fertility. Levels of nutrients contained in the soil organic matter can be determined (but usually aren't), and rates of mineralization or nutrient release from organic matter can't be predicted reliably because of the influences of weather and climate. Organic matter content isn't routinely determined in southwestern soils because the levels are relatively low and normally change only slightly.

MAXIMIZING NUTRIENT USE

Soil analyses can provide information that's important for maximizing nutrient use efficiency and agricultural productivity. Furthermore, a historical record of soil properties provided by long-term soil testing is useful for determining the effectiveness of fertilizer management strategies.

Soil sampling is the critical first step in a soil testing program. The second is selection of a laboratory that will use analysis procedures appropriate for regional soils and conditions. Third, an understanding of the accuracy and limitations of individual procedures and of the meaning of soil test results is essential. The last steps, interpreting soil analysis values and developing a fertilizer management program, are crop specific and sometimes dependent on additional soil and climatic properties. **GCI**

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Stunted growth

Plant regulators are a California course's key to tree canopy management

Golf course management can be a complex job because there are so many strategies that need to be implemented for a facility to operate efficiently. Operating the Glendora (Calif.) Municipal Golf Course, a nine-hole, par-3 facility, presents challenges to the city, specifically keeping the course in good playable condition without exceeding the maintenance budget. And trees are part of that challenge.

Trees are an integral component of a golf course and provide value by:

- Lining fairways;
- Protecting other golfers on the course from stray golf balls;

- Showcasing a putting green; and
- Purifying the air.

At Glendora, trees are adjacent to netting, which is used to protect the public and other golfers on the course. In the past, the city would have to prune the branches away from the netting, and it's not uncommon that when a tree is pruned, secondary pests might attack that tree. Woodborers and dry wood termites might attack weak trees. In addition to insect pests, root rot also can attack weak trees.

When tree canopies are overgrown, they require dead-wood or complete-tree removal. In some cases, heavy equipment needed for

such a job might pose potential problems for golfers and possible damage to the golf course. Glendora has its own in-house tree pruning staff, but equipment limits how high it can prune. On numerous occasions, the golf course's sprinkler heads have been damaged or broken by heavy tree-pruning equipment, creating additional downtime for repairs. Turf damage and soil compaction also are negative consequences of using heavy pruning equipment.

CHOOSE TO INJECT

The city implemented an integrated pest management program for tree canopies. Before



The city of Glendora used to prune branches away from protective netting, which left trees susceptible to secondary pests. Photo: Mike Ventura

deciding on a product to treat the trees, the city needed to decide the application method for the program. Aerial spraying was considered but not prudent because of the liability of drift and off-target movement of the product.

The city also looked into soil drenching the product, but chose not to because it didn't fit the city's integrated pest management program and it's committed to implementing as many integrated pest management strategies as possible.

The city decided to use a tree growth regulator via tree injection. A certified arborist on staff

handles the injections according to manufacturer label rate and recommended timing. But before applying the tree growth regulator, the trees needed to be inspected first. If trees are in a weak growing condition or if they're in decline, they shouldn't be treated. The city first applied the tree growth regulator on Eucalyptus and Shamel Ash trees.

By applying the growth regulator via injection, the city:

- Protects the environment;
- Doesn't place a pesticide in contact with golfers;

- Doesn't have to worry weather conditions negatively affecting the treatment;
- Eliminates pesticides entering the air or soil;
- Eliminates pesticide odor from emanating into the air; and
- Is able to treat all needed trees quickly.

The tree growth regulator (flurprimidol) provides control as long as five years. The tree growth regulator program starts at the time of bud break and continues into May.

However, tree growth regulators aren't for every tree. The city doesn't apply tree growth

IMPACT ON THE BUSINESS

Preconditioning trees pays off

BY CINDY CODE

When it comes to maintaining golf courses, tree care generally isn't what superintendents like to do most – unless quick action is needed to remove trees ravaged by a storm or devastated by insect or disease damage.

While trees are often cited interfering with turf quality and golfer site lines, a proactive tree program and philosophy can add significant

beauty and charm to a golf course.

Just ask Mike Fabrizio, CGCS, director of grounds and golf maintenance for Daniel Island Club's Ralston Creek and Beresford Creek courses in Charleston, S.C. Ralston Creek recently was recognized by the National Arbor Day Foundation for its environmental leadership in tree preservation.

Fabrizio has learned much about

trees in his eight-plus years at Daniel Island. Before his involvement with the Ralston Creek course, he arrived on the scene four months before construction began on Beresford Creek, which was designed by Tom Fazio. This course, too, received the Arbor Day award in 2003.

"It's definitely a tree philosophy around here," Fabrizio says. "Everyone from the developer, who is environmentally conscious, to the architects and everyone throughout the island. Every neighborhood has a park associated with it. Trees definitely give the course a more mature look even when they're brand new. It shows that trees can coexist in a golf environment and enhance it."

Fabrizio's background is turf, but he has surrounded himself with tree experts. He says he's been fortunate to work with Ken Knox of Hendersonville, N.C.-based Tree Doctor. Knox is a consulting arborist who visits courses annually to inspect and diagnoses trees. Fabrizio also has worked with Theo Meade, a local arborist, for about 30 years.

"They both have a passion for trees and help us out tremendously," Fabrizio says. "They catch problems

earlier than I ever would."

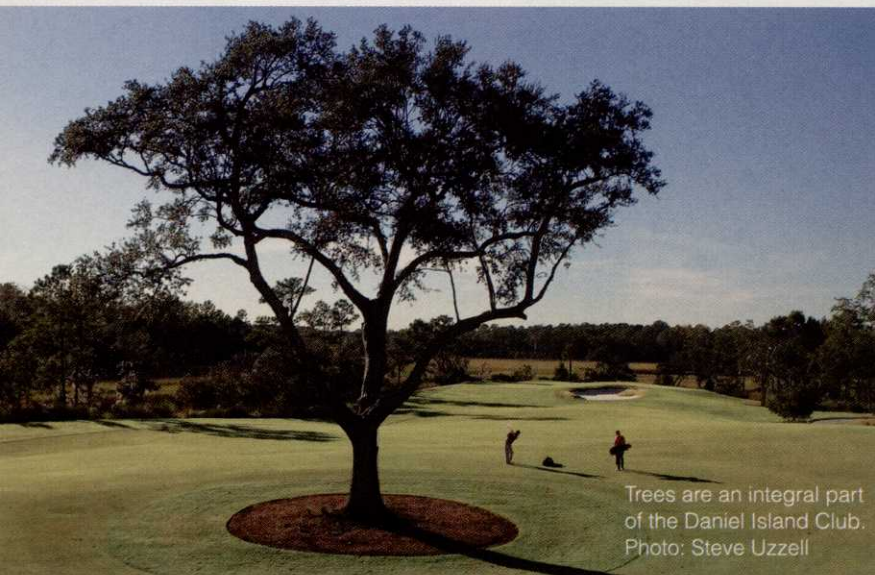
Fabrizio's maintenance budget for grounds and the two courses is about \$2.8 million. Trees alone account for about \$60,000 to \$65,000 annually, primarily for pruning and fertilization. Additional dollars are allocated for tree maintenance if a large tree dies or is struck by lightning.

Larger trees on the course are deep-drilled and aerified annually and fertilized every three to four years. New or recently transplanted trees are fertilized every year. Aside from fertilization, most treatments are curative rather than preventive. An exception is nursery trees susceptible to spider mites.

Small jobs are done in-house while all major pruning, aeration and fertilization are done by an arborist.

Fabrizio spends about \$30,000 to \$35,000 in the spring for mechanical and tree health care. The course's oak trees are pruned to remove heavy foliage that makes trees susceptible to wind damage. They'll also reduce tree canopies to protect turf health if they find they're encroaching on the turf.

The developer and golf course architect, Rees Jones, began working two years before construction started



Trees are an integral part of the Daniel Island Club. Photo: Steve Uzzell

Using plant growth regulators on trees can reduce or eliminate the need for heavy equipment to remove or prune trees. Photo: Mike Ventura



on Ralson Creek to plan a course routing that would impact a minimal number of trees. Preconstruction work included stress conditioning. Root pruning began in the fall of 2003, and the course opened in the spring of 2006.

Arborists removed unnecessary foliage off the top and dead wood from the interior to lighten the trees. Roots on the top 12 inches around trees are pruned. These areas develop small fibrous roots that aid nutrient and water uptake and help trees adapt to new locations.

Fabrizio spent about \$100,000 on preconditioning the trees. Even the trees on the course that weren't moved were pretreated to withstand environmental stresses associated with the dirt moving and shifting all around them.

Once construction was under way, crews transplanted 42 oak trees and about 100 pine trees to other areas of the course. Some oaks were at least 60 years old and had trunks as large as 31 inches wide, requiring one of the nation's largest tree spades to help with the transplanting process.

Dallas-based Environmental Designs was hired to relocate the

trees. They designed a 144-inch tree spade that had to be put together on-site for the project. Standard tree spades are between 90 to 100 inches.

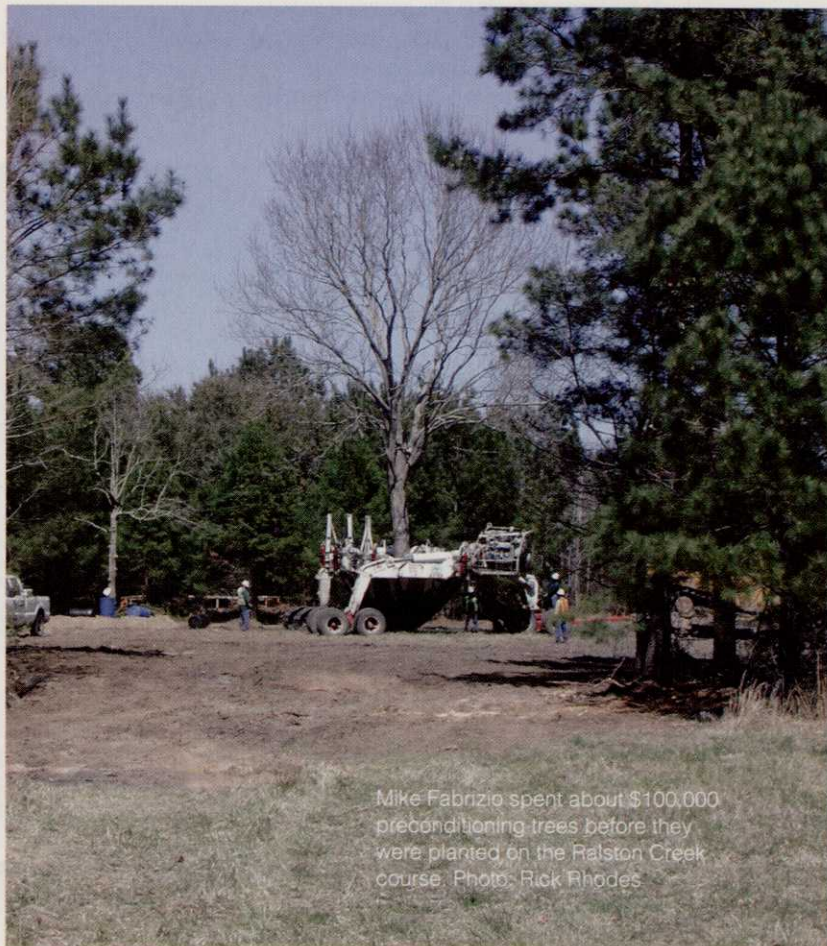
The majority of the trees survived the move, and less than a half dozen died, Fabrizio says.

"I can't stress enough about preconditioning," he says. "It's the third time I've done it, and it's \$100,000 well spent."

In addition to saving trees on the golf course, the Daniel Island Co. has planted more than 16,000 trees on the 4,000-acre island since development 10 years ago.

Fabrizio attributes much of the success to the fact that the corridors are 50 feet wider than most and wider corridors allow one to keep trees and still have healthy turf. Traditional 200-foot-wide corridors force trees to be crammed in resulting in too much shade in the play area.

"With our wide corridors, trees aren't a detriment to golfers," he says. "Sometimes I don't think they realize they're there or appreciate them. The course looks like it's been there for a long time. They take the trees for granted." GCI



Mike Fabrizio spent about \$100,000 preconditioning trees before they were planted on the Ralston Creek course. Photo: Rick Rhodes

Research

regulators on slow-growing trees, only on moderate to fast-growing trees. An understanding of tree physiology is recommended before setting out to inject trees.

Aside from tall trees such as the Shamel Ash and Eucalyptus, the city has numerous smaller trees on the golf course but doesn't treat them because it wants the tree canopies to develop. Once the younger, smaller trees have developed canopies, the trees will be treated.

NO MORE INTERFERENCE

The trees creating the city's greatest challenge are Shamel Ash and Eucalyptus (blue gum) trees. The Eucalyptus is a good fairway tree, providing golfers protection from stray golf balls. Also, protective netting is near many of the tees. The branches and foliage from Eucalyptus trees create a maintenance problem, and replacing the netting is quite expensive.

Since treating the Eucalyptus trees, the city has noticed a decline of new foliage production in the canopy, as well as a darker green foliage, which is desired during the growing season. Without the growth reduction, branches and foliage would be growing into the netting.

Wind damage also can be a problem with the

Shamel Ash and Eucalyptus trees. A tree treated with a growth regulator reduces the potential for limb or tree failure caused by wind.

BENEFITS

The city is benefiting the environment by incorporating a tree growth regulator program into its golf course management program. By reducing the need for regular pruning, the city is able to preserve tree canopies and allow trees to clean the air. A stub or topped tree isn't capable of purifying the air. The city believes that by using tree growth regulators it's able to reduce the cost of pruning and the amount of green waste that would normally end up at a landfill.

Another benefit of tree growth regulator applications is labor savings. Because treated trees grow slower, the city is able to reallocate man-hours and can spend more time managing the turf, soil and bunkers on the golf course because turf conditions and managing the playing surface is critical to a successful golf facility operation. **GCI**

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At the Glendora Municipal Golf Course in California, Eucalyptus tree growth needs to be controlled because they're right next to protective netting. Photo: Mike Ventura

