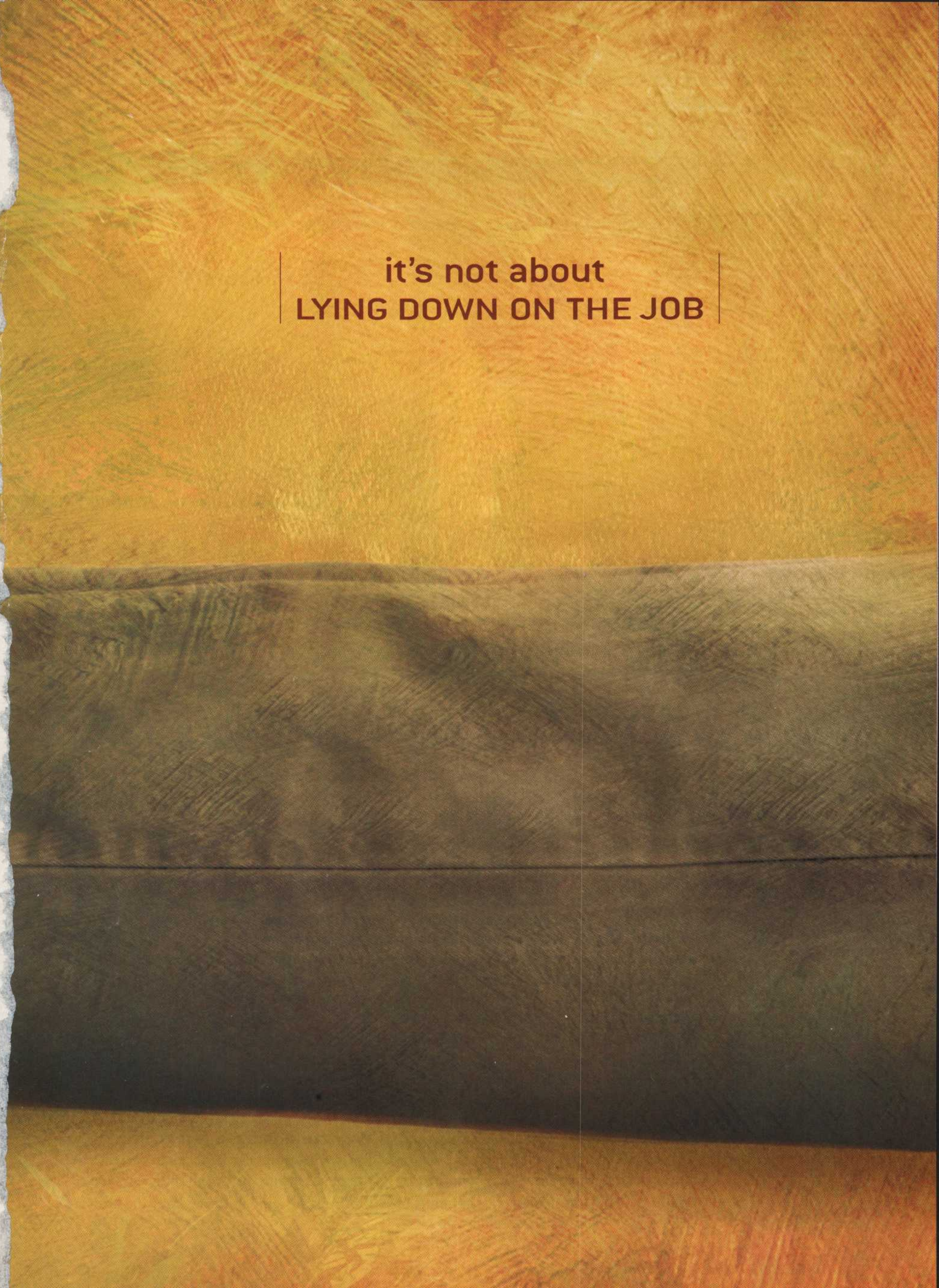
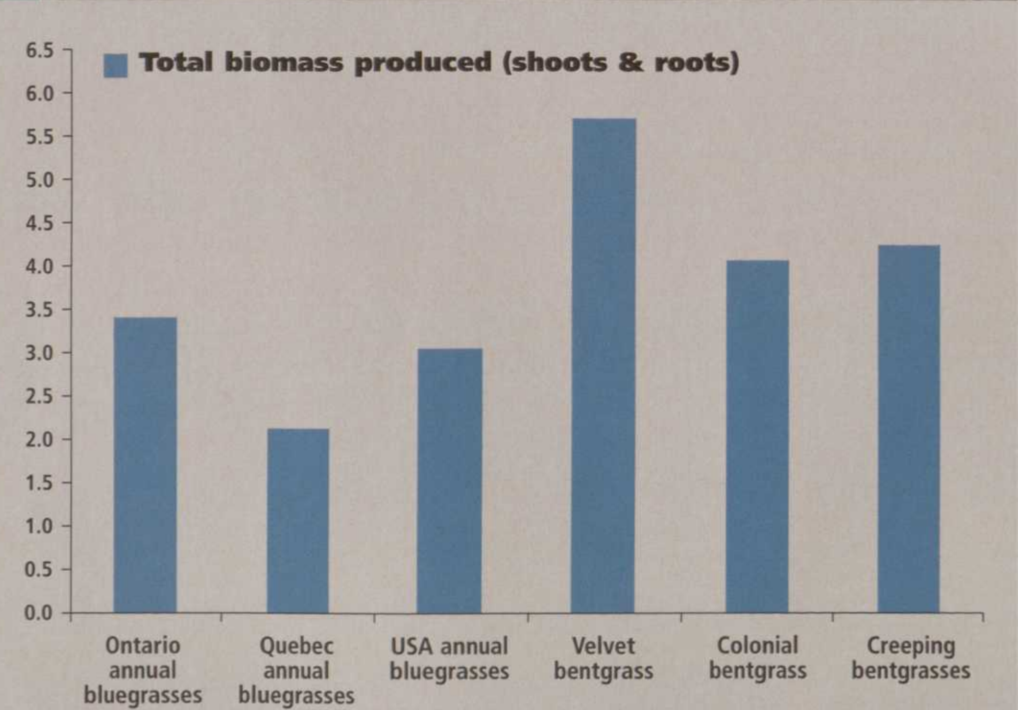

it’s not about
LYING DOWN ON THE JOB

FIGURE 2



Total biomass produced (shoots plus roots) from various annual bluegrass ecotypes and bentgrass species in a greenhouse, University of Guelph.

Continued from page 49

Nitrogen inputs are primarily from fertilizers and plant residues (clippings, if not removed) and to a lesser extent from N in rainfall and irrigation water (Petrovic, 1990) (Figure 1, step 1).

Soil microorganisms mineralize organic N from plant residues and fertilizers to ammoniacal N (NH_4^+) (Figure 1, step 2). Much of the NH_4^+ is converted to nitrate (NO_3^-) by nitrifying bacteria during nitrification (Figure 1, step 3). Turfgrass roots can take up either NH_4^+ or NO_3^-, but there is a preference determined by plant age and species, and the environment (Figure 1, step 4) (Havlin et al., 1999). NO_3^- is mobile in the soil solution and can be readily lost to groundwater or the drainage system by leaching (Figure 1, step 5), or can be converted to N_2, NO, or N_2O by bacteria or chemical reactions (Figure 1, step 6). N_2, NO and N_2O can then return to the atmosphere, thereby completing the N cycle. NH_4^+ is dissolved in the soil solution and is in equilibrium with gaseous NH_3.

If soil pH increases, NH_3 increases at the expense of NH_4^+ and is lost to the atmosphere by volatilization (Figure 1, step 7). Therefore, in turfgrass systems N fertilizers can be up taken by the plant (5-74 percent), stored in the soil plus thatch (15-21 percent, 21-26 percent when clippings are returned), lost to the atmosphere through volatilization (<36 percent) or denitrification (0-93 percent) or leached out of the soil profile (0-53 percent) (Petrovic, 1990).

Little runoff of nutrients from a fairway turf was found to occur in a two-year project at Pennsylvania State University (Linde et al., 1995). On putting greens with a sandy and porous rootzone, anaerobic conditions needed for denitrification are not present. This greatly decreases the risk for N loss.

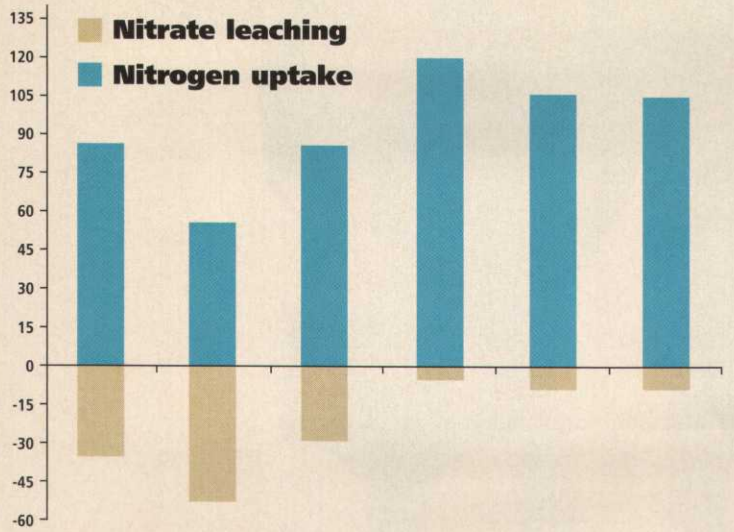
Volatilization of N from N-containing fertilizers can be decreased with a light irrigation after fertilizer application. However, N leaching is a process that is highly variable and depends on numerous factors that include fertilizer source and rate, timing of fertilizer application and irrigation volume (Petrovic, 1990).

Ways to decrease N leaching

Certain measures can be taken to decrease the risk of N leaching. Although sufficient N fertilizer must be applied throughout the growing

Continued on page 54

FIGURE 3



N uptake and nitrate leaching from various annual bluegrass ecotypes and bentgrass species in a greenhouse, University of Guelph.

Continued from page 52

season to maintain an acceptable level of turf quality, the amount can often be decreased. The amount of N applied on golf greens was once much higher than today.

In Canada the yearly application of N to greens is 4.7 pounds per 1,000 square feet (Royal Canadian Golf Association, 2003). James Beard (2002) recommends 0.3 to 0.7 pounds of N per growing month for bentgrass (*Agrostis* L.) and annual bluegrass (*Poa annua* L.) putting greens.

Two types of N fertilizer are used on putting greens: quick-release (water-soluble) and controlled-release (slow-release). Water-soluble sources include ammonium nitrate (34-0-0), ammonium sulfate (21-0-0), potassium nitrate (13-0-44) and urea (46-0-0). Slow-release sources include sewage-based and other waste-based organic materials, ureaformaldehyde (UF), isobutylidene diurea (IBDU), sulphur-coated urea (SCU) and polymer-coated urea. Water-soluble N must be applied more frequently, in small quantities (spoon-feeding), followed by an adequate irrigation to avoid physiological burning of the leaves.

Controlled-released N fertilizers are generally more expensive but have the advantages of less leaching potential and rarely causing leaf burn. Carrow et al. (2001) indicated that the best plant response to N was obtained by light, frequent applications of water-soluble N sources.

It is important to irrigate according to the evapotranspiration of the turf. Weather stations and irrigation softwares now offer a precise mean of evaluating turfgrass water needs. Nitrogen will be absorbed by the root system if it stays in the root profile. If leached deeper by excessive irrigation, roots do not have access to it.

Another way to decrease N leaching is to increase uptake. Optimizing the amount of N taken up by turfgrass is an environmentally sound management practice. Nitrogen recovery in turfgrass plants (clippings, shoots and roots) can range from 5-74 percent of the N applied as fertilizer (Petrovic, 1990). The amount of N assimilated by the plant depends on N fertilizer management (N source, application rate and timing), grass species and site-specific environmental conditions. Specifically, plant N uptake depends on factors affecting grass growth rate, such as temperature, moisture, availability of soil N and the genetic potential of grass species and cultivars to absorb and metabolize N.

N uptake differences in turfgrasses

Morphological and physiological variations affecting N uptake are reported to exist among different turfgrass genotypes.

Liu et al. (1997) compared NO_3^- concentration in soil water and cumulative NO_3^- leaching for 30 cultivars of Kentucky bluegrass (*Poa pratensis* L.), perennial ryegrass (*Lolium perenne* L.) and tall fescue (*Festuca arundinacea* Schreb.). They found that NO_3^- utilization differed among species as well as within the same species.

Bowman et al. (1998, 2002) reported that the root distribution of bentgrass and six warm-season grasses affected NO_3^- leaching potential; a deep-rooted turf absorbed N more efficiently.

At the University of Guelph, Ontario, Canada, Paré et al. (2004) conducted a greenhouse experiment to compare N uptake and leaching potential under various annual bluegrass ecotypes and bentgrass species. Differences in growth characteristics were observed. Annual bluegrasses, especially Quebec ecotypes, had smaller total biomass production when compared with the bentgrasses (Figure 2).

The greatest total biomass was produced by

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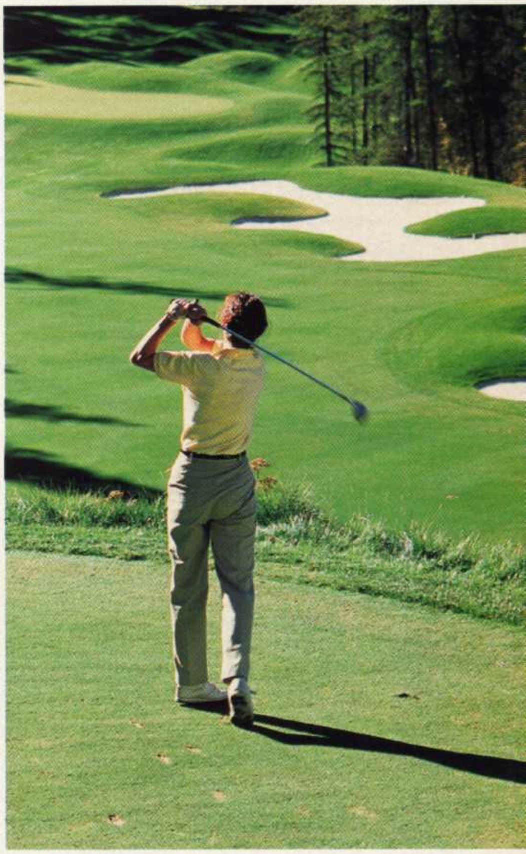
The Andersons ability to formulate small particle products as noted in the chart, deliver up to four times the particles per square inch compared to larger particle-size formulations (SGN240) with the same percentage of active ingredient. This in turn will provide better efficacy and a wider spectrum of weed control. Fertilizers with postemergent combination products allows turf managers to more efficiently utilize key labor resources by taking care of turf nutrition and weed pests in one operation.

Product	Active Ingredient	Key Feature & Benefits
18-5-9 with Millennium Ultra Herbicide	2,4-D Clopyralid Dicamba	■ Both foliar & root absorbed ■ Effective on wet and dry turf ■ Excellent against hard to control weeds like clover ■ Low usage rates ■ SGN150 — excellent coverage ■ Contains NS-52 slow release nitrogen
16-4-8 with Millennium Ultra Herbicide	2,4-D Clopyralid Dicamba	■ Both foliar & root absorbed ■ Effective on wet and dry turf ■ Excellent against hard to control weeds like clover ■ Low usage rates ■ SGN150 — excellent coverage ■ Contains NS-52 slow release nitrogen
21-3-20 Fertilizer Plus Dicot Weed Control III	2,4-D Mecoprop Dicamba	■ Homogenous product ■ Apply to wet turf for best results ■ Fine granules for excellent coverage and weed control ■ Contains methylene urea slow release nitrogen
20-4-10 with Trimec 20-3-3 with Trimec 22-2-4 with Trimec	2,4-D MCPP Dicamba	■ Excellent broad spectrum weed control ■ Both foliar and root absorbed ■ SGN145 for excellent weed coverage ■ Contains NS-52 slow release nitrogen
20-2-6 with 2,4-D & MCPP	2,4-D MCPP	■ Sugar grade consistency to provide maximum foliar contact ■ SGN145 for excellent weed coverage ■ Contains NS-52 slow release nitrogen
K-O-G Weed Control	Dicamba	■ Highly effective against resistant weeds like knotweed, wild onion and wild garlic ■ Label for use on bentgrass greens ■ SNG100 for excellent coverage
29-3-4 with St. Augustine Weed Control	Atrazine	■ Only combination homogenous fertilizer plus post and preemergent herbicide ■ Use on newly sprigged or established St. Augustine; Zoysiagrass; centipedegrass and carpetgrass ■ Contains methylene urea slow release fertilizer ■ SNG125 for excellent coverage



Article contributed by Darrin Johnson, Territory Manager, The Andersons Inc.

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velvet bentgrass. The aboveground biomass production represented 50-60 percent of total plant biomass production for all grasses tested and was greater for the bentgrasses than the annual bluegrasses. In addition, the root biomass was greater for the bentgasses and developed deeper in the soil. It is logical to assume that a plant with a larger root system exploits a larger soil volume and has a greater potential to absorb nutrients.

Bentgrasses had a greater N uptake than annual bluegrasses (Figure 3) (Paré et al., 2004). Most of the variability found in total N uptake was attributable to the greater above-ground biomass of bentgrasses compared to annual bluegrasses. In addition, differences occurred among annual bluegrass ecotypes, with Quebec ecotypes having the least N uptake. A positive correlation was observed between total biomass produced and total N uptake; bentgrasses had a greater N uptake than annual bluegrasses.

A negative correlation was noted between total N uptake and total NO_3-N leached during the study. Since the annual bluegrass ecotypes had a shallower and smaller root system, they took up less N and demonstrated a greater N leaching potential than the bentgrasses (Figure 3).

Conclusions

To prevent N leaching, superintendents need to carry out environmentally sound practices such as reducing the amounts and rates of N applied, spoon-feeding, using slow-release N fertilizers and irrigating according to evapotranspiration.

In addition to these practices, choosing a grass species or cultivar with a low N requirement, a well-developed root system and a high overall biomass production could help decrease N leaching. During the growing season it is essential to fertilize according to the state of the root system. In case of cool-season grasses, practices increasing rooting density and depth during the summer must also be considered. For instance, raising the mowing height, if possible, can help promote deeper roots.

Finally, Kerek et al. (2003) found that organic matter, which accumulates over years, can supply a large amount of N to the turfgrass. Therefore, as the putting green gets older and microorganisms recycle N from the organic matter, less external N may be required.

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Unity for the Sake of Uniformity

New database allows superintendents to measure, compare patchiness of turfgrass

By Douglas Linde

When a golfer stands on the tee and looks out over the fairway, what does he or she see? Is it a well-defined, uniform green fairway or is it a patchwork of browns and greens with a barely visible fairway border? Which condition offers better playability? Which condition is more aesthetically pleasing? Which condition is more agronomically sound?

The answer to these questions is "it depends." It depends on the personal opinion of the course designer, golfers, superintendent and the course officials.

Parameters that assess aesthetics can be measured, but the interpretation of those measurements is subjective because "aesthetics (beauty) is in the eye of the beholder."

Turfgrass uniformity is one of these aesthetic parameters. Although it has been included as a parameter in evaluating turf quality for National Turfgrass Evaluation Program (NTEP) trials (Morris, 2005), turf uniformity alone is not commonly measured by turf managers and scientists.

Measurements of uniformity are most useful when they are compared to someone's or some group's expectation. For example, American golfers often expect a perfectly manicured golf hole, while British golfers are more tolerant of imperfection (Foy, 2002). Golfers who expect perfectly manicured turf likely have high expectations for turf uniformity, thus uniformity measurements become useful. Golfers who don't expect perfect turf likely have lower expectations for uniformity, thus uniformity measurements are not as useful.

Turf managers need to understand their customers' expectations and set turf uniformity standards based upon these expectations. In addition, measurements can be useful in determining if standards are being met and to quantify the effects of a management program change. For example, regular uniformity measurements can be used to monitor the progress of a species conversion program.

From January 2004 to August 2004 a project was conducted by the New Zealand Sports Turf Institute (NZSTI) to benchmark golf course conditions throughout New Zealand (Linde, 2004). The purpose of the project was to develop materials and methods to assess golf course conditioning. Those materials and methods were then used to create a database of course conditioning parameters that the NZSTI could use to advise golf clubs more appropriately.

Turf uniformity was one parameter used to describe conditions of each turf area on a golf course. The method to measure turf uniformity was adapted from a method used in soil science to describe soil mottling (Schoeneberger et al., 1998). Soil mottling is defined as spots or blotches of different color or shades of color interspersed within the dominant matrix color of a soil (Brady and Weil, 2000).

Soil mottles are described by characteristics such as mottle quantity, size and contrast. For this project, a similar term, "patchiness," was used in place of the term "mottling" to describe turf uniformity. A turf area that was uniform had no patches. A turf area that had patches was described by the patch quantity and patch contrast.

Patchiness and uniformity

Patches were defined as visible changes in color and/or texture with the dominant color/texture of the turf area. Patch quantity was the percentage of the area that the patches covered. Values ranged from 0-50 percent. A value of 0 percent patch quantity represented no patches and the turf was uniform. A value of 50 percent patch quantity meant that no one color or texture was dominant.

Patch contrast was a measure comparing how much the patch color or texture contrasted with the dominant color or texture. The area assessed was placed into one of three categories of patch contrast — Faint, Distinct or Prominent. The Faint category represented patches that were indistinct and evident only upon close examination (Figure 1). An example would be a patch of light-green *Poa annua* against a slight-

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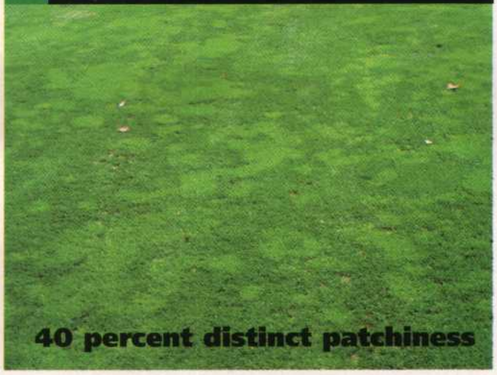
FIGURE 1

20 percent faint patchiness

FIGURE 2



40 percent distinct patchiness

FIGURE 3

50 percent prominent patchiness

FIGURE 4

40 percent prominent patchiness because of texture changes

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ly lighter green background — typical of a 100 percent *Poa annua* putting green.

The Distinct category represented patches that were readily seen and contrasted moderately with the dominant color or texture. An example would be a patch of light-green creeping bentgrass against a dark-green perennial ryegrass background (Figure 2).

The Prominent category represented patches that contrasted strongly with the dominant color or texture. An example would be a patch of dark-green perennial ryegrass against a straw brown background (Figure 3). Figure 4 is an example of prominent patches caused by dramatic texture changes. Prominent patches can be seen from hundreds of yards away. Values were assigned to each patch contrast category; Faint = 3, Distinct = 2 and Prominent = 1.

The entire area to be evaluated was walked. During the walk, the dominant color, patch quantity and patch contrast were assessed in various directions. Observations from directly above the turf and from looking across the turf were made. After the area was walked, the average patch quantity and average patch contrast were determined.

Filled and unfilled divots can be contributors to patchiness. Unfilled divots were included as part of the patchiness measurement. Although divots filled with light-colored soil (i.e. white sand) form distinct patches when among a green background and disrupt uniformity, filled divots were not included as part of the patchiness measure because the practice is accepted by most golfers.

Superintendents and officials who are concerned about filled divots standing out against the green grass would want to include filled divots in their patchiness measurement. Superintendents and officials that host televised tournaments are often concerned about camouflaging filled divots and therefore use dark-colored fill materials or paint to hide the divots.

Patchiness data was collected from 50 of the 400 golf courses in 14 of the 17 geographical regions of New Zealand. For each course, data were collected from three holes on one day of the year during fall or winter. As a result, the data did not fairly represent a course's patchi-

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Continued from page 58

ness throughout the year. The data more appropriately represented patchiness for a course of certain size revenue.

Results and discussion

The courses with annual revenue less than $70,000 had the least contrasting (more faint) patches when compared to all other courses for approaches, surrounds, fairways and rough (Tables 1 & 2, Figures 5 & 6). However, for greens, these courses had the most contrasting (more prominent) patches. The courses with annual revenue greater than $700,000 had the least contrasting patches on greens.

The courses with revenue greater than $700,000 had the lowest patch quantity percent for every area except surrounds. For greens, the courses in the $175,000-$350,000 and $350,000-$525,000 revenue ranges had the highest patch quantity.

Keep in mind that patch quantity and patch contrast should be considered together to assess patchiness appropriately. An area may have 50 percent patches, but those patches may be faint. On the other hand, an area may have only 10 percent patches, but those patches may be prominent. An area that is most uniform would have 0 percent patches. An area that is least uniform would have 50 percent prominent patches.

When considering patch quantity and contrast together, overall for all areas, the greater than $700,000 revenue courses had the fewest and faintest patches, thus had the most uniform turfgrass.

Patchiness (non-uniformity) in turf can be a result of one or more of the following: soil variability, different turfgrass species, weeds, climate, topography, management practices, mismanagement, pests and divots. Depending on its cause or causes, managing for turf uniformity can be costly and at times futile.

TABLE 1

Patch contrast data per turf area sorted by annual revenue of golf courses in New Zealand.

Annual revenue U.S. $ x 1000	Courses surveyed	Patch contrast[z] for each turf area: Green		Collar		Approach		Surround		Fairway		Rough		Tee	
		AVG	Range	AVG	Range	AVG	Range	AVG	Range	AVG	Range	AVG	Range	AVG	Range
≤$70	11	1.8	1.0-2.0	2.3	1.0-3.0	2.5	1.7-3.0	2.4	1.7-3.0	2.7	2.0-3.0	2.5	1.7-3.0	2.4	1.7-3.0
$70-175	8	2.1	1.7-2.3	2.4	1.0-3.0	1.4	1.0-2.3	1.7	1.0-2.7	1.2	1.0-2.0	1.8	1.0-3.0	2.0	1.3-2.7
$175-350	8	2.4	2.0-3.0	2.2	1.0-3.0	2.1	1.3-2.7	1.7	1.0-2.7	1.5	1.0-3.0	1.9	1.0-3.0	1.7	1.0-2.3
$350-525	7	2.2	2.0-3.0	2.4	2.0-3.0	2.1	1.3-2.7	1.7	1.0-2.0	2.1	1.0-3.0	1.6	1.0-2.7	2.0	1.7-2.7
$525-700	6	2.3	2.0-3.0	2.2	2.0-3.0	2.2	1.7-2.7	1.8	1.0-3.0	2.0	1.0-3.0	1.3	1.0-2.0	2.5	2.0-2.8
≥$700	10	2.5	2.0-3.0	2.6	2.0-3.0	2.4	1.0-3.0	2.0	1.0-3.0	2.4	1.0-3.0	2.0	1.0-3.0	2.2	1.3-3.0

z Values range from 1-3 with 1=Prominent, 2=Distinct, and 3=Faint contrast.

TABLE 2

Patch quantity data per turf area sorted by annual revenue of golf courses in New Zealand.

Annual revenue U.S. $ x 1000	Courses surveyed	Patch quantity[z] for each turf area: Green		Collar		Approach		Surround		Fairway		Rough		Tee	
		AVG	Range	AVG	Range	AVG	Range	AVG	Range	AVG	Range	AVG	Range	AVG	Range
≤$70	11	36	12-50	26	4-37	26	18-40	26	7-50	33	17-50	30	15-50	25	6-40
$70-175	8	33	17-50	23	17-30	22	12-32	25	12-40	31	23-40	35	22-50	22	10-37
$175-350	8	43	27-50	22	9-50	24	15-37	20	8-27	26	9-47	28	10-47	22	10-40
$350-525	7	44	40-50	22	10-33	29	20-43	28	20-40	31	17-50	30	15-43	22	13-33
$525-700	6	36	22-43	21	14-28	19	7-30	26	15-50	25	18-33	32	19-50	24	18-32
≥$700	10	25	0-50	19	2-50	18	12-34	26	15-50	24	7-50	25	15-50	17	4-30

z Represents the percent turf area that contained patches. Values range from 0-50%.