methodology, and the lack of benefit to turf students and industry. I feel sorry for them as they apparently lack the moral fortitude and integrity to make their product truly serve the industry. The best way to deal with problems is to communicate and cooperate, not confront. Despite an offer from the C-5 chair to attend a meeting to discuss how a survey could be better conducted in order actually assist the industry and students, their editorial staff has refused to participate. Is this the type of company from whom you want to buy product?

TurfNet has stated that it was unfair to rank the 2 and 4 year programs together in the July survey and will handle them separately in the future. Does that mean persons with 2 yr degrees are ill-equipped to compete in the job market? I would argue otherwise as I've seen plenty of smart, successful superintendents with 2 yr degrees. When I taught the advanced turf physiology and management course at Michigan State University in a classroom of combined 2 and 4 yr students, many of the top students were in the 2 yr program.

Dr. Tom Cook (Oregon State University) put it well-despite being a one-person show, his students have been successful. His program will never have the resources of a North Carolina State University. However, interns are regularly placed at golf courses such as Pebble Beach and Bandon Dunes. The students go on to have successful, rewarding careers. To me, their success depends on the instructor and advisor, not the size of the program's bank account. Those of you who had Dr. J.R. Love or Dr. Wayne Kussow, think about this hard. Did your career suffer because there weren't 200 turf students, with 50 graduates each year all vying for 10 in-state jobs? Has the quality of the golf experience for golfers suffered in Wisconsin? When I arrived at UW-Madison, several golf course superintendents discussed with me the idea of maintaining a balanced program so as to not grow the program too large and degrade the quality of education. In a follow-up editorial in the October issue of TurfNet, John Reitman contradicted his earlier communications and admitted the rankings are all about resources: those schools with the greatest amount of resources will rise to the top of the rankings. If that is the case, why not just title the rankings "The Wealthiest Turf Programs" and call it close enough. Wealth does not necessarily translate into the best program (i.e., New York Yankees) or the most caring and helpful advisors. Ultimately, TurfNet's rankings are all about selling advertisements. Just own up to it-superintendents deserve better.

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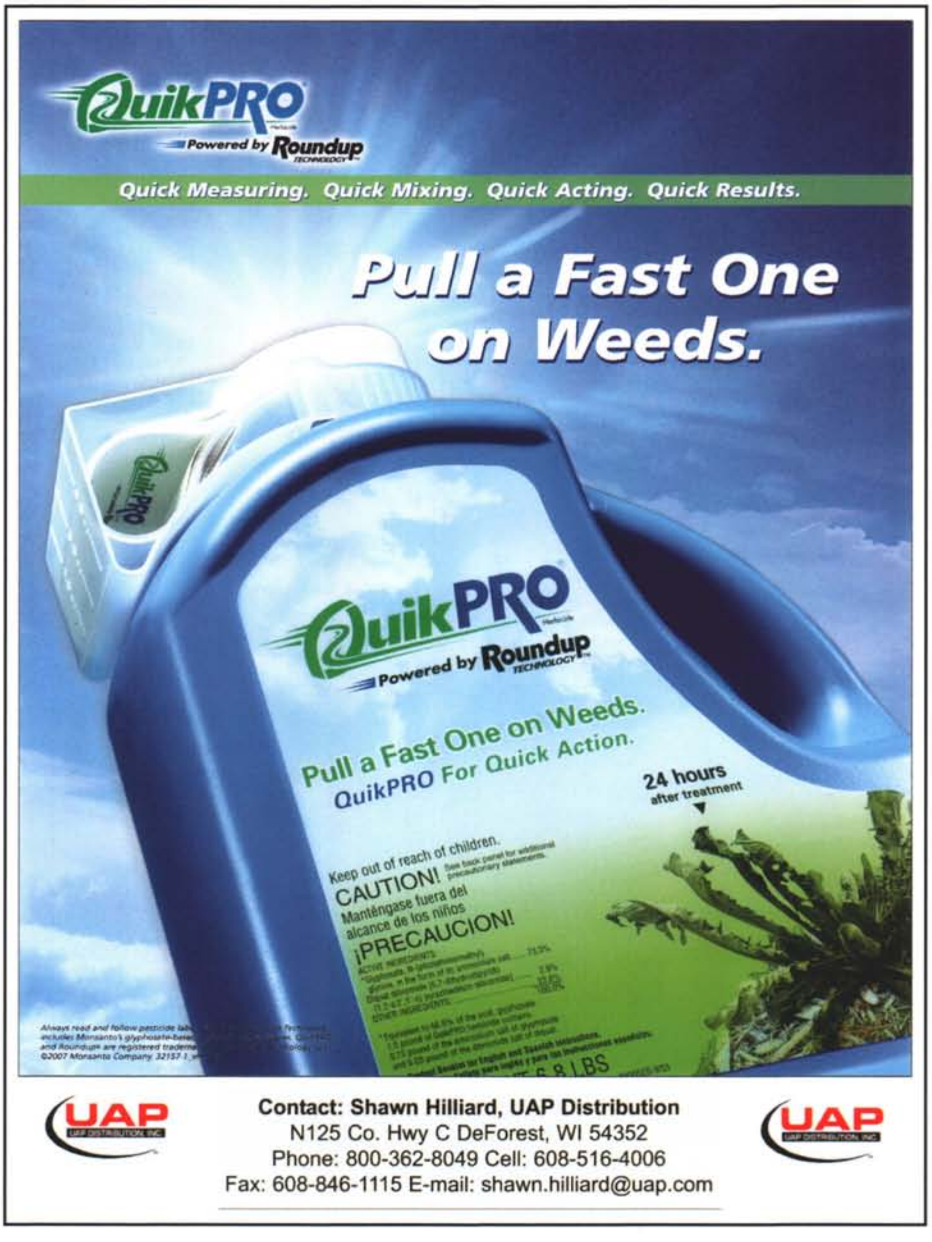

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Potential for the Development of Insecticide Resistance to White Grubs

By Dr. R. Chris Williamson, *Department of Entomology, University of Wisconsin - Madison*

In general, the probability of development of resistance depends on the frequency of the resistance gene in any given population. The higher the resistance gene frequency, the more easily the resistance develops. The basic philosophy of management is that one can prevent the resistance gene frequency by not selecting so rigorously with insecticides.

This being said, there have been relatively few documented cases of insecticide resistance in the turf and landscape settings. This phenomenon is likely due to the life cycle of insects associated with the turf and ornamental landscape. Many turf and ornamental insects have one to two generations per year, especially white grubs. Consequently, the frequency of exposure of an insecticide to turf or ornamental insects is relatively low.

However, where widespread, repeated applications of the same insecticide are made over an extended period of time, insecticide resistance is possible. For example, most turfgrass managers typically rely on annual applications of nicotinoid insecticides (e.g., clothianidin [Arena], imidacloprid [Merit], or thiamethoxam [Meridian]) to manage white grubs. As a result, turf managers may be predisposing themselves to a greater potential or likelihood of resistance since nicotinoid insecticides have fairly long residual activity (> 100 days) and they are frequently applied to relatively large areas of turf on an annual basis.

There are several insecticide resistance management practices that can be employed to reduce the likelihood of developing insecticide resistance, including: 1) alternating among classes of insecticides; 2) making target treatments rather than blanket or prophylactic sprays; 3) using shorter residual insecticides; and 4) selecting non-chemical methods of insect control (i.e., cultural or biological). To this end, the most practical approach to reducing the likelihood of insecticide resistance is to rotate or select alternative classes of insecticide chemistry or to make target treatment applications of an insecticide to areas where the target insect has historically been problematic rather than making blanket or cover sprays.

For various reasons, including: 1) performance; 2) effectiveness; 3) reliability and 4) cost, the nicotinoid class of insecticides dominate the white grub market as the insecticide of choice for preventative control. From an insecticide resistance management perspective, this situation raises concerns as the potential for insecticide resistance is heightened. For this reason, the development and registration of effective, alternative insecticide classes are needed to reduce the potential for the development of insecticide resistance to white grubs.

Fortunately, a new insecticide class has been discovered. DuPont has reported a novel insecticide class named the anthranilic diamides. Anthranilic diamides have a truly novel mode of action–they are not nerve poisons. Rather, the mode of action is the activation of ryanodine receptors in muscle cells that have selectivity for insect receptors. Specifically, the active ingredient (chlorantraniliprole) causes calcium ions to leak out of insect muscle cells, which ultimately results in insect death. Because of this selectivity, anthranilic diamides are extremely safe to mammals (a mammalian toxicity LD_{50} of 5,000 mg/kg). Chlorantraniliprole promises to be a very low toxicity insecticide that is a highly effective preventive grub control material. Chlorantraniliprole is expected to be registered with the EPA and commercially available sometime in the spring of 2008 under the brand name of Acelepryn™.

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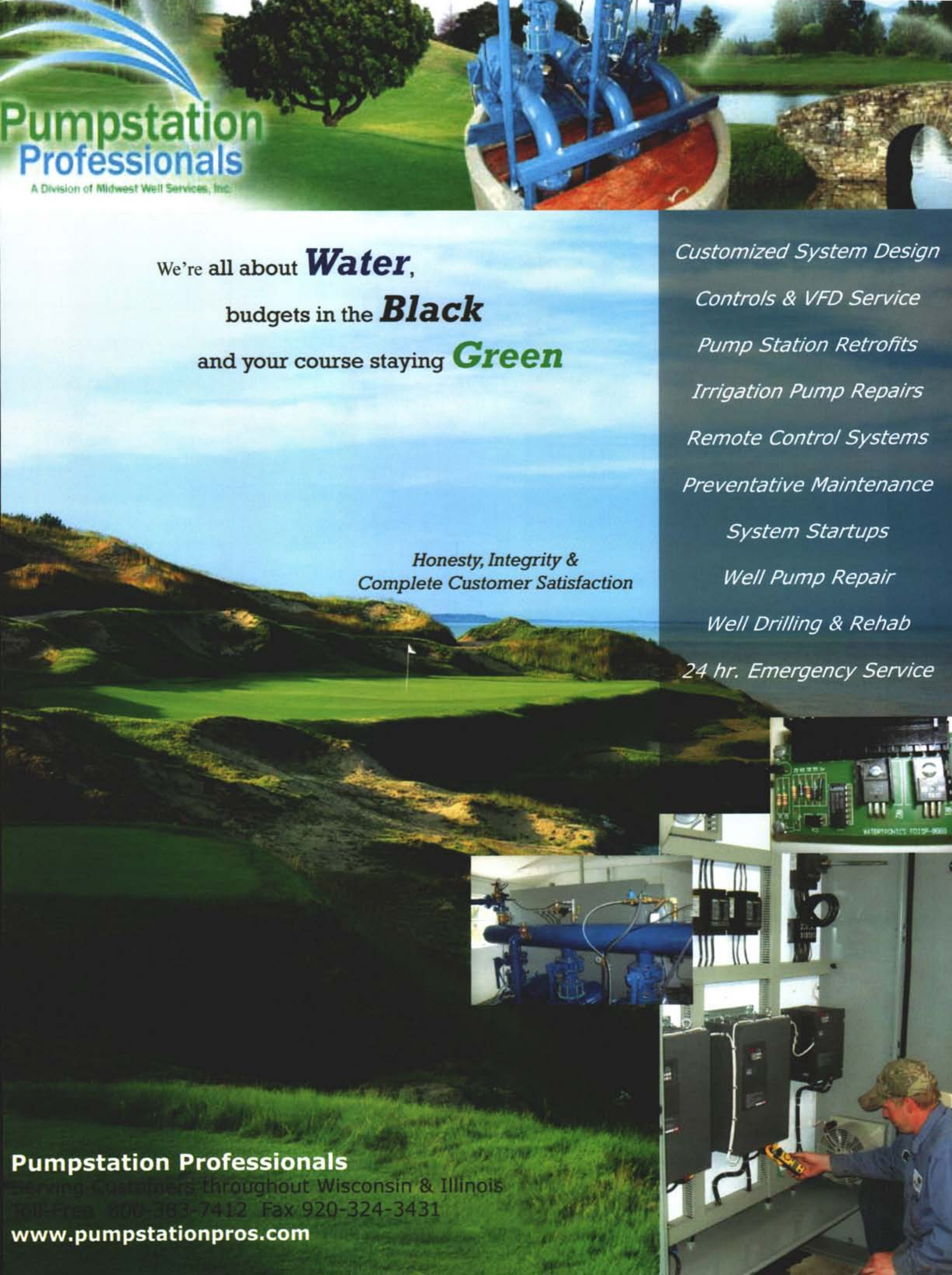
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Statistics and The Science of Turfgrass Research

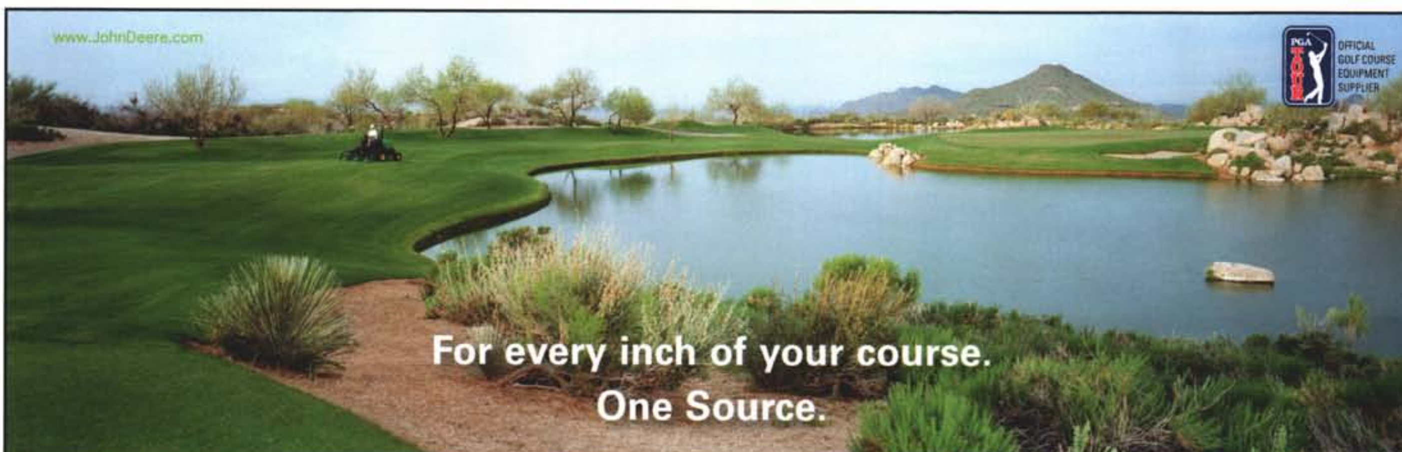
By Tom Schwab, Superintendent, O.J. Noer Turfgrass Research and Education Facility

Author's note: Excuse me for resubmitting this article that I wrote eleven years ago for The Grass Roots. The statistics information has not changed. The Green Bay Packers information, in the first paragraph, needs updating though. It should now read, "the last two times the Packers started the season 8 and 1 they went on to win the title."

What comes to mind when you think of statistics? A most prevalent use of statistics is relating it to sports activities. A batting average, free throw percentage, use of handicaps, and a win/ loss record are all forms of statistics. Many of them are used to predict the outcome of a given event. My favorite statistic is the last time the Packers started out 8 and 1 they went on to win the title. The science of statistics is used to make unbiased inferences about outcomes in many walks-of-life such as sports, business, medicine, engineering, law, education, and also turfgrass management.

The basic concept behind statistical inference is to observe a small part of a large group and from that small group make a prediction of the whole. Two simple terms need to be defined here, population and sample. The large group or real life situation, which you are really interested in, is considered the *population*. The small group or study from which you will be drawing inference to make a prediction on the population is called the *sample*. At the Noer Facility a sample might be to observe a bentgrass putting green that has three different mowing heights. We may be investigating whether the different mowing heights relate to having more or less disease incidence. The *population* of interest in this study would be all bentgrass putting greens.

A criticism that a study like this sometimes receives is that this putting green is not like the real world



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where a green may also have 60,000 rounds of golf played on it. That is true, but this study was not designed to study the whole real life situation. It was designed to investigate one aspect. Then you can take this one aspect and consider how it applies within your whole management scheme.

With careful planning and design of the experiment, using statistics, the researcher can quantify a claim that a certain input will have a chance of giving a certain effect. For example, they can state with a certain level of confidence (say 95%) that XYZ product will increase rooting on native soil bentgrass putting greens. Statistics uses calculations to give a numerical value of whether this difference is meaningful. Then you can judge whether this numerical value is enough for you to be confident in the claim.

Oftentimes we hear from advertisers about how well a new product works. Sometimes we are given testimonials as proof such as, "Joe at Bigwig Golf Links used schmuckum juice to speed germination and his members were playing the new green two weeks after planting." Because most of us value the scientific method over hearsay, we can't be convinced of these claims unless we know more about the testimonial. You rarely hear any statistical techniques mentioned when you hear a testimonial. A testimonial could be believable if the following occurred: the same outcomes were repeated at many different sites, at each site individual *treatments* were replicated a few times to account for experimental error and then compared to non-treated plots at the same site, and each *treatment* was randomly placed into the study to give each one an unbiased placement in the study. (The term *treatment* means the individual manipulations that you are observing in a study. For example in a fungicide study, each different product would be considered a separate treatment. Then you may be observing which treatment lasts the longest.) When analyzing statistical results: find out what tools of measurement were used in analyzing the data, and question whether the conclusions are biased by the people making the claims.

Many of the ideas behind statistical procedures seem like common sense yet their importance in designing an investigation and producing factual analysis cannot be underestimated. I can also tell you that taking a graduate level statistics course is significantly harder than most undergraduate courses I took 15+ years ago. For this novice,

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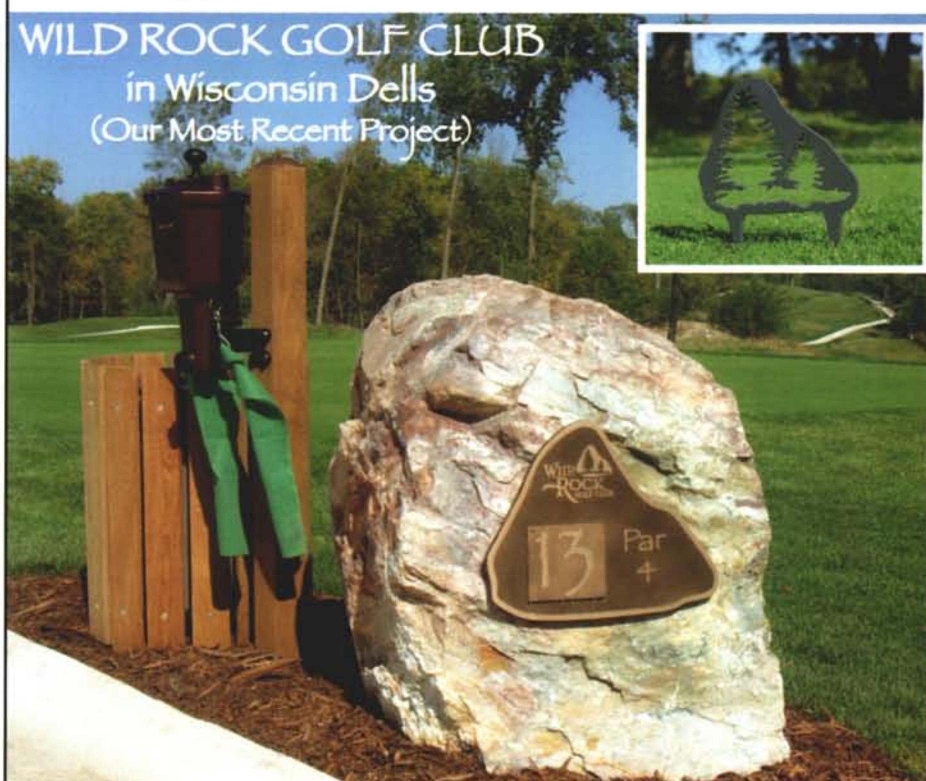

although many of the ideas seem obvious, their actual examination and calculation are very complex. There are many terms and procedures used in statistical science when analyzing data such as Null Hypothesis, Significance Testing, Confidence Interval, Power, Least Significant Difference, Sampling, and many others. I'll try to explain what some of these concepts mean.

Most statistical analysis starts out with a *null hypothesis*. That is an expectation that there is no distinction between the different treatments that you are observing. If there is an observed difference, statistics can be used to determine the probability that this difference is a chance occurrence. If the probability, due to chance, is calculated to be very small than we conclude that the difference is due to the treatment. In actuality, what you most likely want to find is that there is difference between treatments. You would love to learn that one fungicide, for example, will last significantly longer than all the others, unless it costs an arm and a leg. In other words, you'd like to reject the null hypothesis, which states, "The treatments are the same."

The statistical technique used to determine whether to reject or accept the null hypothesis is *significance testing*. Significance is a measure of probability that a certain difference is not due to chance. If the probability that these results could have occurred by chance is calculated to be extremely low, much less than 5%, then the null hypothesis (treatments are the same) should be rejected. If the null hypothesis can be determined not to be true, then you can be pretty sure that this observed treatment would be different from other treatments. Significance is just a way of telling you to what degree the treatment contributed to the difference. Then you can judge for yourself if the calculated significance value will make you believe that the particular treatment will make a difference.

Another similar approach to derive information from statistical inference is to calculate a *confidence interval*. A confidence interval is a plausible range for the true mean of the population. Say you wanted a type of turfgrass that could survive underwater for periods of time because you have some lowlands on your golf course that get flooded. You pay a researcher to investigate five different types of grasses that may be able to withstand submersion. They may find ABC grass can be underwater and survive for a period of one to seven days. The confidence interval in this case is one to seven days. (This is in contrast to significance testing discussed above which would tell you that ABC grass is distinctly better in it's flooding tolerance than the other four turfgrasses, but it would not tell you the upper and lower limit.) If that one to seven day interval is too broad and you absolutely need to know that a grass will last from three to five days underwater, that is, over a narrower interval, the researcher could direct a study towards achieving this. This investigation would be more costly because the sample sizes would have to be much larger to achieve the same amount of confidence in the prediction. Thus more lab time would be needed and the possibility that no turfgrass can confidently be recommended to withstand that interval may be the conclusion. The confidence interval produces a plausible upper and lower limit where most of the data in the population will fall between. This confidence interval approach is related to significance testing because significance will also tell you to what degree the particular range predicts the population.

Power is the name of another statistical calculation. Power considers that the sample results may not be an exact prediction about the population. The power calculation theoretically asks, "If the true population is different from the null hypothesis, to what degree of probability can the test results be expressed?" Say that Organosmellystuff (OSS) fertilizer is expected, from previous knowledge, to keep Kentucky bluegrass growing vigorously for an average period of 40 days. A study is planned to see if this expectation is realized. There is concern that OSS may only last for an average of 35 days. The researcher of the study may ask, "If the true population average longevity of OSS fertilizer is 35 days, then with what probability can I make the statement that my expected longevity of 40 days is not true?" Power is a

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measure of experimental sensitivity that determines how likely the sample results are to lead to rejection of the null hypothesis. Power and some basic algebra can also be used to help you determine how large a sample size, or how many replications that you will need to achieve a certain level of probability in your results.

Least Significant Difference (LSD) is a very common statistics calculation used when analyzing data for a turfgrass research report. LSD is a calculated range, which tells you that any treatments separated by this value or less are not to be considered different. Their difference depends only on the experimental error. For example, let's say you want to look at a National Turfgrass Evaluation Program to see which cultivar of fine fescue performed best. If you see a calculated LSD of 0.8 in the report, then a cultivar that is rated 6.6 is just as good as one rated 7.3. If two cultivars are rated with a difference of 0.9 or greater, then the higher rated one can be considered significantly better in this example.

Sampling is a process which explains that the larger the sample size, the closer the sample mean will be to the true population mean. This means that the more times a given treatment is replicated in a study the closer it will approximate the true population. If a study continues for a longer period it is also considered more accurate. This makes sense because if a study takes place over many years the climatic extremes that are experienced in the short term are balanced out. Longer studies are obviously more expensive so the cost/ benefits have to be weighed with the degree of confidence that you are trying to achieve. Another example is if a researcher is trying to prove their conclusion to a very high degree to a very critical peer group then they would need to replicate the study many more times than if they were just setting up a demonstration for a group of non-professionals.

There is a difference between a demonstration and an experimental research design. Experimental research designs need consistent and controlled data collection and statistical analysis. In contrast, demonstrations often lack that sophistication, but they are still very important. An example of one of these demonstrations at the Noer Facility is our turfgrass variety plot. We planted 20 different types, mixtures, or blends of turfgrass that grow in our upper Midwest climate for homeowners to observe. There is plenty of information already known about many of the characteristics of these turfs. To investigate a certain characteristic to yet a higher degree of confidence than is already available would take considerable amounts of time, effort, and money. Like most demonstration plots, this variety plot was inexpensive to install and yet it provides great information for non-professionals like homeowners. Non-professionals often just want more general information about what varieties to use. Demonstrations are also important in that they may, by chance, present a characteristic or input that should be investigated in much more detail in an experimental research design.

The Noer Facility has many demonstrations as well as experimental designs. An example of the latter is a study that has 15 different treatments with each treatment replicated 10 times. That study was designed by a department statistician. There is another study at the Noer Facility that will take place over ten years. Those are the kind of *samples* that will be able to make very accurate, statistically confident statements about the whole *population*.

There are many products that claim to positively effect turf health, such as decrease thatch, increase rooting, reduce pesticide applications, enhance winter hardiness, increase green speed, and on and on. To make those types of claims, a product needs to be evaluated using some statistical knowledge. If a salesperson or researcher can show you the statistical evaluation done in studying the product then you'll have more confidence in trying it. Every consumer needs some basic understanding of statistics in order to question and understand the claims that are made about a product or practice. Statistics, in spite of its complicated calculations, strengthens our understanding in many walks-of-life, from turfgrass management to sports. I just hope the original Packer outcome prediction holds true. The way that they're pounding the Bears today on December 1, 1996 ***(Substitute Vikings on November 11, 2007)***, as I write this, the prediction looks true with 100% confidence.

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