# Proceedings

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## PREFACE

The objects and purposes for which the **Northwest Turfgrass Association** (NTA) were formed include:

1. to promote, sponsor or conduct research, study and experimentation relative to turf management practices;
2. to promote, sponsor or conduct research, study and experimentation relative to weed, fungus and other pest control;
3. to promote, sponsor or conduct research, study and experimentation relative to the development of new grasses;
4. to promote and sponsor dissemination of information relative to research, study and experimentation findings and conclusions;
5. to promote and sponsor educational opportunities relative to research, study and experimentation findings and conclusions;
6. to promote and sponsor public information relative to growth and maintenance of turf;
7. to promote, sponsor and conduct activities and events designed to generate funds for use in carrying out the objects and purposes herein;

Sponsoring and conducting the **Northwest Turfgrass Conference**, along with publishing the proceedings of the conference, are two of the annual activities of the NTA aimed at accomplishing the above objects and purposes.

## 1993-94 President's Message

On behalf of the 1993/94 Board of Directors of the Northwest Turfgrass Association, it gives me great pleasure to thank the many members, employees,suppliers, companions and fiends who attended and supported the Northwest Turfgrass Association sponsored **48th Northwest Turfgrass Conference**.

The program at this year's conference at Salishan Lodge in Gleneden Beach, Oregon was excellent thanks to to outstanding efforts of the following conference committee chairpersons: Becky Michels-Companion Program; John Monson and Don Clemans-Education Program; Mark Snyder and Grant Rogers-Golf Tournament; Tim Haldeman-Sponsor Program; Jim Dusin-Tours; and NTA staff, Jerry Crabill and Blair Patrick, for promotion, site arrangements and registration. Each of these individuals, along with those who helped them, made this conference a success and they deserve our thanks and congratulations.

We had another year of outstanding presenters who covered a wide range of topics relating to turf management. Space here doesn't permit me to properly recognize or thank them individually but, were it not for them, our conference would not have been the quality it was.

Sponsors are a major source of NTA research and scholarship funds for the year so it gives me great pleasure to offer a special thank you to all suppliers who sponsored a tee, meal or break during the conference. Their support is genuinely appreciated.

Tom Christy, CGCS
1993-94 NTA President

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## EDITOR'S NOTE

A proceedings papers was not received for the following presentations made during the **48th Northwest Turfgrass Conference:**

| | |
|---|---|
| **PROMOTING YOUR OWN IMAGE** | Ms. Bobbie Gee<br>Bobbie Gee Enterprises<br>Laguna Beach, California |
| **WORKING IN TURFGRASS MANAGEMENT IN THE 90'S** | Ms. Bobbie Gee<br>Bobbie Gee Enterprises<br>Laguna Beach, California |
| **IT'S O.K. TO THINK YOU'RE WONDERFUL** | Ms. Bobbie Gee<br>Bobbie Gee Enterprises<br>Laguna Beach, California |
| **WHAT GOLFERS EXPECT TO SEE WHEN THEY ARRIVE AT THE COURSE** | Mr. David Jacobsen<br>Farwest Equipment & Supply<br>Portland, Oregon |

# INTEGRATED TURF MANAGEMENT TECHNIQUES TO LIMIT NITRATE MOVEMENT[1]

Dr. Stanton E. Brauen[2]

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[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.
[2] Research and Extension Leader, Research & Extension Center, Washington State University, Puyallup, Washington.

The Pacific Northwest climate is characterized by dry summers and wet winters. Certainly the first is true. Summers are dry. Average summer rainfall for most areas of western Washington and western Oregon is less than two to four inches from June to October. The winter is a different story. The winters are long, mild, and rainy. Some areas are very wet; others are not very wet. The Olympic mountain rain shadow area often receive as little as 15 inches from October to June. Other areas can get as much as 80 inches. However, most areas where golf courses and athletic turf is managed receive less than 30 inches during the winter. The Puget Sound basin receives about 32 to 40 inches annually. Similar quantities fall annually in the Willamette Valley of Oregon. Higher rainfall is common on the Oregon-Washington coast. Here rainfall ranges from 40 to 60 inches usually. Summer rainfall is also a little higher, but not much. Of course rainfall east of the Cascade mountains is variable and much lower than west of Cascades but often rainfall totals between 10 and 22 inches annually. Evapotranspiration is much higher.

As a result turf areas west of the Cascades are usually green, used all year long and some grasses grow all winter west of the Cascades. Perennial ryegrass and annual bluegrass biotypes grow a lot in winter. Other grasses, such as creeping bentgrasses, Kentucky bluegrass, velvetgrass, tall fescue, and some fine fescues have slow growth rates or approach dormancy from November through February.

So, does N leach in summer, fall, winter or spring or does it leach at all. Some say turf managers grow grass with such luxury and with such free scale application of fertilizers and other chemicals to make it certain that leaching occurs. One thing is certain. The weather conditions and implied management suggest to the public that turf managers practices are a potential threat to environmental quality. If true, the result could be groundwater contamination. But if grass roots serve as good filters, even when growth conditions are slow, nitrate losses could be very limited and controlled by management practices.

## THE PROBLEM WE NEED TO UNDERSTAND

If management can control nitrate leaching from putting greens in the Northwest environment, what kind of practices would be most effective in reducing the threat? Three factors were studied in our research. These were: 1) How much total annual nitrogen is safe? 2) How should it be applied or would frequency of nitrogen application affect or limit nitrate leaching? Would fertilizer applied in lighter doses and at more frequent intervals even from slow-release sources provide increased safety. 3) How important is it to construct the putting greens or athletic fields with rooting mediums of amended or modified sand in comparison to a pure sand?

To study this, 36 miniature golf greens were constructed and each had its own drain installed so all the leachate or drainage water could be collected and analyzed for nitrate nitrogen any day leaching occurred. By knowing how much drainage water was leached through a putting green at all times of the year and what the concentration of nitrate nitrogen was each day, a picture could be developed showing the influence of management practices on nitrate loss. Fortunately, the United State Golf Association (USGA) and the Northwest Turfgrass Association (NTA) agreed and committed funding to support the research required to shed a bit of light on the answers to these questions.

## THE APPROACH WE TOOK

The turfgrass lysimeters were located 30 miles south of Seattle, Washington at Washington State University Research and Extension Center, Puyallup, Washington. Each lysimeter was 32 sq ft., lined with chlorosulfonated polyethylene reinforced liner and fitted with 2" ABS drain tube so leachates that moved through the 12 inch rooting medium, the 3 inch bunting layer and 3 inch pea-sized gravel layer could be collected daily. The rooting medium consisted of pure sand (CEC 2.6 meq per 100 g, pH 6.8) or a mixture of 88% sand, 10% sphagnum peat, and 2% screened Sultan silt loam. Particle size analysis of the sand was 4.2% between 1.0 and 4.7 mm, 85.1% between 0.25 and 1.0 mm, 8.5% between 0.13 and 0.25 mm. and 2.2% $<$ 0.13 mm. The effects of rooting medium, annual nitrogen rate, and nitrogen application interval on leached nitrate nitrogen were monitored for two years.

The nitrogen fertilizer rates were 4, 8, and 12 lb N per 1000 sq ft. per year. The nitrogen was supplied in granular form as greens grade blends of ammonium sulfate, ammonium phosphate, isobutylidene diurea (IBDU), sulfur coated urea (SCU), and methylene urea (MU). The ammonium sulfate and ammonium phosphate quantities were equal for all nitrogen rates and all of the increase in nitrogen rate from 4 to 12 lb was supplied as IBDU, SCU and MU (See Table 1). Phosphorus was supplied from ammonium phosphate and potassium was supplied from potassium sulfate. Fertilizer applications were made every 14 or 28 days in 22 or 11 applications per year. Fertilizers were applied from February to through December.

After construction of the lysimeters during the summer of 1991, the area was seeded on October 3. The first rainfall occurred on October 24, 1991 and leachates were collected in plastic 5.5 gallon buckets beginning on October 25. Leachate volumes were measured daily and subsamples were collected daily when available, for the next two years.

## WHEN NITRATE LEACHED

Nitrates did leach from some of the lysimeters when the creeping bentgrass was very immature, that is, during the first fall and spring following seeding and before many roots had time to develop. As would be expected most nitrate nitrogen was leached from lysimeters that received the most nitrogen at the highest annual rate (8 and 12 lb N per 1000 sq ft.). Very little nitrate was leached at the 4 pound per 1000 sq ft. rate. Nitrate was present in drainage water until late December and declined to low levels in January and February. These lysimeters were seeded to bentgrass the first week of October, a date that would normally be considered late although much later seeding times are often encountered in practice. Considering how fragile these bentgrass seedings were throughout the fall and winter of the first year, an earlier seeding period, say September 1 or before, would have greatly decreased the potential for nitrate leaching from these new greens. In practice, earlier seeding to establish bentgrasses with stronger root systems should be encouraged and will significantly reduce the potential for leaching nitrate from newly constructed pure sand greens.

The concentration of nitrate percolating from the lysimeters, during the first fall, winter and spring following construction and seeding, was considerably different than the concentrations of nitrate leached during the second fall, winter and spring after the turf had matured. These nitrate patterns of the leachates are shown in Figure 1. The differences shown emphasize the changes that occurred in the ability of turfgrass to trap nitrogen as the turf matured. Note the large differences in nitrate concentrations from November to June of 1991-92 when lysimeters were fertilized with 12 pounds N per 1000 sq ft. per year rate verses the lower rates of 4 and 8 pounds nitrogen per 1000 sq ft. in 1992-93.

The first fall when turf was young, there were few grass roots, no thatch and there was no organic matter in the pure sand rooting medium. This resulted in free movement of nitrates through the rooting medium and into the drainage water. Pure sand rooting systems were very susceptible to nitrate leaching immediately after construction. Everyone would have expected this to be the case. As a consequence, nitrates in relatively high concentrations were lost at the highest rate of nitrogen application even though the nitrogen sources were primarily ammonium sources. Little nitrate was leached at the lowest rate.

The frequency of nitrogen application (14 or 28 days) and make-up of rooting medium (pure sand verses organic matter modified sand) were big factors in controlling the quantity of nitrate leached during this first fall and winter when the turf was young. The average monthly nitrate-N concentration of leachate from pure sand rooting medium was significantly greater than the leachate concentration from modified sand rooting medium from November, 1991 to June, 1992.

By the second fall, the turf had become well established. Roots were well defined and a thatch surface had developed. The rooting medium and the frequency of fertilizer application were less important in reducing nitrate movement. Then, the quantity of nitrogen applied was the main factor responsible for nitrate movement into the drainage water.

For the most part, nitrates leached only from lysimeters that were fertilized with 12 pounds of nitrogen per 1000 sq ft. per year during the second year. Rooting medium had little effect in regulating the concentration of leachable nitrate. Frequency of nitrogen application seemed have some effect on reducing nitrate leaching during the late fall and early winter period. Nitrates could be detected during periods when excessive rainfall was experienced following the heaviest nitrogen applications. Periods when this would occur were when nitrogen applications above 0.4 lb N per 1000 sq ft. were applied followed by periods of slow precipitation over the next seven to 10 days and after the rooting medium maximum temperature had declined to below 40° F and the minimum temperature was above 33° F. Under these conditions, halving the rate of nitrogen application and applying on a more frequent interval reduced nitrate movement. As long as the 2 inch temperature of the rooting medium remained in the above range, plant uptake appeared to be great enough to prevent nitrate accumulation in the leachates. November nitrogen fertilization at moderate rates did not result in leaching of nitrate-N.

The highest concentration of nitrates in leachates occurred in early to mid-spring growth periods. The rainfall pattern was significantly different during the winter and early spring of 1993 as compared to 1992. Precipitation occurred early in January in 1992 resulting in very low levels of nitrate concentration in leachates during January and February. Precipitation was considerably lower in March and early April in 1992 as compared to 1993, which may have resulted in lower volume of leachates and higher concentration of nitrate-N in 1992. The differences in nitrate concentrations between these two years also may reflect the differences in maturity of the rooting mediums and the accumulation of organic matter in the rooting medium. Organic matter in the rooting medium had increased to nearly 2% in the pure sand by end of the second year and approached 2.5% in the modified rooting medium. No nitrates were found in any treatment combination during the summer through mid-fall of either year. This would imply that the risk of leaching nitrates in summer due to unexpected heavy rain or over-irrigation is very low when turfs are fertilized on frequent intervals and the total rate of application does not exceed the moderate rates used in these studies.

The quantity of nitrate leached through the greens is a function of the nitrate concentration in the drainage water and the volume of drainage water produced. The product of these two values showed that in the first year, two periods of the year were most sensitive to nitrate leaching. These were in November, four to eight weeks after seeding and in April and May when soil temperatures fluctuated between 45 to 55° F (See Figure 2). Even though the greens were actively growing during this period of the spring, the root systems still lacked sufficient maturity to be highly efficient in nitrate uptake.

As little as 0.33 and as much as 7.55 percent of the applied nitrogen was leached as nitrate in the first year. The highest percent nitrate lost was from the 12 pound nitrogen per 1000 sq ft. rate. In the second year, 1.26 percent was the highest quantity leached. Essentially no nitrate was leached from the 4 or 8 pound rates in the second year in either the pure sand or the modified sand greens (See Table 2). It should be noted that 4 pound nitrogen per 1000 sq ft. per year was insufficient to support bentgrass or annual bluegrass growth in putting greens under play in the Northwest. But 0.36 pound nitrogen per 1000 sq ft. (8 pound nitrogen per 1000 sq ft. per year) applied at two-week intervals was more favorable. At this fertilization rate each 14 days, 2.7 pound nitrate per acre or 2.1 percent of the nitrogen applied was leached in the first year. In the second year, only 0.03 percent of nitrogen applied was leached.

In summary, experimental putting greens which were constructed close to USGA specifications were monitored for concentration of nitrate in leachates from October, 1991 to October 1993. During the first year, the concentration of nitrate nitrogen leached from their profiles was related to rate and was strongly modified by the rooting medium and frequency of nitrogen application made to the immature turf. In this same time period, the concentration of nitrate leached from pure sand rooting medium was much greater than the nitrate leached from the sand rooting medium modified with peat moss. Modified sand greatly reduced the total quantity of nitrogen that was lost as compared to pure sand. The frequency of nitrogen application to young turf during the first year significantly affected the level of nitrate-N lost. Although the impact of this factor was much less than either nitrogen rate or rooting medium effects, it did consistently influence nitrate-N concentration in the leachate. The use of modified sand rooting medium, moderate levels of total annual N application and frequent nitrogen application combined to reduce nitrogen lost in leachates to 2.7 to 3.6 pound acre and the percentage of applied nitrogen lost in leachates to as low as 3 to 5 percent.

In the second year, nitrate-N concentration in the leachates was greatly reduced compared to year one. A significant part of this major change was attributed to more extensive rooting, increase in thatch and increase in organic matter in the rooting medium. The nitrate concentration leached was rate related again but the extent of nitrate leached was not strongly modified by the rooting medium or how often the turf was fertilized. The nitrate concentration leached from pure sand profiles was similar to that leached from modified sand profiles most of the year. In addition, the reduced nitrate concentration in leachates was attributed to a greater quantity of precipitation (2.2 inches) during early spring in 1993, as compared to 1992, resulting in dilution of leachate nitrate concentration. Nearly zero concentration of nitrates were observed in leachates in summer or fall until December.

## CONCLUSIONS

When putting greens were immature and fertilized with a moderate nitrogen rate the most important factor to limiting nitrate leaching was to modify the rooting medium during construction with organic matter, in this case peat. Applying the fertilizer on 14 day intervals also was important particularly during the periods when leaching pressure was high. Managing young greens in this manner essentially eliminated nitrate movement into the drainage system. As putting greens matured and thatch and organic matter levels developed in the pure sand system, nitrogen fertilization rate was the major factor that resulted in nitrate leaching. Eight pounds or less nitrogen per 1000 sq ft. per year annually did not result in nitrate leaching. Applying nitrogen fertilizers with at least 70 percent of the nitrogen source in slow release form on a frequent interval such as every 14 days provided excellent protection from nitrate leaching. At this point in our study, nitrate concentration in drainage water from putting greens can be effectively limited by nitrogen application rates, frequent light nitrogen applications and a modified sand rooting medium during early establishment.

Paper presented at the 48th Northwest Turfgrass Conference at Salishan Lodge, Glenedon Beach, Oregon on September 28, 1994. The research support of the United States Golf Association Green Section and the Northwest Turfgrass Association is greatly appreciated. The effort of several faculty and staff is greatly appreciated. Those who contributed to this research and other aspects of this project were Eric Chapman, Gwen Stahnke, Craig Cogger, Bill Johnston, Bill Pan, Andy Ekuan, Martin Okiro, Robert Ingram, John Hopkins, Carla Putvin, Diane Ritthaler, Jerry Kuo, Jason Kuo, Matthew Webster and Jenifer Brauen.

Table 1: Quantity of soluble and slow release nitrogen applied at each fertilizer application interval.

| Nitrogen Rate | Annual Rate (lb N/1000 sq. ft.) | | |
|---|---|---|---|
| | 4 | 8 | 12 |
| | Eleven Monthly Applications (lb N/1000 sq. ft.) | | |
| Ammonium phosphate | 0.04 | 0.04 | 0.04 |
| Ammonium sulfate | 0.20 | 0.20 | 0.20 |
| Urea | 0.02 | 0.07 | 0.13 |
| Slow release[1] | 0.10 | 0.41 | 0.72 |
| Total Application[2] | 0.3 | 0.72 | 1.09 |
| | Twenty-two 'Two Week' Applications (lb N/1000 sq. ft.) | | |
| Ammonium phosphate | 0.02 | 0.02 | 0.02 |
| Ammonium sulfate | 0.10 | 0.10 | 0.10 |
| Urea | 0.01 | 0.04 | 0.07 |
| Slow release[1] | 0.05 | 0.20 | 0.36 |
| Total Application[2] | 0.18 | 0.36 | 0.55 |

[1]Slow release nitrogen sources consisted of methylene urea, sulfur coated urea and IBDU supplied in quantities to provide equal parts nitrogen from each source. Potassium was supplied from potassium sulfate as a part of the mix.
[2]Pounds of nitrogen applied per 1000 sq. ft. per application.

Table 2: Percent of applied total nitrogen leached as nitrate.

| Rooting Medium | Annual N | Year 1 | Year 2 | 2 Years |
|---|---|---|---|---|
| | Lb/1000 sq ft | % | | |
| Sand | 4 | 5.37 | 0.06 | 2.71 |
| | 8 | 6.31 | 0.04 | 3.17 |
| | 12 | 7.55 | 0.70 | 4.28 |
| Modified | 4 | 0.33 | 0.40 | 0.16 |
| | 8 | 0.91 | 0.02 | 0.17 |
| | 12 | 3.37 | 1.26 | 2.31 |

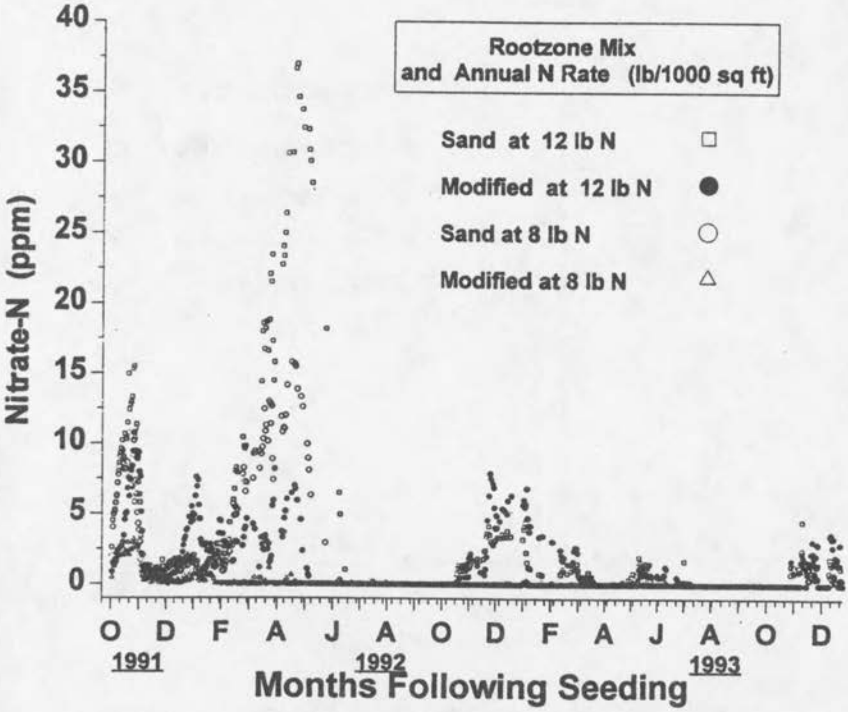


Figure 1. Daily Nitrate-N in Leachates from Sand and Modified Sand Rootzone Putting Green Lysimeters Fertilized with 8 lb and 12 lb N/1000 sq ft Annually. Values summarized over 14- and 28-Day Fertilization Intervals.

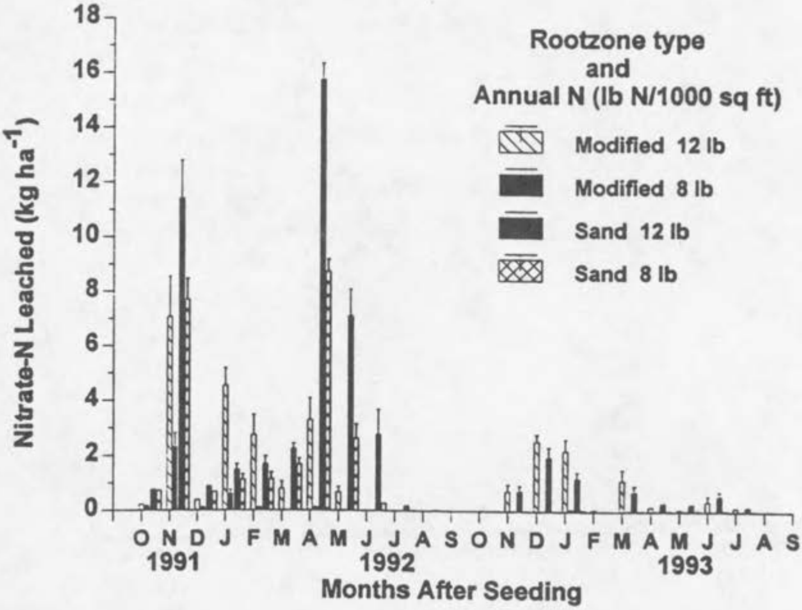


**Figure 2. Monthly Quantity of Nitrate-N Leached from Sand and Modified Sand Rootzone Putting Green Lysimeters Fertilized with 8, and 12 lb N/1000 sq ft Annually. Values summarized over 14- and 28-Day Fertilization Intervals.**

# FERTILIZER EFFECTS ON TURFGRASS DISEASE[1]

Mr. Tom Cook[2]

[1]Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.
[2]Associate Professor, Horticulture Department, Oregon State University, Corvallis, Oregon.

There are a host of factors that determine when and if turfgrass disease symptoms appear. Some of these key factors include grass species and cultivar, light, temperature, and humidity, irrigation intensity, and soil moisture. Other factors include mowing practices, thatch impact, traffic and soil compaction, and the influence of pesticides on plant vigor. In addition to all of these is the effect of fertility on turf diseases. From a holistic standpoint it's impossible to consider just one of these many factors when trying to understand turf disease activity. Whenever diseases occur there is a good chance that most if not all of these factors play a part. In reading the following discussion on turf fertility impacts on diseases keep in mind that it is only one of many factors involved. In some cases fertilizer may be the dominant factor and in others it may play a very minor role. For the most part fertilizer influences the severity of disease not whether or not the disease will occur.

## GENERAL MECHANISMS

Fertilizer affects disease activity directly by influencing macro nutrient levels, micronutrient levels, and nutrient balance. Indirectly fertilizer affects disease by changing soil pH. When fertilizer reduces disease it may do so by stimulabng grass to outgrow the disease, by promoting general health, by stimulating production of toxins within plants, or even by being directly toxic to pathogens. In reality high fertility levels reduce activity of some diseases but increase activities of others. Table 1 lists diseases that are more severe under high or low fertility levels.

Table 1. Disease severity as affected by high and low fertility.

**WORSE UNDER LOW FERTILITY**

| | |
|---|---|
| Anthracnose | *Colletotrichum graminicola* |
| Bentgrass leaf blight* | *Drechslera catenaria* |
| Dollarspot | *Sclerotinia homeocarpa* |
| HAS syndrome | *Complex disease* |
| Pink patch | *Limonomyces roseipellis* |
| Red thread | *Laetisaria filciformis* |
| Rust | *Puccinia coronata, & P. striformis* |
| Winter brown blight* | *Drechslera siccans* |

**WORSE UNDER HIGH FERTILITY**

| | |
|---|---|
| Brown patch | *Rhizoctonia solani* |
| Fusarium patch | *Microdochium nivale* |
| Grey snowmold | *Typhula sp.* |
| Leaf spot | *Drechslera poae* |
| Necrotic ringspot | *Leptosphaeria korrae* |
| Powdery mildew | *Erysiphe graminis* |
| Pythium blight | *Pythium sp.* |
| Yellow tuft | *Sclerophthora macrospora* |

* Based on personal observations. In general Drechslera diseases are considered worse under high fertility, but I consistently see these in the PNW under low fertility conditions.

Fertility level as a concept is difficult to define but in the context of this paper refers to consistent applications of fertilizer applied over a period of at least one year. In the case of nitrogen on turf with clippings removed, levels below 4 lbs N per 1000 sq ft per year are low. Nitrogen levels above 8 lbs per 1000 sq ft per year where clippings are removed are considered high. It's hard to quote low levels on areas where clippings are returned but 2 lbs N per 1000 sq ft per year will generally be low. Above 6 lbs of N per 1000 sq ft per year where clippings are returned would be considered high by my standards.

In terms of short term response, 1/4-1/2 lb N per 1000 sq ft per application is low for turf cut higher than putting greens. Rates above 1 1/2 lb N per 1000 sq ft per application are considered high. On putting greens per application rates of N below 1/4 lb per 1000 sq ft are low while those above 1/2 lb N per 1000 sq ft are high. Newer greens high in sand content may require minimum rates of 1/2 lb N per 1000 sq ft just to see a response.

Regardless of actual fertilizer rates, turf is under low fertility during the growing season when color, density, and clipping production is low. Turf that is dense, dark, and producing excessive or unwanted clippings is under high fertility.

**SPECIFIC DISEASE - FERTILIZER INTERACTIONS**

In the following discussion of specific diseases you will see that fertility-disease interactions range from simple to quite complex. In many cases balance of nutrients is more important than nitrogen level alone but often they work in concert. It will also be apparent we know much more about some diseases than others.

## TAKE ALL PATCH: *GAEUMANNOMYCES GRAMINIS* VAR. AVENAE

Because of its importance worldwide on wheat we probably know more about fertility impacts on Take All than any other disease. With so many new golf courses being planted with bentgrass Take All is once again a very important disease in the Pacific Northwest.

Balanced N-P-K applied consistently in small quantities is the starting point for minimizing severity of Take-All. Target ratios for N-P-K run somewhere in the range of 31-2 to 5-1-4.

Unbalanced N P K high in nitrogen will generally increase disease. Nitrogen sources that remain in the NH4+ form suppress this disease. Nitrate nitrogen tends to increase disease. Therefore Ammonium sulfate, Ammonium chloride, and sulfur coated urea are good nitrogen sources to minimize this disease.

Potassium has no direct effect on Take All. High K with low N or P increases disease. High K in balance with high N and low P reduces disease.

Fertility effects on soil pH have a profound impact on Take All. Low soil pH reduces Take All by reducing nitrification, enhancing growth of antagonistic microorganisms, and increasing uptake of manganese. Manganese is toxic to the Take All fungus but also affects important plant functions because it is needed for lignin synthesis, soluble phenol production, and several enzyme systems.

The role of sulfur in Take All control has long been studied in the Northwest. Sulfur appears to have direct fungicidal properties and causes a decrease in soil pH which reduces nitrification. It also increases availability of manganese. The combination of these events causes a shift in microbes in favor of antagonistic fungi. Historically sulfur has been our most effective tool in managing Take All Patch.

Lime may increase Take All by counteracting the effects-of sulfur and other acidifying fertilizers. Since Take All is a disease of young turf and tends to subside as turf ages, wise turf managers will resist the urge to lime young bentgrass turf when soil pH is between 5-6.

Putting all of this information together leads to a fertility plan that looks something like the following. Use balanced N-P-K year round striving for an approximate ratio of 5-14. Use N sources such as (NH4)2S04, NH4CL or SCU when possible. Maintain total N levels at the moderate level (i.e.) 6-8 lbs N per 1000 per year on sand or 3-4 lbs N per 1000 per year on soil). Apply sulfur consistently, stnving for total annual rates of 3-4 lbs S per 1000. On sand based turf pay attention to micronutrient levels and avoid deficiencies as determined by tissue analyses. Finally, avoid liming if at all possible. Soil pH levels of 5 or above are acceptable for bentgrass turf and do not require liming. If lime is applied for whatever reason make sure adequate sulfur is also added as noted above.

## FUSARIUM PATCH: *MICRODOCHIUM NIVALE*

Over the years a great deal of research has been conducted by Dr. Roy Goss and his colleagues at WSU concerning Fusarium patch. Out of this work has come a relatively clear picture of how to manage fertility to minimize this disease.

On bentgrass the story is simple. Maintain balanced N P K year round (i.e. 5-1-4 ratio). Maintain moderate N (i.e. 6-8 lbs N per 1000 per year on sand based turf). Finally, maintain sulfur at 3-4 lbs S per 1000 per year via small increments applied fall through spring. Sulfur can be applied via (NH4)2S04, SCU, or even urea plus K2S04 or elemental S.

On annual bluegrass you need to change strategy slightly. Maintain N P K balance as per bentgrass. Definitely maintain moderate N levels (i.e. 4-6 lbs N per 1000 per year). Avoid using more than 1.5 lbs S per 1000 per year. Higher S levels will weaken annual bluegrass and actually stimulate Fusarium patch disease.

When dealing with annual bluegrass accept the fact that it is highly susceptible to Fusarium patch. Proper fertility will reduce severity of this disease but turf will still be hit hard. There is no way to grow annual bluegrass on greens and tees without applying fungicides for control of Fusarium patch.

## NECROTIC RINGSPOT: *LEPTOSPHAERIA KORRAE*

Like Take All and Fusarium patch, Necrotic ringspot disease is less severe when turf is maintained with balanced N P K (i.e. 5-1-4 ratio). Moderate N (i.e. 4-6 lbs N per 1000 per year on soil) also seems to reduce disease severity. Fertility programs using natural organic nitrogen or synthetic slow release nitrogen appear to reduce disease severity. High rates of soluble N tend to increase this disease.

Although Necrotic ringspot has symptoms similar to Take All the causal organisms do not react the same way to sulfur. High S fertility does not appear to control Necrotic Ringspot based on research done so far. We have a lot to learn about this important disease of Kentucky bluegrass.

## RED THREAD: *LAETISARIA FUSIFORMIS*

As the most common disease of perennial ryegrass and the fine fescues, Red thread is a classic low fertility disease. Vigorous turf receiving adequate N will consistently have less Red thread than hungry turf. Adequate N on perennial ryegrass grown on soil with clippings removed may run as high as 6-8 lbs N per 1000 per year. With clippings returned, 3-4 lbs N per 1000 per year may be adequate.

Since Red thread occurs primarily in fall through spring it is important to stimulate turf growth adequately in fall to maintain vigor as cold weather approaches. Once temperatures drop to the 35-45°F range it is too cold to expect a rapid response from applied fertilizers.

On hungry turf suffering from Red thread, a single application of N from a soluble source at a rate of 2 lbs N per 1000 sq ft is often adequate to stimulate enough growth to grow out of this disease. This is one case where short term control of the disease is best accomplished with soluble nitrogen. Slow release N is effective as part of an on going fertility program but not for curative control.

Turf receiving balanced N P K will generally have less Red thread than turf receiving unbalanced fertility. While N has a dramatic impact on Red thread, applications of P or K alone have no effect on this disease. The best strategy is good N P K balance with moderate N levels and applications targeted to maintain vigorous growth when Red thread weather approaches.

## RUSTS: *PUCCINIA CORONATA & P. STRIFORMIS*

Rust is another low fertility disease affecting primarily perennial ryegrass and Kentucky bluegrass. More importantly Rust is a disease of nonvigorous grass. Because of our mild climate and the fact that Rust occurs primarily in fall we can reduce disease activity by applying nitrogen to stimulate growth. In areas where Rust is a summer problem nitrogen fertilizer can increase problems by stimulating other diseases.

On grasses susceptible to Rust, the fungus tends to infect mature leaf tissue. When growth is slow there is a high proportion of mature leaves in the canopy. Fertilizing with nitrogen stimulates new foliage which is temporarily resistant to Rust infection. Vigorous turf will still get Rust but symptoms will be partially masked by the high proportion of young shoots that are still resistant.

## BROWN BLIGHT: *DRECHSLERA SICCANS*

Brown blight is a significant problem on perennial ryegrass. It tends to worsen on young turf and particularly on turf that is hungry. We can reduce disease symptoms 50-70% by timely applications of nitrogen. Moderate N applications through fall are effective in controlling this disease in most years.

Most literature on Drechslera diseases indicates they are worse under high nitrogen fertility and in fact this is true in the PNW with diseases caused by D. ~e. I have consistently observed, however, that low fertility perennial ryegrass has more Brown blight than perennial ryegrass receiving moderate nitrogen fertility. This disease is similar to Rust in that it attacks mature leaves first. On a tiller of a vigorous perennial ryegrass there are generally no symptoms on the youngest 2-3 leaves while older leaves show distinct lesions starting at the leaf tips. On weak ryegrass symptoms are often apparent on all visible leaves.

## ANTHRACNOSE: *COLLETOTRICHUM GRAMINICOLA*

Anthracnose is a complicated disease to understand. It affects primarily annual bluegrass putting greens in the Pacific Northwest and appears both in the heat of summer and during winter. In the winter it generally develops the crown rot phase in which individual tillers linger, slowly turning a golden yellow color. In warm summer weather, foliage has more of a bronze color and turf tends to die out in small irregular patches.

My observations indicate that a low nikogen fertilizer level contributes to this disease but is only one of many factors involved. The key in managing this disease with N is to be consistent in applying enough nitrogen to maintain healthy turf during summer and fall without overstimulating turf and increasing the chance of Fusarium patch.

Most of the reported research supports this approach. The key is to remember that nitrogen alone will not control this disease. Fungicides must be applied along with fertilizer N.

## SUMMARY

Fertility is one of many factors that influence severity of turf diseases. Properly managed, fertilizer can help reduce many of our most serious diseases. Key aspects of nutrition we can manipulate include nitrogen rate, timing, and source along with N-P-K balance and micronutrients. Good turf managers will study specific turf disease problems and adjust fertilizer applications to avoid causing disease problems. While we understand some diseases fairly well there is much to learn about many others.

# IS YOUR RODENT CONTROL PROGRAM AN EXERCISE IN FUTILITY?[1]

Mr. Douglas C. Freeman[2]

[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.
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With the loss of certain control agents over the last few years and the ever expanding demands placed on us by the Endangered Species Act, your task of rodent control is becoming almost unworkable. Responsible efforts must be made to protect your investment as well as the concerns of the environment. Nonetheless, lets approach the steps toward successful rodent control, in light of these issues.

The most effective way to deal with an entire range of vertebrate pest problems is to better understand the pest and apply the best method for damage reduction. Certain principles apply as we approach an integrated method for long term pest control.

Hopefully, this article will act as review along with providing you with some of the current methods for reducing animal damage caused by rodents in and around the ranch and farm.

Animal populations will vary according to the situation in which they live. All influences or mechanisms causing their presence are not known but factors such as disease, available food, fertility, stress in habitat, soil and climatic conditions play an important role. Population levels can be reduced when food, shelter and water are reduced below species requirements. This, unfortunately in agricultural situations is usually not an option. Habitat manipulation or modification is generally never practical but never to be overlooked in limited situations. (Example: sanitation, harborage removal around stored grains and equipment). Animals will tend to match or limit their numbers reflecting the capacity of the area to support their populations. In most situations, some form of population control is necessary.

Common agricultural pests found damaging crops or property may be taken at any time by a number of methods but effective control done economically and safely requires some planning.

When population control programs are used against a rodent pest, a mix of information needs to be applied for solid results or for review if the program you used falls on its face and you need to work on plan B or even C. Developing a sound game plan includes what has been referred to by the Pest Control Specialists as Integrated Pest Management. It makes sense and does save money, produces higher results, and reduces risks to non-targets directly and indirectly. So much of our success in controlling or reducing pest damage is proper preparation and execution of a good plan. The major components of an IPM plan include: 1) correct identification of the pest species, 2) using most effective methods and tools in the control program, 3) reinvasion monitoring and follow-up programs.

"The oh well, lets do something" approach to timing of a control program can and does determine the outcome, typically in a negative way. Generally, the timing of a control program as well as the tools and method used will be determined by: the specific pest present, its biology, the crop or location of the infestation, weather conditions, manpower, etc. The biggest factor is, if the pest does really pose some form of threshold damage to your crop or property. In most cases, these threshold levels are quite low leaving control decisions driven by past experience.

The most successful programs utilize some or all aspects of habitat modification, behavioral manipulation, and population control.

Habitat manipulation acts to limit access to one or more of the essential requirements of life; food, water and shelter. Limiting aspects include, rodent proofing buildings, weed control around crops and buildings, elevated storage, removal of debris, etc. Many of these are doable, some are not always practical.

Behavioral manipulation can act to alter the behavior of the animal by introducing nuisance items that try to irritate the acute senses of the pest. Some methods include: frightening devices, repellency agents, bells, horns, lights, etc. Most animals learn to respond to most devices cautiously and not fearfully after they understand the item is not life threatening. Hence, this form of control is generally ineffective on rodents and the damage will usually reoccur.

Population control programs involve direct reduction in the present pest population by utilizing traps, shooting, toxic baits, gases, etc. Reoccurring pest populations will require maintenance approaches where possible and full scale control programs on large site applications. Certain large site projects would be gophers in forage crops and tree fruit crops with historical pest infestations. Maintenance programs would include squirrel or rabbit programs where limited population dictate cyclic control projects repeated systematically. Rat and mouse control programs are generally considered a maintenance program although we start with an intensive knockdown program followed up with monthly control methods.

**Population reduction tools available for field and farmstead include:**

Gophers: gas pellets, poison baits, traps, shooting, burrow flooding.

Ground squirrels: gas pellets, smoke bombs, exhaust fumes, poison baits, traps, tree wraps, shooting, burrow flooding.

Voles: traps, poison baits, shooting, screening.

Rats and mice: Snap traps, glue boards, tracking powder, poison baits, mechanical repeating traps, gases, and smoke bombs.

## PLANNING THE PLAN

1. Determine the type of pest and or pests found in your cropping situation by visual observation of animal or its signs of presence or damage.

2. Design a control program that considers the biology of pest. Rodents vary in their feeding preferences, activity periods, foraging techniques, social interactions, when they go dormant or if they're active through the winter months, etc. Locate and log this information religiously. This step defines the window of optimum control, the best timing for results. Sources of this information are typically found through your local Extension Office.

3. List the tools you can use, and the potential risks to non-targets. When using a control agent, specifically lethal in nature, always follow the written directions or information to reduce risk and improve results.

4. Fit the control program to your specific pest problem. Use a combination of tools when possible. Timing and proper application of control agents will increase your results and reduce risk and cost of the overall project. Always utilize your most effective tool, communication. If you're not sure, contact an experienced representative at your local Extension Office, State University, or manufacturers rep.

5. Monitoring to review results. Additional activity by rodents should be met by a better informed tenant who is using a professional information and his or her own practical knowledge to combat the pest more effectively. Some pests can be an exercise in futility because we have so few good tools at our disposal.

## POCKET GOPHERS

Sign of pest: Earthen mounds randomly spaced that have a typical fan-shaped look with the discharge hole that is found on side of the mound. The plug is generally closed unless the rodent is building the system or trying to dry out the system after a storm or heavy irrigation. The habitat of the gopher is below ground and they venture above ground only to find nesting material or food that is typically within a short distance of burrow opening. Migration to other areas occurs mainly in the late spring and early summer and is made up of mainly juveniles whom have been booted out after weaning is completed. They're example should be heeded by many liberal families in America.

Bio-Profile: The gopher does not go dormant. They dig tunnel systems to gain access to primary food (vegetative matter), for safety (barborage), and for breeding purposes (figure it out). Life span is generally about 1-2 years barring disease, food limiting causes, predation, etc. They're home range is somewhere between 500 to 2,000 sq. ft. They breed once a year to several times a year in optimum environments such as the Southwestern cropping situations in CA and AZ. Litter size ranges from 1-10 with standard field mortality figure in your survival numbers are about 3-6.

Prevention and control: Weed control and vegetative management: Limit when possible forbs that act as an attractive and large underground storage structure of succulent vegetative matter. Use mechanical or chemical means to control. Use grain buffer strips around hay fields to help minimize the migration along with assisting in control programs such as trapping or baiting in the strips.

Crop rotation: Annual grains in rotation with alfalfa can assist in the limiting and follow-up control of historical infestations. Control programs are more effectively executed because of several factors you have not established with the new crop.

Flood irrigation: The success of the program is still questionable but efforts of this type do return some satisfaction if not always the results you would hope. This process can spoil a workable environment for the gopher by creating a habitat too wet to live in and also limit the diffusion of gases because the soil is saturated. Do remove high spots in field where gophers will retreat to.

Repellants and exclusion: Below ground fencing is impractical unless limited to high value landscaped areas or perhaps plastic netting around root ball of select plantings in orchard setting. Typically never practical from economical position. Repellants are considered not effective but we haven't introduced a lot of science into the effort either. Certain predator odors can effectively change the behavior of animals and work is ongoing with other pest animals and eventually will probably find something that might assist in controlling this tough animal.

Toxicants: Rodenticides or baits used to control or limit the damage caused by rodents, specifically the Pocket Gophers are grouped into cumulative (anti-coagulants) and non-cumulative (acutes) types. Standard for the industry has been the strychnine baits, such as RCO Omega Gopher Bait which is an acute type which cause mortality from single ingestion as long as the intake is sufficient. Some gopher species seem to enjoy this compound while most succumb to its efficacy in a short period of time after ingestion. The toxicant is attached with a variety of binders to these grains: oats, milo, or barley. Zinc Phosphide baits are another acute that came on the gopher baiting scene recently with mixed reviews. It has been used for years on squirrels and meadow voles with limited to great success. Studies have revealed up and down results, but that should not warrant not trying the product to census its effectiveness in specific locale. Always incorporate variety to find the best results for your operation.

Anti-coagulant baits have been used extensively for commensal rodent control (rats and mice) for many years with the post W.W. II years seeing the greatest expansion into the American market. A variety of field pests have been added to their labels and new applications have aided the old line acutes to clean up problem situations. Now these new baits are replacing the old line acutes because they're more effective in certain locations, even though they're more expensive. Ail rodenticides have limitations and strengths. Locate a specialist to cover these aspects and always read and follow the directions stated on the label.

Fumigants: as devices have been used for many years in the U.S. going back to the cynogas foot injector units to the present pelleted materials of aluminum or magnesium phosphide. The new pelleted products are widely used with mixed to excellent results. Soil and moisture conditions in application determine results. Elaborate tunnel systems and the defensive nature of gophers make this form of control somewhat less intrusive as the baiting or trapping regimes we perform. This approach is not as disturbing to the habitat as other approaches. There a few newer products on the market that offer promise, but scientific review has raised questions about true control levels. Acrolein is one that might be a contender worth reviewing in your locale. Contact your State Ag Dept. or local pesticide dealership for information. Always request some form of performance data on the variety of gaseous approaches to rodent control. Sometimes they are more gas than reality. Smoke bombs can fall under this category. Typically they offer limited to no control for pocket gophers and EPA should limit the pests on the label of this type of product.

Traps: There are a number of traps that come and go for gophers. They fall into groups that are specialized for killing or live trapping as well as spring or pan traps. Some are more operational and common to the ardent professional such as the Cinch-Gopher Trap. Like many programs going on for rodent control, we are basically bailing water in a sinking ship. We think we control the immediate problem as well as we can, but do not approach the long term problem of large scale reinvasion of the gopher. Our results are sometimes masked by our ability to truly census the true population levels and the effect of our ongoing programs. This is a problem with all the different programs we use. We need to keep better records on the methods we use and build a bank of information about the results and why we got them.

*Information for this presentation from UC Davis, University of Nebraska, OSU and WSU.*

# FUTURE ENVIRONMENTAL CONSIDERATIONS FOR TURF[1]

Dr. Roy L. Goss[2]

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[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.
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Environmental enhancement from turfgrasses has been a way of life for many centuries, but quantitative documentation of environmental benefits to people has been under scientific investigation for only a few decades. The bulk of turfgrass scientific knowledge has been generated since 1960 and many of the knotty problems dealing with soil and soil management, plant nutrition, disease, insect, weed and nematode control, through chemical and integrated pest management, irrigation and varietal improvement have either been solved or sufficiently documented to provide many safeguards for a healthy environment for plants and animals, including people. We still have a long way to go to build this perfect "mouse trap" and not only develop better means of maintaining compatibility of turfgrasses and their environment, but educating the masses of people that compatibility does, in fact, exist. This paper will attempt to identify some of the environmental concerns and what is being done or can be done to help ensure our future on this planet.

## BACK TO BASICS

### SOILS

A thorough knowledge of your soil may help keep you out of court. You must become thoroughly versed in the texture of your soil to know whether it is a sand, sandy loam, clay, or whatever. Knowledge of soil texture will tell you many things that you need to know to maintain the best environmental conditions. The texture of the soil will determine the nutrient holding capacity. When you compare a soil medium of pure sand compared to a sandy loam soil, the sandy loam soil will retain considerably more nutrients from leaching than a pure sand. It becomes obvious, then, that a sand must have nutrients applied at light and frequent rates or the use of slow release materials rather than heavy, infrequent applications.

The water holding capacity of the soil as well as the drainage is also influenced by the soil texture. Heavy soils will hold more available water per foot of depth than the lighter textured soils, such as sands or loamy sands. Lighter textured soils will, likewise, drain more quickly than heavier textured soils and must be taken into consideration with respect to deep percolation. The fixation or binding of various chemicals is strongly influenced by soil texture. Heavy soils, those with higher contents of silt and clay will bind or fix more chemicals as well as certain plant nutrients than coarse textured soils, such as sands.

## GOOD MAINTENANCE PRACTICES

A good program of maintenance may preclude the use of chemicals by maintaining healthy turfgrasses. Some of the contributing factors of good maintenance would include mowing heights that are most practical for the turf you are managing. Extremely close mowing does not promote turf vigor and may result in the requirement for significantly increased chemical maintenance programs. Aerification is essential to provide oxygen to the root zone and also to maintain infiltration and permeability rates through the soil. This is not an operation to inconvenience your clientele. Sand topdressing, whether it is for putting greens or sports fields, is a very useful maintenance program to help prevent the buildup of thatch and also to maintain high infiltration rates of water into the soil. This will also, of course, promote uniformly smooth surfaces.

## IRRIGATION

There are a number of factors that we should all understand with respect to proper application of irrigation water. Since it is a precious natural resource, we should take as good a care of it as possible. Over-irrigation probably contributes as much or more to groundwater pollution as any other single factor. There is little excuse for applying irrigation water that percolates below the root zone of turfgrasses.

In order to understand proper irrigation it is important that the turfgrass manager understand evapotranspiration. In other words, how much water per day is evaporating from the surface and being transpired from the grasses. You can use this as a base for comparing against open pan evaporation, and through very simple formulas, relate this to the amount of water that should be replaced daily or periodically. From the writer's point of view, daily watering is not a good practice except under very extreme conditions, which most often do not occur.

Infiltration and permeability rates of water are, of course, related to soil texture, soil structure, and maintenance practices. We need to know how fast the water is moving into the soil and how fast it moves through the soil.

When in doubt, probe the soil with a soil probe to physically feel the soil moisture content to determine irrigation needs. Frequently, some of our sophisticated methods fail, but a physical examination is the most reliable. I think we should all remember that wall-to-wall green is not a practical goal regardless of what our bosses sometimes would like to see.

## INTEGRATED PEST MANAGEMENT

We cannot afford many preventative programs in our turfgrass management today. Early detection of pest problems and monitoring pest buildup will determine if pesticide curative programs are required. European cranefly larvae are classic examples. Chemical treatment for these larvae is unnecessary if populations are under 30 larvae/$ft^2$ provided the grass is adequately nourished. Most often, we can grow turf faster than the larvae can eat it. Other parameters can be developed for numbers of weeds or disease spots per unit area. What are you and your boss willing to tolerate? Use your best employee for pesticide application and make certain that this person is a licensed applicator.

## EDUCATE THE MASSES!

Do not miss an opportunity to tell the public how safe you, as a turf manager, are making the environment through best management programs. We, as turfgrass managers and research and extension people, are not getting our story out to the public enough, but the environmental activists are screaming their fears, and many people listen even if the information is wrong. There are a number of 'chicken littles' out there, and some of them are honest about their environmental fears because they have little or no scientific or biological background to help evaluate their fears.

## POLLUTION OF GROUND AND SURFACE WATERS

Perhaps this area is one of greatest concern to environmentalists and the public. Once an aquifer is polluted, it is extremely expensive or nearly impossible to clear up the pollution, at least in our lifetimes.

Potable water supplies are shrinking as well as the cost of this water is increasing. Pesticides are the greatest concern to the public, both as surface runoff and leaching downward into aquifers. Fertilizers, especially nitrogen and phosphate, are feared by the public as well. There is no reason why any leaching beyond that acceptable in drinking water standards should ever leach into the aquifers, provided we do our job properly.

Erosion and sedimentation should never be a problem on turfgrass areas except during construction. Turfgrasses are one of the best means of preventing surface runoff and inducing the rapid infiltration rates of water into the soil to prevent surface water contamination.

## IRRIGATION WATER

Our fresh water supplies used for domestic, industrial and agriculture are already stressed. Any new aesthetic and recreational uses of water are viewed critically by our public. Xeriscaping is on the increase, especially for urban areas in arid regions, although this does not enhance the environmental factors that turfgrasses contribute, such as cooling of temperature, providing oxygen, preventing water runoff, and organic filtering of atmospheric pollutants, etc.

## EFFLUENT WATER

The use of effluent water has definitely been on the increase for several years, especially in arid regions. The use of this water is sometimes mandated before the construction permits for golf course developers are approved, and especially so in most areas of Hawaii. Fears of potential disease, salt buildup, which is a reality, heavy metal buildup and toxicity, the logistics of moving water from treatment sites to golf courses, sod farms, etc., and constancy of supply are just a few of the problems associated with the use of effluent water, according to Harivandi (Golf Course Management, July 1993).

On the positive side, large amounts of nitrogen, phosphorus and potassium, as well as some other nutrients, may be provided from effluent water. The U.S. Golf Association and the Golf Course Superintendents Association of America are expending considerable resources to develop uses for effluent water, develop low water use and salt tolerant grasses. The future trend for conserving potable water is toward more natural areas and significantly less water application. This will definitely reduce problems, such as black layer and *Poa annua* populations.

It still does not make sense to the writer that so much energy and resources should be directed to "failure grass" *(Poa annua)* when it is the least friendly with respect to environmental concerns.

## WILDLIFE HABITAT

One of the most successful programs to come down the pike in recent years has been the cooperative program between the Audubon Society of New York State and the United States Golf Association to assist golf courses in enhancing their properties for the benefit of wildlife and other natural resources. According to Jim Snow, the United State Golf Association has contributed $230,000 to the Audobon Society of New York to expand a program called THE AUDUBON COOPERATIVE SANCTUARY PROGRAM FOR GOLF COURSES (paper presented at 31st Western Canada Turfgrass Association Conference, Victoria, B.C. CANADA (February 1994).

Glendale Golf and Country Club at Bellevue, Washington, under the guidance of Superintendent Steve Kealy, has made great progress in environmental enhancement for wildlife, and all superintendents attempting such programs should be recognized.

## INFRASTRUCTURE

Future environmental considerations for golf courses, sports stadiums and other recreational facilities must seriously consider the impact of these facilities on the infrastructure. What impact will a new golf course with housing have on roads, sewer, water, schools, etc.? In Hawaii, the Antidevelopment Activists seem to be more concerned about the infrastructure than environmental pollution. In some cases, the golf course developer has been asked to contribute $100 million for infrastructure purposes before a permit to build a golf course is issued.

The cost of doing business seems to be going up and we shall be accountable for our acts.

# SEED PRIMING TURFGRASS TO ENHANCE GERMINATION AND ESTABLISHMENT[1]

Dr. William J. Johnston, E.S. Maring, Charles T. Golob and C.D. Burrows[2]

1 Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.

2 Assistant Professor, Research Technician III, Research Technician III, and former Graduate Student, respectively, Department of Crop & Soil Sciences, Washington State University, Pullman, Washington.INTRODUCTION

Due to its inherently long germination period, relative to other cool season grasses, Kentucky bluegrass (*Poa pratensis* L.) seed lends itself to preplant seed conditioning. Recent seed conditioning research has focused on a new technique termed matriconditioning or solid matrix priming (Johnston et al., 1993; Khan et al., 1990; Kubic et al., 1988; Taylor et al., 1988).

During matriconditioning, sufficient moisture is permitted to enter the seed for enzymatic and metabolic activities associated with seed germination to occur (Fig. 1); however, at the same time, radicle emergence is prevented by limiting moisture availability.

Micro-Cel E (MCE), a hydrous calcium silicate, has been an especially effective carrier in the matriconditioning process. Research on vegetable seeds, utilizing MCE as a carrier during matriconditioning, has shown beneficial results (increased germination rate, vigor, etc.) (Khan et al., 1990; Khan et al., 1992; Maguire et al., 1991).

## OBJECTIVE

The objective of this study was to utilize the matriconditioning process with MCE serving as the carrier to speed and synchronize the rate of germination and emergence of Kentucky bluegrass seed.

## MATERIALS AND METHODS

Utilizing the technique of Khan et al. (1990), preliminary research at the Washington State University Seed Laboratory with MCE manufactured by Celite Corp. (Wayne, NJ) indicated that a 16:8:18 ratio of seed:MCE:distilled $H_2O$ and matriconditioning in a germinator for 7 d at 15°C, 100% RH, and continuous light was the best regime to matricondition 'SR-2100' Kentucky bluegrass seed. Following matriconditioning, MCE was washed off the seed with deionized $H_2O$ and seed were dried at room temperature. Laboratory germination was tested in accordance to rules of the Association of Seed Analysts. Emergence was also evaluated in the laboratory (Johnston et al., 1993).

Field studies were conducted in 1991 and 1992 at Pullman, WA to evaluate the performance of matriconditioned SR-2100 bluegrass seed (Johnston et al., 1993). Seed were hand sown 11 October 1991. Following emergence, counts were made every 3 d and were terminated 36 DAP (days after planting). On 18 May 1992, two cores were taken per treatment. Individual bluegrass plants were separated from the soil, clipped at crown level, washed, dried at 67°C for 48 h, and weighed. On 11 March 1992, a second field study was begun with the experimental design, plot location, plot size, field preparation, and data collection similar to that used in 1991. Counts were terminated 30 DAP due to tillering. Cores were taken for top growth 70 DAP.

In August 1991, matriconditioned SR-2100 Kentucky bluegrass seed were placed at two separate locations, seed house (11 to 27°C, 40 to 65% RH) and a non-insulated storage shed (-6 to 32°C, 13 to 94% RH), at Pullman, WA. Matriconditioned seed were evaluated for percent germination at 4, 8, 16, 32, and 64 wk. Untreated seed were evaluated at the beginning and end of the study.

In 1994, high and low germinating seed lots of four cultivars of Kentucky bluegrass ('Alene', 'Washington', 'Kenblue', and 'South Dakota') were matriconditioned with varying water amounts (varying MCE:water ratios) of 0 to 8 ml and evaluated in the laboratory for rate of germination and emergence (Maguire, 1962) and percent germination and emergence. The low germination seed lot of each cultivar matriconditioned with 2 ml $H_2O$ was seeded in the field during spring 1994 and seedling emergence counts were made for 6 wk.

## RESULTS AND DISCUSSION

LABORATORY GERMINATION. Preplant conditioning of SR-2100 Kentucky bluegrass seed with MCE induced early germination. The $T_{10}$ and $T_{50}$ (time to 10% and 50% of total germination) for matriconditioned seed were 3.4 and 5.0 d, respectively, compared to 5.8 and 8.5 d for the $H_20$ treatment and 5.5 and 7.0 d for the untreated seed, respectively. All treatments had almost the same total germination (91 to 92%).

LABORATORY EMERGENCE. The performance of MCE-treated SR-2100 bluegrass seed in general exceeded that of $H_2O$-conditioned or untreated seed (Table 1). Total emergence and rate of emergence ($T_{10}$ and $T_{50}$) were significantly better, while plant height and dry weight were numerically greater for matriconditioned seed. This indicates that matriconditioning seed with MCE increases seed emergence and may increase vigor.

FIELD EVALUATIONS. In late fall 1991, preplant matriconditioning SR-2100 bluegrass seed with MCE resulted in significant increases in rate of emergence ($T_{50}$) and total emergence (Table 2). Total emergence for MCE-treated seed was high (78%) compared to untreated seed (27%). This indicates some benefit of matriconditioning when planting Kentucky bluegrass seed at moderately low temperatures, as might be expected in late fall or early spring.

In spring 1992, no differences were found between treatments with respect to total emergence; however, the rate of emergence ($T_{10}$ and $T_{50}$) for MCE-treated seed was significantly better than that of untreated seed (Table 2). The lack of separation between treatment means for total emergence may have been due in part to the relatively mild weather encountered during the 1992 study.

AGING ("Shelf-life"). Untreated SR-2100 bluegrass seed (91% germination) and matriconditioned seed (90% germination at 4 wk) both had 85% germination after 64 wk regardless of storage conditions (seed house or non-insulated storage shed)(Table 3). Seed matriconditioned with MCE had a shelf-life of at least 64 wk.

CULTIVAR EVALUATIONS. During 1993 and 1994, extensive laboratory and field evaluations were done with four Kentucky bluegrass cultivars and a high and low germinating seed lot of each to determine if there was a single best ratio of seed:MCE:water for matriconditioning bluegrass. In the laboratory, germination (percent and rate) and emergence (percent and rate) were evaluated and, in the field, emergence (seedling count) was determined.

All the data from this study will not be presented; however, in general, trends for all laboratory trials were similar and can be illustrated with Figure 2 and Figure 3. The cultivars and seed lots did not perform the same at all water ratios. Also, it did not appear that seed with high germination could be improved by matriconditioning. The high germination lot showed a continual decline as water was added compared to the untreated control (0 ml $H_2O$). However, a poor seed lot with low germination did show improved performance when seed were matriconditioned.

Since only poor seed lots responded favorably to matriconditioning, only poor lots were matriconditioned with 2 ml $H_2O$ for field testing. Seedling counts made 6 wk after planting showed only Alene Kentucky bluegrass performed better when matriconditioned (Fig. 4). These results are similar to those seen spring 1992 when there was no difference in field total emergence due to matriconditioning (Table 2). Additional field testing is needed on these cultivars and lots, e.g., fall planting.

## CONCLUSIONS

In general, matriconditioning SR-2100 Kentucky bluegrass seed with MCE slightly enhanced performance in both laboratory and field studies. The best results with this technique occurred when planting bluegrass seed at moderately low temperatures, as might be expected in the late fall. There appeared to be no single best ratio for matriconditioning all bluegrass cultivars and seed lots and, in general, matriconditioning improved performance in poorer seed lots and was detrimental in good lots One of four cultivars field tested spring 1994 had increased emergence after matriconditioning. Economical analysis is needed to determine if the slight advantage in Kentucky bluegrass seed and seedling performance is worth the cost to consumers.

## ACKNOWLEDGEMENTS

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Table 1. Effect of matriconditioning 'SR-2100' Kentucky bluegrass seed on emergence and vigor at 23°C in the laboratory.

| Seed treatment | Total emergence | Plant $T_{10}$ | Plant $T_{50}$ | height | dry wt. |
|---|---|---|---|---|---|
| | % | d | d | cm | mg |
| MCE | 81a | 4.5a | 5.2a | 5.2a | 0.42a |
| $H_2O$ | 26c | 5.2b | 7.4b | 4.7a | 0.35a |
| Untreated | 41b | 5.6b | 7.6b | 5.0a | 0.36a |

$T_{10}$ is time to 10% of total emergence.
$T_{50}$ is time to 50% of total emergence.

Table 2. Effect of matriconditioning on field performance of 'SR-2100' Kentucky bluegrass seed planted in 1991 and 1992 at Pullman, WA.

| Seed treatment | Total emergence | $T_{10}$ | $T_{50}$ | Plant dry wt. |
|---|---|---|---|---|
| | % | d | d | mg $cm^{-2}$ |
| | | 1991 | | |
| MCE | 78b | 19.5a | 23.8a | 19a |
| Untreated | 27b | 20.1a | 28.5b | 16a |
| | | 1992 | | |
| MCE | 34a | 13.7a | 19.2a | 9a |
| Untreated | 34a | 18.2b | 21.5b | 13b |

Percent emergence 36 d and 30 d after planting in 1991 and 1992, respectively.
$T_{10}$ is time to 10% of total emergence.
$T_{50}$ is time to 50% of total emergence.
Dry wt. measurement taken 220 d and 70 d after planting in 1991 and 1992, respectively.

Table 3. Effect of storage on percent germination of matriconditioned 'SR-2100' Kentucky bluegrass seed.

| Weeks | Control | Matriconditioned |
|---|---|---|
| | —— % —— | |
| 4 | 91 | 90 |
| 16 | | 85 |
| 32 | | 90 |
| 64 | 85 | 85 |

## Fig. 1 Triphasic Pattern of Water Uptake by Germinating Seeds

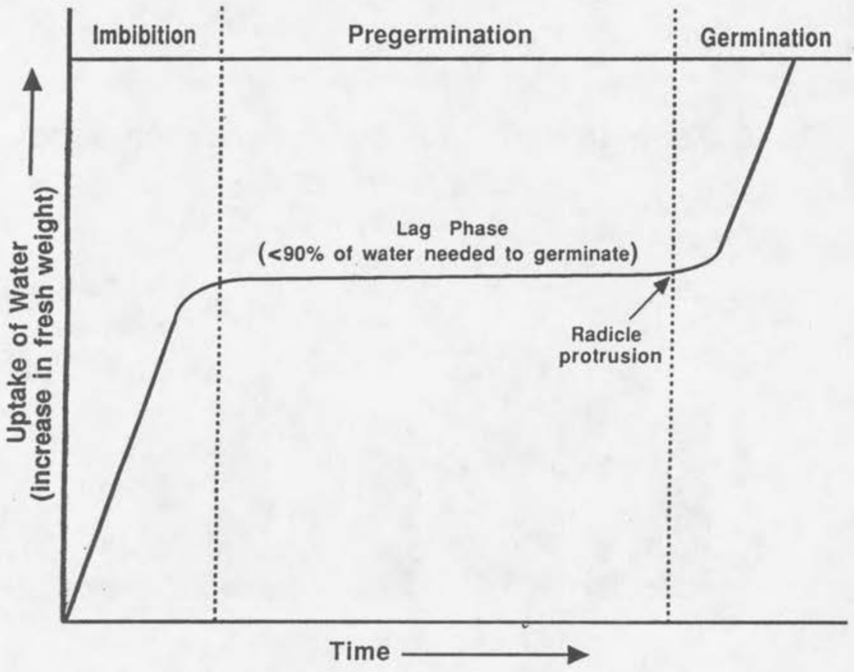


**Fig. 2 Alene High and Low Germination Seed**
Laboratory 28-day

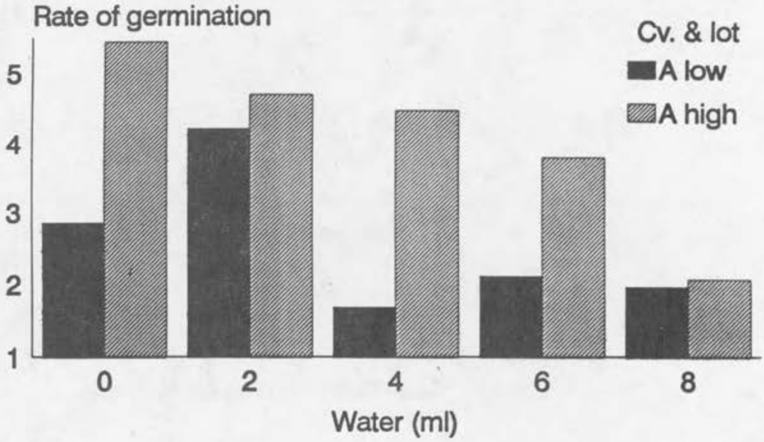
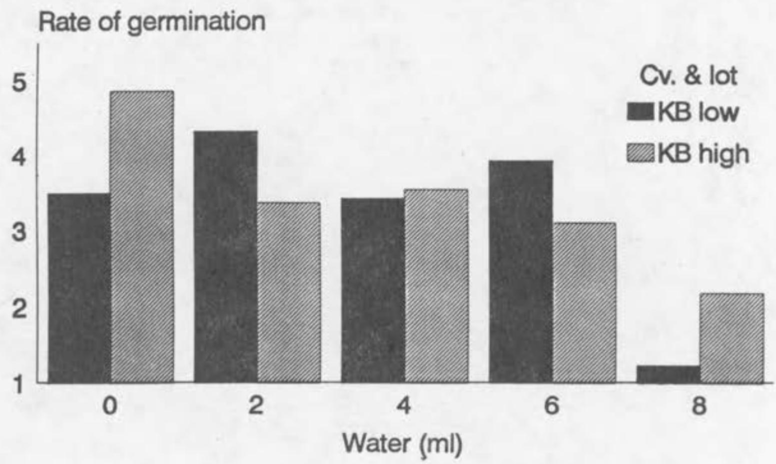
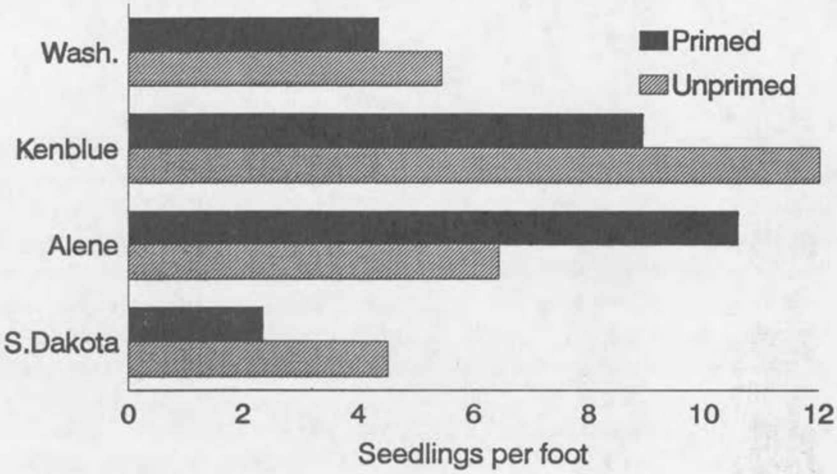



**Fig. 3 Kenblue High and Low Germination Seed**
Laboratory 28-day



## Fig. 4
## Field Emergence of Primed Bluegrass Cultivars
Six Weeks After Spring Planting 1994



# ENERGY AND WATER CONSERVATION; HOW THEY RELATE TO EVAPOTRANSPIRATION[1]

Mr. Carl H. Kuhn, P.E.[2]

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[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.
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Among the many buzzwords of the nineties, be it "Environment", "Wetlands", or "Endangered Species", all of which have substantial impact on our lives and our professions, there is yet another buzzword which we hear of but seldom get overly excited about. That word is "Conservation". Yes, we have applied its meaning to the Florida Everglades, to the old growth timber, to various species of plant and animals. But how often do we think in terms of elements which have been in abundant supply for seemingly endless years? Do any of you remember the neon sign that once was mounted on the high cross members of the U.S. 99 Puyallup River Bridge in downtown Tacoma? That sign read something like "Tacoma, Home of the cheapest electricity in the U.S." Or do you remember when the Northwest, the western slopes in particular, were noted for our overabundance of water and rainfall? Some of us remember when Seattle City Light and Puget Power both served Seattle, each having their own side of the street. You wanted power, you had your choice of purveyor. And they fought to the death to get your connection. They even had "All electric rates"; saying, in essence, the more you used, the less it cost. That was then and today is NOW!

Or, how many of you remember the drought in the Seattle/Tacoma/Portland areas of several years past? Water, ever abundant, suddenly became a scarce commodity. Those of you who used municipal water for irrigation purposes remember this well. If you had a golf course, you might have been allocated water to keep the greens alive and not much more. The impact of this element of conservation even affected municipal courses that had their own water supply, be it a well or lake. It was simply prudent to not have green grass if the electorate had to live with brown grass. Or yet another case where private clubs felt it necessary to mount signs for the public that would read something like "We are using our own well water for irrigation". Whether we like it or not, the public is now aware of the need for water conservation.

What hurts most is when someone else starts talking about conservation and that conservation affects the very guts of your professional industry. To accommodate large scale irrigation projects, we need three things and they are, in the order of priority, **Water, Electricity and Money.** We instinctively react to the money aspect but for many years in the past, water and electricity were natural freebees here in the Northwest. No longer is this the case. We have seen numerous cases of water rationing in recent years; we see constant reservoir or water supply reports; we have seen any number of restrictions on well drilling and a number of cities and counties have already introduced "water budget" restrictions on commercial landscape irrigation systems. In the same vein, we see hydro-electric projects coming under major environmental constraints; we see a constant effort on the part of Power Companies to wrap our water heaters, to use energy-efficient light globes and in the case of golf courses, financial rewards for using lower consumption pump plants such as Variably Frequency Drives.

We have arrived in the era of water and electricity conservation and are now tasked as Engineers and Superintendents, to meet the challenge of conservation.

**EVT = EVAPOTRANSPIRATION = EVAPORATION + TRANSPIRATION**

Evaporation and transpiration are the two ways that we deplete the water in the soil. Transpiration is the vehicle nature uses to provide water to the plant and, of course, evaporation is natures cooling process for our plants and the loss of excess surface water. We can also lose water through surface runoff or by the percolation down and through the soils. The latter is particularly true if we have permeable soils and an over-application of water. We will not dwell on soils at this time as we will address it during the second half of this presentation.

Since we were talking about buzzwords, it is only fitting and proper that we now include "EVT: in our 1990 era vernacular. In years past we never gave EVT much thought except that it appeared in various technical publications and that it had a relationship to the Weather Bureau's dry-pan evaporation rate. So long as we put enough water on our grass to keep it green and at the same time not offend golfers or park users with saturated surfaces, we were able to get by. You used rules of thumb based on the following EVT charts of which two have been selected, one from the Puget Sound country, one from the area east of the Cascades. (Figure 1)

If we designed irrigation systems to the levels established by these reliable charts, we were usually safe excepting the unusual times when we had a week or two of extremely high temperature or drying-wind days at which time we had to do supplemental irrigation. You will note on these charts, the Puget Sound area in particular, that credit is given for rainfall. In other words, EVT (the water plants purportedly require) less the rainfall you receive equals the amount of water that needs to be supplemented to keep turf plants alive. It seems logical to give credit to the rainfall but then what happens if all of that rainfall happened on a single day? For this reason the rainfall line has been asterisked. The other 29 days of the month will get no help from rainfall. So, the conservative designer uses the average of Summer figures for EVT and EVT minus

Rainfall insofar as water supply is concerned and usually has more water than is needed. Better to be safe than sorry! Or, in terse verse, better to have too much than too little. This approach saves measurably on lawyers fees.

For many years we used the very conservative figures noted above. We had little choice if we wanted to keep our jobs. We have often wondered how much gambler there was in a golf course superintendent or a park manager, such person being water conscious and thereby testing his turf with lower and lower amounts of water. This approach worked fine, saved water and finally arrived at a point when the grass all went dead in one massive kill. This is known as professional suicide. There was just no easy way to determine how little water we could use to keep the grass healthy so we were hamstrung when it came to water conservation. It was safe to over-water; conversely, our future was on the line if we attempted to conserve through under-watering.

We have seen actual evidence of courses in the Puget Sound country that require 1" per week by the charts but were kept in top condition with 0.5" to 0.6" per week. This was not a choice of the Superintendents but a function of either a very limited irrigation system which could not possibly put the 1" per week on the course with a 8 hour nightly

## FIGURE 1 - EVAPOTRANSPIRATION AND RAINFALL

The following figures represent inches per month. Negative numbers indicate that rainfall does not meet the EVT requirements. Total column represents total inches per year.

Seattle Area

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | S.S9 | 4.44 | 3.96 | 2.54 | 2.00 | 1.89 | 0.89 | 1.01 | 2.06 | 4.11 | 5.58 | 6.32 | 40.39 |
| EVT | 0.39 | O.S9 | 1.20 | 2.14 | 3.35 | 4.26 | 5.02 | 4.40 | 3.13 | 1.83 | 0.82 | 0.52 | 27.65 |
| Diff | 5.52 | 3.85 | 2.76 | 0.40 | -1.35 | -2.37 | -4.13 | -3.39 | -1.07 | 2.28 | 4.76 | 5.80 | 12.74 |

Spokane Area

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | 2.40 | 1.77 | 1.65 | 1.34 | 1.66 | 1.86 | 0.71 | 0.79 | 1.16 | 1.99 | 2.33 | 2.58 | 20.24 |
| EVT | 0.00 | 0.00 | 0.72 | 1.81 | 3.30 | 4.30 | 5.62 | 4.72 | 2.83 | 1.39 | 0.39 | 0.00 | 25.08 |
| Diff | 2.40 | 1.77 | 0.93 | -0.47 | -1.64 | -2.44 | -4,91 | -3.93 | -1.67 | 0.60 | 1.94 | 2.58 | -4.84 |

water window or they simply had a very limited water supply. However, by some hook or crook, they made it work and they kept their jobs. Fortunately their Board Members were privy to the physical water limitations and accepted the associated problems. Such might not be the case if a Superintendent were merely to experiment with lowering his applications.

Each month was a guess based on daily temperatures with the familiar wetted forefinger in the wind. Soil probes, grass appearance, etc., all played a part but there was no exact way to guess how to reduce the daily, variable water consumption and still remain employed.

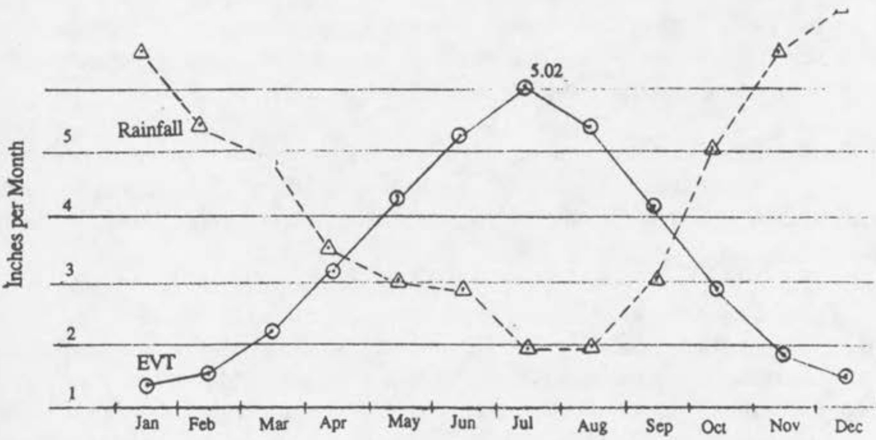
The bell curves shown on Page 39 were based on monthly EVT rates so you divided 30 days by 7 days and came up with 4.2 weeks of "x" inches of water per week. You then divided "x" by 7 days to arrive at "y" inches per day. Everything was an **average.** But west of the Cascades, weather patterns change dramatically from year to year as was demonstrated in 1993 when the rains finally stopped around the 15th of July. In the same manner, weather patterns change rapidly from day to day. The averages we use are simply reasonable guesses and leave little opportunity to meet the challenge of water conservation. So, how do you approach this matter of water conservation without putting your job on the line?

First of all, you need to use the published "average" data as a guide to establish a base irrigation need. Using the Seattle data for the month of July, historically the hottest month, we have the bell curve as shown on Page 39.

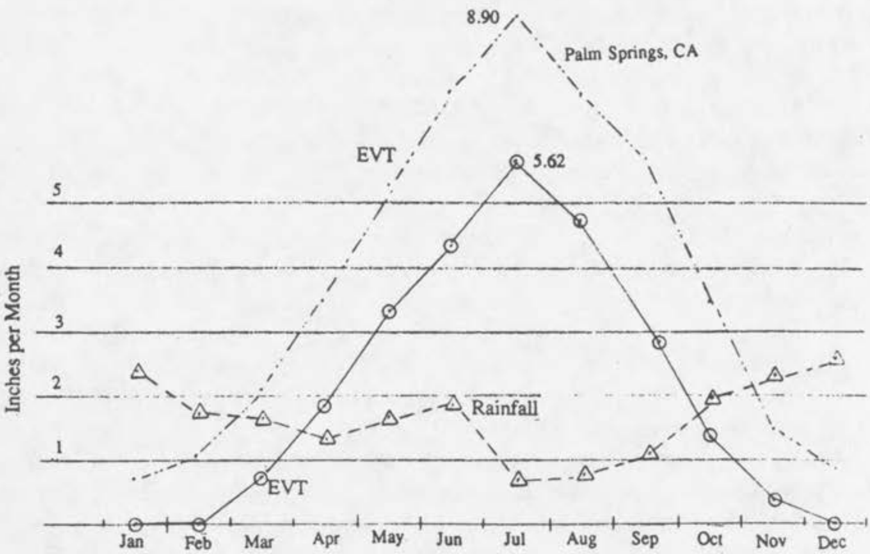
You run that program for a while taking soil probes in the various turfed areas and using plain old visual horse sense. Empirically you would determine your system precipitation rate as follows:

$$P = \text{Precipitation Rate} = \frac{96.3 \text{ x (sprinkler gpm)}}{\Delta \text{ Spacing x } \Delta \text{ Spacing x } 0.866} = \frac{96.3 \text{ x } 21.0}{65 \text{ x } 65 \text{ x } 0.866} = 0.55\text{"/hr}$$

For a 21.0 gpm sprinkler at 65 foot triangular spacing, P = 0.55" per hour. From you bell curve you can extrapolate approximately 1" per week (average July maximum) divided by 0.55 " per hour and arrive at a need to irrigate a given area 1.82 hours or 109 minutes per week. Divide by 7 and you end up with 16 minutes per day. This forms a **base estimate** and it should be that and no more. So, if you have stand alone controllers out in the field, you set each station for 16 minutes (with adjustments for shade, slope, soil, etc.). If you can, you may set up two 8 minute or three 5 minutes sets for better water utilization. (It should be noted that multiple sets are universally better since the first light application helps break down the surface tension of the soil and wetting it sufficiently so that when the next set comes around, the applied water will run down




Puget Sound Area




Spokane Area

# EVAPOTRANSPIRATION vs RAINFALL

into the soil and root zone, not downhill on the surface) So there you are with a worst day scenario for July and the weather changes. Unless you change the timing on each station, and you could have 200 to 500 stations and more, you will give each day the same dose, needed or not. With the older electro-mechanical controllers, your stations were either "on" or "off". Perhaps you could double your dose of water by recycling but you could not cut your application by 25%, 50% or any level of reduction except 100% ("off").

## ENTER THE WORLD OF THE COMPUTER!

Suffice it to say that nothing in this world has had greater impact on turf irrigation than the computer. Yes, the computer is still subject to the old axiom "Garbage in, Garbage out!" But it is still the irrigation wonder of the century. The computer is conservation personified. Properly used, it is our answer to the control of EVT and the control of conservation. It can handle full circle heads, part circle heads, soils, slopes, shade, temperature, humidity and just about anything else. It will allow you to operate each and every station individually so that where one station can tolerate one application of 16 minutes per night, the next station which controls a mound of tight soils can be irrigated with five three minute sets. With controls for flow zones (means of limiting the flow of water to various areas of the course), you can control the entire irrigated area in a manner each area finds best suited to healthy grass growth.

However, if you do not recognize that there are daily variations in the EVT, you might as well have a simple on-off switch as a computer. Conservation as we must start addressing it, means finding ways to conserve the 5% and the 10% differences, seemingly inconsequential on a day by day basis but of measurable consequence if we take in an entire season.

## ENTER THE WEATHER STATION

Now we have a device which tells us the differences in EVT from day to day. May sound very macho and grandiose but when its output is evaluated using good agronomic sense, can be the answer to our attempt to conserve. A hot 80 degree day which might need those 16 minutes per day may be followed by a cloudy 60 degree day. With the computer and with weather station input, we can vary our irrigation water use each day to that which nature requires, a natural move toward conservation of our vital water resources. Conversely, when we get a string of 90 degree days, we can quickly adjust the programs upward to a level of 110% normal, 115% normal, etc.. Quick and efficient.

Weather stations are capable of direct control of the computer. Some operators feel uncomfortable with this approach, rather preferring to use the weather data and then manually changing their computer schedule to their own particular desired daily increase or decrease. This is a most reasonable approach. However, if using the weather station input directly is yet to be proven to some, we would suggest that you take a segment of the turf, and in the case of a golf course, a portion of a given fairway, establish this area as an "Irrigation Test Plot". Obtain approval from your Board and your Greens Committee.. Put up a sign telling everyone that you are involved in a major scientific experiment. Publish this notice in your Club newspaper, emphasizing the trend to conserve. Then watch to see how the direct input varies from your preferred input. Take plugs frequently and check the general health of the turf. If, for any reason, you lose the turf, at least you had the blessing for the test, you alerted the users with signs and news articles and you can go out and trash your weather station. However, it is very likely that you will find that the results will be surprisingly good. The main point is for you to become confident in the use of the computer and the weather station and to recognize that these two tools are the best answer we have to water conservation. If you were like some of us were when we first met up with a computer, sympathy is warranted. However, professional demands have required that one become somewhat proficient in that desk-top monster and it is incumbent upon all major turf managers to do the same. You will find, as we have found, that once the effort was made to learn the science, we and our computers have become inseparable.

## ENTER THE VARIABLE FREQUENCY DRIVE

We have agonized over the savings of water and now can do the same with the precious electricity which we need in substantial quantities each pumping season. There may be some argument over the savings that a VFD station can provide especially if a computer program is properly created. However, there is much to be said about a pumping system which keeps a constant pressure in the mains without the use of pressure-reducing valves to destroy excess pressure. Most constant speed pump plants have a pressure reducing valve on their discharge, the purpose being that when the station is not pumping at its optimum level, the excess pressure created by a pump working at 1/4 or 1/2 of its potential, is controlled by literally destroying the excess energy. So what we have here is kilowatts being used to create hydraulic energy which, in turn, we destroy. This a very common condition in constant speed motors pump plants. One has little choice if the flows from a plant will vary widely. Again, a properly scheduled computer program will eliminate much of the variation in flows I repeat, a **properly scheduled** program.

The variable frequency control on a pump plant simply turns the pump motor at a speed commensurate with the demand for flow. With a low flow you have a slow turning pump motor. With a high flow you have a high rpm up to the maximum rpm of the pump, either 1760 or 3500. A small computer in the VFD plant is the brains of the plant and simply permits you to operate your plant automatically as you would operate a pump connected to a diesel engine. The diesel has a throttle which you can adjust; the VFD has a computer that acts like a throttle. The VFD gives you, figuratively speaking, a hundred different pumps in one pump package.

The savings from a VFD plant have been alluded to reach upwards of 10% over a constant speed plant but you will find some argument with these numbers. Suffice it to say, that the VFD plant offers the opportunity to safe energy and that is what conservation is all about...giving your best shot at trying to save precious commodities.

As a matter of principle, our office did not jump on the VFD bandwagon the minute it hit the streets. We always like to see California and Florida test these products for reliability and performance. The VFD came on slowly and after three years of field use elsewhere, it has become a standard for most irrigation pump plants in the Northwest. Our gained confidence plus the fact that the price differential between VFD plants and constant speed plants has narrowed measurably, suggests that the VFD plant is here to stay and that it has earned our firm's respect.

One other factor weighs in favor of VFD plants. They use standard, every-day motors, constant -speed motors that are commonplace. Science has simply found a gadget that makes those standard motors respond to different stimuli.

## CONSERVATION

Whether we like it or not, conservation is here to stay. Water and electricity, two extremely vital elements in our turfgrass industry, are being earmarked for our close attention. Inasmuch as our industry used a great deal of those two commodities, we had best start taking steps that the government, the media or conservationists recognize as meaningful and substantive. The longer we wait, the great the pain shall be when such measures become mandatory. Like Boy Scouts, "Be Prepared".

# THE RELATIONSHIP OF SOILS TO DRAINAGE [1]

Mr. Carl H. Kuhn, P.E.[2]

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[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.

[2] Owner, Kuhn Associates-Consulting Civil/Irrigation/Drainage Engineers, Mercer Island, Washington.

We shall start this document with a statement I recently made in the WWGCSA publication "Clippings" in which I said "The science of drainage involves 1% of college-level training and 99% common sense." With that astute observation, perhaps we have cleared the air so that we cannot assume the presence of any genius, we shall proceed to validate that statement. We shall expound on the science of common sense.

You may ask of me if I am some sort of a broken record. How many times have I given presentations similar to this one? How come do I say the same things over and over? And why do I come before you to bore you with more of the same, maybe with a bit of warmed up vernacular? The answer to these questions is quite simple: It is because the science of the movement of water through soils has not changed since they first drained the Red Sea. Then they used Biblical magic; today you must use common sense and all too often we see a continuing of honest but misguided efforts.

Our firm has made numerous studies of golf courses, parks, commercial property and even glitzy residences and the problems are the same. Ninety-nine percent of most drainage problems relates to the inability of water to move rapidly through soils; away from people-populated surfaces.

A few pictorial examples from our Kodak carousel may help you to understand this philosophy of which I preach. I will admit that I am like a pastor giving the same sermon over and over until I am convinced that you all have been converted and, as a result, give a tithe in the form of promised, effective drainage improvements.

Let us review once more what happens to water when it falls on your turf. If the application is light, no one will ever notice that there was an impending problem. Increase that dose through rainfall or irrigation practices and let us see what happens.

Before that, however, let us provide some definitions to help you better understand the relationship of soils to drainage:

1. **Gravel: Loose,** big stuff with no sand
2. **Sand:** Small, loose stuff with no gravel
3. **Silt:** Very fine stuff that means that a river probably ran through here once
4. **Clay:** Makes good pottery and means that the glacier was awfully mad at us when it went through this area.
5. **Loam:** Your choice of any of the above, in any ratio of mix, and depends upon who is selling the stuff.

On page 44 you will find the true definition of those particles (without the "infamous" loam).

Now, let us mix some of these soils and then redefine our definitions:

1. Gravel w/ Sand: Should have been all sand. Wasted effort.
2. Gravel Alone: Looks great but has problems of perching when used with sand.
3. Gravel/Sand/Loam: All you did is slow down the drainage.
4. Gravel/Sand/Loam/Silt: Excellent road base material (nature's concrete)
5. Any of the above w/Clay: You have a very serious problem, sir.

Now that you have memorized all there is to know about particle sizes, let us look at how these particles affect drainage. We should all know that differing particle sizes can create real problems with drainage. In golf vernacular, our nemesis is "fines over coarse". The slides I will show are courtesy of WSU and they are as old as Methuselah. That should tell us something and that is that the science of drainage has not changed since the earth was created. Very fines over very course simply creates a perfect perched water table wherein water will not pass from those fines into those course gravels until the fines are totally saturated at the interface. This suggests that we should be very careful in selecting our permeables and that we should attempt to make the transition from one layer to a differing layer with materials that do not have a great difference in particle sizes. In other words, do not go from sand to 1 1/2" rock but rather go from sand to pea-gravel or better yet, sand to even finer gravel, 4x8 gravel.

As noted previously, we must identify the cause of our drainage problems 'before we start throwing money at the problem. Here are a few reasons??? for drainage problems:

1. My course is in Malaysia and we get 3" of rain every day during the rainy season.
2. My course is flat, therefore it must have drainage problems.
3. My owners want the grass green at any cost, even overwatering.

The real reasons are likely to be one of the following:

1. Heavy layer of dense thatch over drainable soils.
2. Dense, slow draining silts, clays or a mix of same.
3. Inability to carry water away once it has left the surface.
4. Overwatering due to poor irrigation design.
5. Bad luck; I just put in a drain tile and it won't work properly.

There are a few simple rules to follow:

1. Dig a hole and analyze the soils. It should not be too difficult to determine the makeup of the soil. Sand, silt, clay?
2. Perc the hole. Fill with water, saturate the hole for several hours and then determine the drop in an hour. 15 minutes per inch is considered the upper limit of good perc.
3. Check the depth and density of the surface thatch. Is the thatch so tight or so thick that it will not pass water?
4. Look to see if your irrigation system impacts a given area because of differing soils, shade, adjacent and contributing slopes.
5. If you want to provide written proof to the guy who writes your paycheck, send your soil to a professional lab for a sieve analysis. Tells the story loud and clear.

Once you or your hired expert have determined you have a problem, determine the best way to correct it.

A. If you have extreme thatch over drainable soils, here are some options:

1. Start a program of continuing aerifying, core and deep tine.
2. Verticut and aerify.
3. Get a bulldozer and strip the thatch (courtesy of R. Goss and T. Cook).

Obviously each remedy has an impact on the site, particularly golf courses. It is one thing to implement a program of surface treatment, another to take a fairway out of play, fully or partially.

B. If you have an irrigation problem, correct it (easier said than done). The remedy may require using a pressure-controlled, valve-in-head sprinkler in the problem area and then scheduling the applications for frequent but light applications. Easy if you have a computer driven system; not so easy if you have an old electro-mechanical system or a stand-alone micro-processor, either of which have all the stations used up.

C. If you have a soil problem, start praying since there is no easy, inexpensive remedy. If you want to improve the drainage, you will have to improve the soil. Referring back to our opening statements, there are numerous ways to do it wrong by mixing sands with bad soils. The only two ways we know of to improve poor surface drainage are:

1. **A**ggressive **S**and **T**op **D**ressing (ASTD): applying heavy doses of 16x60 sand as frequently as possible (meaning how much can you put on without getting the members mad). Do so only when the course is dry and never when the temperature is high. This will, in a period of 3-4 years, provide a clean, drainable surface layer of sand which will remove the water from the surface. Now you must provide some form of underdrainage to evacuate the water once the sand has passed it.

2. Profile Reconstruction

a. **M**aximum **R**epair **A**rea (MRA): excavate the silt/clay and dispose of elsewhere. Excavate at least 6", install underdrains, add 16x60 sand and seed. Hydroseeding appears to be gaining favor as a fast way to get a new turf. Keep the area out of play until the turf has knitted sufficiently to provide some form of cohesiveness to otherwise non-cohesive sand. Tell all golfers not tO slice their ball into the repaired area since walking on non-cohesive sand ruins the planting. (In the real world this means going out each day and repairing the mess the golfers have made).

This approach may be made palatable by doing half a fairway each year, making a par four into a par three by creating a temporary tee or green. Doesn't make some golfers happy but what is new about that?

b. **M**aximum **R**epair **A**rea: Same as above but reapply the sod from the repaired area rather than seed. This will put the course back into play almost immediately. Not recommended, however, but sometimes the only way the members will accept a temporary inconvenience. If you are lucky and can strip the sod thinly, at 3/4" or so, and the sod is more thatch than silt or clay, this might eventually give you a decent repair. Continuing tine aerifications must follow. If the sod you strip is mostly silt, you will find an improved area but will have a continuing problem with the silt layer. Aerification and top dressing must follow.

There are some facts of drainage that must be remembered if we are to solve problems and if we are to spend our money wisely. Remember that water flows downward vertically as a natural result of gravity. The finer the soil, the slower the movement. Some soils are so fine, ie., clay, that the water will not move at all. Course soils such as sand will afford good permeability, silts will provide marginal permeability. Knowing this, stop before you put in a drain tile. Remember that if the water moves slowly down into the soil with the help of gravity, it is surely not likely to move horizontally to a drain tile unless within a few inches of the problem area. **Think before you dig!**

# A QUALITY CONTROL CHECKLIST FOR SUCCESSFUL GREENS RECONSTRUCTION [1]

Mr. James F. Moore and Mr. Larry Gilhuly [2]

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Quality control. Think about those words for a minute. They describe an effort to control or ensure quality. Now consider the construction of a golf green. Greens construction requires a precise combination of artistic talent, a sound scientific base, and the best in workmanship. The reconstruction of greens is one of the most challenging projects in the life of any course. Reconstruction represents a tremendous opportunity for improvement of the facility. This is the chance to correct agronomic problems such as poor drainage, inconsistency in playing quality, weed and pest infestations, and inadequate cupping area. It is a chance to convert to superior turfgrasses, make the course more attractive, and make it more fun to play for all classes of players.

Unfortunately, there also exist many opportunities to make mistakes. Attempting to cut corners during critical aspects of reconstruction invariably leads to problems with the new greens that soon have everyone questioning the worth of the project. Building good greens is not as easy as some think. There are many pitfalls that must be avoided.

Since most of us would expect the new green to last at least 20 years and possibly much longer, quality control in the construction of that green is critical. Who should be in charge of ensuring quality control? Ideally, all participants in the project will strive to do the best work possible and will constantly review their own efforts. The architect, contractor, materials supplier, and blender all should have quality control guidelines and procedures of their own. Certainly, it is in their best interest to construct greens that perform properly.

Those who are paying for the new greens also have a responsibility as consumers to be knowledgeable about what they are buying. It is foolish to assume that the quality control efforts of the seller (regardless of what is being sold) are sufficient to completely protect the interests of the buyer. The buyers need someone on the project representing only their interest. That person needs to have a working knowledge of all aspects of the construction of greens. They should know the area well, be in tune with the desires of those who play the course, and have a vested interest in the success of the project. No one fits this description better than the golf course superintendent.

In most cases the golf course superintendent will serve as the "owners' representative" during the reconstruction of greens. On a project of this magnitude there is a wide variety of tasks and procedures that must be accomplished. In most cases, there are numerous ways to accomplish the same goal. It therefore is quite possible for differences of opinion to arise concerning which method is best. For the superintendent to be effective in such circumstances, the owners must give him/her the authority to halt the project if necessary until a consensus of opinion can be reached.

Obviously, there is a great deal to monitor during a project of this size. Very likely it will prove impossible for the superintendent alone to provide such close scrutiny throughout the project, particularly on courses that remain open during construction. It therefore is a very good idea to appoint a member of the maintenance crew as a "clerk-of-the-works" for the duration of the project. This individual should have no responsibilities other than providing a second set of eyes and ears for the superintendent. Using the guidelines provided below as a beginning, the superintendent should prepare a daily "punch-list" for the clerk-of-the-works, detailing specific aspects of the project to be monitored.

What follows is a checklist to help the golf course superintendent make certain that good quality control is maintained throughout every critical phase of a greens construction or reconstruction project. It is important to note that not every step in the checklist will be appropriate for every job. It is equally important to keep in mind that this list is an example only. Every job is different, and consequently every quality control effort must be individually tailored to the specifics of site, individuals involved, materials, etc. For example, on many jobs a great deal of additional testing of materials may be necessary to meet contractual agreements. This is particularly true in areas where the physical properties of materials are inconsistent.

Once prepared, a quality control checklist such as this one will help the superintendent avoid many of the mistakes commonly made during greens construction. Space does not permit detailed discussion of each guideline. Refer to the March/April 1993 issue of the *Green Section Record* and call your local Green Section office for additional details.

**1. IDENTIFICATION PHASE**

The first step to take before the reconstruction of greens that have a history of poor performance is to ensure all the factors responsible for that poor performance have been identified. Greens fail for many reasons. While an improved root zone mix can correct drainage problems, it cannot provide light, air movement, or additional surface area. Unfortunately, all too often a new green is built without correcting many of the most limiting factors that caused the old green to fail. The first step should be to make certain that poor construction was the principal reason for the existing green's poor performance. The following questions should be asked:

1. Is surface drainage good?
2. Do the greens drain well internally?
3. Have root zone samples been submitted to a physical soil testing lab for analysis?
4. Are there layers in the profile that inhibit drainage?
5. Has deep-tine aerification been tried?
6. Is the existing root zone high in silt and clay?
7. Is the existing root zone of consistent depth?
8. Have the terminal points of the drainage tile been found and checked for blockage?
9. Has the drain tile system been flushed?
10. Does sufficient light reach the turf surface at all times of the year?
11. Is there sufficient air movement across the putting surface?
12. Is the green large enough to take the traffic?
13. Are there adequate entry and exit points to the green to distribute the traffic?
14. Have nutritional requirements been met?
15. Has there been a check for nematodes?
16. Have irrigation average and application needs been met?
17. Could water quality problems (either physical or chemical) be the basis for the problems?
18. Have walk-behind mowers been tried instead of triplex equipment?
19. Are the greens being cut too low and kept too fast?
20. Is the type of grass on the greens appropriate for the demands of your climate?
21. If part of the reason for rebuilding is to eliminate *Poa annua* in the greens, has *Poa* been controlled on the rest of the course?
22. Is the membership happy with the architectural characteristics? Remember, the desire of the players for a better design is as much a justification for reconstruction as poor drainage.
23. Has your regional Green Section agronomist been asked to examine the greens and help identify and document the problems causing their failure?

## II. SELECTING CONSTRUCTION MATERIALS

**A. Is climate an issue?** These questions must be answered prior to selecting construction materials.

1. Will the greens be maintained in a climate of extreme dryness and high evapotranspiration rates

2. Will the greens be maintained in a climate of frequent and prolonged wet weather high humidity and heat?
3. Will the root zone be irrigated with water high in sodium, salts, or both?

**B. Selecting materials**

1. Have you personally visited local suppliers to collect samples for submitting to a lab?
2. Have you discussed with the supplier the construction of greens so they understand the need for preciseness during the project?
3. What is the source of the material?
4. Is the source consistent?
5. How much notice is needed to guarantee that the required quantity and quality will be available?
6. Can they stockpile the materials at their site throughout the project, or must the stockpile be kept at the golf course site?
7. Is their stockpile area free of weeds and soil?
8. Can they mix organic matter and sand or will a custom blender be hired?
9. Will they mix the components and then wait until an outside lab tests the mixture?
10. Can they incorporate nutrients?
11. Do they keep "in-house" quality control records?
12. Do they use their own trucks for delivery?
13. How much are shipping costs over FOB?
14. To what other golf courses have they supplied material?
15. Has a physical soil testing lab been located, and have their fees and testing standards been determined?
16. Does the lab test according to the procedures published by the USGA?
17. Have all of the materials (sands, organic matter, and gravel) been submitted to the lab to verify their suitability for the construction of greens according to the USGA Green Section recommendation?
18. Has a sample been prepared according to the lab's mixing ratio to serve as a visual "standard" throughout the project?
19. If because of cost or lack of availability the proper material cannot be acquired, have you discussed with your Green Section agronomist the possible repercussions of whatever compromises must be made?
20. It is likely that more than one sand and organic matter mixture will fall within the guidelines. Have you discussed the various mixtures available with your Green Section agronomist to help you select the material best suited to your needs?
21. Once a root zone mixture is determined, has a chemical soil test been run to identify which nutrients should he added prior to planting?

## III. MONITORING QUALITY DURING MIXING

This is one of the most critical phases of a greens construction project, and therefore good quality control efforts are mandatory. What follows is a sample quality control program that will suffice for many projects. However, not that this aspect of quality control program must be tailored to fit the specifics of your situation. It may prove necessary to include much more testing throughout the project, depending on the consistency of the materials meet contractual agreements.

1. Test the first load mixed to verify that the mixing procedure is valid. The project will have to be put on hold for 24 to 48 hours while the lab verifies that the field mixing duplicates the recommendations offered by the lab.
2. Remove samples daily or anytime the mixing operation is interrupted and compare them to the standard.
3. Be prepared to mix as much of the material at one time as possible and stockpile it.
4. Each delivery truck should be inspected as the load is dumped and the mix compared against the standard.
5. Collect a one-gallon composite sample from every green, and label and store it.
6. Submit to the lab a composite sample from every third green built.
7. When moving root zone mix from stockpile into trucks, closely monitor the loader operator to ensure that the bucket is not collecting the underlying soil or asphalt and that cleated tires or tracks are not "tilling" other material into the mix.

## IV. CONSTRUCTION

### A. Location of the Green

1. Will there be plenty of air movement across the green?
2. Will sunlight be a problem in summer or winter?
3. Will tree roots compete with turf?
4. Will there be good access to the green?
5. Is there room for triplex greensmowers to turn?
6. Is a perimeter irrigation system needed?
7. Is the green site prone to flooding?
8. Is enough surface area provided to withstand anticipated traffic?
9. Are there enough hole locations?
10. If not all the greens are to be rebuilt, does the design of the new greens complement the old greens?

**B. Subgrade Checks**

1. Are there prior construction problems such as still-functional drain lines from the previous greens?
2. Have the new drainage outlet point(s) been identified?
3. Is the material to be used for the surrounding base of good quality?
4. Is the material free of large organic matter clumps and stone?
5. Is the subgrade smooth and compacted?
6. Are there any water-collecting hollows?
7. Has the architect approved the grade?
8. Has the superintendent approved the grades?
9. Has the club's representative approved the grade?
10. Have the grade stakes been installed and checked?
11. Are the side walls of the cavity stable?
12. Has the plastic barrier been installed along the side walls of the cavity?
13. Has the green perimeter location wire been installed?
14. Have pictures been taken of the subgrade?

**C. Tile Line Installation**

1. Are trenches at least 8" deep, after cleaning?
2. Are bottoms of ditches smooth and clean?
3. Is enough fall provided?
4. Are the lateral lines within 15 feet of each other?
5. Have "smile" drains been installed at each surface runoff location?
6. Has the subgrade been cleaned of soil displaced during trenching?
7. Has gravel been laid and firmed on the bottom of the trench?
8. Are connections taped or glued?
9. Are all lines completely free of buckles or bridges?
10. Have lines been "shot" to ensure proper grade?
11. Has the tile location wire been installed?
12. Have flush points been installed, capped, and marked with metal for future location?
13. Have the perimeter and tile location wires been brought to the main flush point?
14. Has the inspection drain in front of the green been installed?
15. Have pictures been taken of the finished drain tile system?

**D. Gravel Layer**

1. Is the gravel clean and properly sized?
2. Has care been taken not to crush drain lines?
3. Have joints been checked to ensure they are intact after gravel has been spread?

4. Is the surface of the gravel smooth?
5. Are grade stakes still intact?
6. Has the finished grade of the gravel layer been checked to ensure it "mirrors" the desired finished grade of the putting surface?
7. Have pictures been taken after gravel installation?

**E. Intermediate Layer**

1. Has the gravel contour been preserved?
2. Has the sand been kept moist during installation to help prevent occlusion?
3. Have grades been rechecked?
4. Have pictures been taken?

**F. Root Zone Mix**

1. Is the depth of the root zone mix uniform throughout the green?
2. Was the mixture kept moist during installation to help prevent occlusion?
3. Has the mix been firmed?
4. Have all grades been checked?
5. Have amendments been added?
6. Have samples of the mix been collected?
7. Does the finished grade mate well with surrounding soil?

**G. Irrigation System**

1. Has single-head control been provided?
2. Has coverage been checked?
3. Have quick couplers been installed?
4. Is a perimeter system needed?
5. Have isolation valves been installed?
6. Have all ditches been firmed and leveled?

**H. Final Checks Prior to Planting**

1. Have all drains been checked?
2. Have all terminal points of drains been protected?
3. Have nutrients been added?
4. Has the root zone mix been compacted?
5. Is the irrigation system completely functional?
6. Have all parties approved of final construction?
7. Is certified seed or sod being used?
8. Has enough root zone mix been stockpiled for the first year's topdressing?

9. Has all heavy equipment damage been repaired?
10. Have the surrounds been sodded to prevent erosion during grow-in?
11. Has fumigation been accomplished in areas prone to nematode, nutsedge, or warm-season grass contamination problems?

A properly built USGA green can provide many years of dependable, relatively low-cost service. Where problems have occurred with USGA greens, often it was because shortcuts were taken or mistakes were made without someone being aware of what was happening. Developing and following a good quality control program is a small price to pay for ensuring success in the construction of the most important features of the golf course.

# MAXIMIZING BIOLOGICAL POTENTIAL IN TURF [1]

Mr. Matthew C. Nelson and Dr. William J. Johnston [2]

[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.
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With increased environmental awareness from the public over the past decade, the need for turfgrass managers to become knowledgable about environmental issues and manage accordingly and responsibly has never been greater. Having a solid understanding of issues such as water pollution (both surface and ground), wildlife habitat, urban development, wetlands, and historical sites and being able to effectively communicate about these issues will be crucial in gaining public support of turf management practices. This means superintendents and other turfgrass managers will have to impose comprehensive ecosystem management measures, and utilize environmentally responsible techniques in the timing and application of fertilizers and pesticides. This paper will deal with some biological options to pest control including cultural practices to enhance the competitive ability of turfgrass, and touch on some means of incorporating a greater holistic ecosystem regime into turfgrass management.

Perhaps everyone has heard at one time or another that the best safeguard against weeds and disease is a healthy turf. Turfgrasses are subject to competition from neighboring grass plants, weeds, insects, and diseases. Strong, healthy turf combats these competitors much better than damaged, weakened turf. In a specific example, it has been shown that leaf smut drains carbohydrate reserves in the turfgrass plant causing increased tillering. This in turn requires more water usage by the plant, and therefore in times of water stress the pathogen compounds the problem of water conservation by the plant (Nus, 1990). In another example, a correlation between snowmold incidence and mowing height in perennial ryegrass was shown in eastern Washington. Increased cutting height in the fall caused an increase in snowmold (Johnston, 1986). It seems that increased foliage provided a more ideal environment for the development of the disease due to an abundant food base for the fungus (Gould, 1979).

The first step in turfgrass managment should be the selection of an appropriate grass species and cultivar. Many future problems can be greatly alleviated by this critical decision. A couple of visits to your nearest turfgrass research facility conducting the National Turfgrass Evaluation Program should help considerably. It would be best to visit a site with climatic patterns closest to those at your site to evaluate environmental tolerance and disease resistance. At the WSU turfgrass research area in Pullman, WA., differences in competitive ability against annual bluegrass among fine leaf fescues and perennial ryegrass cultivars was quite obvious. If *Poa annua* invasion is a problem in your area, selection of a vigorous competitor will be to your advantage. Also noted were different levels of glyphosate (Roundup) resistance in an outgoing fineleaf fescue trial. This leads to the presumption of different herbicide resistance among cultivars for most chemicals. Inquiry as to resistance levels among applied chemicals will lead to a greater effectiveness in pesticide application when the proper turfgrass is chosen.

Extreme differences in Kentucky bluegrass morphology, disease resistance, and herbicide tolerance has been observed in an evaluation of 245 germplasm accessions from the USDA Plant Introduction world collection at Pullman, WA. This is very encouraging when considering the development of new cultivars that could require less water and fertility, and have increased resistance to diseases, weeds, and other pests. These possibilities demonstrate the utmost in environmentally sound turfgrass management by greatly reducing the required inputs necessary for high performance turfgrass.

Increased public concern about environmental safety and groundwater contamination has placed emphasis on research directed toward reducing the use of synthetic chemicals. One method of accomplishing this is the biological control of pests. One study conducted at WSU has demonstrated the effect of rhizobacteria on plant (weed) suppression. Specifically, isolates of bacteria (*Psuedomonas* spp.) have been found that suppress root growth of downy brome, a troublesome grassy winter annual weed, but did no damage to winter wheat (Kennedy, 1991). Toxic effects of microorganisms are plant species and cultivar specific. An interesting avenue of future research involving turfgrass, may be finding bacteroids specific to the suppression of annual grassy weeds. At Pullman, we plan to start a program for the control of annual bluegrass, and feel there may be potential due to the correlation between *Poa annua* and downy brome, since they are both C3, grassy winter annuals. Finding bacterial isolates specific to annual bluegrass in the lab would be a starting point. After accomplishing this, integrating this measure in management practices would have to be evaluated. For example, of particular interest in the downy brome, winter wheat study was the method the bacteria were applied in the field. Water was the carrier, and the application was made to the soil just prior to spring germination of downy brome. It seems worthy of trial, if indeed a successful isolate is located, to incorporate the bacteria into aerification with the hydroject. If it works, the benefits of an already used management practice could be increased. "Bugs in the jug," if you will.

Another biological mechanism with potential, is the increased use of endophytes in turfgrass management. Endophytes are fungi involved in a symbiotic relationship with the host plant. The fungus spends most of its time deep in the basal sheath whorls of the grass plant, but as the seedhead elongates and the plant flowers, the fungus moves up the stem and into the aluerone layer of the developing seed. The seed is how the fungus is transmitted from one site to another. Alkaloids secreted by the fungus have been shown to effectively protect turf against sod webworms. This suggests the possibility of using endophytes in turfgrass management for protection from European craneflies on the west side of the Cascades. As knowledge of endophytes and their relationship in the turfgrass community increases, the developement of and location of endophytes in new species and cultivars becomes imminent.

As we move into this new era of turf management, focus must be on both specific practices and the broader aspect of ecosystem management. Sound understanding of ecological principles and plant community relationships are a must in management of turfgrass. One should incorporate as many facets of environmental management and enhancement as possible, and be able to effectively defend any practice causing scrutiny. All to many times, people are both misinformed and uninformed regarding turfgrass management and environmental issues, and it increasingly becomes the responsibility of the turfgrass manager to properly educate those in doubt. The turfgrass manager must also strive to prevent any negligience on his or her behalf.

Two of the biggest environmental issues affecting golf courses and other turfgrass areas are wetlands and wildlife managment. Many golf courses border or surround wetland areas. Giving these areas the utmost care and consideration is foremost in gaining public support of turfgrass management. Wetland management begins by taking baseline water quality data for nitrate, phosphorous, temperature, pH, and dissolved oxygen. This is a safeguard against accusations of eutrophication and degradation provided you have done your job correctly. We have been shown by many how effective turfgrass is as a filter for both nutrients and pesticides when responsible management is employed.

Clearly delineating the wetland is a must. Hiring of an environmental consulting firm can accomplish this legally and definitively. After this has been done, stay out of the wetland. This means keeping people out, and keeping chemicals out. In a newly developing site, protecting the wetland from sedimentation and runoff can be done by installing plastic barriers until turfgrass has become fully established. Where necessary, permanent retaining walls may need to be installed to prevent undesirable affects to the wetland. When fertilizing or applying pesticides, use extra caution along the wetland to prevent any overlap into the wetland. This can be done by applying by hand with a drop spreader along the wetland and using extra caution. Wetlands are extremely productive areas that harbor tremendous biological diversity, but the proper balance can be destroyed easily by negligient management.

Integral to every ecosystem is the wildlife. Turfgrass managers must realize that they are responsible for maintenance of but a fraction of the surrounding greater ecosystem. Often times, golf courses and parks are in very strategic locations with regard to diurnal movements of wildlife. For example, a golf course along a waterway may be between the water and a large area of animal habitat. At some time, these wildlife species need to get to the water. This is where 'greenways' become important. Greenways, or travel corridors, are important for the movement of most animal species. Federal regulations require agencies such as the Forest Service and the BLM to leave connecting corridors between timber projects to provide travelways for species which may be vulnerable to crossing large open spaces. These corridors provide both physical and thermal cover to wildlife, and also preserve diverse natural habitat necessary for survival of stable populations. Not only will this enhance wildlife populations and diversity at your site, it will serve to distinquish you as responsible, comprehensive manager. At the Whitefish Lake Golf Club in Whitefish, MT, a covenant restricting activity for 100 feet on either side of the property line along the southern boundary of the newly developed South course, creates just such a greenway. Even though the covenant was established to create a physical boundary between the golf course and the adjacent property (owned by the individual who sold the land to W.L.G.C.), a travel corridor for wildlife was nonetheless established between Lost Coon lake and a large chunk of state land above the golf course (Collins, 1994).

Critical to wildlife survival is the preservation of natural habitat. The diversity in the natural environment provides the niches required for the survival of many species. Ample roosting and nesting sites for bird species, cover and forage for both small and large mammals, and protected waterways for clean and temperature regulated water for aquatic life are among integrative techniques for preserving the local diversity. Preserving natural habitat in your management area provides an added environmental attraction and maintains diversity. It may also lower the work load by reducing the amount of acerage under turfgrass management.

To even further enhance your image as a sound turfgrass manager, get involved in the Audubon Cooperative Sanctuary Program. For more information contact the Audubon Society or the USGA.

As we get set to enter the next milennia, it is obvious that turfgrass managers must utilize the most environmentally sound management practices available. Increased scrutiny from the public will require increased ecological education of turfgrass managers and an increased understanding of how to manage their microcosm within the greater ecosystem. A comprehensive management regime will help turn the tide of public support of turfgrass practices and demonstrate the viable and valuable role of turfgrass areas in the environment. Act responsibly, take the extra time and care with sensitive areas, and keep in mind the larger picture of inter-connectedness among all aspects of the environment. It is our role to keep searching for better practices and options for managing turfgrass while simultaneously enhancing the environment.

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# PLANT ANALYSIS FOR TURFGRASS [1]

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## INTRODUCTION

Most turf fertilizer management decisions made in golf course or parks and recreation settings are based on past experience or standard practices. Plant testing and soil analyses are not as popular in turf management as they are in other agricultural operations. Turf responds quickly to nitrogen additions and as long as N is regularly applied few problems are apparent. Including phosphorus, potassium, and some micronutrients in a turf mix has been regarded as relatively inexpensive insurance since toxicities are rare and costs small. Optimizing turf fertility while minimizing fertilizers use has not been a high priority. However, as environmental concerns about the use of agricultural chemicals increase, issues about nitrate contamination in groundwater become more public, and turf managers realize that one of the keys to minimizing pesticide use is to maintain healthy well fertilized turf, optimizing turf fertility without overapplying fertilizers is becoming more important. Plant analysis provides useful information on the nutrient status of turf, and should accompany any soil sampling and analysis program. Either soil or plant analyses by themselves can be misleading but combining the two test approaches provides an excellent assessment of fertility status.

Newly developed analytical equipment is being used in a wide variety of commercial and state-operated laboratories. More efficient equipment and increased competition are making analyses quicker and less expensive. Most laboratories conduct a total determination of the elemental content in the plant tissue after it has been dried, ground, and ashed. Ashing refers to either a combustion (dry ash) or chemical digestion (wet ash) of the sample to remove the organic matter while leaving the minerals one wishes to analyze. The final product of the ashing process is a liquid sample ready for analysis. In most conventional procedures an acid digestion technique is used for nitrogen, and a second ashing (either wet or dry) is used for the other elements. Nitrogen digests are commonly analyzed with automated colorometric techniques. The second group of ashed elements are often analyzed by emission spectroscopy. Modern equipment can simultaneously analyze twenty or more of the elements in a single liquid sample providing high speed and low cost. It is not unusual for laboratories to process hundreds of samples in a single day. For some applications the determination of the elemental composition of the soluble fraction of plant tissue is appropriate. The concentrations of nitrate-nitrogen, phosphorus, and potassium in the juice of freshly crushed petioles is routinely used in monitoring of potato crops. It is doubtful that these soluble fraction tests will be utilized for turf. The available information on critical values for total elemental concentrations for turf species is limited with hardly any work on the more difficult to interpret soluble fraction analyses.

Nondestructive analysis of dried ground samples has become routine in forage quality evaluations and is beginning to be implemented in nitrogen analyses for turf. This technique uses the reflectance patterns from different wavelengths of light to determine the chemical composition of a sample. The near-infrared (NIR) reflection of light from a carefully exposed sample is very dependent on it's chemical composition. Computer programs can determine chemical compositions directly from ground samples, thus ashing is not necessary. These NIR machines are relatively simple to use and provide instant evaluations. Some advocates are even suggesting that an analytical unit could be purchased by a golf course and instant analyses could be conducted whenever desired. Simple drying and grinding facilities are all that is required. The technique works reasonably well for chemical components (such as proteins) that directly alter reflective properties, thus total N can probably be reasonably estimated with NIR approaches. Chemical components (such as most nutrient elements) that do not directly alter reflection properties are more difficult to estimate and require sophisticated empirical computer models to make predictions from reflectance data. Although I am optimistic about the future for instant nitrogen analyses, I am less optimistic about the feasibility of using NIR techniques for the nondestructive determination of other elements.

## CONCEPTS OF TURF FERTILITY

Plant nutrients are grouped into two categories. The macronutrients (N, P, K, Ca, Mg, S) are generally required in large amounts and measured in units of percent. The micronutrients (Mn, Fe, Zn, Cu, B, Cl, Mo) are required in much smaller concentrations and are usually measured in ppm units. Although required in lesser amounts micronutrients are equally essential and plants cannot grow without them. Although not considered essential, Al and Na are of special interest in plant nutrition because they are commonly toxic. Aluminum toxicity occurs at low soil pH, and Na is a common problem in arid areas.

The mobility of the nutrient elements in both the plant and soil are presented in Table 1. Mobility in the plant is a function of how well a nutrient is transported in the phloem. Xylem delivery to leaves is driven by transpiration and all nutrients are easily transported to the leaves once they are taken up. However not all elements are equally transportable out of the leaf to other plant tissues. Remobilization and transport of nutrients throughout the plant requires movement into the phloem. Many elements are not accumulated in the phloem thus they are not remobilized. Plant mobile nutrients tend to be higher in young immature tissues, often low in old tissues, and produce nutrient deficiency symptoms that first appear on the old leaves. Immobile nutrients are lower in immature tissues that are serviced primarily by the phloem, and produce symptoms that first appear in the newest leaves. Older tissues often have a buildup of immobile nutrients. Since immobile nutrients are not transportable, the plant does not have reserve supplies and constant new uptake of immobile nutrients is required to avoid deficiencies.

Table 1. Mobility of nutrient elements in soils and plants

| | |
|---|---|
| Mobile in soil | Mobile in plant |
| N, S, Cl, B, (Na)[z] | N, P, K, Mg |
| Somewhat immobile in soil | Somewhat immobile in plant |
| K, Ca, Mg | S, Fe, Mn, Cu, Zn |
| Very immobile in soil | Very immobile in plant |
| P, Fe, Mn, cu, Zn, (Al) | Ca, B |

[z]Items in parentheses are not considered essential for plants, but are important (sometimes toxic) elements in mineral nutrition.

Soil mobile elements are easily leached under rainy conditions or with excessive irrigation. Under arid conditions, soil mobile elements become concentrated in soils and water. These elements are often present in high concentrations whenever evaporation exceeds infiltration. It is not surprising that three of the most mobile elements in soils (Na, B, Cl) are commonly toxic and are major problems in some irrigation waters in arid regions.

Soil mobile nutrients have little long term residual fertilizer effects, and the amount needed is largely determined by how much plant growth occurs. The amount of immobile nutrient required depends on both how tenacious the element is bound to the soil, and specific plant properties that effect nutrient uptake. For example much P is required to satisfy the absorptive capacity of the soil before the plants have access to it, where a large portion of applied N (if it is not leached) is easily accessible to the plant. Extensive fine roots systems are more important for the uptake of immobile nutrients than mobile ones. As long as a plant can consume water it has access to the mobile nutrients present in the soil solution. Nutrient mobility in soils is a relative term and actual mobility is dependent on soil properties. In an inert sand without organic matter nutrient adsorption is minimal and all elements are mobile. When even small amounts of clay are present mobility differences among nutrient elements become very apparent. For immobile nutrients much of the total amount present in the soil is in adsorbed or precipitated forms. These less available forms tend to buffer nutrient concentrations in the soil solution, thus any changes in solution concentrations that occur after nutrient addition is reduced.

The soil pH is an important factor affecting nutrient availability. The availability of Fe and Mn, and to a slightly lesser extent Zn is pH dependent. At pHs of 8.0 and above deficiencies in Fe, Mn, and Zn may occur. Under acid conditions the availability of metal ions generally increase and high levels of Mn and Al may be toxic. Phosphorus is less available at either high or low pH extremes. Although not as pH dependent as other nutrient elements, K and Mg are less available under acid conditions. Soils differ in the rate their pHs change. Sandy soils (especially if also low in organic matter) are less buffered and their pHs can change much more quickly than soils with more clay.

Turf management of sandy artificially-created, new putting greens creates some special challenges. Sandy, low organic matter soils are less buffered and therefore prone to more rapid changes in both solution nutrient concentrations and soil pH. This can be a disadvantage because nutrient additions quickly alter the soil solution concentrations. Unbuffered soils are less forgiving of mistakes. In fact most of the severe nutritional problems in turf management are the result of an inappropriate application of fertilizer or lime in a poorly buffered system. As a putting green matures, organic matter increases and they become more buffered. Fairways and other soil based turf areas are generally much better buffered and less tricky to manage.

Nutrient availability is also controlled by the presence or absence of competing elements. All of the macronutrient cations (Ca, Mg, K) can compete with each other to some degree. An excessive amount of one can lessen uptake of the others. Nitrogen additions commonly reduce P uptake. An imbalance between N and S can also lead to S deficiency. Although less predictable micronutrient elements can also interact with each other to produce unanticipated nutritional disorders. One of the best uses of plant analysis is in the detection of nutrient interactions.

Calcium, Mg, and K are the major cations in soil solutions while sulfate (S), and Cl are the major anions. Calcium is generally found at levels greater than Mg, and soil solution Mg concentrations are generally much greater than K. Although present in large amounts in plant tissue, N and P are generally found at much lower concentrations in the soil solution. These two elements must be constantly replenished (N from organic matter; P from insoluble forms in the soil) to maintain their low solution concentrations. Given their relative plant requirement (N>K>Ca>Mg ; S ; P) and their abundance in the soil solution it is not surprising that N is most commonly deficient, K and P are sometimes deficient, Mg and S rarely deficient and Ca very rarely deficient.

Micronutirent deficiencies are rare in turf. Molybdenum is required in such small quantities that a deficiency is not likely. Although Cl is a micronutrient it is also one of the major anions in soil solutions so it is unlikely to ever be deficient. Boron and Cu are also unlikely to be deficient due to their relatively low requirement in most grass species. Both B and Cl are soil mobile nutrients, thus they can build up in soils where evaporation exceeds infiltration (most arid climates). Iron and Mn, may become deficient at high pHs. Zinc deficiencies may occur at high pH especially on sandy soils.

## USES OF PLANT ANALYSIS

The standard approach to interpreting analyses is to compare observed concentrations to standard reference values (critical concentrations or sufficiency ranges). Specific sample times and sample collection procedures are followed. Regular sampling of a specific location is more valuable than using plant analysis only when nutritional problems are suspected. A series of analyses over a period of years can indicate approaching nutritional problems.

In addition to routine samples, sampling to investigate specific problems can be useful. Plant analysis can confirm visual symptoms that suggest deficiency or toxicity. One can also determine if a fertilizer treatment has led to an increase in the specific nutrient in question. When troubleshooting, samples need not be collected at a specific time or from a specific tissue. Similar tissues are collected from healthy and unhealthy plants. Both samples are analyzed and compared. If a problem is nutritional, obvious differences are often apparent. However, if the problem results in growth restriction there may be little or no differences in element concentration. It is also possible to confuse symptoms with causes. An unhealthy plant (for whatever reason) can have strange elemental concentrations even though they are not directly related to the problem.

For some agricultural crops (potatoes in the Columbia Basin) routine monitoring of mineral status is conducted throughout a growing season. Samples are collected at 10 day to two week intervals and fertilizer is applied according to the plant analysis results. Some turf managers feel that a similar system may be applicable to turf. However, much of rationale behind the potato system concerns making a smooth transition from vegetative growth to tuber production. Precise control of N is required to avoid delaying tuber initiation while still producing adequate vines. Similarly K supply is matched to the new demands that tuber production brings. Turfgrass management is not as concerned with reproductive physiology. The color and growth rate of the sod provide a good indication of its nitrogen needs, and K requirements will not radically change throughout the season. Annual or semiannual routine sampling is adequate. Additional samples can be collected if nutritional concerns warrant evaluating good and poor areas.

## SAMPLING

It is always important to know the age, leaf type, and time of sampling that is associated with any particular set of standards. Unless the sampling conditions for the sample being evaluated is similar to the standard sampling procedure,. the critical levels will not apply. Sampling either the wrong tissue, or collecting samples at the wrong time are the most common sources of diagnostic error. While specific sampling instructions for different conditions and turf species are often presented (3,4), the guidelines discussed here generally apply. Most analysis laboratories routinely request some information about the samples to be analyzed. Since the actual analysis results are only a portion of the information used to make a diagnosis, it is helpful to complete questionnaires.

Dead plant tissue or turf under severe stress will not give realistic or useful values. When sampled for confirmation of a suspected nutritional disorder, the turf should be sampled immediately upon the appearance of symptoms. Routine monitoring should be done at least once a year, preferably in mid-season under good growing conditions. Samples are difficult to interpret when collected during a growth flush or just prior to senescence or dormancy. Hand clipping is preferred to a collection of mower clippings, but because of the convenience most clippings are collected from mowers.

## CRITICAL LEVELS FOR TURFGRASS

Some general purpose sufficiency range guidelines have been reproduced in Table 2 (2).

Table 2. Sufficiency Range Chart

| Element | Sufficiency Range | General Comments |
|---|---|---|
| *Major Elements* | | |
| Nitrogen (N) | 2.75%-3.50% | Deficiency from inadequate fertilization, over-irrigation or possible root damage. Most common deficiency of all major elements. |
| Phosphorus (P) | 0.30%-0.55% | Deficiency from inadequate fertilization. More danger from excess than deficiency on intensively managed turf. Concentration should not exceed 1.00%. |
| Potassium (K) | 1.00%-2.50% | Deficiency from inadequate fertilization, or may be induced by high Ca and Mg soil levels. |

| | | |
|---|---|---|
| *Secondary Elements* | | |
| Calcium (Ca) | 0.50%-1.25 | Deficiency not likely to occur. High concentration may indicate some other deficiency or disorder. |
| Magnesium (Mg) | 0.20%-0.60% | Deficiency caused by low soil pH, or excessive K or possible $NH_4$-N fertilization. High Ca soil levels in comparison to low Mg soil levels. |
| Sulfur (S) | 0.20%-0.45% | Deficiency from use of "high analysis" (low S) fertilizer, or imbalance between N and S. |
| *Micronutrients* | | |
| Boron (B) | 10 ppm-60 ppm | Deficiency unlikely, toxicity possible with some types of irrigation water. |
| Chlorine (Cl) | not known | Deficiency not expected. |
| Copper (Cu) | 5 ppm-20 ppm | Deficiency not likely to occur. |
| Iron (Fe) | 35 ppm-100 ppm | Deficiency when soil pH is high or when turf is under stress. |
| Manganese (Mn) | 25 ppm-150 ppm | Deficiency when soil pH is high. |
| Molybdenum (Mo) | not known | Deficiency not likely. |
| Zinc (Zn) | 20 ppm-55 ppm | Deficiency when soil pH is high and on sandy soils. |

The above ranges are based on general observations and, therefore, not equally applicable to all turf or every growing condition or situation.

Reproduced from Jones, 1980.

Critical levels for various turf species are listed in several reference publications (3,4). In most instances N, P, and K ranges vary slightly (OSU range for N is 3.25-4.00), but sufficiency ranges for other elements are remarkably similar for a wide variety of species and growing conditions. Our approach at OSU is to use suggested ranges as a starting point to a diagnosis rather than a rigid criterion. Understanding how various factors effect ones interpretation of the plant analysis results and modifying recommendations accordingly is far more important than having a fixed and rigid sufficiency range.

## FACTORS IN INTERPRETATION

We routinely consider five major factors that alter interpretation of plant analysis results.

1) Growth rates of either shoots or roots that result in a concentration or dilution of minerals.

2) Growth rates of roots and general health of turf that alter uptake efficiency (especially for soil immobile nutrients).

3) Physiological age (time of year) of the tissue sampled.

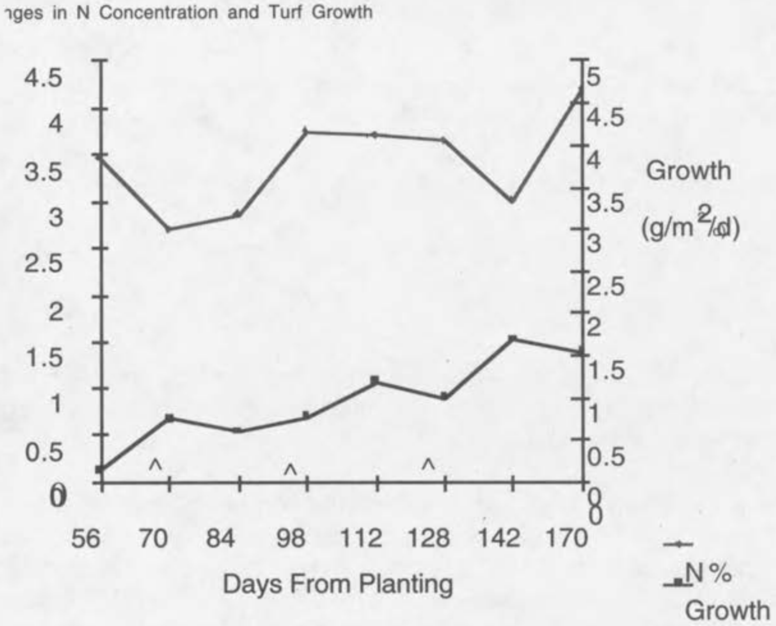
4) Portion of turf sampled (mowing height; young or old).

5) Nutrient interactions.

A complete treatment of the many possible scenarios that effect the interpretation of plant analysis results is beyond the scope of this presentation, but some examples of interpretation complexity are presented below.

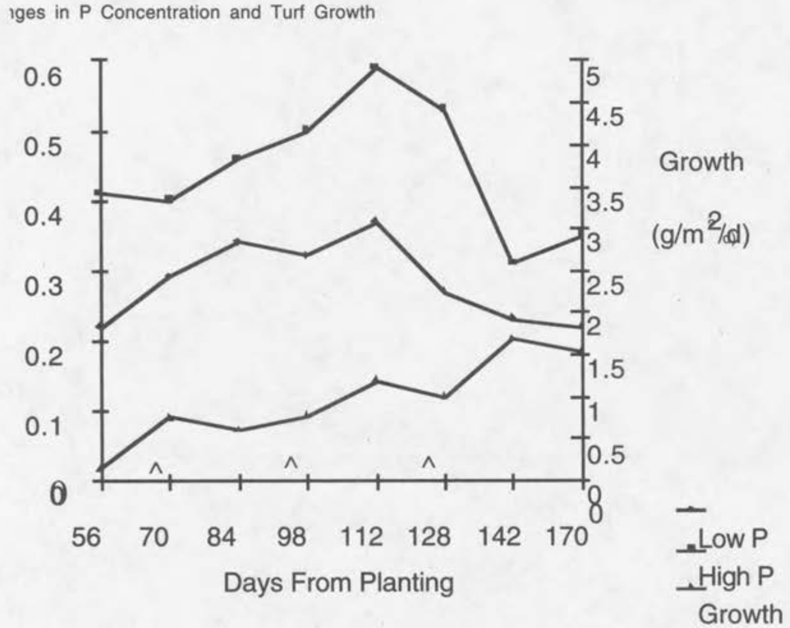
Rapid growth can result in a general dilution of minerals while stunted growth can increase concentrations. This is especially true for elements that vary over a narrow range. Nitrogen concentrations that differ by as little as 25% are large enough to place concentrations outside a suggested sufficiency range and drastically effect an interpretation. Unfortunately these differences in concentration may not reflect differences in N uptake or N availability. In Figure 1, data on both N concentration and growth rate for turfgrass during a 170 day evaluation period are presented. The "^" symbol on the x-axis mark times (70, 98 and 128 days) when N was added. An N application was also applied before planting. Nitrogen concentrations either increased, slightly decreased, or sharply decreased immediately after these applications. An initial evaluation of the N concentrations after each N application is certainly confusing. These results demonstrate how mineral concentrations (especially N, which varies over a narrow range) can be misleading. It is unlikely that the N status for the soil was lower one week after the first postemergence N application than it was one week before. However, the N concentration of the grass was approximately 3.5% before N was applied and less than 3% one week later. Evaluating both growth rate and N concentration gives a clearer picture. When growth was rapid (1st, 4th, 6th growth periods) N concentrations decreased; when growth was slow (last time period) N concentrations increased. When evaluating N concentrations (and other elements as well) both mineral concentrations and growth need to be evaluated.

Figure 1. Nitrogen concentration and growth rate for turfgrass during the 170 day period after planting. Nitrogen was applied before planting and immediately after sampling at days 70, 98, and 128. Fertilization days are marked with "^". Data is from Waddington et al. 1992.




In Figure 2., data from the same experiment discussed above (6) is shown for P concentrations and growth rates. There is more variability among sample dates of the same P treatment than there is between high and low P fertility programs. This is important because the amount of change is large enough to alter ones assessment of P needs if fertility judgments were based on the sufficiency levels presented in Table 2. Interpreting P values requires the same considerations involving growth that were expressed above for nitrogen, but is further complicated by phosphorus immobility in soils. The general declining trend for P levels toward the end of the experiment (last three sample periods) is likely due to the increasing growth of the grass. However, although general growth increases can cause a dilution in P concentrations; more root growth enhances the uptake of P and other immobile nutrients. In the early part of the experiment (first four sample periods) increasing root growth may explain the trend of increasing plant P. Any dilution of P with growth is more than offset by increasing root efficiency. Root growth is often a limiting factor for the uptake of soil immobile nutrients.

Figure 2. Phosphorus concentration and growth rate for turfgrass during the 170 day period after planting. Nitrogen was applied before planting and immediately after sampling at days 70, 98, and 128. Fertilization days are marked with "^". Data is from Waddington et al. 1992.




Sometimes seasonal trends cannot be explained by either general growth differences or the specific factors that alter root efficiency. Figure 3. shows the steady decline of Mn concentrations with time in the same experiment previously described (6). These type of season long trends generally reflect changes in the root environment that effect nutrient availability. Although I can only speculate about what may be responsible for the general decline I would guess it may be associated with either changes in soil pH or aeration. An increasing soil pH or increasing aeration could lessen Mn availability. Manganese concentrations are high at the start of the experiment. In the example shown Mn levels are generally above the sufficiency ranges suggested in Table 2. Severe toxicity or a Mn deficiency is unlikely. However, the seasonal variability demonstrates how one could be mislead with only a single analysis, and supports our contention that trends from a series of analyses (collected at similar times and turf condition) over several years are more valuable than a single sampling.

Figure 3. Manganese. concentration -for turfgrass during the 170 day period after planting. Nitrogen was applied before planting and immediately after sampling at days 70, 98, and 128. Data is from Waddington et al. 1992.

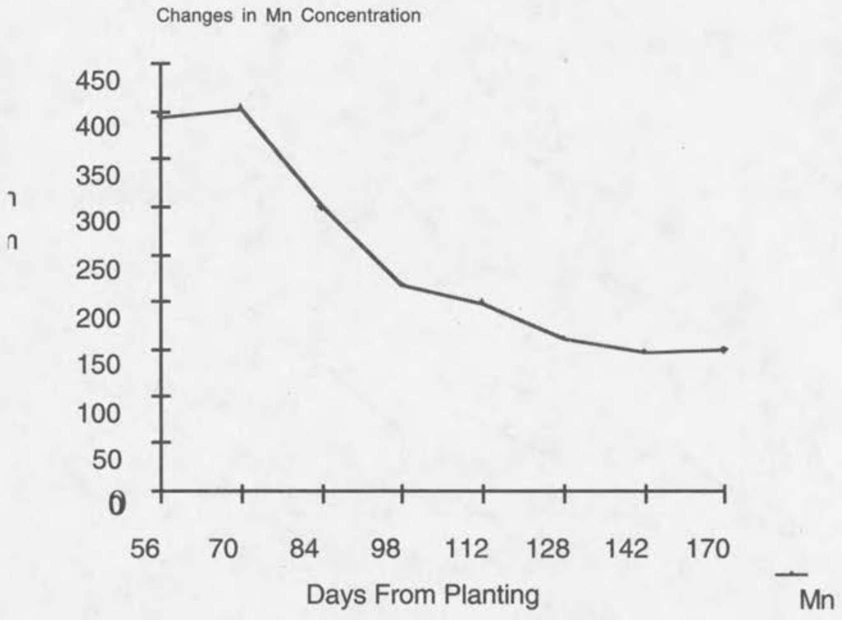



Table 3. demonstrates the effects of physiological age on nutrient concentration. This data is for an experiment where the most recent growing point of the turf was compared to clippings collected in a mower(6). The most recent blade of grass can have a very different concentration than what one would observe for the clippings. Clippings will reflect the status of the whole plant, where the concentration of the young blade can be affected by both soil fertility status and the movement of nutrients from old to young tissues. Phosphorus and K are both mobile in the plant and often high in young tissues. In low fertility situations N is often found in higher concentrations in young leaves. The fact that N levels are relatively high (~3.5%) may explain why first blade and clipping values are similar in this example. As expected for a plant immobile element, Ca is much lower in the young blade than in the clippings. This example demonstrates why a different mix of young and older tissue can give different results. Sampling method effects mineral concentrations. The amount of new growth, mowing heights, time of season, and other factors can all alter the relative amounts of young and old leaves in a sample and must be considered when making an interpretation.

Table 3. The effect of sampling methods on mineral concentrations of turfgrass. The newest growth (first blade) is compared to lawnmower clippings.

| ELEMENT | FIRST BLADE | CLIPPINGS |
|---|---|---|
| N | 3.48% | 3.55% |
| P | 0.42% | 0.34% |
| K | 2.99% | 2.42% |
| Ca | 0.55% | 0.98% |
| Mg | 0.22% | 0.33% |

Data from Waddington et. al, 1992.

A creeping bentgrass example has been selected to demonstrate the most common nutrient interactions in turfgrass nutrition (5). In Table 4. the effect of K fertilizer on the Ca and Mg levels of turf is illustrated. Adding K depresses Ca and Mg. When either of the three major cations (K, Mg, Ca) appear unusual, it is best to evaluate the other two and consider any practices that may have altered relationships among them. Increasing N can depress P concentrations. This is apparent in Table 5 where the form of N (urea, nitroform and arginite) led to different N concentrations with the higher N concentrations associated with decreasing P (5). The P values for the milorganite source do not follow the same pattern, but this is expected since milorganite is an organic N source that also contains P. The other three forms did not increase soil P and differences in soil P are not significantly different among them. Monitoring N-P and K-Mg-Ca relationships over time is the best way to insure that the fertility practices for one element do not interfere with another. Deficiencies for P, K, or Mg are not common, but when they do occur, they are often aggravated by imbalanced fertility programs.

Table 4. The effect of K fertilizer on the chemical composition of Penncross Creeping Bentgrass

| K RATE | MINERAL CONCENTRATION | | |
|---|---|---|---|
| (Kg/100m$^2$) | K | Ca | Mg |
| 0 | 1.98% | 0.58% | 0.30% |
| 1.2 | 2.47% | 0.47% | 0.24% |
| 2.4 | 2.60% | 0.45% | 0.23% |

Data from Waddington et al. 1972

Table 5. The effect of different N sources on soil P and the N and P concentrations in Penncross Creeping Bentgrass.

| N SOURCE | SOIL P (ppm) | PLANT N (%) | PLANT P (%) |
|---|---|---|---|
| ARGINITE | 6 | 5.39 | 0.48 |
| NITROFORM | 8 | 5.72 | 0.44 |
| UREA | 8 | 5.90 | 0.43 |
| MILORGANITE | 44 | 5.67 | 0.59 |

Data from Waddington et al. 1972

## INTERPRETATION GUIDELINES

Interpretation is best viewed as a system where sufficiency ranges are considered a starting point for corrective action and are one of many factors to consider. Most private and state tissue analysis laboratories place elements in one of five ranges: deficient, below normal, sufficient, above normal and excessive. Initiating a fertilizer program or increasing current fertilizer application rates are generally advised when values are below sufficiency ranges. Decreasing or eliminating the fertilizer rates when values are above sufficiency ranges is often appropriate. However, this simple rule of thumb is not rigidly followed. Recommendations vary for each element and involve considerable judgment. Only when considering long term trends, determining growth rates, evaluating physiological age, accessing possible interactions, and thinking about the specifics of the turf being evaluated can a recommendation be made. The following guidelines are presented to summarize important aspects of interpretation.

## NITROGEN

From a practical perspective, N concentrations can be interpreted if turf vigor is also considered. Adequate vigor is best defined by what the manager judges to be adequate color and growth rate. I view sufficiency ranges as applying to turf with normal vigor and modify interpretation accordingly. The deficiency ranges that most laboratories use are low enough that one can assume that N fertilizer rates can be increased if samples are deficient. However, few samples fall in this range. The vast majority of samples are either within the sufficiency range, slightly less (below normal) or slightly higher (above normal), and must be evaluated relative to turf vigor. If vigor is adequate and values are within the sufficiency range continuing the current fertilizer program is appropriate. For turf with above-average growth, below-normal values are often the result of dilution, and N fertilizer rates do not necessarily need to be increased. Similarly plants with insufficient growth often have above-normal N concentrations. If growth is above normal and N levels above normal, fertilizer rates can likely be reduced. If growth or color is below average and N levels below normal, fertilizer N rates should probably be increased. If a sample falls in an excessive category, one can generally assume N levels should be reduced with one major exception. When plants are severely stunted, N is concentrated in the leaves and excessive N values are a likely symptom of some other problem rather than a cause of the poor growth observed. In any case, excessive N values are rare.

## PHOSPHORUS

Deficiency from inadequate fertilization is possible but rare. Since P is immobile in the soil regular P fertilization generally results in a buildup of soil P and favorable long term P fertility. When values are below normal or deficient either low P availability or some other factor limits P uptake. Low values are often associated with diseased or otherwise stressed turf especially on low pH soils. Correcting other problems is probably more important than altering P status. There may be more danger from excessive P levels than P deficiencies on most intensively managed golf courses. Leaf analysis can detect P excess and a discontinuation of P fertilizer is recommended if P is above normal or excessive.

## POTASSIUM

Values for K vary considerably among sample dates, thus it is advisable to base fertilizer changes on several analyses. The biggest factors to consider when evaluating K status are the levels of Ca, and Mg. If above-normal Mg or Ca levels are encountered, marginal K levels should be evaluated more closely, and small doses of K are certainly appropriate even if the K levels in themselves do not suggest a major problem. It is easier to add K than reduce the other cations. However, Mg or Ca containing products should be avoided if K levels are marginal. Above normal K levels are generally not a major concern unless Mg concentrations are also marginal.

## SULFUR

Sulfur has only recently been routinely monitored in Oregon turf. Current sufficiency levels are tentative and difficult to interpret. The same growth dilution and concentration concerns that were discussed for N apply to S. Responses have not been observed, but high rainfall and declining use of S-containing N fertilizers suggest the possibility that deficiencies may develop. Sulfur applications are only recommended when deficient values are accompanied with poor color that can not be explained by N deficiency (N levels are high). Since S is relatively immobile in the plant, chlorosis first appears on the newest leaves. Their is some concern that high levels of N when applied without S might create an imbalance.

## CALCIUM

Calcium deficiency is unlikely. Since Ca is the major cation in soil solution, it will probably never be deficient. When below normal Ca values are observed, they are almost always the result of water stressed or otherwise unhealthy turf. Above-normal or excessive Ca concentrations can be important indicators of marginal K or Mg nutrition.

## MAGNESIUM

Magnesium deficiencies can occur. When levels are below normal or deficient and soil pH is low, dolomitic limestone is recommended. Values in either the deficient or below normal category are rarely encountered when soil pH is considered adequate unless K is also above normal or excessive. Excessive Ca caused by either unusually high Ca to Mg ratios in the soil or by unnecessary gypsum or lime applications can aggravate a Mg deficiency.

## MANGANESE

Manganese concentrations are strongly correlated with soil pH. Deficiencies are only likely on alkaline soils. The most useful aspect of Mn concentrations is in evaluating the effects low pH is having on turf and the need to lime. When Mn concentrations are above normal or excessive, more extensive soil sampling is recommended. A more detailed soil sampling almost always reveals a low pH that should be corrected. Similarly, if a low soil pH is accompanied by a normal Mn concentration, more detailed soil sampling often reveals that the pH problem is less severe than the single soil sample may indicate. High Mn levels can also be associated with poor drainage. Although the above guidelines are useful, Mn-containing fungicides can contaminate leaf samples.

## IRON

Iron concentrations are also correlated with soil pH. However the relationship is not as strong as for Mn. Therefore the latter is more useful for diagnosing pH problems. High soil pH and poor color may be a more reliable indicator of iron deficiencies than total leaf Fe. Foliar sprays will quickly improve the chlorosis caused by Fe deficiency (1), and can be used as a tool to confirm a diagnosis. Foliar sprays can also be used as a management tool to enhance color but since Fe is immobile in the plant any new growth immediately develops deficiency symptoms.

## ZINC

Zinc deficiencies can occur on sandy soils especially if pH is high. Zinc concentrations are a good indicator of Zn deficiencies. In the rare cases where deficiencies occur they are easily corrected with Zn applications. However there is little carry-over into succeeding seasons, so frequent applications are required. In view of the modest cost and general effectiveness annual applications are recommended if Zn deficiencies have been recently (last several years) observed.

## BORON

Although B is commonly deficient in fruit trees throughout the Pacific Northwest, B is required in much smaller quantities for grasses and B deficiencies are unlikely. Since B is a soil mobile nutrient it does become concentrated in arid areas where evaporation exceeds infiltration and leaching. Boron toxicities can occur in arid areas. Some poor quality irrigation waters in drier areas can have excessive B. Leaf analysis is a good diagnostic tool for detecting B toxicities.

## COPPER

Copper deficiencies are unlikely to ever occur in turf. The application of Cu containing products could result in Cu toxicities, but this is also unlikely.

## CONCLUSION

Mineral analysis of turf is becoming an increasingly valuable tool as concerns for the environmental impact of agricultural chemicals increases. Interpretation is not simple because turf nutrition is complex. However, attempting to maintain leaf elemental analyses within the appropriate sufficiency ranges should enhance turf quality. Refinements to a diagnosis can be made by considering vigor, cultural practices, and general turf condition. In any case, regular sampling provides more information than sporadic evaluations. A series of foliar analyses over a period of years can indicate approaching nutritional problems.

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# RETIREMENT PLANNING: PERSONAL INVESTING FOR YOUR FUTURE[1]

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[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.
[2] Vice President, Ragen MacKenzie, Inc., Tacoma , Washington.

Our regional northwest firm is headquartered in Seattle and is known for our straight forward value-oriented investment philosophy and our expertise in following Northwest companies, as well as national companies. My approach to investing is really quite simple: 1. Define your goals, objectives, & risk tolerance, 2. Invest for the long haul in good solid companies, 3. Review periodically for changes, 4. Remember, it's not what you earn, it's what you keep.

Where to get started? When clients come to me, I always ask them about where they're at today. I need to see the big picture. The first thing we talk about is your assets/ liabilities and net worth. I've included a simplified version of how to calculate this, see Exhibit A. This is a great tool to force you to sit down and list your assets and liabilities and to see, after expenses, where you are at financially.

The next thing I do is discuss your goals. How much income do you need when you retire to maintain a comfortable lifestyle? How much in assets will it take to produce your desired income? Where will those assets come from: 1.) Co. pension, 2.) investments, 3.) social security, 4.) part time employment, 5.) downsizing your home. Do you know how much retirement money is generated by pension plans today? Thirty to fifty percent, the rest (60%) has to come from you. So planning ahead and managing your money is very important. Once I know your present financial resources, your annual amount available for investment, and you time frame until your retirement, I determine the future financial resources needed to achieve your objectives and the rate of return required to increase your present resources to the necessary amount, taking taxes and inflation into account.

One problem area I see is that most people have too much debt. Debt on your home or rental property is good from a tax standpoint. Debt on credit cards, boats, raw land, and personal loans are terrible and one of the first things I encourage people to get rid of before trying to save for the future with discretionary money. If you're paying 15% interest on debt and saving money for retirement you've got to be earning over 15% on your savings to break even. In the stock market of the 80's you could probably come close to that, but in the stock market of the 90's and beyond I think it will be increasingly difficult to generate those types of returns.

You've probably heard of the rule of 72 which means you divide 72 by the number of years in which you want to double your money and the result is the interest rate you need to earn. Example: 72/5yr = 14.4% rate of return.

Besides earning 14.4% return on your money, what else can you do to double your net worth in 5 years? Two other areas to consider...

1. Decrease your liabilities. Example: your mortgage payments on your home are decreasing your balance every year by 1-2%.

2. Increase your contributions to your 401-k plan by 1-2 per year. Taking these two items into account, you actually need to earn between 10-12% on your investment money in order to double your net worth in 5 years.

Let's talk about college education now. It currently costs approximately $7000 for the University of Washington per year, $12000 for Seattle University per year, and approximately $20000 per year for Stanford. I recently calculated an approximate amount of yearly savings required for a client who has a 2 year old child. They needed to save $158 per month or approximately $1900 a year, assuming a 10% rate of return on their investments and a college tuition inflation rate of 6% in order to send her to a state school like the U of Wa.

Set up college accounts with you as custodian for your minor child using their social security number. The first $600 of unearned income to your child is not taxed, the next $600 is taxed at your child's bracket, probably 15%. If your child is under 14, any additional unearned income over $1200 is taxed at your bracket. Be careful if your child is over 14, the additional income will be taxed at their bracket. If you find your child's income is being taxed at your bracket, you should consider tax-free investments held in your name.

A word of caution, if the money is in their name with you as custodian, the money is legally the child's so make sure you plan on letting them have it. There are also 10 year trusts available if you want to limit their access to it for ten years.

Just in passing let me mention estate planning as it goes hand in hand with wealth accumulation. Make sure your wills are updated and guardians are established for your children. If your net worth is over $1.2 million, which includes the face amount of your life insurance policies, you should consider the use of bypass trusts to shelter the first $1.2 million from estate taxes upon the second death. Without by-pass trusts an estate worth $1.2 million would pay approximately $235,000 in taxes, upon the death of the surviving spouse, with the by-pass trusts the estate will pay $0.00 in estate taxes. If your estate is $3 million, you will be in the 55% tax bracket! Gifting $10,000 a year per person is another way of reducing estate taxes and avoiding gift taxes. It is not difficult or that expensive to establish a trust, but just like the financial review, it's a matter of taking time.

Let's talk about insurance for a moment. I think insurance is most important when you have young children, a mortgage, or other large debt that you would want paid off. Some people believe adequate insurance coverage is your present salary times 5 years plus any amount you want to go toward paying off a mortgage, college education, etc.

As you get older, your needs are less. The one reason to use insurance in your later years is to help pay estate taxes. There are excellent vehicles available, called second-to-die policies, in the insurance field that I use to cover this specific purpose. They're cheaper and designed especially for estate tax planning.

I'm a much bigger fan of term insurance than whole, universal, or variable life. Term insurance is pure, inexpensive insurance. It is more beneficial in the long run to buy cheap insurance and be disciplined and invest the extra money you would have spent on whole life or variable insurance in solid long term investments.

Let's move along to the investment section. I have enclosed an investment pyramid (see Exhibit B) to show you various examples of asset types and categories. The bottom tier is your safe, liquid money. The next level is your safe, fixed income money but longer term oriented. The third tier is where we allocate your long term growth money and the top, speculation, is where a smaller portion of your total assets should go. The first question is how much goes where? That will vary for each one of you based on your goals and risk tolerance.

If you are conservative and feel that bonds are most comfortable for you, I use a strategy with bond portfolios known as laddering bonds. This means that I buy bonds with varied maturities. For example: a 2 yr maturity, a 4 yr maturity, a 6 yr maturity, an 8 yr maturity, and a 10 yr maturity. This way I can have bonds maturing every 2 years to take advantage of any rise in interest rates and then I rebuy a 10 year bond with that money to take advantage of the usually highest relative point in the yield curve. For international investing, I use mutual funds. It's a much safer way to invest globally. A mutual fund is a group of stocks or bonds in a pool and all the investors own a portion of the total based upon the amount of their dollars invested. Rather than owning 5-6 foreign stocks with $20,000 investment, you can own 40-50 stocks for $20,000 in a mutual fund. This diversification reduces your risk. You can also use mutual funds to invest in U.S. stocks and bonds. One last observation about bonds and bond mutual funds that I'd like to mention. In a rising interest rate market (meaning that interest rates rise from where they are at today) investors need to understand how this affects bonds, and bond prices. There is an inverse relationship between the two. An example of this:

Interest rates and bond values. A 1% increase in interest rates will reduce the market value of a five-year bond by 4.25%...a 10-year bond by 7.13%... a 30-year bond by 11.58%. These changes affect you only if you sell the bonds before maturity. If you hold bonds until maturity, you will receive their full face value. Source: Ken and Daria Dolan, editors, *Straight Talk on Your Money.*

Because of this interest rate risk and the well-known stock market risk, asset allocation and a long-term time horizon become very important in managing your assets, see Exhibit C. One other important consideration is keeping what you earn. If taxes take 30% of your investment return it will take you much longer to reach your goals. So keep in mind that if you can use a company sponsored pension plan, such as a 401-k plan, use this first. You can contribute before tax dollars, grow your investments tax-deferred and have varied investment choices that should meet your goals.

Another way to reduce taxable income is to use cafeteria plans offered through work to pay for your out of pocket medical, dental, and business expenses. These are also paid with before tax dollars. One caution, money allocated to this must be used by December 31 or you will lose it, so estimate your expenses carefully when deciding how much money you should contribute to this. *IRA' s* are still a good place to invest $2, 000 a year if you can put away the extra money. You may not get a tax deduction but you get tax-deferred growth. If you're doing all of these, there are still a few other places to put investment money besides in taxable accounts. For conservative investors municipal bonds are a terrific way to make your money work harder for you—especially in today's income tax environment. Tax rates have increased to the top bracket of 39%. Therefore a tax-free bond paying 6% tax-free annual interest income is the equivalent of a 8.33% taxable rate of return in the 28% tax bracket. How you figure this is something you may want to know so you can check tax free yields against their equivalent taxable yields for yourself. You divide the tax-free yield by one hundred minus your tax bracket. For example 6/(100-28)=72 or 6/72=8.33%. To beat the tax-free yield you would have to buy a taxable bond/CD with the same maturity that would yield you better than 8.33%.

Another way to make your money work harder for you is to use tax-deferred annuities. You can choose a fixed interest rate annuity or a variable annuity. Variable annuities use mutual funds as your investments choices. Thereby increasing the potential rate of return you could recognize by choosing a stock mutual fund, for example, but also increasing your risk. Annuities are intended as long-term investments. They have rules similar to IRA's. The returns on your investments are tax-deferred until you take your money out. However, you need to leave your money in your IRA and/or annuity until you're over 59 1/2 to avoid an IRS early withdrawal penalty of 10%.

So in conclusion of this section, I'd like to say investing with before tax dollars is the best -ie 401-K pension plans. After you have maximized this, turn to other investments such as tax-deferred IRA's and annuities or tax-free bonds. Time is your friend - the longer you leave your money the better overall return you'll see. Asset allocation based on your risk tolerance is very important. It is also better to position yourself on the more conservative side when just starting out.

Now I'd like to move on to developing an investment strategy that's right for you. See Exhibit D and answer the questions. Now let's look at your score, Exhibit E. Your risk tolerance can be used to determine how your should allocate your assets, see Exhibit F. In the first set of vertical boxes put your percentages from your investments objectives score. I'll use a balanced account as an example 15, 25, 60. Now fill in an expected rate of return for each category. I'll give you some reasonable assumptions. Liquidity and Safety 4%, Bonds and Income 7%, and Stocks and Growth 11%. Then the weighted average rate of return is 15*4%= .6, 25*7%= 1.75, 60*11%= 6.6. When you add the third column, you get 8.95%, this is the average rate of return you could expect on your total investment portfolio if you allocated your assets according to your risk tolerance score. If this doesn't seem high enough you may need to take a bit more risk and move up the scale to a higher growth allocation.

Now let's look at your current asset allocation, Exhibit G. Place your current assets in the left column. In my example, I will use cash with a current value of $10,000, bonds with a current value of $50,000, and stocks with a current value of $40,000 for a total value of $100,000. Cash represents 10% of the total, bonds 50%, and stock 40%. Now if my investment objective and risk tolerance indicated a balanced account, I would need to make some changes to my current investment portfolio. If this is the case, I recommend doing so gradually maybe over a period of 6 months or so to avoid any sudden downturns in the markets.

The last item I wanted to talk about was the monitoring of your investments. If you work with an investment professional make sure you communicate and agree on a time table for reviewing your portfolio and your entire investment strategy. Some people want to be more active and rebalance monthly, others quarterly; semi-annually and sometimes annually works well enough. It is more of an individual preference than anything but I always recommend at least annually.

If you are unsure about how to get started or how to project income and asset needs down the line for retirement, college or estate planning, turn to a professional in this field. I suggest you make sure they will perform the analysis you want done before deciding to work with them. Just like any other profession, there are some individuals who do this kind of work for their clients and there are many others who will not. Anyone you speak with should encourage you to take the information and show it to your CPA and/or attorney before implementing the investment strategy. When I do this analysis there is no charge. There are other people called financial planners who will either charge you a straight hourly fee and send you to someone else to implement the final strategy or they will not charge you a fee but expect you to purchase their investment products. Again, just be prudent, up front, when deciding to work with someone. Make sure they understand your investment objectives, goals and risk tolerance—make sure you do too.

One last comment, if you would like a way to get started without any obligation I invite you to fill out the short financial questionnaire I've given you and mail it to me and my partner, George Bonney. We will be happy to give you suggestions. As with anything, the hardest part is just sitting down to fill in the information. Just know that the time spent here will benefit you for years to come and probably save you a small sum in income/estate taxes as well.

Exhibit A

# Summary Financial Profile

| | | |
|---|---|---|
| Name | Ages | Date |
| Children's Names | Ages | Phone # |

## PART 1 - NET WORTH

| | | | |
|---|---|---|---|
| 1. Liquid Assets | $ | 6. Short Term Liabilities | $ |
| 2. Other Investment and Business Assets | $ | 7. Long Term Liabilities | $ |
| 3. TOTAL | $ | 8. TOTAL LIABILITIES (total assets - total liabilities) | $ |
| 4. Personal Assets | $ | | |
| 5. TOTAL ASSETS | $ | 9. NET WORTH | $ |

## PART 2 - INCOME & EXPENDITURES

| | | |
|---|---|---|
| 1. Income From Employment | | $ |
| 2. Basic Lifestyle Ependitures (Housing, Transportation, Food, Clothing) | $ | |
| 3. Taxes (Including Income & Social Security taxes) | $ | |
| 4. Discretionary Expenditures (Entertainment, Vacation, Gift, Contributions) | $ | $ |
| 5. Amount Available | | $ |
| 6. Income From Investments and Other Sources | | $ |
| 7. Amount Available for Goals | | $ |

## PART 3 - LIFE INSURANCE

| | Husband | Wife |
|---|---|---|
| 1. Company Provided | $ | $ |

Exhibit A Cont.

| | | |
|---|---|---|
| 2. Individual | $________ | $________ |
| 3. TOTAL | $________ | $________ |

## PART 4 - GROSS ESTATE

| | |
|---|---|
| 1. Net Worth | $________ |
| 2. Insurance | $________ |
| 3. TOTAL GROSS ESTATE | $________ |

## PART 5 - TOP (MARGINAL) TAX BRACKET

| | |
|---|---|
| 1. Income Tax | ________% |
| 2. Estate Tax | ________% |

Exhibit B

# INVESTMENT SPECTRUM

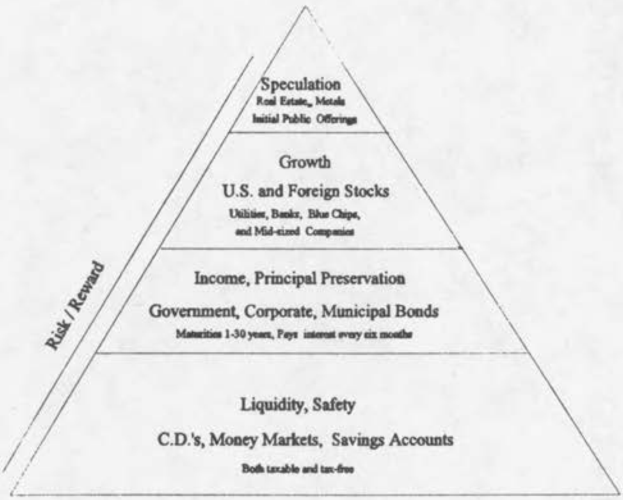

Exhibit C

# UNDERSTANDING THE RISKS AND REWARDS OF LONG-TERM INVESTING

## How $1000 Has Grown

### Compound Average Annual Returns

| | In Stocks[1] | | In Bonds[1] | | In Savings Institutions[2] | |
|---|---|---|---|---|---|---|
| Over the Past 10 Years | $4026 | 14.9% | $3,713 | 14.0% | $1,887 | 6.6% |
| Over the Past 20 Years | 11,036 | 12.8 | 6,925 | 10.2 | 4,014 | 7.2 |
| Over the Past 30 Years | 19,770 | 10.5 | 9,243 | 7.7 | 6,408 | 6.4 |
| Over the Past 40 Years | 86,551 | 11.8 | 12,109 | 6.4 | 8,630 | 5.5 |

[1] Source: Ibbotson Associates (Based on statistics from Standard & Poor's 500 Composite Index and Soloman Brothers High-Grade Corporate Bond Index).

[2] Based on figures supplied by the U.S. League of Savings Institutions and the Federal Reserve Board, whnhich reflect all kindfs of savings deposits, including longer term certificates. SUch deposits, if held to maturity, offer a guaranteed return of pricipal and a fixed rate of interest, but no opportunity for capital growth. Maximum allowable interest rates were imposed by law until 1993.

All figures through 12/31/93, with dividends reinvested or interest compounded.

Exhibit D

# U.S. Capital Markets

| | MOST | VERY | SOME | LITTLE | NONE |
|---|---|---|---|---|---|
| 1. **LIQUIDITY:** How important is immediate access to your money? | 1 | 2 | 3 | 4 | 5 |
| 2. **CURRENT INCOME:** How important is current income? | 1 | 2 | 3 | 4 | 5 |
| 3. **LONG TERM GROWTH:** How important is it that your investments keep pace with inflation or do better than inflation? | 5 | 4 | 3 | 2 | 1 |
| 4. **SAFETY & PRESERVATION OF CAPITAL:** How important is no fluctuation in price? | 1 | 2 | 3 | 4 | 5 |
| 5. **SAFETY / SLEEP WELL:** How important is it that the value of your investments not drop more than 20% in any one year? | 1 | 2 | 3 | 4 | 5 |

Exhibit E

# INVESTMENT OBJECTIVE SCORE

| SCORE | | ASSET ALLOCATION<br>Money Market / Income / Growth |
|---|---|---|
| 25 | Aggressive Growth | 05 / 10 / 85 |
| 20-24 | Growth | 10 / 15 / 75 |
| 15-19 | Balanced | 15 / 25 / 60 |
| 10-14 | Moderate Risk | 20 / 40 / 40 |
| 6-9 | Low Risk | 30 / 50 / 20 |
| 5 | Ultra Conservative | 50 / 50 / 0 |

Exhibit F

# YOUR INVESTMENT STRATEGY

| OBJECTIVE | DESIRED ALLOCATION OF YOUR INVESTMENTS % (1) | EXPECTED RATE OF RETURN ON DESIRED ALLOCATION % (2) | WEIGHTED AVERAGE RATE OF RETURN % (3) |
|---|---|---|---|
| LIQUIDITY SAFETY | ex. 15 | 4% | .6 |
| INCOME | Ex. 25 | 7% | 1.75 |
| GROWTH | Ex. 60 | 11% | 6.6 |
| | % | % | 8.95% % |

Exhibit G

# REVIEW OF YOUR PRESENT ASSETS

| Type of Asset (1) | Current Value (2) | % Investment Total (3) | Investment Objectives (4) |
|---|---|---|---|
| Cash | 10,000 | 10% | 15% |
| Bonds | 50,000 | 50% | 25% |
| Stocks | 40000 | 40% | 60% |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| Total | $ 100,000 | 100% | ______% Safety<br>______% Income<br>______% Growth<br>100 % |

# BIORATIONAL METHODS TO LIMIT EUROPEAN CRANE FLY POPULATIONS[1]

Dr. Gwen K. Stahnke, Mr. A. Antonelli, Mr. J.D. Stark and Dr. Stanton E. Brauen[2]

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[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.

[2] Extension Turf Specialist, Extension Entomologist, Research Entomologist/ Toxicologist, and Turf Research/Extension Leader, respectively, Research & Extension Center, Washington State University, Puyallup, Washington.

Healthy turfgrass can withstand populations of 25 to 40 European crane fly larvae/ $ft^2$ without showing damage. Larvae can be controlled using one of several registered insecticides in early April when larvae numbers are above threshold levels. Previous studies in 1991, 1992, and 1993 have shown that two types of nematodes and Turplex, a neem extract, can give adequate larval suppression or reduction.

A randomized complete block consisting of 5 replications was initiated at High Cedars Golf Course in Orting, WA, on 4/19/94. Plots were each 70 ft2. Six 4-inch diameter cores were pulled from each plot and crane fly larvae were counted using the soil core destruction method. There were no significant differences in larval numbers between plots before treatment. Over three years, a study comparing core destruction and soil drenches for determining crane fly larval populations showed that none of the drenches used estimated the population numbers as well as core destruction (Table 2).

The treatments examined in this study consisted of: 1) nematodes (active at <50° soil temp. ), Steinernema feltiae (1 billion/A), 2) *Steinernema feltiae* plus Silwet, a silicone surfactant, 3) nematodes (active at 50° soil temp. ), *Steinernema carpocapse (1* billion/A), 4) *Steinernema carpocapse* plus Silwet, 5 ) neem extract , Turplex (2 apps . 14 days apart), 6) pyrethroid #1, Deltamethrin (DTM) 5SC, 7) pyrethroid #2, Tralomethrin (TLM) Saga 40WP, 8) chlorpyrifos, Dursban (1 lb. a. i. /A) and 9) No treatment (Table 1). Plots were resampled on 5/23/94 (4 weeks after treatment) to evaluate reduction in crane fly larval numbers. Dursban alone significantly reduced the number of crane fly larvae (78%) 4 weeks after application (Figures 1 & 2). The experimental pyrethroid #2 and the *Steinernema carpocapsae* plus the silicone surfactant, Silwet, both reduced larval populations by 48%. Turplex and *Steinernema feltiae* plus Silwet reduced populations by 39% and 30%, respectively. None of these 4 treatments (other than Dursban) were statistically different from the control, however, a population reduction of 3096-48% could bring larval numbers below damage threshold levels while not being as detrimental to other beneficial organisms in the turfgrass system. These products have a place as a tool within a turfgrass management plan.

**Table 1. 1994 European crane fly treatments**

| Treatment | Rate |
|---|---|
| No treatment | |
| Turplex (2 apps./14 d) | 20 g a.i./A |
| S. carpocapsae | 1 billion/A |
| S. carpo. + Silwet | 1 billion/A |
| S. feltiae | 1 billion/A |
| S. feltiae + Silwet | 1 billion/A |
| Dursban DTI | 1 lb a.i./A |
| Pyrethroid #1 (DTM 5SC) | 3.0 ml/gal @ 4 gal/M |
| Pyrethroid #2 (Saga 40WP) | 0.35 g/gal @ 4 gal/M |

**Table 2. Cranefly monitoring methods soil drenches vs. core destruction**

| | ( Larvae/Ft$^2$ ) | | |
|---|---|---|---|
| | 1992 | 1993 | 1994 |
| Cores | 27 a* | 23 a** | 25 a* |
| Dursban | 11.7 b | 16.3 b | 6.1 b |
| 2% Safer's Soap | 5.1 bc | 8.2 b | 2.5 bc |
| 2% Lemon Joy | 5.0 bc | 6.1 b | 0 c |
| 2% Ammonia | 2.0 c | 6.1 b | 6.1 bc |
| 2% Bleach | 2.0 c | 15.3 ab | 3.4 bc |

According to DMRT, treatments with different letters following them are significantly different at the 0.05 (*) level and the 0.10 (**) level, respectively.

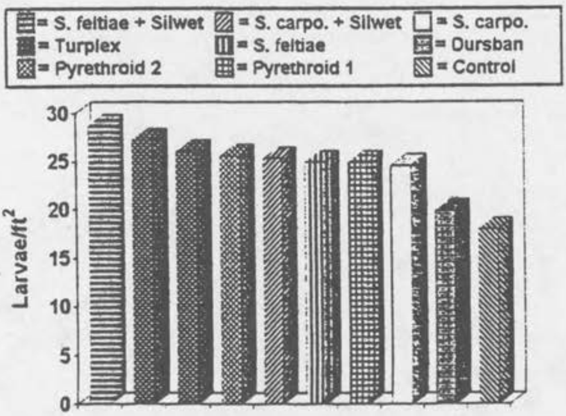


**Figure 1. Average number of European crane fly larvae/ft$^2$ pretreatment (4/22/94)**

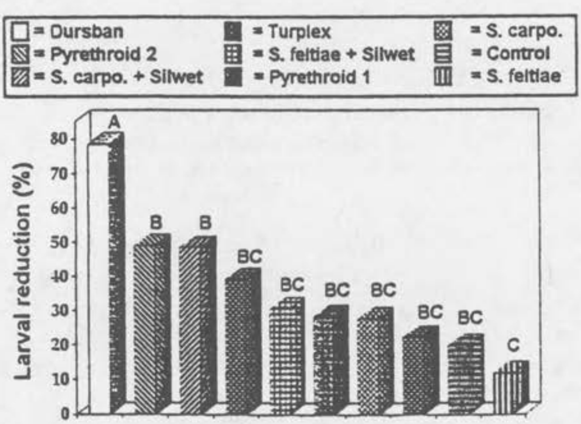


**Figure 2. Percent reduction in Europe: :rane fly larvae/ft$^2$ 4 wks. after treatm· (5/23/94)**

# ENVIRONMENTAL FATE OF COMMONLY APPLIED PESTICIDES IN TURF[1]

Dr. Thomas L. Watschke[2]

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[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.

[2] Professor of Turfgrass Science, Pennsylvania State University, University Park, Pennsylvania.

In this day and age, the environmental soundness of a golf course is constantly being questioned. Whether it has been in existence for decades or simply being proposed, concern over the use of fertilizers and pesticides dominates much of the public's attitude toward golf courses. Irresponsible and one-sided mass media coverage of pesticide use in general has helped fuel much of the concern being expressed. Unfortunately, there are also periodic instances of irresponsible abuses of pesticides on golf courses and other turf areas that only serves to fan the flames of public outcry.

Fertilizer and pesticide use on golf courses is absolutely necessary to provide a playing surface that is adequate to satisfy the requirements of the game. Proper choice and use of fertilizers and pesticides is fundamental to sound management strategy and provides the backbone to which other maintenance practices are connected. At the focal point of fertilizers and pesticides is the golf course superintendent who makes the decisions concerning their use. As a result, it is incumbent on the superintendent to be as conversant and literate about fertilizers and pesticides as possible. Central to the issue of pesticide literacy is having a working knowledge of pesticide fate. With this knowledge, golf course superintendents can appropriately answer questions about pesticides and the environment whether they are posed by a golfer, a club official, local citizen, or even members of the media. The balance of this article will be directed at the subject of pesticide fate in the hope that the information will be valuable on the job and in the process of communicating with others.

## COMMON PERCEPTION

Most people assume that when fertilizers and pesticides are applied to golf courses that they either move off the site in runoff water or move downward with percolating water until it comes in contact with groundwater, at which point contamination takes place. Certainly, one or both of these possible fates may take place; however, several other possibilities also exist.

## WHAT CAN HAPPEN AFTER APPLICATION?

In order to use a chronological approach to discussing pesticide fate, let us assume that a pest has been identified and the appropriate pesticide has been chosen for application for the control of said pest. Assuming that a properly calibrated sprayer or spreader is used and that the pesticide has been intercepted by the turf and/or soil (no drift or other off site movement has occurred), the initial consequences of having introduced the pesticide to the site begins.

## ADSORPTION

Adsorption is the binding of a chemical to the surface of plants or soil. This binding phenomenon is influenced by a number of factors; the nature of the surface, moisture, pH, and the various physical and chemical properties of the chemical that has been applied. From a soil standpoint, those that are high in organic matter or clay tend to have the highest adsorptive capacity, while coarse, sandy soils that are low in organic matter are less adsorptive.

Adsorption is critically important as it influences the other fate processes. Any pesticide that is tightly adsorbed or bound to the soil or organic matter is less likely to volatilize, leach, be degraded by microorganisms, or even be absorbed by plants. Certainly, those chemicals that have properties which lend themselves to strong adsorption, have a very low potential to move in surface water; and therefore, pose little risk of pollution from runoff. Two such compounds are pendimethalin, a commonly used preemergence herbicide for the control of summer annual grasses, and chloropyrifos, a thatch active insecticide that is commonly used for the control of chinch bugs and other thatch inhabiting insects. Research at Penn State University has shown that these two pesticides do not move in water either off the site with runoff or down through the profile of a silt loam soil. Even when excessive amounts of water were applied, these two pesticides were never detected, even though the detectability level was one part per billion. Obviously, chemicals that are tightly adsorbed do not threaten water resources.

## VOLATILIZATION

Volatility is the state of being volatile, or readily vaporized. It must be considered as a relative term because every substance is volatile under the right conditions. Under normal circumstances, however, most things are not volatile, at least not at detectable levels.

Regardless of whether a chemical is a solid or a liquid, it can change physical state at a given pressure. This pressure is referred to as vapor pressure, which is the point at which solids vaporize and liquids evaporate. An example of a solid vaporizing would be what happens to a moth ball, and water evaporating is an example of what happens to a liquid. Both solids and liquids increase vaporization as the temperature increases. Furthermore, pesticides formulated as esters have a much greater potential for volatility than amine formulations. By adding side chain molecules, however, low volatile ester formulations are available when the need to use an ester formulation arises.

Pesticide volatilization also increases with high air movement, and low relative humidity and is also favored by high soil moisture content. The best way to reduce the potential of volatilization losses is to use amine formulations, never use ester formulations when temperatures are above 80 to 85 degrees and when the relative humidity is low.

## PHOTODECOMPOSITION OF PESTICIDES

Sunlight transformation can be a significant environmental fate for pesticides, especially for those that are applied to the surface of plants and soils which is quite common of pesticides applied on golf courses. The transformations brought about by the exposure of a pesticide to sunlight generally alter the chemical properties of the pesticide to the extent that it is less toxic and more susceptible to further environmental degradation by other chemical and microbial processes which will be discussed later.

Any sunlight induced transformation of a pesticide is the result of a highly complex set of responses to the absorption of radiation. When a pesticide that is susceptible to sunlight degradation absorbs radiation, an electronically excited molecule is the result. Molecules in such a state undergo various chemical and physical changes. Although all chemicals can absorb radiation of sufficient energy, sunlight wavelengths cause degradation of a small number of pesticides. However, photodegradation can be so significant that certain pesticides are only effective when applied as granular formulations or when incorporated into the soil.

## RUNOFF

The movement of chemicals in runoff water or in the sediment carried by the runoff is a common fate of certain pesticides. Obviously, chemicals that are tightly bound to soil that is eroded and carried by runoff have a relatively high pollution potential. On established golf courses, movement of soil particles in runoff is almost non-existent and the amount of water that actually moves from high quality (good stand density) sites is extremely small. Runoff research at Penn State has shown that, even under extreme conditions, the amount of water that moves from sodded sloped sites is very small.

Throughout production agriculture, when soil erosion due to runoff from cultivated fields treated with pesticides is thought to be an environmental problem, the solution is to plant grass buffer strips between the treated fields and any nearby body of water. The grass buffer strip slows the overland flow velocity of the water which allows the sediment (which contains most of the offending pesticide) to settle out and infiltration of gravitational water increases thereby decreasing total runoff.

Certainly applications of pesticides when soil moisture conditions are high and heavy rainfall is predicted, can only serve to substantially raise the potential for the movement of pesticides in runoff. Sound management practices dictate that label recommendations always be followed and that good common sense be used.

## CHEMICAL CONVERSION

The hydrolysis of chemicals is another major fate of pesticides applied to land and water. Most chemical conversions that result as a specific fate of a pesticide occur in aquatic environments. However, adsorption-desorption processes that take place in the soil, can modify the aqueous environment.

Such processes can have significant effects on the relatively simple hydrolysis reactions that occur in aqueous environments. Little research has been done to date to document such effects, but that which has been conducted indicates that the hydrolysis pesticides can be either enhanced or reduced by the presence of mineral or organic absorbing surfaces. As further research is conducted, the ability to predict hydrolysis rates in field situations will continue to improve.

## ABSORPTION

The movement of pesticides into plants and to a much lesser extent into soil-borne animals is referred to as absorption. Once absorbed by plants, most pesticides are degraded and when the plant dies the residue serves, in part, as an energy source for the soil microbiological population. In the case of most herbicides, absorption is the key environmental fate necessary for the pesticide to successfully control the pest. When weed control fails, one or more of the other possible pesticide fates has reduced the available dosage of the herbicide, to the extent that control is not possible.

## BIOLOGICAL DEGRADATION

Much of the natural degradation of pesticides occurs due to the action of the microbiological population in the soil and thatch. In fact, current research into the genetic engineering of microbes that attack and degrade specific chemical groups is being actively funded by the environmental protection agency. There have been very encouraging results that lead many scientists to believe that the ultimate solution to the chemical cleanup of the many toxic waste dumps in this country will be through the introduction of microbial populations that use these toxic substances for an energy source (in other words, for food).

Environmental conditions have a significant impact on the activity of the soil microbiological population. Warm, moist soil that is well aerated and having a pH range of 6.5 to 7.0 represent conditions that promote microbial degradation. Obviously, turfgrass management on golf courses can significantly enhance biological activity and promote the degradation of applied pesticides. Those management practices that promote good turfgrass growth and competitiveness are also those that enhance microbial activity, which is no small coincidence!

**REMOVAL FROM THE SITE**

The final fate to be discussed in this article has to do with the physical removal of pesticides from the site to which they are applied. On the golf course, the most obvious source of this pesticide fate is the removal of clippings. When treated plants are moved from the site, any pesticide residues that remain, are removed also.

Disposal of clippings on golf courses is accomplished in a variety of ways. Regardless of the disposal method, the potential for pesticide residues to be present on or in these clippings can be significant. Very little research has been conducted as to the extent to which such residues exist or whether their presence could have negative environmental consequences. However, it is known that grass clippings that contain recently sprayed herbicides can negatively effect sensitive plants if the clippings are used as a mulch around such plants. Golf course superintendents must be aware of the potential for the present pesticide residues on grass clippings, particularly in an age when clippings are being collected from more areas of the golf course than ever before. Storage and disposal of clippings should be as well thought out as any other part of the overall turfgrass management program. Since the primary means for the degradation of most pesticides is microbial activity, considerable emphasis should be placed on the potential that composting of clippings offers as an environmentally harmonious means for disposal.

Increasing ones knowledge of pesticide fate in the environment, is only preparation for the next challenge--communicating that knowledge to others. The golf course superintendent is often looked upon as the turfgrass expert in the community. Since the pervasive public attitude appears to be that golf courses contributed to the demise of the environment, it is incumbent on every golf course superintendent to be as environmentally conversant as possible. Hopefully, some of the discussion contained herein will be helpful to that end.

# TURFGRASS AS A BIO-FILTER[1]

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[1] Presented at the **48th Northwest Turfgrass Conference**, Salishan Lodge, Gleneden Beach, Oregon, September 26-29, 1994.
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Turfgrasses have provided many environmental, recreational, and psychological benefits to mankind for centuries. However, many of these benefits have only recently been recognized because turfgrasses, in general, are "just there" and have been taken for granted. Appreciation for the contributions to the quality of everyday life provided by turfgrasses can only be achieved when one envisions the planet without them. Consider the inhospitability of the worlds deserts. Only those creatures most uniquely adapted are able to survive.

The recent recognition of the benefits of turfgrasses has been a result of the industry's attempts to counter the negative press about lawns and golf courses. This negative press has unfairly characterized the turfgrass industry as irresponsible consumers of natural resources, polluters of water resources, and the perpetrators of exposure of the unknowing to highly toxic substances. To be characterized in such an unfair manner has galvanized the turfgrass community into an action plan of public relations that has led to the development of significant documentation of the benefits of turfgrasses to the environment and society at large.

This public relations approach, focused on public education, has only partially succeeded primarily because those media engaged in negative press have not embraced in an equal amount of positive press. Progress has been made however, and it is incumbent on the turfgrass industry to keep the message out there.

Perhaps of even more importance, is the challenge to the turfgrass industry to seek out and explore opportunities to utilize turfgrasses as solutions to societal problems. One of these opportunities is currently at hand as we develop the uses of turfgrasses in stormwater management systems.

Currently, golf courses are being used as integral components of stormwater management systems providing areas for detention and infestation. As watersheds are developed, the green space set aside in the form of golf courses provides unique opportunities for providing of both the quantity and quality of stormwater runoff. Providing a solution to the problems associated with the quality of stormwater runoff is an opportunity for turfgrasses. With the current EPA regulations that municipalities with over 100,000 population must provide stormwater management plans that deal with both quantity and quality of stormwater, the use of turfgrasses provides an outstanding method for meeting the regulations.

When stormwater is completely enclosed in a piped system, the pollution from deposits on the impervious surfaces of the watershed (roadways, parking lots, etc.) can go directly into receiving bodies of water (creeks, streams, rivers, bays, reservoirs, lakes, etc.). When stormwater is handled in such a manner, the polluting materials cannot interact with any biological system that might have the microbiological potential to immobilize or even degrade such substances. Without some method of biological interaction, the ability of a stormwater collection system to significantly impact the quality of the water is minimal.

Since one of the most microbiologically active locations on the planet exists in the upper soil profile under turfgrasses, it makes very good sense that placing stormwater runoff in contact with turfgrasses would provide filtration and improve quality. Grass buffer strips are used extensively in agricultural settings to reduce runoff and associated sedimentation from farm fields. This practice not only reduces the volume of water leaving the farm, but entraps the pollution laden sediment in the grassy areas. Once entrapped and ultimately moved via infiltration into the soil underlying the grass, the microbiological population degrades the potentially polluting substances.

Currently, the use of grassed (even sodded) swales, referred to as infiltrating conveyances, are being designed into new stormwater collection systems. These infiltrating conveyances allow for a portion of the stormwater collection system to provide a method for dealing with the quality of the water as well as the quantity. Relatively modest amounts of infiltrating conveyance can provide significant impact without creating large areas of turfgrasses that would have to be maintained. Little or no fertilizer would be required and weeds and other pests would not require control unless they destroyed the turf to the extent that erosion was occurring. Soil preparation during construction of the conveyance must be accomplished in a manner that minimizes compaction and preserves soil structure. Certainly, the use of sod as a grass establishment method would be preferred as the surface structural integrity of the soil would be protected quickly.

Little research information is available with respect to the impact such infiltrating conveyances might have on water quality. Hopefully, funding will be forthcoming as, although the approach is perfectly logical and makes good sense, documentation is critically needed. Documentation is particularly needed in the area of removal of heavy metals, petrochemicals, asbestos, and other substances routinely found in stormwater runoff.

Substantial documentation exists with regard to how stormwater is degraded by developing the land and most of the degradation occurs as a result of runoff from the impervious surfaces. The value of utilizing turfgrasses to help solve this serious national problem cannot be overstated.

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