CORNELL UNIVERSITY TURFGRASS TIMES

CUTT

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Turfgrass Management Influence on Water Quality

Part 1: Pesticides

Concern about sources of agricultural pollution has raised questions about the contribution of turfgrass to water contamination and has motivated research on the role of pesticides and nutrients on contamination of water supplies. Turfgrass, while not the largest acreage crop, is in many cases the most intensively managed ecosystem. However, turfgrass management does not necessarily imply environmental degradation; in fact turf provides many benefits. The functional, recreational and aesthetic benefits provided to humans are unmatched by other crops.

Turf provides sediment reduction, runoff control, flood control, reduction in point- and non-point source pollution, water filtration, heat dissipation, and oxygen production. In many cases turfgrass has been used to remediate harmful chemicals leaving a site. Daniels and Gilliam found runoff transported from agricultural fields and flowing through a grass filter underwent significant sediment and chemical load reductions. In fact, the grass filter was more effective at reducing chemicals and sediments than the use of both a grass and a riparian filter.

Golf courses have been shown to be effective filters of surface water, especially for nutrients such as ammonium (NH_4^+-N) and, in some cases, nitrate (NO_3^--N). To be an effective filter, grass must produce a dense canopy, and deep, fibrous roots, which are capable of removing water from the soil at great depths. A dense canopy will slow and filter chemicals from runoff. Increased plant shoot density will reduce runoff and hence the chemical load leaving a site by creating a more tortuous pathway and increasing soil infiltration of water.

In any case, nutrients and pesticides found in water supplies can cause problems for both humans who rely on clean water for consumption, irrigation and recreation, and organisms that must have clean water for survival. The Environmental Protection Agency (EPA) has established maximum contaminant levels (MCL) for drinking water, above which human consumption is unsafe. The effect of these MCLs on aquatic organisms is generally much greater, suggesting that the use of aquatic toxicities may be a better indicator of water contamination. An in-depth review of the literature reveals a lack of work regarding the specific effect of pes-

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This Times

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Clippings

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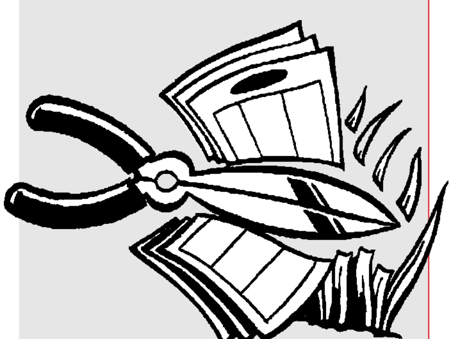

Joann Gruttadaurio Receives NYSTA's Highest Honor

The Citation of Merit Award is given by the New York State Turfgrass Association (NYSTA) to a person in the turfgrass industry who demonstrates the following qualities: dedication to turfgrass research and education; involvement in and support of association activities; interest in promoting careers in the turfgrass industry; community involvement; and the admiration and respect of peers and colleagues. This year's recipient certainly embodies all of these qualities. NYSTA is pleased to announce the winner of the 2003 Citation of Merit Award: Joann Gruttadaurio.

Joann's long and distinguished career in the turfgrass industry made this year's decision an easy one. Joann has shown tremendous dedication to turfgrass research and education. She has been with Cornell University since 1974 and is a member of the Turfgrass Team in the Horticulture Department. She has a Bachelor's degree in Agronomy and a Master of Science degree in Extension Education from Cornell.

She is responsible for developing resources and programs for commercial horticulturists. Too, she is an instructor and serves as the Director for Cornell Cooperative Extension's education programs for professional turfgrass managers. These programs include the *Cornell Turfgrass Management Short Course*, which provides intensive training on best management practices for the establishment and maintenance of turf, the advanced turf Short Courses, and the *Turfgrass Field Diagnostic Course.*

Joann's enthusiasm for horticultural education started early in her career. In 1974, she worked with Professor Ernest Schaufler, Cornell Department of Horticulture, on developing the "Talking Plant", a model that explained the importance of plants to humans and the environment. The "Talking Plant" included a cassette, which taught students the major parts of the plant, the functions of plant parts and interesting ways to grow plants. Professor Schaufler describes his association with Joann in this way, "Joann Gruttadaurio was hired as an assistant in my State 4-H program for Floriculture and Ornamental Horticulture in 1974. She was (and is) outgoing, enthusiastic and enjoyed working with youngsters. A prototype of the "Talking Plant" was available and she took it to a nearby school, found a youngster perfect for a tape, and worked with teachers to form an accepted teaching aid. It caught on and Joann was the flower of the talking plant. Joann deserves full credit for its success."

Joann has had a very active involvement in NYSTA activities. She can always be counted on to be a moderator or speaker at the many conferences held each year. As a matter of fact, recently Joann partnered with Frank Rossi on two presentations. In 1996, NYSTA recognized her for her "years of dedicated service in coordinating the Cornell Turfgrass Management Short Course."

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Send Us a Letter

We often receive letters from our readers reacting to the articles and information presented in *CUTT*. Encouraging a free-flowing, two-way communication between our readers and Cornell's Turfgrass Team can only make *CUTT* a better, more relevant publication. Accordingly, we will be instituting a "Letters to the Editor" section. Send your comments via regular mail to *Cornell University Turfgrass Times*, 134A Plant Science Building, Cornell University, Ithaca, NY 14853, or via email to fsr3@cornell.edu.

Your Daily Nitrogen?

Turfgrass fertility is the cornerstone of efficient and effective turfgrass management programs. While there is reasonable debate regarding the amount of macro and micronutrients needed for healthy turf, there is little question regarding the importance of nitrogen (N).

The questions regarding nitrogen use typically involve growth response, source of nitrogen and environmental issues. Clearly, the use of slow release nitrogen has aided the turf manager's ability to regulate growth as compared to high rate applications of water soluble N that produced growth surges. But what if we could supply very low amounts of N on a daily basis, as might be possible with fertigation; would there be any benefit to the plant?

Professor Dan Bowman from North Carolina State University, an expert in the area of N fertility, conducted a study with perennial ryegrass to determine the short and long term effects of daily versus periodic N applications. Potassium nitrate was supplied daily or every 8, 16 or 32 days.

As expected, the daily N applications resulted in a more stable growth habit, as measured by clippings and tissue N level, whereas the intermittent applications produced surges of growth. Interestingly, the ryegrass turf demonstrated exceptional ability to capture all but the highest N level supplied daily (0.25 lb per 1000 square feet). The intermittent N applications were equally well captured, demonstrating an ability to absorb almost 1 lb of N per 1000 square feet over a 5 day period.

This study found no difference in shoot to root ratio between plants fertilized at high rates intermittently and daily N applications. Furthermore, Bowman suggests that there is likely a lag period when N is applied in high rates and the time it takes to make it to leaf tissue. This would be further affected by frequent mowing that removes tissue and potentially lessens the influence of higher N rates.

With increased concern for nutrients and water quality, having a defensible N management strategy not based on quality, but based on efficiency, is critical. This research contributes to a growing body of physiological projects to more fully understand turf N management and how distinctly different it is from production agriculture.

From: Bowman, D.C. 2003. Daily vs. periodic nitrogen addition affects growth and tissue nitrogen content in perennial ryegrass turf. Crop Science 43:631-638.

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Scanning the Journals

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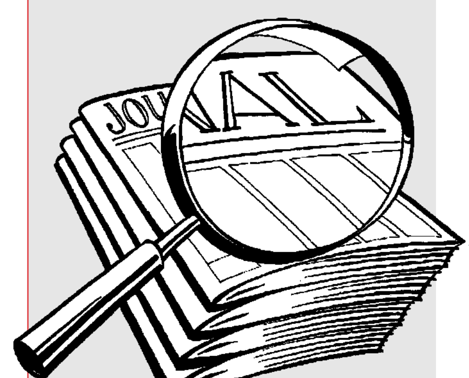

Gruttadaurio

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Joann has always had an interest in promoting careers in the turfgrass industry. According to friend and Cornell University associate, Nina Bassuk, Professor in the Urban Horticulture Institute, "It's over 23 years now that Joann and I have been friends and colleagues at Cornell. I'm so pleased she is being recognized for her tireless efforts on behalf of the turfgrass industry. It is so well deserved."

Through the words of her friends and colleagues, it is clear that Joann has made a positive impact on their lives and she has been effective at educating young people and promoting the industry through her instruction, outreach and research.

After reviewing the list of Joann's good deeds and professional accomplishments, it's fair to say that Joann herself leads with her heart and good sense. Her passion for what she does, desire to inform and educate, and expectation of excellence has made her an integral member of our association. She has definitely garnered the admiration and respect of her peers and colleagues.

Carl F. Gortzig, who served on the Cornell Faculty for 30 years and worked as a Cooperative Extension field staff member for nearly ten years wrote, "I don't know many people who are as committed and conscientious in pursuit of their work in behalf of an organization!"

Finally, Greg Chorvas really sums up what many of her friends and colleagues feel about her and her selection for this award: "I got to know Joann six or seven years ago when she invited me to participate as an instructor at her week-long Cornell Short Course. I feel I am a better person and fortunate in knowing and being associated with Joann over the years. A caring and positive attitude, exceptional work ethic, knowledgeable commitment, and profes-

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Turfgrass Management and Water Quality

continued from page 1

ticide use, differing nutrient sources and management practices on drainage water quality from turfgrass.

Management Systems

There are many management systems in use on turfgrass today, but they are generally a variation on one of three types. Preventative management, which entails pesticide applications made on a preventative, or preemergent basis, and high rates of water soluble fertilizers. In this system, pests are not tolerated, and are generally treated prior to or at first observance. Integrated Pest Management (IPM) is a widely adopted system that utilizes all current practices, including cultural, biological, physical, and chemical practices to reduce pest pressure. Pesticide applications are curative, and made only when viable alternatives do not exist. Nutrient sources range from organic composts to water soluble inorganic sources.

Organic management systems are recently becoming more and more acceptable, as people realize the perceived benefits with going organic. This system does not utilize any synthetic pesticides, but may use organic pesticides, if they exist. Pest pressure is reduced by alleviating the environmental stress on the turfgrass. Nutrient sources include manures, compost and commercial organics, usually exhibiting low solubility. All systems have the potential to contaminate water.

Pesticides

With the increased demand for food, fiber and recreation, pesticide use has increased dramatically. Pesticide use on turfgrass, although a relatively small proportion of total use, is significant, as it is typically the most intensively managed ecosystem. Movement of pesticides off-site can have dire implications for biotic systems. These chemicals negatively impact drinking water quality and organisms living within. Pesticides today are much more selective, and generally less toxic to nontarget organisms than in the past. However, the sheer quantity of pesticides applied makes their detection in water more frequent.

There is a relationship between the frequency of pesticide detection in water and increased land use of the compound. High detection frequency and concentrations of pesticides were more likely to occur in water near land application sites. The EPA has established threshold levels below which human consumption is thought to be safe. Exceeding these standards can be harmful to human health. However, lower levels have been shown to be problematic for aquatic organisms. Baird, et al, suggest that aquatic toxicities may be a better measurement of dangerous pesticide levels, since they are generally lower than human toxicity levels.

Pesticide movement in the environment is a function of many different factors which interact in multiple ways. Major factors include the composition of the soil, chemical degradation time, thatch composition, application timing, pesticide chemistry, rainfall patterns, soil microbial population, plant uptake and metabolization, temperature, antecedent moisture, pesticide sorption process, and slope. In general, surface movement of pesticides can be grouped into two areas: the properties of the pesticide and the environmental or site conditions. Pesticides found in ground water have several common characteristics: most are highly mobile in the soil, weakly adsorbed, long lived, and applied at high rates or detectable at low levels.

In the past, movement of pesticides to ground water was considered unlikely and insignificant. Dilution, binding, degradation, and metabolism were thought to remove a pesticide from the soil before it could move to and contaminate groundwater. The soil was believed to filter the contaminants and impurities before they could reach water supplies. Little work has been done on the fate of pesticides once they have entered ground water, but degradation of pesticides in aquifers is unlikely, and slow, due to reduced organic carbon and microorganism populations. Many pesticides have been found at detectable levels in ground and surface water. Well water testing yielded detections of sixteen pesticides, many at levels well in excess of mandated MCL.

In a study commissioned by the National Water Quality Assessment (NAWAQ) program, and completed by Barbash, et al, pesticides were detected more frequently, and in higher concentrations in shallow ground water than in deep aquifers. Detection was mainly a function of frequency of use and mobility. Concentrations of pesticides in ground water in a study by Loague, et al, were a function of the soil

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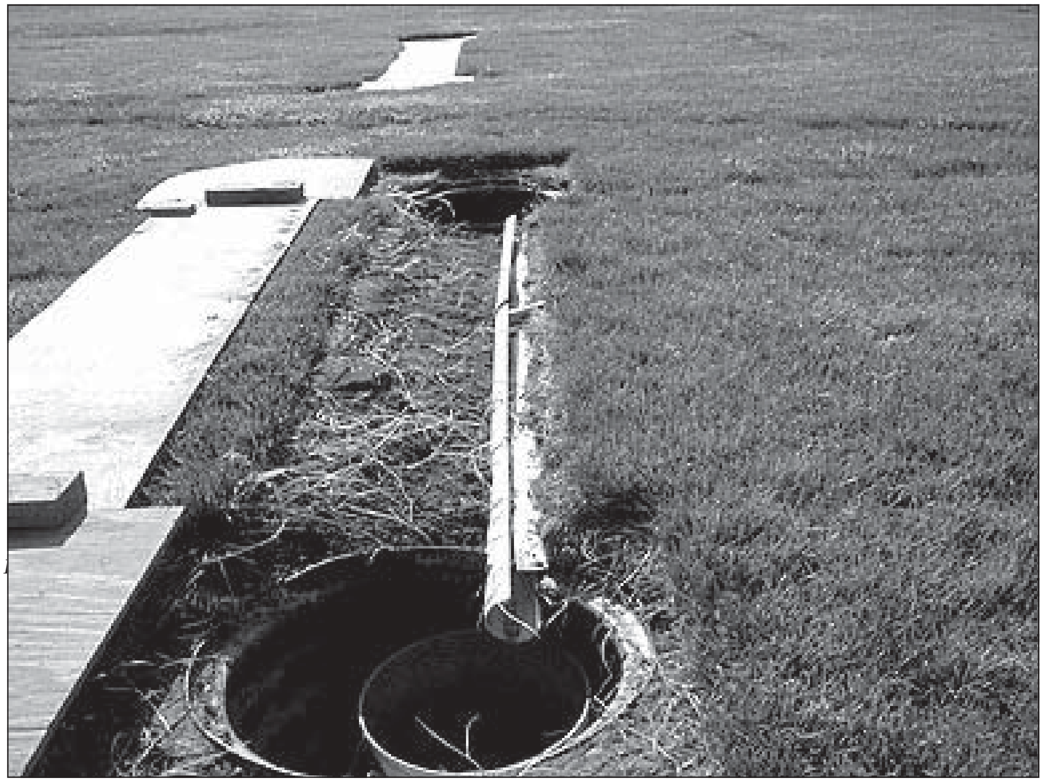

Runoff collection study area at the Cornell Turf and Landscape Research Laboratory.

depth and soil hydraulic properties. The assumption being that greater depth to the water table allows for greater residence time and increased degradation. This assumption may be valid for uniform, disturbed soils, with no macropore transport (preferential) flow. Soils under no-till management (such as turfgrass) have been found to have a very large macropore flow component.

Macropores and Fingers

Macropores can transmit both adsorbed and non-adsorbed pesticides quickly and deeply into the soil profile. Wilkinson and Blevins found that macropores were responsible for up to 35% of the water flow through a clay soil. These preferential flow paths have been found to be capable of allowing strongly bound contaminants to be quickly transported to ground water, suggesting that the use of highly toxic compounds should be reexamined in the presence of preferential flow. EPA regulatory approval is based on the assumption of uniform transport through the soil which allows the compound time to degrade. The presence of preferential flow dramatically reduces degradation time and increases the likelihood of water contamination.

Sandy soils, such as those used on golf course greens, can form fingers which function very similarly to macropores. Fingers, once formed, can transmit large volumes of water repeatedly. Nektarios, et al, saw average water velocities in fingers on sand-based putting greens approach 0.76 cm min^{-1}, allowing rapid transport of contaminates to ground water, reduced efficacy of applied compounds, and reduced time for degradation, binding, and plant uptake. Once preferential pathways have moved pesticides past the root zone, degradation slows, and in some cases ceases altogether. However, Loague, et al, present evidence that pesticide leaching through an unsaturated profile can be significant, particularly for compounds with long soil half lives, or those that are dangerous at very low levels compared to the amount applied.

Runoff

Clearly, the first runoff event following pesticide application generally contains the highest concentration of pesticides. Ground and surface water face the largest risk in the first 24 hours following treatment. The highest pesticide concentrations in runoff (800, 800, and 360 $\mu g\ L^{-1}$ for mecoprop, 2,4-D and dicamba respectively) were seen by Shuman, et al, 24 hours after application. Drying time and foliar adsorption require at least 24 hours to effectively bind the pesticide and prevent excessive off site movement. Ma, et al, found an average of 73% of pesticide loss is from the first runoff event

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Turfgrass Management and Water Quality

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following application, 24.5 % of applied for dicamba. Mecoprop and 2,4-D had observed losses of 19.9 and 18.9% respectively.

In a separate study, Ma, et al, found high levels of atrazine, approaching 500 µg L^{-1}, in runoff from the first event following application, which in some cases accounted for 89% of the total loss. Concentrations in runoff water declined rapidly after application. Carroll, et al, saw 70% of the dicamba present on the foliage lost in a rainfall event occurring 8 hours after application. Watschke, et al, measured mecoprop concentrations in runoff of >4700 µg L^{-1} 24 hours after application. However, concentrations declined rapidly, undergoing a 99.5% reduction in 14 days. In the same study, mecoprop levels in leachate were high initially following application, >600 µg L^{-1}, but declined to below detectable levels with in 2 months.

In a study conducted by Baird, et al, 2,4-D and mecoprop mass losses in runoff varied from 0 to 15% of applied, and were generally a function of solubility and K_{oc}. Smith and Bridges found very high levels of 2,4-D, dicamba and mecoprop (810.7, 279.2, and 820.0 µg L^{-1} respectively) in runoff water less than 24 hours after application. They also found that only samples collected over the first week contained any significant concentration (i.e. above minimum detection levels) of pesticides in runoff. In the same study, they saw low levels of the same pesticides in lysimeter leachate water, <3µg L^{-1}, presumably due to good water soil contact (the soil was disturbed, so macropores did not likely exist or contribute to flow). These results were verified in a similar lysimeter study conducted by Smith and Tilloston. They saw 2,4-D levels generally below detection limits (5 µg L^{-1}), despite a sand-based rooting mix. Evert concluded that soils repacked into lysimeters in laboratory experiments effectively remove the macropore flow component from the equation.

Leaching

In a leaching study carried out by Carroll, et al, thatch was found to be an important component in reducing pesticide leaching over bare soil. Supporting this finding is a study by Cisar and Snyder which found that the majority of applied pesticides (90-100%) remained in the thatch, leaving little to be transported in runoff or leachate. However, the remaining 10% of a pesticide could cause significant damage to water bodies. Observed levels in leachate were <1% of applied. The organic carbon present in the thatch layer is very effective at binding and ultimately removing a pesticide from potential transport. However, pesticide chemistry can determine its ability to be bound. A pesticide is a threat to ground water if it has K_{oc} <1900 L kg^{-1}, water solubility >3mg L^{-1}, or a soil half life >610 days.

Many of the pesticides used in turfgrass have all or some of the above characteristics, yet do not leach significantly. This is perhaps further evidence that environmental conditions play a major role in pesticide transport, detention and degradation in ecosystems. However, pesticide mobility is a significant issue when making direct comparison of compounds. Both dicamba and 2,4-D are considered potential leachers, but Dicamba is more mobile than 2,4-D. In fact, despite only 10% as much dicamba as 2,4-D was applied, nearly the same quantities of each was leached.

Season was found to significantly affect the leaching of dicamba in a study by Roy, et al. High evapotranspiration rates (Et_o) were found to reduce total leaching losses in the summer, but losses in the fall approached 1000 µg L^{-1} dicamba, because of reduced plant uptake, high application rate and reduced soil and microbial degradation from lower soil temperatures. A large portion of pesticide mass loss occurs in the winter despite little or no pesticide application. Runoff and leachate losses are greater in the winter months due to reduced evapotranspiration and increased rainfall. Cooler weather results in reduced degradation and metabolization of pesticides as well as reduced turfgrass growth, leaving more pesticide to be transported to water. Pesticide formulation can have a significant impact on water quality. Harrison, et al, measured the acid form of 2,4-D at concentrations greater than 200 µg L^{-1}, while the ester form was below detection levels.

How Pesticides Move

Transport of pesticides can follow a number of paths. Pesticides can move from the soil surface via runoff, in the soluble form, or attached to sediments (negligible with established turfgrass). Ma, et al, discovered that pre-wetted sites were much more prone to pesticide loss via runoff. Much of the transport from established turfgrass is of the soluble form. Smith and Tilloston state that the formulation of 2,4-D, dicamba, and MCPP normally applied has a high average water solubility (<50 mL g^{-1}), allowing it to move rapidly through a soil profile. Toranio, et al, found pesticides had a greater potential to leach if the K_{oc} was less than 1900 mg L^{-1}. However, rooting can affect pesticide mobility greatly. Deeply rooted turfgrass has a greater influence on subsurface water movement than shallow rooted turf. Branham, et al, state that pesticide applications to turf reduced leaching losses over bare soil.

Golf course greens have the potential to allow large pesticide losses. The sand-based rooting mix has low organic matter content, metal oxides and an open matrix which all combined to reduce the interaction of a pesticide with the soil, thereby reducing potential attenuation and binding. The coarse, sandy soil allows for rapid water movement and little potential attenuation because of a low cation exchange capacity. Over-application of water will cause pesticides to be transported through the soil to ground water. Greens are generally watered heavily which increases leaching. However, pesticide movement with the water can be greatly reduced by thatch which binds and degrades large quantities of pesticides. Runoff is usually negligible on sand-based golf greens. Concentrations of a compound may be high in runoff, but mass losses are low. They observed 2,4-D concentrations as high as 314 µg L^{-1}, but runoff depth was minimal.

Zachary Easton
Ph.D. Candidate Cornell University

Editors Note: Zach is currently pursuing his Ph.D. with Professor Marty Petrovic investigating landscape, watershed and water quality issues. This is the first of a three part series on the current status of water quality research as it relates to turfgrass management.

Deeply rooted turfgrass has a greater influence on subsurface water movement than shallow rooted turf. Branham, et al, state that pesticide applications to turf reduced leaching losses over bare soil.

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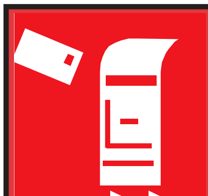

Please Note:

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sionalism are but a few of Joann's many fine attributes. [She is] a tireless individual who goes above and beyond in her work and dedication to the industry and her profession. A most deserving individual for this prestigious award."

It is clear that Joann Gruttadaurio is deserving of the 2003 Citation of Merit Award. Congratulations Joann, and thank you for all of the contributions you have made to our association and community.

NYSTA Funded Projects

There is a lack of current soil test calibration studies with newer varieties and contemporary fertilization practices. The purpose of this project is to improve the Cornell University fertilizer recommendations by conducting soil test-turf response studies with newer varieties managed under various management practices.

Improving Turfgrass Soil Test Recommendations

Soil testing can be one of the most useful ways to determine the amount of nutrient (phosphorus (P), potassium (K), calcium, and magnesium) and pH modification that is needed to produce healthy turfgrass. Soil testing may also be a best management practice used to reduce the risk of phosphorus runoff. Fertilizer recommendations based on soil testing are developed from years of turf performance and soil test calibration research. There is a lack of current soil test calibration studies with newer varieties and contemporary fertilization practices. The purpose of this project is to improve the Cornell University fertilizer recommendations by conducting soil test-turf response studies with newer varieties managed under various management practices.

Locations of Project

Three sites, including the Cornell Turfgrass Research and Education Center in Ithaca and several locations around New York (Bethpage, Long Island, and Lake Placid in the Adirondacks) in cooperation with extension field staff and other cooperators.

Methodology

Selected sites initially had low levels of P and K. Sites had different soil textures (sandy to silt loams) but the same turfgrass species or varieties. On each site, 3 levels (1/2 X, 1X and 2X the soil test recommendation) of P and K were used, coupled with 3 different nitrogen levels, an unfertilized control, and a high rate of N, P, and K. Turf performance was evaluated by standard measurements of turf quality, density, yield, pest infestation when evident, and other special methods based on turf use. Soil nutrient levels and tissue levels were determined twice during the year. Turf performance vs. soil and tissue nutrient values were correlated to determine the optimum performance based on soil test levels.

The treatment list for the Ithaca site for 2002 is shown in Table 1. The site was seeded in the fall of 2001 with a mixture of 70% Kentucky bluegrass, 20% perennial ryegrass and 10% fine fescue, seeded at a rate of 4 lbs/1000 sq.ft. Urea was applied at 1 lb N/1000 sq. ft and lime at 40 lbs/1000 sq.ft. prior to seeding. Soil samples and clippings (at a height of 2.25”, from an area of 52.5 sq.ft.) were collected on July 26 and October 25, 2002. Soils and clippings were analyzed at the Cornell ICP and Nutrient Analysis Laboratories. Visual quality (1-9 scale where 6 is acceptable) ratings were taken monthly from June through October in 2002 (see Table 2).

Results

The first year of data collection gave us limited information. As seen in the figures on page 9, turf quality was not affected by the soil test level for either phosphorus (P) or potassium (K). Increasing the soil level of either P or K did not increase the percentage of P or K in the clippings. The clipping yields were higher as soil K levels increased for 200 lbs/a to 300 lbs/a. As clipping content (percentage) of P and K in-

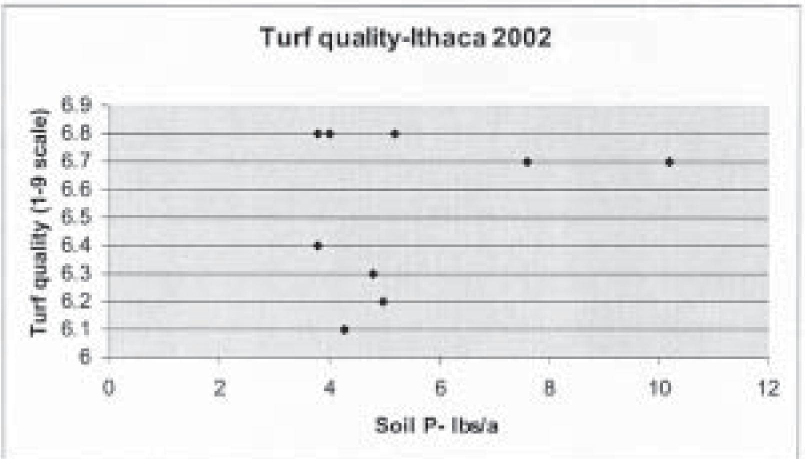
Table 1: Treatment list for Ithaca site, 2002

	Treatment made on, as lbs/1000 sq.ft			
	28 Jun	26 Jul	22 Aug	1 Oct
Treatments				
1. Check				
2. Nitrogen* 1/2 x rate	1		1	
3. Nitrogen 1x rate	1	1	1	1
4. Nitrogen 2x rate	2	2	2	2
5. Phosphorus at 1/2x rate	No P needed			
6. Phosphorus at 1x rate	No P needed			
7. Phosphorus at 2x rate	No P needed			
8. Potassium^ 1/2x rate	0.23		0.23	
9. Potassium 1x rate	0.23	0.23	0.23	0.23
10. Potassium 2x rate	0.45	0.45	0.45	0.45
11. N-P-K at 2x rate	2 N + 0.45 K	2 N + 0.45 K	2 N + 0.45 K	2 N+0.45 K
12. Nature Safe (1x N rate)	1	1	1	1

* Polyon SCU (35-0-0), ^ Potassium sulfate (0-0-50), + 8-3-5

creased the clippings yields and quality increased, indicating that tissue levels of P and K may be a better indicator of turf growth and quality than soil test levels. The treatments that contained nitrogen increased the uptake of P and K in the turf and resulted in more clipping growth and higher quality.

A. Martin Petrovic



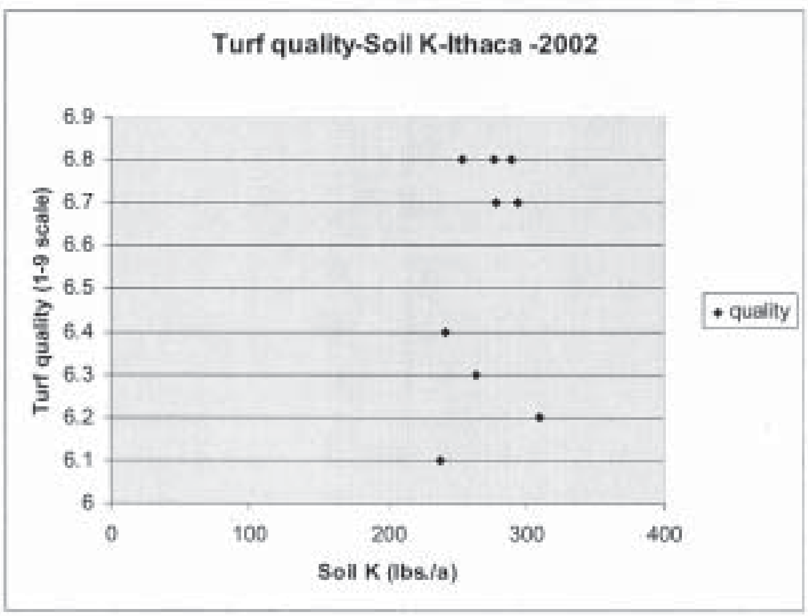


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Table 2: Average visual turf quality for 2002, Ithaca Soil Test Calibration Study

Treatment	Visual Quality
Unfertilized control	6.1b*
Potassium 1/2x rate	6.4a
Potassium 1x rate	6.3b
Potassium 2x rate	6.2bc
Nitrogen 1/2x rate	6.8a
Nitrogen 1x rate	6.8a
Nitrogen 2x rate	6.7ac
Nitrogen 2x + K 2x rate	6.8a
Nature safe (1x N rate)	6.7ac

* Values not followed by the sample letter are significantly different (P=0.05).

NYSTA Funded Projects

Repetitive overseeding was conducted on two sports fields in the Capital District of New York. Research has demonstrated that dramatic increases in turfgrass density were possible when high rates of perennial ryegrass (Lolium perenne) *were overseeded* weekly *on a simulated sports field.*

Success With Overseeding for Sports Fields

Overseeding, or distributing seed over an existing turfgrass area to increase density, is a traditional practice followed by many turfgrass managers. Unfortunately, success in overseeding is not easily accomplished. To improve the chances that a high rate of seed germination and establishment will occur, it is often recommended that some sort of cultivation is done before seeding. Types of cultivation include removing cores of soil (core cultivation), spiking, and vertical mowing.

An aggressive overseeding program for a sports field might be to overseed four or five times per year, hoping each time for some limited success. Home lawns and commercial properties, which are not usually overseeded, might be overseeded once or twice per year in a "best case" scenario. With limitations on the use of pesticides increasing, overseeding might seem to be a better option than ever. However, turfgrass managers often report disappointing results with overseeding. This is especially true on low-input fields, or fields where fertilizer, irrigation, weed management, and other cultural activities are limited or nonexistent. The cultivation requirement attached to overseeding can be disruptive to the use of the turf area in question, as well as adding costs. Clearly, easier and more effective ways to overseed turfgrass areas are needed.

The Research Project

In August of 2003 a research project examining heavy, repetitive overseeding was conducted on two sports fields in the Capital District of New York. This study was designed to put into practice the ideas of Dr. Frank Rossi, Extension Turfgrass Specialist at Cornell University. Dr. Rossi has demonstrated that dramatic increases in turfgrass density were possible when high rates of perennial ryegrass *(Lolium perenne)* were overseeded *weekly* on a simulated sports field.

The objective of this study was to demonstrate the practice of heavy, repetitive overseeding on two low-input Capital District sports fields using three seeding rates.

Procedures

Anyone who has visited practice soccer and football fields at high schools and parks would probably agree that many are examples of ugly, beat-up turf and weeds. Two fields were used in this study. The practice football field at Averill Park High School had compacted clay loam soil, a low pH (5.9), and was composed of bare spots, crabgrass, knotweed, plantain, dandelion, perennial ryegrass, and Kentucky bluegrass. The second field was a multipurpose soccer/football field in an inner city park, Prospect Park, in Troy. The soil was a loam with pH 7.5. The predominate species here were purslane, Kentucky bluegrass, perennial ryegrass, and goosegrass. See Table 1 for a description of the initial composition of each field.

Four treatments were made: no seed (check plots), and overseeding at rates of 2, 6 and 10 pounds of seed per 1,000 square feet (M), with three replications made of each treatment at each site. Overseeding started on August 14 and continued weekly (except for the week of 9/18) until October 16, for a total of 10 applications in 11 weeks. Seed was distributed evenly across the plots using a Gandy drop spreader. There was no cultivation done on the sites (other than that done by the football/soccer players or other field users); the seed was simply spread on the plots. No irrigation was supplied, as rainfall was abundant. Traffic and wear on the Averill Park field was concentrated in the center, and as a consequence one set of plots received light traffic, one medium, and one heavy. All of the plots at the Prospect Park field seemed to receive equal traffic.

Table 1: Initial composition (% of each component) on the two study fields

	Per. ryegrass/ Ken. bluegrass	Bare	Purslane	Goosegrass	Crabgrass	Plantain	Knotweed	Dandelion
Averill Park High School	4.4	1.3	0	0	57.8	2.1	32.3	0.8
Prospect Park	17.5	38	27.9	15.2	<1	<1	<1	0

Table 2: Average percent turfgrass for eight treatments over ten seedings at Averill Park High School

Treatment	Week 0	Week 5	Week 11	Net increase in turfgrass density
Check, light traffic	3.1	12.5	28.1	25.0
Check, heavy traffic	9.4	34.3	46.8	37.4
2 lbs./M, light traffic	12.5	71.9	96.9	84.4
2 lbs./M, heavy traffic	0	28.1	59.3	59.3
6 lbs./M, light traffic	0	62.5	100.0	100.0
6 lbs./M, heavy traffic	0	31.2	78.1	78.1
10 lbs./M, light traffic	15.6	81.3	96.9	81.3
10 lbs./M, heavy traffic	3.1	53.1	75.0	71.9

Results

Results for the Averill Park field are outlined in Table 2. Turfgrass density increased for all treatments, even for the check plots that did not receive overseeding. Small amounts of turfgrass already existed in these plots, and when competition from the weeds was removed after they died from frost and cooler temperatures, the density of the grasses increased. This same phenomenon is also partly responsible for the increase in density of the overseeded plots as well, except for the three treatments that started with no turfgrass, in which case the increase in density can be attributed to overseeding alone.

"Net increase in turfgrass density" was calculated as the density estimated at Week 11 minus the initial density. It is an attempt to measure the density increase caused by overseeding and to remove the influence of a plot having some turfgrass at the beginning of the study. The largest net increase in turfgrass density was seen in the 6 lbs/M light traffic plot, where density increased from 0% turfgrass at Week 0 to 100% at Week 11. The largest increase in net density for heavy traffic plots was also seen in the 6lbs/M plots, where density increased from 0 to 78.1%. Plots overseeded with 10 lbs/M had higher net increases in density at Week 5, but the 6 lbs/M plots had greater net increase in density by Week 11 of the study. A visual comparison is shown in photo 1.

Very different results were obtained at Prospect Park (see Table 3). In the first few weeks of the study, perennial ryegrass seedlings were observed to be germinating in many of the plots. After Week 5, all of the plots, except the untreated checks, had a net increase in turfgrass density. The largest increase of 50.9% was seen in the 10 lbs/M plots. After the week 5 observations, however, the 2 lbs/M plots continued to show an increase in turfgrass density, while the 6 lbs/M and 10 lbs/M showed decreases.

This was largely due to factors on the site. The middle of this field is very compacted and slightly depressed. Given the large amount of rainfall during the time period this study was conducted, this depressed area flooded repeatedly. Seed from treated plots was observed to have washed away and moved onto untreated strips between the plots. Seedlings may have also been uprooted or died from flooding. While a net increase in turfgrass density was still achieved for all seeded treatments, these confounding factors decreased the possible gains which could have been made. These results clearly indicate that the topography of the field will influence the success of overseeding.

Conclusions

These results indicate that heavy, repetitive overseeding using perennial ryegrass can improve turfgrass density on low-input sports fields. Greater increases were seen in plots receiving light traffic versus heavy traffic, yet even in plots with heavy traffic, significant increases were still seen. The least successful situation seen in this study was on the Prospect Park field, where the uneven topography combined with heavy rainfall caused seed to wash out of treated plots and seedlings to die. An even (or at least

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Table 3: Average percent turfgrass for four treatments over ten seedings at Prospect Park

Treatment	Week 0	Week 5	Week 11	Net increase in turfgrass density
Check	12.5	6.2	13.6	1.0
2 lbs./M	9.4	20.8	30.2	20.8
6 lbs./M	15.6	43.8	23.9	8.3
10 lbs./M	12.5	63.4	33.3	20.8

Overseeding

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not severely rutted) field surface is therefore important to overseeding success. Overseeding at the 6 lbs/M rate gave the greatest increase in net density and is also a less expensive alternative to the 10 lbs/M rate.

Is heavy, repetitive overseeding a cost-feasible proposition for sports fields? An internet search shows that perennial ryegrass seed prices range from $1.40 to $2.80 per pound; wholesale prices and bulk quantities can push the low end to less than $1.00 per pound. Given a $1.00 to $2.80 price range, the cost for a 10 week overseeding program at a 6 lb/M rate would be $60.00 to $168.00 for 1000 square feet.

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If a school wanted to overseed the middle of a worn football field (approximately 18,000 square feet), the cost would be in the range of $1,080.00 to $3,024.00. While this may not be an insignificant cost to financially-troubled school districts, it seems far less expensive than most pesticide treatments, or a lawsuit brought about from a student athlete's injuries suffered due to a poorly-maintained sports field. Since cultivation is not necessary with heavy, repetitive overseeding, further expenses are avoided, and fields can remain in play as the overseeding is taking place. The effect of providing high-phosphorus fertilizer with overseeding should be studied, since such starter-fertilizer can increase seeding success and is fairly affordable.

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A project examining how this system performs in spring conditions on home lawns is planned for 2004.

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Thanks to The New York State Turfgrass Association for providing funding for this study; Dr. Frank Rossi of Cornell University for technical support; and Dennis Weatherwax of the Averill Park School District and Jim Conroy from the City of Troy for research sites.

Photo 1 (below): *From left to right: 2 lb/M, 6 lb/M and 10 lb/M seeding rates in a heavily trafficked portion of the practice field at Averill Park High School.*

Photo 2 (right): *The sports field at Prospect Park, with the worn, depressed area evident in the middle of the field.*

The Precautionary Principle

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The Wingspread Conference added the elements of *reversing the burden of proof* (the "polluter pays" principle), as well as the importance of *open dialogue* and the *democratic process in decision-making.* Another new concept was the *full exploration of alternatives.* The importance of planning and considering alternatives in the decision making process is closer to the original German concept of the "foresight" principle.

Predicting Hazards to Humans

Scientists use a variety of tools to predict hazards in people. One example of harm or irreversible damage detected in laboratory animals before there was "proof" of harm in humans was data on the chemical vinyl chloride. Years before a similar type of liver tumor was observed in plastic manufacturing workers exposed to high levels of vinyl chloride, a rare type of liver tumor was identified in controlled laboratory animal studies.

The National Toxicology Program still oversees a variety of short and long term studies in laboratory animals used to identify potential chemical hazards in humans. Of the 509 chemicals tested so far, 42 (8%) have been identified as causing mammary (breast) tumors in control laboratory animal cancer bioassays.

Court Rulings

Policy makers and regulatory agencies in the United States have had a strong history of precautionary approaches to protect public health even when there is scientific uncertainty of a cause and effect. Unfortunately for our nation's children, the phaseout of lead in gasoline was too long in coming. From 1922 to 1985 more than 15.5 billion pounds of lead were used as a gasoline additive in the United States. With the phaseout of lead in gasoline in the 1970-80s, lead levels in air had been reduced by 80% by the 1990s. But lead still persists in soil since it does not degrade. Public health scientists had testified and protested the use of lead in gasoline as early as 1925. One of the leading public health scientists of that time, Dr. Thompson of the US Public Health Service had stated, "…lead has no business in the human body....Everyone agrees lead is an undesirable hazard and the only way to control it is to stop its use by the public."

Nearly 60 years later we are still struggling with how very low levels of lead affect the body's immune system and cognitive development in children. However, the push to use lead in gasoline in the 1920s was made under the guise of global competitiveness and the industrial supremacy of the United States. We, our children, and generations to come, will pay the price for the decision to use lead in gasoline for more than 50 years.

For the protection of our children's health, the American Public Health Association (APHA) affirmed its endorsement of the Precautionary Principle as a cornerstone of public health. In a 2000 policy statement, the APHA encouraged governments, the private sector and health professionals to promote and use the Precautionary Principle to protect the health of developing children.

US Federal Agencies Take Precautionary Approaches

Examples of landmark federal legislation using a precautionary approach include the Food, Drug and Cosmetic Act. This law requires pharmaceutical manufacturers to demonstrate safety of the drug prior to market approval by the Food and Drug Administration (FDA). The 1970 Occupational Safety and Health Act requires employers to provide workplaces free from recognized hazards.

The EPA requires pesticide manufacturers to submit the results of animal cancer bioassays prior to registration approval to determine if the pesticide is a cancer hazard. Unfortunately, there is a lack of transparency in this process. The cancer bioassay reports are submitted to the EPA, but remain the property of the manufacturer. The results of the reports are rarely published in the open scientific literature, and often can only be obtained though the tedious process of a Freedom of Information Act request. But since proprietary (trade secret) information can be found in the reports, the manufacturer retains the right to edit (black out) parts before they are released if copies are requested under the Freedom of Information Act. While some requests have quick turnaround of one to three months, Breast Cancer and Environmental Risk Factors program staff have waited up to 18 months to get copies of reports evaluating the cancer-causing potential of certain pesticides.

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The Precautionary Principle

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Criticisms of the Precautionary Principle

Opponents of the Precautionary Principle have argued that many US federal agencies already use a precautionary approach and that we have a history of environmental legislation with a precautionary approach. There are important elements that have been introduced into environmental legislation—including adding extra safety factors—when setting limits on certain chemicals. For instance, an extra 10-fold safety factor can be used when setting maximum levels of pesticide residues, called tolerances, on food.

Much of chemical regulatory policy in the United States is based on a more traditional risk assessment procedure where harm must be proven before a chemical is removed from the manufacturing stream, and steps are then taken to mitigate the risk by limiting exposures. This approach can result in a very lengthy risk assessment procedure that can delay policy decisions. It also does not have the advantage of

Chemical regulatory policy in the United States is based on a more traditional risk assessment procedure where harm must be proven before a chemical is removed from the manufacturing stream, and steps are then taken to mitigate the risk by limiting exposures. A criticism of the Precautionary Principle is that this approach can result in a very lengthy risk assessment procedure that can delay policy decisions.

A second criticism is that a precautionary approach will invoke a "monsters under the bed" syndrome.

The definitions of the precautionary principle have the common element that precautionary action should be taken when there is credible, scientific evidence of harm.

The Precautionary Principle Thus Far: Where It's Been, Where It's Heading

As a tool of public policy-making, the Precautionary Principle has evolved considerably since its earliest incarnations. Its history and current status can be summarized as follows:

- It was used extensively in US environmental decision-making in the 1970s.
- It has been and continues to be the cornerstone of the public health system.
- It is already being used as a cornerstone of environmental decision-making in European nations—especially Denmark, Sweden, and Germany—as well as in Canada.
- It can be used to enhance the collection of cancer risk information on high production volume chemicals.
- It must be science-based.
- It does not eliminate the need for risk assessments.
- It is enhanced by public participation.
- It requires transparency of data on health risks of chemicals.
- It has spurred a debate on whether the principle should embrace the "polluter pays" directive, which places the responsibility for providing risk assessment information with industry. Some advocates of precaution believe that evaluations by independent agencies and researchers are also important.

Recent Legislation in Canada Based on Precautionary Policy

Precautionary Framework Policy Passed

On August 5, 2003, the Canadian Cabinet formally approved policy that will apply the Precautionary Principle to all decisions made by federal policy-makers that "carry a risk of serious or irreversible harm where there is a lack of scientific uncertainty."

Québec Pesticide Laws

In July 2002, Québec enacted a *Pesticide Management Code* which will phase out the use of certain pesticides on lawns in public and municipal areas. Restrictions will be extended to the private lawns of homeowners by 2005. The legislation will change requirements for the training of persons working in retail pesticide sales, and will also broaden requirements that must be met for certification of farmers and forest managers who apply pesticides. The legislation will also specify which chemicals (called the "active ingredients") will be allowed for pest control inside and outside in elementary and secondary schools, and daycare centers.

providing a wealth of scientific data upon which to make decisions. Again, the cost is often time and continued exposure of the chemical to at-risk populations while risk assessment data is being collected. For instance, special review and re-registration assessment of certain pesticides by the EPA may take as long as five to ten years.

The second criticism is that a precautionary approach will invoke a "monsters under the bed" syndrome. As a scientist, I would agree that this is a potential problem. It is important to realize that the precautionary approach does not eliminate the need for assessing harmful effects of chemicals. The definitions of the Precautionary Principle outlined earlier in this article do have the common element that precautionary action should be taken when there is *credible, scientific evidence of harm*. Action should not be taken because of a perceived risk. But, under this principle action can be taken when there is still scientific uncertainty in order to protect public health.

The third argument is that the Precautionary Principle is not science-based. In response, many scientists and policy makers emphasize that the best science must be brought to the table when using the Precautionary Principle to make policy decisions. The decisions cannot be made in a vacuum. They cannot be made without scientific evidence of potential harm. We know very little about the risk of many chemicals. The absence of data does not mean there is an absence of harm, but rather that data must be gathered to provide a basis for decision-making.

The Precautionary Principle, as invoked in the EU REACH program and in a policy framework recently enacted by the Canadian government (see side-bar article), does not require less science. On the contrary, because of the absence of data on so many chemicals, a precautionary approach will require more extensive risk assessments to evaluate if actions are necessary. The question still remains, however, what level of scientific evidence is needed to trigger policy actions based on a precautionary approach. According to John Carins, at Virginia Polytechnic Institute, "… the Precautionary Principle requires scientists to develop and improve methods and procedures for studying complex natural systems." The best elements of a precautionary approach do not demand less science; rather, it is a challenge to the scientific community to improve methods used for risk assessment.

The fourth criticism is that the use of the Precautionary Principle will stifle industry and competitiveness. Yes—and no. It may cause some industries to no longer operate if a chemical is regulated, but at the same time such action may create entirely new industries. For example, "green" industry could produce environmentally friendly products creating a new and viable, market-based industry. For instance, the phasing out of mercury thermometers resulted in an entire digital industry for measuring temperatures in the ears of feverish children. The auto industry survived phasing lead out of gasoline. So did the paint industry. New alternatives for medical tubing without phthalates are now available. This means premature babies and dialysis patients no longer have to be exposed to harmful phthalates that can leach out of plastic tubing. New markets for new products were created that are safer for people and the environment. Seeking alternatives may open up competitiveness for multiple manufacturing streams to replace a single, environmentally toxic product.

A summary of the International Summit on Science and the Precautionary Principle, held in Lowell, Massachusetts in 2001, stated: "Applying the Precautionary Principle can foster innovation in materials, products and production processes. The goal of precaution is to prevent harm—not progress—and support a sustainable future." Our inventiveness can be the best measure of our competitiveness in a global market that will no longer tolerate products that harm human health or the ecology of the earth.

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CUTT

A Healthy Ecosystem

Definitions of the Precautionary Principle are evolving. An early one: In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities.

Do No Harm: The Precautionary Principle

Precautionary approaches to public health have a long history. The father of the precautionary approach is Hippocrates, who said, "As to diseases, make a habit of two things: to help, or at least to do no harm."

Precautionary actions have been a cornerstone of public health. For example, the physician John Snow mapped cases of London's cholera epidemic of the mid-1800s. He observed that most cases of cholera were grouped around dwellings that used a certain well for drinking water. Until then it was thought that diseases were only transmitted in the air. The possibility of water transmission was hotly debated. While the organism that caused cholera was not identified for another 30 years, the removal of the handle at the Broad Street pump was a precautionary action by Dr. Snow that had a major impact on halting the 1854 cholera epidemic in the Soho district of London.

Origins of the Modern Precautionary Principle

In more modern times, the origins of the Precautionary Principle can be traced to Germany's emerging environmental movement of the 1970s. "Precautionary Principle" is actually the English translation of the German phrase "Vorsorgeprinzip," and the direct translation is "Foresight Principle." There is no one definition of the Precautionary Principle; one of the early definitions was drafted in 1992 at the United Nations Rio Conference on the Environment and Development:

"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Definitions of the Precautionary Principle continued to evolve. A conference that had a major impact on redefining the Precautionary Principle was the 1998 Wingspread Conference held in Racine, Wisconsin. The 32 participants at the conference included scientists, lawyers, treaty negotiators, and activists from the United States, Canada and Europe. The participants drafted statements calling on policy makers, corporations, scientists, and communities to implement Precautionary Principles in making decisions affecting the environment. The principles they drafted at the end of the three-day conference included:

- "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.
- "In this context the proponent of an activity, rather than the public, should bear the burden of proof.
- "The process of applying the Precautionary Principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action."

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