A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

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Turf Research: Nature, Needs and Net Results

Eliot C. Roberts, Ph.D.

As we approach the year 2000, turfgrass research efforts in the United States have been underway for well over 100 years. In fact, this research has become the backbone of the whole turf management segment of the green industry. We have advanced in all technical aspects of turfgrass culture because of the science that supports the development of new fertilizers, soil conditioners and activators, equipment for grooming and irrigation, pesticides, and turfgrass cultivars. Without both public (primarily Land Grant University) and private (industry) research, the quality of landscape and sports turf would be much lower quality than we enjoy today. Research has been a major driving force, a critically important element, in advancing "know-how" as we are about to enter the 21st Century. Furthermore, the research we need is far from complete, not even after 100 plus years of scientific effort.

We all recognize that times are changing. Public perceptions of research, particularly in agricultural and related sciences, have changed and are continuing to change. Government funding is thought to be of greater need in other areas, especially those related to socioeconomic and humanistic concerns. As a result, limited funding becomes a serious liability at a time when costs of turfgrass research are on the increase.

Questions We Must Answer

- How do we need to grow grass?
- How does grass grow?
- What is good turfgrass research?
- How can we recognize the best in turfgrass science?
- Are some values from research of higher priority than others?
- How can researchers, who specialize in basic science, work more closely and effectively with turf managers, who are masters in the art of growing grass?

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The question of who will pay becomes one of major importance. How much public funding can be made available? How much industry funding can be passed along to the consumer of goods and services? There are no other sources and we must recognize that ultimately research costs fall to the consuming public, one way or another.

Because we live in a time when hard decisions need to be made, we all must understand what turfgrass research is all about, including the nature and politics of turf as a component of Landscape Horticulture. It's time, perhaps past time, to get serious about turfgrass research. Let us take the time to look at this topic from the broadest possible perspective.

The Turfgrass Commodity: Plant Characteristics and Management Needs

The turfgrass commodity is unique among plant kinds and thus presents some interesting prospects for research. Perhaps no other plant is cultured at a higher density (population of plants per unit area), often close to 800,000 per per 1,000 square feet. These plants compete with each other, with other plants, and with woody landscape plants whose roots intermingle with grass roots. They also compete with macro- and microorganisms. Some 45 quadrillion (15 zeros) per 1,000 square foot to a six-inch rootzone depth utilize nutrients essential for life processes. Thus, turfgrass is an excellent specimen for study of ecological principles.

In addition, turfgrasses are defoliated (pruned) regularly. This might be daily on a golf green or weekly on a home lawn. No other plant is trimmed this regularly. Furthermore, the intensity of trim varies from 1/3 inch on a golf green to as high as three inches on a home lawn. Different grasses tolerate clipping at different heights. For all of them, defoliation has a pronounced effect on the development of the root system. At times, grasses might become so severely weakened by close clipping that disease incidence is increased and loss of turf cover results. At other times, this weakness is manifested later in the season under adverse climatic conditions - too wet or too dry, too hot or too cold. In effect, persistence of a turf stand is directly related to energy reserves stored underground. Thus, relationships between mineral nutrition and organic nutrition within these plants can be studied effectively using turfgrasses as test specimens.

Further, because of the nature of turfgrass use involving traffic and play of the game requirements, it serves as an excellent plant to evaluate effects of soil compaction on soil air/water relationships in the rootzone. And, since turf quality is evaluated daily during the growing season, and even on through late fall, winter and early spring, this plant commodity serves well in monitoring plant responses throughout the entire year. This is unlike other agricultural or ornamental plants that are grown for yield at harvest time or for seasonal flower or foliage quality.

Finally, few other plant kinds are as intensively maintained as turfgrass. This applies especially to golf course and sports turf where foot traffic abrasion and soil compaction can be so detrimental on plant quality and persistence. As much as 70 percent of

Looking at Turfgrass From the Broadest Possible Perspective

I. The Turfgrass Commodity - Plant characteristics and management requirements.
   A. Team effort between plant scientists and turfgrass managers.

II. Research Strategies - Purposes, needs, and applications.

III. Efforts, Needs and Challenges
   A. Early Research - where we have come from.
   B. Present Research - where we are now
   C. Future Reseach - where we are going

IV. Knowledge Gained
   A. From Applied Research
   B. From Basic Research
   C. From Research Synthesis

V. Benefits
   A. Values from research findings for a.) industry, b.) grounds managers, c.) public education, d.) environmentalists, e.) fortifying political correctness.

VI. Research Funding

turfgrass quality can be accounted for by proper irrigation practices. Also having a profound influence on turfgrasses are use of fertilizers, biological activators, soil conditioners, surfactants and pesticides. Practices, such as mowing, aerification, thinning and grooming add to an ultimate realization of high quality in the sward.

These plant characteristics and management requirements make desirable a close working relationship between the turf research scientist and the professional turf manager. Either party acting alone will be less effective than when a team approach is followed. Golf course superintendents across the country have increasingly recognized this in recent years.

Research Strategies
Purposes, Needs and Applications

Consequently, research planning and implementation is a task for joint attention by scientists and practitioners. Difficulty arises when either group attempts to see the entire picture from a single perspective. First, we should look at the purpose or purposes of conducting turfgrass research. Together, we need to increase emphasis on developing a research strategy.

Purposes - There's an old saying that speaks much truth, "If it's not broken, don't fix it." The purpose of turfgrass research should never be to fix something that is not broken. Research is conducted for the purpose of preventing a breakdown or in order to strengthen a weakness in management that has resulted in turf failure in the past. The most positive and longest lasting purposes of research are often genetic in nature. For exmaple, to improve disease or insect resistance genetically is superior to developing a new pesticide that organisms could become resistant to in time. This is not to say that pesticide research is not valid. It is indeed necessary and a high priority issue.

Testing and demonstration research fulfills an important purpose. How else can we know if trial and error based testimonials are worth anything? What works under one set of conditions might not work under another. Subjecting turf responses to an analysis of variance and reporting results in least significant differences might not make good advertising copy, but it does provide a clear picture of which differences are real and which are wishful thinking.

Product development research has a highly useful purpose - only through emphasis in this area do we realize mechanical improvements and more effective chemicals that can make turf management easier and result in higher quality. Like basic research, product development studies might not have clear-cut objectives at the start, but as pieces of information relate to one another, a precise understanding of the purpose of this work becomes real.

Needs - It is relatively easy to come up with a laundry list of research wants. But, how many of these are really needed? Where are the probabilities of a breakthrough most likely? These are the areas that might well be explored first in meeting current needs. And, just because a topic has been under investigation for the past 50 years, doesn't mean that new technology or a new approach cannot be put to good use in making a significant advancement. This particularly applies well to investigations of a longstanding nature that have to date yielded little in the way of positive results. Soil microbiology, seems to me, is ripe for major advancements now at the close of the 20th Century.

Application of Findings - In all likelihood, we already know far more about how to grow turfgrass than we put to good use. Does that mean we should slow down research efforts until our application successes catch up with the reserve of information on hand? Not at all. The probability exists that each new finding will help us better understand and apply knowledge already in existence. In other words, research must be backed up with education in order to increase usefulness of findings.

This was the original concept of Cooperative Agricultural Extension within the Land Grant University System. Now, with turfgrass research conducted at many institutions and locations, it's not clear how effective Extension Education is these days. Certainly Division C-5 of the American Society of Agronomy/Crop Science Society of America and the International Turfgrass Society, among other professional societies, are key educators in the practical applications of turfgrass findings. In addition, practical research digests for turf managers, such as *TurfGrass TRENDS*, have important roles to play in this process.

Efforts, Needs and Challenges Past, Present and Future

At this point, there should be value in looking at turfgrass research from a historical perspective. In order to plan for the future, we need to know where we've been. Otherwise, we are likely to repeat past failures and missed opportunities.

Early Research - Most turfgrass research in the United States before World War II was an outgrowth of forage and pasture studies. However, the increasing popularity of golf provided incentive for specialized research that would be of benefit to the playability of golf course tees, fairways and greens. Application of research results was also directed towards lawns across the country and this spin-off caused an increasing realization of the true extent of the importance and value of the turfgrass commodity. Thus, these early trials and demonstrations concerned with adaptation of turfgrass varieties, weed control, and fertilization whetted the appetites of agronomists and horticulturists for better things to come.

Present Research - Following World War II, there has been realized a 50-year period of unprecedented progress and growth in turf research. Full-time turf specialists, trained in agronomy and horticulture, devoted major effort to teaching, research, and extension in nearly every state. These scientists affiliated with the American Society of Agronomy in order to share research methodology and the results of current experimentation. They worked as partners with golf course superintendents (once known as greenskeepers) to provide firm, practical foundations for their research endeavors. During this period, we have seen tremendous progress. Perhaps this impressive list of accomplishments might tend to indicate that the turf research mission has been completed and that there is little more to do. Not so. We should now look into the future to see what must come next.

Post-War Turfgrass Research Progress

- Development and standardization for use of selective herbicides
- Development and standardization of soil sterilization practices from a scortched earth technology to relatively fast acting chemical treatments for improved seed beds and turf renovation
- Development and standardization of soil aerification practices that have replaced the use of dynamite and spade forks. These include mechanical devices as well as chemicals to increase soil wettability.
- Development and standardization of fungicides, insecticides, and nematicides
- Development and standardization of new fertilizers, soil conditioners and biological activators
- Development and standardization of equipment for turf irrigation and grooming
- Development and evaluation of new grass cultivars engineered genetically to meet specific use requirements on lawns and sports turf
- Advances in our understanding of how grass grows, especially in relation to concepts of stress physiology
- Advances in our understanding of safe use and handling of pesticides and other chemicals essential in the turf management process.

Future Research - As we enter the 21st Century and start a second hundred years of turf research, where must emphasis be placed? We should consider briefly the following six topics for investigation: Socioeconomics, Computerization and Automation, Turfgrass Improvement, Turfgrass Stress Physiology, Soil Biology and Plant Ecology.

Socioeconomic Research

Socioeconomic studies investigate relationships between green industry products and services and consumer needs. These will result in an orderly maturation of industrial components with emphasis on public relations.

Within all areas of turfgrass specialization today exist many misunderstandings, old wives' tales, and just plain false teaching based on trial and error technology of years gone by. Science-based technology has made great inroads on many of these misconceptions and yet others still linger on. These can be found across the board, from the professional turf manager to the weekend home gardener. Some gainfully employed writers and educators perpetuate misconceptions and some of the products and practices. The net result of this situation is a loss of credibility within the turfgrass segment of the Green Industry. The value of lawns and sports turf and the benefits in terms of environmental quality are much greater than the general public realizes. For the past 20 years, we have bemoaned this public relations problem, but have done little to correct it. Socioeconomic studies, designed to relate products and services with consumer needs in order to promote a better understanding of true value, are of critical importance now and will continue to be so well on into the 21st Century.

Computerization and Automation

Computerization and automation of turf management systems within limits is needed so that the "man" in management is not replaced. Turf culture should continue to be considered labor intensive.

There are too many uncontrollable variables in soil, plant, and environment to ever make turfgrass management a push-button, mechanical operation. Often, we note that it's the "man" in management who makes the system, whatever it is, work. However, in recent years, computerization and resulting automation have found a useful place in nearly all endeavors, including agriculture and turfgrass management.

There seems to be nearly no limit to what the computer can do in the improvement of turf quality. But, there have to be limits because computers can only do what we program them or tell them to do.

Increasing research effort is needed in order to expand what we already know into an information system that can help solve problems not yet thought of. And, we need to be aware that these problems do exist, although not fully identified to date. Our only fear is that, in an effort toward higher and higher technology, the little grass plant might suffer by making maintenance operations less labor intensive. After all, from golf turf to home lawns, a hands-on approach yields highest quality. At least for now, our hands provide the best in tender loving care.

Genetic Improvement

Genetic turfgrass improvement can result in higher quality with lower maintenance inputs. We need to further explore and utilize the grass genetic pool for the benefit of humankind.

In all areas of science, biochemical research is reaping big rewards. The more we understand the chemistry of biological systems, the better we can control adverse reactions or even prevent breakdowns that otherwise might be fatal. With turf, high quality is realized as long as growth conditions are favorable for the grass, or at least more favorable for it than for associated plants in the sward. But at times, when stress is placed on the plant, such as temperature and soil moisture extremes, turf quality can deteriorate rapidly. We know that these environmental stress conditions can present themselves unannounced throughout most of the year. At these times, we are faced with the greatest challenges as turf managers. In order to be prepared for these unexpected occurences, we must have a better understanding of turfgrass biochemistry. Insights gained to date would seem to have only scratched the surface in terms of what there is we should know.

Microbiological Research

Soil biology studies are needed to better understand the microbiology of soil systems active in the rootzone of densely populated grass stands.

Among the earliest agricultural research projects, well over 100 years ago, were studies on the value or organic matter (manures) in crop production. And yet today, we still have not learned all the secrets related to soil organic matter and its decomposition to form humic acids and humus by soil macro- and microorganisms.

Microorganisms have a short life span, perhaps only a few minutes before they reproduce and die. In good, biologically active soil, there can be as many as 45,000,000,000,000,000 (quadrillion) microorganisms in the rootzone of 1,000 square feet of turf. In fact, the most productive agricultural soils worldwide are those that formed under the influence of prairie vegetation, where resulting levels or organic matter are near seven percent. Thus, we have a good understanding of the value of organic matter as a soil conditioner in the seedbed, but little appreciation of the value of humus and related bioactivators in the hardiness and persistence of turf over time. For microbiologists looking for research challenges into the 21st Century, studies of microbiological activity in close association with turfgrass root systems as they grow, die off, and regrow, would be of significant interest and value.

Ecological Research

Plant ecological studies are necessary to build on our current understanding of the nature of competition within living systems. Ecological principles govern relationships between all living organisms, including all the surrounding biosphere and us. Therefore, ecological research of any kind is considered to be highly important.

Turfgrass ecology fits right in because the grass covered soil system on lawns, parks, roadsides, and golf courses is a major entity for the percolation of water to underground reservoirs. As water moves down through the soil profile, impurities and contamination are filtered out and biodegraded. In addition, grass roots stabilize the soil to help reduce wind and water erosion, thus helping to keep streams, ponds, lakes and rivers cleaner than they would otherwise be. Further, from the stand-point of environmental education, our closest contact with the existence of natural ecological principles is right there in the lawn and under foot. In a real sense, all lawn or turf care really amounts to is the shifting of ecological forces so as to favor the little grass plant at any given time. When we do this, the turf benefits and so does the entire surrounding community. Thus, we dare not slacken our future turf research effort in this important area.

Knowledge Gained From Basic, Applied, and Synthesis Research

Throughout the past 100 years of turfgrass research, three major types of emphasis have been realized. These include applied, basic, and synthesis research. Each has value and only in the aggregate can we gain all the knowledge that scientific research can provide. I would suggest that scientists should continue to work in each of the following areas.

Applied - Applied research yields the most direct answers to most practical lawn and turf problems. Experimentation is designed for that purpose. Often the researcher has a hunch, based on previous knowledge and experience, that a certain approach will yield accurate information leading to a correct interpretation and resolution of the existing problem. Less often does the researcher shoot in the dark as a totally unbiased investigator. Usually basic research is less expensive to conduct and often grant-in-aid funding is available from concerns that might have a vested interest in the results. And applied research is ideally suited for cooperative effort between the turf scientist and turf manager-practitioner. Results of applied research are usually subjected to an analysis of variance so that real differences between products and/or treatment rates can be identified. Such procedures require that different entries or treatments be replicated.

Basic - Basic research is conducted without concern for the practicality of results obtained. This doesn't mean that practical applications cannot be made, but only that information for information's sake is sufficiently important to justify the time and expense involved in the study. Often one basic investigation leads to another and another over a period of time and thus establishes the scientist as an expert in his particular field. The more complex the physiology or chemistry of the process under investigation, the more such studies lend themselves to a team approach.

Basic research often involves use of advanced technology, such that apparatus and standardization of methodology are not only expensive but also time consuming to master. From time to time, large competitive grants-in-aid are available for scientists with well-established reputations. In the final analysis, basic research is necessary to keep turfgrass science at the forefront with other leaders in the fields of agronomy and horticulture.

Synthesis - Research synthesis is featured in some fields of investigation where there are serious limitations on the generation of new data. In these instances, the experimentation and conclusions of a number of researchers are reviewed and new or varying conclusions are drawn by another investigator. These reports feed on one another and tend to polarize conclusions toward pro or con perspectives.

Significant benefits can be derived from these types of studies. The author, in an editorial capacity with The Lawn Institute from 1982 to 1992, regularly presented a "Threshing the Journals" feature in TLI's quarterly newsletter *Harvests*. From time to time, several reports with varying results would be reviewed in an attempt to relate environmental differences and/or research methodology in terms of explaining deviance of results among the reports. Such analysis should be helpful in understanding why a specific turfgrass rates higher in one location than in another. Or, why fungicides, insecticides, or herbicides yield varying levels of control in nationwide tests conducted at different locations around the country.

This library or office type research is relatively inexpensive to conduct and yet information gained can be of considerable value. In effect, we need not be finished with research data filed away in publications and forgotten. Reprocessing and evaluation can lead to important new conclusions.

Benefits From Research Findings

In the final analysis, we must answer the question, "What are the benefits obtained from research findings?" Without benefits that are clearly identified and understood, we miss the mark in what we do. And, who among us benefits? How about the green or turf industry, or grounds managers, or environmentalists, or educators, or politicians, or all of the above including the general public?

Industry Benefits - Turf research benefits the Green Industry either directly or indirectly. Direct benefits result from new product development through increased sales or through more effective product use resulting in increased consumer satisfaction. In either instance, product acceptance is enhanced and public appreciation of the turf commodity is increased.

This latter benefit (increased public acceptance) must not be underemphasized as it has been in the past. For in a real sense, Green Industry products and services do not compete with each other for consumer dollars nearly as much as one might think. Consumer expenditures within the Green Industry compete more with non-Green Industry products and services. Funds devoted to improvements inside the house are not available for lawns and gardens. As we address research at the close of the 20th century, turf does not receive its fair share of consumer dollars.

Grounds Managers - Turf research benefits grounds managers from professionals to the weekend home gardener. New information generated through continuing research properly interpreted and in the hands of interested practitioners, brings about improved turf quality that results in increased satisfaction on the part of all whom enjoy out-of-doors sports, lawns, and gardens. These benefits are appreciated not only by athletes who play more safely on live turf, but also by spectators, tourists and local residents.

Educational Benefits - Turf research benefits those who teach and learn from courses in the plant sciences, including horticulture and agronomy. Education in the biological sciences not only presents various plant responses, but also provides detailed explanations for such responses. These types of information are only available and kept up to date through continuing research. Many teachers also conduct research projects with their students who have direct classroom benefits.

Environmental Benefits - Environmental concerns are the direct beneficiary of all turf research, so much so that specialization in the field of ornamental horticulture is now known as environmental horticulture. Landscape plants, including turf, offer both physical and psychological benefits. Physical improvements in the soil associated with grass roots result in improved infiltration and purification of rainwater. Also, less soil erosion is associated with sod ground covers. In addition, landscape beauty offers pychological benefits for those exposed to gardens and gardening. A relatively new field of specialization is horticultural therapy, created to help those suffering from both physical and mental disabilities. These and other environmental benefits should rank high on our list of reasons for maintaining an active turf research posture.

Political Correctness - Turf research benefits should be focused on the political correctness of current governmental practices. For example, the pesticide issue in recent years has been distorted by groups of activists interested in advancing their cause, irrespective of facts backed by research. Toxicology clearly indicates that it's "the dose that makes the poison."

But, political correctness often holds to zero tolerance. With increasing sensitivity of analytical chemical methodology, some determinations can now be made within the parts per quadrillion (PPQ) ranges. At this level, the probability of biological significance is extremely low. Despite this recognition, public perceptions inflamed by activist rhetoric lead to stances of political correctness. Adding more fuel to this already dangerous fire is a certain amount of "junk research" (poorly conceived, utilizing inferior methodology and biased interpretation of results) that lacks scientific credibility from start to finish. Good, sound turf research will continue to be of benefit in influencing many diverse elements of political correctness.

Public Benefits - Finally, the public stands to benefit in all of this. Insofar as research results report the truth and this information is used throughout the Green Industry and made a part of practicing grounds management, environmental affairs, education, and the political process, the public will benefit, regardless of specific interest in lawns and sport turf.

Research Funding

Now, we're down to the bottom line, funding. Research is expensive to conduct and dissemination of information to all who can use new approaches and technology is also time consuming. Who pays the bill? Fifty years ago, funds were very limited. Then, increasing support came from agricultural experiment stations. This funding has now leveled off and in many locations has started to decrease. The United States Department of Agriculture has suffered major cuts in its research budget. The once extensive turf research effort has been reduced to a program of national variety trials based at Beltsville, MD.

Many feel that turf research, now and into the future, is in deep trouble. Grant-in-aid money has always been available from industry sources. It is adequate for result-demonstration type investigations, but inadequate for much in the way of basic research. Royalties from the release of new turf cultivars have been a significant help to those experiment stations involved in breeding and genetics.

Science foundations sponsor competitive bidding for grants-in-aid. Where these were once available primarily to agricultural experiment stations, where a land grant philosophy influenced research objectives, the tendency now is to open the competition to private colleges and universities, where politically-correct, hidden agendas often influence the research conducted and the usefulness of the results. At times, third party research confuses issues to the point where we cannot be certain what studies are underway.

Government seems to feel that sufficient "seed" money has been invested in turf research during the past 50 years to enable this specialized area of agriculture to now stand on its own. They look at the sports turf and lawn care related industry as sufficiently mature to recognize the importance of turf research and to arrange for adequate funding. Within an industry as diverse as this, there is reasonable doubt that the level of funding required can be generated from industry alone.

More likely is a joint effort among various firms and associations to make research funds available through state and regional turfgrass conferences and show. Certainly associations, such as the Professional Lawn Care Association of America (PLCAA) and the Golf Course Superintendents Association of America (GCSAA), will remain active at the national level. Each of these groups will maintain committees to identify research needs and to allocate funding, as appropriate. A major effort to coordinate research activity nationally will be needed in some form. This is just another challenge for turf researchers in the years ahead.

With the growth of the industry currently and the increasing importance of the turfgrass commodity, turfgrass research needs will continue into the 21st Century. To realize an adequate effort to meet consumer and general public needs, the backing of a mature, public oriented Green Industry will be required. To this end, all of us involved must put our shoulders to the wheel.

Eliot C. Roberts was formerly executive director of The Lawn Institute. He served as chairman of the Department of Ornamental Horticulture at the Univeristy of Florida and the Plant and Soil Science Department at the University of Rhode Island, and turfgrass scientist at the Iowa State University and the University of Massachusetts. He now is a consultant with Rosehall Associates, 2080 Red Road, Sparta, TN 38583, (931) 277-3374.

BOOK REVIEW

Redesigning the American Lawn: A Search for Environmental Harmony

by F. Herbert Bormann, Diana Balmori and Gordon T. Geballe
Yale University Press, New Haven, CT

Review by Richard J. Hull,
University of Rhode Island

Redesigning the American Lawn is not a new book, having been published in 1993. However, it has become widely read and generally accepted by many concerned with environmental and conservation issues as an honest assessment of the environmental impacts of lawns and their management. Because the authors are respected educators and practitioners, and the book is published by one of our more prestigious universities, it tends to receive more attention than it might otherwise deserve. As professional turf managers, you could be confronted by references to this book, so you might want to read it or at least know that it exists.

I was unaware of *Redesigning the American Lawn* until a TGT reader asked my opinion of it. He had read a favorable review of it in the *New York Times* but found it to disagree with some statements I had made in an article on nitrate leaching from turf. I was embarrassed to admit that I had not seen the book but was eager to read it with this apparent disagreement in mind.

Redesigning the American Lawn began in a seminar course on "The American Lawn," organized by the authors at the Yale School of Forestry and Environmental Studies and the School of Art and Architecture. Twelve graduate students in the course wrote the five chapters which became this book. In the Prologue, the basic premise of the book is set forth: " It is the purpose of this book to explore the numerous connections between the lawn and the earth's biosphere, to point out the many ways that we as lawn owners through our lawn management practices diminish in small but collectively significant ways local, regional, and global environments, and finally to suggest ways by which we can enjoy the many virtues of the lawn while reducing our impact on nature." Right away the reader realizes that this probably will not be a glowing endorsement of lawns or their care.

The book starts innocently enough with a brief history of the origins of lawns in Europe and their greater development and acceptance in the United States. The second chapter traces the growth of environmental concerns and makes a somewhat tenuous connection between general environmental deterioration and contemporary lawn management. Several examples of lawn-free residential landscapes are discussed with a clear message given that these are environmentally superior in many ways to more conventional landscapes featuring a prominent lawn.

In Chapter 3, the concept of a "freedom lawn" as opposed to the conventional "industrial lawn" is developed. A freedom lawn is an open area which is mowed periodically but not fertilized or irrigated in which any plant that can tolerate mowing is permitted to grow. No pesticides are used so the plant population becomes quite varied and includes turfgrasses, wild plants and various invasive weeds. The remainder of the book draws comparisons between this freedom lawn, which the authors conclude is much more environmentally legitimate, and the industrial lawn desired by many homeowners and advocated by landscapers, garden centers, lawn care companies and most of the commercial sector trying to sell goods and services. To this point, I have no particular quarrel with the authors' contentions, being more than willing to grant freedom of choice and seeing no particular virtue in landscape uniformity.

However, beginning with Chapter 4 titled "Environmental Costs," the authors attempt to validate their case by citing the technical literature. The book is extensively referenced and, unlike many semipopular works, some primary scientific literature is cited. This tends to give the reader confidence in the arguments being put forth. Unfortunately, in this case the reader would be deceived. Numerous examples of incomplete or misleading references can be cited but, in the interest of brevity, I will discuss only a couple.

In their discussion of "water pollution" the authors cite a Long Island study which implied that fertilizers used on residential lawns and gardens were a major source of nitrate present in well water. This research was conducted mostly during the 1970s and was among the first to implicate lawn fertilizers as contributing to ground water pollution. The citation that 60% of nitrogen applied to lawns and gardens ends up in ground water is clearly not consistent with current thinking. The Long Island researchers showed only that nitrate in ground water was of human origin. They could not identify its source as being from septic systems, agricultural uses or residential grounds. Because the magnitude of nitrate release from septic systems had not yet been quantified and the substantial nitrate losses from disturbed agricultural sites was underestimated, these investigators assumed that home lawns were a major source of the nitrate present in domestic wells. They assumed that the only real loss of nitrogen from lawns was through clipping removal. If clippings were retained on a lawn, all the nitrogen applied as fertilizer had to go someplace and leaching to ground water appeared likely.

Since then, numerous research reports have been published and they all conclude that lawns leach very little nitrate to ground water. Elevated nitrate levels present in well water invariably are derived from other sources. Lawns probably contribute no more than 5% to ground water nitrate which is much less than the 60% cited in this chapter. The authors compared nitrate losses from home lawns to those of native forests but failed to mention that one of the references they cite concluded that home lawns were second only to forests in contributing minimum nitrate to ground water. Several agricultural land uses and domestic septic systems all leached more nitrate than a normally maintained home lawn.

The authors later concede many of these points but then go on to say, ". . . . lawn fertilization may account for a relatively minor part of a ground water pollution problem. On the other hand, by reducing or eliminating the use of lawn fertilizer, the homeowner can minimize the lawn's contribution to nitrate pollution as well as save money." In other words, rather than confront the real causes of ground water pollution, stop fertilizing your lawn and make believe you are being environmentally responsible.

In that same section, the authors go on to describe the interconnectedness of water bodies and the high nitrate loads being carried by many of our largest rivers but they never show a connection between this and lawn fertilization. What these authors do not mention is the extensive use of grassed buffer zones and filter strips designed to capture nutrients present in runoff water before they enter streams or ponds. Grasses are generally acknowledged to be most effective in scavenging nutrients from soil or water. This is not consistent with grass lawns contributing to ground water pollution.

Further on, a case is made for lawns contributing to pesticide pollution of ground and surface waters. The common turf herbicide, 2,4-D, is cited as being considered by EPA to be a "priority leacher" that travels quickly to ground water. This is strange because 2,4-D is ranked by the Natural Resources Conservation Service as having a "medium" leaching potential and is rarely found in well water samples. Recent research also shows that the thatch layer present in turf strongly binds many pesticides and reduces their capacity to leach.

The authors go on to state that, "A component of 'agent orange', a defoliant used in the Vietnam war, 2,4-D has been linked to cancer and birth defects." This unreferenced statement is just plain wrong. Few pesticides have been studied as extensively as 2,4-D and after many years of review by federal and private agencies no evidence of it causing cancer or birth defects has been substantiated. The great preponderance of evidence indicates that 2,4-D poses less risk to human health than almost any commercial pesticide marketed in the US. True, 2,4-D was one of three or four components of infamous 'agent orange' but it was never shown to be the cause of problems associated with its use. A dioxin contaminant of another herbicide component, 2,4,5-T, ostensibly was the cause of most health problems experienced by the native Vietnam populations and US soldiers. Linking 2,4-D with cancer and birth defects is clearly not supported by any reputable literature and one wonders why the authors make the statement at all.

This latter point is what bothers me most about *Redesigning the American Lawn*. The book appears to be well researched and is written by respected academicians and yet it contains many statements which are not supported by the preponderance of published literature or even by the primary literature they cite. It almost appears that the authors knew the arguments they wanted to make and gleaned from the literature statements which appeared to support their position. Little matter that statements were taken from old, largely discredited studies or that most recent research was largely ignored. Any graduate student who destroyed most of his data and saved only that which supported his hypothesis would be thrown out on his ear by any reputable university. One might ask why such selective reporting of the scientific literature is acceptable when writing for the general public. I also question how well students are being introduced to the scientific method when such selective interpretation of scientific data is practiced.

Unfortunately this apparently biased reporting of the scientific literature is characteristic of much popular environmental writing. Bringing valid environmental issues to the public's attention is not well served by this practice. It may even contribute to a growing cynical view that most environmental problems are grossly overstated and serve only special interests. This is clearly not what the authors of such pieces intend but it is the inevitable consequence of departing from scientific objectivity. I am sorry to say that, its several virtues not withstanding, *Redesigning the American Lawn* is a less than objective analysis of the environmental impacts of lawns and their management.

USGA Green Section Research

Mobility and Persistance of Turfgrass Pesticides in a USGA Green

Authors: Drs. George H. Snyder, John L. Cisar of the University of Florida, IFAS.

The use of reduced irrigation for one week following fenamiphos application was studied as a means of reducing fenamiphos and its metabolites leaching from a USGA green in south Florida. Leaching was reduced during the period of limited irrigation, but total leaching was equivalent for low and high irrigation treatments over a longer period that included plentiful irrigation and rainfall. It appeared that the fenamiphos and its metabolites that were not leached when irrigation was restricted eventually leached when excessive irrigation and rainfall occurred.

The percolate collection system in the USGA green at the Ft. Lauderdale Research and Education Center was expanded to include 12 lysimeters. This will permit greater numbers of replications in studies involving two or more treatments, which is very important for pesticide studies.

During excavation, it was noted that seven cm of topdressing had accumulated on the green since the lysimeters were first installed. This layer appeared to hold more water than the underlying media. It contained somewhat higher percentages of the finer sand sizes. It also had considerably more organic matter than either the original rooting mix or than the topdressing material. No movement of rootzone mix into the coarse sand layer, or of coarse sand into the underlying gravel, was observed during excavation for the newly added lysimeters.

Volatilization of the organophosphate pesticides isazofos, chlorpyrifos, and fenamiphos was measured in two studies. Volatilization was greatest for chlorpyrifos and least for fenamiphos. It was less for an application that was followed by rainfall than for one followed by dry weather. Isazofos volatilization amounted to 1 and 9 percent of that applied for the two rainfall situations, respectively.

Evaluation of Management Factors Affecting Volatile Loss and Dislodgeable Foliar Residues.

Author: Dr. John M. Clark, University of Massachusetts.

Volatilization can be a major route of pesticide loss following application to turfgrass. Consequently, a significant portion of applied pesticide might be available for human exposure via volatile and dislodgeable residues. In previous USGA-funded research carried out by this laboratory, volatile and dislodgeable residues were determined following application of triadimefon, MCPP, trichlorfon, and isazofos to an established plot of Penncross creeping bentgrass. For each application, a ten-meter radius plot was sprayed and the Theoretical Profile Shape (TPS) method was used to estimate volatile flux. Dislodgeable residues were concurrently determined by wiping treated turfgrass with a water dampened piece of cheesecloth.

Less than eight percent of the total applied triadimefon was measured as volatile residues with nearly all volatilization loss occurring within five to seven days of application. Diurnal patterns of triadimefon volatilization were evident with volatilization greater at mid-day than morning and late afternoon.

Less than one percent of the total applied MCPP was measured as volatilie residue. Volatile MCPP residues decreased over time to non-detectable levels by Day 5. Both triadimefon and MCPP dislodgeable residues were greatest on Day 1 following application and dissipated over time. By Day 5, triadimefon dislodgeable residues decreased to 0.04 percent of the initial residue level immediately following application and MCPP dislodgeable residues were non-detectable.

For trichlorfon and isazafos applications, less than 12 percent of applied insecticide was lost as measured volatile residues during the experimental sampling periods. Volatile loss declined in a diphasic pattern with most loss occurring within five to seven days of application. Irrigation greatly reduced initial volatile and dislodgeable residues. Subsequent volatile and dislodgeable residues, however, decreased substantially on Days 2 and 3 compared with residue levels in the absence of irrigation.

Trichlorfon dislodgeable residues never exceeded one percent of applied compound in the absence of irrigation. In contrast, with irrigation dislodgeable residues of trichlorfon and isazofos were never greater than 0.5 percent of applied compound. Irrigation increased the transformation of trichlorfon to DDVP, a more toxic insecticide.

Inhalation and dermal exposures were estimated using measured air concentrations and dislodgeable residues, respectively. Hazard quotients (HQs) were calculated for both volatile and dislodgeable residues of each pesticide. An HQ less than one indicated that the residue level is below a concentration that might reasonably be expected to cause adverse effects in humans.

Triadimefon and MCPP volatile and dislodgeable residues resulted in HQs below 1.0 throughout the entire 15-day experimental period, indicating that exposures were below any level expected to cause adverse health effects.

We have determined the critical US EPA Office of Pesticide Programs Reference Dose above which no turfgrass pesticide will result in dermal HQ greater than 1.0 to be between 0.005 to 0.013.

We have collected appropriate weather data with this residue set. With the help of Dr. D. Heath at Cornell University, we are modeling this data into a temperature-dependent algorithm that will determine the critical surface temperature below which no volatile turfgrass pesticide will result in an inhalation HQ greater than 1.0.

In summary, we have shown that organophosphate insecticides that possess high toxicity and volatility can result in exposure situations that cannot be deemed completely safe as judged by the US EPA Hazard Quotient determination.

In order to more accurately predict the health implications of pesticide exposure to golfers, a relevant study measuring exposure during play needs to be carried out. With more accurate exposure estimates, it is our belief that the true exposure to pesticides on a golf course will be found to be less than those reported in our research.

Evaluation of Best Management Practices To Protect Surface Water From Pesticides and Fertilizer Applied to Bermudagrass Fairways.

By Dr. James H. Baird, Oklahoma State University

In 1995, research was conducted to evaluate the influence of buffer strips on pesticide and nutrient runoff from bermudagrass turf. In 1996, two experiments were conducted to further examine the effects of buffer-strip mowing height and length on pesticide and nutrient runoff from bermudagrass turf on a six percent slope. Buffer strips were mowed at three heights, 0.5, 1.5, and 3.0 inches.

In the length experiment, the area receiving pesticides and fertilizer was upslope from the buffer and was mowed at 0.5 inch. Urea, sulfur-coated urea, triple superphosphate, chlorpyrifos, 2,4-D, mecoprop and dicamba were applied at recommended rates to each experiment. A portable rainfall simulator was used to apply a precipitation rate of 2.5 inches per hour for 75 minutes within 24 hours after chemical application.

In the mowing height experiment, the three-inch buffer was most effective in delaying start of runoff and decreasing total runoff volume. Pesticide and nutrient losses to surface runoff volume were as great as 11 percent and ten percent, respectively, from the 1.5 inch buffer strips. Overall, there appeared to be no advantage in mowing the buffer strip at either 0.5 or 1.5 inches in terms of reducing pesticide and nutrient runoff. The positive effect of the three-inch buffer would most likely be overcome by higher soil moisture and runoff conditions during periods of rainfall.

Pesticide and nutrient loss to surface runoff was less than seven percent in the buffer-strip length experiment. The differences in surface runoff losses between the two experiments were most likely due to differences in soil moisture at specific locations. Overall, data from this experiment reaffirmed that buffer strips are effective in reducing pesticides and nutrient runoff. In addition, these data might be very useful for extrapolating effective buffer strip lengths for testing on larger watersheds.

A reduction in nitrogen found in surface runoff occurred for SCU applied in the buffer strip mowing height study. However, these results might have been caused by differences in soil moisture between testing locations.

Results of the experiments confirm that use of buffer strip, application of pesticides and fertilizers with lower water solubilities, and avoidance of pesticide and nutrient application when the soil is saturated, all help to reduce chemical loss in surface runoff from turf.

Cultural Control, Risk Assessment, And Environmentally Responsible Management of White Grubs And Cutworms

By Dr. Daniel Potter, University of Kentucky

Research on the biology of black cutworms revealed ways that this pest can be more effectively managed. Nearly all of the eggs laid on creeping bentgrass putting greens are glued to the tips of grass blades, where they are removed by daily mowing and disposal of clippings. Most eggs can survive passage through the mower blades and will later hatch. We advise golf course superintendents to dispose of clippings well away from greens and tees.

Cutworm moths also lay eggs on higher-mowed turf in fairways and roughs. But, most eggs are laid lower down on grass plants where they would not be removed by mowing. Thus, reservoir populations can develop in high grass surrounding greens and tees.

Cutworms are most active on putting greens between midnight and one hour before sunrise. Pesticide treatments are best applied toward evening. Contrary to expectation, cutworms were not attracted to aerified bentgrass. Sand topdressing seems to partially deter cutworms.

Mowing an hour before dawn might provide substantial control by shredding. Since cutworms can crawl as far as 70 feet in a single night, we suggest a 30-foot buffer zone be treated around putting greens.

Perennial ryegrass and tall fescue (without endophyte) were found to be as suitable for cutworms as creeping bentgrass, but Kentucky bluegrass was highly unsuitable as food. The use of Kentucky bluegrass around greens and tees, coupled with daily mowing and clipping removal can improve control.

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