The

NATIONAL TURFGRASS RESEARCH INITIATIVE

Enhancing America's Beauty
Protecting America's Natural Resources
Ensuring the Health and Safety of all Americans

April, 2003

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THE NATIONAL TURFGRASS RESEARCH INITIATIVE

Turfgrasses impact Americans in many ways on a daily basis. Millions of acres of turfgrass on home lawns, commercial landscapes, roadsides, parks, athletic fields, golf courses and sod farms improve our quality of life by providing open space, recreational and business opportunities, enhanced property values, and the conservation of important natural resources. With its above-ground network of leaves, shoots, and stems and an extensive fibrous root system below, turfgrass removes dust and dirt from the air, reduces soil erosion, filters water, and produces a safe playing surface for children, adults, and athletes. In addition, scientific research has shown that hospital patients recover faster when beautiful landscapes are in view. Therefore, turfgrass not only enhances the value and beauty of our lives but also contributes to improvements in our physical and mental health.

Rapidly expanding urbanization profoundly affects the economic and environmental future of turf use and management. The U.S. turfgrass industry is already a $40 billion annual business that provides hundreds of thousands of jobs and promises even more in the future. The rapidly expanding uses of turf can create challenges as our urban areas try to do more with finite natural resources. There are growing concerns about levels of use of water, fertilizer, pesticides, fossil fuels and machinery on turf establishment and maintenance. In some locations, these turf inputs are being severely restricted, if not eliminated. For instance, severe drought conditions in many regions have resulted in government-imposed water restrictions or the use of lower-quality effluent water sources. Also, in some communities where concern about exposure to chemicals has reached heightened proportions, pesticide use on turf is now banned.

At the same time inputs for turf establishment and maintenance are becoming less available, a growing, more prosperous population is demanding increasingly more from our current turfgrass-based recreational facilities. In addition, our nation's awareness of safety is at an all-time high. Turfgrass provides multiple benefits to society including child safety on athletic fields, protection of groundwater, reduction of silt and other contaminants in runoff, green space in home lawns, parks, golf courses, etc. New facilities will have to be constructed with many located on abandoned sites such as landfills, industrial brownfields, gravel pits, or mine spoils. Turf in these areas will play an important role in both reclamation and recreation.

Balancing multiple economic, aesthetic and environmental goals for turf requires new technologies and management strategies. Conducting the research to discover and integrate the knowledge, plant varieties, and technologies needed to provide these new technologies and strategies will require a sustained and cooperative effort among federal,

state, and private sectors. The USDA's Agricultural Research Service (ARS) can contribute uniquely and significantly to turf research through its national network of multi-disciplinary laboratories and a commitment to long-term research to achieve economic and environmental sustainability. To identify how they can best serve the turfgrass industry, ARS scientists met with turf providers, managers, and users at a workshop in Dallas, Texas, January 22-25, 2002. The research priorities described in this document were identified at the workshop.

The USDA has a unique opportunity to significantly increase the benefits of turf use by developing and promoting turf management systems that require less pesticide, water and other inputs as well as other efforts to improve integrated pest management programs, recycling, etc., the USDA has a unique opportunity to significantly benefit the turfgrass industry. While the vast majority of the USDA's funds have been and will continue to be directed toward traditional "food and fiber" segments of U.S. agriculture, it is important to note that turfgrasses (e.g., sod production) are defined as agriculture in the Farm Bill and by many other departments and agencies. *It should also be noted that the turfgrass industry is one of the fastest growing segments of U.S. agriculture, while it receives essentially no federal support*. The turfgrass industry is important to nearly every local economy in every region of the United States. Turfgrasses are produced, marketed and maintained in every Congressional district of the U.S.

The National Turfgrass Research Initiative proposes a coordinated research program targeting this industry, to be funded through USDA-ARS and conducted through a coalition including the USDA, the university research community, and the turfgrass industry. This proposal discusses the industry, the crucial need for this research initiative, and specifically identifies priority research goals and key programs.

The National Turfgrass Research Initiative has been developed with much discussion among industry, academic, and government researchers, and fine-tuned through the recent efforts of a joint working group of industry leaders. The Initiative is the exciting result of a new alliance, proposing a new level of cooperation among industry, academia and the Federal government, for research in an area that, up until now, has not been federally supported.

Federal attention to the issues and research goals identified in this Initiative is critical to the continued success of the turfgrass industry.

WHY SHOULD THE FEDERAL GOVERNMENT INVEST IN TURFGRASS RESEARCH?

✓ Turfgrass covers 50 million acres in the U.S., with an estimated value of $40 billion annually.

✓ Turfgrass is enjoyed by millions of homeowners with lawns, millions of athletes, young and old, that use athletic facilities, 26 million golfers and the many people that use parks and other recreational facilities on a daily basis.

✓ Turfgrass provides many environmental and societal benefits including reducing soil erosion, filtering water, trapping dust and pollutants, reducing heat build-up in urban areas, and safer playing surfaces for athletes.

✓ Turfgrass provides economic opportunities for the millions of people it employs at lawn care companies, athletic and park facilities, golf courses, highway departments, sod and seed producers, as well as support industries such as equipment manufacturers and fertilizer suppliers.

✓ There are many challenges facing the turfgrass industry in the 21st century:

- Water use restrictions and/or mandated use of recycled water on turf
- Pesticide use restrictions or bans on pesticide use in some areas
- Fertilizer use restrictions and/or bans on fertilizer use in some areas
- Safety concerns due to intense demand and subsequent abuse of turf on athletic fields, parks and other recreational facilities
- Limited diversity of germplasm presently available and being utilized

✓ Privately-funded foundations currently support more than $10 million in turfgrass research annually. However, almost no federal dollars are devoted to directly support turfgrass research.

✓ Long-term, basic research is much needed in the turfgrass industry. However, private foundations and universities do not have the time nor the resources to conduct risky, long-term studies. The industry looks to the Federal Government to fund this type of research, the building blocks to which industry and universities utilize to further their more applied, limited-term research programs.

GOALS OF THE TURFGRASS RESEARCH INITIATIVE

- Aid urban, suburban and rural communities across the United States by developing improved management systems and technologies that conserve and protect valuable natural resources, including water, soil, the atmosphere, and fish and wildlife habitat.

- Maintain biodiversity through germplasm collection, enhancement and preservation, so that useful traits may be transferred to future generations.

- Protect the environment, including human health and safety, through research leading to the reduced use of pesticides and fertilizers and to reduce leaching, runoff and exposure.

- Enhance environmental restoration and protection efforts on agricultural lands, landfills and industrial sites, in urban, suburban and rural communities through research to improve the ability of grasses to prevent and mitigate environmental pollution.

- Document economic impacts of the turfgrass industry on local and regional economies that are becoming increasingly urbanized.

- Enhance quality of life of Americans through increased participant safety and beautification of recreational facilities, school grounds, lawns, roadsides and common areas.

- Increase international competitiveness through research leading to improved products and production strategies.

INTRODUCTION

The turfgrass industry consists of many diverse groups including millions of homeowners, athletic field managers, lawn care operators, golf course superintendents, architects, developers and owners, landscape designers and contractors, seed and sod producers, parks and grounds superintendents, roadside and vegetation managers and cemetery managers. Turfgrass beautifies tens of millions of home lawns, provides safe playing surfaces on over 700,000 athletic fields, outdoor recreation for nearly 26 million golfers on over 17,000 golf courses and economic opportunities for tens of thousands of seed and sod producers, lawn care operators and landscapers. In addition, turfgrasses provide safety and dust control along millions of miles of highways and thousands of airport runways. Turfgrasses beautify our parks and landscapes. They are part of a larger "green industry" that improves the physical and mental health of Americans, particularly in crowded urban and suburban areas. Finally, turfgrasses provide environmental protection and enhancement by purifying and protecting our water, soil and air wherever they are grown. Turfgrasses truly touch each and every American in some way every day!!

Following are some facts about turfgrass:

Cooling: Average-size front lawns of eight homes have the cooling effect of about 70 tons of air conditioning.

Air-cleansing: A 2500 square foot lawn absorbs carbon dioxide and releases enough oxygen for a family of four.

Soil & Water Protection: A healthy lawn absorbs rainfall and reduces runoff up to 80 times more efficiently than impervious surfaces, such as driveways, sidewalks and parking lots.

Safety: To reduce injuries, over 90% of National Football League players prefer natural turf to artificial turf. The safety benefits of well-managed turf extend to all levels of athletic activity, particularly primary and secondary schools that often lack the supervision and equipment found in professional and college sports.

Economic: Studies also have shown that aesthetically-pleasing landscapes, including turfgrass, contribute up to 15% to home property values.

As the turfgrass industry grows, there are significant issues that must be addressed to ensure the benefits of turf are available to all our citizens. Some of these issues are:

- *Water use* - drought conditions in many areas of the U.S. have resulted in watering bans on lawns, landscapes, golf courses, etc. or restrictions on planting turfgrass by local jurisdictions.

- *Pesticide use* - concerns over the impact of pesticides on human health have resulted in pesticide bans in some local communities.

- *Fertilizer use* - nitrate and phosphorous pollution of waterways and groundwater supplies have prompted some states and jurisdictions to require reduced fertilization of turfgrass.

- *Safety concerns* - overuse of athletic fields have resulted in unsafe conditions prompting liability lawsuits in some areas.

- *Biodiversity* - providing acceptable habitat for fish and wildlife while systematically preserving grass germplasm for future generations.

The turfgrass industry desires to be part of the "solution" rather than the "problem". However, we want to address these issues with science-based information and with improvements in turfgrass development and management. Since these issues are national in scope and importance, the turfgrass industry feels that ARS is the appropriate agency to conduct the research needed. Therefore, many national associations including the National Turfgrass Evaluation Program (NTEP), United States Golf Association (USGA), Golf Course Superintendents Association of America (GCSAA), Professional Lawn Care Association of America (PLCAA), Turfgrass Producers International (TPI), Oregon Seed Council (OSC), Sports Turf Managers Association (STMA), the Irrigation Association (IA) and others have come together to put forward this Initiative. This Initiative has been developed, discussed and approved by these groups in conjunction with the USDA-ARS.

Size and Scope of the Industry

There are approximately 50 million acres of managed turf in the U.S. This places turfgrass third in total acreage nationwide. In many states such as Maryland, Pennsylvania, Florida, New Jersey, and North Carolina; turf is the number one or two agricultural commodity. In addition, it is estimated by the Economic Research Service that the turfgrass industry, in all its forms, is a $40 billion industry. Yet almost no federal dollars (less than 0.0005 percent of USDA plant and animal research) are devoted directly to this industry's research needs.

Industry Research

The turfgrass industry has been quite active in providing grant-in-aid and competitive grant funds, mainly through its own privately funded research foundations. Industry-funded grants for research to benefit the industry total more than $10 million each year. The industry has a long history of commitment to supporting its own research needs, and is prepared to continue to do so. However, these funds are unable to meet the industry's research needs and often only address local or state problems. Therefore, the Federal government needs to play a leadership role in research which cannot be undertaken by the private sector or individual states.

The Federal government has a well established and important role in funding agricultural research. Industry-supported research tends toward applied programs of limited term. Federal support can provide greater depth, increased duration, and better long-term coordination of

research efforts. It is important to note that this proposal envisions using federal funds to expand research efforts rather than replace or duplicate privately funded efforts that will be on-going. A basic premise of this proposal is that Federal research dollars should be directed toward programs which cannot be funded adequately by the states or industry, particularly for programs where the Federal government can play a coordinating role not possible for any other entity. Some research programs, for example, increased understanding of basic biological processes, are too risky or long-term for private industry to fund. Other research programs might be particularly appropriate for government support because they clearly benefit society at large, as with much environmental research. With many programs, the Federal government can play a coordinating role which is not possible for any other entity but which is essential to ensure cooperation and maximum efficiency. Federally-funded research programs also increase the credibility of results beyond what might be afforded privately-funded programs. Finally, the industry looks to government to fund the long-term basic research, the building blocks to which the industry applies in its own, more limited-term research programs.

Increased Federal research funding for the turfgrass industry will return benefits not only to the industry itself but also to the environment, homeowners, athletes - young and old and those who appreciate the beauty of our world. This Initiative will benefit rural and suburban economies across the country, increase our international competitiveness and improve our quality of life.

STRATEGY FOR CARRYING OUT THE RESEARCH INITIATIVE

Industry-Academic-Government Partnership

Since the goals of this Initiative are broad and national in scope, a cooperative effort between industry, universities and government is needed. We propose that the Agricultural Research Service be the coordinating agency for the conduct of this research. Programs could be conducted by ARS, researchers at leading universities, other federal agencies, industry, or through any combination that would maximize the effectiveness and efficiency of the research itself. The intent of this Initiative is to conduct research in the most appropriate locations and with the most qualified people; not to add unnecessary or duplicate infrastructure.

Research Teams

The Initiative will be largely implemented by **research teams.** These teams will frequently involve multiple research locations spread across several states to ensure the right mix of scientific skills are available for a systematic research strategy. The research dollars will be coordinated by and through the Agricultural Research Service budget. In turn, ARS will work with university and private industry researchers to establish research teams. The value of the team approach is to maximize cooperation among all of the various research communities.

Interdisciplinary Approach

The need for interdisciplinary research strategies and teams is paramount. In addressing each of the research areas suggested by this Initiative, researchers must consider not only the specific goals of a project, but also how the results might impact or interact with other real-world production aspects. For example, "solving" a problem through biotechnology or genetic manipulation would only be useful if it does not create or exacerbate other problems encountered in producing or maintaining turfgrass in the field. None of the specific research programs in this Initiative is intended to be developed in isolation.

Interaction with Other Agricultural Research

This Initiative also envisions that research should seek to adapt results from other agriculture (or other biological) research areas, rather than starting anew for each crop or project. For example, if research is being conducted on corn or wheat that might benefit turfgrasses, then a valid research proposal would build on, rather than duplicate that research. In addition, all aspects of grassland agriculture (turf, forage, biofuels and ecosystem restoration) will benefit from a coordinated, national effort to collect, evaluate and preserve grass germplasm. Therefore, this strategy will achieve a greater return on every dollar invested in research.

Accountability and Communication

Accountability is an important consideration in all research efforts, and nowhere more so than when Federal funds are involved. Since this Initiative has been formulated with the joint input of industry, academic and government researchers, its success relies on that continued, joint input. This Initiative envisions that ARS will work with the industry to establish an on-going system of communication among the tripartite members of the coalition to ensure that research programs remain relevant to the needs of the industry.

OVERVIEW

RESEARCH PROPOSAL - TURFGRASS

TOTAL FUNDING REQUESTED: *$32.4 MILLION*

I. Q: *How will we have enough water in the future to sustain our industry?*

A: **By improving turfgrass water management strategies and practices**
(*see component I on page 11*)

- Increase the basic understanding of turfgrass water use/efficiency
- Improve the management of available water
- Evaluate the use of non-potable and poor quality water sources and their impacts on turfgrass and the environment

II. Q: *How can we improve turfgrasses so they can better resist diseases, insects and drought?*

A: **Through germplasm collection, enhancement and preservation programs**
(*see component II on page 13*)

- Collect, evaluate and preserve valuable turfgrass germplasm. This will benefit all aspects of grassland agriculture in addition to turf
- Increase our understanding of turfgrass biology and genetic systems for stress tolerance
- Improve turfgrass stress tolerance through genetic improvement

III. Q: *How do we successfully and profitably manage weeds and other pests?*

A: **By improving pest management practices**
(*see component III on page 15*)

- Increase our understanding of the life cycle and biology of fungal pests
- Increase our understanding of the life cycle and biology of insect pests
- Increase our understanding of the life cycle and biology of weed pests
- Increase our understanding of the life cycle and biology of vertebrate animal pests
- Refine the use of Integrated Pest Management (IPM)
- Investigate biological control methods

IV. Q: *How can we better demonstrate our commitment to environmental stewardship?*

A: **By understanding and improving turfgrass' role in the environment**
(*see component IV on page 17*)

- Assess and characterize environmental impacts of turfgrass and management techniques including the role of turf systems at the watershed and ecosystem level
- Evaluate and develop management strategies and technologies to enhance the environmental quality of turfgrass systems

V. Q: *How can we best utilize and improve marginal soils for turfgrass production and recreational uses?*

A: **Through the development of soil enhancement techniques and management practices** (*see component V on page 18*)

- Overcome soil limitations to turf production, establishment and use
- Investigate the potential of using agricultural and industrial by-products for turf applications

IV. Q: *How do we deliver and implement knowledge gained from research on all aspects of turf management to maximize economic and environmental benefits?*

A: **Through the development of integrated turf management systems**
(*see component VI on page 19*)

- Develop economic-based integrated turf management tools to enhance environmental quality
- Develop decision tools for integrated turf management practices

I. IMPROVEMENT OF WATER MANAGEMENT STRATEGIES AND PRACTICES

(FUNDING REQUESTED: *$5.85 MILLION*)

Water management is a key component of healthy turfgrass, and it directly impacts nutrient use efficiency and turf productivity as well as potential nutrient and pesticide losses into the environment. Increasing demands and competition for potable water require that turfgrass be irrigated more efficiently. Technologies are needed to apply irrigation water more efficiently to meet turf needs based on turfgrass species/cultivar selections and site-specific factors such as soil type, topography, and sun exposure to achieve desired turfgrass quality for the intended use. Best Management Practices (BMPs) are needed for efficient use of water and nutrients to achieve desired turfgrass quality. To increase water availability for turfgrass irrigation, we must also utilize treated and untreated waste water and poor quality water sources. However, some of these waste waters contain contaminants such as pathogens, heavy metals, organic compounds and salts. Consequently, movement and accumulation of these contaminants in the atmosphere, plant tissues, soil profile, and ground water must be determined.

1. Increase the basic understanding of turfgrass water use and efficiency

1. Identify basic turfgrass water characteristics in relation to a wide range of stresses such as soils, salinity, atmospheric evaporative demand, and temperatures to characterize turfgrass drought and temperature hardiness.

2. Measure water use by turf species and varieties under a range of environmental and management conditions.

3. Develop improved water stress measurement tools for turfgrass biochemical and biophysical responses.

4. Modify and develop improved, water stress and plant growth models for turfgrass to quantify growth and development.

2. Improve the management of available water

1. Develop and evaluate water conservation measures with respect to water consumption and turf quality.

2. Develop improved irrigation technologies for a wide range of geographic environments and soils for use in Best Management Practices (BMPs) that utilize water and nutrients efficiently, minimize on- and off-site water quality concerns, and achieve turf quality appropriate for intended use.

3. Develop improved BMPs to meet site-specific turf requirements for quality, mowing height, mowing frequency, cultivar selection, nutrient management, fertigation, composting residues, and plant growth regulators.

3. Evaluate the use of non-potable and poor quality water sources and their impacts on turfgrass and the environment

1. Determine turfgrass response to varying quality irrigation waters. Identify pesticide and salinity interactions in turfgrass and disease, insect and weed growth.

2. Determine the on-site impacts and the transformation and movement in the air, soil, plant, and ground water of biological and chemical substances contained in treated and untreated waste water used for irrigation of turfgrass.

3. Develop technologies to utilize waste waters (both treated and untreated effluents) from concentrated animal feeding operations, agricultural and municipal waste treatment plants, and urban and rural storm runoff to meet local, state, and federal regulations across a wide range of geographic environments and soils.

4. Develop technologies to diagnose, mitigate, and remediate areas of turfgrass affected by salinity across a wide range of geographic environments and soils and to develop safe and environmentally sound methodologies to use saline waters for turfgrass irrigation.

II. COLLECTION, ENHANCEMENT AND PRESERVATION OF TURFGRASS GERMPLASM (FUNDING REQUESTED: *$5.4 MILLION*)

Genetic resources are essential for the continued development of improved turfgrass cultivars. All aspects of grassland agriculture (turf, forage, biofuels and ecosystem restoration) will benefit from a coordinated, national effort to collect, evaluate and preserve grass germplasm. To date, the nation has not initiated a systematic genomic and genetic program for grasses even though they cover about one-half of the continental U.S. A strong research program focusing on important turf grasses would be a significant start on meeting this national need. Lack of new germplasm and insufficient evaluation and characterization of existing collections are serious constraints to solving problems associated with pests, extreme temperatures, water, and other plant stresses that limit turf performance and persistence. Turfgrasses and their successive variations that lack sufficient representation and diversity in present collections need to be collected and made accessible for research. Collections must be maintained and preserved to limit the loss of their genetic integrity and characterized to quantify diversity and enhance utilization. In addition, little is known about the biology and genetics of some plants used for turf, and many are genetically complex. Further, turf is grown on environmentally variable sites and under widely differing use and management conditions. New plant materials are needed that withstand environmental and biotic stresses and will be more sustainable, require lower input management, and provide the aesthetically pleasing turf desired by users. Genetic improvement of both native and introduced plant germplasm is necessary to meet the current and future broad requirements and uses of turf in multiple landscape settings.

1. Collect, evaluate and preserve valuable turfgrass germplasm

1. Collect and maintain germplasm of native and introduced turfgrasses and nontraditional species.

2. Evaluate and characterize germplasm by agronomic and molecular methods and document data in the Germplasm Resources Information Network (GRIN); develop a nationally coordinated competitive funding source for evaluation of new germplasm sources at diverse locations and for diverse uses. Distribute collected germplasm for research purposes.

3. Preserve genetic resources, by seed or vegetative means, of turf species to ensure genetic integrity, viability, and accessibility.

2. Increase our understanding of turfgrass biology and genetic systems for stress tolerance

1. Identify physiological and biochemical functions or genetic mechanisms that control resistance or tolerance of turf plants to stresses caused by disease, drought, flooding, salt, insects, extreme temperatures, shade, traffic, management, and soil conditions.

2. Identify, characterize and map genes controlling stress reduction and provide genetic screening techniques to improve plants used for turf and seed production.

3. Develop strategies to regulate expressions of functional genes in turf plants. Identify morphological and physiological characteristics that improve turf plant performance and incorporate them into germplasm.

3. Improve turfgrass stress tolerance through genetic improvement

1. Enhance turfgrasses to improve resistance to or tolerance of stresses caused by drought, flooding, salt, extreme temperatures, shade, traffic, management, and soil conditions.

2. Develop turf germplasm with resistance to diseases, insects and nematodes using conventional and molecular genetics approaches.

3. Develop turfgrass germplasm that can biochemically inhibit weeds and vertebrates.

4. Improve adaptation of plants used for turf in specific environments, including poor and variable soils, application of recycled water effluent or micro-infiltration/treatment water basins, riparian and flood zones, and low input management such as reduced irrigation and chemical inputs.

5. Provide new genetic sources from alternative or native species or through genetic transformation that can enhance turfgrass performance under low maintenance and reduced inputs.

6. Quantify gene flow and genetic contamination among and between cultivated turfgrasses and/or native plants.

7. Assess risks associated with incorporating new genes in turf plant improvement through genetic transformation or from wide crossing with wild relatives and provide protocols for controlling contaminants.

III. IMPROVEMENT OF PEST MANAGEMENT PRACTICES

(FUNDING REQUESTED: *$5.4 MILLION*)

Disease, insect, weed and animal pests reduce revenue from seed and sod sales, decrease property values and aesthetic appeal, and increase costs for treatment and renovation. Reduced pesticide use and economical and efficient pest management practices, leading to a reduced need to re-establish, could save millions of dollars annually. These measures also would reduce potential hazards to people and wildlife and environmental contamination from chemical runoff, leaching, and evaporation. Reliable diagnostic techniques, pest-resistant cultivars, and economic and environmentally sound management practices are needed to address these problems. Development of environmentally sound, cost-effective practices for controlling invasive pests along roadsides and other right-of-ways would make a significant contribution to protecting adjoining natural and agro-ecosystems.

1. Pathology (Disease) research

1. Develop or apply molecular biological tools for efficient and reliable identification and characterization (race, biotype, and virulence) of fungal, bacterial, viral, and nematode pathogens of turf.

2. Develop basic knowledge of biochemical and physiological processes in the host and pathogen during infection and the disease process.

3. Develop environmentally friendly approaches to disease management, including biological controls and Integrated Pest Management (IPM) strategies.

2. Entomology (Insect) research

1. Develop a better understanding of the population biology of insect pests as parts of various turfgrass ecosystems.

2. Improve the detection and monitoring techniques available to scientists and turfgrass managers.

3. Develop environmentally sound approaches to insect management, including biological controls and Integrated Pest Management (IPM) strategies.

3. Weed management research

1. Characterize weed species and their population dynamics to better understand how they successfully compete with turfgrasses.

2. Develop environmentally sound approaches to weed management, including biological controls and Integrated Pest Management (IPM) strategies.

3. Identify the turf management and ecological implications of introduction of herbicide-resistant turfgrass cultivars.

4. Vertebrate animal research

1. Increase basic knowledge of habitat requirements of vertebrate pests of turfgrass for use in developing new control technology.

2. Develop environmentally sound approaches to vertebrate animal management, including biological controls and Integrated Pest Management (IPM) strategies.

IV. UNDERSTANDING AND IMPROVEMENT OF TURFGRASS' ROLE IN THE ENVIRONMENT (FUNDING REQUESTED: *$6.3 MILLION*)

The assessment of turf's function as a source or sink for pollutants is of vital importance in addressing the role of turf in the landscape. The development, improvement, and implementation of integrated turfgrass management practices and technologies will enhance our ability to take advantage of the environmental, cultural, and economic benefits (erosion control, adsorption of atmospheric pollutants, mitigation of water pollution, dust control, cooling effects, noise abatement, enhancement of real estate value, and provision of wildlife habitat) that turf systems provide to society and eliminate or mitigate the detrimental impacts.

1. Assess and characterize environmental impacts of turfgrass and management techniques

1. Collect data sets at a range of temporal and spatial scales that capture and quantify both positive and negative potential contributions of turf systems to environmental concerns related to soil, water, and air due to nutrients, pesticides, sediment, pathogens, and heavy metals.

2. Assess the impact of exposure to applied chemicals on beneficial soil and non-target organisms and mammals.

3. Determine the mechanisms controlling transformation and movement of nutrients, pesticides, sediment, pathogens, and heavy metals in turf systems.

2. Evaluate and develop management strategies and technologies to enhance the environmental quality of turfgrass systems

1. Develop new and modified physical, biological, and chemical conservation practices that further exploit the environmental benefits of turf systems and mitigate undesirable impacts.

2. Develop methods to reduce inputs and increase input use efficiency including rate, time, and methodology of input applications while maintaining turf quality.

3. Develop region- and species-specific guidelines to design, construct, and use turf production systems that maximize environmental benefits and mitigate or eliminate negative impacts.

4. Synthesize findings and developments into a useful computer model that permits a realistic evaluation of the effects of land use management from turf systems on soil and water resources.

V. ENHANCEMENT OF SOIL AND SOIL MANAGEMENT PRACTICES

(FUNDING REQUESTED: *$4.5 MILLION*)

Soils degraded by natural processes or human activities can possess physical, chemical, and biological limitations that make it difficult to establish and maintain turf. Soil erosion; loss of organic matter; poor soil structure; soil compaction; soil acidification; buildup of salts, trace elements, and organic chemicals; and limited or nonexistent populations of beneficial soil microorganisms can create unfavorable conditions for root proliferation, water storage and use, aeration, and nutrient supply and cycling. Correcting these soil limitations will contribute to improved turf production, establishment, and use. Many of the by-products of our farms, cities, and industry can have considerable value as low-cost soil amendments in the turf industry. They can be used to improve soil properties in existing turf, to create favorable soil conditions where new turf is to be established, and to create artificial soils for a variety of turf applications.

1. Overcome soil limitations to turf production, establishment and use

1. Identify desirable soil characteristics for a specified turf use.

2. Develop management practices and decision tools to overcome soil limitations to turf production in existing turf.

3. Develop management practices and decision tools to overcome soil limitations prior to turf establishment.

2. Investigate the potential of using agricultural and industrial by-products for turf applications

1. Determine benefits and risks of using by-products for turf applications.

2. Develop guidelines for the use of by-products in turf applications.

3. Develop use-specific guidelines for construction of artificial soils using by-product materials.

VI. DEVELOPMENT OF INTEGRATED TURF MANAGEMENT SYSTEMS

(FUNDING REQUESTED: *$4.95 MILLION*)

Turf managers need information tools to identify the best economic combinations of management practices for their enterprises. They must be able to address local natural resource concerns that can be integrated with management plans for other enterprises within their communities. When problems exist, managers need to know how to rectify those problems as well as to enhance beneficial effects. Because managed turf has a range of uses and is found at different landscape scales, solutions need to be considered at the home lawn, golf course, farmland and watershed levels. Research results generally are available to help managers choose the single best practice for managing fertilizer applications, insect and weed pests, mowing, and irrigation for specific locations where the research was conducted. However, often lacking are ways to consider the interrelated effects of different kinds of practices and ways to recommend the optimal management configurations for the overall best effects, at the least cost, and with the greatest environmental benefits. Management decision aids are needed that utilize manager expert knowledge to choose the best options for turf management.

1. Develop economic-based integrated turf management tools to enhance environmental quality

1. Collect management practice and operation cost information from a broad range of turf enterprises and use results to adapt and validate economic and environmental quality assessment tools for turf applications.

2. Develop optimization models for greatest economic return that comply with local and regional environmental regulations and standards.

3. Build and test a user-friendly interface for use on the worldwide web that is accepted by a panel of turf managers and deliver to the industry.

4. Produce management plans that economically address natural resource concerns at the landscape level.

2. Develop decision tools for Integrated Turf Management Practices

1. Assess the research to date regarding optimal management practice effects, determine the kinds of research needed and conduct additional research to fill these gaps.

2. Create management and economic optimization analyses.

3. Produce an analysis tool that allows managers to use their expert knowledge to choose the best combinations of practices suited for their local conditions. Create a user-friendly decision aid interface for the worldwide web that is tested and accepted by a turf manager panel.

The

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