Ecologically Sound Lawn Care for the Pacific Northwest

Findings from the Scientific Literature and Recommendations from Turf Professionals

David K. McDonald
December 1999

Seattle Public Utilities

Community Services Division
Resource Conservation Section

ABSTRACT: Turfgrass management since 1940 in the U.S. has been characterized by intensive use of synthetic chemicals including water-soluble fertilizers, herbicides, insecticides, and fungicides. Conventional practices also generate solid waste (through removal of grass clippings) and hazardous waste (leftover chemicals), and use large amounts of irrigation water, which may be wasted through overwatering or runoff.

A review of current science suggests that these practices may be harmful to human and wildlife health, and also negatively impact the turfgrass ecosystem, contributing to significant declines in populations of beneficial soil organisms, soil acidification and compaction, thatch accumulation, and diminished resistance to diseases. Interviews with turf professionals around the Pacific Northwest region and a review of scientific and technical literature indicate that a proven alternative approach exists. It is based on observation of the entire soil and grass ecosystem, appreciation that turfgrasses are sustained by the activities of soil-dwelling organisms, and understanding that this grass community is a dynamic equilibrium among many plants, invertebrates, and microbial organisms. This equilibrium can then be shaped to support the natural vigor of the grass plant and the beneficial soil organisms, and to minimize pest problems, by application of proper cultural practices.

Recommended practices include: setting realistic expectations for lawn appearance and tolerating a few weeds; proper site selection and soil preparation; using site-adapted grasses; mowing higher; leaving clippings; correcting soil deficiencies; moderate use of natural or slow-release fertilizers; irrigating deeply but infrequently; renovation practices including aeration, over-seeding, and compost topdressing; and use of the integrated pest management process.

Key Words: turfgrass, lawn, pesticides, herbicides, earthworms, biological controls, IPM, grasscycling, compost, natural fertilizers, ecological lawn care.

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Look under the "Natural Lawn Care"

The author welcomes comment, field experiences, and new scientific evidence. Please address correspondence to the author at the address above, or e-mail: david.mcdonald@seattle.gov

Cover photo: ecologically maintained turf in performance amphitheatre at Metro Washington Park Zoo in Portland, Oregon (see description on page 3).

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Foreword

To the readers of "Ecologically Sound Lawn Care for the Pacific Northwest",

The Puget Sound region is blessed with exceptional natural resources, which have sustained and delighted our growing communities for over a hundred years. We now know, however, that those resources are not limitless, and that our use of them sometimes has unintended consequences. The recent listing of the Puget Sound Chinook salmon as a threatened species is a potent reminder that we all have to live within the limits of what nature provides. Clean water, clean air, and healthy stream, forest, lake and marine habitats are all integral not only to our lifestyle, but to the continued prosperity of this region. As we grow into the limits of our natural resource base, we must learn to do more with less, by working in concert with nature.

Our agency has received an increasing number of calls asking for information about how to grow and maintain beautiful landscapes that are easier on the environment – landscapes that need less water, produce less waste, and do not pollute our streams, lakes, and marine waters. This report is one part of our attempt to answer those questions. Based on interviews with landscape professionals, and an extensive review of the scientific and professional literature, it presents an environmentally sustainable approach, which is rooted in turfgrass ecology.

This report provides the technical base for the "Natural Lawn Care" public outreach campaign that we and our partner agencies around the region have launched. It is part of our overall resource conservation outreach to citizens and industry. We are grateful for the assistance of landscape professionals in developing this guide, and look forward to continuing collaboration with the landscape industry. This report has been in draft, being reviewed and tested, for over two years. I am proud to offer it now, in final form, to our citizens, landscape professionals, and to our neighbors around the region.

This is not the only valid approach, and certainly not the last word on sustainable lawn care. Instead, it is intended as a starting point, to stimulate a dialogue among professionals and citizens about how to have the green landscapes we love, without damaging the natural environment we depend on. Our challenge, as agencies, businesses, and citizens entering the new millennium, is to learn to live lightly on the land. This document is one step along that path.

Respectfully,

Diana Gale
Director, Seattle Public Utilities
December, 1999

Summary: Ecologically Sound Lawn Care for the Pacific Northwest

This report consists of three tools for persons interested in environmentally best practices for lawn care:

◊ An introduction to the concept of ecologically based lawn care, and a review of the scientific literature that supports a change from traditional chemical-intensive practices;

◊ Complete practical recommendations for ecologically sound lawn care in the region west of the Cascade mountains, assembled from interviews with turf scientists and professionals and an extensive review of literature;

◊ An annotated bibliography that reviews source documents useful to residents, landscape professionals, and public resource managers.

Lawn Care: An Ecosystem Approach

Like forests or prairie grasslands, lawns are dynamic ecosystems: communities of plants, soil, and microbes; insects and earthworms and the birds that feed on them; and humans who mow, water, fertilize, and play on the lawn. The interactions of all these community members shape the dynamic equilibrium we see as a lawn. Understanding and working within the natural processes that shape the lawn and its soil community can yield a durable, beautiful lawn that is easier to care for. As it turns out, these ecologically sound methods will also help reduce water use, waste generation, and water pollution.

Why Make A Change?

The ecological approach to lawn care described in this report has several advantages, including:

◊ Reduced mowing time and fertilizer needs, and improved turf color, quality, and density.

◊ Enhanced resistance to diseases and weed invasion.

◊ Improved nutrient availability, and less soil compaction, acidification, and thatch buildup.

It is also useful to understand the disadvantages of some common current lawn care practices:

◊ **Water use** Lawn and garden watering in the Seattle area increase water use by 30% during the summer. Endangered Species Act listings of salmon will increase the cost of new water supplies.

◊ **Solid and hazardous waste generation** Grass clippings from lawns are overloading regional composting facilities, when they could be reducing fertilizer use by 25-50% if left on the lawn, thus potentially reducing water pollution. Disposal of leftover pesticides costs Seattle $90,000 a year.

◊ **Current pesticide use in the Puget Sound region** The EPA estimates that 1.1 million pounds of pesticides are applied in urban areas of this region each year, with 213,000 pounds being applied by private households, predominantly on lawns and gardens. 50% of King County residents say they use "weed and feed" (a pesticide/fertilizer mix) on their lawns. The list of top selling pesticides in King County is similar to the list of pesticides most commonly found in streams in the Puget Sound basin, including Thornton Creek in Seattle and Mercer Creek in Bellevue.

◊ **Fertilizer and pesticide pollution, and effects on aquatic life** King County estimates that 62% of the phosphorus entering Lake Sammamish comes from single-home residential areas; sources include fertilizers and soil wash-off. Excess nutrients promote algae blooms that then decompose and deplete the oxygen needed by fish and other aquatic life. State Dept. of Ecology scientists found 23 pesticides in streams in the Puget Sound region, and found a greater number of pesticides in urban areas than in agricultural areas. Many of these products are widely used on lawns. DOE scientists warn that fish and other aquatic life may be experiencing adverse effects.

◊ **Side effects of pesticides and soluble synthetic fertilizers on the turfgrass ecosystem** A number of studies demonstrate that regular use of these products, especially at higher levels, can reduce the diversity of essential soil life, such as earthworms, and contribute to soil compaction and acidification, and increased thatch build up in lawns.

◊ **Possible human health effects of pesticides** While not conclusive, a number of epidemiological studies have reported an increased incidence of cancer and other health problems among families that use common lawn and garden pesticides. Children may be particularly susceptible.

Healthy Lawns Grow on Healthy Soil: Cultural Practices that Support the Turfgrass Ecosystem

This report assembles current best practices for lawn care, west of the Cascade mountains, drawn from interviews with turf professionals and an extensive review of the scientific and professional literature. Recommended lawn care practices include:

◊ Setting realistic expectations for lawn appearance, and tolerating a few weeds.

◊ Proper site selection, and preparing the soil by tilling in compost to a depth of 6 to 12 inches.

◊ The selection of site-adapted and disease-resistant grasses.

◊ Moderate fertilization with natural or natural/synthetic-slow-release combination fertilizers, *to build soil nutrient reserves and biodiversity.*

◊ Mulch-mowing (also called "grasscycling") whenever possible.

◊ Mowing regularly (remove only 1/3 of grass height each time), and mowing a little higher, at 2 to $2^1/_2$ inches on most lawns (or 1 inch for bentgrass lawns).

◊ Avoiding over-watering: watering deeply, to moisten the whole root zone, but infrequently, *to limit disease and build deeper roots*; and watering dormant lawns at least once a month during the dry season, *to improve post-drought recovery.*

◊ Renovation/improvement practices that include aeration, compost topdressing, and overseeding, *to reduce compaction, increase water infiltration, improve soil structure and natural disease control, and crowd out weeds.*

◊ An integrated approach to pest problems (weeds, insects, and diseases) that includes:

1) Correctly identifying the cause of the problem
2) Understanding the biology of the pest organism and its natural predators
3) Setting realistic thresholds of acceptable damage to the lawn from pests
4) Monitoring for pest problems at appropriate times of the year, and
5) Treatment of over-threshold problems with methods that support the turfgrass ecosystem and have the least non-target impacts on beneficial soil organisms, wildlife, pets, or humans. *Repeated broadcast or calendar-based applications of pesticides should be avoided because they may damage the diversity and stability of the grass/soil ecosystem.*

In Conclusion: Towards Sustainable Lawn Care

The turf professionals interviewed reported a number of barriers to the widespread adoption of the recommended practices, including: customers' lack of tolerance for some weeds in lawns; the desire for a deep blue-green lawn color, which can only be maintained by overfertilization; the erroneous belief that grasscycling contributes to thatch build up in lawns; the promotional power of the chemical industry; lack of knowledge about alternatives; and the demand for immediate results on a limited budget.

Lawns are a meeting point for many public concerns, including water use, disposal of mountains of clippings and containers of hazardous chemicals, water and air pollution, human health effects, effects on salmon, birds and other wildlife, and the desire for attractive green spaces to play and live in. This offers a challenge and an opportunity for groups of resource agencies, citizens, and landscape professionals to come together and develop a consensus for change.

This entire report can be downloaded off the internet at http://www.seattle.gov/util/services/yard

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Author's Note

There is a wide range of scientific evidence, and considerable controversy among scientists, about the effects of turf chemicals on the soil, people, pets, wildlife, and the environment. Likewise there is a wide and evolving range of opinions and experience among turf and landscape professionals about the best practices for maintaining healthy, attractive lawns. This report presents some of that range of evidence and professional opinion, but many other valid points of view exist. Both science and professional practice are enriched by that controversy.

This report is intended to share information and stimulate discussion about environmentally preferable methods of turf culture. Readers are encouraged to seek out other points of view, form their own opinions, try out new methods in the field, and to share their ideas with others.

Objectives and Intended Audience

The intent of this project was to assemble field-tested and scientifically sound ideas that could help both residents and professionals to plant and maintain lawns that:

1) meet their aesthetic and functional needs, and are easy to care for;
2) have lower adverse impacts on our regional environment, particularly in terms of water use, solid and hazardous waste, and water and air pollution.

This report was written to inform resource managers, landscape professionals, and those involved in public education about ecologically based lawn care appropriate to the Pacific Northwest region, west of the Cascade Mountains. The bulk of the research for this report was done in the fall and winter of 1996-1997. Numerous comments from technical reviewers have helped shape this final draft.

Sources of Information

Two distinct standards of evidence were used in assembling this report:

- The section "Why Make a Change" presents evidence from the scientific research literature only, as is appropriate in view of the controversy surrounding chemical-intensive cultural practices.
- The remainder of the report, " Cultural Practices that Support the Turfgrass Ecosystem", draws on three sources: the scientific literature; the writings of practicing turf professionals (particularly in the Pacific Northwest); and interviews and field tours in 1996-97 with the turf professionals and scientists listed below, whose experience in the field ranges from 10 to 40 years each. Where individuals had strong dissenting views from the practices recommended by the majority, those views are presented in the footnotes.

Acknowledgments

A great many people helped to assemble and review the information presented here, and I thank them all. I would especially like to acknowledge the turf professionals and scientists who consented to be interviewed for the "cultural practices" section. They generously loaned their own manuscripts, and many of them reviewed the resulting report. Not all of them agreed on every recommendation – I have attempted to present points of consensus and to note dissenting opinions as well. The strengths of the cultural practices section belong to them; the failings are entirely my own. My sincere thanks to:

Tim Aalbu, *President, Aalbu Landscaping, Everett, WA*

Jim Chapman, *President, Prescription Turf Services, Bellevue, WA*

Carl Elliot, *Gardener, Seattle Tilth Association*

Rick Hanes, *Senior Gardener, Metro Washington Park Zoo, Portland*

Jerry Hilperts, *Golf Course Superintendent, Broadmoor Golf Course, Seattle*

Fred Hoyt, *Grounds Supervisor, Center for Urban Horticulture, Seattle*
Jeff Hughes, *Lead Groundskeeper, Children's Hospital, Seattle*
Dr. Elaine R. Ingham, *Dept. of Botany and Plant Pathology, Oregon State University*
Phil Marks, *Vice President, D. F. Marks Seed Company, Woodinville, WA*
James "Ciscoe" Morris, *Grounds Manager, Seattle University*
Tim Rhay, *Turf and Grounds Supervisor, City of Eugene Oregon Public Works*
Ladd Smith, *Vice President, In Harmony Landscaping Inc., Woodinville, WA*

Use of Trade Names: Pesticides in this report are generally referred to by the commonly used chemical name for the active ingredient. Trade names, used in a few places in this report, are printed in italic, and are presented for the sole purpose of helping the non-technical reader to identify the general type of products that contain the specified chemical.

How to find names of products using the chemical name: The easiest way to look up the trade, or product names for the pesticide chemicals referred to in this report is to go to the California Department of Pesticide Regulation's website at http://www.cdpr.ca.gov/dprdatabase.htm
Click on "Product/Label Database", then on "Search for products using multiple variables", then go to "chemical code lookup" and enter the chemical name.

"**Ecosystem** – A community of organisms together with their physical environment, considered as a unit."

American Heritage Dictionary of the English Language

Lawn Care: An Ecosystem Approach

Introduction

Like forests or prairie grasslands, lawns are dynamic ecosystems: communities of plants, soil, and microbes; insects and earthworms and the birds that feed on them; and humans who mow, water, fertilize, and play on the lawn. The interactions of all these community members shape the dynamic equilibrium we see as a lawn.

Understanding and working within the natural processes that shape the lawn and its soil community can yield a durable, beautiful lawn that is easier to care for. As it turns out, these same ecologically sound methods will also help reduce water use, solid and hazardous waste generation, and water pollution. The union of science and centuries of practical experience has produced a modern approach to the ancient art of "grass gardening" that is being practiced successfully today, here in the Pacific Northwest.

Ecological Lawn Care

Ecology is the study of interactions and relationships between living organisms, their environment, and each other. This report assembles the work of many scientists who have looked at those relationships, together with the experience of professionals who are managing lawns in ways that build the health of the soil and support the natural vigor of the grass plant and the diverse community of soil organisms that sustain it.

The practices recommended in this report had to meet these tests:

- ◊ Be cost-effective in the long run,
- ◊ Be easy to learn and apply,
- ◊ Enable both residents and lawn care professionals to maintain acceptable-quality turf,
- ◊ Have been field-tested successfully in the Pacific Northwest,
- ◊ Make efficient use of the grass ecosystem's natural processes, and
- ◊ Have minimal adverse impacts on people, pets, wildlife, and the Northwest environment.

Historical Context: How We Got Here

Although lawns were cultivated in ancient China and Persia, historians agree that the modern American lawn arose out of the "grassy meades" that surrounded British estates.[1] Originally kept short by browsing sheep (as the city parks of Auckland, New Zealand, are today) these formal lawns were later maintained by gardeners with scythes. American aristocrats copied this "manor house" aesthetic, but the invention of the push lawnmower in 1830 placed lawn maintenance within the reach of common people, and lawns spread quickly in the American landscape.[2] As early as 1880, state agricultural colleges began breeding improved grass cultivars for lawns.[3]

The next major change began during World War II, when chemical research led to the development of the first selective herbicides (such as 2,4,5-T and 2,4-D), which kill broad-leaved plants but not grasses.[4] Wartime chemical factories were readily converted to post-war domestic production. Together with the development of synthetic fertilizers (from natural gas) and the rise of the suburban dream among the growing middle-class, this led to the growth of a lawn care industry that by 1982 had annual revenues estimated at $25 billion, including seed, maintenance services, equipment, fertilizers, and pesticides. Pesticides alone accounted for about $700 million.[5] ("Pesticides" is the generic word that includes such products as herbicides, fungicides, insecticides, and other "-cides" designed to kill certain classes of living things.)

The publication of Rachel Carson's book *Silent Spring* in 1962 sparked a public debate about pesticide use that continues to this day. This has fueled a search by chemical manufacturers for pesticides that are less acutely toxic and less persistent in the environment. (DDT, banned in the United States in1972, is still found in mother's milk throughout the country.)[6] In the last three decades, other environmental concerns have surfaced as well: water contamination by soluble synthetic fertilizers, the impact of grass clipping disposal on shrinking landfill space,[a] the expense and risks involved in disposing of hazardous waste such as partially used household yard and garden chemicals, and the impact of landscape irrigation on limited municipal water supplies.

Meanwhile, some turf professionals, concerned about the health risks of pesticides and side effects such as increased turf diseases, thatch build-up, pest resistance to chemicals, and breakdown of soil structure, began to re-examine the central question of their profession: "How can we grow attractive, durable grass areas, with dependable results, minimal pest problems, and predictable (preferably low) maintenance requirements?" The US Golf Association, the Rodale Institute, the seed-industry supported Lawn Institute, state Cooperative Extension universities, and the US Environmental Protection Agency took the lead in funding research into pesticide and fertilizer fate in the environment and less-toxic alternatives. Here in the Pacific Northwest, some observant professionals began to focus on building soil health; growing well-adapted grasses; mowing and fertilizing to support vigorous grass plants; and taking an observant, innovative approach to weed, disease, and insect problems called "Integrated Pest Management".[7] These professionals found that the turf they managed thrived and, as business-people, they saw that the efficiencies inherent in more natural turf management could give them a competitive edge in the marketplace.

Ecological Turf Management in the Pacific Northwest: Four Successful Professionals

City of Eugene, Oregon

Sixteen years ago, Tim Rhay, Eugene's Turf and Grounds Supervisor, was ordered by his boss to attend a seminar on something called "Integrated Pest Management" taught by one of the modern leaders in that science, Dr. William Olkowski. Though he was skeptical in the extreme and considered it a waste of his time, Tim went, and today says, "I did one thing right that day. I didn't check my brains at the door." He listened, and realized that he now had a powerful new way of looking at turf management. Since then he has managed Eugene's extensive parklands and playfields with a proactive program of mulch-mowing, aeration, topdressing and overseeding, and an IPM approach to pest problems. (These practices are all described in this report; see Table of Contents.) A turf zoning system allows him to put irrigation and renovation efforts into the high-use or high appearance-standard turf, and maintain large areas at a lesser standard without irrigation or intensive maintenance. Though his staff shrank 16% during this period,

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[a] Excess grass clippings are also a problem at municipal composting facilities, where the large amounts of clippings arriving in spring and summer can overload the system with high nitrogen material and turn the process anaerobic, resulting in air pollution violations from the odors of methane, ammonia, and other gases released.

local soccer clubs attest that their playing turf looks better than ever and stands up to heavier playing schedules. Under his IPM approach of monitoring and setting tolerance thresholds for pest problems, Tim's crews have had to spot-spray for weeds only once on three playfields out of Eugene's 25 fields in the last 16 years. The city has abandoned the use of phenoxy herbicides such as 2,4-D altogether, in favor of less hazardous or controversial compounds.

Aalbu Landscaping, Everett, Washington

Tim Aalbu manages a large lawn and landscape business, and is convinced that shifting his mowing crews over to "grasscycling" (mulch-mowing, or leaving clippings on the lawn) has saved his business thousands of dollars and given him the competitive edge. By buying mulching mowers that left a clean appearance in most conditions he was able to convert customers to mulch-mowing, often without their noticing any difference (his crews grasscycle 100% on many sites, but still bag grass about 40% of the time for some customers). In 1992, Aalbu Landscaping won the contract to maintain the million-square-foot Hewlett-Packard corporate site. The former contractor had a full-time dedicated crew of five employees on that site. Aalbu now manages it with a crew of two by grasscycling 100% of the time. Aalbu Landscaping recently won a competitive contract renewal. Because of the improvement in the turf, Hewlett-Packard now specifies that the contractor must grasscycle.

Metro Washington Park Zoo, Portland, Oregon

Rick Hanes, Senior Gardener, had two problems: rising disposal costs for grass clippings, leaves, and manure from the zoo, and declining turf quality because of soil compaction from heavy use and diminished organic content in the soil. In 1989 he began to turn those problems around. "The idea was to improve the soil with humus." The zoo now sends its animal wastes to a local natural fertilizer company (Whitney Farms), which returns part of them in trade as high-quality compost that is used for topdressing turf areas. All turf areas in the zoo are fertilized with natural ("organic") fertilizers to build soil structure and turf health. Mowing heights are set at $2^{1}/_{2}$ inches to help crowd out weeds and develop deeper grass roots, and all areas are grasscycled. Under IPM monitoring and setting tolerance thresholds for pest damage, zoo gardeners have spot-applied herbicides on three areas in the last six years, and have not had to treat for fungal diseases (such as red thread) or insects (such as crane fly).

Rick is proudest of their large grass amphitheatre (see photo on cover), where two to four packed concerts are held every week throughout the warm season, rain or shine. At the end of the concert season, the turf still looks perfect. They keep it that way with regular core aeration, topdressing with a sand and compost mix, bi-annual slice seeding to fill in worn spots, mulch-mowing at $2^{1}/_{4}$ inch (they sometimes use a blower to break up clumps if it's wet), and regular applications of natural fertilizers. In six years they have never used any herbicides on this lawn. Rick says "I did have to hand-weed a little the first year - two dandelions."

In Harmony, Inc., Woodinville, Washington

Ladd Smith has worked 20 years in the commercial lawn-care business. His horticultural training led him to believe that there must be a better way than year-round calendar-based "cover" spraying programs and application of highly soluble fertilizers in a region with frequent rain and high runoff. Four years ago, he and a partner went into business for themselves to prove it. In Harmony uses grasscycling, aeration, compost topdressing, and overseeding to build a diverse soil community and dense, vigorous turf. They fertilize with "bridge" products (part natural-organic, part slow-release synthetic) to give customers the quick green-up they expect with a sustained fertility that means fewer return trips over the year.

Their first line of defense against weeds is dense turf, mowed 2 to $2^{1}/_{2}$ inches high to crowd out weeds. In Harmony uses IPM practices everywhere, but they offer customers the option of spot spraying if tolerance thresholds are reached, or a "completely organic" option for customers willing to accept the occasional broad-leaf plant (particularly clover). In Harmony's customers live in middle- and upper-class suburban neighborhoods where lawn appearance expectations are very high, and the business is growing fast, mainly by referrals from friends and neighbors. Ladd Smith notes, “It’s time to change our industry – it all comes down to basic plant health care and feeding the soil.”

> "The lawn surrounding our home can be a source of delight or cause for despair. Our society has traditionally valued the aesthetic standard of a uniform, dense, close-cropped and geometrically edged lawn. Trying to maintain such artificial standards, perhaps more to please our neighbors than ourselves, we can set ourselves up for failure. We also allow ourselves to become easy victims of advertisements promoting a lethal assortment of chemicals guaranteed to solve our lawn problems."[8]
>
> *David Johnson, Director of Grounds Maintenance at Children's Hospital, Seattle, 1979-1993*

Why Make A Change?

Advantages of an Ecosystem Approach

The ecological approach to lawn care described in this report has a number of measurable advantages over conventional chemical-intensive practices, among them:

◊ Reduced mowing time and fertilizer needs, and improved turf color, quality, and density.[9 10 11]
◊ Enhanced resistance to diseases and weed invasion.[12 13]
◊ Improved nutrient availability, and less soil compaction, acidification, and thatch buildup.[14 15 16 17]

These advantages have led many residents and professionals to begin to change their lawn care practices. But it is also useful to understand the disadvantages of some current lawn care practices. Some common practices may harm the environment, human health, and the health and vigor of the lawn itself. Concerns include excessive water use on lawns, solid waste generated when clippings are removed, and the impacts resulting from broadcast use of pesticides (herbicides, insecticides, and fungicides) and dependence on high levels of soluble fertilizers (salt-based compounds such as ammonium sulfate, or carbon-based compounds like urea). This section reviews some of the scientific research in this area.

Water Demand for Lawns

Lawn and garden watering increase water use in the greater Seattle area by 30% during the irrigation season (mid-May to mid-September), and increase it by over 100% on the hottest days. According to Seattle Public Utilities, which supplies water to most of King County, a significant amount of that water is wasted through overwatering or runoff.[18] Overwatering promotes lawn disease (see page 39). Meanwhile the regional population is growing at over 1% per year, at the same time as the Endangered Species Act listing of local Chinook salmon populations as threatened is creating increasing pressures on regional water supplies.

Waste Generated by Current Practices: Grass Clippings and Pesticides

Grass clippings collected in most of the Puget Sound region now go to composting facilities rather than landfills. But composting facilities have recently been overloaded by the spring and summer rush of clippings. In Seattle and King County, for example, yard waste collected in the April-July period was 64,638 tons in 1996, but increased by 26% to 81,585 tons during the wet spring of 1997.[19] Between 70 and 88 percent of that tonnage is estimated to be grass clippings.[20] If left on lawns those clippings would improve lawn health and reduce fertilizer requirements by up to 25-50% (see page 36), thus potentially reducing pollution of lakes and streams by fertilizer runoff. Hazardous waste generation is also a concern: in Seattle alone, 30 tons of pesticides are disposed of annually, at a cost of about $90,000.[21]

Current Pesticide Use in the Puget Sound Region

According to a 1988 study for the US Environmental Protection Agency, approximately 2.8 million pounds of pesticide active ingredients are applied annually in the Puget Sound region, with about 1.1 million pounds being used in urban/suburban applications. (Active ingredients usually make up less than half of the product formulation, often less than 10 percent in consumer products.) Of that, private households applied an estimated 213,000 pounds of active pesticide ingredient, predominantly on lawns and gardens.[22]

Pesticide use by residents is common, especially on lawns. In a 1996 survey of 1,200 King County residents, 46% reported using a "weed and feed" type product on their lawn in the last year. In a separate question, 53% said they had used weed killers, bug killers, or other pesticides in the last year (44% said they used them on lawns, and 27% on landscape areas). In general, bug and weed killers were more likely to be used by suburban homeowners with higher incomes (over $40,000). Seattle residents were less likely to use these products – 43% used them, compared to 60% of Eastside and South King County residents.[23] These rates of pesticide use are corroborated by a separate series of surveys by a different research firm, where 50% of King County residents with lawns reported using "weed and feed" products in 1997, and 52% in the 1998 survey.[24 25]

Twenty three pesticides were detected in Washington streams by the state Department of Ecology in 1992-94.[26 27 28 29] Streams in King county were again sampled by the DOE and the US Geological Survey in 1998. Five pesticides were at levels that exceeded the National Academy of Sciences recommended maximum concentrations for aquatic life (see p. 8). The most commonly detected pesticides are listed below, next to the most commonly sold pesticides in 1997 at home and garden stores in King County.[30 31]

Pesticides most commonly detected in Washington streams, 1998[a]	Pesticides most commonly sold in King County home and garden chain stores in 1997 (in decreasing sales order)[a]
herbicides	*Herbicides*
2,4-D	2,4-D (commonly found in "weed-and-feed" products)[b]
MCPP (mecoprop)	MCPP (commonly found in "weed-and-feed" products)[b]
dichlobenil	Dichlobenil
prometon	Prometon
trifluralin	Tryclopyr
MCPA	
triclopyr	
insecticides	*Insecticides*
diazinon*	diazinon* (used for crane fly control in lawns, also used on trees and shrubs)
carbaryl*	carbaryl*
malathion*	malathion*
chlorpyrifos*	chlorpyrifos* (also used for crane fly control in lawns)

[a] Source: U.S. Geological Survey. *Pesticides Detected in Urban Streams and Relations to Retail Sales of Pesticides in King County, Washington*. April, 1999, p. 2 USGS Fact Sheet 097-99. Available by calling USGS at (253) 428-3600, or download off internet at http://wa.water.usgs.gov/ps.nawqa.html
Only those pesticides for which both stream water detection data and sales data were reported are shown in this table – see the USGS report for the full list of pesticides detected in streams.

[b] dicamba is also in many "weed-and-feed" type products and was found in 70% of the streams tested, but was not tracked in this sales data

* exceeded NAS Recommended Maximum Concentrations for protection of aquatic life. (RMC's have not been established for all compounds. Lindane, not shown in this table, also exceeded the NAS RMC.)

Nationwide, a 1994-95 EPA market study reports that Americans used 1.22 billion pounds of pesticide active ingredient in 1995 (not counting wood preservative and chlorine products). Of that total, 11% was sold in the home and garden market, where the top sellers were 2,4-D, glyphosate, dicamba, MCPP (mecoprop), diazinon, chlorpyrifos, carbaryl, benefin, and dacthal.[a] The study estimated that 74% of US households use pesticides annually. The amount of herbicides purchased for home and garden use increased by 42% between 1979 and 1995, from 33 million pounds to 47 million lbs. of active ingredient.[32] Another EPA survey, (in 1992) estimated that 82% of US households use pesticides annually (75% used insecticides inside the home, and 22% used insecticides or herbicides in the yard or garden).[33]

Turf Chemicals and Water Quality: Effects on Salmon and Other Aquatic Life

Research on runoff and leaching

Several university trials have attempted to quantify the amount of pesticide or chemical fertilizer escaping turf areas after application, either through leaching (below the root zone, into groundwater) or surface transport in runoff water. Trials on mature turf grown on high quality loam soils have generally reported relatively low amounts (2% or less of applied amount) of fertilizer and pesticide escaping through leaching or runoff.[34] [35] [36] [37]

On clay soils in Georgia, however, researchers simulating very heavy rainfalls (2 inches of precipitation) over slightly sloped plots, one to two days after applying chemicals, reported that 16% of nitrate fertilizer was washed off of green grass plots, and 64% off dormant grass plots. Among herbicides tested, 10% of 2,4-D, 14% of mecoprop, and 15% of dicamba washed off the green plots, and the amounts leaving dormant grass plots for those herbicides were 26% (2,4-D), 24% (mecoprop), and 37% (dicamba). Average concentrations for each of these three herbicides in the runoff water from these plots ranged from 360 to 1,959 parts per billion (ppb).[38] It is appropriate to look at these three herbicides since they are commonly combined in over the counter weed-killers and "weed and feed" fertilizer-with-herbicide products.

Another trial in New York looked at leaching in turf grown on a sand medium, such as is used for some golf greens and high-use sports fields because it resists compaction under heavy use and allows surface water to escape. Normal and above-normal rainfall patterns for that region were simulated on different plots over the season, and leachate was collected at a 15-inch soil depth, well beyond the root-zone of the turf. In these extremely leachable soils, 51% of the applied mecoprop herbicide leached out under normal rainfall conditions, and 62% under above-normal rainfall.[39]

While these two studies represent extreme "worst case" situations (soils that are very prone to surface runoff in the first study, and to leaching in the second), they indicate that chemicals do wash off and through some soils.

But are these chemicals actually getting into our streams and lakes in this region?

Fertilizer pollution in lakes in King County

King County estimates that 62% of the phosphate currently entering Lake Sammamish is from single-family residences; sources include both fertilizers and soil wash off.[40] Excess phosphate nutrients promote blooms of algae and other aquatic plants, which then decompose and use up oxygen in the water as they do. This is called "eutrophication". In fresh water, phosphate is usually the limiting nutrient for

[a] According to *Chemical Times and Trends* (July 1995, p. 33) 2,4-D is still the "most prominent herbicide" in the consumer lawn and garden marketplace. 2,4-D is the active ingredient in numerous over-the-counter products, and is formulated together with dicamba and mecoprop in "weed and feed" type fertilizer/herbicide products, as well as broadcast sprays available from lawn services.

this algae growth, in marine waters it is usually nitrate.[41 42] The decreasing oxygen levels affect the most sensitive species of animals first, possibly including young salmon if present. Several small lakes around King County are already being managed to control phosphorus levels, including reducing soluble fertilizer nutrients, and court action by citizens has led to a County management plan to reduce phosphorus runoff from new developments around Lake Sammamish by 50%.[43 44 45]

Pesticide pollution in western Washington streams and estuaries

In 1992, 1993, and 1994 the Washington State Department of Ecology sampled water at 13 sites around the state and analyzed it for some common pesticides. To represent urban areas, samples were taken on Thornton Creek in north Seattle (1992 only) and Mercer Creek in Bellevue (all three years), each of which drain only urban and suburban areas, not farmland. In general, a greater number of pesticides were detected in urban streams than in agricultural streams.[46] In 1992, nine pesticides including glyphosate, diazinon, and 2,4-D were detected in both Thornton and Mercer Creeks.[47] In 1993, the DOE report states, "Fifteen pesticides were identified in samples from Mercer Creek. Two compounds exceeded NAS recommendations [the National Academy of Sciences recommended maximum concentrations to protect aquatic life and wildlife - exceeded by diazinon and malathion]. These data indicate that urban pesticide use around Mercer Creek is a significant problem."[48] In 1994, 33 pesticides and breakdown products were identified in Washington streams, including 13 in Mercer Creek. 2,4-D and diazinon were again the most frequently detected pesticides. In Mercer creek, diazinon and malathion again exceeded NAS standards. The DOE report concludes, "Flora and fauna in Mercer Creek may be experiencing adverse effects from long term exposure to multiple pesticides," and recommends that public agencies develop education "that identifies urban pesticide use as a significant problem and lists BMP's [best management practices] that will reduce the number and amount of pesticides entering waters of the state."[49] All Washington cities and counties with NPDES stormwater discharge permits (currently including Seattle and Tacoma, and King, Pierce, Snohomish and Clark counties) are now required to have programs designed to reduce pollutants associated with the application of pesticides and fertilizers.[50]

In 1998 the US Geological Survey and Washington Department of Ecology sampled 12 urban and suburban creeks in King County, Washington, and related the pesticides found to 1997 sales data from chain hardware stores in King County. The list of pesticides found and the list of top selling pesticides in the hardware stores were similar (see table, page 6). In the 1998 sampling, five pesticides were found at levels that exceeded the National Academy of Sciences recommended maximum concentrations for aquatic life (diazinon, chlorpyrifos, malathion, lindane, and carbaryl). On the days the samples were collected, diazinon exceeded NAS standards in all streams sampled.[51]

But these pesticides were all found at less than 1 part per billion (ppb) in the streams. Is that enough to pose a threat to creatures we care about, like salmon?

short and long term effects on wildlife The LC_{50} (the concentration that kills half the fish over a short exposure) for salmon and other fish of common turf pesticides is usually reported in the scientific literature as several hundred to several thousand parts per billion.[52] But with longer exposures much less is needed. For instance, one study reported that chinook salmon alevins (young fish) all died during an 86-day trial in water with 2,4-D at 40 ppb.[53] Chronic effects on health and reproductive capability have been noted in some studies at much lower levels. A recent laboratory trial in Britain examined the olfactory sensitivity of mature Atlantic salmon exposed to varying levels of diazinon. The fish were tested for their ability to detect waterborne hormones that have been shown to be essential in synchronizing mating behavior. The report states, "Responses to this prostaglandin were significantly reduced at concentrations [of diazinon] as low as 1.0 ppb, and the threshold of detection was reduced 10-fold at 2.0 ppb. Mature male salmon exposed for a period of 120 hours to diazinon (0.3 ppb concentration) also had significantly reduced levels of the reproductive steroids."[54] On the days that water was sampled in Mercer and Thornton creeks by DOE scientists in 1992-94, diazinon levels ranged between 0.03 and 0.094 ppb.

In some cases pesticides have proven immediately toxic to valued wildlife, as was the case with the numerous documented bird kills attributed to diazinon use, which led to its being banned in 1990 for use on golf courses and sod farms (though not on home lawns).[55] [56] [57] [58] [59] As recently as 1998, the Washington Department of Fish and Wildlife attributed a series of waterfowl deaths to diazinon use on lawns.[60] But pesticides may also indirectly harm creatures by damaging the food web that supports them. For example, the LC_{50} for midge larvae, uninteresting creatures except to a hungry young fish, was reported in one study to be 0.03 ppb of diazinon, and the level at which the midge's development through larval stages was impaired was 0.0006 ppb.[61] Or low levels of chemicals may impact organisms' health without killing them outright: a number of studies have reported changes in fishes' immune response, hormonal systems, stress response, and other systems when exposed to sublethal concentrations of various pesticides.[62] [63] [64] [65] [66]

bioconcentration and bioaccumulation *Bioconcentration* is another concern when assessing pesticide effects on wildlife (and humans). Some pesticides have an affinity for body tissues or are not well excreted, so that organisms that live in contaminated waters retain it in their bodies. For instance, some studies have concluded that fish concentrate diazinon in their tissues at levels up to 200 times higher than the concentrations in the waters swim in, and may concentrate chlorpyrifos at levels 100-5000 times higher.[67] [68] Some pesticides may then *bioaccumulate* to higher concentrations as they move up the food chain (for instance, from aquatic invertebrates to small fish to salmon to eagles, or humans). This is the process that endangered the bald eagle in the U.S. during the 1960's and '70's, from bioconcentration and bioaccumulation of DDT.

"inert" ingredients and contaminants in pesticides So-called "inert" ingredients in pesticide formulations have sometimes been reported to be more toxic, especially to aquatic life, than the tested active ingredient.[69] Several pesticides commonly used on lawns have also been reported in some studies to be contaminated by related chemicals that are much more toxic, such as dioxins.[70] [71] [72] [73] [74]

effects of multiple chemical exposures Some studies have concluded that pesticide and other chemical effects are often additive, or even multiplied (synergistic effects) by certain combinations.[75] [76] [77] [78] [79] In the real world, pesticide chemicals are often combined in a product (such as "weed and feed" products– a mixture of fertilizers with the herbicides 2,4-D, mecoprop and dicamba). Households that use one pesticide product usually use several.[80] [81] Likewise, aquatic organisms in Washington may also be exposed to a great variety of pesticides and other chemicals in the waters they swim in – state scientists identified 23 pesticides from a limited list that they sampled for.[82] Thus the effects on a creature or ecosystem from all the chemicals it is exposed to may be much greater than laboratory studies with isolated chemicals suggest.[83]

While more work needs to be done to assess the effects of mixes of pesticides on aquatic organisms and the food chain, enough scientific data exist to suggest that efforts to reduce unnecessary pesticide use are warranted, to protect fish and the entire aquatic ecosystem.[a]

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[a] The literature search for this section was done in 1996. For a more recent review, see "Diminishing Returns: Salmon Decline and Pesticides" by Richard D. Ewing, PhD, Institute for Fisheries Resources, Eugene Oregon; 1999. That document can be downloaded off the internet at http://www.pond.net/~fish1ifr/salpest.pdf

Side Effects of Pesticides and Soluble Synthetic Fertilizers on the Grass Ecosystem

> "It is noteworthy that excessive thatch accumulation and outbreaks of insects and diseases rarely occur in turfgrass that is under minimal maintenance. This implies that low maintenance turf is a relatively stable habitat in which thatch accumulation is balanced by decomposition and in which pests are held in check by predators, parasites, or plant resistance."[84]
>
> *Dr. Daniel A. Potter, Soil & Turf Entomologist, University of Kentucky*

Earthworms and other soil invertebrates are essential to maintaining soil structure and recycling organic debris, such as thatch, back into nutrients available to the grass plant.[85] [86] [87] Thousands of microorganism species (bacteria, fungi, and protozoa) form the food base for these invertebrates.[a] The microorganisms perform the essential first steps in nutrient recycling, and build soil structure at the microscopic level.[88] [89] They also compete with and (along with predacious invertebrates) prey upon the relatively few fungi and insects that cause pest problems in turfgrass.[90] [91] Several studies have identified negative side-effects of regular use of pesticides and soluble fertilizers on the health of this soil ecosystem, and on turfgrass vigor, drought hardiness, soil compaction, and thatch buildup.

A study measuring acute toxicity to worms concluded that most pesticides were "very toxic to extremely toxic" (LC_{50} = 1-100 $\mu g/cm^2$, which means that at that concentration half the earthworms died during a short experiment) and reported that the breakdown products of 2,4-D were more toxic than the original material. The soluble fertilizers that were tested, ammonium nitrate and methyl urea, had LC_{50}'s in the 100-1000 $\mu g/cm^2$ range.[92] Another study concluded that earthworm growth and reproduction is significantly reduced at much lower chemical concentrations than those that cause death.[93] Several turfgrass trial studies with commonly used fungicides, insecticides and herbicides have reported large reductions in earthworm activity and a significant buildup of thatch layers, compared to untreated control plots.[94] [95] [96] [97] [98] Another study reported that mechanical exclusion of earthworms (by mesh bags) prevented thatch breakdown, and concluded that earthworm activity provides benefits (such as soil incorporation into the thatch layer) that are comparable to topdressing with topsoil.[99]

A trial that simulated a high-maintenance (synthetic fertilizer, herbicides and insecticides) lawn care program for four years concluded that "soil and thatch pH decreased significantly [soil became more acid] and thatch accumulation more than tripled under the high maintenance program" compared to untreated control plots. Soluble nitrogen fertilization commonly results in soil acidification, which inhibits microbial activity and soil invertebrate populations.[100] A seven-year trial of varying rates of ammonium nitrate fertilization on turf reported that soil acidity and thatch thickness increased, and earthworm and other invertebrate populations decreased, in direct proportion to increasingly high levels of nitrogen fertilization.[101]

Soil compaction, like thatch buildup, causes poor root development, lack of drought hardiness, and lack of vigor in grass plants.[102] A trial on British sports fields where worms were killed with a strong insecticide reported that water infiltration rates fell 16% by six months after treatment, and fell 40% by twelve months after the worms were killed. This study concluded that "The main cause of the reduction was blockage of the main conducting channels," as these large pore spaces were no longer being created

[a] Dr. Elaine Ingham of Oregon State University notes, "Earthworms do not make the enzymes to degrade organic matter – they have the enzymes to digest bacteria and fungi and absorb the soluble nutrients that are released. Bacteria bind the smallest building blocks of soil into microaggregates. Fungi, and root hairs, bind the small building blocks into larger aggregates. Earthworms consume these aggregates, with the bacteria, fungi, root hairs, protozoa, nematodes and arthropods in them. Earthworms then build larger channels in soil, but the smaller aggregates and other organisms must be present for earthworms to survive in soil."

by the earthworms.[103] In a laboratory experiment, researchers concluded that the presence of earthworms "greatly enhanced" the growth of perennial ryegrass. "Uptake of most major and trace elements by ryegrass was increased in the presence of earthworms." That study also concluded that earthworms reduced soil compaction and increased pore space in the root zone of the ryegrass plants.[104]

Most plants, including grasses, depend on webs of beneficial fungi, which grow in and around their root systems, to provide both nutrients from the soil and protection from disease-causing fungi.[105] Several studies have concluded that these beneficial "mycorrhizal" fungi ("root-fungi") are inhibited by fungicides, and also by high levels of fertilization.[106] [107] [108]

Resurgence of disease and insect problems is commonly reported after use of fungicides and insecticides, because of reductions in fungi and insects that compete with or prey upon the problem pests.[109] Resistance to pesticides developed by both insects and fungal diseases is also commonly noted by turf scientists and professionals.[110]

The scientific literature reviewed here suggests that turf management techniques that support the diversity of life in the soil community, through proper cultural practices and through limiting the intensity and frequency of chemical applications, will yield healthier turf with less thatch and fewer soil compaction, disease, and insect problems.

Possible Human Health Effects of Pesticides

Several epidemiological studies have reported an increased incidence of certain health problems, notably certain types of cancer, in families that use yard pesticides.[111] [112] [113] [114] [115] Some studies of professional pesticide applicators and other exposed professional groups have also reported increased health problems, including cancer and birth defects.[116] [117] [118] [119] Other studies have not reported increased health problems, or have reported mixed or inconclusive results.[120] These correlations do not by themselves prove that a certain chemical causes a certain health problem. For instance, in the EPA's most recent (1996) peer review of the evidence on 2,4-D, a common herbicide, the panel of scientists concluded, "the evidence is inadequate and cannot be interpreted as showing either the presence or absence of carcinogenic effect."[121] The US General Accounting Office and the California Senate Office of Research have reported that health studies required for re-registration of pesticides have often been delayed, and those two agencies questioned whether current regulatory practices adequately protect public health.[122] [123] [124] [125]

Many citizens and scientists look to the federally-funded National Institutes of Health (NIH) for an impartial and scientific evaluation of possible public health risks. Scientists with the National Cancer Institute, one of the National Institutes of Health, have several times reviewed current science and reported possible health effects from pesticide exposures.[126] [127] [128] In a 1995 review of science, the NIH scientists concluded, "...it is striking that many of the reported increased risks [in children] are of greater magnitude than those observed in studies of pesticide-exposed adults. These reports suggest that children may be a particularly sensitive subgroup of the population with respect to possible carcinogenic effects of pesticides. This is of concern, given the children employed in farmwork and the high prevalence of pesticide use in the home in the general population."[129]

Besides these reports of possible long term health risks, the risk of acute poisoning is also a potential concern.[130] In 1996, the American Association of Poison Control Centers reported handling 86,912 poison exposure cases involving pesticides. More than half of these (45,897) were reported to involve children under the age of six.[131]

Cost and Availability of Pesticides

Between 1950 and 1985, the cost of developing a new pesticide increased at an exponential rate.[132] The EPA is currently going through a re-registration process requiring more stringent studies of pesticides' long-term effects, and the U.S. General Accounting Office has reported that many manufacturers have fallen behind in completing that process.[133] Human health effects data continue to accumulate in the scientific literature. And recent animal studies have reported disruption to hormonal systems and reproductive success at pesticide levels much lower than the cancer-causing levels used to set current tolerances, which has prompted the National Academy of Sciences and the EPA to launch a major review of this new scientific evidence.[134] [135]

For these reasons, the cost of pesticides may continue to rise sharply and products that professionals and residents are accustomed to using may be withdrawn from the market due to either tighter regulations or increased cost of registration. Landscape professionals may wish to learn about the alternatives to chemical-intensive management in order to have business and management options available to them as pesticide costs increase and availability decreases.

The remainder of this report describes some of those alternatives, as they are being practiced today by turf professionals around the Pacific Northwest.

"It is critical to educate the general public that the darkest green turf, which many people strive for, is not in fact the healthiest turf. A medium green turf with a moderate growth rate will have the deepest root system with less thatching, reduced disease and insect problems, and increased tolerance to environmental stresses such as heat, drought, cold, and wear."[136]

Dr. James B. Beard, Prof. Emeritus, Texas A & M University, author of the text Turfgrass: Science and Culture, writing in the Journal of Environmental Quality, May 1994.

Healthy Lawns Grow on Healthy Soil: Cultural Practices that Support the Turfgrass Ecosystem

The remainder of this report assembles current best practices for lawn care, drawn from interviews with turf professionals (listed in acknowledgments) and from writings of scientists and professionals, particularly those practicing in the Pacific Northwest (see references and bibliography). Citations are given to support certain key statements, and footnotes will direct the reader to sources that explain a recommended practice in more detail.

Building Soil Health - Key Recommendations

The goal of this section is to recommend practices that support the natural vigor of grass plants and the soil community that sustains them, and minimize the need for practices that diminish that vigor. Recommended practices will include:

◊ Setting realistic expectations for lawn appearance, and tolerating a few weeds.

◊ Proper site selection, and preparing the soil by tilling in compost to a depth of 6 to 12 inches.

◊ The selection of site-adapted and disease-resistant grasses.

◊ Moderate fertilization with natural or natural/synthetic-slow-release combination fertilizers, *to build soil nutrient reserves and biodiversity.*

◊ Mulch-mowing (also called "grasscycling") whenever possible.

◊ Mowing regularly (remove only 1/3 of grass height each time), and mowing a little higher, at 2 to $2^1/_2$ inches on most lawns (or 1 inch for colonial bentgrass lawns).[a]

◊ Avoiding over-watering: watering deeply, to moisten the whole root zone, but infrequently, *to limit disease and build deeper roots*; and watering dormant lawns at least once a month during the dry season, *to improve post-drought recovery.*

◊ Renovation/improvement practices that include aeration, compost topdressing,[b] and overseeding, *to reduce compaction, increase water infiltration, improve soil structure and natural disease control, and crowd out weeds.*

◊ An integrated approach to pest problems that includes:

1) Correctly identifying the cause of the problem
2) Understanding the biology of the pest organism and its natural predators

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[a] Alternatively, Washington State University recommends a mowing height of $1^1/_2$-2 inches for perennial ryegrass mixes west of the Cascade mountains, or ¾-1 inch on colonial bentgrass.

[b] Dr. Stahnke of WSU has reservations about topdressing with pure compost, due to potential layering, particle size, stability, and cooler soil temperatures west of the Cascades. See page 25 for more information on topdressing.

3) Setting realistic thresholds of acceptable damage to the lawn from pests (weeds, diseases, and insects)
4) Monitoring for pest problems at appropriate times of the year, and
5) Treatment of over-threshold problems with methods that support the turfgrass ecosystem and have the least non-target impacts on beneficial soil organisms, wildlife, pets, or humans. Where chemical solutions are necessary, time applications for maximum effect and use spot applications. *Repeated broadcast or calendar-based applications of pesticides should be avoided because they may damage the diversity and stability of the grass/soil ecosystem.*

Setting Expectations and Tolerance Levels: What Color is a Healthy Lawn?

As described in the first section, professionals find that ecologically managed lawns can meet high appearance standards with appropriate management. But it is important for professionals, customers, and yard owners to ask themselves, "What do I want my lawn to look like, and why?" While customers may say they want a weed-free lawn, professionals report that most people visually rate a vigorous, healthy, neatly mowed lawn that includes many broadleaf plants as having a good overall appearance.

Clover is perhaps the prime example of a "weed" that is difficult to eradicate, even with chemicals. Clover accepts mowing well, is green year-round, fixes nitrogen and improves the soil, coexists well with grasses in native meadows as well as lawns without dominating, and was traditionally included in grass seed mixtures for all these reasons. Then clover-selective herbicides were developed and it became a "weed".[137] Families that have a member allergic to bee stings may want to hand weed or spot chemical-treat clover. For most people, however, accepting a few clover or other broadleaf plants in the lawn will save a lot of work and pesticide exposure without detracting from appearance.

As noted by Dr. Beard in the quotation that leads this section, many people have unfortunately developed an unrealistic expectation of a deep blue-green lawn. While that color can be maintained for a while in Kentucky bluegrass turf under high rates of nitrogen fertilization, that much nitrogen damages the health of the grass plant and soil (see page 10 for citations). And Kentucky bluegrass just doesn't grow well in our wet winters west of the Cascade Mountains. The grasses that do grow well, such as the turf-type fescues and perennial ryegrasses, have a lighter, meadow green color when grown on fertile soils (though some newer cultivars are darker than others).

Another common misperception is that lawns should be a single species, or monoculture. In nature, grass ecosystems consist of several site-adapted species. This diversity lends stability to the system because no disease or pest is likely to wipe out every plant, and it allows each species to thrive under the soil or shade conditions that suit it best. Modern grass seed mixes for this region emulate this natural diversity, and over time these planted grasses will be joined in the lawn by other native or introduced species (such as annual bluegrass) that do well under the same conditions. While a fairly uniform stand can be maintained by annual overseeding, the best strategy is to accept the slightly different hues of green these various grasses show, and manage for overall health of the ecosystem.

Letting go of the absolutely uniform blue-green carpet is the first necessary step towards ecologically sound lawn care.

Making the Choice for Ecological Management

Horticultural professionals know that while a wide range of practices may sometimes be used together, some combinations of practices just don't work out well. In lawn care, the use of high levels of nitrogen fertilization along with regular spraying for the diseases and pests that are more prevalent under that approach seemed to work well for a while: the combination made sense. Likewise, ecological lawn care comes as a logically consistent set of practices, that starts with Hippocrates' premise, "First, do no harm. Then, try to do good."

In the real world, some practices *only* work well together. For instance, scientific trials and professional experience show that mulch-mowing and fall application of screened compost will build up the organic content, structure, and nutrient reserve of the soil, *but only* if there are earthworms and other invertebrates and an active microbiota to incorporate these materials into the soil. So these soil-building practices will not work well in combination with frequent broadcast use of pesticides, "weed and feed", or heavy use of soluble nitrogen fertilizers, all practices that reduce worm populations (see citations, page 10). And worms, actively tilling and aerating the soil, leave small mounds of earth on the soil surface which can be unsightly in closely mowed turf, but disappear in a dense turf that is mowed at 2 to $2^1/_2$ inches as advocated here. Give the practices recommended here a fair try, observe the results, share information, and adapt the best of what you learn to your own situation.

Looking at Lawns: Evaluation and Monitoring

Soil Analysis

The starting point for building soil and grass health is knowing what's there. A soil analysis is an excellent beginning, whether you're installing a new lawn or improving an old one.[a] The test can reveal acid conditions, which are common west of the Cascades because of rainfall leaching the soil or because of previous use of synthetic fertilizers, and the results will also tell how much lime to add to correct this condition. Salt build-up from soluble fertilizers or nutrient deficiencies of calcium, magnesium, sulfur, phosphorus, and potassium are all difficult to determine visually, but easy to read from the test results, which should include recommendations about how much of what amendment is needed to correct the problem.

Visual Evaluation

This is the time to set your expectations and tolerance levels. Stand across the street and look at the lawn's overall appearance. Then walk slowly closer, looking for differences in color and density, particularly brown or yellow patches. Notice how close you have to get for the weeds to show up. You may decide that big weeds like dandelion and plantain have to go (use a long-handled weed puller to get them without stooping, or spot spray). But smaller plants like lawn daisies, clover, buttercup, or yarrow can actually look just fine from street distance. Decide which plants you really don't like: now they are the "weeds", and the others are just part of the lawn community. (Don't worry, healthy grass can out-compete most broadleaf plants with proper management.) As you walk closer, identify the areas that seem least healthy, and those that look best. Now it's time to figure out why these areas are different.

Looking Below the Surface: The Life of the Soil

A **T-handle soil core sampler** (or soil augur), available from garden stores or catalogues, is the most valuable lawn monitoring tool you can own. For evaluating different areas of the lawn, the soil sampler makes it easy to pull a 4-6 inch deep plug to compare soil texture, color, and compaction. When irrigation season comes, the soil sampler is handy to check on whether water is penetrating through the root zone. A sharp trowel or knife can also be used to cut 6-inch deep plugs that can be cleanly replaced after evaluation. For problem areas, cutting a one-foot square of turf on three sides and folding it back like a rug will give more information. Good soil will be crumbly, brown, sweet smelling, and lively with earthworms, predacious beetles, and other smaller invertebrates, most of which are beneficial.

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[a]Call your local Cooperative Extension for information on soil analysis sources. In King County, call 296-DIAL (206-296-3425) and select tape #144 to hear an excellent introduction to soil analysis, potential soil problems, and reading test results. Or call 296-3900 and ask for their soil test factsheet.

Problems to look for include:

◊ **Overall yellowish, thin lawn appearance, with weeds getting the upper hand**: unhealthy, infertile soil, correctable with the practices outlined in "Renovating or Replacing Old Lawns" (p. 24).

◊ **Yellow or brown patches in grass**: signs of dog urine damage, fertilizer burn, scalping with lawnmower, or sometimes disease or insect damage. Water and time will cure the first three of these.

◊ **Heavy clay soil, or hardpan a few inches down**: causes poor drainage and root development – in extreme cases lawn may need to be torn out and compost tilled in eight inches deep to improve the soil structure, before replanting. Compost incorporation is the key to both "opening up" clay soils and to improving the fertility and moisture-holding capacity of sandy soils.

◊ **Hard, compacted soil**: signs of heavy wear, usually correctable over time with core aeration, grasscycling, compost topdressing, and then avoiding use of chemicals toxic to earthworms. Compacted soils may also be found after years of heavy pesticide and soluble fertilizer use.

◊ **Infertile soil with little organic matter**: usually lighter in color, sandy, gravelly, sometimes subsoil left after grading for construction. Again, compost is the answer. See "Topdressing" (p. 25).

◊ **Poor drainage**: standing water in winter; blue, gray, yellow or black soils, sometimes bad-smelling. Area may need to be re-graded so water drains off, or soil may need to be improved with compost so water drains through, or both, followed by replanting. Sometimes a subsurface drainage system can be installed to drain the root zone, but this is expensive and will require maintenance. In extreme cases, consider replacing the lawn with ground cover plants that tolerate saturated soils.

◊ **Shallow root development**: all of the above conditions can cause this, as well as inadequate topsoil depth, frequent shallow or excessive watering, and excess thatch layer. Roots should extend at least four to six inches into soil, be white or light tan color and be strong enough to be hard to pull out.

◊ **No worms**: usually caused by overuse of pesticides and soluble fertilizers, sometimes by very poorly drained soils. Soil life will return over one to two years with proper management. Worms working the soil aerate, improve drainage, and incorporate thatch, grass clippings, and topdressed compost into the root zone - they are the best, easiest, cheapest lawn improvement tool you can get.

◊ **Root-eating grubs**: crane fly larvae are the only serious insect problem in this region, sometimes causing noticeable brown patches in early spring, but birds feeding on the lawn in the winter usually keep them under control. If you see more than 25 ¾-inch-long gray-brown grubs per square foot when you turn back the lawn "rug" in February or March, turn to the "Crane Fly" section (p. 49).

◊ **Excess thatch**: the layer of tough, brown, fibrous material on top of the soil in your plugs is called thatch. It is roots, stems, and stolons (above-ground roots) that haven't broken down yet (not grass clippings). One-half inch of thatch helps turf stand up to wear; much more than that is a problem causing shallow root development and poor water infiltration. It's usually a sign of over-fertilization, over-watering, compacted soil, or over-use of chemicals, particularly on thatch-prone bentgrass lawns. See "Thatch Removal" (p. 26).

◊ **Moss**: may be a sign of acidic, compacted, infertile, over-watered or poorly drained soil, or a site that's just too shady for grass. Essentially the moss is out-competing the grass for space. To help the grass re-colonize the site, correct the problem conditions, see page 43.

Building soil health – the structure, organic content, and diverse life of the soil – is the key to growing healthy, vigorous grass that out-competes most weeds, resists disease, stands up to drought, and is easy to care for. Like any garden plant, grass has conditions that suit it best: deep, fertile, well-drained soils; full sun to medium shade; neutral to slightly-acid pH; and the full complement of naturally occurring soil organisms, particularly earthworms. The next sections will detail how to provide these conditions when installing, maintaining, or restoring lawns.

Installing New Lawns

Size and Location of Turf Areas: How Much is Enough?

While low maintenance grass areas can get by with only occasional mowing and without irrigation or fertilizer, high quality turf for lawns requires a lot of work to install and maintain, and will usually need some water and fertilizer to look its best. Other options, including drought-tolerant perennial plants, shrubs, and trees (including site-adapted native species) have a place in the home, commercial or institutional landscape. These options have value in providing visual variety, privacy, wildlife habitat, soil and water conservation, and ease of maintenance. So it's worth asking some questions when planning a landscape:

- ◊ How will the proposed turf areas be used (sports, play, picnicking, ornamental, etc.)?
- ◊ What size and other attributes are needed for these uses, and for ease of maintenance (shape, levelness, drainage, sun/shade, high or low appearance standards)?
- ◊ How much work and resources will it take to install and maintain that turf? What are the options? Can turf areas be reduced or relocated so that grass is growing in level, sunny, well-drained sites that serve the uses, while lower-maintenance plantings fill other areas?[a]

Site Requirements: Drainage, Slope, & Sun

Drainage: Grasses won't grow well in saturated soil. So lawns need two kinds of drainage: surface and sub-surface. First, lawns need a surface shape that has no low spots for water to puddle and a slight slope so that some water from heavy rains can run off. Second, lawns need a soil profile that is "well drained", where water can percolate through to below the root-zone (at least 8 inches deep). In extremely low sites, subsurface drainage systems may allow a successful lawn to be planted where the water table would otherwise rise to the surface during winter months.[b] Sandy loam soils are ideal for grasses, but other soils such as clay and hardpan that create drainage problems can be amended (see "Soil Preparation" below).

Slope: A slight slope away from buildings is recommended – at least 1% (1 foot drop in 100 feet) to as much as 6% (6 ft. in 100 ft.). Slopes between 6% and 12% are manageable but will probably have some problems with local dryness in summer, and will be less resistant to heavy wear. Over 12% (12 ft. drop in 100 ft.) it becomes difficult to establish, water, and mow a lawn, and lawn quality suffers. These slopes should generally be converted to some lower maintenance grass or perennial plant landscaping, with full ground coverage and heavy organic mulching to resist soil erosion.

Sun: Most grasses grow best in full sun to medium shade (see "Seed Selection" below). Light shade from deciduous trees is be fine for some grasses like the fescues, and can reduce the need for summer watering. But solid shade from buildings or dense coniferous trees always results in a weak, sparse lawn. Convert these areas to other uses (see "Size and Location" above).

Soil Preparation

Those lucky enough to have an agricultural-quality sandy or clay loam soil at least 12 inches deep can proceed to grading and planting. All other soils, whether sand, glacial till, or clay, should be amended as follows:

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[a] An excellent introduction to selecting alternative plantings is the Washington Toxics Coalition's four-page factsheet *Appropriate Plants for Northwest Landscapes* (see WTC under "Organizations" in the Bibliography).

[b] For a good discussion of drainage, soils, and grass varieties see *Home Lawns*, available from WSU Cooperative Extension, in the bibliography.

***minimum specification**:* 2 inches of compost that meets Washington's Grade A guidelines[a] [138] tilled and completely mixed into the upper 6 to 8 inches of soil, for a finished organic amendment content of 20 to 25%.[b]

***preferred specification**:* 4 inches of Grade A compost completely mixed into the upper 12 inches of soil, again for a finished compost content of 20-25%. This is valuable for improving drainage in the root zone, though regrading the surface for better runoff or installing a subsurface drainage system may also be needed on very wet sites. A tractor-mounted rotovator is useful for this depth of tilling, and a ripping plow may be necessary to break up "hardpan" or compacted glacial till soils.

***optional additional seedbed preparation**:* An additional 2 inches of the same or slightly finer screened compost, or topsoil, completely tilled into the upper 3 inches of soil.

***nutrient and pH correction**:* A soil analysis is preferable (see page 15) to reveal nutrient deficiencies or acidity, which can be corrected with amendments such as dolomitic lime tilled in at this time, although the added compost will also tend to buffer soils toward a more neutral pH and supply some missing nutrients. 100 lb. of dolomite lime per 1000 sq. ft. can be tilled in with good effect if no soil test is available. (Attempting to amend soils with uncomposted organic materials is not recommended, but if done it requires a soil test after tilling, because of the widely varying pH and nutrient levels of these raw materials.)

The goal is to never have sharp horizons ("layers") in the soil profile, as these will tend to limit the depth of root development. Complete tilling is also critical – buried organic layers such as old lawns under a layer of topsoil can also limit root development. The use of raw, uncomposted organic materials such as sawdust, wood chips, bark dust, or fresh manure is not recommended, because of problems with nitrogen deficit in the woody materials and weed seeds in fresh manure, and uneven settling encountered with both. It is better to hot-compost these materials on site for at least a month before tilling them in.[c]

Mature compost, while costing more than uncomposted organic materials, enhances the quantity, diversity, and stability of soil life from microbes to earthworms;[139] improves structure;[140] tends to correct pH imbalances;[141] [142] improves water infiltration;[143] [144] [145] and reduces damping off, red thread, and other fungal diseases.[146] [147] [148] Compost also inoculates the soil with beneficial "mycorrhizal" fungi, which improve the vigor of grasses and other plants by making more nutrients available to the root hairs, and protecting them from disease-causing fungi.[d] [149] [150] [151]

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[a] The compost manufacturer should be able to document compliance with the guidelines for "Grade A Compost", as described in Washington State Department of Ecology's *Interim Guidelines for Compost Quality*. Guides to compost use include the excellent *Using Composts to Improve Turf Performance* (Penn State University Cooperative Extension) and the *Cedar Grove Compost Users Guide for Landscape Professionals* (Seattle Public Utilities) both listed in "Organizations" section of bibliography.

[b] Some experts prefer to recommend a compost content of 15%-20% in the finished soil, citing the potential for waterlogging (excess moisture retention) on some soils. Generally 25% is the maximum recommended, though some professionals recommend up to 30% compost on some sites. This 30% is the level used in recent trials by the City of Redmond, WA. Redmond is working on a model building regulation and inspection effort to require soil preparation with compost when landscaping new sites. For information, or a copy of their report "Guidelines for Landscaping with Compost-Amended Soils", call (425)556-2815 or e-mail pcohen@ci.redmond.wa.us.

[c] Chipped woody wastes generated in site development can be hauled to a composting facility or composted on site prior to use by adding a nitrogen source such as grass clippings, manure, or fertilizer. Some knowledge of compost process is required; see Seattle Public Utilities in bibliography. A less preferable alternative is to soil-incorporate them along with 20-30 lbs. actual nitrogen per ton of woody waste, at least one month before seeding.

[d] Regarding mycorrhizae ("root fungi") Dr. Elaine Ingham of Oregon State University notes,

> "Mycorrhizal fungi colonize the roots, and in exchange for carbon (starch, sugars) from the plant, they bring back to the plant N, P, Fe, Ca, numerous other micronutrients, and at times, water. Thus, the plant grows much

According to Dr. Peter Landschoot, who has conducted extensive turf trials for Penn State University Cooperative Extension, 2 inches of compost well tilled in "can supply all the nutrients necessary for turf growth and development for an entire year."[152] For these reasons, Grade A compost may also deliver more benefit per dollar than topsoil mixes. Composted organic amendments (generated on or off site) which do not meet the Grade A standards can be very valuable, but may contain weed seeds or varying nutrient levels.[a] When buying topsoil mixes or ungraded compost, be sure to request nutrient and weed-seed test results.

what about adding topsoil? Commercial "topsoils" are usually a mixture of compost and subsoils of varied origin. They may contain invasive weeds, inadequate or toxic levels of some minerals, or be structurally incompatible with your existing soil. In general it is better to buy Grade A compost and till it in to your existing soil. The exception is where your soil is pure gravel – then you will have to add some mineral soil along with the compost. In that case, be sure to buy topsoil from a reputable supplier, and ask for a written commitment that it is free of invasive perennial weeds.

for clay soils: The addition of sand to clay soils is not recommended, because it may create a concrete-like structure. Clay soils are "opened up" most effectively by tilling in compost. Use the amounts of compost recommended above, or use larger amounts of a mixture of compost with coarser materials like bark. Do the tilling when the soil is not waterlogged, if possible, to avoid damaging the soil structure. If at least two months of warm weather is available before seeding, clay soils can also be successfully amended by tilling in large amounts of fall leaves or grass clippings and letting them decompose.

Seed Selection

For conventional lawns west of the Cascade Mountains (the region covered by this report), most turf professionals say that mixtures of turf-type perennial ryegrasses and the fine fescues (such as chewings, creeping red and hard fescue) offer the greatest flexibility and adaptability to local conditions.[b] A <u>mixture</u> of species and varieties will withstand diseases and adapt to various sites much better than a monoculture. In general, ryegrasses like full sun, whereas the fescues do well in sun (and are more

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better. Mycorrhizal fungi also often protect the roots against disease-causing organisms – from bacterial pathogens, fungal pathogens, and root-feeding nematodes.

"Grasses are, for the most part, obligately mycorrhizal – that is, they require mycorrhizal fungi in order to obtain nutrients from the soil when in competition with weeds. The particular types of mycorrhizal fungi that colonize grasses are VAM, or vesicular arbuscular mycorrhizal fungi. That means the fungus produces arbuscles and vesicles inside the root cells of the plant.

"If, in the soil preparation step, the VAM fungi are destroyed, the grass will not be able to compete with the weeds. Fertilizer also reduces or destroys the VAM component. We have data showing that places receiving fertilizer have much lower levels of VAM colonization. Compost usually contains a reasonable amount of VAM innoculum. In some restoration studies (classic work done by Odum on restoration of mine spoils in Kentucky and Tennessee) it was not possible to get anything but weeds to grow until the soil was innoculated with VAM." (E. R. Ingham, pers. comm., 3/9/97. See also her web site, http://www.soilfoodweb.com)

[a] Compost should preferably have passed through a hot (150° F. for 3 days) aerobic process and have a sweet, earthy smell. (But on-site produced compost may not need a hot process if no weed seeds are present in the materials.) To reduce weed problems when using compost that has <u>not</u> passed through a hot process, as well as fresh manure or "topsoil" mixes, incorporate them at least a month before seeding, water, and then cultivate the surface shallowly two or three times before planting to kill the sprouting weed seeds.

[b] *Turfgrass Seeding Recommendations for the Pacific Northwest* from WSU Cooperative Extension (see bibliography) gives the range of cultivars for conventional lawns and seeding rates (lb. of seed per 1000 ft.^{2}).

drought tolerant) but are also among the most shade-tolerant of Northwest-adapted species. Ryegrass stands up best to heavy wear, much better than fescues, so it is the choice for sports fields. But most rygrasses have a higher nitrogen requirement than the fescues, and so are is less appropriate for low maintenance turf. Seeding a blend of several species and varieties will allow each to thrive in the lawn area that suits it best.[a]

Even for a low maintenance lawn of fescues, planting a mix that includes some rye makes sense because the rye sprouts and grows quickly, helping to close the turf canopy and prevent weed invasion. Kentucky bluegrass, which dies out after a few seasons in this region, is used in some mixes for this same purpose. White clover, strawberry clover, or other clovers in the mix will fix nitrogen from the air and reduce the need for fertilizer. Always buy seed grown and adapted to this region and buy from a knowledgeable dealer. Buy the best seed available, preferably certified seed, which is weed-free and germinates dependably. Good seed is inexpensive compared to sod or other lawn materials.

Other lawn seed possibilities

- ◊ Seed-borne *endophytes* are symbiotic fungi that are naturally found in some grasses. They impart some insect and disease resistance[153] and possibly drought hardiness.[154] Several rye and fescue cultivars are currently available with endophyte inoculation, although they have not proven resistant to the European crane fly, the one insect pest in this region. They should not be planted in or near pasture areas because of possible ill-effects to grazing cattle. (Another more common, and non-toxic, kind of beneficial fungi, the soil-borne *mycorrhizal fungi*, are essential to vigorous turf but cannot be inoculated on the seed. Fortunately, good turf practices like using compost and reducing pesticide use can encourage growth of these essential mycorrhizal fungi. See footnote, previous page.)
- ◊ Kentucky bluegrass does not grow well west of the Cascades, although up to 10% in a mix can perform the same function as rye of closing the canopy quickly, before it dies out.
- ◊ Dwarf tall fescues need to be mowed higher, 3-4 inches, and have a rougher appearance. But they develop deep root systems in good soils and stand up to drought, poor drainage, and salty soils better than most grasses. And they have the fescues' low fertilizer requirements. They are bunch-type grasses, and don't spread into garden beds like creeping varieties.
- ◊ Colonial and creeping bentgrasses do spread, but are well adapted to western Washington. They can be the most thatch-producing, but that tendency can be controlled by minimal fertilization and proper mowing height (mowing too high produces more thatch in these species). Unlike the other grasses mentioned, the colonial bentgrasses look best when mowed at 1 inch (or even less, down to $^1/_2$ inch!)

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[a] Tom Cook of Oregon State University (originator of the Eco-Lawn mixes, among other accomplishments) suggests a very different approach to selecting lawn seeds. He argues that native and naturalized species, such as the bentgrasses, annual bluegrass and velvet grasses, are best for planting in low maintenance lawns, because they have low fertilizer and water requirements, and because they will move in and dominate eventually anyway. He comments,

> "The reality is throughout the Pacific Northwest that regardless of what you plant in the way of popular domesticated grasses, indigenous species which are better adapted will encroach and dominate the site. These climax grasses include bentgrasses, roughstalk bluegrass, annual bluegrass, and velvetgrass primarily. Climax grasses handle wet soils, have better shade tolerance than any of our domesticated fine or tall fescues, generally grow well on infertile soils, and survive drought stress periods well by going dormant or producing seed. In many respects they are the ultimate low input lawns. They also are grasses that look best in summer when they are irrigated frequently though not heavily. By ignoring these grasses you end up encouraging people to plant perennial ryegrass which has the highest fertility requirement of all turfgrasses we grow and sets the standard for red thread susceptibility. Adding fine fescues to perennial ryegrass means the fine fescues will dominate the mix at most sites and give you a serious thatch and red thread problem. These may be the grasses sod [and seed] growers want to grow and maintenance people want to maintain, but they are not the grasses most people end up with in their lawns. Ignoring them won't make them go away, and spraying out your lawn periodically and replanting increases use of pesticides and fertilizers."

though this also means a shallow root system and quick browning in the summer. They tolerate acid soils, recover well after drought, and are often prevalent in older lawns (see Tom Cook's footnote, previous page).

◊ "Low Grow" mixes that are slower growing (and don't require fertilization after they're established) generally include the slow-growing Barclay's Rye along with fescues and white clover. They can be mowed and watered less frequently.

◊ "Eco-Lawn" mixes combine Barclay's Rye or fescues with yarrow, English daisy, strawberry clover, and other small flowering plants to produce a lawn that prefers no fertilizer and needs only monthly watering to stay green through the summer. Eco-lawns have small flowers blooming through most of the season. A very low maintenance option, these seed mixes are more expensive and the lawn, an attractive low meadow, is farthest from the conventional, uniform and flowerless traditional suburban lawn (see p. 22 for more information).

Seed or Sod: Pros and Cons

Each approach has its uses, and for immediate establishment and use or quick repair, sod is the clear choice. Sod is usually weed free, whereas seeding may require some weed control efforts in preparing the seedbed, and until the new grass thickens into a dense turf. However, sod also has several drawbacks which should be considered:

◊ The soil preparation is exactly the same for seed or sod (minimum of 6 inches of compost-amended soil, see p. 17). So sod installation will be more expensive and just as time-consuming as seeding. Installing sod over un-amended soil (unless it's a high-quality topsoil at least 6 inches deep) is a recipe for lawn failure.

◊ Sod is usually perennial rye-grass and Kentucky bluegrass (quick growers) neither of which is the best lawn choice by itself. Look for a rye-fescue or other mixed-species sod that meets your site requirements.

◊ Grass root development will be diminished by any change (layer) in the soil composition, and since it is difficult to get sod grown in a soil medium that matches the site's soil, this may lead to poor rooting depth in the long term, when compared to a lawn that is seeded on well-prepared soil.

◊ Sod's roots are easily damaged by drying in the sun before laying or contact with dry soil after laying, which will also have long-term effects on rooting depth. Buy freshly-cut sod, and lay sod on misty days over well-prepared moist soil; then water regularly until fully established.

Seedbed Preparation, Seeding, and Care of Young Turf

preparation: After tilling in mature compost or topsoil and any amendments indicated by the soil test (see Soil Preparation above), the site should be graded, then rolled and re-graded to ensure a smooth seedbed. Any unevenness will cause the mower to scalp the high spots later. Ideally, the site would be irrigated after grading and rolling, left to settle for a week, then re-leveled and planted.

when to seed (or sod): Early fall, from September 1st until October 15, is the safest time to seed lawns west of the Cascades. (Fine fescues should be seeded in early to mid September.) New seed or sod will need a steady water supply for at least six to eight months to become fully established. Prepare the site in late summer and, if possible, irrigate it to moisten the soil and cause weed seeds to sprout. Then till shallowly or rake, just before seeding, to kill the young weeds (though tilling will not kill invasive grasses like bentgrass and quackgrass, if present). Early spring (April to mid-May) is also a good time to seed, if irrigation is available for the summer. For the first few months, on hot sunny days the young grass plants will need light irrigation two to three times a day. Even with fall planting it is best to irrigate once a week during the following summer, to build a dense, deep-rooted turf.

seeding: Just before seeding, rake the seedbed to loosen the upper $^{1}/_{2}$ inch. Moisten the seedbed well with irrigation if needed. Divide the seed in half and sow twice to get more uniform coverage – if using a spreader go perpendicular to the first pass on the second seeding. After seeding rake lightly, or scatter a very thin ($^{1}/_{8}$ inch) layer of sifted compost. Then roll to insure good seed-soil contact. For large sites or sloped areas, hydroseeding is effective, but be sure that the seed mix fits the site and maintenance plan.

care of young lawns: Young grass needs soil that is moist, but not waterlogged. Be ready to irrigate if the rains fail, and in hot, sunny weather irrigate lightly two or three times a day for the first two months. Use of a high quality mature compost in the soil preparation will greatly reduce the chance of damping-off or other fungal disease.[155] Begin mowing when the grass reaches the recommended mowing height, unless the ground is too soft to walk on without leaving depressions, and mow weekly at 2 to $2^{1}/_{2}$ inches height (or 1 inch on bentgrass lawns). Be sure to leave clippings on the lawn; they're free fertilizer and will nourish earthworms and other beneficial soil life.

If the soil is properly prepared with mature Grade A compost and mineral amendments (see page 17), no additional fertilizer will be needed for the first 6 months of the lawn's life.[156] This eliminates the danger of fertilizer burn (with soluble fertilizers) and also the leaching or runoff of fertilizers into ground water and streams, a problem that research at WSU has shown to be most pronounced on new turf in soils with low organic content.[157] Where lawns are planted on high-quality topsoil, but without compost, fertilize lightly at planting ($^{1}/_{2}$ lb. actual nitrogen per 1000 ft.^{2}) with a complete natural-organic fertilizer, or with a "bridge" fertilizer (natural plus slow-release synthetic), to feed both the germinating grass and the developing community of soil organisms.

Lawn Alternatives: Eco-Lawns, Moss Lawns, and Other Ground Covers

Various lower maintenance and site-adapted alternatives exist where a strictly conventional lawn appearance is not required. Just including clover (white, strawberry, or other turf-compatible clovers) in a grass seed mix will reduce the nitrogen needs of the lawn. Possibilities include:

Eco-lawns: These mixes, originally developed by Professor Tom Cook at Oregon State University, include low maintenance grasses, clovers, yarrow, daisies and other small flowering plants to emulate a natural grass community that can stand mowing. They do well in dry sites, should not be fertilized at all, and need only monthly watering in the summer to stay green once established (just as much irrigation is required for establishment as a conventional lawn). They can be mowed less frequently, at 2 to 4 inches high (mow them down to 2" at the start of the winter).[a]

The seed is relatively expensive, so it is more appropriate for a home lawn than a large site. Tom Cook recommends a seeding rate of 2 lb. seed per 1000 ft.^{2}, which is higher than the seed packages usually say. To reduce invasion by bentgrass, Professor Cook recommends that old lawns be removed with a sod-cutter or killed with glyphosate (*Roundup*; see Lawn Replacement Techniques below) before seeding Eco-Lawn mixes. Some residents report success by just de-thatching old lawns and overseeding Eco-lawn seed, but it is not clear whether the seeded plants will be out-competed by bentgrasses over time. Liming to reduce acidity <u>may</u> help shift the balance in favor of the seeded plants.

moss lawns: Fescues are the most shade-tolerant of commercially available grasses (although Tom Cook of OSU notes that naturalized grasses like roughstalk bluegrass, annual bluegrass, and bentgrass, which are found in older lawns, are fairly shade tolerant). But heavy shade and acidic soils under conifer trees will keep any grass from doing well. Under these conditions, mosses will start to predominate in the lawn. One approach that has been suggested (but not well tested in controlled trials in this region) is to

[a] Current information about Eco-lawn research can be obtained from Oregon State University Cooperative Extension, Corvallis OR 97331.

encourage the moss, and discourage the grass "weeds" by acidifying the soil further, to the point where a complete moss ground cover is established. In heavy shade areas, sprinkling powdered sulfur (alone or with aluminum sulfate) on the designated area to lower the pH to 5.0 to 5.5 (a soil test is recommended) will reduce grass growth and provide ideal conditions for mosses to colonize the area fully, which will take four to twelve months.[158] Moss lawns are fairly tolerant of light traffic, and offer an evergreen alternative to grass in very shady areas.[a]

other shade tolerant ground covers: Shady sites may also be planted with shade-tolerant ground covers. Sloped sites where mowing will be difficult also lend themselves to certain ground covers, and some residents prefer to convert all or most lawn areas to plantings that don't require mowing, fertilization, or watering. A wide range of native or locally adapted plants are available, depending on site characteristics such as soils, sun, and intended use. Books, brochures, and local extension services can help with selecting and finding sources for appropriate plants.[b]

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[a] Moss lawns and other alternatives, as well as ecologically sound care for grass lawns, are discussed in a well illustrated booklet from the Brooklyn Botanic Garden, *The Natural Lawn & Alternatives* (in bibliography).

[b] Numerous alternative grass and ground cover species are described in *The Wild Lawn Handbook* (see bibliography). For information on locally adapted ground covers, call your Cooperative Extension Service. In the Seattle area, excellent information and brochures are available through the Green Gardening Program, Cooperative Extension, and also Seattle Public Utilities' Resource Conservation office (see "Organizations" section of bibliography). Professionals seeking native plants should consult the periodically updated listing *Hortus West* (see bibliography).

Renovating or Replacing Old Lawns

Deciding Whether to Improve ("Renovate") or Remove and Start Over

Older lawns can be renovated without complete replacement if:

- ◊ The lawn is up to 50% weeds.
- ◊ The grasses are of inferior appearance or are disease prone.
- ◊ The soil is compacted, but not underlain by hardpan within 6 inches of surface.
- ◊ The owner is willing to accept gradual improvement over one to two years.

On the other hand, complete removal, soil amendment, and replacement is preferable under these conditions:

- ◊ Soil is low in organic content, deeply compacted (more than 2 inches down), underlain by hardpan, or very poorly drained. These soils need to be amended, and subsurface drainage systems may be needed to solve drainage problems (see page 17).
- ◊ Owner or manager desires a rapid improvement. Professionals may find that it is more efficient to remove old lawns and improve the soil for quick and dependable results.

Renovating Lawns: Restoring an Old Lawn to Top Condition

Grass varieties available for lawns have improved considerably in recent years, in terms of appearance, disease and insect resistance, and local adaptation. Grass plants in our lawns get old, and we mow them too short to allow them to set seed and rejuvenate our lawns as they do in natural meadows. We also play hard on our lawns, and may have used chemicals that reduce the populations of earthworms and other organisms that prevent compaction and recycle nutrients in natural grasslands (citations, page 10).

An older lawn can greatly benefit from ***aeration*** to reduce compaction and improve water infiltration; ***overseeding*** to rejuvenate the grass community and fill in bare spots where weeds might take hold; and ***topdressing*** with compost to feed the soil, build earthworm populations, improve drainage, and protect against fungal disease (citations, page 18). Lawns that have been over-fertilized or treated with broadcast applications of pesticides (such as "weed and feed" products), or bentgrass lawns that are mowed too high, may also have accumulated more than $^1/_2$ inch of thatch, and need ***de-thatching***. Spring (April to mid-May) or fall (from September 15 until October 15) are the best times to renovate.

step one: Aeration

Compaction is one of the main causes of poor lawn appearance, whether it's caused by heavy wear or overuse of chemicals. Core aeration removes plugs of soil and thatch to improve water infiltration, drainage, and oxygen content of soils. Dry, hard soil can be irrigated deeply to allow better penetration, but the best times to aerate are in the spring and early fall when soils are naturally moist and grass is growing quickly. The deeper the penetration of the aerator the better. Walk-behind aerators, available from equipment rentals, pull cores 2 to 3 inches deep under the ideal moist soil conditions. Make several passes (3 or more is best) and leave the cores on the lawn – dragging or raking will help them break down more quickly. For sites with deeper compaction and drainage problems or heavily used athletic fields, tractor-mounted "shatter-core" aerators can penetrate 6 inches or more, or a "mole plow" can created drainage channels even deeper.[a] Very small lawns can be aerated with a garden fork, by inserting the fork 6 inches deep every 4 to 6 inches and levering back gently. Aeration should be followed by overseeding, and then, preferably, by topdressing to fill the core spaces with improved material.

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[a] Deep aeration is a relatively infrequently used but extremely valuable practice for poorly drained or high wear soils in the rainy Northwest. Finding a contractor with the right equipment and skills may take some detective work. Start with "Landscape Contractors" or "Lawn and Grounds Maintenance" in the Yellow Pages.

step two: Overseeding

Overseeding will be most successful following aeration or when done with a tractor-mounted slice-seeder, but even heavy raking or power de-thatching can help to create the necessary seed-to-soil contact. Overseed when conditions are good for germination and growth: ideally April to mid-May in spring, or September 1st to October 15 in the fall. The soil must be moist, and warm enough for seeds to germinate well - after April 1st and before October 15 in the Puget Sound region. Overseeding thin lawns in September will help to crowd out weed seeds that have dispersed through the summer and might take over in fall otherwise. Professionals find that both aeration-and-overseeding and slice-seeding can also be practiced in late August so that when the rains come the seeds are waiting in the soil and will compete well with weed seeds. This requires a tractor-mounted aerator or slice-seeder to penetrate the dry soil. Spread improved seed mixes (see Seed Selection) at one-half the coverage rate that is recommended for new lawn establishment, to ensure vigorous competition with weeds. Overseeding should preferably be followed with at least a light topdressing to cover the seed. An exception is when the seed is placed into the soil with a slice-seeder, but even then topdressing has added benefits.

step three: Topdressing with compost

Topdressing with sand or topsoil has long been practiced to improve soil structure and drainage and encourage microbial breakdown of thatch buildup. Recent studies and trials have demonstrated even greater benefits from applying mature compost as a topdressing, including improved resistance to turf diseases and an increase in the soil fertility, resistance to compaction, and the diversity of beneficial soil organisms (see citations and footnotes, pages 17-19 and [159] [160] [161] [162] [163] [164]). Some turf managers use a 60/40 mix of compost and sand or topsoil, which is heavier than pure compost and settles into aeration holes or thatch layers more readily.

While several of the turf professionals interviewed are topdressing with pure compost with good results, Dr. Stahnke of Washington State University has reservations about topdressing with compost. The concern is that with repeated applications, compost may accumulate as a surface organic layer. When making repeated applications of compost, always check a soil core to see that previous applications have been mixed into the soil before topdressing again. Aeration before or after topdressing (or both) will help mix compost into the soil.

Topdress when the grass is growing vigorously: in early to mid-spring or early fall. Avoid summer applications which may dry and form a moisture repellent layer on the surface. Use a "Grade A" compost product (see explanation, page 18) or compost known to be weed-seed-free, screened to $^{3}/_{8}$ inch and applied with a manure spreader or topdressing machine. On home lawn-sized areas, simply scattering compost with a shovel from a wheelbarrow and raking out with a leaf rake works well. Apply up to $^{1}/_{2}$ inch after core aeration (1.5 cu. yd. per 1000 ft. sq.) or up to $^{1}/_{4}$ inch without aeration, except on closely mowed bentgrass areas where $^{1}/_{8}$ inch is better. The grass should be standing up through the compost after application, not bent over or buried by it.

Raking or dragging after topdressing will help the compost fill the aeration holes better. On soils with an active earthworm population, compost topdressing can be applied without aeration, but watch out for a surface organic layer developing; aeration is always better. Before making repeated applications, check a soil core to see that previous applications have been mixed into the upper soil, rather than building up as a surface layer.

The normal sequence is aeration, overseeding, and then topdressing. But if no seeding is anticipated, the compost can actually be incorporated better by topdressing first, then aerating (in several passes), and finishing by dragging or raking. [a]

Compost topdressing should be practiced with care on turf that has been heavily treated with pesticides or water-soluble (quick-release) fertilizers, which can cause a decline in soil organisms (see citations, page 10). Without earthworms and other soil organisms to incorporate the material, an organic layer may build up on the surface, limiting root growth and water infiltration just like thatch buildup. On these soils, apply no more than $^1/_4$ inch of compost (with aeration), twice a year, until significant earthworm activity is noted and core samples show that the material is being incorporated into the upper soil layer. Generally, soil life should return to normal within 1 to 2 years after heavy chemical use is stopped.

optional step: Thatch removal

Thatch is the woody parts of the grass plant – stems, roots and stolons (above-ground roots) – that accumulate above the soil. Thatch is not grass clippings, which break down and return to the soil quickly. In plugs or core samples, thatch is the brown, fibrous layer on top of the soil. A moderate thatch layer, about $^1/_2$ inch, protects the soil from erosion, binds plants together to resist wear, and cushions falls from people playing on a turf area. But much more than $^1/_2$ inch can be a problem, reducing aeration and water infiltration. Extreme thatch buildup (several inches) causes the active roots of the grass plant to grow in the thatch layer rather than the soil, making the lawn nutrient-starved and prone to drought stress. Excess thatch accumulation is associated with over-fertilization and heavy broadcast use of pesticides (citations, page 10). Over-watering, or frequent shallow watering, may also promote thatch accumulation by promoting surface rooting. Bentgrass lawns are prone to thatch accumulation, and must be mowed at the proper height (about 1 inch), and fertilized lightly to avoid thatch buildup (with mulch-mowing, use 1 to 2 pounds of nitrogen/1,000 sq. ft. per year from a slow-release, balanced fertilizer).

In natural grass ecosystems, earthworms constantly deposit nutrient- and microbe-rich castings in the thatch layer, which accelerate the fungal and bacterial breakdown of thatch and its recycling into nutrients available to the grass plant. On lawns with excess thatch accumulation (over $^1/_2$ inch), this natural breakdown process can be enhanced by mulch-mowing, topdressing with thin layers of mature compost in the spring and fall, and more moderate (less total nitrogen) fertilization with non-soluble fertilizers, particularly from natural sources that release nutrients more slowly. Some microbially-inoculated, compost-based, natural fertilizer products (such as *Ringer Restore*) have been shown to help decrease thatch thickness and increase earthworm populations.[165]

In extreme cases, (when thatch thickness is more than 1 inch) power de-thatching is sometimes used on a one-time basis, in the spring or fall when the lawn is actively growing. Prior to de-thatching, "scalp" the lawn by mowing as short as possible. (Alternatively, some professionals prefer to dethatch first, then scalp with a bagging mower to pick up the thatch.) De-thatchers or power rakes can be rented. The process involves two or three passes at 90° and then at diagonal angles, with thatch raked out and removed for composting or disposal between passes. The lawn should then be aerated and overseeded, and preferably topdressed with compost or topsoil, to fill in the grass stand and prevent weed seeds from taking hold in the exposed soil. Dethatching requires a lot of work and does considerable damage to the lawn's root system and appearance. It may be preferable to break down the excess thatch over time with compost or soil topdressing, a change in fertilization (see above), and reduced use of pesticides (see pages 10, 18, and 25 for supporting scientific research).

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[a] The best explanation of compost use in soil preparation or topdressing for turf, including criteria for choosing compost products, is *Using Composts to Improve Turf Performance* (available from Penn State Cooperative Extension - see "Organizations" section of Bibliography) or the article by the same author, Peter Landschoot, "Improving Turf Soils with Compost" in the June, 1995 issue of *Grounds Maintenance* magazine. "The Compost Factor" by Susan J. Harlow in *Turf North*, Nov. 1994, gives a brief overview of current applications research.

optional step: Weed control

The practices recommended above will help the grasses out-compete weeds in a lawn, and many professionals find them sufficient to bring a weedy lawn back to better health and appearance. But where weeds exceed 30% coverage in the lawn, professionals often recommend spot-treating weeds (see the Weeds section under Integrated Pest Management, page 46). Broadcasting selective herbicides is the least preferable method because of damage to soil life, but a single spray treatment by a licensed applicator may be justified where weed coverage is up to 50%. The turf professionals interviewed consider granular herbicides such as those in "weed and feed" products to be the least effective per amount of herbicide applied, because they just roll off the leaves of small broadleaf weeds, and are only effective if the leaf is moist but rain does not wash them off.

Removing Old Lawns and Starting Over: Four Replacement Methods

Professionals report that older lawns can be renewed, the soil improved, and weeds crowded out using the steps described on the preceding pages. Even lawns with 50% weed coverage can be spot-treated once with herbicides and renovated. But where the soil is very poor (low in organic content), deeply compacted, or underlain by hardpan within 6 inches of the surface, or where a rapid change in appearance is desired (changing grass varieties and removing weed plants), replacement may be the answer. The key here is to improve the soil conditions so that the new lawn thrives. Some professionals also recommend weed control with non-selective herbicides (which kill all growing plants, most commonly glyphosate – brand name *Roundup, Rodeo*[a]) as part of this process, especially when dealing with hard-to-kill invasive grasses like quackgrass. Here are four methods commonly used in replacing lawns.

Sod cutter method

This method allows the soil to be amended with compost plus lime or other minerals as indicated by a soil test. It also allows for practices such as deep tilling with a tractor-mounted tiller to break up hardpan layers, the installation of sub-surface drains, or re-grading to improve surface drainage or eliminate dips and humps. The method requires a rented sod cutter and a pickup or dump truck. As with renovating, spring or fall are the best times for this method, when the soil is moist but not waterlogged. The sod is cut, rolled up, and hauled to a topsoil or composting facility for disposal (call around for facilities that accept sod) or composted on site.[b] Then the site is tilled with Grade A compost and other amendments, graded, rolled, and planted (see “Installing New Lawns”, pages 17-22).

Where the intent is to slow the re-establishment of undesired grasses (such as bentgrass) or deep-rooted problem weeds, some professionals prefer to spray the entire area with a non-selective herbicide, such as glyphosate (see footnote [a]), two to three weeks before removing the sod. The grass must be actively growing for glyphosate to work, so irrigation may be needed if this is done in late summer in preparation for September sod removal. Remember that this will only slow re-establishment: if the conditions are right, the undesired species will eventually move back in. To limit bentgrass dominance: increase the soil pH with lime; mow higher (2 to $2^1/_2$ inches); reduce soil compaction by aeration, and tilling in or topdressing with compost; overseed annually with the preferred grasses (such as fescue/rye blends); and irrigate deeply once a month during the dry season. These practices may tip the ecological balance away from bentgrass, in favor of the preferred species. Alternatively, learn to live with the bentgrass.

Multiple-till and irrigation method[c]

This method is effective at destroying weed seeds, but will not completely kill invasive grasses (see preceding paragraph about reducing re-invasion by unwanted grasses.) It can be used for replacing old lawns, but is particularly recommended for controlling weed growth prior to new lawn installation where

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[a] Assessing the comparative risks involved with using various herbicides is difficult. Summaries of current scientific information on glyphosate are available in the factsheet produced by Seattle’s Green Gardening Program and the fully referenced chemical information factsheets from the Northwest Coalition for Alternatives to Pesticides; both organizations are listed in the bibliography. To lower pesticide risks, always read the label completely each time you use it and follow directions completely. The *Rodeo* formulation of glyphosate, which does not contain a surfactant has lower impacts on aquatic life and is preferable near streams - no pesticide should be used directly adjacent to streams or lakes. For recommendations on choice and use of pesticides call your county Cooperative Extension Service.

[b] To compost sod on site: stack the sods upside-down to form a tight pile several feet high. As each layer is added, water it well and sprinkle some nitrogen fertilizer, if desired, to speed the breakdown. Cover the pile with black plastic to block out light. Once a month peel back the plastic, poke holes in the pile with an iron bar, and water well – the sod must stay moist to compost. At the end of a year, the sod will have turned into a pile of rich topsoil.

[c] The multiple-till method is well explained in *Least Toxic Pest Management for Lawns*, in the Bibliography.

topsoil or uncertified compost (both of which may contain weed seeds) have been added, or where the soil has been open and weed seeds have blown in. Note: tilling in excessive thatch layers is not recommended – dethatch first if thatch thickness exceeds ¾ inch.

The method requires moist but not soggy soil (a saturated soil's structure can be damaged by tilling, especially in clay soils), a powerful 8 hp walk-behind tiller or tractor-mounted tiller, and three to six weeks of time. First add the soil amendments: 2 inches of compost, plus lime or other minerals as indicated by a soil test (uncomposted manure might be used too, since most sprouting weeds will be killed in this process). On an existing lawn, adding some quick-release nitrogen fertilizer at this point will cause any roots that survive the first tilling to grow quickly and exhaust their reserves, and so be easier to kill on the second tilling. Then till deeply to incorporate the amendments, and to completely chop up the existing sod, if it has not already been removed. Irrigate to moisten the upper 2 inches of soil. After one to two weeks, when weed seeds and the remaining live grass roots have sprouted, till shallowly (1 inch deep) to kill them (hot sun will help). Irrigate again and repeat the shallow tilling when more seeds sprout – don't till deeply because that will bring more seed to the surface. Three tillings will deal with most weed seeds; more may be needed to kill resprouting grass roots. After the initial deep tilling, an alternative to re-tilling is to kill sprouting weeds with a flame-weeder.[a] Finish by grading, rolling, and replanting (see "Installing New Lawns", pages 17-22).

Plastic mulch / sheet-composting methods

This method is commonly used to replace turf areas with garden beds, but can also be used for lawn replacement. To simply kill out an old lawn, weeds and all, fertilize with any nitrogen source, water deeply, and cover with black plastic. Two months in summer will kill most grasses and weeds; six to eight months is better.

To kill the lawn, improve the soil, and break down the fibrous sod structure preparatory to creating a garden bed or re-installing an improved lawn, start in spring or fall and use the sheet-composting method. Fertilize as above (this is optional), then cover the area 6 to 12 inches deep with compostable material: grass clippings, leaves, manure - whatever is available. Water deeply, then cover with black plastic for six months; bury the plastic's edges in soil. Once a month the plastic should be peeled back and rain or irrigation allowed to thoroughly re-moisten the composting material. If this process is started in the fall (when leaves are readily available for the compost layer), let it go until early May to allow the soil to warm so that most of the latent weed seeds will sprout and die under the plastic. If started in early spring, let it go until mid-September. By then both the "compost" and the former sod structure will be mostly broken down, weeds will be dead, and the site will be ready for rototilling and re-planting (see "Installing New Lawns", pages 17-22). Tilling twice as described above under "Multiple-till method" will ensure fewer weed problems if the process has been shortened or where hard-to-kill weeds are a concern.

Another option where the appearance of black plastic is objectionable is to fertilize, water, then cover the ground with newspaper, four sheets thick. Then pile compostable material such as leaves and grass on top and finish with flakes of straw or wood chips to hold the material down and give a better appearance. This works best fall-through-spring, when winter rains will keep the pile moist. If wood-chips are used on top, rake most of them off before tilling in spring; the straw can just be tilled in.

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[a] Flame weeding torches are available from Flame Engineering Inc., PO Box 577, La Crosse KS 67548, (800)255-2469. They are also starting to be sold in local garden stores, and through professional equipment suppliers.

Herbicide method [a]

This method involves killing the existing lawn, de-thatching, and replanting into the dead sod. It does not allow addition of amendments, so should only be practiced where the structure, drainage, and organic content of the existing soil are adequate. Because it requires broadcast spraying with an herbicide, does not allow soil amendment, and because it could result in an impermeable organic layer of dead sod, it is less preferable than the other methods described here. This method is often prescribed to effect a complete kill of bentgrass lawns for replacement with preferred species, but the professionals interviewed indicate mixed success at this; bentgrass often recolonizes from surrounding areas quickly. See note under "Sod cutter method" above about reducing reinvasion. It may be best to accept these successful grasses, and use the other recommended practices to thicken the turf, crowd out weeds, and improve appearance.[b]

Three weeks before reseeding, fertilize the lawn (if growing slowly) and begin to irrigate; glyphosate works best on actively growing plants. Two weeks before reseeding, spray glyphosate (*Roundup, Rodeo,* see footnote on use, page 28) according to label directions for this use. A blue dye can be added to mark the sprayed areas. Keep children and pets off these areas for at least two days, and never apply any pesticide next to streams or lakes. One week before seeding, glyphosate can be spot-applied to any living plants. On the day of seeding go over the lawn repeatedly with a rented de-thatcher (see page 26) to expose as much bare soil as possible, then with a power aerator. Spread and rake in $^1/_2$ inch of certified compost or topsoil (page 18). Follow the seed selection and seeding recommendations for new lawns (page 19). Then cover with $^1/_8$ inch of compost or topsoil and roll to ensure good seed contact.

Because the soil has not been amended, a "starter" fertilizer will be needed (proportionately high in phosphorus). Apply a natural-organic fertilizer at the time of seeding. Or, if using a synthetic fertilizer, use a very light application at planting and another light application in two months, to decrease leaching and runoff. With spring seeding, keep the soil moist with irrigation as twice daily if needed for the first two months, then every other day through the first summer. Shift to infrequent, deep waterings in the second season. Fall-planted lawns can do well without irrigation except when a dry, sunny period occurs in the first two months.

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[a] The herbicide and sod cutter methods are described in *Lawn Maintenance and Renovation, or How to Have a Dynamite Lawn*, by Ciscoe Morris, see "Articles and Manuscripts" in the Bibliography.

[b] One point that could not be clearly established through this research was whether <u>any</u> cultural practices could prevent eventual reinvasion by bentgrasses, but the professionals interviewed indicated that improving the soil with aeration and topdressing and regular overseeding can at least prevent bentgrass from dominating. On low maintenance lawns, mowing higher, occasional topdressing with lime and compost and overseeding with fescues, moderate fall fertilization with non-soluble natural fertilizers, avoiding broadcast use of pesticides, and a monthly deep watering during the summer dormancy period will help the fescues compete well with bentgrass, and the two together can make a fine lawn.

Maintaining Lawns

A lawn composed of a mix of locally adapted grass species growing in well-drained, fertile soil on a site with adequate sun will have few disease or pest problems, and can out-compete most weeds with proper management. The first step in maintaining a healthy lawn is to avoid practices that diminish the natural vigor of the turf ecosystem, such as broadcast applications of pesticides (which kill beneficial soil organisms as well as target species), over-watering (which promotes shallow rooting and fungal diseases), over-fertilization (which promotes thatch buildup, decreases soil biodiversity, and forces lawns to grow too fast), and improper mowing (mowing at the wrong height or too infrequently).

Key Recommendations

As previously stated, the goal of this report is to recommend practices that support the natural vigor of grass plants and the soil community that sustains them, and minimize the need for practices that diminish that vigor. Key practices include:

◊ Setting realistic expectations for lawn appearance, and tolerating a few weeds.

◊ Proper site selection, and preparing the soil by tilling in compost to a depth of 6 to 12 inches.

◊ The selection of site-adapted and disease-resistant grasses.

◊ Moderate fertilization with natural or natural/synthetic-slow-release combination fertilizers, *to build soil nutrient reserves and biodiversity.*

◊ Mulch-mowing (also called “grasscycling”) whenever possible.

◊ Mowing regularly (remove only 1/3 of grass height each time), and mowing a little higher, at 2 to $2^1/_2$ inches on most lawns (or 1 inch for bentgrass lawns).[a]

◊ Avoiding over-watering: watering deeply, to moisten the whole root zone, but infrequently, *to limit disease and build deeper roots*; and watering dormant lawns at least once a month during the dry season, *to improve post-drought recovery.*

◊ Renovation/improvement practices that include aeration, compost topdressing,[b] and overseeding, *to reduce compaction, increase water infiltration, improve soil structure and natural disease control, and crowd out weeds.*

◊ An integrated approach to pest problems that includes:

1) Correctly identifying the cause of the problem
2) Understanding the biology of the pest organism and its natural predators
3) Setting realistic thresholds of acceptable damage to the lawn from pests (weeds, diseases, and insects)
4) Monitoring for pest problems at appropriate times of the year, and
5) Treatment of over-threshold problems with methods that support the turfgrass ecosystem and have the least non-target impacts on beneficial soil organisms, wildlife, pets, or humans. Where chemical solutions are necessary, time applications for maximum effect and use spot applications. *Repeated broadcast or calendar-based applications of pesticides should be avoided because they may damage the diversity and stability of the grass/soil ecosystem.*

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[a] Alternatively, Washington State University recommends a mowing height of $1^1/_2$-2 inches for perennial ryegrass mixes west of the Cascade mountains, or ¾-1 inch on colonial bentgrass.

[b] Dr. Stahnke of WSU has reservations about topdressing with pure compost, due to potential layering, particle size, stability, and cooler soil temperatures west of the Cascades. See page 25 for more information on topdressing.

Mowing

Mowing height and frequency

Several controlled trials, as well as professional's experiences, have demonstrated that simply raising mowing heights to 2 to 2½ inches can reduce invasion of turf areas by weeds, encourage deeper root development, and improve resistance to drought stress.[166] [167] [168] [169] [170] [171] [172] The turf managers interviewed for this project recommend a mowing height of 2 to 2$^{1}/_{2}$ inches for rye/fescue lawns in the Pacific Northwest. [a] For colonial bentgrass lawns, which have a more prostrate growing habit, 1 inch (or no higher than 1$^{1}/_{2}$ inches) is recommended – a reel-type push or power mower is ideal for these lower mowing heights. (Creeping bentgrass, used on golf putting greens, must be mowed much shorter, but this also promotes shallower rooting and this grass is not recommended for home lawns.) Below 1 inch, rotary mowers tend to scalp the lawn (the reel type mowers used on putting greens are less prone to scalping). Scalping is a major source of lawn stress and encourages weed invasion: raising mowing heights and leveling uneven lawns will eliminate scalping. Humps in lawns can be reduced by rolling (rental rollers are available) and low areas can be filled with topsoil and reseeded, or gradually raised by adding $^{1}/_{2}$ inch of topsoil at a time when the grass is actively growing.

Regular mowing is a key practice for lawn health – try to remove only 1/3 of the grass height at each mowing. Weekly mowing in the springtime, when the lawn is growing fastest, is the least stressful to the lawn. The worst mowing scenario is to mow an overgrown lawn from 7 inches down to 2 inches all at once, just before the start of the summer drought. This can shock and seriously weaken a lawn. Instead, mow as high as possible, then gradually reduce the mowing height every five days until the recommended height is re-established. Avoid early spring fertilization, which promotes rapid top growth that robs the plant's carbohydrate reserve and requires more frequent mowing (see Fertilization, below). Regular mowing should continue through the summer, even on dormant lawns, to cut down flowering weeds before they set seed.

Keeping mower blades sharp is important. Sharp mower blades will limit stress and possible disease entry from ragged cutting, produce a better appearance (no brown tips), and allow any mowing equipment to do a better job of mulch-mowing.

"Grasscycling" or mulch-mowing

Grasscycling means leaving the clippings on the lawn, where they break down quickly and provide free fertilizer. Grasscycling does <u>not</u> cause thatch buildup; thatch is woody stems and roots, not clippings. A six-year trial comparing grasscycled rye/fescue turf with areas where clippings were bagged and removed (plots mowed at 2.5 to 2.8 inches, no fertilizer added) at the Rodale Institute in Pennsylvania produced the following findings:[173]

◊ Grasscycled plots grew faster, greened up earlier in spring, and stayed green longer in fall. [This has also been shown in a four-year trial in Connecticut,[174] and a two-year trial at WSU-Puyallup[175]]

◊ Grasscycled plots had fewer broadleaf weeds than bagged plots. [This was perhaps due to faster, denser growth – recall that no additional fertilizer was used. In WSU's trial, while turf density increased and turf disease decreased, annual bluegrass, a "weedy" grass, increased in the grasscycled plots.]

◊ Bagging clippings almost doubled the total mowing time required compared to grasscycling.

◊ Bagging generated 6 to 11 tons (wet wt.) of clippings/acre/year; or 1,000 to 3,800 cu. ft./acre/year.

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[a] Washington State University Cooperative Extension prefers a mowing recommendation of 1$^{1}/_{2}$-2 inches on rye-fescue, and ¾-1 inch on bentgrass. The key here is to watch the lawn, and mow at a height where the grass stands straight rather than growing sideways or developing "false crowns", as bentgrass does when mowed higher.

◊ In 1 year, annual clippings contained 5.3 lb. of nitrogen, 1.8 lb. of phosphorus, and 4.8 lb. of potassium per 1000 square feet of lawn. (Or per acre: 235 lb. N, 77 lb. P, and 210 lb. K.)

◊ Neither the bagged nor grasscycled areas developed any thatch buildup.

Grasscycling is a key practice. It improves the organic content of the lawn's root zone (through the activities of earthworms, bacteria, and fungi mixing and decomposing the clippings). It reduces the frequency and amount of fertilizer applications needed. It may reduce disease outbreaks.[176] And it reduces compaction and enhances natural aeration, infiltration, and drainage, through the movement of earthworms between the deep soil layers and the surface. The professionals interviewed advocate grasscycling because of improved turf quality and because of the considerable labor and cost savings in not removing the clippings, but note several realities that need to be taken into account:

◊ Grasscycling may encourage a higher percentage of annual grasses, such as annual bluegrass (*Poa annua*) in the lawn mix because their seeds are not collected. (Professionals' opinions were mixed on this statement.)

◊ Clippings left on the surface, while they break down in a few days, can detract from appearance and are also easily tracked into buildings. This problem can be minimized by using mulching-type mowers, which chop clippings finely and blow them down into the turf so that the surface is left as clean as if it had been bagged (see Equipment, below), and by blowing clippings off walks and bagging or raking high-traffic turf areas near building entrances. Mowing when the lawn is dry and keeping mower blades sharp will also give a cleaner appearance.

◊ Depending on equipment, grasscycling may require more frequent mowing during rapid spring growth (minimize this by avoiding early spring fertilization, and by using mulching-type mowers), and requires the mower operator to slow down in denser patches to achieve a clean cut (although much more time is saved by not bagging the clippings).

◊ Grasscycling may not be compatible with heavy use of pesticides and soluble synthetic ("quick-release") fertilizers, because these chemicals reduce the populations of earthworms and other soil organisms which recycle the clippings into the soil (citations, page 10). Grasscycling is best incorporated as part of a transition away from chemical-intensive management.

Mowing equipment: practical and environmental considerations

Grasscycling mowers should ideally chop clippings finely and blow the resulting mulch down into the turf, so that the surface is left as clean as if the clippings had been bagged and the mulch breaks down very quickly into the soil. Over the last 10 years, mowing equipment manufacturers have pursued this ideal in their designs, with considerable recent success.

Residential-grade mulching mowers now will produce a clean appearance while grasscycling year-round in the Pacific Northwest, even when mowing wet or overgrown grass.[177] While residents *can* grasscycle successfully with conventional power mowers by mowing more frequently in the spring and keeping mower blades sharp, when it's time to buy a new mower they should consider buying a *mulching* mower, which now cost no more than conventional mowers of comparable quality. However, buyer beware! Many mowers that are called "mulchers" do not actually mulch-mow well under wet Northwest conditions. Fortunately there are several sources of information for identifying the best residential-grade gas or electric mulching mowers.[a]

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[a] *A Shopping Guide to Mulching Lawn Mowers* provides information on selecting a mower (available from the Seattle Public Utilities, Resource Conservation section, 710 2nd Ave., Suite 505, Seattle, WA 98104). *Consumer Reports* magazine tests and rates residential-grade mowing equipment, including mulch-mowing performance, annually – ratings are usually reported in the April, May or June issue, available in local libraries.

Push-mowers also work well for home grasscycling, although not all of them can be set as high as 2-2½ inches (look for a secondhand Scotts or Yardman mower). They are ideal for the lower mowing heights needed on bentgrass lawns (about 1 inch) because they don't scalp as easily as rotary mowers. Under wet conditions they do not leave clumps as conventional power mowers often do. But, like the conventional mowers, push mowers do leave the clippings scattered on the surface where they take a few days to break down and disappear. Raking high-traffic areas will minimize tracking-in of wet clippings. But if a clipping-free finished appearance is desired, the best electric or gas mulching mowers will be a better solution.

Professional-grade mulching mowers have likewise improved greatly in recent years, but unfortunately have not yet received the independent comparative testing that residential equipment has. Turf professionals who have improved their competitiveness by switching to grasscycling have had to spend considerable time locating equipment that works well for their situation. Their recommendations:

⇒ Ask around among professional contacts, and test out several types of equipment before buying.

⇒ Consider the appearance standard your customers require: a perfectly clean finished appearance will generally require more power, slower mowing, and a mulch-dedicated type of mower. (Overall mowing time is still greatly reduced by not bagging and hauling the clippings.)

⇒ Mulch-mowing requires about 20% more power than bagging at the same speed. Mowers with hydrostatic drive seem to handle varying conditions better than direct-drive equipment.

⇒ Easy adjustment of the mowing-deck height is essential to adapt to varying site conditions. Adjusting the front-to-rear cant of the deck may improve mulching performance.

⇒ Ideally, the equipment should convert quickly from mulching to either side-throw or bagging, to handle extremely wet, overgrown conditions.

⇒ Sharp blades are essential for successful mulch-mowing.

Reducing pollution. According to the EPA, older gas mowers emit 10 times the pollutants that modern cars do, per hour of use, and those pollutants are released in the immediate breathing zone of the operator. Equipment manufacturers are now moving to redesign engines for lower emissions. Ways to decrease pollution include:

⇒ Use a push mower.

⇒ Replace 2-cycle gas engines with 4-cycle engines, which have lower emissions.

⇒ Avoid spilling fuel or oil, and recycle used oil; never pour gas or oil down storm drains. (For recycling locations in King County, call the Hazards Line at (206) 296-4692; in the rest of Washington call 1-800-RECYCLE.)

⇒ Keep gas-powered equipment well tuned and maintained, so it runs cleaner.

⇒ When buying equipment, request and compare emissions information.

⇒ Consider electric (or propane) options. String trimmers, blowers, and mowers are available in electric versions, both corded and cordless battery-powered. Comparative trials of residential-grade, rechargeable electric mulching mowers in Seattle showed that this equipment is safe, durable, much quieter and easier to operate/maintain than gas equipment, and capable of grasscycling year-round under conditions found in the Pacific Northwest, with performance equal to the best gas mulch-mowers.[178] [a] While an excellent choice for residents, these mowers will be of limited use to professionals because of their running time (60 to 100 minutes at full power per charge) at least until

[a] *A Shopping Guide to Mulching Lawn Mowers* (available from Seattle Public Utilities, Resource Conservation section , 710 2nd Ave., Suite 505, Seattle, WA 98104) contains information on both corded and cordless rechargeable electric mulching mowers.

the manufacturers come out with models with replaceable batteries, but the electric string-trimmers or blowers are certainly worth trying. Propane-powered professional-grade mowers are also becoming available.

Fertilizing for Lawn Health

"Feed the soil, not the plant." – Ecological fertility management

There is a great range of opinion and scientific evidence regarding lawn fertilization practices. Starting in the 1930's, synthetic chemical fertilizers came into wide use, based on the theory that soil essentially just holds the plant in place and that all necessary nutrients could be supplied in water-soluble form directly to the plant's roots. Ammonium nitrate, ammonium sulfate, and urea are common *quick-release* water-soluble-nitrogen synthetic fertilizers that have been used in this "feed the plant" approach. In the last 15 years, however, recommended rates of application for nitrogen have been greatly reduced as certain problems surfaced. It is now clear that heavy use of soluble synthetic nitrogen sources is associated with decreased populations of earthworms and other beneficial soil organisms, decreased soil pH (increasing acidity), increased thatch accumulation, increased soil compaction (citations, page 10), and increased incidence of certain turf diseases,[179] as well as rapid shoot growth which requires more frequent mowing and can exhaust the plant's carbohydrate reserves.[180]

Many turf professionals now believe that it is easier to grow grass in biologically active soil, where earthworms and other organisms recycle the nutrients from thatch, grass, and other organic material into non-leachable forms that are adsorbed and slowly released by *humus* (decomposed organic matter) in the root zone. Soil amendment and fertilization practices should aim at building the structure, organic content, natural nutrient cycling processes, and nutrient reserves in the soil, which then provides complete nutrients to the grass plant during its annual growth cycle.

This "feed the soil, not the plant" approach includes several key principles:

◊ Grasscycling, compost topdressing, and moderate fertilization with non-soluble sources will build soil fertility, promoting diverse soil life and dense, vigorous turf.

◊ Fall is the key time to fertilize, in order to build plant carbohydrate reserves in the roots during slow fall and winter growth.

◊ Applying just enough nitrogen to promote dense turf and prevent yellowing will yield healthier turf. Over-fertilization promotes rapid shoot growth (requiring more mowing), thatch, and disease.

◊ Besides nitrogen, lawns need phosphorus, potassium, and calcium, which are often deficient in the highly-leached soils west of the Cascades. WSU Cooperative Extension recommends using fertilizers with a N-P-K ratio of 3-1-2.[a] Calcium is critical both as a nutrient and to maintain the optimal soil pH for grasses. Calcium carbonate (lime) needs can be determined by a soil test.

◊ **Fertilizer sources** should be chosen to minimize leaching and toxicity to soil organisms, provide a complete range of nutrients to the soil, and release nutrients as slowly as possible. For these reasons, ***quick-release*** water-soluble chemical fertilizers are the least preferable. The ***slow-release*** synthetic chemicals such as IBDU and sulfur- or poly-coated urea compounds are better because they are released into the soil more slowly (though they may still be toxic to earthworms and susceptible to leaching). Most preferable are the ***natural*** fertilizers, which are derived from organic (living)

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[a] WSU's recommendations for fertilization and liming are summarized in *Home Lawns* (EB04082) and *Fertilizer Guide: Home Lawns, Playfields & Other Turf* (FG0041) (see Cooperative Extension in bibliography).

materials and minerals; they are also sometimes called *organic*[a] or *natural-organic* fertilizers. They are generally very resistant to leaching, release a more complete array of nutrients much more slowly, sometimes contain high levels of beneficial organisms, and may be considered a food source rather than a toxicant to earthworms and other beneficial soil life.[181] (The term *bridge fertilizer* is used to refer to fertilizers that contain some combination of quick- and slow-release synthetic sources, or slow-release synthetic combined with a natural fertilizer.)

◊ As soil organic content, biodiversity, and nutrient reserves increase in well-maintained mature turf, fertilizer inputs can gradually be lowered from the levels required for establishment or during transition from chemical-intensive management.[182] Ultimately, fertilizer requirements will depend on soil fertility and the quality of appearance desired. High-quality, high-use turf (dense, durable to wear, and weed resistant) will always require some fertilization, preferably from natural sources.

Fertilization recommendations

How much? Washington State University currently recommends that lawns west of the Cascades need a total of 4 lb. of nitrogen per 1000 square feet per year, as part of a balanced fertilizer with a N-P-K ratio of 3-1-2 or 6-1-4. This is consistent with the needs of perennial ryegrass lawns. Fescues and bentgrasses have somewhat lower nitrogen requirements. Shifting to grasscycling (leaving clippings on the lawn) can supply a large part of that nitrogen requirement.

According to Tom Cook of Oregon State University, a good rule of thumb when grasscycling is to start out by cutting fertilizer use in half. Washington State University recommends a more modest reduction, about one-quarter. This range is consistent with the scientific literature on the quantity of nutrients returned by grasscycling. Annual clippings collected in three studies contained from 2.8 to 5.3 lb. of nitrogen per 1000 square feet (plus 0.4 to1.8 lb. phosphorus and 2.3 to 4.8 lb. potassium).[183] [184] [185] In another study, on grasscycled plots "the yield of grass increased by about one-third and nearly equal portions of the nitrogen in plant tissue came from soil, fertilizer, and grass clippings." Total nitrogen uptake into the grass plants was 40% higher on the plots that were grasscycled. After four years, the amount of nitrogen retained in the soil on grasscycled plots was 45% higher than on plots that were also fertilized but had the clippings removed.[186] [187] (Incidentally, all of the studies reviewed for this report found that grasscycling did not cause any significant increase in thatch thickness.)

So for grasscycled rye-fescue lawns west of the Cascade mountains, a total annual application of 2 to 3 lb. of nitrogen per 1,000 square feet per year in a balanced fertilizer (NPK ratio of about 3-1-2) is a good starting recommendation. (WSU prefers the 3 lb. level.) Lawns on poor soils, and lawns that have been heavily treated with pesticides (and thus have fewer soil organisms to recycle clippings) will need more fertilizer initially – aeration and compost topdressing will help improve nutrient cycling in both of these cases. Lawns that receive heavy wear (which should contain ryegrass because of its wear-resistance) may need higher rates, as well as annual core aeration, overseeding, and topdressing. Fescue and bentgrass lawns have lower nitrogen needs, and the thatch-producing tendency of bentgrass and fescue is minimized at lower nitrogen rates.

When? For the reasons stated on the previous page, natural or combination natural/synthetic slow-release ("bridge") fertilizers are preferred. If only one fertilization per year is planned, the most important time is fall, to build up the grass plant's root system and carbohydrate reserves during slow fall and winter

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[a] The term *natural* is preferred here because of the confusion that arises over two usages of the word *organic*. The primary definition of organic is "Of, pertaining to, or derived from living organisms," and thus corresponds to natural or organic fertilizers. A technical usage exists, however, in chemistry, "Of or designating carbon compounds." Thus most plastics and pesticides, as well as urea-based synthetic fertilizers, are chemically *organic*, though obviously not organic in the primary sense of the word. Until the common-sense definition of organic is incorporated into fertilizer packaging standards, using the word *natural* will avoid this confusion.

growth. Synthetic *slow-release* fertilizers can be applied up to the end of November. *Natural* fertilizers should be applied at least 6 weeks earlier (by October 15) because of their slower breakdown in cool soils. (Dr. Stahnke of WSU recommends fertilizing earlier in the fall – in early September – especially with natural-organic fertilizers.) If two fertilizer applications are planned, some professionals recommend doing both in the fall (early September and late fall) while others recommend late fall and late spring (after the rapid spring growth slows, in mid to late May). With three applications, late spring and early and late fall are the preferred times. Irrigated lawns can also receive a June application, but with natural fertilizers and grasscycling this may not be needed.

Unless the lawn needs help to overcome disease or insect damage, do not fertilize in the early spring. Early fertilization promotes rapid top growth which requires more mowing and can exhaust the plant's carbohydrate reserves – wait for the spring flush of growth to slow before fertilizing. Yellowing is the clearest sign that a lawn is nitrogen deficient, whereas a dark blue-green color with very rapid growth are signs of over-fertilization that may lead to weak root systems, thatch build-up, and disease.

If water-soluble (*quick-release*) synthetic fertilizers are used (they are usually cheaper) several steps can be taken to minimize negative impacts. Maintain a high organic level in the soil through grasscycling and aeration and compost topdressing, to help adsorb the water-soluble nutrients onto the organic particles and keep them from leaching. Apply synthetic fertilizers at rates of 1 lb. nitrogen per 1,000 sq. ft. or less per application. On sandy soils, glacial till soils, or soils low in organic matter, apply at a rate of 1/2 lb. nitrogen/1,000 sq. ft. per application. Dividing the annual fertilizer budget into four to eight applications this way will minimize leaching, overgrowth of the grass, and toxicity to soil organisms from soluble synthetics, but obviously requires more work than fewer applications of natural or slow-release sources. Avoid use of "weed-and-feed" products, which also contain herbicides (usually a mix of 2,4-D, mecoprop, and dicamba) for the reasons explained on pages 5-11. Irrigate slowly after applying fertilizers, particularly with soluble sources that can "burn" the lawn, but don't apply just before heavy rains, to reduce leaching and runoff.

What about compost as a fertilizer? Topdressing with compost in the spring and/or fall, preferably following core aeration, is an excellent way to improve soil structure and provide a wide range of nutrients. (See page 18 for compost benefits and page 25 for proper application techniques, including information resources.) But most yard-waste composts are relatively low in immediately-available nitrogen compared to natural or synthetic fertilizers, so some additional fertilizer will probably be needed to maintain the best quality turf, particularly in the short term.[a] If the grass yellows, it needs more nitrogen.

Be sure to use a finished compost: it should be dark brown to black, crumbly, and earthy-smelling. Unfinished composts can actually deplete soils of nitrogen. Some professionals prefer a compost-sand or compost-topsoil mix, which is heavier and works its way into aeration holes and thatch layers more quickly. Choose a material that has been screened to $^3/_8$ inch maximum particle size. The compost should be weed seed free: buying "Grade A" compost is the best way to ensure this (see page18).

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[a] As an example of nutrient content, Seattle's Cedar Grove Compost (made from yard waste) has N-P-K dry weight percentages of 1.4-0.4-0.6, or about 10 lb. nitrogen, 3 lb. phosphorus, and 5 lb. potassium per cubic yard at finished moisture content (ref. *Cedar Grove Compost Users Guide for Landscape Professionals*. 1994, p. 10).
So a $^1/_2$-inch thick application of this material (the maximum that should be applied at any one time) contains the following nutrients per 1,000 square feet: 15 lb. N, 4.5 lb. P, and 7.5 lb. K (a $^1/_4$-inch application contains half those amounts). But only 0.6 lb. of that nitrogen is in immediately available water soluble forms: most of the nutrients are bound in *humates* (organic complexes) and only released as the compost is incorporated into the root zone by earthworm and other soil organism activity. Aeration before or after topdressing will help to speed this process.

Early fall application of compost will provide nutrients for spring growth. Early to mid-spring application is also fine, but don't apply compost just before or during the summer, to avoid creating a dry organic layer that resists water penetration. Before making another application, especially on poor soils or soils where chemical use has been heavy, check a core to see that the compost is not just forming an organic layer at the surface. (Without earthworms and other soil life it won't be incorporated – wait for one layer to break down, then add more.) Apply up to $^{1}/_{2}$ inch of Grade A compost after core aeration (1.5 cu. yd. per 1,000 square feet) or up to $^{1}/_{4}$ inch without aeration. Aeration always helps, to incorporate compost into the soil. Six months after starting to apply compost and grasscycle, try adjusting other fertilizers downward. Grasscycling will help maintain the lawn's nitrogen needs, but watch for signs of deficiency, such as yellowing or decline of preferred species like ryegrass. If the lawn stays thick and a medium green color, without weed invasion, it's doing fine.

What about lime? Calcium is a critical lawn nutrient[a] that is often deficient in high rainfall regions due to leaching. Lime (calcium carbonate), or dolomitic lime (a mixture of calcium and magnesium carbonates) are also useful for correcting acid soils. Soils become more acidic as a result of leaching, and also from prolonged use of salt-based water-soluble fertilizers (quick-release fertilizers). Liming increases earthworm populations,[188] and improves soil structure.[189] More finely ground lime dissolves more quickly – an advantage where acidity is the problem. Dolomite lime also supplies magnesium. A soil test is the best way to determine calcium needs, and also the balance between calcium and magnesium (and so whether to use dolomitic lime). Test soil when making the transition from chemical-intensive maintenance, and ideally every three years on established lawns.[b] In the absence of a soil test, some professionals recommend liming Northwest lawns in the fall (or early spring) every one or two years with 25-35 lb. lime per 1,000 square feet of lawn. Applying lime after core aeration is an excellent way to place it in the root zone more quickly. Never apply lime to established lawns at rates higher than 50 lb. per 1,000 sq. ft., to avoid creating a lime layer in the thatch that is slow to break down.

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[a] For an excellent discussion of the role of calcium in soil fertility, see *Common-Sense Pest Control* by Olkowski, page 524, or *Role of Lime in Turfgrass Management* (Cooperative Extension EB1096), in the bibliography.

[b] See page 15 for soil test information, and WSU Cooperative Extension's bulletin FG0041, *Fertilizer Guide: Home Lawns, Playfields and other Turf* (in bibliography) for how to interpret test results into application rates for lime.

Irrigating for Lawn Health and Water Conservation

Healthy lawns need less water

◊ Proper soil preparation with composted organic matter improves both the drainage and moisture-holding characteristics of soils. Amending soils with compost before planting (to a depth of at least 6 inches, and preferably 12 inches – see page 17) can greatly increase the rooting depth of grasses compared to un-amended soils.

◊ Core aeration, compost topdressing, and avoiding regular broadcast use of pesticides can also help to reduce compaction and increase rooting depth on established lawns.

◊ Moderate fertilization with slow-release sources does not cause the rapid shoot growth and consequent water stress that result from high levels of soluble fertilization.

◊ Moderate fertilization with natural sources and compost topdressing help prevent or correct thatch build-up: thatch build-up limits air and water penetration, and in extreme cases causes the grass roots to grow in the thatch layer rather than the soil. (Power de-thatching may be necessary in extreme cases, see page 26.)

◊ Raising mowing heights shades the soil surface and encourages deeper rooting, which helps grasses survive drought stress. Grasscycling builds soil organic reserves.

◊ Less frequent, slow, deep watering – to moisten the whole root zone – also encourages deeper rooting.

All of these practices will help create a lawn that stays green longer between waterings, or can go dormant and then recover more quickly if not irrigated.

Over-watering causes lawn problems

◊ Frequent watering can cause lawns to develop shallow root systems.

◊ Over-watering in the summer (or poor drainage in the winter) keeps soils saturated. Constant saturation causes nutrient leaching and oxygen depletion in the grass root zone, poor root development, and encourages the growth of fungal diseases as well as weeds such as buttercup, speedwell, and annual bluegrass.[190] [191] [192] [193]

Grasses are ecologically adapted to environments that are seasonally dry, and they compete best if the soil in the root zone is allowed to partially dry between waterings, and then is replenished at least as deep as the roots penetrate. This strategy will conserve water and improve turf health.

Irrigating for turf health: deep, slow, and infrequent

During Puget Sound summers established lawns need 1 inch of water per week, on average, to replace losses from *evapotranspiration* (the combined total of *evaporation* from the soil surface and *transpiration* from the grass's leaves, also called "E.T."). In clay or organic-rich soils, the best strategy for replacing this water is with a once or twice-weekly slow watering that penetrates at least 6 inches, or deeper if the roots are deeper. Watch out for runoff – some soils become "hydrophobic" when completely dry, and need stop-and-start or slow watering to re-wet them without wasting water on runoff. In sandy or gravelly soils, where water drains away quickly, the goal should be to wet just the root zone, which may mean splitting that 1-inch of water per week into two, three, or four applications. Techniques to make irrigation more effective include:[a]

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[a] Principles for turf irrigation and improvement are explained in *Water Use and the Healthy Lawn,* which summarizes recommendations from WSU Cooperative Extension, available from Seattle Public Utilities, listed under "Organizations" in the bibliography.

- ⇒ Wait to water until the lawn needs it. Depending on root depth, allow the upper 2 to 4 inches of soil to partially dry out before watering. This can be checked either by pulling a core with a soil core sampler (see page 15) or by inserting a spade 6 inches deep and levering back to open a slit in the soil that can be observed. Signs of incipient water deficit include a dull color and slight wilting of grass blades, and the "footprint" test: the grass does not bounce back as quickly when stepped on.
- ⇒ Water just enough – don't over-water. To determine how much is needed, set the sprinklers running with tuna cans or other shallow containers arrayed over the lawn. Time the run, and when 1 inch of water accumulates in the cans turn off the system. This is the total amount of time you should irrigate each week, on average, whether split into several shorter waterings or all at once. If some cans have much more than others, repair or change sprinkler systems to provide more even coverage. An hour after running the tuna-can test, check with the core sampler or spade to see that water has penetrated at least 6 inches.
- ⇒ For best results, water somewhat less than the 1-inch-a-week average during the "shoulder" months of May, June, and September, and somewhat more during the hottest periods of July and August.
- ⇒ Water slowly, or intermittently, to ensure that water infiltrates rather than running off. Some soils become "hydrophobic" (water repellant) when allowed to dry out – slow or intermittent watering is needed to re-wet them. Watch for water running off during the time test. If so, adjust sprinklers to a slower setting or stop and start the irrigation to allow time for penetration. (Some professionals say that topdressing with compost reduces "hydrophobic" tendencies in soils.) Remember that compacted soil and thatch build-up (over ½ inch) both limit rates of infiltration. Correct both of these problems with core aeration and compost topdressing. Thatch build-up may also be reduced by some microbially-inoculated natural fertilizer products or power de-thatching (see page 26).
- ⇒ Don't water the pavement. Adjust sprinklers so that they just reach the edge of the lawn. With oddly shaped areas that are difficult to water, consider replanting them with more drought-tolerant plants, or let these turf areas go dormant (see below).
- ⇒ Water in the early morning, if possible, to limit evaporation and avoid standing water at night that encourages fungal disease. (Watering just before dawn is ideal because it's less windy, but anytime before the sun hits the grass is O.K.) If that is not possible, water in the late afternoon or evening, to avoid evaporation losses – mid-day watering wastes up to 50% of the applied water through evaporation. An automatic timer is useful for morning watering as well as intermittent watering to reduce runoff. Turn off automated systems to avoid wasting water when rain is imminent, or has already provided the needed water, unless the system is tied to a computerized ET (evapo-transpiration) control system that will automatically skip an irrigation.
- ⇒ Or let lawns go dormant (see below).

The brown lawn option: avoiding drought damage on summer dormant lawns

Unlike most plants, grasses have leaves that grow from a crown near the soil surface rather than from their tips. This, and certain metabolic adaptations, allow some grass plants to go dormant during the dry season and recover without damage when fall rains come. (Turf-type ryegrasses do not go fully dormant, and are susceptible to drought damage; fescues, on the other hand, are much more resistant to drought damage.) So one approach to lawn irrigation is to just forget it, and let the lawn go brown. But in our long, dry summers growing crowns may be damaged, especially in ryegrass, and the lawn is placed at a competitive disadvantage to deep-rooted weeds like dandelions. So many turf professionals recommend that dormant lawns be watered deeply once each rainless month. Because the soil is very dry, though, the water will penetrate more slowly. To avoid wasting water in run-off, use the start and stop method or a very slow sprinkler. Again, water deeply: check to see that the soil is moistened as deep as the roots reach.

Dormant lawns do not stand up to wear very well, so areas that are used for play or other heavy traffic should probably be irrigated regularly to avoid damage. Continue to mow dormant lawns often enough to keep dandelion flowers from setting seed, and bag clippings if many seed heads are present.

When September rains come, weed seeds from the summer take hold in any thin places in the lawn. This is a good time to aerate, overseed, topdress with compost, and fertilize to thicken the grass stand and help crowd out weeds. Or at least rake thin areas to expose the soil and overseed to fill in the stand – this will save a lot of weeding later.

Irrigation problem areas: slopes, compacted soils, thatch, and high wear

All four of these problems often cause irrigation water to run off rather than penetrate. The solution is essentially the same for all: core aeration (with or without compost topdressing) in the springtime and/or fall, and slower or intermittent watering. Sloped areas will always be dryer than the rest of the lawn. While periodic aeration will help, it can be dangerous to run aeration equipment on slopes. In the long run it is probably better to re-landscape slopes with drought-tolerant plantings. Soils that are compacted from high wear, low organic content, or overuse of chemicals respond well to core aeration and compost topdressing in the spring and fall. Thatch build-up (beyond the ½ inch that is beneficial) can also be reduced by these methods, but in extreme cases power de-thatching will increase water infiltration more quickly.

Renovation Practices As Part of Lawn Maintenance: Aeration, Overseeding, Topdressing, and De-Thatching Revisited

Many professionals use some of the renovation practices described on page 24 on an annual basis, particularly on stressed, thin, or weedy turf, or on high-wear areas. Besides proper mowing, fertilization, and irrigation, professionals recommend using these practices in the spring and/or fall to keep lawns in top condition:

⇒ Raking thin areas to expose the soil and *overseeding* at the end of the summer will help fill in the turf with grasses rather than the weed seeds that have blown in, and to maintain preferred grasses in the lawn mix. This is the easiest and most important preventive maintenance practice.

⇒ Even better, *aeration* and *overseeding*, combined with proper fertilization, can help fill in the grasses so they out-compete weeds. A weedy lawn can actually be recovered with these practices.

⇒ *Aeration* and compost *topdressing* will reduce compaction and improve nutrient cycling in high-wear or chemically-damaged turf, and improve both drainage and moisture holding capacity. (Deep aeration, 4 to 8 inches deep, of particular benefit on soggy soils or dry slopes).

⇒ *De-thatching* is often practiced in spring or fall where excessive thatch (over 1 inch) is limiting water infiltration or turf vigor. (Aeration and compost topdressing, or some microbially inoculated natural fertilizer products [page 26], will also reduce thatch, but more slowly.) De-thatching should only be needed once: professionals experienced with ecological turf management report that thatch build-up simply is not a problem for them (see pages 2 and 10).

Integrated Pest Management: Preventive Health Care for Lawns

> "Integrated pest management, or IPM, is an approach to pest control that uses regular monitoring to determine if and when treatments are needed, and employs physical, mechanical, cultural, and biological tactics to keep pest numbers low enough to prevent intolerable damage or annoyance. Least-toxic chemical controls are used as a last resort."[194]
>
> *Daar, Olkowski, & Olkowski: IPM Training Manual for Landscape Gardeners*

Healthy Turf Resists Pests

Every organism from grasses to humans occupies a niche in the environment, surrounded by beneficial organisms that sustain it, organisms that compete for the same resources, parasitic organisms (diseases or pests) that may damage it, and all the organisms that compete with or parasitize those disease organisms. Just as good diet, exercise, and a healthy environment can prevent many diseases in humans, the goal of ecological turfgrass management is to:

- ◊ support diverse populations of beneficial soil organisms: bacteria, fungi, protozoa, and invertebrates (such as earthworms, and many other species of soil animals) that make loose, fertile soil and recycle nutrients to the grass plant
- ◊ create conditions that favor the preferred grass species over "weed" competitors
- ◊ avoid stressing the grass with improper mowing, fertilizing, or watering practices
- ◊ avoid providing ideal growth conditions for disease or pest organisms, and
- ◊ maintain healthy populations of organisms that compete with, eat, or parasitize disease or pest organisms (everything from the beneficial fungi that parasitize disease-causing fungi, up to birds that eat crane fly larvae).

That seems like a lot to keep track of, which may be why people are often tempted to apply a chemical quick fix to stop or prevent problems. The bad news is that broadcast or calendar-based use of chemicals often kills the beneficial organisms (such as earthworms, or fungi that attack disease fungi, or birds that eat crane fly larvae) and contributes to soil compaction, acidity, thatch build-up, disease susceptibility, and extreme nutrient swings that favor weeds and diseases over healthy turfgrass (see citations, page 10).

The good news is that for the most part those chemicals are unnecessary, and a simple, common-sense approach will prevent most problems. The professionals interviewed for this report say that it is easy to maintain healthy turfgrass by focusing on building healthy soil and providing for the grass plant's needs, using the practices described in this report (see summary of recommendations, page 13).

One cautionary note – often, what is assumed to be a pest problem is really a result of soil problems, poor cultural practices, or other causes like dog urine, mower scalping, fertilizer burn, etc. (see page 15 for more on assessing lawn problems). Observing carefully, checking the soil, and figuring out what the real cause of the problem is can save a lot of work, and will also help prevent unnecessary chemical applications.

Key Pest-Prevention Practices for Pacific Northwest Lawns

The main pest problems in this region, and brief preventive approaches, include:

◊ ***Weed invasion*** Aerate and topdress to correct compaction and build fertile soil. Overseed at summer's end with locally adapted grasses to fill bare areas with grass rather than weeds. Correct acidity or poor drainage. Mow higher (2-2½ inches, or 1 inch on bentgrass), fertilize moderately with slow-release or natural products, water deeply and infrequently in the summer. Tolerate some small broad-leaf plants like clover and daisies. Hand weed or spot-spray problem weeds in spring or fall to stop them before they spread.

◊ ***Moss*** Moss is a sign of infertile, acidic, compacted, over-watered or poorly drained soil, or a site that's just too shady for grass. Essentially, the moss is better adapted to the site's conditions than the grass is. Test the soil and correct acidity with lime. Correct compaction and drainage problems with core aeration. Stop watering or let soil dry completely between waterings. De-thatch to remove most moss and expose soil, and then overseed with shade-tolerant fescues. Fertilize properly – using an iron-containing fertilizer when overseeding has been shown to limit moss regrowth. Limb up trees to reduce shade. If the grass still doesn't do well, replace it with a more shade-tolerant ground cover.

◊ ***Lawn diseases*** Red thread is the only real problem here on naturally managed turf. It is temporary, and does little damage. Fertilize moderately in the late fall with slow-release or natural sources. Correct calcium deficiencies with lime (a soil test is best). Correct drainage problems and avoid over-watering. Build beneficial microbe populations with compost topdressing to control disease fungi. If red thread strikes, mow it off and fertilize lightly – the grass will grow through it and recover.

◊ ***Insect pests*** European crane fly larvae that eat grass roots in late winter are the only real problem in western Washington. Correct drainage problems. Fertilize moderately. Birds feeding in fall eat most larvae; avoid poisoning them with pesticides. Monitor for over-threshold larvae populations in February; if control is needed try mechanical and biological controls first (see page 49). Once damage becomes noticeable, in late spring, it's too late for chemicals to help – de-thatch and overseed in May to restore the lawn.

The Integrated Pest Management Process

True IPM is a powerful approach that anticipates and prevents most problems through proper cultural practices and careful observation and knowledge of the life cycles of both beneficial and pest organisms. Several excellent resources exist to introduce everyone from residents to landscape professionals to turfgrass IPM.[a] The IPM process for lawns includes the following steps:[b]

1) Correctly identify problem pests and understand their life cycle
2) Establish tolerance thresholds for pests

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[a] Residents will find all they need in *Least Toxic Pest Management for Lawns.* Landscape workers and managers will want to add the plain-English practical guide, *IPM Training Manual for Landscape Gardeners*, as well as subscriptions to the *B.U.G.S. Flyer* and *The IPM Practitioner.* The standard reference work for IPM control techniques in home, garden, and landscape is the well-indexed, encyclopedic *Common-Sense Pest Control.* Turf and landscape professionals will find a wealth of scientific information summarized in the dense (630 page) but well organized *Handbook of Integrated Pest Management for Turf and Ornamentals* (all listed in the bibliography). One excellent IPM-oriented brochure series for Pacific Northwest residents is the Washington Toxics Coalition's "Home Safe Home" factsheets, including *Lawn Care, Weed Management for the Lawn and Garden,* and *Appropriate Plants for Northwest Landscapes*. Another is the lawn, disease, weed , and IPM booklets produced by Thurston County (WA) Environmental and Community Programs. (See "Organizations" in the bibliography. The Thurston County booklets are not widely available: consult or photocopy them at the listed libraries.)

[b] The IPM hierarchy presented here is adapted from *Least Toxic Pest Management for Lawns*, Sheila Daar, ed. Bio-Integral Resource Center, POB 7414, Berkeley, CA, 94707; 1992, pp. I-1 to I-4 (see bibliography).

3) Monitor to detect and prevent pest problems
4) Modify the maintenance program to promote vigorous grass and discourage pests
5) If pests exceed the tolerance thresholds, use cultural, physical, mechanical or biological controls first; if those prove insufficient, use the chemical controls that have the least non-target impact
6) Evaluate and record the effectiveness of the control, and modify maintenance practices to support lawn recovery and prevent recurrence

step one: Correctly identify problem pests and understand their life cycle

This step includes:

1) correctly identifying problem pests,
2) deciding that they are enough of a problem to pay attention to, and then
3) observing and reading about their life cycle to know how to prevent or control them effectively.

For example, (1) yellowing because of lawn mower scalping, fertilizer burn, or dog urine damage is often mistaken for a disease problem. Proper identification is the key.[a] Once the problem is properly identified a choice can be made (2) whether to work on preventing or controlling it, or to just support the lawn with proper cultural practices and let it run its course, as most lawn problems will. Tolerating a few weeds or occasional insect damage will save a lot of work and chemical exposure. If the choice is control (or prevention), then (3) it's time to observe the problem more closely and study up on its life cycle (see resources in bibliography, or call your Cooperative Extension Service).

step two: Establish tolerance thresholds for pests

Every lawn has a few weeds, root-eating larvae, and fungal disease organisms present all the time, and this is good because it keeps populations of beneficial organisms that attack those pests present, too. The problem arises when the pest gets out of control. Tolerating a certain number of small mowable broadleaf plants (like clover) and concentrating on larger, easier-to-control dandelions may yield an overall "weed" threshold that is easier to attain. Weed tolerance thresholds are mostly subjective. On the other hand, research has established a threshold number of European crane fly larvae that threaten damage to an otherwise healthy lawn (between 25-40 larvae per square foot). The goal is to keep pest populations below the levels at which they would have unacceptable impacts on lawn appearance.

step three: Monitor to detect and prevent pest problems

Monitoring is a key practice to anticipate and prevent major pest outbreaks. It begins with a visual evaluation of the lawn's condition. Take a few minutes before mowing to walk around looking for problem areas in the lawn (see "Looking at Lawns: Evaluation and Monitoring" on page 15.) Specific monitoring techniques can be used in the appropriate season for some potential problem pests, such as European crane fly (see page 49). Keep a notebook, recording when and where a problem occurred, then monitor for it at about the same time in future years.

step four: Modify the maintenance program to promote vigorous grass and discourage pests

The lawn maintenance and improvement practices recommended in this report will prevent most pests from ever becoming a problem. Some practices are particularly helpful to prevent a particular pest problem. For example, aeration and overseeding along with proper mowing height, fertilization, and irrigation will help the grass out-compete weeds. Compost topdressing in fall or spring will help lawns resist fungal diseases. And correcting drainage problems and letting the soil dry between waterings in the summer may reduce the number of crane-fly larvae that survive.

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[a] For disease identification, see the bulletin *Diseases of Turfgrass* (EB713) from WSU Cooperative Extension. Or try the photo and IPM database on the University of California IPM website, at http://axp.ipm.ucdavis.edu

step five: If pests exceed the tolerance thresholds, use cultural, physical, mechanical or biological controls first; if those prove insufficient, use the chemical controls that have the least non-target impact

When a pest outbreak strikes (or monitoring shows one is imminent), first review the best cultural practices for grass to see if something may have been left out or needs to be added. Then consider the control options that are least toxic, or have the least non-target impact. Some examples:

- ◊ Red thread disease is more prevalent under conditions of low nitrogen fertility. A red thread outbreak can best be treated by mowing to remove diseased blades and light fertilization to help the lawn recover, then changing to fall fertilization with a natural source and grasscycling, to provide an even supply of nutrients.
- ◊ Other, warm-weather disease outbreaks can often be prevented by switching to early-morning irrigation, so that the grass blades dry before night.
- ◊ Crane flies are most prevalent on lawns that stay saturated in the winter and are irrigated in the summer, both conditions that can be modified. It may be possible to reduce crane fly larvae numbers by using a power de-thatcher on a cool, cloudy day when they are feeding near the surface (a mechanical control), or with certain species of nematodes that parasitize the larvae (a biological control). (See suggested IPM resources in the footnote, previous page, or bibliography for specific biological controls for various lawn problems.)

Public concern over the toxicity and persistence of conventional pesticides has encouraged research and created a market for alternative control products, such as insecticidal soaps, the neem tree oil that has been shown to reduce European crane fly larvae populations, fatty-acid based spot weed killers, and the use of corn-gluten meal as a pre-emergent weed control (see next page). These products usually give less complete control than conventional pesticides, but have lower impacts on non-target beneficial organisms or lower toxicity. Read the label of any pesticide product carefully before each use, and follow all directions. Comparing the EPA-required cautionary statements will give a rough idea of the relative toxicity of various products: "Danger" identifies the most hazardous pesticides, "Warning a moderate hazard, and "Caution" for less hazardous pesticides.[a] Information on alternative controls can be found in the IPM resources previously mentioned, or through local public education programs such as Seattle's Green Gardening Program (see bibliography). Recommendations for conventional pesticide use, as well as some alternative controls, are available from the Cooperative Extension Service.

step six: Evaluate and record the effectiveness of the control, and modify maintenance practices to support lawn recovery and prevent recurrence

Keep a notebook log of when, where, and what symptoms or monitoring revealed a pest problem, what controls were applied when, and the effectiveness of the control (whether by observing lawn condition, or direct monitoring techniques like re-counting number of crane fly larvae per square foot). Mark next year's calendar to monitor at the appropriate time to anticipate the problem. Review your lawn maintenance and cultural practices to see if they can be modified to prevent or reduce the problem. For example, late fall fertilization with natural/slow-release sources, grasscycling, and correcting calcium

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[a] For more toxicity (and precaution) information, consult the manufacturer's Material Safety Data Sheet (MSDS). Independent scientific reviews of conventional pesticide products are available through the EXTOXNET web site and the well-researched factsheets and articles from the Northwest Coalition for Alternatives to Pesticides (NCAP) and the Washington Toxics Coalition. For researchers, valuable resources include NCAP's *Pesticide Chemical Information Packet*, the encyclopedic review of research in the book *Basic Guide to Pesticides, Their Characteristics and Hazards*, the aquatic and terrestrial toxicity tables in *Golf Course Management and Construction: Environmental Issues*, and the EXTOXNET and California Department of Pesticide Regulation web sites (all in bibliography).

deficiencies will decrease red thread outbreaks. The IPM resources listed throughout this section give more information on preventing specific problems.

Applying the IPM Process to Common Pest Problems in Northwest Lawns

Weeds (in general)

1) Weed identification and life cycle Neighbors, nursery staff, or Cooperative Extension Master Gardener clinics can often help with identifying weeds and understanding their life cycles.[a] Some, such as buttercup, speedwell, annual bluegrass, chickweed, and moss, thrive in wet, poorly drained soils and shady sites (for moss control, see page 43). Others, such as dandelions, take over in drought conditions. They all do better than grass will on compacted soils with low mowing. Most weed seeds will germinate in both the spring and the fall, when temperature and moisture conditions are right.

2) Establish tolerance thresholds With weeds this is mainly subjective, based on lawn appearance. Accepting some broadleaf plants like daisies and clover in the lawn will save a lot of work and pesticide exposure, and you may find them quite attractive with a slight aesthetic shift. As a nitrogen fixer, clover even improves soil fertility. On the other hand, if certain weeds are unacceptable (like dandelions, for instance), controlling them by spot-weeding at a fairly low threshold may make for the least work in the long run, by avoiding seed spread.

3) Monitor Spring and early fall are the key times to monitor for weeds. This is when most weed seeds germinate, and also when the ground is moist enough for easy pulling. At the same time, look for weed-promoting conditions, such as infertile, low organic content, compacted, soggy, or acidic soils; thin unhealthy grass; shade; slopes – anything that helps the weeds out-compete the grass.

4) Modify maintenance program to promote vigorous grass and discourage weeds This is the key to easy weed control: grow healthy grass that out-competes weeds. Professionals often improve weedy areas simply by raising mowing heights to 2-2½ inches (1 inch on bentgrass), along with aeration and over-seeding when the fall rains come to fill in bare or weedy patches with thick grass. Proper fertilization (plus aeration, overseeding, and compost topdressing) promotes dense grass stands. Correcting acid conditions and calcium deficiencies (or others revealed by a soil test) will give the grass plants, and the earthworms and soil life that sustain them, better conditions to thrive. Correcting wet season drainage problems, and irrigating in the summer (without over-watering) will also shift the ecological balance towards grass dominance.

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[a] WSU Cooperative Extension's *Lawn Weed Control for Homeowners* (EB0607) has line drawings of common weeds and some life-cycle information (along with chemical control options). The *Weed Images* and *University of California IPM* web sites have photos with common and scientific names of weeds (including many not found in this region) – see "Internet Sites" in bibliography.

5) If weeds exceed thresholds, use cultural, physical, mechanical or biological controls first; if those prove insufficient, use the chemical controls that have the least non-target impact

◊ ***cultural controls*** The maintenance changes described in Step 4 above will usually prevent weeds from becoming a serious problem, and have also proved effective by themselves in reducing high weed populations. This may be all that's needed.

◊ ***physical controls*** Long handled *pincer-type weeding tools* make quick work of weeds without any bending over, particularly difficult weeds with taproots, like dandelions. Most garden stores sell them. Step down to drive the tines into the soil on either side of the weed; lever back to make the tines pinch the root and lift the weed. They work best in moist soil (spring and fall, or water first). For best appearance, carry a container of topsoil with a little grass seed mixed in to fill the holes from the weeds. *Flame weeders* (see footnote on page 29 for source) are very effective for controlling weeds in sidewalk, brickwork patio, or driveway cracks or graveled areas. *Hot water weeders*, which inject near-boiling water around the roots, are effective but are currently quite expensive and bulky.

◊ ***least-toxic chemicals*** By far the least-toxic chemical control is the recent (and untested in this region) use of ***corn gluten meal*** as a pre-emergent suppressant of weed seeds. Trials at Iowa State University have demonstrated that this by-product of corn processing has the same seedling root-inhibitory effect as substances long known to be released into the soil by many grasses and desert plants. Over a four-year trial, this product significantly reduced populations of weeds (it does <u>not</u> produce immediate reductions).[195] Because the inhibitory effect subsides quickly, it works best when a spring or fall rain (or irrigation) germinates the weed seeds and then a dry period causes the seedlings to die before the root-inhibition effect wears off, so timing of use is critical. The product is a food-grade non-toxic material and releases about 10% nitrogen as breaks down, and for these reasons has been touted as an "organic weed and feed". While untested in this region, and currently fairly expensive, trials elsewhere suggest that this product may be worth trying.[a] For home lawns, however, the best strategy is still to accept some weeds, and to use good cultural practices to prevent weeds from dominating.

  Fatty-acid (soap) based non-selective herbicides (such as Safer's *Sharpshooter*) are for spot-spraying weeds. Their limitation is that they kill the top but not deep roots, so re-application is often needed.

  The conventional herbicide method with the least non-target impact is spot-spraying of the problem weeds, which has much less impact on lawn health than repeated broadcast applications. (Consult your local Cooperative Extension Service for help in selecting herbicides, wear protective equipment, and read and follow all label precautions; see footnote page 45). For very weedy lawns, it may make sense to hire a lawn service to spot-spray weeds once, and two weeks later, after killing the weeds, aerate, overseed, and topdress, and institute a proper maintenance program (see above) to grow dense, vigorous grass and prevent weeds from coming back. Alternatively, some professionals recommend a one-time broadcast spraying with a broad-leaf selective herbicide, to reduce major weed populations, followed by overseeding and proper maintenance to fill in the turf with grasses.

6) Evaluate and record control effectiveness; modify maintenance to promote lawn recovery and prevent recurrence See step 4 above. Whether hand weeding or spot-spraying, always follow up with over-seeding; never leave bare ground open for weed seeds to sprout on. Concentrate on growing healthy vigorous grass, to crowd out weeds and save all the work of controlling them.

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[a] Some garden stores and landscape wholesalers in this region are starting to carry this product. One mail-order retail source is Gardens Alive!, 5100 Schenley Place, Lawrenceburg, IN 47025, (812) 537-8650. Another local source is Walt's Organic Fertilizers, POB 31580, Seattle, WA 98103, (206) 783-6685.

Diseases, especially red thread [a]

Red thread is the only significant disease on naturally managed lawns west of the Cascades, although many others are found on turf that is highly fertilized, on soils low in humus, is mowed short, has the clippings removed, has high winter moisture levels, or is frequently irrigated in summer.[b] The key preventive practices for lawn diseases are avoiding watering late in the day, avoiding over or under-fertilization, grasscycling, and top-dressing with compost.

1) Red thread disease identification and life cycle Red thread (*Laetisaria fuciformis*) is a fungal disease that affects lawns primarily in cool, wet weather, fall through spring.[c] It begins as wet, dark patches, 2 to 24 inches in diameter, that become bleached or tan and may then appear pink as the red, thread-like fungus strands grow. It affects all grasses but particularly fescues and perennial ryegrasses. Lawns are predisposed to red thread disease by low nitrogen levels (though *high* levels encourage most other diseases), saturated soils, and calcium deficiency. Red thread will not kill the lawn and disappears as the weather warms and the grass grows out of it.

2) Establish tolerance thresholds Red thread is primarily an appearance problem, though it can weaken turf and invite weed invasion or drought stress. It is occasionally seen in mild form on naturally managed lawns, and may be taken more as an indicator of fertility imbalance than a cause for concern.

3) Monitor Red thread is mostly seen in wet, cool winters and early spring. Other diseases are more common in warm, wet weather, or if the soil is not allowed to dry between summer waterings.

4) Modify maintenance program to promote vigorous grass and discourage red thread disease
Maintaining adequate but not excessive fertilization is the key. Correct calcium deficiencies (with agricultural or dolomitic lime) and drainage problems (with core aeration). Fall fertilization with a natural or slow-release fertilizer will help prevent red thread from appearing or being more than a passing problem. Grasscycling (mulch-mowing) also significantly reduces the incidence of red thread.[196] Compost topdressing has been demonstrated to give broad prevention and control of many fungal diseases, including red thread, although the degree of control varies between different compost products.[a]

5) If red thread exceeds thresholds, use cultural, physical, mechanical or biological controls first; if those prove insufficient, use the chemical controls that have the least non-target impact

◊ ***cultural and physical controls*** Best cultural methods are described in Step 4 above. If a red thread outbreak occurs, usually during cool, wet weather, several other steps can be taken. Mow regularly and bag the clippings (just during the outbreak; as a general practice *leaving* clippings on the lawn promotes disease resistance). On large turf operations, disinfect mower decks and shoes with a 1:10 bleach solution before moving from infected to unaffected areas. Fertilize lightly, mow regularly, and the lawn will grow through the outbreak and recover.

◊ ***biological controls*** Light topdressing with compost is now used to prevent and control various diseases on golf course turf (which is inherently stressed because it is mowed low, heavily trafficked,

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[a] "Compost tea", foliar applications or soil drench with a water extract of compost microbes, has recently been shown to have potential for controlling or preventing a variety of fungal diseases on food crops, ornamental plants and on turf. For some current research, see Dr. Elaine Ingham's web site at http://www.soilfoodweb.com The City of Seattle will be testing compost tea for turf disease control during 2000; contact the author for results.

[b] For disease identification, consult the photos in *Diseases of Turfgrass*, WSU Cooperative Extension Bulletin EB713, or the *University of California IPM* website, http://axp.ipm.ucdavis.edu Some cultural (plus fungicide) controls are in WSU Coop Extension's *Disease Management in Home Lawns*, EB3938.

[c] Life cycle and prevention of red thread are well explained in Thurston County's *Common Sense Gardening: Avoiding Lawn Disease* (in bibliography). Or see WSU Extension bulletin EB1016, *Red Thread of Turfgrass.*

and over-fertilized). Regular compost topdressing (combined with fall fertilization) will also help prevent red thread outbreaks by improving the nutrient-holding capacity and biodiversity of the soil. Trials at Cornell University have demonstrated that some special microbially inoculated compost products, applied after outbreak of red thread, will give significant control of the disease.[197] (The most effective products in those trials included Ringer's *Compost Plus* and *Turf Restore*, as well as a sludge-based municipal compost.) Similar control has been demonstrated for other diseases.[a] [198] (See pages 18 and 25 for more references on turf disease control with compost.)

◊ ***chemical controls*** No fungicidal control is recommended for red thread disease because a) it is a passing problem, will not kill the lawn, and primarily serves as an indicator of soil nutrient deficiencies, and b) fungicides also kill the many species of fungus that recycle dead organic material back into available nutrients, and those that attack or compete with disease fungi. Thus the cure would be much worse than the disease.

6) Evaluate and record control effectiveness; modify maintenance to promote lawn recovery and prevent recurrence Fertilize affected areas and mow regularly to promote recovery. Red thread is a sign that the soil is too poor to supply the grasses' needs during the cool, wet season. This season, fall and winter, is also the key time for the grasses to build carbohydrate reserves for the next spring and summer. For both these reasons, fertilize in the fall. Improve the nutrient-holding capacity of poor soils by topdressing with compost (with aeration), grasscycling, and avoiding pesticides. For warm-season diseases, grasscycle, avoid watering late in the day, and allow the upper soil layers to dry out between waterings.

Insects, especially European crane fly

European crane fly larvae ("leatherjackets") are the only significant insect pest problem on turf west of the Cascade Mountains. (Consult the local Cooperative Extension office in other regions.)

1) Crane fly identification and life cycle The European crane fly (*Tipula paludosa*) is an introduced insect that has spread south along the Pacific coastal region as far as Eugene, Oregon over the last 30 years.[199] There are many native crane flies that don't damage lawns – only the European crane fly is a problem, and usually only when it first invades a lawn. The adult flies look like large mosquitoes ($^1/_2$ to 1 inch long). They emerge from lawns in mid-August to late September, mate, lay eggs in the soil, and die in a few days. The eggs will die quickly in dry soil, and require moist conditions to survive. They hatch in the fall to produce gray-brown worm-like larvae which develop a tough skin (hence the common name "leatherjackets") and live in the upper 1 to $1^1/_2$ inches of the soil. Larvae feed on grass roots and root crowns, and are heavily preyed upon by birds, such as robins and starlings, in both fall and spring. They go dormant in the soil through the winter (though in mild winters they may stay active through January). The greyish brown, inch-long larvae begin to feed heavily again in late February or March through April During the day they feed on roots within $1^1/_2$ inches of the surface, while on moist nights or wet, cloudy days they feed closer to the surface or emerge to feed on root crowns. They stop feeding in May and are

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[a] The article cited is, "What will biologicals do for turfgrass management?" *TurfGrass Trends*, January 1994, pp. 10-13. It provides an excellent overview of current scientific research into biological controls for problem insects and disease fungi. See also footnote "a" on previous page, for compost tea information.

inactive in the soil until they emerge as adults in August. (The dates noted here can vary up to a month, depending on weather variations, especially temperature.) [a]

Crane fly damage usually becomes noticeable in May or June (*after* feeding has stopped) as a sparse or brown patchy lawn. Thin areas then become susceptible to weed invasion. In rare, extreme cases the lawn can be wiped out and must be re-seeded. The first year that crane flies invade a lawn is usually the worst; thereafter natural diseases, parasites, and predators seem bring them under control over a period of several years.[200]

2) Establish tolerance thresholds As noted, crane flies are usually only a serious problem for one or two years until their natural enemies become established. So one approach is not to worry and just accept the possibility of needing to re-seed the lawn if they arrive in force one year. For high-value turf such as golf courses, sports turf, or premium quality lawns, however, an early spring monitoring program is recommended. Suggested thresholds for action: 25 leatherjackets per square foot is a sign for concern on otherwise healthy lawns. 30 to 40 leatherjackets per square foot indicates a need for treatment to avoid significant damage. Thin, unhealthy lawns can be damaged at lower numbers (10-15 larvae per sq. ft.).[201]

3) Monitor Birds such as robins and starlings feeding heavily on the lawn in fall, or particularly late winter, are the best indicator that crane fly larvae may be present in sufficient numbers to warrant monitoring. (Studies show that birds can consume more than half the larvae between fall and spring.) Monitor for crane fly larvae when warmer weather comes at winter's end and the grass starts to grow, this is when they start to feed. In exceptionally mild winters start monitoring in January, but in most years about March 1-15. Cut several 6 inch squares of turf, 2 inches deep, and turn them over on a tarp. Tear them apart completely, especially the thatch layer, and count the greyish brown, ¾ to 1-inch long leatherjackets. Multiply your count for each 6-inch-square plot by 4 to estimate the number of larvae per square foot. Then average those per-square-foot totals to get an average number of larvae per square foot for the whole lawn. (Replace the soil, water, and sprinkle some grass seed to help restore the sampled areas.)

Professionals use a 4-inch diameter core sampler (such as the tool used for making golf course holes) to pull cores 2 inches deep from a number of places around the turf area. (This can also be done with a sharp knife and a 4-inch diameter cardboard disk as a guide.) The cores are torn apart to count the leatherjackets. Again, be sure to tear the cores completely apart – on cool, moist days many larvae will be in the thatch layer. The total counted is multiplied by 11.5 and then divided by the number of cores taken to estimate the average number of larvae per square foot.

Another monitoring method is to drench several 1 foot squares with a soap solution (1 oz. liquid soap in a gallon of water), wait about 10 minutes, and count the larvae that emerge from the surface. Trials at WSU indicate that this method only reveals about 1/4 of the larvae actually present, so it is not useful for determining action thresholds, but it will reveal whether larvae are present.

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[a] Three good guides to identification, prevention, monitoring, and non-chemical control are the *Common Sense Gardening: Crane Fly* brochure (Thurston County Community and Environmental Programs; because limited copies are available please read or photocopy at the listed libraries), *Crane Flies, Diazinon, and Dead Ducks* (Local Hazardous Waste Mgmt. Program in King County) and, for professionals, *Pro IPM: European Crane Fly* (from the Green Gardening Program, all listed under "Organizations" in bibliography). WSU Cooperative Extension's bulletin EB0856 *The European Crane Fly: A Lawn and Pasture Pest* includes photos of adults, larvae, and pupae with an excellent description of life cycle and timing (but not kinds) of control options. For turf professionals, the cited reference article, "European crane flies in the Pacific Northwest" is a valuable resource for life cycle, monitoring methods, and less toxic alternatives as well as conventional chemical controls (by Drs. Gwen Stahnke and Arthur Antonelli of WSU Cooperative Extension, in *Pest Control Progress*, newsletter of the Interstate Professional Applicators Assn., Vol. 13, No. 2, 1998, pp. 1-8.)

4) Modify maintenance program to promote vigorous grass and discourage crane fly Vigorous lawns are rarely heavily damaged by crane fly larvae, and recover more quickly. Crane fly eggs, laid in August and September, will die immediately if the soil around them dries. Water infrequently in late summer and make sure that the upper 2 inches of soil dries out completely between waterings; or stop irrigation altogether, especially if crane fly adults are seen on the lawn.

Several professionals have noted that crane fly damage seems to be worst on lawns where the soil stays saturated through the winter, perhaps because the wet soil protects them from cold desiccation (drying out). Core aeration will help improve drainage on compacted, organic poor soils. More serious measures like deep aeration (see page 24), re-grading to allow water to run off low areas, or even installing subsurface drain tiles may be needed on some lawns. Though expensive, these measures will make for a much better lawn. Grass will never grow well in soggy soil.

5) If crane fly larvae numbers exceed thresholds, use cultural, physical, mechanical or biological controls first; if those prove insufficient, use the chemical controls that have the least non-target impact

Note: Monitoring is the only way to prevent lawn damage. By the time thinning or browning appears in the late spring, the larvae are near the end of their feeding cycle and the damage is done. No control, chemical or otherwise, will help at this point. In fact, chemicals may poison the birds that would otherwise aid in reducing the larval populations. Any controls should be applied between March 15 and April 15, when larvae are actively feeding, and <u>only</u> if monitoring reveals an over-threshold population.

◊ ***cultural control of crane fly*** See maintenance modifications in Step 4 above. At levels of 10 to 15 larvae per square foot in March (see "Monitoring"), begin light fertilization to help the grass grow through the damage (spring fertilization on healthy lawns is usually left until late April or May, but in this case some extra nutrients are needed earlier).

◊ ***mechanical*** Three methods of physical or mechanical control are reported, though they have not been well tested with comparative trials.[202] The first is power aeration, which kills any larvae the tines contact. A second potentially effective method is to go over the lawn with a power de-thatcher on a cloudy, damp, or drizzly day when the crane fly larvae feed closer to the surface or even emerge to feed on root crowns. The third method is to drench the entire lawn with a soap solution (use a low-phosphate soap, not detergent; insecticidal soaps available at garden stores work best). Larvae that emerge at the surface can then be raked up. Repeat the monitoring process after any of these methods to verify that larvae numbers have been reduced below the action threshold.

◊ ***biological*** Birds and small mammals are the most effective control of crane fly larvae, usually reducing them to below problem numbers between fall and spring. Natural parasites will become established in the soil in the years after crane flies arrive. For over-threshold populations, significant control (about a 50% reduction in WSU trials) has been demonstrated with the application of beneficial nematodes that multiply rapidly and parasitize the larvae.[a] They are most active at soil temperatures above 55° F, which may limit their effectiveness in late winter, and they must be watered in well and the soil kept moist for them to be most effective.

◊ ***chemicals with the least non-target impact*** An oil extracted from the subtropical Neem tree has come into use as a botanical larvacide because of its relatively low toxicity to birds and mammals

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[a] Several species of beneficial nematodes are on the market now for different soil grubs or larvae: when buying be sure to the product is labeled for use on crane fly. (Two nematode species reported to be effective are *Steinernema carpocapsae* and *Steinernema feltiae.* Of the two, *feltiae* is reported to be more active at lower temperatures so may be a good choice for early spring control.) Follow label directions: these are living creatures and must be handled properly to survive. Many garden centers now sell them.

compared to conventional insecticides. (It *is* toxic to some aquatic organisms, and should not be used near streams or where runoff is likely.) In a trial at WSU one neem product (*Turplex*; another one on the market is *Bio-Neem*) reduced crane fly larva numbers by 39%,[203] which would usually be enough to bring them below the serious damage threshold. While somewhat less effective in WSU trials than nematodes, neem extract has the advantage of not being affected by temperature, so may be used earlier in the spring to limit early feeding and reapplied later if necessary. Monitor two weeks after application to verify that larvae have been reduced below the action threshold.

Conventional pesticide control is not recommended here because of hazards to humans, birds, and aquatic life, and damage to essential soil organisms. Both of the chemicals commonly used to prevent or control crane fly damage, chlorpyrifos and diazinon, are organophosphate insecticides with relatively high toxicity to humans, pets, beneficial soil organisms (earthworms, etc.), bees, birds and fish.[204] Documented mass kills of birds have led to diazinon being banned from use on golf courses and sod farms, though not yet on home or commercial lawns.[205]

6) Evaluate and record control effectiveness; modify maintenance to promote lawn recovery and prevent recurrence

Follow-up monitoring is recommended after any control measure. Continue to fertilize lightly to help grass grow through the damage. In April or May, de-thatch affected areas and over-seed: this is a key practice to prevent weed invasion. Even extremely damaged lawns are readily restored with this practice, but remember that spring-seeded grass will need regular irrigation through its first summer (see pages 19-21 and 25 for seeding procedures). Endophyte-enhanced grass seed has shown resistance to other soil-dwelling larvae, though this has not yet been demonstrated for crane fly larvae (see cautions, page 20).[206]

Summary of Ecologically Sound Lawn Care Practices

The goal of this report has been to recommend proven practices that support the natural vigor of grass plants and the soil community that sustains them, and minimize the need for practices that diminish that vigor. Turf professionals report that this approach results in easier lawn maintenance over the long term, and a healthier, better-looking lawn.

Key Recommendations

Recommended practices described in this report include:

- ◊ Setting realistic expectations for lawn appearance, and tolerating a few weeds.
- ◊ Proper site selection, and preparing the soil by tilling in compost to a depth of 6 to 12 inches.
- ◊ The selection of site-adapted and disease-resistant grasses.
- ◊ Moderate fertilization with natural or natural/synthetic-slow-release combination fertilizers, *to build soil nutrient reserves and biodiversity.*
- ◊ Mulch-mowing (also called "grasscycling") whenever possible.
- ◊ Mowing regularly (remove only 1/3 of grass height each time), and mowing a little higher, at 2 to $2^{1}/_{2}$ inches on most lawns (or 1 inch for bentgrass lawns).
- ◊ Avoiding over-watering: watering deeply, to moisten the whole root zone, but infrequently, *to limit disease and build deeper roots*; and watering dormant lawns at least once a month during the dry season, *to improve post-drought recovery.*
- ◊ Renovation/improvement practices that include aeration, compost topdressing, and overseeding, *to reduce compaction, increase water infiltration, improve soil structure and natural disease control, and crowd out weeds.*
- ◊ An integrated approach to pest problems that includes:
    1) Correctly identifying the cause of the problem
    2) Understanding the biology of the pest organism and its natural predators
    3) Setting realistic thresholds of acceptable damage to the lawn from pests (weeds, diseases, and insects)
    4) Monitoring for pest problems at appropriate times of the year, and
    5) Treatment of over-threshold problems with methods that support the turfgrass ecosystem and have the least non-target impacts on beneficial soil organisms, wildlife, pets, or humans. Where chemical solutions are necessary, time applications for maximum effect and use spot applications*. Repeated broadcast or calendar-based applications of pesticides should be avoided because they may damage the diversity and stability of the grass/soil ecosystem.*

Calendar of Recommended Lawn Maintenance Practices for the Puget Sound Region

This calendar presents two ends of a continuum, from the minimal maintenance for a healthy lawn to the extra practices that will maintain a high lawn appearance year-round. Additional practices useful on high wear turf such as playfields are summarized in the third column. These dates are for Puget Sound, and are only a rough guide. Each site is unique. The keys to developing an ecologically sound plan for maintenance are careful observation of grass growth, soils, and site characteristics, and a willingness to experiment, learn, and work *with* the natural processes that sustain the lawn ecosystem.

	Low maintenance lawns	*extra practices for* Higher maintenance lawns	Additional practices for high wear turf
Mar.	Correct drainage problems, or consider replacing poorly-drained lawn areas with more wet-tolerant plantings. Begin mowing.	Monitor for crane fly, and red thread disease. Get soil test every 2-3 years, and apply lime if needed, now or fall.	**Aerate** regularly through use season. Limit traffic on soggy soil. Look for and correct surface or sub-surface drainage problems.
April	**Leave clippings on lawn all year**. Mow at 2 to $2^1/_2$ inches, or 1 inch on bentgrass. Rake thin areas and overseed.	Aerate, overseed, and top-dress with compost in spring, fall, or both. If thatch thickness is 1" or more, dethatch	Overseed thin or weedy areas with each aeration. Locally-adapted perennial ryegrasses stand heavy wear best.
May	Pull (or spot spray) dandelions and other problem weeds to prevent spread.	**Fertilize** ($^1/_2$-1 lb.N) mid to late May when growth slows. Remove weeds Apr-June. Use mulching mower year-round.	Mulch-mow as much as possible through whole season.
June	Mow regularly (weekly) until lawn goes brown and dormant. **Limit wear on dormant lawns**.	Mow high (2-2½") and often; leave clippings. Turn off irrigation system if it rains.	Check irrigation systems at season's start, to verify uniform coverage with no runoff.
July	In dry years, water dormant lawns slowly and deeply once each rainless month.	Water deeply and slowly, 1" each rainless week. (Sandy soils need more frequent.)	High wear areas must be irrigated through summer. Aerate if use is heavy.
Aug.	Mow every 2 weeks on dormant lawn to limit dandelion spread.	Set timer to water just before dawn to limit disease. Let soil dry between waterings.	
Sept.	When rains come, rake thin areas and **overseed**. Aerate if compacted. Pull weeds.	**Fertilize** with natural fertilizer ($^1/_2$-1 lb. N /1000 ft^2) in early Sept. Pull weeds.	**Renovate** early to mid fall depending on use (aerate, overseed, topdress).
Oct.	For poor soils/poor lawns, topdress with compost now or in April, or both, to improve.	**Renovate**/replace lawns from Sept. 1st to Oct. 15. Aerate, overseed, topdress.	If renovation is not planned, at least overseed to crowd out weeds, & de-thatch if needed.
Nov.	**Fertilize** Sept.-Oct. 15 with natural fertilizers (1-2 lb. N/1000 ft^2); or up to Nov. 30 with synthetic slow-release	**Fertilize** Oct. 15 with natural fertilizers; Nov. 30 with synthetic slow-release (1 lb.N/1000 ft^2)	Continue aerating through playing season.
Dec.	Rake leaves off lawn, or mulch-mow in. Mow down to $1^1/_2$" on last mowing.	Birds feeding heavily on lawn in fall may signify need to monitor for crane fly in spring.	Limit traffic on frozen grass or saturated soils.
Jan. & Feb.	Sharpen mower blades, tune up equipment.	In warm winters, start crane fly monitoring.	

"We have met the enemy, and he is us."

Pogo

In Conclusion: Towards Sustainable Lawn Care

America is a land of lawns. While society's view of lawns is changing, there will always be grassy areas for play and relaxation, for their expansive visual effect, or because they are *there*, and seem to mostly take care of themselves. Grass ecosystems are diverse and durable, resistant to drought, erosion, and grazing (or mowing), and for these reasons once covered a large part of North America. Yet in our pursuit of an idealized unvarying green carpet, our lawns have become a resource sink of water, fertilizer, pesticides, and solid and hazardous waste disposal costs, as well as a significant source of non-point water pollution in our urban areas.

It is time to move towards more sustainable lawn care. Our challenge is to re-evaluate our expectations of what a lawn should be, and perhaps to loosen and soften those expectations. We can then begin again by learning to understand and work within the natural processes that shape the lawn and the community of soil organisms that sustains it. Professional experience has shown that this approach can yield a durable, beautiful lawn that is easier to care for, and fits well into the landscape of the Pacific Northwest.

Barriers to Change Reported by Turf Professionals

The professionals interviewed for this report were asked the following question in closing: "What barriers exist to widespread adoption of the recommended practices?" Their responses are summarized below, in their rough order of priority and frequency of mention.

1) **Lack of tolerance for some "weeds" (broadleaf plants) in lawn.** While mixes of the right grasses sown on fertile soil, mowed and fertilized properly, can out-compete most weeds, it is impossible to maintain a completely weed-free lawn without several broadcast herbicide sprayings annually. Relatively low levels of weeds can be maintained by regular overseeding of thin areas, and by spot-spraying or manual control. The "weed" invader that is most common and persistent in professionally maintained turf is clover. Natural grass systems always include legumes, and lawn grass mixes used to include clover, a perennially green, mowable nitrogen fixer. Tolerance for clover, annual bluegrass, and some (10 to 20%) broadleaf plants is essential to natural lawn care. Carl Elliot notes, "While most people will say they don't like weeds, if you show them a healthy, neatly mowed lawn with 20% broadleaf weeds, they don't mind it."

2) **Perception that lawns should be a deep blue-green.** The dark blue-green color attainable with fertilized Kentucky Bluegrass (which does not grow well here), can only be approximated in our rye-fescue lawns by pumping soluble nitrogen to them 5 to 7 times a season, which lays them open to disease and drought stress, and destroys soil structure (and may pollute surface and ground water). Professionals agreed that the public needs to understand that a healthy lawn in the Pacific Northwest is a medium "meadow" green, and that fertilizing heavily to deepen the color will only work for a few years before the soil is compacted and the lawn is choked by thatch.

3) **Perception that mulch-mowing causes thatch buildup.** Numerous studies have demonstrated that this is not true on moderately fertilized turf. Thatch buildup (over the 1/2 inch that is healthy) is caused by over-fertilization and the reduction of earthworms and soil microbiota by broadcast herbicides, insecticides, and soluble fertilizers. Professionals reported that naturally maintained lawns almost never have a thatch problem, and that mulch-mowing helps to reduce thatch by putting a moist, nitrogenous material in contact with the ligneous thatch layer (compost topdressing also works). Grasscycling reduces disease incidence and can provide 30-50% of the nitrogen needs of a highly maintained lawn, or 100% for a low-maintained lawn that includes clover growing on healthy soil.

4) **The promotional power of the chemical industry.** (Three professionals brought this up.) Ladd Smith of In Harmony (a residential lawn care business) notes, "There's a lot of money to be made in chemicals. Monitoring and spot-spraying takes time, but it is cost-effective because I use less product and much less expensive equipment. I also need to fertilize less frequently by using natural sources. However, the chemical industry won't give up easily."

5) **The assumption that chemicals are easy to use and always effective, and that they wouldn't be on the market if there were health risks.** (See first section of this report for information on pesticide effectiveness, and possible human health effects.)

6) **Inertia.** Tim Rhay (Turf and Grounds Supervisor, City of Eugene, Oregon) notes, "First you have to convince people that they *can* do things differently, and get them to try it and observe the result. With professional crews, you need to bring both the boss and the field crew on board: train them both, then give the field crew license to practice and improvise, and the time to observe and learn as they go."

7) **Lack of knowledge about alternatives to chemical-intensive lawn care.**

8) **Budgets.** Turf managers are always under pressure to get immediate results on a limited budget.

Beyond Barriers: Steps Towards Sustainable Lawn Care

for Public Resource Managers

Lawns are a meeting point for many public concerns, including water use, disposal of mountains of clippings and containers of hazardous chemicals, water and air pollution, human health effects, effects on salmon, birds and other wildlife, and the desire for attractive green spaces to play and live in. This offers a challenge and an opportunity for groups of resource agencies and citizens to come together and develop a consensus for change. As this report demonstrates, lawns can be healthy, easy to maintain, and sustainable. Education about these alternatives can be a community-wide project. Possibilities include:

◊ Work with existing citizens groups or volunteer-based public education programs (such as Master Gardeners). Produce a slide show with local examples that these groups can use.
◊ Produce a simple lawn care factsheet that fits local conditions.
◊ Use media events to get coverage on local TV and radio.
◊ Build information resources for professionals and residents in local libraries (see bibliography).
◊ Sponsor field days for residents and for turf professionals demonstrating modern mulching mowers (including electric mowers), proper mowing height, and irrigation methods.
◊ Sponsor professional seminars. Write articles for professional association newsletters.
◊ Educate residents about what questions to ask when choosing a lawn care company.

◊ Work with professional groups to develop education and certification for ecological lawn care professionals, and support their marketing efforts.

◊ Develop code specifications (and training for inspectors) for proper soil amendment and site preparation for lawns on new construction sites.[a]

for Landscape Professionals

The lawn care market in America is changing, with customers asking more questions about how their yards or institutional areas are maintained, what products are used, and what their effects are. Environmentally sound lawn care practices such as grasscycling, less frequent natural fertilization, spot spraying of weeds, and an observant IPM program can save labor, equipment, and disposal costs, and are already giving some businesses a competitive edge. These practices will position your business in the growing ecological lawn care market. They also help to insulate your business from rising pesticide costs and increasing pesticide regulation, changes in grass disposal requirements, and liability claims by customers and neighbors. To take advantage of this opportunity:

◊ Use the resources listed in the bibliography to learn more about ecological approaches to lawn care.[b]

◊ Encourage professional organizations and Cooperative Extension universities to offer training and support research in your region.

◊ Share ideas – find our what other professionals in your region have tried, and what worked.

◊ Research and try out mulching mowers, and try mowing a little higher (in the Puget Sound region, 2 to 2½ inches on most lawns, 1 inch on bentgrass) .

◊ Educate customers about the benefits of mulch-mowing and reducing pesticide use.

◊ Try "bridge" fertilizers that combine natural-organic sources with synthetic slow release. Try late fall fertilization (west of the Cascade mountains). Combining natural fertilizers with mulch-mowing should allow a decrease in the frequency and quantity of fertilizer applications. On disease-prone turf, try topdressing with mature screened compost, and moving from soluble fertilizers toward natural-organic sources.

◊ Use the resources listed in the bibliography, professional associations, and your local Cooperative Extension, to learn more about local pest problems: how to monitor for them, preventive cultural practices for your region, and least-toxic control methods.

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[a] The City of Redmond, WA has been working on a model code for soil amendment. For information, and a copy of their report, *Guidelines for Landscaping with Compost-Amended Soils*, contact Phil Cohen, P.E., Natural Resources Div., City of Redmond Public Works, Redmond, WA 98073, (425)556-2815 or e-mail pcohen@ci.redmond.wa.us

[b] Bibliography resources useful to professionals at different levels of interest or prior knowledge include:

- introductory level *B.U.G.S. Flyer* (professional journal); *Least-Toxic Pest Management for Lawns*; *IPM Training Manual for Landscape Gardeners*; *Handbook of Successful Ecological Lawn Care*; *The Natural Lawn (& Alternatives)*; *The Chemical-Free Lawn*; and the article "Using Compost Successfully."
- more technical ***Handbook of Integrated Pest Management for Turfgrass and Ornamentals***; *Controlling Turfgrass Pests*; *Golf Course Management & Construction - Environmental Issues*; and the articles "Improving Turf Soils with Compost" and "Enhancing Turfgrass Disease Control with Organic Amendments."

Ecologically Sound Lawn Care for the Pacific Northwest

ANNOTATED BIBLIOGRAPHY

These books, articles, journals, videos, organizations, and Internet sites will be useful to residents or professionals interested in installing and maintaining attractive, durable lawns that require less water, fertilizer and pesticides, and create less solid waste, hazardous waste and water contamination. **Key resources are identified by bold titles** - these titles provide an excellent starting point for reading.

These documents may be found at the locations coded at the end of the reference entry:

SPL Seattle Public Library, Main Branch, 1000 4th Ave., Seattle, WA 98104. (206)386-4636

HWL King County Hazardous Waste Library, Anne K. Moser, Librarian
130 Nickerson St., Suite 100, Seattle, WA, 98104. (206) 263-3051, fax 263-3070
This library is key regional resource for IPM and other toxic reduction information.

CUH Elisabeth C. Miller Library *(reference only)*, Valerie Easton, Librarian
Center for Urban Horticulture, University of Washington, 3501 NE 41st St.,
Box 354115, Seattle, WA 98195-4115. (206)543-8616, fax 685-2692

Books

Ball, Jeff and Liz. ***Smart Yard: 60-Minute Lawn Care***. Golden, CO: Fulcrum Publishing, 1994. *SPL*

Companion text to the video *How to Care for Your Lawn* (below), this complete and accessible text will answer most home lawn questions. Particularly valuable for analysis and correction of problems.

Balogh, James C. and William J. Walker, eds. *Golf Course Management & Construction: Environmental Issues.* Boca Raton, FL: Lewis Publishers, 1992. *HWL*

An exhaustive review of issues, with design and management alternatives for golf course managers, designers and developers. Relevant to design and maintenance of other turf/landscape areas (parks, commercial, institutional) as well as golf courses. See especially the chapter, "Development of Integrated Management Systems for Turfgrass."

Beard, James B. *Turfgrass: Science and Culture*. Englewood Cliffs NJ: Prentice Hall, 1973. *SPL*

The standard text and reference on turf science. At 650 dense pages, best used for reference on specific topics, see for instance the discussion of properties of various naturally-derived fertilizers.

Bobbit, Van. *Pacific Northwest Landscape IPM Manual.* Pullman, WA: WSU Cooperative Extension, 1996. *HWL*

An excellent resource for landscape professionals.

Bormann, F. Herbert, with Diana Balmori and Gordon T. Geballe. ***Redesigning the American Lawn: A Search for Environmental Harmony***. Yale University, 1993. *HWL, SPL, CUH*

An examination of the history of lawns, the rise of the "Industrial Lawn", the environmental impacts of modern lawn care, and a proposal for change in the way Americans view their lawns. This book is long on lawn history and philosophy and short on specific practices for change, but provides an excellent starting place for re-thinking lawn uses and cultural practices.

Briggs, Shirley A. *Basic Guide to Pesticides: Their Characteristics and Hazards*. Washington: Taylor and Francis, 1992. *HWL, CUH*

Descriptions, uses, brand names and human and wildlife health effects citations for all pesticides.

Center for Resource Management. ***Golf and the Environment: Environmental Principles for Golf Courses in the United States***. Available from The Center for Resource Management, 1104 East Ashton Avenue, Suite 210, Salt Lake City, Utah 84106, (801)466-3600. Or available on-line at the Golf Course Supt. Association web site, see "Internet Sites" section. 1996. *HWL*

Excellent brief (15 pages)"best practices" document produced by discussion and consensus among very diverse stakeholders, including US Golf Assoc., National Golf Foundation, Golf Course Superintendents Assoc. of America, Audubon International, Friends of the Earth, Sierra Club, US EPA, and ten other scientific, industry, and environmental organizations.

Daniels, Stevie. *The Wild Lawn Handbook.* New York: Prentice Hall MacMillan, 1995. *SPL, CUH*

A well researched and readable guide to prairie, wild grass, and non-grass alternatives to the traditional lawn, including considerable species and region specific information.

Daar, Sheila, ed. ***Least Toxic Pest Management for Lawns***. Bio-Integral Resource Center, (POB 7414, Berkeley, CA, 94707, (510) 524-2567) 1992. *HWL*

This collection of articles from *Common Sense Pest Control Quarterly* and *The IPM Practitioner* presents a fairly complete description of specific IPM strategies appropriate to Northwest lawns, in language accessible to interested amateurs as well as professionals.

Daar, Sheila, with Helga Olkowski and William Olkowski. ***IPM Training Manual for Landscape Gardeners***. Berkeley: Bio-Integral Resource Center (address above) 1992. *CUH*

The best non-technical guide to IPM practice in the field. 50 pages, clear language, with field-based practical techniques. See also appendices on designing IPM policies, for resource managers.

Daar, Sheila. *Establishing Integrated Pest Management Policies and Programs: A Guide for Public Agencies.* Davis, CA: IPM Education and Publications. 1994 *HWL*

A practical guide to designing and implementing IPM policies and practices.

Franklin, Stuart. ***Building a Healthy Lawn***. Pownal, VT: Garden Way Publishing, 1988. *SPL, CUH*

Complete information on creating and maintaining a vigorous lawn that is easy to care for with minimal or no chemical inputs; this book is both readable and technically sound. Like *The Chemical-Free Lawn* (below), the major failing is lack of specificity for the Pacific Northwest. Both books should be combined with a PNW-specific guide like the Cooperative Extension's *Home Lawns* for information on locally adapted grass species, soils, and diseases.

Jenkins, Virginia Scott. *The Lawn.* Washington: Smithsonian Institution Press, 1994.

A complete scholarly history of lawns, well referenced. Of particular interest for documentation of the changes in lawn care wrought by the introduction of synthetic chemicals and the rise of the lawn care industry.

Leslie, Anne R., ed. US EPA. ***Handbook of Integrated Pest Management for Turfgrass and Ornamentals***. Boca Raton, FL: CRC Press (Lewis Publishers), 1994. *HWL, CUH*

An excellent text for turf professionals and resource managers. The Environmental Protection Agency solicited experts in each field to write the chapters of this substantial book, which would be useful both as a field practitioner's guide and a textbook for IPM students. Each article synthesizes the best current research and presents the information in clear language. The articles cover an overview of IPM practices and rationale as well as discussing hundreds of specific weed, insect, and disease problems in detail. Many readers may want to start with the case studies by landscape professionals in the back of the book, which highlight the pitfalls and successful strategies they encountered in implementing IPM practices in the real world.

Leslie, Anne R., and Robert L. Metcalf, eds. *Integrated Pest Management for Turfgrass and Ornamentals*. Proceedings of 1987 Symposium, "Urban Integrated Pest Management: An Environmental Mandate." Washington: US EPA (Office of Pesticide Programs, Field Operations Division, Wash., DC 20460), 1989. *CUH*

This symposium led to the creation of the *Handbook* above, and some papers are duplicated in both. See especially the section on endophytes in grass.

Lewandowski, Ann, ed. ***The Soil Biology Primer***. USDA Natural Resources Conservation Service, 1999. Free publication available by calling 1-888- LANDCARE (1-888-526-3227)
A text version (minus many of the illustrations) can currently be downloaded at http://www.statlab.iastate.edu/survey/SQI/ *HWL, CUH*

A concise (50-page) explanation of the soil ecosystem, its organisms and how they interact, and its importance in soil functions and plant health. Each section is written by scientific authorities in non-technical language and illustrated with excellent graphs, illustrations, and micro-photographs. This publication is essential for any one working in landscapes or agriculture.

Marinelli, Janet, ed. ***The Natural Lawn (& Alternatives)***. Brooklyn Botanic Garden Record, 1000 Washington Ave., Brooklyn, NY 11225. 1993 *SPL*

This short (100 page) booklet is clear and engaging enough for amateurs, but informative enough to introduce professionals to ecological lawn care. Short chapters written by a variety of experts are full of practical instruction and excellent photos. There are also several chapters on "alternatives", notably moss "lawns", other shade-loving ground covers, native low-growing grasses, and meadows.

Olkowski, William, Daar, Sheila, & Olkowski, Helga. ***Common-Sense Pest Control***. Newtown, CT: Taunton Press, 1994. *HWL*

Encyclopedic authority on Integrated Pest Management techniques, including an excellent introduction to IPM and a comprehensive sections on lawns, ornamentals, etc. The basic reference.

Raymond, Dick. *Down to Earth Natural Lawn Care.* Pownal, VT: Storey Publishing, 1993. *SPL, CUH*

A fairly brief, readable description of lawn care basics. Good illustrations of re-seeding techniques.

Sachs, Paul D. *Handbook of Successful Ecological Lawn Care*. Newbury, VT: Edaphic Press, 1996. *HWL*

Professionals will find a fairly complete discussion of ecological lawn care techniques and rationale, including references. Of particular interest is the section on marketing for lawn businesses.

Schultz, Warren. ***The Chemical-Free Lawn***. Emmaus, PA: Rodale Press, 1989. *HWL, SPL, CUH*

This is a complete "how-to" manual for all aspects home lawn installation and care, written in clear language, accessible to everyone and well illustrated with line drawings. It does not contain information specific to the Pacific Northwest, but is a good basic primer.

Schultz, Warren. *Natural Insect Control: The Ecological Gardener's Guide to Foiling Pests*. Brooklyn, NY: Brooklyn Botanic Garden. 1994. *HWL, CUH*

With photographs and illustrations aiding pest identification, this book gives control methods for over 50 common insects found in North American gardens. More applicable to other landscapes, but some turf IPM practices.

Shurtleff, Malcom C., with T.W. Fermanian and R. Randell. *Controlling Turfgrass Pests.* Englewood Cliffs, NJ: Prentice Hall, 1987. *CUH*

For professionals: weed & disease photos, turf cultural practices, and some IPM methodology.

Articles, Manuscripts, and Professional Journals

Source scientific articles for the report "Ecologically Sound Lawn Care for the Pacific Northwest" are listed in the References section of the report. The journals and articles listed below are of general interest, and include a few key source articles.

B.U.G.S. Flyer. (Biological Urban Gardening Services, POB 76, Citrus Heights, CA 95611) $18 for 4 issues. Plain-English reviews of current IPM research, and field-tested techniques, for professionals.

Hortus West: A Western North America Native Plant Directory & Journal. (PO Box 2870, Wilsonville, OR 97070-2870) Two issues/year for $12. *CUH* Cross-referenced lists of western native plants and vendors, technical articles, and a professional services directory.

Alexander, Ron, and Rod Tyler. "Using Compost Successfully." *Lawn & Landscape Maintenance,* Nov. 1992, pp. 23-34.

Tested methods and tips for compost use in landscaping, including turf seedbed prep and topdressing.

Chollak, Tracy, and Paul Rosenfeld. "Guidelines for Landscaping with Compost-Amended Soils." Research report fo City of Redmond, WA Public Works. Download under "Publications" at http://depts.washington.edu/cuwrm/ or available from Phil Cohen, project manager for City of Redmond, (425) 556-2815 or e-mail pcohen@ci.redmond.wa.us 1998.

Results field trials, including cost/benefit projections and specifications for using compost.

Kolsti, Kyle F., Burges, Stephen J., & Jensen, Bruce W. *Hydrologic Response of Residential-Scale Lawns on Till Containing Various Amounts of Compost Amendment.* Unpublished masters thesis and report to Washington State Department of Ecology. Available from Univ. of Wash. Center for Urban Water Resources, Roberts Annex, FX-10, Seattle WA 98195, (206)543-8954. 1995. *HWL*

Reports positive effects of compost amendment on storm-water infiltration and detention.

Landschoot, Peter. "**Improving Turf Soils with Compost**." *Grounds Maintenance,* June, 1995 pp.33-39

Summarizes Dr. Landschoot's (Pennsylvania State University) turf trials with various compost amendments. See also his user specifications manual, listed below under Penn State Coop. Extension.

Morris, James "Ciscoe". ***Lawn Maintenance and Renovation, or How to Have a Dynamite Lawn***. unpublished manuscript, 1991. *HWL, CUH*

Practical directions for lawn maintenance in the NW. See section on lawn replacement techniques.

Nelson, Eric B. "**Enhancing Turfgrass Disease Control with Organic Amendments**." *TurfGrass Trends: A Practical Research Digest for Turf Managers,* Vol. 5, No 6, 1996, pp. 1-14. Reprints available from TurfGrass Trends, 1775 T Street, NW, Washington, DC 20009-7124. *HWL*

An excellent summary of Dr. Nelson's research at Cornell University in compost amendment and topdressing for superior growth and disease control on turf, for professionals or interested lay readers. This journal, ***TurfGrass Trends***, is a valuable resource for any turf professional.

Potter, Daniel A. "Earthworms, Thatch, and Pesticides." *USGA Green Section Record*. Vol. 29, No. 5, 1991.

Summarizes the role of earthworms in turfgrass, and the relationship between earthworms, thatch, fertilizers, and pesticides.

Videos

Ball, Jeff. ***How to Care for Your Lawn***. (available from Kartes Video Communications, 7225 Woodland Drive, Indianapolis, IN). 53 min. *SPL*

Excellent complete guide to lawn establishment and maintenance, and basic IPM, for homeowners.

Clokey, Joe, and Jim Harrigan. *Integrated Pest Management in Turf*. Los Osos, CA: San Luis Video. 25 min. 1992. *HWL*

A good guide to IPM approaches, but not specific to Northwest pest problems.

Love, Sam. *Naturescaping: A Landscape Alternative.* (available from Public Production Group, 900 Second St. NE, Suite 4, Washington, DC 20002, (202)898-1808). 29 min. 1991. *SPL*

Explores alternatives to the traditional suburban landscape.

Robinson, Naomi, and The Toronto Environmental Alliance. *Growing Like A Weed*. (available from The Video Project, 5332 College Ave., Suite 101, Oakland, CA 94618, (800)475-2638). 29 min. 1992. *SPL*

Combines interviews with Toronto residents, toxicologists, and landscape architects to make a case for chemical-free lawn care and alternative landscaping.

Rodale Institute and the Composting Council ***Using Compost for Landscaping and Nursery Production***. (available from The Rodale Institute, 611 Siegfriedale Road, Kurtztown, PA 19530, (610) 683-1400). 1996

Practical professional guide to the benefits of compost and the range of compost uses, including lawn seedbed prep and turf topdressing.

Wisconsin's Environmental Decade Institute. *Great Lakes, Great Lawns: A Homeowners Guide to Growing Lawns Without Pesticides.* (available from Wisconsin's Environmental Decade Institute, 122 State Street, Suite 200, Madison, WI 53703, (608)251-7020. 29 min. 1996. *HWL*

Identifies effects of lawn chemicals on the Great Lakes and residents. Interesting and informative, but short on specific techniques for chemical-free lawn care.

Organizations offering Brochures, Periodicals, and other Information

Bio-Integral Resource Center. (BIRC) PO Box 7414, Berkeley, CA 94707. (510) 524-2567, fax (510)524-1758, web site: http://www.igc.apc.org/birc/

Science and field-based information resources for Integrated Pest Management. Titles include:

Least Toxic Pest Management for Lawns. See description under Daar, Sheila, ed. in Books section.

IPM Training Manual for Landscape Gardeners. See description under Daar in Books section.

Common Sense Pest Control. See description under Olkowski, Daar & Olkowski in Books section.

Catalogue of BIRC publications. Numerous reports and reprints covering specific pest problems, written for professionals and interested amateurs, $1.00

BIRC also publishes two excellent periodicals, subscriptions included with memberships:

Common Sense Pest Control Quarterly. Written for general public. *HWL, CUH*

The IPM Practitioner. For professionals. *HWL, CUH*

California EPA Department of Pesticide Regulation. 1020 N Street, Room 161, Sacramento, CA 95814-5604. (916)324-4100, Web site: http://www.cdpr.ca.gov

Besides the searchable pesticide database at their web site, the DPR also publishes factsheets and:

Suppliers of Beneficial Organisms in North America. A free cross-indexed catalogue of vendors of biological control organisms in the US, Canada and Mexico, very useful to IPM professionals.

Clean Washington Center. (CWC) Publications, 2001 6th Avenue, Suite 2700, Seattle, WA 98121. (206)587-5520, fax (206)464-6902, Web site: http://www.cwc.org/

CWC provides technical support to developing markets for recycled materials. Full reports or “factsheet” summaries can be ordered for each research project (the factsheets are also on the Web):

Commercial Development of Disease-Suppressive Compost. (CM-93-2)

Compost Use for Wetland Restoration Projects. (CM-96-2)

Compost End-Use Guidelines. (CM-96-1)

Environmental Protection Agency. (EPA) Public Information Center, 401 M Street SW, Washington, DC 20460. (202)260-2080 Web site: http://www.epa.gov Titles include:

Healthy Lawn, Healthy Environment. (EPA 700-K-92-005) Home lawn care with IPM. *HWL*

Citizen’s Guide to Pest Control and Pesticide Safety. (EPA 730-K-95-001) Practical IPM application to home and yard, including a very clear section on reading and understanding pesticide labels. *HWL*

Pest Control in the School Environment: Adopting Integrated Pest Management. (EPA 735-F-93-051) Useful for re-thinking pest management approaches. Includes resource listings.

National Publications Catalogue. (EPA 703-B-95-001)

Catalogue of Office of Pesticide Programs. (EPA 730-B-94-001)

Golf Course Superintendents Association. 1421 Research Park Drive, Lawrence, KS 66049-3859. (800) 472-7878, e-mail: dbishop@gcsaa.org, Web Page http://www.gcsaa.org/

A membership organization with a growing commitment to building environmental principles into golf course management, offers IPM training courses to members, some public information on Web.

Green Gardening Program. Seattle Tilth Association, 4649 Sunnyside Avenue N, Seattle, WA 98103. (206) 547-7561. (A collaboration of Tilth, Wash. Toxics Coalition, and WSU Coop. Extension KC.)

Promotes alternatives to pesticides through presentations to groups and training for nursery and garden store staff in King County, WA. Well researched brochures for the Pacific NW include:

Six Steps to A Healthy, Pesticide-Free Garden. Excellent introduction to ecological landscaping.

Pro IPM series. Science-based factsheets for landscape professionals on common pest problems: their identification, life cycle, setting action thresholds, and control options. Series currently includes Aphids, Brown Rot, European Crane Fly, Fungal Diseases on Roses, Root Weevil on Rhododendrons, Tent Caterpillar, Annual Weeds, and Perennial Weeds, and is constantly expanding.

Irrigation Association. 8260 Willow Oaks Drive, Suite 120, Fairfax, VA 22031. (703)573-3551. Or contact the WA chapter at (206)467-6419. Web site: http://www.irrigation.org/

Produces a directory of certified irrigation specialists and conducts irrigation auditor training and design training. On-line newsletter and useful irrigation cross-links at web site.

Irrigation Training and Research Center. Cal. Poly. University, San Luis Obispo, CA 93407.

Produces technical conservation-practices manuals for central-control irrigation system professionals: *Landscape Water Management Principles.* and *Landscape Water Management Auditing.*

Local Hazardous Waste Management Program in King County. 130 Nickerson St., Suite 100, Seattle, WA, 98104. Web site http://www.metrokc.gov/hazwaste/house/

Besides co-sponsoring the Green-Gardening Program above, the LHWMP web site provides a number of resources on alternatives to hazardous products in the home and garden. Two brochures, which are also available through the Natural Lawn Care hotline (1-888-860-LAWN) are:

Crane flies, diazinon, and dead ducks. Easy to understand and well illustrated guide to identifying, monitoring for, and least toxic control methods for European crane flies in Northwest lawns.

Four reasons to kick the weed and feed habit. Science-based, includes alternatives.

Northwest Coalition for Alternatives to Pesticides. (NCAP) PO Box 1393, Eugene, Oregon 97440. (541) 344-5044, e-mail info@pesticide.org, website http://www.pesticide.org

Well researched information on pesticide issues and alternatives. Write or see Web page for full list of documents and prices. Titles applicable to turf management (some can be downloaded from website) include:

Pesticide Chemical Information Packet. Complete collection of 2-4 page factsheets (also available individually) on more than 20 pesticides, synthesizing best current knowledge, with references (call for current price). 1994, continually updated. *HWL*

Lawn Care. Facts and resources for reducing pesticide use on turf areas. *HWL*

Pesticides on Golf Courses. Discusses issues and some alternatives. *HWL*

Diminishing Returns, Salmon Decline and Pesticides. Download at website, http://www.pesticide.org

NCAP also sells the books *Common Sense Pest Control* and *Natural Insect Control*; see Book section above for notes on these books.

Membership includes subscription to the ***Journal of Pesticide Reform***, notable for articles on pesticides and alternatives that are researched and referenced to scientific journal standards.

Pennsylvania State University Cooperative Extension. ***Using Composts to Improve Turf Performance***. author: Peter Landschoot, Associate Professor of Turfgrass Science. Available from Publications Distribution Center, Penn State University, 112 Agricultural Administration Bldg., University Park, PA 16802. (814)865-6713. 10 pages. 1996.
download at http://www.agronomy.psu.edu/Extension/Turf/TurfExt.html or *HWL*

For turf professionals, the best brief guide to application of compost in soil prep. and as topdressing.

Seattle Public Utilities, Resource Conservation section. 710 2nd Avenue, Suite 505, Seattle, WA 98104. (206) 684-7560. Web site http://www.ci.seattle.wa.us/util/rescons

Besides sponsoring the Green Gardening Program (see above), and maintaining an informative Natural Lawn Care web site and hotline (1-888-860-LAWN), SPU distributes brochures, including:

Natural Lawn Care for Western Washington. Complete, easy to understand and well illustrated steps to ecologically-sound lawn care for residents, in an eight-page booklet.

A Shopping Guide to Mulching Lawnmowers. For home-grade mowers, includes grasscycling tips.

Grasscycling. Complete basic information for successful mulch-mowing.

Salmon Friendly Gardening. How reduce our impacts on salmon at grow beautiful gardens.

Home Composting. The brochure that launched a thousand urban composting programs, by Seattle Tilth. Still the best brief primer on composting concepts and methods.

Cedar Grove Compost Users Guide for Landscape Professionals. A guide for professionals, with purchasing and installation specifications for various compost uses.

For Seattle residents, the SPU supports the **Compost Hotline - 633-0224**, staffed by Seattle Tilth.

Thurston County Community and Environmental Programs. 2000 Lakeridge Dr. SW, Bldg. 4, Olympia, WA 98502.

Excellent brochures in the Common Sense Gardening series include:
Lawn Care, Avoiding Lawn Disease, Understanding Weeds, Plan Before You Plant, ***Crane Fly****,* and *How Does it Work?* (basic IPM) Note: Because of limited funding they can only provide single copies to libraries. For reference see complete set of these brochures at *HWL.*

U. S. General Accounting Office. (U.S. GAO) PO Box 6015, Gaithersburg, MD 20884-6015. (202)512-6000, fax (301)258-4066. (1st copy of each report is free.)

The GAO has released several informative reports about pesticide use and health effects, including:

Lawn Pesticides: Reregistration Falls Further Behind and Exposure Effects Are Uncertain. RCED-93-80. April, 1993.

Pesticides: Issues Concerning Pesticides Used in the Great Lakes Watershed. RCED-93-128. 1993.

Lawn Care Pesticides: Risks Remain Uncertain While Prohibited Claims Continue. RCED-90-134. 1990.

U.S. Geological Survey, Puget Sound NAWQA (National Water Quality Assessment Program), 1201 Pacific Avenue, Suite 600, Tacoma, WA 98402. (253) 428-3600 (x2653), or dowload reports off web site http://wa.water.usgs.gov/ps.nawqa.html

Summaries of current surface sampling in the Puget Sound region, include:

Pesticides in Selected Small Streams in the Puget Sound Basin, 1987-1995. USGS Fact Sheet 067-97

Pesticides Detected in Urban Streams During Rainstorms and Relations to Retail Sales of Pesticides in King County, Washington. USGS Fact Sheet 097-99, 1999.

See also the national NAWQA web site, http://water.wr.usgs.gov/pnsp/ for several reports on pesticides in waters around the U.S. especially *The Quality of Our Nation's Waters: Nutrients and Pesticides.* U.S.G.S. Circular 1225, 1999.

Washington Toxics Coalition. (WTC) 4649 Sunnyside Ave N, Suite 540E, Seattle WA 98103. (206) 632-1545

Authoritative and readable factsheets on alternatives to toxics, $1.50 each, or download many of them from the WTC website: http://www.watoxics.org/ Turf-related titles include:

Lawn Care. An excellent brief guide to ecological lawn care. *HWL*

Weed Management for the Lawn and Garden. Again, clear, authoritative, and specific to the Pacific Northwest. *HWL*

Appropriate Plants for Northwest Landscapes. The best starting point for selecting trouble-free plant species. *HWL*

WSU Cooperative Extension. USDA, Washington State University, Pullman, WA 99164. or King County Coop Ext. (206)296-3900. Call for free catalogue. Some publications can be downloaded from the WSU Master Gardener website at http://gardening.wsu.edu/ Titles include:

Home Lawns. EB0482 Basic lawn installation and maintenance, specific to Pacific Northwest.

Diseases of Turfgrass. EB713 Color pictures of fungal diseases in Northwest.

Turfgrass Seeding Recommendations for the Pacific Northwest. PNW299 Seeding rates.

The European Crane Fly. EB0856 Life cycle and chemical control of crane fly

Construction and Maintenance of Natural Grass Athletic Fields. PNW0240

Concepts of Integrated Pest Management in Washington. EB753

Read Pesticide Labels. EB1468

and the DialExtension recorded lawn & garden tapes which can be heard at (206) 296-3425

Internet Sites

Turfgrass Information Center. http://www.lib.msu.edu/tgif/

Comprehensive searchable database of turf scientific literature, at Michigan State University, with one section available free and the whole database accessible by subscription. Also useful links to other turf sites for turf professionals.

Soil Food Web. http://www.soilfoodweb.com

Dr. Elaine Ingham's (Oregon State university) site, the best starting point for information on soil ecology and how soil organisms provide essential functions like nutrient cycling and disease protection to plants. Information on compost and compost tea benefits and uses.

NRCS Soil Quality Institute. http://www.statlab.iastate.edu/survey/SQI/

Professional publications on soils, including the excellent reference for professionals, educators, and citizens, ***The Soil Biology Primer***, at http://www.statlab.iastate.edu/survey/SQI/primer/index.htm

Weed Images. http://www.rce.rutgers.edu/weeds/

Index of common "weed" plants with clear images for identification that load in about 15 seconds, as well as higher resolution images that take much longer and won't load on some systems.

EcoNet Home Page. http://www.igc.apc.org/igc/econet

Searchable news page and crosslinks to sites dealing with environmental issues.

Penn State Turfgrass Extension. http://www.agronomy.psu.edu/Extension/Turf/TurfExt.html

Download excellent turf-related publications, especially Dr. Peter Landschoot's "**Using Composts to Improve Turfgrass Performance**", the best brief guide to soil prep and topdressing with compost.

Cornell Composting. http://www.cfe.cornell.edu/compost/

On-line and print resources for the compost amateur or the waste management professional, well indexed, with links to all the other useful sites. Persons starting large or small composting systems will find an excellent tutorial and references in the "Science & Engineering" files.

U.S. Composting Council. http://compostingcouncil.org/index.html

Professional training for compost facilities operators, also compost use information for landscapes.

compost tea: two sites offering equipment for making compost tea for plant disease control and technical information on this subject are: http://www.growingsolutions.com/ and http://www.soilsoup.com/

Cityfarmer's Urban Agriculture Notes. http://www.cityfarmer.org

High quality reports from Cityfarmer - Canada's Office of Urban Agriculture. Large and small scale urban agriculture and composting documentation from Canada and around the world.

Seattle Public Utilities. http://www.ci.seattle.wa.us/util/rescons

Extensive and user-friendly information on natural lawn care, water conservation, composting, salmon-friendly gardening practices and watershed protection. Also download this report.

WSU Master Gardener. http://gardening.wsu.edu/

Information on lawn care, gardening, IPM, composting and more for Western Washington.

Soils for Salmon. http://dnr.metrokc.gov/swd/resrecy/soil4salmon.htm

Download illustrated issue paper or slide show that explain the role of living soils and compost soil amendments in reducing stormwater runoff and water pollution, and standards for soil restoration.

Local Hazardous Waste Management Program in King County. http://www.metrokc.gov/hazwaste/house/

Home and yard hazards and alternatives, including identification pages for both pests and beneficial bugs, and information on pest resistant plants for the Pacific Northwest.

See the LHWMP main page, http://www.metrokc.gov/hazwaste for a wide range of information to help businesses and individuals reduce, recycle or dispose safely of hazardous waste.

U.S. Geological Survey, Puget Sound NAWQA (National Water Quality Assessment Program). http://wa.water.usgs.gov/ps.nawqa.html

Summaries of current pesticide sampling research in the Puget Sound Basin. See reports listed under U.S. Geological Survey in Organizations section. See also the national NAWQA site for several reports on fertilizer and pesticide contamination around the U.S., http://water.wr.usgs.gov/pnsp/

Northwest Coalition for Alternatives to Pesticides (NCAP). http://www.pesticide.org

Science-based information about pesticide issues and alternatives, see entry in Organizations section.

Environmental Protection Agency Home Page. http://www.epa.gov

Current publications, programs, and information/support available from the EPA. Of particular interest is the information on lawn and garden equipment emissions and ways to reduce emissions, located at http://www.epa.gov/OMSWWW/lg-emiss.htm Also see the Office of Pesticide Programs at http://www.epa.gov/pesticides/

Professional Lawn Care Association of America. http://www.plcaa.org

Information for professionals, including home-study opportunities, research abstracts, and links to other lawn professional sites, from the organization that popularized the term "Grasscycling".

Biocontrol Network. http://www.biconet.com/

Current news, research, and cross-links on integrated pest management and biological pest control.

BIRC - Bio-Integral Resource Center. http://www.igc.apc.org/birc/

Science-based integrated pest management information, training documents, and useful links to related sites, from the publishers of *IPM Practitioner* and *Common Sense Pest Control Quarterly.* (See complete list of resources available at entry under "Organizations.")

IPM Access - Integrated Pest Management Practitioners Association. http://www.efn.org/~ipmpa/

This site is currently under construction – it will serve as an information forum for IPM professionals.

University of California Statewide Integrated Pest Management Project. http://axp.ipm.ucdavis.edu/

Excellent photos, descriptions, and lifecycle of many weeds, insects and diseases found in residential, commercial and agricultural settings, including turfgrass pests. Includes both cultural and chemical control methods. This California database includes many, but not all Northwest pest problems.

IPMnet - Center for Integrated Pest Managment. http://ipmwww.ncsu.edu:8150/cipm/

A network sponsored by the chemical industry, universities and NSF for IPM professionals. Numerous useful links, but some commercial info: note source when reading.

California EPA Department of Pesticide Regulation. http://www.cdpr.ca.gov/

Searchable databases of pesticide information, created in cooperation with the US EPA; crosslinks to pesticide sites; on-line edition of their catalogue, ***Suppliers of Beneficial Organisms in North America***.

Golf Course Superintendents Association of America.   http://www.gcsaa.org/

Environmental practices training for members, and free public access to the *Environmental Principles for Golf Courses* document (see description in "Books" section.)

Irrigation Association.   http://www.irrigation.org/

On-line newsletter, searchable abstracts, links and training opportunities for irrigation professionals.

University of Washington Center for Urban Water Resources Management. http://depts.washington.edu/cuwrm/

Technical reports on surface water management and best current technologies, including soil amendment with compost to restore soil functions, permeable paving, etc.

Clean Washington Center.   http://www.cwc.org/

Technical reports on recycled materials, esp. compost. See description in "Organizations" section.

For a broad list of sites useful for resource managers, request the ***Internet Bookmarks Resource List*** from Anne Moser, Librarian, Hazardous Waste Management Program, 130 Nickerson St., Suite 100, Seattle, WA 98104-1598. (206) 263-3051. E-mail: anne.moser@metrokc.gov

For current resources, see the "Natural Lawn Care" section of the web site:
www.seattle.gov/util/services/yard

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