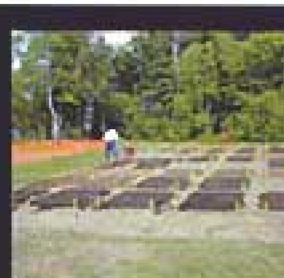
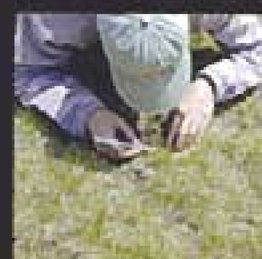
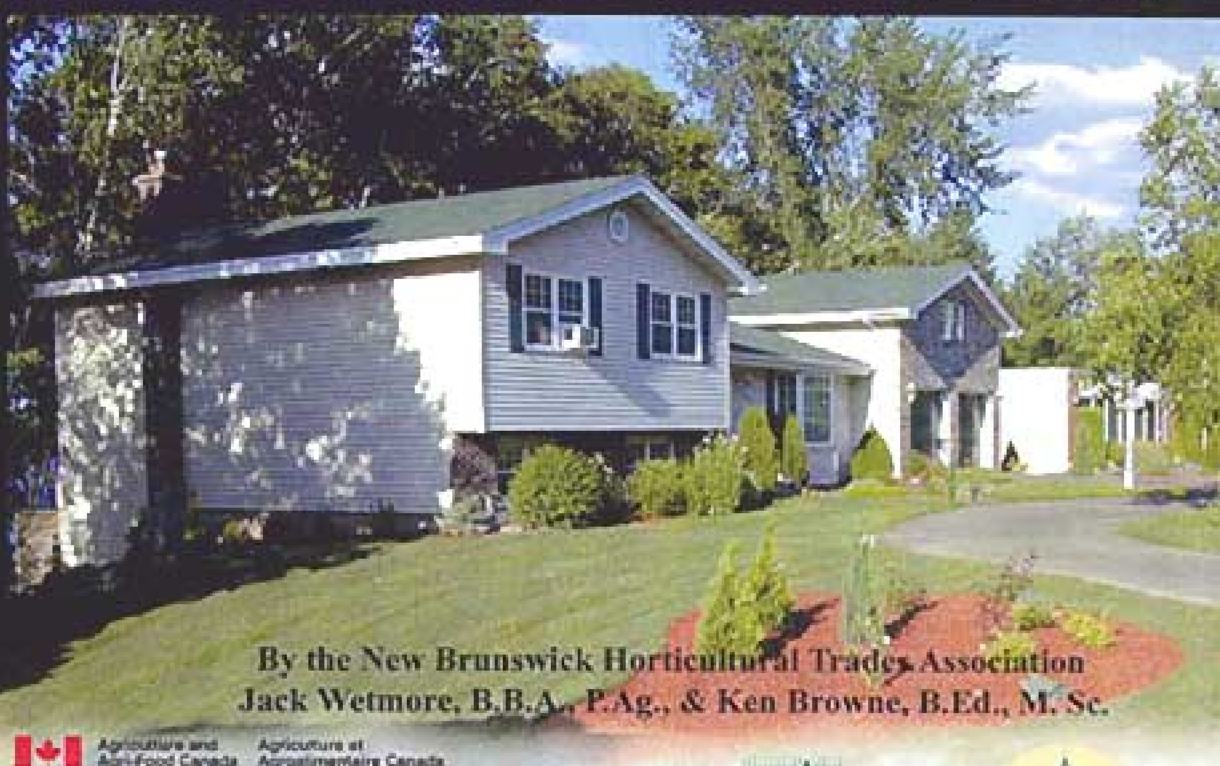
SUSTAINABLE TURF

Establishment, Maintenance, and IPM Guidelines for Turf in Atlantic Canada

First Edition, 2003







By the New Brunswick Horticultural Trades Association

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Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

New Nouveau Brunswick

New Brunswick Agricultural Council

Landscape Nova Scotia

LANDSCAPE

National Library of Canada Cataloguing Publication Data

Main Entry under Title:
Sustainable Turf – Construction, Maintenance, and IPM Guidelines for Atlantic Canada / Jack Wetmore, Ken Browne First Edition, 2003.

Authors:
Jack Wetmore, BBA, P. Ag.
Ken Browne, B. Ed., M. Sc.

Previously published: Wetmore, Jack, 1938 -
Topsoil Guidelines For Landscaping and Home Gardening in New Brunswick (1995).
Topsoil Recovery Potential from Highway Construction Projects in New Brunswick (1997).
Topsoil Recovery Potential From Construction Sites in New Brunswick (1997).

Issued by The New Brunswick Horticultural Trades Association.
155 pages, includes bibliographic references and index.
ISBN 0-9734392-0-3

1. Turf Management – Atlantic Provinces. 2. Turfgrasses industry – Environmental aspects – Atlantic Provinces 3. Turfgrasses – Diseases and Pests – Integrated control – Atlantic Provinces. I. Browne, Ken, 1943 – II. New Brunswick Horticultural Trades Association. III. Title.

SB433.17.C3W48 2003 635.9’642 C2003-907137-5

The current address may be found on the NBHTA website: http://nbhta.ca/index.htm
Phone 1-866-752-6862

The first edition of these guidelines will be circulated for at least one year in order to gather more input, and to incorporate current research and practical experience. Comments may be forwarded to the NBHTA for consideration in future updates. The guideline, and periodic updates, will be available for download, in pdf format, on the publisher’s website. It would be appreciated if credit is given to the publisher for the use of any of the content quoted or reproduced.

Citation: Wetmore, J., and K. Browne. *Sustainable Turf – Construction, Maintenance, and IPM Guidelines for Atlantic Canada. First Edition, 2003.* The New Brunswick Horticultural Trades Association, NB, Canada.

Cover design by Annette Wetmore with graphics by Geoffrey Roy, symbolizing some of the concepts in sustainable turf: conserving topsoil, research, establishment, and monitoring for pest problems.

Suggested Retail Price: $30.00

Printed in Canada on recycled paper.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial assistance and other support received from the New Brunswick Department of Agriculture, Fisheries and Aquaculture, the New Brunswick Department of Environment and Local Government, and the Canadian Adaptation and Rural Development (CARD) fund, through the agency of the New Brunswick Agricultural Council. This funding and support has made it possible to complete the project.

A great deal of help has been received from people in the industry and academic circles who have acted as a sounding board to clarify technical points. Garth Nickerson, Herb Rees, Chris Maund, Pat Toner, Gerry Chevrier, Kevin McCully, Kelvin Lynch, Brian Dykeman, Charles Karemangingo, Alan Scott, Lien Chou and Bernie Ziebarth - staff members of both the Provincial and Federal Departments of Agriculture - have spent many hours fielding questions, researching answers, and generally keeping the technical issues (and the project!) on-track. Other researchers have also assisted significantly: Sophie Rochefort, Doug Cattani, Greg Lyman, Gordon Fairchild, Jack Eggens, Bob Sheard, Gwen Stankhe, Peter Landschoot, and Gary Johnson.

A number of research projects, conducted by the New Brunswick Horticultural Trades Association and supported by the AEMI program from the New Brunswick Department of Agriculture, Fisheries and Aquaculture, have contributed both directly and indirectly to the technical content in the manual, strengthening the applicability of many of the recommendations to our regional conditions. Input from Landscape Newfoundland and Labrador and the St. John's office of Agriculture Canada (Cle Newhook and Peggy Dixon) - with preliminary chinch bug life cycle data from Newfoundland - was also most helpful. Jeff Morton has contributed sections on sod webworm and crane fly management, based on his experience in Nova Scotia.

Constructive criticism of the manual content in the draft stages has come from many different directions. Abe Ghanem and Jim Patterson have been major contributors. Others – Wendy Betts, Neil Pond, Alison Wellwood, Chuck Egleston, Dan Dinelli, Ken Pavely, Corrie Almack, Don Legacy, Steve Nason, Jim Moore, Myles Storey, Grant Mosher, Tony Bradshaw, Phil Craul, David McDonald, Laurie Mills, Jeff Morton, Al Streatch, Karel Michelica, Richard Malone and Henry LeBlanc – have provided comments that clarified points, or suggested areas for expanded discussion. These have been most appreciated; most of the comments have been incorporated.

Karen Richard, Geoff Roy, Jeff Betts and Annette Wetmore have provided much-appreciated assistance with layout, graphics and printing details.

Above all, we owe a major thank-you to Dr. Linda Gilkeson for her editorial expertise. She has taken some very rough material and polished it into a much more comprehensible document.

Our thanks go to all for their help.

In the final analysis, this manual is the result of the contributions from many sources. The authors have attempted to pull it together; we take full responsibility for any errors or omissions.

Jack Wetmore and Ken Browne
Fredericton NB, October 2003.

Postscript:

There were a great number of early mornings and late nights involved in getting the manual to this stage. I owe a great deal to my son Rod, who, in taking over the reins of our company, gave me time to work on the project. My wife, Margaret, also deserves a lot of credit for her patience – putting up with those odd hours without an undue amount of grumbling!

Thank you both.

Jack.

ABOUT THE AUTHORS

Jack Wetmore is the founder of Wetmore's Landscaping, Sod and Nursery, one of New Brunswick's older horticultural operations. A multi-faceted operation founded in 1973, the firm introduced a number of innovations to the NB industry including hydraulic seeding (1976) and the use of biosolids in sod production. The firm is now in second-generation management. Jack has completed numerous industry conservation studies for the New Brunswick Horticultural Trades Association in cooperation with the provincial government. Awarded the Professional Agrologist designation (one of the few non-science people to be so recognized) in 1995, Jack has also acted as a national judge in the Communities in Bloom program, and has consulted in Egypt on sod production opportunities in that country. He has written several articles and conducted a number of seminars and training sessions on industry management and environmentally friendly turf care, and has been the recipient of numerous awards for his industry involvement. Jack is currently on the board of the NBHTA, acting as the IPM projects coordinator for that association, and the Environment Committee chair for the Canadian Nursery and Landscape Association.

Ken Browne is a biologist and educator, with more than 27 years of experience in the risk management of hazardous materials for the New Brunswick Department of the Environment, including being Director of programs in pesticide management, contaminated orphan-site remediation, waste-oil recovery, and PCB storage site management. Since retiring in 1998, he has founded the private consulting company Atlantic Information Services, has become a certified auditor for the Agrichemical Warehouse Standards Association of Crop Life Canada, and is authorized to present pesticide certification trainer programs in the Atlantic Region. He has authored or co-authored numerous reports, including development of a code of good practice for the safe handling, storing, using and disposing of pesticides at federal facilities and pesticide certification training manuals for farmers, the lawn & landscape industry, and pesticide vendors in the Atlantic Region. He has also worked with the Chilean Department of Agriculture on the development of a series of education and training programs for the safe management of crop protection products and improved pesticide legislation in Chile and is working on similar programs in Paraguay and Uruguay.

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FORWORD

Lawns are wonderful creations!

Healthy lawns make a positive contribution to our environment and quality of life. Lawns around our homes and buildings fill a variety of functions and provide many benefits. These areas of lawn (called turf, or turfgrass, by lawn care professionals):

- provide cooling in urban areas,
- reduce noise and glare and keep down dust,
- improve the soil and protect groundwater,
- displace noxious plants and plants with pollens that cause allergies,
- lower fire hazards,
- control soil erosion and reduce risk of flooding,
- provide an aesthetic appearance, and
- provide a low-cost surface for sports and leisure activities.[1]

An estimated 45,000 ha of general turf are maintained in the Atlantic region by either professionals or homeowners.[2] This is a sizeable component of horticulture, representing a large investment of labour, money, and inputs such as water, fertilizer and pesticides. A key question for everyone involved in managing this turf is: How can we provide the best results, most efficiently, while protecting the environment? In other words: *How do we grow sustainable lawns*?

Purpose of This Manual

Concern over environmental and health impacts is placing intense pressure on the turf to reduce lawn care inputs, such as pesticides, fertilizers and water. Experience has shown that we can substantially reduce these inputs, *while satisfying customer expectations*. For example, by adopting sound turf management practices and applying the principles of integrated pest management, studies have shown that pesticide use can be reduced by over 80%.[3] Fertilizer use can also be significantly reduced by fertilizing according to soil tests, improving the timing of applications and switching to slow-release products. Such success is only possible, however, if sound information is made available to the industry and the public, if it is delivered effectively, and then put into practice.

This manual was developed to assist in providing this information. It incorporates the most up-to-date research and local experience on managing turf to:

- encourage healthy growth,
- protect the environment,
- conserve topsoil and water, and
- reduce the use of pesticides and fertilizers.

Construction practices for new lawns that improve long-term results and reduce the need for inputs in the future are also covered.

This manual discusses the construction and management of general-purpose lawns rather than specialty turf, such as golf greens or playing fields. It is intended to provide standardized information for the Atlantic region. This is because current recommendations on lawn care practices vary widely, even from turf professionals and government advisors. For example, a recent survey of the New Brunswick Horticultural Trades Association found that members used a wide variety of practices in their efforts “to do the right thing”.[4]

This is neither a manual of organic lawn care practices nor a pesticide applicator-training manual. Rather, it is basic guide to sustainable management practices that will be useful for anyone caring for a lawn.

Everything we do to – and for – our lawns has an effect, positive or negative, on turf growth and on our environment. This manual is intended to show the relationship between our turf management practices, the overall health of the turf, and our surrounding environment. With such information we can make choices that are practical, economical and provide the best results, while protecting the environment. In short, this manual describes changes in our approach to total turf management, and how we can make those changes successfully.

Who is the audience?

Everyone who makes decisions about turf installation and maintenance needs to know what long-term impacts their decisions have. This manual is for those involved in any aspect of turf management. It is for all who want to ensure that their lawn care practices are effective while protecting the environment. This includes homeowners, turf industry professionals and suppliers, architects, property managers, as well as government regulators and environmental groups.

Lawn installation and management practices are driven largely by consumer expectations. While this manual will mostly be used by turf industry professionals, it is important to remember that many people carry out their own turf maintenance.[5] Consumers have indicated their commitment to using sound cultural practices and moving toward environmentally responsible approaches.[6] Because consumer desires are the driving force behind our practices, consumer education is an essential component of any risk reduction program. This document supplies important cultural information for our region that is often missing or glossed over in other consumer documents. It complements and expands on existing information published by industry and government agencies.

What is a sustainable lawn?

The short answer is that a sustainable lawn is a healthy lawn. Dr. James B. Beard, a recognized authority on lawns, wrote “….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.”[6]

The turf industry is driven by expectations of consumers. They have been conditioned by years of promotion to expect a manicured, closely cut, deep green, “golf course putting green” look. While such a surface is necessary for high quality golf play, it requires very skilled management that is neither appropriate, nor necessary, to produce a healthy lawn. The information in this manual shows how the desired characteristics of an attractive lawn (uniform colour; dense, resilient growth) depend on what happens below the surface. Like all plants, turf grasses depend on the root system to foster growth. Practices that encourage deeper, more vigorous roots result in healthier turf that can be maintained with fewer inputs. Conversely, practices that slow root growth will show up in poorer appearance of the turf and create the need for more labour, water, fertilizer, insect and weed control to keep the turf looking good.

Sustainable lawns require a minimum of irrigation water to maintain health. An important observation that will be described in greater detail in this manual is that some lawns in our region stay green through the long summer drought without irrigation. Studies have shown that these 'sustainable' lawns are on soils with adequate moisture storage capacity and an uninterrupted capillary flow of moisture to the surface. This manual reviews steps that can be taken during construction, at little or no additional cost, to preserve or re-create such natural soil profiles.

Another characteristic of a sustainable lawn is one that resists insect and weed infestation. This manual describes an Integrated Pest Management (IPM) approach to pest problems. IPM is defined by the national Pest Management Regulatory Agency as a process for planning and managing sites to prevent pest problems and for making decisions about how and when to intervene when pest problems occur. It is a sustainable approach to managing pests that provides excellent, long-term results, while minimizing risk to human health and the environmental. Although various groups and practitioners have devised other terms – such as Plant Health Care, Environmentally Friendly Plant Care, Low Input Lawn Care, the Healthy Lawns approach, etc. – no matter what you call it, the aim is to provide acceptable growth and appearance of turf, while reducing inputs and risks to the environment.

This manual arose from a proactive attempt by the turf industry in New Brunswick to address the issues of sustainability and environmental protection. Recommendations have been broadened to include all four Atlantic Provinces. It is hoped that the information it contains, along with future training initiatives, will demonstrate our commitment to environmentally responsible practices and make it possible for these practices to be widely used.

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[2] Nickerson, G. Nursery and Landscape Specialist, New Brunswick Department of Agriculture, Fisheries and Aquaculture. Nov. 2001. Personal communication.

[3] Rochefort, S., J. Brodeur, Y. Carriere and Y. Desjardins. *Making IPM Work in Turf*. Centre de recherché en horticulture, Department de phytologie, Université Laval, PQ. Presented by S. Rochefort at the New Brunswick Horticultural Congress 2002, Moncton NB. Feb. 12, 2002.

[4] NBHTA. Survey of Membership Regarding Soils and Integrated Pest Management Options for Turf. 2000. Unpublished. Available from: NBHTA, 1235 Rte 172, Letete NB E5C 2R6.

[5] PMRA Healthy Lawn Meeting, Dec. 2000. It was indicated that 75% or more of pesticides used in the lawn and home garden sector were applied by homeowners rather than by professionals.

[6] Ipsos Reid survey, April 2001. Attitudes to Pest Control Study.

[7] Beard and Green, op. cit., p. 458.

FURTHER READING

McDonald, David K. *Ecologically Sound Lawn Care for the Pacific Northwest*. 1999. Seattle Public Utilities. Seattle, WA. 79 pages. An excellent overview of current environmentally friendly turf maintenance approaches and practice. Application rates and timing apply to west coast conditions, therefore should be adjusted to our climate. Includes a comprehensive summary of current turfgrass references. Available on-line at: http://www.ci.seattle.wa.us/util/lawncare/LawnReport.htm; hard copies available from New Brunswick Horticultural Trades Association; cost $15 plus postage.

Eggens, J. L. *Turf Management – Principles and Practices.* Study Guide, 11th Ed. 1998. Department of Horticulture, University of Guelph. 1-519-824-4120 Ext 2232. Cost $25. The most comprehensive and informative Canadian text available to turf managers.

Sheard, R. W. *Understanding Turf Management*. 2000. Sports Turf Association of Ontario. ISBN 0-9686568-0 3. Excellent discussion for the concerned turf manager, by one of Canada's top turf experts.

TABLE OF CONTENTS

CHAPTER 1. INTRODUCING INTEGRATED PEST MANAGEMENT

INTRODUCTION

This section introduces the definitions of Integrated Pest Management (IPM) and sustainability. It covers how these concepts apply to turf management, how to maintain a profitable business while moving toward an IPM program, and discusses professionalism and the role of consumers.

WHAT IS INTEGRATED PEST MANAGEMENT?

Definitions of Integrated Pest Management IPM vary, but at the core of current definitions are two important concepts: IPM is based on preventing pest problems, and IPM is a decision making process for determining what actions to take when pest problems occur. In IPM programs, all available information and treatment methods are considered in order to manage pest populations effectively, economically and in an environmentally sound manner.

The elements of IPM, as defined nationally,[1] are:

1. preventing organisms from becoming pest problems by planning and managing ecosystems,
2. identifying pest and beneficial species,
3. monitoring pest and beneficial species populations, pest damage and environmental conditions,
4. using injury and action thresholds to determine when to treat pests,
5. using treatments that usually include a combination of methods, such as cultural, biological, physical, mechanical, behavioural, or chemical methods, to achieve acceptable control with minimal impact on the environment, and
6. evaluating the effects and efficacy of pest management strategies.

A well-developed IPM program emphasises making changes in the way we manage plants and how we design sites to prevent pest problems from occurring. For turf, this mean shifting operations from a focus on regular mowing and spraying programs to providing conditions that produce healthy, sustainable growth. Much of the information in this manual applies to this aspect of IPM.

IPM/PHC (Plant Health Council) of Canada Definition of IPM

The IPM/PHC has re-stated the national IPM definition for use in it's Industry IPM Accreditation program, as the following steps:

- manage landscapes to prevent pests from becoming a threat,
- identify potential pests (weeds, diseases and insects),
- monitor environmental conditions, pest and beneficial organism populations and pest damage,
- decide whether treatment is needed on the basis of population and damage thresholds,
- use biological, mechanical and behavioural control methods (such as resistant plant varieties, physical barriers and traps) to reduce pest populations to acceptable levels,
- when necessary, use targeted applications of pesticides, and
- have a built-in evaluation process.

A key concept is that IPM programs are usually intended to suppress pest populations, keeping them at an acceptable level (i.e., below a level that causes damage). It does not usually involve eradication, which is the total elimination of a pest population. In the case of insects, for example, it is actually desirable to have low numbers of pests present to feed the natural enemies of the pests and keep them present in the area.

IPM is a Process--Not a Blueprint

IPM is a decision process rather than a specific prescription for turf management. It provides a framework that allows the turf manager a great deal of latitude in selecting the techniques suited to the site, the available resources, and the desired results. It is a decision process that applies equally to organically managed lawns, to sites where no pesticides can be used and to sites where pesticide use is permitted.

A parallel might be the transportation system. A manager needs a crew at a work site. There are many options available: the crew can walk, they can take a cab or bus, they can be given bicycles, cars, a crew cab or a van. Depending on the location, the resources available, and when they have to be there, the manager makes decisions, all the while considering safety, time constraints, and budget. So it is with an effective IPM program – an owner or manager selects from a number of choices, all aimed at developing healthier plants and reducing the need for pesticides.

There are three essential steps that could be used to determine whether or not a management program is following an IPM format. A program that clearly includes these steps is moving towards IPM:

- identifying pest problems before taking action,
- an effective monitoring program, and
- applying the concept of using thresholds for treatment decisions.

Applying these three steps can provide short term, immediate and dramatic reductions in pesticide use in turf. For example, applying these steps resulted in a reduction of over 80% in herbicide and insecticide use in “conventional” turf care programs in Quebec, while maintaining the same appearance standards.[2] With the addition of management practices that improve the health of turf (the prevention element), and the follow-up, evaluation step, a complete IPM program can eliminate unnecessary pesticide use.

Role of Prevention

Prevention is the basis for IPM programs. This is because avoiding pest problems—for example, by growing turf that resists pest invasion—is usually cheaper and gives better long-term results than relying on treatments. Even where pest problems do occur, preventative steps can lessen the extent of the problem and make any treatments that are required more effective and economical.

Prevention is a long-term, ongoing activity, because it can take time to develop a healthy lawn, especially where past management practices have created stressed, shallow rooted turf. With respect to turf, prevention has two components:

- Creating optimum conditions when turf is being established or renovated for healthy, sustainable growth. This includes preserving (or restoring) a soil profile during construction that can maintain adequate moisture reserves and upward capillary flow (see Chapter 2). It also includes selecting lawn species appropriate to the site. Most, if not all, of the challenges faced in maintaining turfgrass are dramatically reduced when sites are correctly designed from the outset.

- Managing existing turf to optimise the growing conditions on the particular site. Experience shows that this can require a two to five year program. Taking soil tests and correcting nutrient and pH deficiencies are important components in this step.

Using Damage Thresholds for Decisions

In IPM programs it is only necessary to keep pest numbers, whether weeds or insects, below a level that is perceived as damaging. This is the damage or injury threshold. Where pesticides are the treatment method, the damage threshold is essentially the same thing as an action or treatment threshold (see text box for an explanation of the two concepts). Where the number of pests in a lawn stays below the damage threshold, there is no need for treatment. The point of a monitoring program is to get an accurate estimate of how many weeds or pest insects are present. This estimate is then compared to the number set as a damage threshold in order to decide whether or not treatment is required.

Damage vs. Action Thresholds

In IPM programs, determining when to apply treatments really involves two related concepts: injury threshold (also called an injury threshold or injury level) and action threshold (or treatment level). The damage threshold is the number of pests that it takes to cause damage. For example, the number of weeds in a lawn that are noticeable, thus considered damaging, might be 3 weeds per square meter. The action threshold for using herbicides to control the weeds is essentially the same thing because the herbicide acts quickly—so it might also be 3 weeds/m^2. The difference between damage thresholds and treatment thresholds becomes apparent when different types of controls are used. For example, the action threshold for hand weeding might be only 1 or 2 weeds/m^2 because it is labour intensive and it is a method well suited to picking out low numbers of individual plants.

The damage threshold is not the same for every lawn or turf area. For example, some lawns may be valued as highly decorative turf; others may be valued as safe, resilient play areas for children or as general use areas in a park landscape. The damage threshold for the first type of lawn would usually be much lower than for the other two types of lawns. A residential lawn or general use area in a park might have quite a high tolerance for the presence of plants other than turfgrasses so the damage threshold would be higher.

One way to focus management activities is to divide turf areas into high, medium and low maintenance categories. Consider separating turf areas into Class A, B and C categories, as developed in British Columbia:[3]

- Class A – High level of service: *fine ornamental lawns, golf and bowling greens, irrigated sports fields.*

- Class B – Moderate level of service: *residential and commercial lawns, boulevards, recreational areas, golf fairways.*
- Class C – Low level of service: *Meadows, picnic areas, rough grass, undeveloped and naturalized areas.*

Each of these categories would have different thresholds for treatment decisions. Using such categories to allocate maintenance work and inputs helps turf managers provide a reasonable compromise between aesthetics and economics.

Evaluation

The evaluation and review component of an IPM program is essential. It is a "wrap-up" step to evaluate what worked, what didn't, and to plan more effective approaches next year. Keeping and reviewing records of soil tests, turf maintenance activities, pest monitoring and treatment results provide important management information. Over time, good records will show whether turf quality is improving and what the long-term costs have been. Such records can provide the information needed to base decisions on solid facts, rather than on subjective judgements. For example, records will help answer such questions as:

- Can treatment thresholds for insects or weeds be increased as cultural conditions improve?
- Does increased consumer tolerance permit increasing weed thresholds in a particular area?
- Did a particular treatment work?
- What controls used in other areas might apply here?

IPM AND SUSTAINABILITY

IPM is a vital component of sustainability. The concept of sustainability applies to the entire spectrum of lawn care activity from pre-construction planning through establishment and later maintenance of the turf.

The term 'sustainability' has many interpretations. Dr. Phillip Craul, formerly of the Harvard Graduate School of Design, states: "There has been much written, discussed, and reported about the term *sustainability*. To reduce confusion for our purposes I define *sustainability* as the ecological and technological planning, design, implementation, management, and maintenance of a landscape project that reduces environmental impact both on the project site and off the site".[4]

Craul's criteria for sustainable turf projects include:

- Projects are not sited on prime agricultural land.
- Construction and on-going management of the project do not have environmental impacts on other sites.
- The materials and products used in the project are recycled or from renewable resources.
- The production and by-products of these materials and products have minimal environmental impact.
- The final project does not require prolonged input of energy-consuming products or non-renewable materials.

Topsoil as a Sustainability Issue

The practice of covering the material on a construction site with topsoil and planting a lawn in that layer is not a sustainable practice because:

- True topsoil has become a scarce and expensive material. Bringing topsoil from other sites is no longer acceptable because of the environmental damage it does to the site of origin. In most cases, the topsoil should remain for use on the original site.
- Spreading topsoil or any material as a layer over an unknown sub-base material is unwise. Instead, the entire soil profile should be designed to accommodate the existing conditions and provide future growing conditions that will require the minimum of fertilizer, water and other inputs.

The use of existing site materials as a component of a soil mix should be considered (see Chapter 2 for information on manufactured topsoils), as well as amending the soil with recycled materials such as compost and waste mineral material. It is Dr. Craul's contention that "the technology … has progressed to a sufficient degree that permits the serious consideration of a totally sustainable soil. That is, a soil composed entirely of recyclable materials and containing no non-renewable resources."[4]

Sustainability Tips from James C. Patterson*:

1. Reuse what is there,
2. purchase ingredients to make what is there, work, and
3. if there is something undesirably toxic on the site – get rid of it.

*Research Agronomist (ret'd), Center for Urban Ecology, National Capital Region, Washington DC

MANAGING FOR SUCCESS

It takes time and expertise to implement an effective IPM program. The initial steps – identifying pests, establishing population thresholds, and monitoring – require a thorough understanding of the pest. This includes knowing the pest's appearance, behaviour and life cycle and when to use appropriate control methods to interrupt that cycle. The longer term steps – improving turf health and performance – require an understanding of plant biology and the impact of maintenance practices. The good news is that, as the cultural improvements to the turf take effect, long-term savings in cost and labour will offset the initial effort required to develop a successful program. The following sections include tips for managing an IPM service and improving your bottom line, while providing a high quality service.

Include Your Customer in the IPM Program

IPM programs also involve communicating with employees, customers, agencies and the public to inform them of the goals, methods, results and benefits of using IPM.

The customer is purchasing your professional expertise and experience to give them a quality turf. They also have a role to play in achieving the goals so they should be aware of the long-term management strategy and where they fit.

As a professional, your role is to:

- prepare a package of cultural practices,
- explain the reasons for each cultural practice,
- outline what the client can do to assist in achieving the long-term goals, and
- highlight the long term cost savings and benefits to the environment.

A big advantage of developing this package approach is that it lets you work with the client over a 3 to 5 year period. The long-term benefits are multi-year contracts and a sustained client base rather than annual competitions for the lowest bid on fertilizer and pesticide applications.
To make this approach work demands that staff be professional and well trained in each aspect of turf management. This also improves the image of the turf industry as environmental stewards.

Tips on Making Your IPM Business Profitable

The following tips come from Neil Pond of Urban Landscaping Ltd., Saint John NB, one of the region's most experienced IPM practitioners. While he uses organic methods in his IPM programs, the sales and management approaches he suggests are relevant to any type of program.

- **Expect to increase prices**: Organic fertilizers and natural controls cost more. IPM takes more time. Do not try to be, or expect to be, as cheap as conventional lawn care services. The customer has to fund your business (they get what they pay for).

- **Offer full season service – No partial programs:** Get away from the idea of selling applications and calendar based programs. Sell only full season contracts and encourage your customers to take continuous service from year to year. It is better to have fewer customers with full services all season, year after year, than to sell partial services. This is more profitable because you have fewer service calls on poor lawns and you do not have to deal with over-capacity or under-capacity through the season.

- **Emphasize service:** Include monitoring, using environmentally safe products, timing of treatments based on thresholds and IPM strategies, and customizing your work to the lawn's needs. Emphasize safety and superior agronomics over conventional chemical-based programs.

- **Differentiate your service**: The biggest challenge is education and awareness. Start with an IPM brochure or fact sheet that you can leave behind. Use newsletters and give talks to interest groups to spread the word.

- **Believe in what you are doing!** This includes getting your employees to buy in to the program and believe in the changes. For example change your terminology to reflect the change in philosophy: use 'control materials' rather than 'pesticides', 'selective weed control' vs. 'weed spray', 'visits' vs. 'treatments'.

- **Start with customers that don’t want pesticides used:** Work with them and convert them to organic only programs first. Offer them an all-natural control option using low-risk pesticides only.

- **Training is vital!** Develop a training program and educate your technicians and staff. IPM requires individual thinking and judgements in the field. Your people will sell and service your customers better when they are well informed and confident in their knowledge.

- **Change customer perceptions**: Let them know exactly what to expect in a **service agreement** that reinforces your organic turf management or IPM message. The service agreement is an appendix to your contract; it should stipulate in detail the terms and conditions of service and product use. For example: “We reserve the right to refuse to apply controls if thresholds and action levels are not reached”. Customers also need to know that “zero tolerance” for pests is not realistic. In your service agreement, attach conditions to your guarantee based on following the guidelines of your IPM or organic turf management.

- **Develop an effective monitoring system:** We use an **Agronomic Assessment** to evaluate each property during the season. We leave a carbon copy for the customer and have technicians call customers to review the assessment. This is an opportunity to educate customers and also sell your service. We also keep a **Technician IPM Report** for each visit. This is a record of monitoring information; a carbon copy is left with the customer so they can see the result of each visit.

- **Develop information sheets:** These educate your customers and are useful to inform local media. We also use them as handouts at seminars we give.

- **Promote additional services**: For example, core aeration, topdressing with compost and slice seeding. Look at this as an opportunity to add new business revenues to your operation by adding such customized services.

- **Promote soil testing:** Make a soil test a requirement for new customers and promote this to existing customers every two or three years.

- **Use organic fertilizers:** At least half of the N should come from natural organic sources; use less than 20% water-soluble N. Use synthetic organics that are water insoluble to make up the extra nitrogen requirements.

- **Place less emphasis on nitrogen and more on nutrient diversity:** The total nitrogen should be less than 20% of the total applied products. Concentrate on getting the maximum amount of organic material on the lawn rather than nitrogen. For example, well-cured compost with a low carbon:nitrogen ratio can provide the equivalent of 0.5 kg of soluble nitrogen/100 m^2 (1 lb of nitrogen per 1,000 ft^2).

- **Brush up on soil science!**

Facing the Challenges

The turf management industry has gone through a period of dramatic expansion over the past few years. The service area that has grown the most provides weed control with the objective of providing clients with a weed-free lawn. This industry now faces a challenge as it comes under attack from concerned citizen groups and municipal councils over the use of herbicides and other lawn care chemicals. The industry is also being encouraged by provincial and federal regulators to move away from the use of chemicals as a primary management tool and adopt sustainable approaches to managing turf. Key among these is IPM.

It is important to remember that the landscape industry is built on sales of products and services to customers. It is increasingly clear that sales and use of some types of pesticide products will continue to be reduced. This may be because of changes in public attitudes, because restrictive regulations are enacted, or because product registrations are withdrawn. For example, a once widely used insecticide, diazinon, is no longer registered for use in residential areas. On the other hand, more low toxicity or alternative pesticides are becoming available, such as the recently registered corn gluten herbicide. There will be a continuous learning challenge as the industry learns how to use new products effectively.

At this point, there is considerable resistance from consumers toward paying for professional turf management service, such as site visits for monitoring, when no products are applied. This is a major challenge for the industry. Our industry can learn a great deal from the structural pest control industry that only a few years ago made major changes in the attitude and approach to managing pests. They are now recognized more as inspectors and pest management professionals, not just applicators of pesticides. The turf pesticide applicator segment of the Quebec industry has achieved some success in meeting this challenge by moving from calendar based spray programs toward the service provider concept.[2]

Although there may continue to be work for companies that offer only chemical application programs, they will find that their market opportunities will be more restricted in the years ahead. Those in the industry who want a sustainable, long-term business will find it more profitable to move toward total lawn care management programs for their clients. There has already been a shift in this direction with government regulators promoting, and municipalities demanding, IPM programs. An indicator of this is that requirements for basing management decisions on monitoring and thresholds are increasingly being written into turf maintenance contracts.

The information in this manual is intended to help the industry meet these challenges by providing a practical guide to applying IPM and developing sustainable lawns.

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[3] Gilkeson, L. and R. Adams. *Integrated Pest Management Manual for Landscape Pests in British Columbia*. 2000. BC Ministry of Environment, Lands, and Parks. p. 45.

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FURTHER READING

Gilkeson, L. and R. Adams. *Integrated Pest Management Manual for Landscape Pests in British Columbia*. 2000. BC Ministry of Environment, Lands, and Parks. 128 pp. Available on-line: http://wlapwww.gov.bc.ca/epd/epdpa/ipmp/ipm-manuals.html; hard copies from: Office Products Centre, Victoria, BC. 1-250-952-4460; cost $15 plus postage. Contains an excellent in-depth discussion of the IPM process and how to get started.

MacDonald, Leslie S., (ed). *IPM for Turfgrass Managers*. 2002. Western Canada Turfgrass Association, Maple Ridge BC. ISBN 0-7726-4832-8.

CHAPTER 2. STARTING WITH SOIL

INTRODUCTION

This section explores the physical characteristics of soil, including a review of soil textures, role of organic matter and how moisture moves in soils. It describes the nature of both topsoil and subsoil and concludes with a discussion of manufactured topsoils and how to use soils with rocks and debris.

The soil foundation, more than any other single factor, influences the long-term health and sustainability of a lawn.* This foundation extends downward for a metre or more — it is not just the few inches on top.

The primary factors that determine the suitability of soil for landscapes and other horticultural uses are:

- soil texture,
- organic matter levels, and
- moisture storage capacity.

These factors determine the capacity of the soil to support vigorous plant growth. All can be adjusted at reasonable cost during construction, but it is usually not possible to make changes afterward without reworking the entire planting area.

Many lawns in this region stay green through most of our dry summers without irrigation. This is highly desirable because these lawns conserve water, yet have sufficient moisture for healthy turf growth. Such lawns have been observed in Rothesay, Fredericton, Bathurst, Doaktown, Moncton, Grand Falls, Saint Andrews, Wolfville, Truro and Kentville, and other locations. They are typically found around homes built before World War II. In contrast, most lawns constructed since the war seem to require irrigation to remain green during the summer.

This raises the question ‘Why?’ The fact that these lawns have been observed in many areas rules out variable precipitation rates: there seems to be enough rainfall everywhere to keep them green. It isn’t just due to cooler temperatures and lower evapo-transpiration in coastal regions, because these lawns also occur inland. Whatever the reason, it seems that the soil profile is making sufficient moisture available to the turf plants during the dry period.

It’s What’s Underneath That Counts

Limited investigations have found a common element in the lawns that stay green all summer. They have at least a two to three foot soil horizon of sandy loam to silty loam (in other words, mud!) beneath the root zone. There is no sand, gravel or crushed rock layer to disrupt the capillary flow of moisture to the surface.

* For further reading, see Osborne[1] and Logsdon.[2]

The reason green lawns are more common in older construction may be because pre-war construction excavations were done with horse-drawn scoops or by hand and moved the minimum amount of material. This left the original soil profile largely undisturbed. In contrast, in recent years, it has become common to use heavy equipment to dig bigger holes, spread the subsoil over the existing topsoil, and bring in gravel fill or crushed rock for a more convenient working surface around the site. Unfortunately, these practices disturb the soil moisture reservoir and disrupt the capillary movement of water upward to the root zone. A 4-6 inch layer of topsoil brought in to finish the job would have, at best, two or three weeks of moisture storage capacity. If not watered in the dry season, the lawn turns brown.

SOIL TEXTURE

Soil texture describes the proportion of sand, silt and clay particles found in the soil. These proportions determine:

- the size of the pore spaces between the soil particles and the air, and to a large extent,
- the moisture and nutrient holding capacity of the soil.

Soil particles less than 2 mm in size are classified into threes sizes: sand (largest), silt, and clay (smallest). Particles over 2 mm are coarse fragments, gravel, rocks and woody debris. The coarse particles and debris have little impact on growth and moisture storage characteristics of the soil, although they can be a problem during construction and later use of the finished surface (*see* Soils With Rocks and Debris, this chapter).

Soils are classified according to the ratios of these different sized particles. For example, soils classed as “sandy” soils are more than 50-55% sand, whereas “clay” soils have a clay content of 20% or more. “Loam” is an intermediate classification with all three particle sizes well represented. It is generally best suited to growing a variety of plants, including turf. The sand component strengthens soil and improves drainage, while the finer clay and silt particles hold plant nutrients and make them available to plant roots. Loams also have a good balance between the larger pore spaces (aeration pores), which normally contain air, and the smaller pore spaces (capillary pores), which hold the moisture.

The soil triangle (Figure 2-1.) shows the proportions of particles in silt loam, loam and sandy loams, which are the soil textures most recommended for topsoil. The more soil texture departs from the loam textural classification, generally the more management is required to maintain the same level of turf performance. For example, sandy soils need closer attention to moisture and nutrient levels, while high silt or clay soils may require aeration to relieve compaction.

It is the percentage of sand that primarily determines long-term performance and maintenance costs. As the sand fraction falls below 70-75%, the structural strength of the soil, and resistance to compaction, decreases rapidly. As the sand percentage decreases the soils also become more difficult to handle when wet and more vulnerable to compaction during placement. In one example, a loam with 42% sand subjected to rough handling during placement, set up like concrete. Although this was extreme, such problems should be expected as sand content drops toward 20%. It will require a couple of winters’ freeze-thaw cycles to eliminate the compaction in these situations.

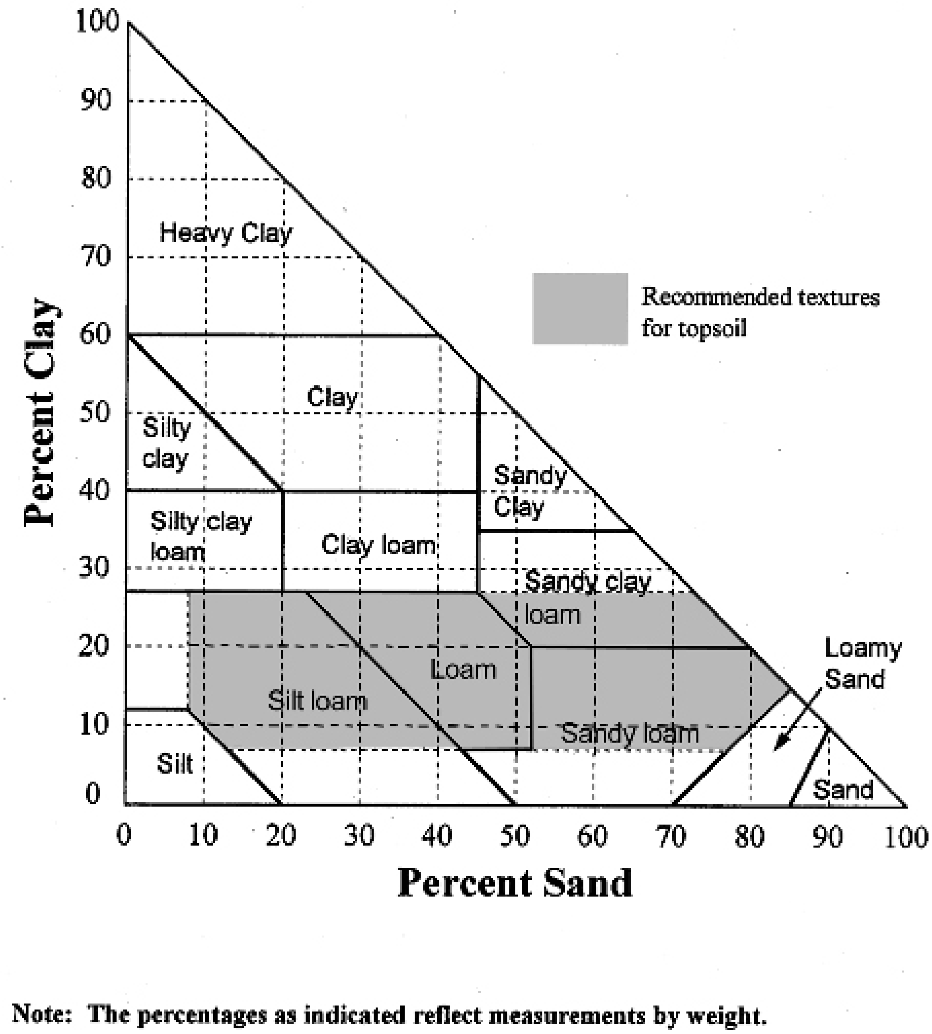


Figure 2-1. Soil texture triangle showing recommended textures for topsoil (shaded). Only sand and clay scales are shown (silt makes up the remainder).
Note: Although this diagram, developed by the Canadian Society of Soil Science, [3] differs from the equilateral triangle shown in US texts, the boundaries of the texture classes are essentially the same.

As the percentage of sand rises above 60%, the soil drainage capacity increases, but this results in a growing medium with a lower capacity to store moisture and nutrients. For high traffic turf, soil textures with 60-70% sand offer a compromise between providing structural strength and maintaining good growing characteristics. For sensitive sites, such as high quality playing fields or golf greens, resistance to compaction is improved by choosing a grade of sand that is sharp, rather than round, and grading the percentage of coarse vs. fine sand particles.

A silt loam, with 10-30% sand content, is typical of the soil in many areas of the region. It grows beautiful turf, but it takes very little foot traffic, when the soil is wet, to compact it like a rock. Such soils work well for a home lawn, but are disastrous on a playing field surface.

The ratio of silt to clay in the soil seems to have little impact on turf performance, although some clay must be present to store nutrients and make them available to plant roots. The Canadian System of Soil Classification suggests a minimum of 7% clay (the British Standard[4] specifies 5%) and maximum of 27% is desirable in topsoil. Soils with clay levels above 27% will also grow vigorous turf, but are more sensitive to traffic damage when wet, and are more difficult to handle during construction.

Most natural soils in the region fall within the recommended range, although effort may be required to provide a minimum of 5-7% clay in manufactured topsoils (*see* Manufactured Topsoil, this chapter).

Textural Barriers

When soils more than two textural classifications apart are placed in layers above one another, a boundary layer is created that can disrupt capillary water movement and root development. Mixing the soils together to ensure a 50 to 75 mm (2 to 3 in) mixed layer at the boundary, using the scarifier attachment on a York™ rake, for example, will help reduce this barrier.

There have occasionally been problems from the use of sod grown on organic soil placed on silty loam or clay loam soil. This is clearly illustrated in the photo at right. This photo was taken about a year after the organic sod was placed on clay loam; virtually no rooting action has occurred. In a similar example, an entire playing field in Fredericton had to be replaced two years after establishment, because organic sod had been installed over silt loam subsoil, and virtually no rooting took place.

Fig. 2-2. Rooting action suppressed by textural barrier. ***Photo courtesy of Dan Dinelli, Superintendent, North Shore Country Club, Glenview Il.***

Determining Soil Texture

Soil texture can be determined precisely with a soil mechanical analysis test (from NB Department of Agriculture, Fisheries and Aquaculture∗), at a cost of $40.

∗ New Brunswick Department of Agriculture, Fisheries and Aquaculture, P.O. Box 6000, Fredericton, N.B. E3B 5H1. http://www.gnb.ca/0179/01790003-E.ASP

A practical alternative to a laboratory test is the bottle test:

The Bottle Test for Soil Texture

1. Use a clear, preferably straight-sided glass bottle with a tight lid (a large mouth is preferable for easier filling.)
2. Fill half of the bottle with the soil to be tested, add water to the ¾ level, cover and shake well. Adding a couple of drops of Calgon™ or other liquid detergent helps break down the structure, but slows the settling process.
3. In about half an hour, the sand will settle to the bottom. The silt fraction will be separate in a couple of hours, and the clay will be rise to the top after a day or so.

4. The key component is the sand fraction. Estimate this (within about 5-10%) by measuring the sand layer and the total height of the soil and calculating what percentage is sand.

For example, the photo shows a sample after sitting for 24 hours. It shows the sand fraction (darker, from the bottom up to about 27 mm), silt fraction (27 to 46 mm) and clay fraction (the top 4 mm). Some of the clay is still in suspension in the water after 24 hours because of the detergent action, but it is not enough to affect the result. The sand fraction in this sample is about 27 mm of a total height of 50 mm, therefore the sand component is 27/50 or about 50 to 55%.

Unfortunately, the turf manager has little control over the soil texture on an existing site. Attempting to modify soil texture with topdressing and aeration alone is not an effective approach.[5] It is generally not practical to undertake the massive renovations necessary to incorporate amendments to the full depth of the root zone. Knowing the soil texture, however, will help the manager understand the strengths and weaknesses of the site so that management methods can be adjusted accordingly.

When establishing a new lawn, there are important benefits from tailoring the soil texture to the expected uses. For example, on playing fields, which must withstand foot traffic quickly after a rain, a soil profile with a higher sand content will provide better drainage and resist compaction. Although there may be a limited choice of textures available in a particular market area, it is practical and cost effective to amend the soil to achieve the desired texture at the time of installation.

See Wetmore[6] and Landscape Nova Scotia[18] for more information on soils commonly encountered in landscapes and for guidelines on the range of soil textures with acceptable plant growth and handling characteristics.

SOIL STRUCTURE

The structure of soil depends on the size, shape, arrangement and stability of particles in the soil. These characteristics are a result of soil formation processes, including soil chemistry, the activity of micro-organisms and plant roots and the seasonal freeze-thaw cycle. Although important in long-term plant growth, soil structure appears to have a minor impact on the successful establishment of turfgrasses. This may be, in part, because the roots of grasses are particularly good at improving damaged soil structure over time.

The way landscape soils are handled during construction almost certainly destroys most of the natural soil structure. Soils should not be transported or spread when wet. Wet soils are difficult to work with, and handling them when wet squeezes the air out, causing clumping and compaction that may slow down establishment and growth.

SOIL ORGANIC MATTER

Decaying plant material, or organic matter (OM), is a commonly overlooked factor that promotes healthy plant growth (*see* Parnes[7]). Soil organic matter, also called humus, is a fertile component of soil. OM in the soil:

- feeds the soil life, including micro-organisms that, in turn, make nutrients available to plants,
- improves soil structure,
- improves the moisture holding capacity of soils, and
- improves the capacity to hold plant nutrients.

The level of OM is a key indicator of the capability of soil to grow plants (if the soil is also of a suitable texture). Soils with 1% OM (*see* text box on organic matter tests) give predictably poor performance, while soils with over 2% OM seem to perform satisfactorily for lawns, when pH and nutrients are also adjusted to optimum levels.

A Note About Organic Matter Tests

The OM figures quoted in this document are percentages of organic matter by weight as determined by the Walkley Black OM test.

Two other test protocols used in the region are: Loss on Ignition (LOI), and Leco. For the same soil sample, the LOI test provides readings that are approximately double the Walkley Black readings. The Leco test results lie about midway between the two. Because of the wide variation in test readings, it is vital to understand which test protocol is being referred to when discussing OM values, *particularly when reading specifications and bidding for jobs.*

The growth of turfgrass will increase soil OM levels over time as the roots of grasses and recycled grass clippings add OM to the soil. Tests have shown varying OM levels on established lawns.[8] These ranged from 2.8% in relatively new lawns (3-5 years old) and in older lawns established on subsoil, to over 5% OM in some mature lawns. Some tests showed that OM levels doubled over a ten-year period.

Forested areas have a "duff" layer over the soil consisting of decayed plant material accumulated over centuries. The duff layer gives the cushiony feel underfoot when walking in these areas, and is an excellent source of organic matter. It can be incorporated into topsoil reclaimed from wooded construction sites, or used in manufacturing topsoil. It is generally very acid, so particular attention must be paid to adjusting the pH of the end product. (In one Saint John soil recovery test where the duff was mixed into the recovered topsoil and subsoil, OM tested over 9%, and the pH was 4.9).[8]

OM is a valuable and expensive component; it is wasted if buried below the 20 cm (8 in) root zone.

AIR EXCHANGE

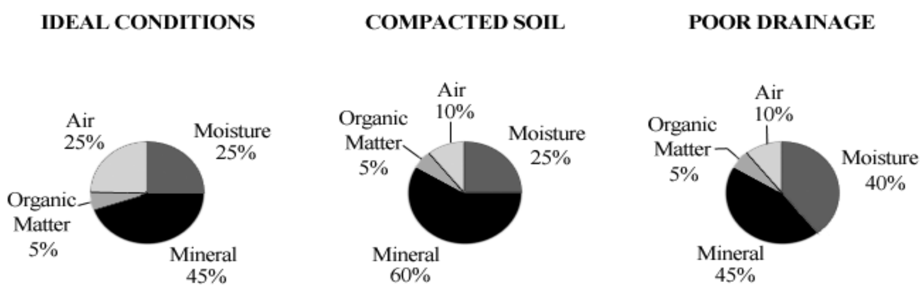


Figure 2-3. Proportions of air, moisture, organic matter and mineral soil found under ideal conditions and poor conditions. (Adapted from Emmons[10])

Cells in plant roots and soil microorganisms use oxygen to sustain life and, in the process, they give off carbon dioxide as a waste product. Both oxygen and carbon dioxide are found in aeration pores in the soil. This is where oxygen moves into the soil zone in exchange for carbon dioxide diffusing out of the soil. When the volume of air in the aeration pores is reduced, there is less air exchange. This means root cells get less oxygen and are swamped with carbon dioxide.

The figures above illustrate these conditions. In the ideal soil chart to the left, air and moisture are balanced. In the compacted soil illustration, centre, the air has been squeezed down to about 10% of the total volume by the higher soil density. In the right figure, water has displaced air. Both compacted and poor drainage conditions limit nutrient uptake and root growth. Compaction also restricts growth because of the sheer physical force required to push roots through compacted soil.

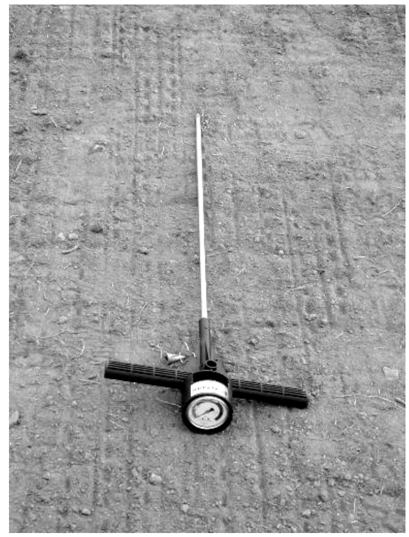
Bulk Density

Bulk density is a measure of soil density that is directly related to compaction. A bulk density of 1.65 grams/cubic centimetre indicates a soil that is firmly packed enough to limit root growth – the point where compaction becomes a problem. Bulk densities of hard packed surfaces can be upward of 1.9-2.0 g/cc. Soil in a good root zone ranges from 1.2 to 1.4 g/cc. Soils with bulk density figures lower than 1.2 g/cc will generally shrink appreciably with time.[9] (This occurs when OM levels are above 10-15%.)

Bulk density can be determined in a soil lab by drying and weighing a soil core of known dimensions, however, in the field, the problem range (compacted soil) is easy to check with the probe tool described below.

A Practical Test For Compaction

The picture shows a commercial compaction tester that costs around $300. A simple field probe to do the same job can be made from a 1 m (3 ft) length of 13 mm (½ in) steel rod with a tee handle welded across the top. The bottom 2.5 cm (1 in) should be tapered to a sharp pointed cone.



When about 30 kg (65 lb) of 'push' is needed to force the rod further into the ground it means that compaction is enough to limit turf roots. It is easy to get the feel of this much force by calibrating it periodically with a bathroom scale. Place the tip on a piece of board on the scale, and push until the desired weight shows on the dial. (The board protects the platform).

This tool is also useful for finding a capillary disrupting layer of sand, gravel or crushed rock under the surface. The grating sound is quite audible as the rod penetrates the gritty material. Check the depth as the rod is pulled out to find out how deep the soil is above the problem layer.

Most soils provide sufficient air exchange for turf growth if the subsurface drainage is acceptable, and if traffic is managed according to the soil sand content, as, for example, keeping foot traffic to a minimum when heavy soils with low sand content are saturated.

MOISTURE STORAGE

A consistent supply of moisture is one of the most important characteristics of sustainable turf, yet it is probably the most difficult to establish in disturbed soil profiles. How much water is available to plant roots depends on the following four factors: infiltration rate, percolation rate, water holding capacity and capillary action.

Infiltration rate: This is a measure of how fast soil absorbs surface moisture from a rain event or irrigation. Soils with large pore spaces, such as coarse gravel or sandy soil, are able to absorb (but not store) 30 times more water per hour than the small pores spaces of clay soil. Water pooling on the surface can indicate poor infiltration rate. This may be because of compacted soil on the surface or because pore spaces between the soil particles are too small. When this happens, water is more likely to run off or evaporate and is less available to the turfgrass. This factor is often overlooked in management of irrigation equipment and results in wasted water (*see* Irrigation, Chapter 6).

Percolation rate: This is the rate that moisture entering the soil moves downward through the soil pores due to gravity**.** Coarse textured soils have a high percolation rate, resulting in the moisture moving quickly downward past the root zone.

Water holding capacity: This is the ability of the soil to hold moisture; it is a function of soil texture. Agronomy texts, such as Brady[11] show that the moisture holding capacity of soils ranges from 1" of water per foot for sand, to 3.5" water per foot for clay. Craul reports a range of 3.0-4.4" of water per foot through the range of sandy soils.[12] Craul's data came from urban soils and is probably a more accurate reflection of conditions in landscapes.

In most situations, less than half of the moisture in the soil is available to plants. The remainder is bound tightly to the surface of soil particles and is never released. The amount of moisture that is actually available is called the plant-available moisture. Craul reports that this ranges from 0.65 to 2.4 inches per foot of soil depth (55 to 200 mm per metre), with the lower figure found in high-sand soils.[12] This is consistent with observations in New Brunswick.

Table 2-1. Comparison of soil moisture availability (inches per foot of soil depth) from two sources.

Soil Texture Classification	**Plant-Available Moisture**	
	Craul[12]	WSU[13]
Sand	1.59	0.7
Loamy Sand	1.21	0.8
Loamy Fine Sand	0.65	1.2
Sandy Loam	1.48	1.4
Loam	1.87	2.0
Silt Loam	2.39	2.2
Sandy Clay Loam	1.43	2.1
Sandy Clay	0.94	2.3
Clay Loam	1.52	2.2
Silty Clay Loam	1.79	N/R
Clay	1.38	2.3

Capillary action: This is the movement of moisture between soil particles, even against gravity. In fact, through capillary action moisture can run uphill – the phenomenon that keeps all plants alive.

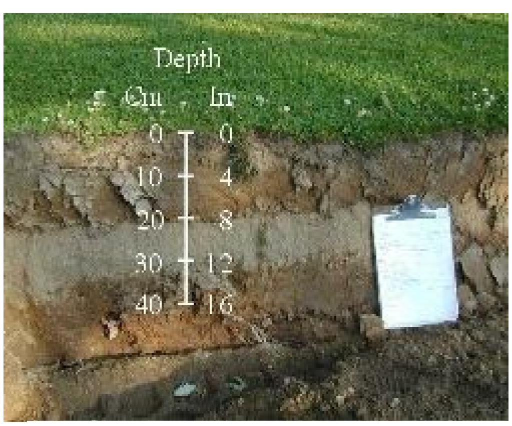


Figure 2-4. The sand layer between 20 and 30 cm depth effectively blocks upward capillary flow.

Capillary action is probably the single most important factor in the underlying soil profile that determines turf growth. It is also probably the most commonly overlooked factor! It is estimated that over 95% of turfgrass moisture needs are supplied by capillary action, with moisture being drawn from as deep as 3 m in silt loam soils.

Most natural soil profiles in this region have sufficient moisture storage capacity to ensure that lawns stay green throughout the summer. However, the capillary moisture path upward is often disrupted during construction activity, resulting in the need for irrigation to keep the lawn green. It is notable that even a 25 mm (1 in) layer of a very different soil type can block capillary flow to the surface (*see* Sheard[14] on Textural Barriers).

Examples of barriers to capillary flow found in turfgrass installations include:

- layers of different soil types, gravel, crushed rock, concrete or asphalt,
- soil placed over a layer of thatch or dead grass,
- a layer of compacted soil, or
- large rocks or debris beneath the surface.

Figure 2-5. Construction sites with concrete (left) and crushed rock (right) about to be covered with soil, creating a barrier to capillary moisture movement. ***Photos courtesy of Dan Dinelli.***

Figure 2-6. The results of capillary barriers introduced during construction.

In the left photo, square drain holes were cut in the asphalt, and 30 cm of soil placed over asphalt for the island. Capillary action from the soil below the asphalt kept the squares green. On the right, crushed rock placed under the curbs flowed out toward the centre of the area (as in the right photo in Fig. 2-5 above), causing irregular browning. This is often found next to driveways and sidewalks in home lawns. Close attention to soil handling and placement is needed during construction to avoid these situations.

Turfgrass Moisture Requirements

Throughout the early and late portions of the growing season in our region, natural rainfall is sufficient to meet turf needs. Prolonged summer droughts are common, with 8 to 12 weeks of little, or no, rainfall. During this period, soil moisture levels decline as the moisture moves into the air by surface evaporation, and by evapo-transpiration from plant tissues. As soil moisture reserves are depleted, some lawns stay green, but growth slows dramatically. Other lawns turn brown as they naturally become dormant until moisture levels recover. Many property owners, however, find the brown appearance unacceptable.

In the Atlantic region, turf requires about 25 mm (1 in) of available moisture per week to maintain healthy growth. However, experience shows that a lawn in most parts of the region will stay green with about 13 mm (½ in) of plant-available moisture per week. Coastal regions with cooler temperatures may require less, because of lower evapo-transpiration rates. Thus, a lawn with 25 mm (1 in) of plant-available moisture storage capacity in the top 15-30 cm (6-12 in) of soil, will remain green for only two to three weeks after rains stop. Allowing for some recharge from summer rainfall events, it is likely that soils that can hold 100 mm (4 in) of available moisture can keep a lawn green through the entire summer. Unless irrigated, the turf in Fig. 2-4 will brown out two to three weeks after the rains stop.

As described in the previous sections, there are two requirements for constructing a lawn that stays green through the summer, without irrigation:

- a soil foundation that provides about 100 mm (4 in) of available moisture storage capacity, *and*
- an uninterrupted capillary path for that stored moisture to move upward to the surface.

These requirements can be met by ensuring there is a soil storage reservoir below the root zone. For example, this could consist of 0.6 to 1 m (2-3 feet) of mud, with 10-70% sand content and without capillary barriers, such as a layer of sand, gravel or crushed rock.

The Importance of Drainage

Surface and subsurface drainage are also important factors in the long-term health of plants. Puddles of water on the surface will eventually kill most plants, while poor subsurface drainage or high water tables in the root zone also damages plant roots. Correcting these factors during construction is cost-effective, but both are expensive to correct after the fact.

Providing surface drainage has proven adequate to avoid root suppression in heavier (silt loam) soils in the region. To move the excess water off site requires a minimum of a 0.5% grade (about 5 cm in 10 m, or ½ inch in 10 ft). A 1% grade is a safer target as it is easier to construct and allows some latitude for settling.

Underground water moving onto the site from adjacent, usually higher, sites can also cause problems. If this is not corrected during construction, drains will have to be installed later, usually with a significant cost (and a dissatisfied customer). Experience with adjacent properties may give you an idea of whether or not this could be a problem.

NATURAL TOPSOIL

The word "topsoil" means different things to different people. Among soil scientists, topsoil is generally accepted as the top layer of soil on the ground in which most plant root activity occurs. This is the "A" soil horizon and is generally 10-30 cm (4-12 in) deep. It is usually biologically active (rich in earthworms and micro-organisms) unless plant growth has been suppressed for an extended period of time, or the soil has been contaminated.

The landscape industry and the public usually consider good topsoil to be loose or friable, free of rocks and weeds and the darker in colour it is, the better. Unfortunately, this description also applies to subsoil. Customers have unwittingly accepted the inferior material without realising that it is missing the key factor that distinguishes topsoil from subsoil: soil life.

Knowing the source, and the depth of stripping to obtain the soil, can tell you whether the soil is topsoil or subsoil. If stripping goes deeper than 30 cm (12 in), it means that some (or all) the soil is coming from the subsoil. This is not necessarily a problem, but the final soil product will need amendments to produce the desired growth performance (*see* Subsoil, below).

Soil Life: Earthworms and Microbial Activity

Earthworms and the soil microbial community are the living components in topsoil that are essential for healthy, sustainable plant growth. In effect, these make up Nature's food processing factory.[15, 16] Without soil life present; plants require high levels of management to flourish – virtually a greenhouse type management program.

These organisms thrive in the same soil conditions of oxygen, moisture, organic matter (OM), pH and temperature that foster good plant growth. Shifting these soil conditions away from optimum – for example, to low OM, waterlogged or compacted soil, or low pH - slows down both plant growth and soil life. Heavy fertilizer applications and the resulting high salt concentrations do the same thing. Herbicides also affect the soil life, while some insecticides and most fungicides virtually wipe it out. (For an excellent description of the impact of these chemical products on soil life, see McDonald[16].) Since these organisms are so important in the breakdown of thatch, it is no coincidence that poor conditions for the soil life lead to a build-up of thatch (*see* Managing Thatch, Chapter 6).

It is important that turf management practices encourage, rather than suppress, these all-important soil organisms. Some soil conditioners, such as properly matured compost, not only enhance the activity of soil micro-organisms, but also add some to the soil. It should be noted that both organic matter and biological activity occur mainly in the root zone, which is roughly the top 20 cm (8 in) of soil.

The Role of earthworms in building soil

Earthworms play an important role in both the nutrient cycle, and in building soil. This is illustrated dramatically in the accompanying photos, taken at a site in England. Turf was established on construction debris and brick rubble at the University of Liverpool in the mid-sixties. Prof. Tony Bradshaw, a noted British soil reclamation researcher and author, suggested at the time that a cost-effective reclamation approach could be to modify such soil as existed in the rubble for optimal nutrient levels, seed it and see what happened. The pathway behind Prof. Bradshaw approximated the original surface texture.

This picture of the soil profile taken a metre or so from the path shows a wonderfully rich soil layer about 100 mm in depth. This soil has been moved to the surface by earthworm activity in the 35 years since establishment.

Although, at this time, there is no practical direct test for soil life, there are some indicators that tell us that soils are likely to be biologically active. For example, the presence of earthworms, or an OM test showing 2% or higher levels of organic matter, indicate that conditions are suitable for healthy growth. The absence of excessive thatch build-up in turf also indicates a healthy microbial community. Knowing the source of soil is one way to guarantee that it is topsoil and likely to be biologically active. The presence of high weed populations can also indicate that the soil came from the top, biologically active layer of the soil horizon. This is because soil from the top levels of farm fields contains high numbers of weed seeds that have accumulated in the soil 'seed bank' over decades.

SUBSOIL

The soil below the "A" horizon is subsoil. Much of this falls within a suitable textural range for plant growth. Even if this layer contains a high percentage of rock material it can still support vigorous plant growth (*see* Soils With Rocks and Debris, this chapter).

Subsoil has been used extensively for building lawns in some areas of the region. In one study, samples taken of lawns established on subsoils found that soil texture ranged from sandy loam to silty loam, and organic matter levels were 0.4-1.2%.[8] Soil texture fell within the acceptable range outlined in the *Topsoil Guidelines*[6], but OM levels were below both the 1.5% minimum in the New Brunswick regulation, and the 2% minimum in the Federal topsoil specifications.[17]

Problems observed on these installations included:

- Lawns were slow to establish after seeding, when compared with those seeded in topsoil.

- Even with adequate pH, nutrient and moisture levels, colour was typically pale and growth anaemic for the first year or two.

Deficiencies in growth were less apparent after two to three years, provided nutrient levels were maintained and other growing conditions were acceptable, such as depth of soil and drainage characteristics. While micronutrient levels in subsoils are normally deficient, this does not seem to be limiting to turf growth. Healthy growth occurs after a few years in most subsoils, yet the fertilizers and lime applied to establish and maintain the lawn would not have made an appreciable difference in soil micronutrient levels. Sodded lawns seem less affected by the deficiencies in subsoil and they generally become established satisfactorily when placed on subsoil bases.

Organic Matter Deficiency

Slow establishment in lawns seeded in subsoil may be due to OM deficiency. When organic matter levels are low, soil biological activity is low, so fewer nutrients are available to the plants. The recovery to an acceptable growth rate over time appears to result from increased OM levels and biological activity created by the growth of grass roots. The better performance of sodded lawns may be due to the micro-organism populations in the soil accompanying the sod. This may inoculate the relatively sterile subsoil and stimulate the growth of microbial populations in the soil profile.

Although subsoil is typically deficient in organic matter and biological activity, it can be used to extend topsoil volumes. It can also be manufactured into ‘topsoil’ by raising the organic matter levels either by amending with compost or mixing with topsoils containing higher OM levels (*see* Manufactured Topsoil, below).

Subsoil as a Natural Growth Regulator

The poor growth characteristics of subsoil can be used to advantage in certain situations as a natural growth regulator. Turf growth rates can be reduced by half or more by using soils in the 1% OM range for a seedbed, and by minimizing nutrient applications after establishment. This can result in savings, both in establishment costs (by using lower cost soil) and in future mowing costs. It may have practical application on low-maintenance commercial sites and many highway rights-of-way.

MANUFACTURED TOPSOIL

Professionals in the landscape industry have generally regarded subsoil as a poor growing medium. However, experience with subsoil amended with both compost and manure shows that amended subsoil can perform as well as, or better than, purchased topsoil. This has important implications for topsoil conservation. It means that a substantial portion of natural topsoil supplies can be replaced with manufactured topsoil. Such topsoil can be made from subsoil in place on building sites, as well as from fill materials excavated during construction.

The benefits of using manufactured topsoils are, that it:

- reduces pressure on current farm land sources of topsoil,

- provides an environmentally sustainable and economical soil for lawns and other plantings, and
- provides a substantial market for compost from the composting operations in the region.

Using Compost to Amend Manufactured Topsoils

There should be a minimum of 1.5% organic matter in manufactured topsoil; OM levels of 2% or higher are preferable. The main ways of accomplishing this are:

- mixing with topsoil containing higher OM levels, such as the duff layer in forest soils, or
- amending with a suitable OM source, such as properly matured compost.

Compost is the most practical amendment for topsoil manufacturing operations.∗ It is a convenient product to handle. When properly prepared, it has few nuisance problems such as odour or weed populations.

There are, however, two potential problems to be aware of:

1. There is a potential safety hazard for people with compromised immune systems and other health problems. They may develop a lung infection from *Aspergillus fumigatus*, a common fungus found in decaying organic matter (*see* Appendix I).

2. Compost production is just starting to gain momentum in this region and quality can be variable. Ingredients and processing techniques vary with the sources and may result in differences between batches, even from the same producer. This variability has a significant impact on the quality and production costs of the end product.

It is important for topsoil producers to test the available composts for several critical quality parameters, such as:

- maturity,
- weed content,
- foreign matter,
- trace elements, including heavy metals,
- organic matter content, and
- pathogens, if biosolid products are used.

Compost maturity and weed content have been the only factors that have caused problems for turf growth observed to date. Using immature compost products gives much the same result as using subsoil. Growth is slow and anaemic as the compost competes with the turf for nitrogen until it is finished composting. In one instance, it was observed that such problems lasted for three years. High weed content, from poorly controlled compost processes that do not generate sufficient heat to kill the weed seeds, has also been noted in the region.

∗ For an excellent, in-depth discussion of compost characteristics, see the Landscape Nova Scotia publication.[18]

Quick Test for Compost Maturity

Place a 2-litre sample of compost in an airtight plastic bag and leave it, sealed, at room temperature for a week. Open it and sniff.
An earthy smell indicates a mature product. If it stinks, or has an ammonia smell, it needs more curing time.

The other parameters have safety, environmental and economic implications. The presence of foreign objects such as glass or metal fragments ("sharps") can pose a safety hazard. Heavy metal and pathogen content are regulated for both health and environmental reasons. When compost products have a lower OM (or high mineral soil) content, greater volumes of compost are required to reach target OM levels in the final product.

More detailed information on these parameters and testing protocols may be obtained from provincial departments of environment, and in the LNS Soil and Compost Use Guidelines.[18]

SOILS WITH ROCKS AND DEBRIS

Rocky topsoil and forest soil are excellent growing media that have been overlooked for landscape purposes because the debris content makes them difficult to work with. Such soils may contain rock (coarse fragment) and debris (roots or other non-soil material). These have little impact on the growth potential for a given soil. They are, however, major factors to consider in handling and cultivating because few practical, clean-up methods have been developed. Glass and metal fragments ("sharps") in soil may also be a safety hazard.

The high quality of this type of material was demonstrated during the recent construction of the Leo Hayes High School in Fredericton. The topsoil was conserved from the wooded construction site of the project, processed and replaced for the landscaping on the site. The recovered topsoil, estimated at 8-12% debris content by volume, proved superior in organic matter content and texture to any commercially available products in the area. Costs to recover the soil and clean up the debris were about half that of purchasing topsoil.

The potential exists for the use of a much wider range of soil material as suitable topsoil for lawns and other planting applications. To do this we must learn how to clean up the materials efficiently, how to recognise the cultural deficiencies of the lower quality materials, and how to amend such products effectively and economically.

Research shows that the rock and debris content of most rocky or forested soils cleared for construction is unlikely be more than 40% of the total material by volume.[19] When working with on-site soils containing rock and debris, it is only necessary to remove a thin layer (5-7 cm, or 2-3 in) of surface material. This can be done with equipment currently available, such as the new Harley™ rock rake. Preliminary tests show that it costs about $2.00 per cu yd (under $3 per cu m) to clean up the top 5-7 cm (2-3 in) of a soil with 15% debris content.[8] This provides a layer of soil that can be easily worked into a smooth finished seedbed, without hazards to mowers or foot traffic from rocks or debris.

Recommended maximum stone sizes in the finished surfaces for various applications are discussed in *Specifications for Topsoil* BS 3882:1994 (section N.6.3).[4] The recommended stone sizes are:

- a maximum size of 20 mm for lawns and playing fields, and
- a maximum of 50 mm for amenity areas, such as parks.

Potential Problems

Architects and inspectors have raised concerns that woody debris in subgrades can cause lawn problems. One has only to look at the many lawns constructed incorporating this type of material in recent years to realise that this concern is of relatively minor importance. Other factors, such as the depth of moisture retaining material, soil texture, and organic matter levels in the top layer, have a far greater influence on the quality and sustainability characteristics of the turf.

Irregular settling is the major problem that results from using subgrade material with significant levels of debris. This type of material can be spread and compacted satisfactorily, provided extra care is taken during the operation. It is ideal if the subgrade material can be placed and left to settle over winter, with the final grading and topsoil spreading done in the spring. This allows the natural freezing and thawing action to stabilise the soil and eliminates the majority of settling problems.

QUALITY PARAMETERS FOR TOPSOIL

There are two important parameters to consider when attempting to grade or classify topsoil: cultural and mechanical. No attempt has been made at this point to tie them together into a formal rating system, but here are the essential factors:

Cultural qualities: Sufficient organic matter content (i.e., 2% or more) provides some assurance of biological activity in natural soils. Manufactured soils, however, may need particular attention to the source of organic matter.

- Low OM is quite expensive to correct, and therefore downgrades the product value considerably. Only biologically active amendments, such as properly matured compost, will kick-start the soil microbial activity in low OM soils.
- Soil with more than 10-15% OM content will be soft under foot, and will probably settle in the years following installation.

Mechanical characteristics: These describe the soil texture and the content of coarse fragment and debris.

- The ideal soil for the root zone is a loam texture with 2% or more OM content. The farther the soil departs from the loam texture classification, the more maintenance costs increase. Turf grows well in soils with lower sand content, but is vulnerable to compaction problems; turf in sandier soils resists compaction, but requires higher water and fertilizer to flourish. In both cases, the higher maintenance costs downgrade the product.
- Debris has little impact on plant growth, but raises installation costs. Debris free soil (or soil screened to 15 mm or ½ in minus) is easiest to handle. Only the top 5-7 cm (2-3 in) requires screening or cleanup.

KEY POINTS

- The sustainability and water requirement of the turf depend on the composition of the full 60 cm to 1 m (2-3 ft) depth of the soil profile.
- Eliminate capillary barriers during construction.
- Test problem areas with a probe to see if compaction, or a layer of sand, gravel or crushed rock is present below the surface.
- Verify subsurface water conditions, and surface grades during construction.
- Select high (60-75%) sand content soils for high traffic areas.
- Check organic matter content for the top 15-20 cm (6-8 in) root zone; 2% OM, or higher, gives good results.
- Focus management inputs to protect, rather than disrupt, the all-important soil microbial life.

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CHAPTER 3. FERTILIZING THE SOIL

Feed the soil, not the plants!

INTRODUCTION

Through their roots, plants get essential nutrients from the soil. To grow healthy turf, then, requires that the right nutrients are present in the soil and that they are available to the roots. This chapter discusses basic soil chemistry, including liming to correct soil pH, the role of major plants nutrients and the different types and timing of nitrogen applications. Soil chemistry is a complex subject; therefore this chapter reviews only the basic principles as they apply to turf. More detailed information is available from the references listed at the end of the chapter.

The Importance of Soil Tests

A soil test is an all-important tool for managing turf. It tells you the current condition in the soil, and usually recommends nutrient and pH changes that will improve results. This helps you tailor product applications to overcome deficiencies, while eliminating unnecessary applications. Take soil tests now, and repeat every two to three years. Save money and lessen the impact on the environment at the same time!

Where to Get a Soil Test
Low-cost and accurate tests are available from most Provincial agriculture departments.

New Brunswick Department of Agriculture, Fisheries and Aquaculture
Lincoln Road, P. O. Box 6000 Fredericton, NB E3B 5H1
(506) 453-2666 http://www.gnb.ca/0179/01790003-E.ASP

Newfoundland and Labrador Department of Forest Resources and Agrifoods
Soil and Land Management Division, Provincial Agricultural Building,
Brookfield Road Box 8700, St. John’s, NL A1B 4J6
(709) 729-6734 http://www.gov.nf.ca/agric/soils/sl164.htm

Nova Scotia Department of Agriculture and Fisheries,
Quality Evaluation Division, Laboratory Services,
P.O. Box 550 Truro, Nova Scotia B2N 5E3
(902) 893-7444 http://www.gov.ns.ca/nsaf/qe/labserv/soilsamp.htm

PEI Agriculture and Forestry Agriculture Resource Division
Research Station, University Avenue, Box 1600, Charlottetown PE
(902) 368-5600 http://www.gov.pe.ca/af/ard-info/index.php3

How to Take a Soil Sample

A soil test is only as good as the sample!
A lab needs about 500 ml (2 cups) of soil to make an analysis. For the most accurate assessment of soil nutrients and pH, the soil sample must be representative of the turf root zone all across the lawn. Since most roots are in the top 5-10 cm (2-4 in) of soil, samples should be taken from this depth.
Take a couple of tablespoons of soil from 2 to 3 locations for every 100 m^2 (100 yd^2) of lawn. This is 6 to 10 sample locations for an average front yard. For more detailed instructions see the Nova Scotia website: http://www.gov.ns.ca/nsaf/qe/labserv/soilsamp.htm

SOIL pH

The pH of the soil is the measure of hydrogen ion activity (or concentration) in a soil solution. This is a key element of soil chemistry that determines how available most nutrients are, both to plants and to the soil micro-organisms. A neutral soil has a pH of 7.0—it is neither too acidic or too alkaline. As the concentration of hydrogen ions increases, the soil becomes more acidic (due to the way it is denoted scientifically, it actually means that the pH number decreases). At a pH of 5.0, which is quite acidic, less than half of the major nutrients are available to the plants.

The little p in pH

In math, "p" is used to denote the negative log of…

In this case, it is the negative log of hydrogen ion (H) concentration in the solution.

Pure water contains some molecules that have broken apart into individual ions, either hydrogen (H^+) or hydroxyl (OH^-).

$$\text{water } (H_2O) = H^+ + OH^-$$

In pure water, there is an equal amount of hydrogen and hydroxyl ions, and the pH is neutral. If you were to count the number of $H^=$ ions in pure water, you would find

$$\frac{1}{10,000,000} \text{ moles of } H^+ \text{ ions per litre of water}$$

In scientific notation, this is 10^{-7} $H^=$ ions, and the negative log of this number is the positive value of the little number on top or 7. As the concentration of hydrogen ions increases, the value of the pH decreases and the solution becomes more acidic.

Source: Reid, K., (ed). *Soil Fertility Handbook*. 1998. Queen's Printer for Ontario, Toronto.

Soils in most of the Atlantic region range from pH 4.5 to 5.5. They are naturally acidic for several reasons:

- the mineral and organic matter composition of the soil,
- the generous rainfall in our region, and
- the increasing acidity in that rainfall over the region.

Turf grasses grow best in soils with a neutral pH of 6.5 to 7.0 through the entire root zone. When higher rates of nutrients are added to acidic soils in an attempt to get the expected growth, it:

- increases costs,
- can reduce soil microbial activity (due to higher salt concentrations from fertilizers), and
- can cause environmental problems as excess nutrients contaminate surface and groundwater.

Weed problems are also worse in low pH soils. This is because many weeds thrive in acidic soil, and because the turfgrass is less competitive. Weed species adapted to a lower pH can use more of the available nutrients and grow more aggressively. By raising the soil pH, the weeds become less competitive. The vigour and density of the turfgrass also improves, which suppresses weed germination and growth.

Correcting Low Soil pH

Applying agricultural lime adds calcium to the soil, which raises the pH. The lime (pelletized or powdered) can be mixed with the soil or added as topdressing, according to rates recommended by soil tests. Powdered limestone formulations are relatively slow acting. Some of the pelletized products contain a portion that is faster-acting calcium hydroxide or quicklime. Dolomitic lime contains a significant proportion of magnesium as well as calcium.

How Much Lime Does it Take?

To raise the soil pH one point, from pH 5.5 to pH 6.5, takes 4-5 tonnes of lime per hectare in average soils.
For smaller areas this translates into:

- ½ kg per square metre
- 1 lb per square yard
- 50 kg per 100 square metres
- 100 lb per 100 square yards

It can take a lot of lime to raise pH (see text box). It is estimated that lime moves downward about 13 mm (about ½ in) per year in loam soils. (It moves faster in sandy soils and slower in heavier silt or clay soils). This means that it can take 10 to 15 years to change the pH in a 15 cm deep root zone, using surface applications of lime.

It is common practice to apply the full amount of lime topdressing in one or two applications. The maximum recommended single application is 25 kg/100 m^2 (50 lb/100 $yd^{2)}$. It may be more effective, however, to divide the total amount into smaller portions and apply it over a longer period. For example: applying lime at a rate of 5 kg/100 m^2 (10 lb/100 yd^2) each time. This is desirable because it assures a more uniform pH profile through the root zone. Lime can be applied any time during the operating season. However, it will move into the soil more rapidly if it applied it before the periods of highest rainfall.

Table 3-1. Beneficial effects of raising pH on availability of nutrients (NPK) and on fertilizer efficiency.

Soil pH	**Nitrogen Efficiency**	**Phosphorous Efficiency**	**Potash Efficiency**	**Fertilizer Wasted**
pH=7.0	**100 %**	**100 %**	**100 %**	**0 %**
pH=6.0	**89 %**	**52 %**	**100 %**	**20 %**
pH=5.5	**77 %**	**48 %**	**77 %**	**33 %**
pH=5.0	**53 %**	**34 %**	**62 %**	**54 %**
pH=4.5	**30 %**	**23 %**	**33 %**	**71%**

Adapted from Adrian Gallant[1].

Fertilizer is used most efficiently at a pH of 7.0 (see Table 3-1), however; it takes very high rates of lime to maintain this target. Given that turfgrass performs well at pH 6.5 and nutrient losses are also minor at pH 6.5, this is the generally recommended target.

When calculating lime requirements, the fact that the nitrogen (N) component in fertilizer is an acidifying agent must be taken into account. Most of the common nitrogen sources or carriers 'consume' (require the neutralizing value of) about 2 units of lime per unit of nitrogen.[2] For example, turf fertilized at the rate of 1.5 kg of N per 100 m^2 (3 lb N/1000 ft^2) will require about 3 kg of lime per 100 m^2 (6 lb/1000 ft^2), every year, to counter the effect of the nitrogen on pH. This works out to 300 kg/ha (250 lb/acre). Natural rainfall, which is somewhat acidic, is estimated to consume about 150 kg of lime per hectare (125 lb/acre) per year.

A Rule of Thumb for Applying Lime

To maintain pH and compensate both for nitrogen applications and the effects of acid rain in this region:

- determine the total weight of fertilizer applied to an area for the year, and
- apply the same weight of lime during the season.

Note: this application rate does not correct for low pH conditions. It only balances the acidifying effects of fertilizers and rainfall.

CATION EXCHANGE CAPACITY

It's important for soil particles to be able to hold essential elements, yet release them into a water solution so they can be taken up by the roots of plants. In solution, these elements become positively charged (called cations). Soil particles are negatively charged, therefore they attract the cations. The capacity of the soil to attract cations is called the cation exchange capacity (or CEC). It a measure of the capability of soil to release elements, such as calcium, magnesium, and potassium, into soil solutions. The smaller the soil particles, the more surface area is available to hold and exchange nutrients. This is why clay soils and those with higher organic matter content have a higher CEC. Experience shows that a clay content of 5% or higher, and OM content of at least 2%, have enough exchange capacity to provide acceptable results.

In good soil, CEC tests commonly show ranges of 10 to 20 meq/100 g.[*] Readings below 10 meq/100 g may indicate sandy or low OM soil conditions.

The CEC reading is an indicator of soil quality that responds slowly to cultural practices. It will increase over time in most new lawns, as nature, turf roots and favourable management practices restore the soil structure and raise soil OM levels.

Corrie Almack has written a very readable description of this soil characteristic.[3]

PLANT NUTRIENTS

Turfgrasses need 16 elements for growth and development. Thirteen of these are available in the soil, some as a result of microbial activity. The other three (carbon, oxygen, and hydrogen) come from air and water. Nitrogen, phosphorous and potassium are three main elements that have a major impact on plant growth. Trace elements such as magnesium, calcium and sulfur, and micronutrients (barium, chlorine, copper, iron, manganese, molybdenum, and zinc) also play a significant role in turfgrass growth, but are required in far smaller amounts.

Most topsoil and subsoil found in the region have sufficient levels of trace elements and micronutrients to support satisfactory turf growth. It is nitrogen, phosphorus and potassium that can be deficient and that are commonly corrected by adding fertilizer. How much of each to apply depends on the results of soil tests and on management decisions, such as the level of nitrogen fertilization. Use soil tests to determine what fertilizer formulations your soil needs, rather than advertising!

PHOSPHORUS AND POTASSIUM

Phosphate is the common name for phosphorous (P) carriers (products supplying the elemental form of phosphorous to plants). Potash describes potassium (K) carriers. Both elements are important for

[*] CEC test results are reported routinely in soil tests carried out by the New Brunswick Department of Agriculture, Fisheries and Aquaculture Soil Laboratory.

healthy growth. In simple terms, phosphorous is generally recommended for growth of roots, fruit and flowers, and potassium promotes healthy stem and cell growth.

While not yet supported by research, observations of lawns and nursery sod production in New Brunswick over the past 25 years have shown that medium levels of P and K (as reported by soil tests) have given satisfactory results. The recommendations accompanying soil test reports often suggest adding enough P and K to raise levels to 'high' ranges. However, the medium levels of both elements may be an appropriate target, given the concern over environmental impacts and the added costs of excess or unnecessary fertilizer use. Both P and K are considered reasonably stable in most soils once target levels have been reached (unless they are depleted by continuous removal of clippings).

It is a common assumption that the addition of potassium to the soil will enhance plant winter hardiness. Although high potassium "winterizer" fertilizers are common turf formulations, the author has not yet observed cases where turf injury could be correlated with low P and K levels in New Brunswick lawns. Therefore, it is questionable whether higher rates of these elements are necessary. While they probably won't hurt (there is little evidence of problems with potash leaching off the site), they haven't been shown to help significantly, either, and they cost money.

Since most fertilizers contain some P and K, using formulations with the lowest levels of these elements (e.g., a 4:1:1 or 5:1:1 ratio) would be sufficient, once target levels of P and K have been achieved. It is possible to buy nitrogen-only formulations (such as SCU 32-0-0, ammonium nitrate 34-0-0 or urea 46-0-0), however, they are risky to apply with common push type fertilizer spreaders. Their actual application rates are so low that too much of these products may be applied, causing damage to the lawn.

NITROGEN

Of the three major nutrients, nitrogen is required in the highest amounts. Nitrogen fertilizer is a primary turf management tool because it has a major impact on turf growth and colour – the more N the plants take up, the greater the growth and deeper the colour. It is the most expensive ingredient in most fertilizers. It also has the greatest potential to damage the turf and the surrounding environment, if not used correctly.

Nitrogen is found in soil in a number of forms, but is only available to plant roots in two water-soluble forms: as nitrate (NO_3^-) or ammonium (NH_4^+). Other forms of N must be converted into these available forms by Nature's food factory – the soil's microbial population.

Turfgrass roots are very efficient at trapping nitrogen. Under a normal fertilization program, when turf is actively growing, the plants take up all (or most) of the water-soluble N in the root zone.[4] This rapidly improves the appearance of a lawn by stimulating growth and enhancing the green colour. High rates, however, are not healthy for the turf (*see* Nitrogen Application Rates, below).

Although complex forms of N are relatively stable in the soil, the fast release, water-soluble forms are the most mobile of the nutrients in the soil. Water-soluble N is subject to leaching through the root zone and can also be lost to the environment through volatilization or evaporation. Such losses occur when water-soluble N is available, and the roots are unable to take it up. This can happen when the N is applied:

- in a period of turf dormancy or slow growth (e.g. mid summer, or late fall),
- in excessive amounts, or
- when excessive rainfall or irrigation washes it down through the root zone.

Environmental tip:

If you're applying fertilizer containing fast-release nitrogen components, be sure to get it on at least 4 weeks before the grass goes dormant (mid-summer or fall). This way, the grass gets most of the nitrogen, rather than the environment!

Sources of Nitrogen

Nitrogen in turfgrass fertilizers is grouped into two broad types: fast release (or water-soluble), and slow release.

Fast Release Products: Nitrogen is usually present in water-soluble fertilizer formulations as soluble nitrate (NO_3^-) or ammonium (NH_4^+). It is readily available for uptake by the roots and gives a rapid growth response. Common nitrogen sources are ammonium nitrate and urea. The effect of these formulations generally lasts up to 30 days after application. These products must be applied carefully. Higher concentrations, of over 0.5 kg/100 m^2 (1 lb/1000 ft^2), can damage (chemically burn) turf.

Water-soluble nitrogen is quite mobile in the soil. It is not analyzed in New Brunswick soil tests because levels in the soil will have changed significantly by the time test results are received.

Slow Release Products: Slow release nitrogen is available in two forms: chemical and organic. Both types safeguard the environment by reducing the amount of N that can leach off site.[5] The nitrogen in most common slow release formulations must be broken down by soil micro-organisms into the water-soluble form before it is available to roots. The conditions that support the highest microbial activity (warm soils and adequate moisture) are also optimum for turf growth. This means the actively growing plants take up water-soluble nitrogen as it is converted, leaving little or no N lost into the environment. There is also little loss of the remaining N in periods when the turf is dormant in summer (when it is dry) and in winter (when soils are cold), because the soil microbial activity is not producing it.

Chemical Sources of Nitrogen: The chemical formulations of slow-release fertilizers consist of water-soluble nitrogen in resin or sulphur based capsules. As the capsules break down in the soil, usually through soil microbial activity, the nitrogen is released. The product most commonly found in turf fertilizers is sulphur-coated urea (SCU™). The effects of SCU generally last about two months under active growing conditions. Products with longer lasting N formulations (such as Methydure™) are also available.

Organic Sources of Nitrogen: Organic materials, such as compost, animal waste, blood meal, feather meal, and grass clippings, release nitrogen as micro-organisms break them down in the soil. Nitrogen can continue to be released from these materials for a few weeks up to several years. For example, it has been shown that compost releases only 10-15% of its nitrogen content each year. The advantages of using organic materials are:

- they make N available in the root zone over a long period of time,
- the N is less likely to leach off site and contaminate ground water, and
- there is little chance of chemically injuring the turf.

Compost is gaining in popularity for use on turf. Anecdotal reports suggest that compost may provide benefits beyond the supplying nutrients and organic matter. These may include: improving soil structure, increasing disease and insect resistance, and reducing the requirement for other nutrients. These benefits may be due to increased activity of soil micro-organism, but this requires more research.

Organic Buyers Beware

Note that the Canada Fertilizer Act allows *organic based* fertilizer products to contain up to 85% chemical fertilizer. Since chemical fertilizers are considerably less expensive per unit of nutrient than organic products, such blended formulations are cheaper to produce. Users who need organic products that meet certified organic standards or personal preferences must check the labels carefully to ensure the products meet their requirements.

Nitrogen Application Rates

How much N to apply generally depends on the preferences of the end users. In the quest for deep green lawns and rapid growth, nitrogen fertilizers have become the primary turf management tool. As Beard and Green point out[6], however, these deep green lawns are not healthy lawns. Furthermore, there are increasing concerns about the cost and environmental impact of high fertility programs.

If the uniformity of green colour, rather than depth of colour, is acceptable as a criterion for turf appearance, the turf manager can focus on maximizing the health of the turf, rather than on maintaining a deep green colour. This gives considerably more flexibility in adjusting nitrogen application rates and timing to:

- reduce workloads and costs,
- improve pest resistance and reduce pesticide requirements,
- minimize environmental risks from nutrient leaching, and
- enhance the image of the industry or individual as environmentally responsible.

The N requirement for lawn areas varies depending on the soil base, pH, levels of P and K, the types of plants in the lawn, and whether or not the clippings are left to decompose on the lawn (s*ee* Grasscycling, Chapter 6). For example:

- Lawns on a ‘sustainable’ soil base (i.e., deep soils with uninterrupted capillary movement of moisture) perform well with lower rates of N than those on only 100 mm (4 inches) of soil over gravel.
- Lawns with higher populations of clover need less added nitrogen because the clover makes nitrogen available naturally.

- Bluegrass-fescue blends require less N than pure bluegrass turf, because the fescue grows well at lower N levels.[7] (New selections of Kentucky bluegrasses with lower N requirements exist, but are not yet generally available).

How Much Nitrogen is Enough?

Many lawns in our region perform acceptably without annual fertilizer applications. However, the addition of fertilizer will likely improve turf health. The question is: how much? The decision about the how much and when to apply N will depend on the site's unique soil and turf conditions, as well as the user's expectations and budget.

Provincial recommendations vary for nitrogen use on general use turf (home lawns and parks). For example:

- New Brunswick recommends that total N for the season should not exceed 1.5 kg/100 m^2 (3 lb/1000 ft^2), [8] with no single application greater than 0.5 kg of soluble nitrogen/100 m^2 (1 lb /1000 ft^2). (Some slow release formulations have higher recommended single application rates because of the reduced potential for burning).
- Nova Scotia recommends not more than 1 kg/100 m^2 (2 lb/1000 ft^2 [9].)

Most published recommendations are for higher annual application rates, but these are for regions with longer growing seasons. For example, recommended rates for Kentucky bluegrass, (the species with the highest N requirement), start at about 0.2 kg/100 m^2 (0.4 lb. of N/1000 ft^2) per growing month[7]. In Ontario, Eggens suggests using 1 to 1.75 kg/100 m^2 annually (100-175 kg/ha) on medium maintenance turf.[10] Using these figures as a guide, the New Brunswick and Nova Scotia figures above give reasonable upper ranges for the 5 to 6 months of active growth in our region.

When calculating the amount of nitrogen required, it is important to realise that leaving clippings on the lawn will reduce the need for added N by one-third to one-half.[11, 12, 19] Applying properly matured composts can produce the same result. A healthy turf on a sustainable soil base, using mulched clippings, will perform well with an annual N application rate of 0.5 kg/100 m^2 (1 lb/1000 ft^2) or less.

Nitrogen Drives Clipping Production

Applying increased rates of nitrogen to turf generates a large amount of leaf tissue. A Winnipeg study showed an average of 90% increase in the yield of clippings with an increase of 0.5 kg/100 m^2 (1 lb/1000 ft^2) in the N application rate.[13]

Recent studies in Fredericton showed that lawns yield an average clipping mass of about 12 kg per 100 m^2 (26 lbs/1000 ft^2, wet weight).[14] This means a typical 500 m^2 home lawn could produce about 1.2 tonnes of clippings annually; a hectare would generate over 24 tonnes. Assuming the Winnipeg findings are transferable, a 0.5 kg increase in nitrogen application rates would almost double clipping production—to over 22 kg/100 m^2. That is a lot of extra mowing! On the other hand, reducing nitrogen application rates is a way to significantly reduce clipping yields, workloads and landfill pressures.

Timing of Nitrogen Applications

Past practice has been to apply the first feed of N at or before the first mowing, with additional applications through the season. Research has found, however, that early spring applications of N to healthy turf cause a decrease in root growth and plant nutrient reserves.[15] The additional N appears to stimulate excessive tissue growth at the expense of root growth.

The best time for a single nitrogen application is the beginning of the September-October growth period.[16, 17] This is a relatively new concept in turf nutrient management. Turfgrass uses nutrients most effectively during this period to build up reserves for over-wintering. This also prepares the turf to begin the next spring flush with healthy nutrient levels.

The second best time to apply N is immediately after the spring growth flush, which is about mid-June in this climate. The timing of June applications of fertilizers containing water-soluble N is critical both from the point of view of plant health and environmental impact. This is because grass growth generally slows down by mid-July and may stop all together by the third week of July as soil moisture is depleted. When fertilizer is applied too close to this summer dry period, it can produce high nitrogen levels in the plants and increase plant stress. (The stress from high N levels in the dry period shows up as a greyish green sheen on the turf.) Any remaining soluble nitrogen, not taken up by the plants, dissipates into the environment. In most of the region, N can be applied between June 10th and 20th with a reasonable assurance that there will be 30 days of active growth to fully use the soluble nitrogen. Of course, individual sites may vary, depending on the soil base, climate, and irrigation practices.

Fertilizing turf in late fall, after top-growth ceases, is recommended in many regions, however, this practice is not recommended for our region. This is because there is a risk of soluble nitrogen remaining in the soil at the time the ground freezes up. It has been recognized for some time that this N can potentially leach off site over the winter.[18] To avoid this problem, apply the last N fertilizer at least four weeks before mowing stops in the fall.

Table 3-2: Suggested fertilizer application schedule for the Atlantic region.

Applications per Year	Timing of Applications			
	Early May	June 10 to 20	Mid-September	Mid-October
1			X	
2		X	X	
3		X	X	X
4	X	X	X	X

Multiple applications are recommended if annual nitrogen application rates are higher than 0.5 kg/100 m^2 (1 lb/1000 ft^2). When using up to 3 applications per year, the total annual application rate should be divided evenly into the number of applications desired. A fourth (May application) might be desirable for young turf (e.g. planted last season and just becoming established) or where turf shows excessive winter injury. In these cases, a reduced N rate is suggested – about half the rate of the other applications.

To minimize streaking or overlapping that might burn the turf, spread half the total amount in two applications, made at right angles to each other. Check the spreader delivery rate, and adjust as necessary, taking care to spread the fertilizer on the turf, not on sidewalks or driveways.

ENVIRONMENTAL STEWARDSHIP

There are several ways a turf manager can move further toward environmentally friendly practice, while providing healthy turf. These include:

- Consider the impact on the environment when choosing the type of nitrogen fertilizer, the application rate and timing. There are direct impacts, such as leaching of excess nitrogen off site, and indirect impacts, such as energy wasted on excess mowing, removing clippings, and transporting them to landfills or other disposal sites.
- Avoid fertilizing in the early spring, near the time of the first mowing, because this accelerates top-growth. Not only does this increase mowing and clipping disposal costs, but it can also have a negative impact on the health of the turf, and significantly increase the risk of nitrogen loss to the environment.
- Reduce the need for fertilizers by adjusting the soil pH to 6.5 and by leaving grass clippings on the lawn.
- Make sure fertilizers are applied only to the lawn and not to the surrounding driveway or sidewalk where rain will wash it into watercourses.
- Schedule applications of soluble nitrogen products at least 4 weeks before turf dormancy begins, both in summer and late fall.

KEY POINTS

- Take soil tests now to determine soil pH, P and K levels; repeat every two to three years to review the results of your management program. Let your soil, rather than advertisers, tell you what fertilizer to use!
- Aim for a pH 6.5 target. Consider splitting lime applications over several years.
- Recycle clippings wherever possible (grasscycling).
- Balance nitrogen applications with lime, to keep the pH up.
- Use fertilizer ratios required to correct P and K deficiencies, then switch to products with high N and low P and K content (4:1:1 or 5:1:1 ratio).
- Evaluate current nitrogen application rates and reduce rates where appropriate.
- Consider using only fertilizers with controlled release N formulations.
- Consider timing fertilizer applicators for mid-September and mid-June.
- Where more than one application is scheduled for the season, split the N rates equally (with a reduced rate for May if applicable).
- Check the spreader delivery rate, and adjust as necessary
- Spread the fertilizer on the turf, not on sidewalks or driveways.
- To minimize unevenness, spread half the total amount in two applications at right angles to each other.

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CHAPTER 4. SELECTING TURF VARIETIES

INTRODUCTION

Selecting the right turfgrass varieties and mixtures is an essential part of establishing a healthy, sustainable lawn. Turf research has produced a wide range of named varieties (cultivars) with improved colour and texture, disease resistance, drought and wear tolerance, and vigorous growth. This makes it possible to choose the cultivars that may be better suited to a particular site.

This chapter contains basic information about lawn species and choosing seed mixtures to suit site conditions.

LAWN SPECIES

Notes on species grown in lawns in this region are included below. Detailed descriptions of species characteristics are not included because these are easy to find in turfgrass references (s*ee* Further Reading at the end of the chapter). For information on cultivar characteristics, consult seed supplier bulletins. Some features are also rated and published by the National Turf Evaluation Program (NTEP - *see*: http://www.ntep.org/).

Common Turfgrasses

The most common turfgrass species used in general purpose lawns in the Atlantic region are Kentucky bluegrasses, creeping and fine fescues.

Kentucky Bluegrasses: The most desirable species for colour, density, and cushiony feel underfoot. They have high nitrogen and water requirements, however, and are quite vulnerable to chinch bug damage. An important advance in Kentucky bluegrass research, which should have a major impact in the next 3-5 years, is the development of cultivars that perform well at low rates of nitrogen (e.g., 0.5 kg/100 m^2 or 1 lb/1000 ft^2).

Fescues: These blend nicely in a turf surface with bluegrasses, are very winter hardy, thrive under lower nitrogen programs than bluegrasses, are more tolerant of drought and poor soil conditions, and seem to be more resistant to chinch bug damage. Fescues tend to be somewhat stiffer in texture and lack the resilience of bluegrasses underfoot, which may make a pure fescue lawn less desirable from the customer’s point of view.

Other Turfgrasses

Ryegrasses: Because ryegrass germinates in 3-5 days under good conditions, they are normally incorporated in seed mixtures to provide rapid cover. They act as a nurse crop for the slower germinating permanent turfgrasses. Both annual and perennial ryegrasses are available, but both are essentially annuals in New Brunswick and the zone 4 areas of other provinces. Tests at Truro have demonstrated that perennial ryegrasses may survive for longer periods, but they cannot be considered a reliable, permanent cover.

Since perennial ryegrasses rarely survive more than two years in local conditions, it is more economical to use the lower cost, annual selections in seed mixtures. A ryegrass content of up to 20% by weight of the total seed mix is adequate for this purpose. Using higher amounts of ryegrass tends to suppress root development of permanent species.

Tall Fescues: These are not generally used in the region as they seem to be less winter hardy. While there are reports of limited success using tall fescues in Nova Scotia, there is little experience with them in New Brunswick.

Bent Grasses: Also not normally used in lawns in this area.

Other Lawn Species

There is a growing awareness of the benefits of biodiversity in lawns. This means allowing or intentionally planting a variety of plants, not just turfgrasses. The benefits include:

- improved drought tolerance, which saves water,
- reduced need for fertilizer and chemical inputs, and
- high tolerance to chinch bug damage.

In 2002, a chinch bug survey conducted in New Brunswick found little visible damage in biodiverse lawns.[1] This was even at population counts of up to 1200 chinch bugs per square foot (0.1 m^2). There was obviously damage to the bluegrass, and possibly to the fescue, but the other plants growing in the lawn masked the damage.

White clover: This plant has good potential for use as a complement to turfgrasses. In a recent trip to the UK one of the authors found that most turf – even at Windsor Castle – contained an even distribution of clover. There are several advantages to seeding a mixture containing 5% or more white clover. The clover plants generate a substantial amount of nitrogen naturally (estimates of 50 to 150 kg of N/ha annually have been reported). This is sufficient to feed the turf plants with little or no added nitrogen. The deep-rooted clover also remains green through the summer drought when the turf species turn brown.

CHOOSING SEED MIXTURES

Turf seed is sold in pure form, as blends and as mixtures. A blend is two or more cultivars of a species, such as ‘Baron’ and ‘Midnight’ Kentucky bluegrass. A mixture contains two or more species, such as Kentucky bluegrass, creeping fescue, and ryegrass.

Qualities to consider when deciding on a seed mixture for a new lawn include:

- quick establishment into a uniform turf with high customer appeal (conventional seed mixtures meet these requirements in most situations),

- low maintenance characteristics, such as drought tolerance or a low requirement for nitrogen, that help reduce environmental impacts,
- tolerance or resistance to pests, such as to chinch bugs or turf diseases.

Starting with a mixture of bluegrasses and fescues ensures there is enough variety in the mix to provide a turf that will adapt to the site and the maintenance conditions over time. For high quality turf, starting with blends of two or more of the superior cultivars of each of the permanent turf species can ensure the best performance.

Shade Tolerant Turf

Turfgrasses need plenty of light to thrive. While some mixtures are promoted as shade mixes, they do not add a significant level of shade tolerance. Re-seeding sparse areas in shady areas generally does not succeed in the long term. This is because the shade is often from trees in the landscape; as they grow to maturity, the expanding canopies will further reduce light levels. A more effective solution is to replace the turf in such locations with a bed of shade-tolerant perennials.

Seed Containing Endophytes

Some fescue and ryegrass seed selections have been identified that contain endophytes.[*] These are fungi that live inside the grass plant, benefiting the host plants by providing protection from insects that attack the shoots. (For an interesting discussion of endophytes, see the University of Rhode Island site http://www.uri.edu/ce/factsheets/sheets/endophyte.html.) So far, no bluegrasses have been found with this characteristic.

Cultivars containing endophytes cost more, but the extra cost may not be justified at this time, because:

- no research exists under our conditions to show the effectiveness of endophytes against chinch bugs,
- endophytes in seed can die under poor handling and storage conditions and there is no practical field test to determine whether they are still alive at planting time, and
- only fescue cultivars (in the permanent species for our region) contain endophytes. In a severe infestation chinch bugs will likely decimate the bluegrasses anyway, leaving a patchy appearance.

Seed Counts in Mixtures

The actual seed count in a mixture is quite different from the ratio shown on the label because of the differences in both size and weight of seeds of different species. For example, compare two mixtures:

[*] A list of perennial ryegrass and fine fescue varieties and their endophyte content can be found in: 'Turfgrass Insects' from Colorado State Univ. Co-op. Extension: http://www.colostate.edu/Depts/IPM/natparks/turfpest.html *See* Table 1. Endophyte Levels for Perennial Ryegrass, and Table 2. Endophyte Levels for Fine Fescues.

- a commonly available mixture for general purpose turf with a ratio of 40% Kentucky bluegrass: 40% fescue: 20% ryegrass, by weight. This contains over 75% Kentucky bluegrass by seed count because the seed is smaller than the other species (*see* Table 4-1).
- a popular mix for shade, with a higher fescue content, has a ratio of 30% bluegrass: 60% fescue:10% ryegrass, by weight. While it would seem otherwise, this mix is nearly two-thirds bluegrass.

Both mixtures provide 30,000 - 55,000 seeds per m^2 at the recommended seeding rates of 1.5 to 2.5 kg/100 m^2 (3-5 lb/1000 ft^2):

	Number of seeds in 1 lb. (0.45 kg)					
Type		40-40-20 mixture	% of type in mixture	30-60-10 mixture	% of type in mixture	Approximate germination time
Bluegrass	2,200,000	880,000	76	660,000	63	1 - 2 weeks
Fescue	600,000	240,000	21	360,000	35	5 - 7 days
Ryegrass	200,000	40,000	3	20,000	2	3 days
Totals		1,160,000		1,040,000		

Table 4-1. Seed counts and germination times for Kentucky bluegrass, fescue and ryegrass. (From Beard[2]).

FACTORS AFFECTING TURF COMPOSITION

Despite efforts to choose the best blends and mixtures for the lawns, the desired results may not materialize. Three general factors that may affect what ultimately grows in the lawn are discussed below. These are:

- Turf variety test results do not necessarily apply to Atlantic conditions.
- The Canada Seeds Act offers little assurance of quality.
- What you plant isn't necessarily what you get in the established lawn.

Turf Variety Test Results Do Not Necessarily Apply to Atlantic Conditions

Most research and testing is done under warmer conditions than those in the Atlantic region, therefore performance may be different here. For example, in one trial conducted in New Brunswick in the mid-1970's with 10 of the top NTEP rated Kentucky bluegrass cultivars, half of those tested performed more poorly than the control seed plots.[3] This was primarily due to lack of winter hardiness – a factor that is not rated in most testing programs, but is quite significant over most of the region.

Disease resistance ratings are generally not important under New Brunswick conditions, because the climate appears to suppress turfgrass diseases in general use turf. Disease ratings may be important in other centers in the region, however, where some disease problems have been reported.

The Canada Seeds Act Offers Little Assurance of Quality

Under the Canada Seeds Act, grading standards for Canada No. 1 Lawn Grass Mixtures (which applies to most seed mixtures supplied to the trade) call for:

- a minimum of 70% germination for each seed component,
- 85% pure seed by weight,
- a maximum of 5% by weight white clover, brown grass, orchard grass or tall fescue, and
- a maximum of 2.5% by weight of weeds and other plants.[4]

This specification allows a great deal of latitude for troublesome weeds and objectionable turf varieties, such as annual and rough-stalked bluegrass. At normal seeding rates, the allowable limit of 7.5% by weight would allow up to 100 undesirable seeds per square metre. This sounds like a lot, but in most situations the seed bank already in the topsoil is more of a problem than contaminants in the seed mixture.

In special cases, however, the permitted contaminants can be a serious problem. For example, in one case of seed purchased for a field of sod, the rough-stalked bluegrass component was tested at 0.1%, which is about one-twentieth of the allowable limit. This resulted in about 20 rough-stalked bluegrass seeds per square metre and nearly forced the sod producer out of business. In such critical situations, the purchaser should seek assurance, in writing, from the seed supplier that the product is free from specific objectionable contaminants.

No Canadian turf seed mixtures can be labeled with a grade higher than Canada No. 1. Specifications are often written that call for Certified mixtures; these specifications are incorrect because the more stringent "Certified" ratings are discarded when containers of Certified seed are opened for mixing.

What You Plant Isn't Necessarily What You Get

The results of seeding or sodding may be determined more by site soil conditions and follow-up maintenance than by the original blend and quality of the seed mixture.

Three important factors determine the result of seeding:

- the original seed mixture (discussed above),
- the survival of the seeds planted, and
- the adaptation of cultivars to the site conditions.

The final composition of the lawn is determined by how well the plants survive after seeding, and how they adapt to the site. This depends on the timing of the seeding and the effect of moisture and growing conditions on the establishment of the turf (*see* Chapter 5). The long-term adaptation to the site depends on the soil conditions and on the management practices.

The impact of soil quality on establishment

The site in this photo was prepared in late August. One operator prepared and seeded the area to the left (between the curb and the property line) using high quality manufactured topsoil. A second contractor prepared the area to the right, using a poor quality soil. Both areas were hydraulically seeded at about the same time; seed mixtures, fertilizers and follow-up care were essentially the same. This picture, taken the following spring, shows the positive impact of the high quality soil. The area on the left had established satisfactorily, while the area to the right, as well as the remainder of the property, had to be reseeded.

THE CASE FOR SUSTAINABLE LAWNS

Choosing the right seed mixtures for the site and the intended management regime reduces the need for water, fertilizer and herbicides. For example, under good soil conditions, with adequate moisture, a mix of bluegrass and fescue provides a healthy dense stand of turf. This resists weed invasion and has some resistance to chinch bug damage. Under poor soil conditions, however, bluegrass-fescue mixtures require considerable fertilizer and water to remain attractive and are more vulnerable to insect damage.

A better choice for poor conditions would be a pure fescue turf. It requires fewer inputs and (with selected varieties) may be chinch bug resistant, although it does not have the same appealing appearance of a pure Kentucky bluegrass or bluegrass-fescue mixtures.

Growing a biodiverse lawn, with white clover or other plants, is a radical departure from the traditional idea of weed-free turfgrass lawns. However, it has several advantages, including substantial resistance to chinch bug, tolerance to drought and reduced fertilizer needs. Clover in a turf can produce enough nitrogen to feed the turf plants.

KEY POINTS

- The major factors affecting the quality of the lawn are soil conditions, and growing conditions after seeding.
- General-purpose bluegrass-fescue-ryegrass mixtures work well in most situations.
- Premium seed mixtures require a high-quality soil foundation to realize their potential.
- Where seed quality is critical, obtain written assurance from the supplier that contaminants are not present.
- Consider incorporating white clover in the seed mixture or sod to take advantage of the natural nitrogen source and chinch bug resistance.

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CHAPTER 5. ESTABLISHING NEW TURF

INTRODUCTION

Rapid establishment of turf, whether from seed or by laying sod, is desirable: it quickly stabilizes the soil and controls erosion, it suppresses germination of weed seeds in the soil ‘seed bank’ and it satisfies the customer. The following chapter covers preparation of the site and tips for successfully establishing lawns from seed and from sod.

Rapid Establishment Reduces Erosion

A key step to reduce erosion is to establish turf cover on a site as quickly as possible. This can be accomplished by:

- seeding when natural rainfall can be expected to water the site (before mid-June, or between mid-August and mid-September),
- irrigating if seeding is required outside the window for best natural establishment, and
- increasing the amount of annual ryegrass applied during seeding.

Initial growth will be enhanced by light nitrogen applications or 10-20 kg N/ha (10-20 lb N/acre) in May, early June, early September or early October to take advantage of natural rainfall. This should be discontinued after the first year in low maintenance areas; other areas should continue a normal fertilizer program (*see* Chapter 3, Fertilizing the Soil).

Choosing Seed or Sod?

Turfgrass can be established by planting seed directly or by laying sod. Since the long-term results of either method are the same, the decision depends on such factors are:

- available budget,
- size and topography of the area to be covered,
- resources available for post-planting maintenance,
- whether a short time-to-use period is required, and
- preference of the property owner.

Table 5-1. Comparison of direct seeding vs. laying sod for initial establishment of turf.

Seeding	**Sodding**
Cheaper	Faster establishment
Allows wider choice of species	Good weed suppression
Can be established without follow-up watering	Requires substantial watering if placed in dry weather
	Offers some erosion protection
	Gives better results in low OM soil or subsoil for the first 3-5 years

It is important to realize that most of the long-term success of either approach is determined *before* any planting takes place. Effective site and soil conditions are covered in Chapters 2 and 3, and in other references (*see* Further Reading at the end of the chapter).

PREPARING THE SITE

An adequately prepared surface is important for successful establishment of turf. The requirements are the same for both directly seeded and sodded lawns. As long as a friable seedbed, some nutrients, and follow-up watering are provided, the new grass will grow well in the short-term. (These conditions also work, short-term, on a jute doormat or a moist towel!) Ensuring long-term, sustainable growth, however, is more demanding. It involves amending the top layer of soil to provide adequate nutrient levels, pH and organic matter, as determined by soil tests (*see* Chapters 2 and 3).

Ideally, site preparation begins with saving and stockpiling the site topsoil near the construction site. If screening is needed to clean it up, it can be done any time the soil is reasonably dry.

Begin rough grading by removing as much construction debris, tree stumps, and rocks as practical, and installing any service, drainage, or lighting conduits. This is the time to look for, and correct, problems with surface or underground water moving onto the site. For example, it may be necessary to divert possible water flows using berms at the top of slopes or by adding extensions to eaves trough downspouts.

It is important to allow for the fact that soil expands in volume by as much as a third when it is moved around. Settling will occur unless all disturbed areas are compacted to the original soil density during rough grading operations. Since a lot of settling will take place over the first winter, even a perfectly finished surface will appear uneven by the following spring. This is more obvious if significant amounts of rock or root debris remain in the subgrade. It is also particularly noticeable over trenches and next to foundations. In both of these situations, the settling indicates that not enough care was taken to compact the sub-base properly.

Attempting to correct surface unevenness later, by surface rolling after seeding or sodding, has little effect. This is because the weight and ground pressure of commonly used rollers have little impact below 5 cm (2 in). Although waiting is not always practical, results will be much better if the subgrade can be left over winter and finished the following year.

Ideally, soil amendments, nutrients and lime (*see* Chapter 3) should be incorporated into the top 10-15 cm (4-6 in) of soil, while the surface is being prepared. Applying lime and nutrients to the surface, however, as done with hydraulic seeding, has proven reasonably effective. Early results from 2002 trials in Fredericton showed higher leaf tissue yields on sites with surface nutrient applications than those where nutrients were incorporated to a depth of 15 cm (6 in). This may be a short-term response, however, and later years may show different results.

The ideal finished surface for either seeding or sodding is a 2.5 to 5 cm (1-2 in) layer of loose soil with a reasonably smooth surface. Ridges from gaps in the rake teeth are not a problem, but a 2-5 cm ridge left by the edge of a rake will remain as bump in the final surface.

SEEDING

Once the seed is chosen (*see* Chapter 4), long-term success depends on the care taken to apply seed evenly, as well as on the care of the lawn during the critical germination and early growth stages.

Timing

Moisture for germination is required to establish turf successfully from seed. Moisture must also be available for long enough after seeding to allow the slowest germinating species (i.e., Kentucky bluegrass) to develop enough strength to survive the winter.

Where irrigation is not available or water must be conserved, it is best to place seed either before mid-June or between mid-August and mid-September. In most parts of the region, there is enough natural moisture for seed establishment until about mid-June; rainfall normally returns in September. If irrigation is available, seeding can be completed at any time through the season with reasonable success.

Seeding after September 15 in Fredericton results in a marked reduction in bluegrass survival. It may be possible to seed up to two weeks later in coastal and zone 5 regions because freeze-up is later in these areas, but there is no research supporting this. In any case, the cooler temperatures in these regions may offset any benefit from a longer fall growth period, so the net result may be the same.

Current recommendations for clover suggest that it is necessary to plant in the spring for successful establishment. Therefore, if a clover is included in the mixture, seeding should be done before mid-June.

Seeding Rates

Commonly recommended seeding rates range from 1.5 to 2.5 kg of seed per 100 m^2 (3 to 5 lb/1000 ft^2 or 130-220 lb/acre). Nursery sod has been successfully established using rates of 0.5-0.75 kg of seed per 100 m^2 (1-1.5 lb./1000 ft^2 or 50-75 lb/acre).

In healthy, established turf, shoot counts of 100 to 250/dm^2 (6-15/in^2) have been reported.[1,2] Since the recommended seeding rates, above, supply about 325 – 600 seeds/dm^2 (20-35/in^2), there is a substantial margin to compensate for low germination rates, poor seeding practices, consumption by birds or poor follow-up watering.

A healthy, strongly rooted turf can be established over time from counts of permanent species as low as 1 seedling per square inch, because most turfgrasses spread from the roots.

Using seeding rates higher than the recommended rates (above) gives a filled-in appearance more quickly, but is not necessarily desirable. This is because competition between the crowded seedlings can actually suppress root development.

When establishment fails…….is the seed really to blame?

When a failure occurs in a seeding job, it is easy to blame the seed. One of the authors had a number of seeding failures over nearly 50 years, and – of course – felt the seed was always to blame. Later, when using the blotter test (like the bean germination experiment in science class) to check the seed germination, the seed *always* grew.

It appears that most establishment problems are moisture related: either there is insufficient watering after seeding in dry weather, or there is enough watering to get seeds started, but then the new seedlings are allowed to dry out and die. Late seeding has also resulted in some failures. In one stubborn case, after four repeated hydraulic seedings failed, the probable cause was found to be a Killex™ application the previous season, which had been buried by 10 cm of topsoil before seeding.

Seeding Techniques

Seed must be uniformly distributed over the area. It must also be lightly covered – ideally about twice the seed's diameter. The following section describes four techniques for applying seed: broadcasting and hydraulic seeding are the most widely used; using a Brillion seeder and compost seeding are other possibilities.

Broadcasting: The seed is applied with a drop-type fertilizer spreader, rotary spreader, or by hand. For even distribution, spread half the seed over the whole site, moving in one direction; then apply the remainder, moving at a right angle to the first direction. A leaf rake works well for incorporating and covering the seed. The area may also be rolled lightly to improve seed to soil contact. Lightly covering the area with straw mulch, before rolling, helps germination by shading the soil and reducing evaporation. Use about 2 bales or 50 kg of straw per 100 m^2 (or 100 yd^2). This process introduces some foreign seeds into the turf, but in most cases this is overshadowed by the seed in the soil seed bank.

There are a couple of drawbacks to broadcast seeding:

- Because of the light weight of the seed, windy conditions can cause misses in the seeded area.
- The raking process can leave gaps: each time the rake is dropped onto the surface, it moves soil (and seed) away from the contact point.

These problems may be overcome somewhat by making multiple passes (at right angles) with the spreader and raking lightly between each pass. The seeding rate for each pass must be adjusted accordingly to reach the target seeding rate.

Hydraulic Seeding: Hydraulic seeding is a method of pumping seed mixed in water through a hose or gun onto a prepared surface. The process is popularly called 'hydroseeding', but this term is a registered trademark of Bowie Corporation, an equipment manufacturer.

This method was originally developed as a quick method for seeding slopes, hard to reach areas, and large areas, such as roadside rights-of-way. It is now commonly used for residential and commercial seeding operations. While unit costs are significantly higher than conventional seeding methods, the higher costs are justified because of improved efficiency and customer satisfaction, with fewer call-backs to correct deficiencies.

Figure 5-1. One-step Hydraulic Seeder at an NBHTA Topsoil Conservation Project.

The application can be done either as a:

- single-step process, with the mulch (shredded paper or wood fibre) added to the seed-water-fertilizer mix to create a slurry, or
- two-step process, with chopped hay or straw mulch blown onto the area after it has been hydraulically seeded with a seed-water-fertilizer mix. The two-step process is not practical for areas under 4-5 ha (10 acres), because the higher equipment costs and difficulty of controlling application in small areas.

There are two basic types of hydraulic seeding equipment:

- recirculation mixing units, which are smaller units, have water tank capacities of 250-1000 US gallons. These mix the ingredients in the tank by pumping water back into the tank through strategically placed jets,
- paddle mixing units, which are larger units, have tank capacities of 800-3000 US gallons. These have a large rotating auger in the tank to mix the ingredients.

For a given sized unit, the paddle mix unit covers twice the area per tank of water in the single step seeding process, because it has a higher slurry concentration. It is also more expensive because of the complexity of the auger system.

In the single step process, the limiting factors for using any unit are the availability of water and capacity of the mulch delivery system. Application rates of mulch range run from 750 to 1500 kg/ha (or lb/acre). The recirculating units can only handle up to 2.5% concentrations of mulch by weight, while the paddle mix units can deliver 4.5 to 5% concentrations of mulch. Thus an 800 gallon recirculation unit can hold 150-160 lb of mulch and cover between 400 and 850 m^2 (500-1000 yd^2) per load. An 800 gallon paddle mix unit delivers twice the coverage for the same volume of water. Since water normally has to be trucked to the site, the paddle mix units save travel and refilling time.

Although water is applied during hydraulic seeding, not enough is used to count as irrigation. At the 1500 kg mulch application rate, the recirculation units apply 5 litres per m^2 (about 1 gal/per yd^2). This is equivalent to about 5 mm (0.2 in) of rainfall. Paddle mix units at the 750 kg rate apply about 2 litres per m^2 (1/3 gal/yd^2), equal to about 2 mm (0.05 in) of rainfall.

The quantity of mulch used in hydraulic seeding mainly helps the operator to control the seed application; mulch rates below 2500 kg/ha appear to do little to conserve moisture. Experience shows that the 750 kg/ha application rate provides satisfactory results. Little cultural benefit has been reported from the higher rate of 1500 kg/ha,[3] however, customers may be more satisfied because the green dye in the mulch remains visible a few days longer at the higher application rate.

Erosion control agents, such as Benovert™ or Terratack™, can be incorporated with the mulch or added to the tank mix to improve the stability of the seeded area. In the experience of one author, it is questionable whether the additional cost of these products is justified. Limited testing in side-by-side situations showed there was little benefit to using erosion products – if there was enough water flow to disturb the earth, erosion resulted anyway. Blowing 3000 lb/acre of chopped hay or straw, followed by 750 lb/acre of wood fiber mulch, has been found to be an effective stabilization method.[4]

Hydraulic seeding allows seed to be presoaked, which speeds up germination. Soaking the seed for 24 hours can shave two days off the time before new seedlings become visible (and makes customers happier).

The Benefits of Hydraulic Seeding

Wetmore's Landscaping had the first commercial one-step hydraulic seeder in Atlantic Canada – purchased in 1976. Experience with this unit has found the lower application rate (750 kg/ha) works well and is cost effective. Under the same watering program, establishment time appears to be about same for hydraulic seeding and conventional seeding, although the hydraulically seeded lawns might need to be mowed a day or two sooner.
There are also other benefits to hydraulic seeding:

- faster seeding operations,
- fewer holdups from weather,
- more uniform establishment with less skilled applicators, resulting in fewer callbacks and improved customer satisfaction, and
- the process seems to keep the birds off, probably because the fertilizer in direct contact with the seed in solution gives the seed a bad taste.

Many customers feel that hydraulic seeding gives better results than conventional seeding. Maybe the "high tech" aura of the process encourages them to pay better attention to follow-up watering?

Most of the larger units have the choice of delivery through a nozzle or a hose. On residential sites, the hose gives closer control of the spray pattern and makes it easier to avoid overspray onto buildings and walkways.

Brillion Seeder: This is a mechanical seeding unit mounted on the three-point hitch of a tractor. It plants the seed at optimum depths in friable seedbeds. It is not readily adapted to residential or confined commercial situations because it cannot work close to obstructions.

Compost Seeding: This is a new concept gaining popularity in the US, but not yet seen in this region. The process uses a blower type applicator that mixes the required amount of seed into compost. The operator then applies the mixture through a hose, leaving a 15-50 mm (0.5- 2 in) layer on the surface. The deeper, 5 cm (2 in) layer is reported to be effective both for establishment and for erosion control.[5]

ESTABLISHING SOD

Sod comes in a variety of lengths, widths, and thickness. These include 1 yd^2 rolls or about 0.6 yd^2 slabs for manual handling, and large rolls (up to 30 yds^2) for mechanical laying. Normal widths are 16, 18 and 24 inches (measurements are commonly in imperial units in this sector of the industry, because harvesting equipment is normally of US manufacture).

Various turf mixtures are available as sod, from pure bluegrass blends to bluegrass-fescue mixtures, depending on the supplier.

The recommended maximum thickness for the soil layer on sod is about 1.5 cm (½ in).[6] A thinner sod is preferable because it:

- establishes faster as root growth "explodes" from pruned points. The thinner the sod, the more root pruning has occurred, with the more potential growth points,
- is also more economical to handle and transport due to lighter weight,[*] and
- conserves topsoil in sod production fields.

On the other hand, thinner sod has less soil attached to store moisture, and therefore requires more attention to watering.

For best results, the soil texture in the sod should be similar to that of the site. Soil textures that are more than two textural classifications apart (*see* Chapter 2) create a boundary layer that hinders the movement of moisture and slows root development. In a case in Fredericton, there was complete failure when sod grown on organic soil (peat sod) was laid on silt loam. Other reports from field experience indicate that peat sod dries out more quickly than sod grown on mineral soils and needs more attention to follow-up watering.

Installation of Sod

Sod can usually be installed at a rate of 25-40 yards per person-hour. The weight of sod ranges from 7 to 22 kg per yard (15-55 lb), depending on thickness and soil moisture content. Sod weighing less than about 10 kg (20 lb) per yard is quite dry. Such sod must be delivered quickly after harvest and placed and watered immediately to avoid failure. If lightweight sod remains on pallets for more than 24 hours after harvest in hot weather, it may be damaged from "stack burn", caused by overheating that kills the roots. Suppliers are generally aware of this, and usually cut sod immediately before delivery, to assure the customer of a fresh product. If laying operations are held up for any reason in hot weather, the sod should be removed from the pallets, the rolls or slabs spaced out (not necessarily unrolled) and watered thoroughly.

[*] A 1.6 mm (1/16 in) change in sod thickness represents a weight difference of 2 tonnes (4400 lb) per 1000 yds^2 with dry sod, considerably more if the sod is wet.

When laying lightweight (low soil moisture) sod in dry weather, it is strongly recommended that the soil surface be moistened just before laying. This dramatically reduces transplant shock and results in faster establishment under these conditions.

The soil should be saturated 7-10 cm deep (3-4 in) immediately after the sod is placed. This softens the soil, makes rolling more effective, and insures that the first sod placed stays moist while the job is completed.

There is some controversy over whether sod should be placed horizontally or vertically on slopes. If the sod is properly placed with tight joints, experience shows there is little difference between these methods. It also doesn't seem to matter once it is established whether the joints are staggered, as long as they are tight.

Sod may be installed successfully at any time of the year (even over frozen ground) if the surface is adequately prepared. In one case, a Fredericton contractor successfully placed several thousand yards of sod in January on a nearby site. Topsoil was stored in a heated warehouse, and the sod (cut in December and allowed to freeze) was moved inside for several days to thaw. The site surface was graded, and the topsoil and sod was placed quickly during a mild spell.

Tips for Laying Sod Efficiently

- Spot the pallets in the centre of each 50 to 75 yd^2 area covered by the pallet, rather than at the edge; this saves 10 to 20 minutes of labour per pallet by reducing carrying time.
- When carrying rolls from the pallet to the laying area, drop them so they unroll correctly. They can unroll to the right or to the left. Orienting them correctly, so that they unroll in the desired direction, saves labour, as they don't have to be picked up again to turn them around.
- Start laying from the back edge of the site to minimize traffic on the new sod.
- Start against the longest edge of an area to minimize the amount of cutting.
- Avoid overlapping edges, which results in dead sod.
- Place full-width strips at the edges next to drives, curbs and walkways, and move fitting and trimming activity in one sod width from the edge. This will minimize the risk of foot traffic flipping the narrow pieces.
- Thin, damaged areas or weeds are easily spotted when laying. Tear these open and fold the flaps back to mark them clearly so they can be patched later.
- When patching, place a piece of good sod on top and cut through both layers (linoleum knives work well for this) to create a patch with a perfect fit.
- Check the moisture at the soil surface by lifting a corner of a roll in the sunniest area. If it's dry, more frequent watering is needed.
- Note that sunny slopes and the outer perimeter of sprinklers can dry out more quickly.

Erosion Control with Sod

Sod can provide some erosion control on slopes, particularly when it is staked or pegged in place. It will not protect slopes where there is enough water flow to move the soil beneath the sod. This can occur when runoff from the surface above the slope is concentrated into a relatively narrow drainage (e.g., a low spot at the edge of a parking lot). It may be necessary to protect sod from washout in such situations with a berm or a sandbag dam.

MANAGING THE NEW LAWN

Watering

Roots of germinating seeds, and freshly placed sod, are very susceptible to drying out—they must be kept moist or they die. Experience in our region has shown that for every hour a seedbed dries out, a day of growth is lost; a day's drying out will cost a week of growth. It is important for the first week or two to keep the top 6 to 12 mm (¼ - ½ in) of soil moist to sustain new seedlings. Sod requires a continuous supply of moisture in the sod layer and in the soil just below the sod to about 2.5 cm (1 in) deep. Watering deeper is largely wasted, and has resulted in loss of nitrogen as the soluble component is dissolved and moved below the root zone.

After the first week or two, as the roots begin to grow, watering practice should be modified to promote deeper root growth. Roots go where the water is, therefore keeping a seedbed continually moist also keeps root shallow. Instead, force the roots to grow downward by providing a good soaking to a depth of 10 cm (4 in), then allow the surface to dry out for a day or two between watering. Maintain this program until the first mowing for seeded lawns, or for 3 to 4 weeks for sod.

Mowing

If the turfgrass is established from seed, the first cut should be delayed until the grass reaches a height of 10 cm (4 in) or so (depending on the owners' preference). Ryegrass grows considerably faster than the permanent species. This means that a newly seeded lawn needs to be mowed more often for the first year or so, until the ryegrass dies out. Frequent mowing after the first cut, leaving the clippings on the lawn, not only keeps the lawn attractive, but also helps to encourage root development and faster fill-in.

For sodded lawns, begin a normal mowing program as soon as the grass reaches the desired height (50% above mowing height). This usually occurs within a few days after the sod is placed.

Follow-up Fertilizing

All new turf will benefit from a light, follow-up application of nitrogen 4 to 6 weeks after establishment. If irrigation is not available, and the application would fall in the dry, summer period, the application should be postponed until natural rainfall returns in September.

LONG TERM SURVIVAL OF LAWNS

What species and cultivars continue to grow in the lawn depends on which ones survive the establishment stage and how well the plants are adapted to the site and the management regime. The survival of the turfgrass depends on the following factors:

Timing

When the seed is planted can make a large difference. For example, bluegrass requires 6 to 8 weeks of good growing conditions to become established. If planted after September 15, in most areas of the region, bluegrass survival decreases. While fall moisture conditions are normally adequate, if the fall is cool, the plants may be too weak to survive the winter.

Dormant seeding (i.e., in November) is not a reliable technique for establishing turf and cannot be recommended for most of the region. For example, in Fredericton, only the fescue component in the seed mixture survived to the following spring after seeding operations were carried out by one of the authors in October and November. Another dormant seeding operation in Nackawic was a total failure.

Moisture conditions

Availability of water after seeding has a major impact on the survival of the various components in the seed mixture. In a typical bluegrass–fescue–ryegrass mix, the bluegrass seems to be most sensitive. It requires 6 to 8 weeks of adequate moisture to become established. A late June seeding under natural moisture conditions (i.e., no irrigation and limited rainfall in July) can result in a complete failure of the bluegrass. This is typically masked by the ryegrass in the mix until the following spring when the ryegrass disappears, leaving the remaining stand nearly all fescue.

Growing Conditions

Seeding (and sodding) might be compared to a paint job on a car: the quality of the results depend on how well the surface is prepared. The surface preparation for a car compares with the soil foundation for turf. Unless good growing conditions are established before seeding (*see* Chapters 2 and 3), even planting high quality seed blends will disappoint the end user.

Adaptation to the Site

Regardless of the care taken in initially establishing turf, the long-term composition of the turf depends on survival of the fittest plants. The composition of the turf changes over a period of years depending on growing conditions and maintenance practices; Beard describes this characteristic as plant succession.[7] For example, poor soil and low soil moisture reserves favour fescues, while poor soil, coupled with nutrient and pH deficiencies, favours aggressive weed growth that can suppress both fescues and bluegrasses.

While nursery sod is fully established at installation time, succession still occurs as the plants adapt to maintenance practices and soil conditions that differ from conditions in the nursery. For example, pure bluegrass sod will decline if placed over poor or droughty soil. Such conditions favour fescue, so if there is a fescue component in the sod, it becomes the dominant species over time. Plant succession also explains why a seeded or sodded patch in an established lawn stands out at first, but blends into the lawn after a few years.

RENOVATING EXISTING LAWNS

Existing lawns occasionally need to be repaired or renovated for a variety of reasons. In severely degraded sites it may be necessary to replace (renovate) the entire lawn. In other cases, the existing lawn may be enhanced by overseeding.

Overseeding

Overseeding is the application of seed to an existing lawn. It is done to repair thin or damaged areas or to introduce new species or cultivars. The same principles apply to overseeding as to seeding a new lawn. The seed must be in firm contact with the soil and sufficient moisture must be available long enough to allow the seed to germinate and develop a healthy root system.

There are several ways to overseed, including:

- applying seed before or after aeration,
- incorporating seed with, or followed by, topdressing, or
- applying seed using a slit seeder, which cuts a slit in the soil and drops seed into the cut.

The success of any method depends on how good the contact is between the seed and the underlying soil. If, for example, a topdressing mixture is applied, but the existing grass and thatch prevent the mixture from reaching the soil, little of the seed will grow. It has been suggested that overseeding may help to enhance the soil seed bank with desirable species, which will then emerge if conditions permit.[8]

Overseeding is most successful before mid-June or in early September, when there is enough natural moisture to ensure establishment.

It should be noted that overseeding only provides a short-term fix in cases where the thin turf areas are caused by cultural deficiencies.[9] In these situations, it is essential to diagnose and correct the underlying problems. If the problems are nutrient related, this will stimulate the natural spreading characteristics of the existing turf plants to fill in the turf and may restore the lawn without the need for overseeding. If shallow soil or capillary barriers cause the problems, a major reworking of the soil foundation will be needed.

Renovating

Renovation is a more drastic approach to correcting turf problems. It involves getting rid of the existing turf, cultivating the surface and reseeding. It is most often used:

- to remedy sparse turf, or
- to repair a surface that has become too uneven to mow or use as intended.

If sparse turf is the problem, the causes are most likely soil or nutrient deficiencies. To ensure long-term success, these must be explored and corrected.

KEY POINTS

- Seed before September 15 to assure good establishment of bluegrass.
- Seed before June 15, or between August 15 and September 15, to conserve water.
- Take the extra time and care to establish a good soil foundation.
- Take soil tests, and adjust pH, nutrients, and possibly organic matter content, as recommended from the test results.
- For the fastest seed establishment, keep the top 6 to 13 mm (¼-½ in) of soil moist for the first week or two. Deeper watering is wasted.
- To assure successful establishment of sod, keep the soil in, and below, the sod layer moist for the first week or two.
- Train deep roots by watering correctly. After the initial couple of weeks, reduce watering frequency and increase the duration to allow moisture to penetrate 6-8 cm (3-4 in) deep. Let the surface remain dry for a half-day or so before watering again.
- Begin mowing when the grass reaches a height of 10 cm (4 in).

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CHAPTER 6. MAINTAINING TURF

INTRODUCTION

This chapter describes sound practices for long-term maintenance of lawns in this region. How we take care of established lawns affects more than the immediate appearance of the turf—it also affects the long-term health of the turf and its resistance to pest attack. The sections in this chapter provide basic information on watering, mowing, grasscycling, managing thatch and aeration. These are practices that anyone can use to improve results, while conserving water and minimizing the use of fertilizer and pesticides.

WATERING

The objective of watering practices should be to conserve water, while sustaining healthy turf. This section discusses the moisture needs of turf, irrigation practices to encourage deep rooting of the turf, and ways to conserve water.

Watering requirements for established turf differ from those for newly established lawn (which is discussed in Chapter 5, Establishing New Turf).

Deciding Whether to Water

Whether or not to water depends on the soil foundation of the lawn, on the customer's preferences and on management practices. Natural rainfall is sufficient to meet turf needs throughout the early and late part of the growing season in our region. Prolonged mid-summer droughts are common, however, with up to 12 weeks with little or no rain. During this period, soil moisture levels drop as the water moves into the air by surface evaporation, and by evapo-transpiration from the leaves of plants.

Many lawns in our region stay green through our dry summers without irrigation, although growth rates slow as soil moisture reserves decline. This indicates that sufficient natural moisture is available in our region to maintain green turf, if the underlying soil foundation has the capacity to store the moisture (*see* Chapter 2 for information on the moisture capacity and capillary flow in soils). Healthy turf generally does not require irrigation in this region, unless it is subject to additional stress, such as occurs on playing fields.

If not irrigated, however, some turf will turn brown in midsummer. This does not harm turf. It is a sign that the turfgrass has become dormant, which is a natural response that enables grasses to cope with drought. The green colour returns rapidly after rainfall returns.

Do Weeds Get Ahead in a Dormant Lawn?

Broadleaf plants (e.g., dandelions and clover) are more visible when turf is dormant because they remain green. They have deeper roots so can reach down to the scarce soil moisture. Although they stay greener longer than the turf, there has been little evidence that the populations increase as a result.

In some locations, the soil depth is not adequate to supply enough moisture. This can happen, for example, for lawns constructed on sites with solid rock a few centimetres below the surface. A homeowner or turf manager faced with a brown lawn in midsummer has a problem that cannot be corrected without a major rework of the site. They must choose between accepting the dormant appearance, and watering to compensate for the construction deficiency.

Turf growth and colour normally returns after rainfall.

Turf stressed from drought (left), recovered a week after rainfall returned (right). Note in the left photo that the area alongside the house remained green, because of the reduced moisture requirements in the shadow of the house. The area at the base of the hydro pole at the rear also remains green, possibly due to the mud in that area remaining from the hole dug for the pole, and the additional moisture storage reservoir it provides for the turf.

If the decision has been made to water through the dry period, then it should be done as efficiently as possible to conserve water and obtain the best results. The source of water should also be considered. For example, if water is drawn from wells, it is important to check that sufficient volume will be available from the pumping system and well, without disrupting the water quality or supply. Sustained high demands may drain a well, or cause murky water. Provincial regulations require a permit for well water usage above 50 cu m/day (about 8 gpm).[1] (Most home wells and pumps operate in the 5 to10 gpm range.)

Turfgrass Moisture Requirements

Water use varies greatly between species and cultivars, with fescue species requiring much less than Kentucky bluegrass turf.[2] It is generally accepted that healthy turf growth requires about 25 mm (1 in) of available moisture per week in the region.[*]

Anecdotal reports suggest that about 13 mm (½ in) of available moisture per week is enough to maintain the green colour in turf in our region.[3] With water conservation in mind, we suggest that

[*] Beard[2] cites a daily moisture requirement from 0.1 to 0.3 inches per day or 0.7 to 2.1 inches per week.

this figure be used as a target to be refined through observation and research in the upcoming seasons.

If the decision to water is made, there are two choices:

- apply enough water to keep the turf green, which requires about 15 mm (⅝ in) per week, or
- irrigate enough to maintain vigorous growth, which requires about 30 mm (1.3 in) per week.

These application rates are somewhat higher than the targets cited above of 13 mm and 25 mm per week, to compensate for evaporation loss.

Table 6-1. Water volumes required, by area, to provide 13 mm or 25 mm water, assuming an irrigation system operating at 75% efficiency.

Watering once								
		1 sq yd	1000 sq ft	100 sq m	500 sq m lawn	1 acre	1 ha	100 homes @ 500 sq m
13 mm (1/2")	Imp gal	3	350	375	1,875	15,000	37,500	187,500
	Liters	14	1,600	1,700	8,500	69,000	170,400	850,000
25 mm (1")	Imp Gal	6	700	750	3,750	30,000	75,000	375,000
	Liters	28	3,200	3,400	17,000	138,000	341,000	1,700,000
Watering eight times through the summer								
		1 sq yd	1000 sq ft	100 sq m	500 sq m	1 acre	1 ha	100 homes
13 mm (1/2")	Imp gal	24	2,800	3,000	15,000	121,000	299,000	1,495,000
	Liters	114	12,800	13,600	68,000	552,000	1,360,000	6,800,000
25 mm (1")	Imp gal	48	5,550	6,000	2,900	242,000	598,000	2,990,000
	Liters	227	25,600	27,200	136,000	1,104,000	2,720,000	13,600,000

Cultural practices have a marked influence on water requirements for turf. Cutting with dull mower blades, using higher rates of nitrogen, and intense traffic all increase water demand.

On lawns affected by browning, some areas, such as on sunny slopes, will brown more quickly than others. Shady areas and the north sides of buildings will usually stay green longer. These areas can be irrigated less frequently, which saves water.

Water used by turf plants declines as soil moisture drops or as irrigation frequency decreases.[2] The deeper the roots, the better turf plants tolerate drought. Cultural practices that encourage deep rooting reduce irrigation requirements, as well as promote healthy turf. In contrast, frequent light sprinkling encourages the development of shallow roots, and should be avoided.

The Need for Water Conservation

The amount of water used on the average lawn is surprisingly large. The decision to irrigate could consume 1,700 to 3,400 litres per week (*see* Table 6-1) assuming the irrigation system is operating at 75% efficiency. If irrigation is required for 8 weeks (supplemented with a normal number of rainfall events through the summer), this would require about 13,500 to 27,000 litres of water per

100 m^2 of turf area. This is 68,000 to 136,000 litres for a typical 500 m^2 home lawn. Evaporation losses from typical overhead irrigation systems can raise these figures significantly. The figures can be doubled by poor management of the irrigation system: for example, by leaving sprinklers running an extra hour or two, or allowing water to run down the curb or other hard surfaces.

At the municipal level, the numbers are more striking: irrigating 100 average sized lawns through an average season could consume 6,800 to13,600 cubic metres of water (assuming no waste). Poor irrigation practices can easily double these figures. It is clear why this is a major concern for municipalities, especially since the water used on lawns is mainly of drinking water quality—our most valuable water.

There is a great deal of potential for reducing the amount of water used on lawns. This can be done right now through conservation measures. In the future, it can be done by introducing construction standards that require provision of a 'sustainable' soil base under lawns in new construction.

Sprinkler Design and Efficiency

Every irrigation setup is different, with different equipment, delivery rates and soil conditions. Each setup should be carefully evaluated to maximize both irrigation efficiency and water conservation.

Irrigation delivery methods include overhead, surface and subsurface sprinkler systems. Micro- and drip irrigation and soaker hoses use water most efficiently. However, overhead delivery systems are the most practical for turf because they cover a larger area and less labour is required to move the units. Overhead units are available with:

- rotating nozzles covering full circles (some models can be set to cover part circles) with spike or flat plate bases, or
- oscillating bars on a plate or skid mount that delivers a rectangular pattern.

The units mounted on skid or plate bases are a bit easier to manage than the spike mounts. Also, units delivering a rectangular pattern are easier to control in confined areas and allow more uniform coverage with less over-spray onto sidewalks and driveways. They are also preferable during sod installation, because the more controllable pattern reduces interference with the laying crew.

Typical overhead lawn sprinklers deliver 8 to 20 litres (2 to 5 US gal) per minute, depending on nozzle hole size and water pressure. This is equivalent to rainfall of 3 to 25 mm (0.1-1 in) per hour.

For rotating sprinklers, the effective coverage area is about 65-70% of the total area wetted, in windless conditions. This is because the amount of water delivered to the surface tapers off toward the outer edges of the area covered. For such sprinklers, a 30-35% overlap of wetted areas is necessary to assure reasonably uniform application. The units with rectangular patterns seem to require less overlap to provide effective coverage.

Evaporation reduces sprinkler efficiency. As much as 50% of the water leaving the nozzle may be lost to evaporation in extremely hot, windy and low-humidity conditions.[4] For our conditions, a 75% efficiency (25% loss) figure is probably a fairer estimate. (Rain Bird and Nelson irrigation equipment catalogues provide good reference data on nozzle delivery rates and coverage areas.)

How Often to Water

How often to water to apply the total amount required each week depends on the objectives of the watering program and the soil base under the lawn.

Most soils—even a 10 cm (4 in) layer of topsoil over gravel—can hold enough water from one weekly application to keep the turf green. That is, they can hold 13 mm (½ in) of available moisture, without becoming so saturated that water is wasted. If the decision is made to irrigate at this rate, a weekly watering (depending on rainfall) will suffice.

If the target is to water enough to maintain vigorous growth, it will require 25 mm (1 in) of water in a week. One weekly application of the full amount is usually more effective than applying half the amount twice a week, because it encourages plants to develop deeper roots. However, in sandy soils or shallow soils over gravel, this may result in a significant waste of water. If a lawn turns brown within three to four weeks after the last good rain, it may indicate that the soil is sandy, thin, or both.

In sandy soils, a single application of 25 mm of water will soak down as far as 45 cm (18 in), assuming no runoff.[5] If the topsoil is 15-20 cm (6-8 in) of sandy loam over gravel, or there are other disruptions to capillary movement (*see* Chapter 2) at least half of the water will move below the top layer of soil and be lost to the turf.[*] Under these conditions, it would better to apply two, 13-mm applications per week (taking natural rainfall into account).

On heavy soils, 25 mm of water will soak in to a depth of 15-20 cm (6-8 in). If the soil is this deep, the full amount can be put on in one application. To check this, shortly after watering lift the sod in an out-of-the-way spot and dig down to the gravel layer. If the gravel is moist, it means that too much water has been applied. (The lifted sod won't be injured if it is replaced and kept moist for a few days). Cutting back on sprinkler time, and scheduling irrigation for every 5 or 6 days rather than weekly, can reduce this waste of water.

The soil infiltration rate is another variable that determines how much water can be applied at one time without waste. Light sandy soils on level ground can absorb 13-18 mm (0.5 to 0.75 in) of rainfall equivalent per hour, while heavy soils may accept only 2-6 mm (0.1-0.25 in) per hour. On slopes, infiltration rates may be 20% lower on 6-8% grades, and 40% lower on 9-12% slopes.

How Long to Water

How long to operate the irrigation system depends on how long it takes that particular sprinkler and hose combination to deliver a given quantity of water. It all depends on the capacity of the soil to take up and hold that water. To determine this, the irrigation system must be calibrated.
Calibration is done in two stages:

[*] Loss of irrigation water may occur on thin soil over sand or gravel if the soil is watered beyond the saturation point, and surplus drains down through the gravel. (For a good visual description of this phenomenon, see Brady.[6]) The amount drained into the gravel cannot move back to the surface through capillary action and is lost to the plants

The first stage: Find how long it takes to apply 13 mm (½ in) of water to the surface:

1. Place 4 straight-sided cans of the same diameter about half way out in the sprinkler delivery pattern, then run the sprinkler for 15 minutes. (Using 4 cans improves the accuracy of the sample, and reduces the time required for the test).

2. Pour all of the captured water into one can and measure the accumulated depth of water. This will likely range from 6 to18 mm (¼-¾ in). This total gives a reasonable estimate of rainfall equivalent per hour delivered by that sprinkler, compensating for evaporation loss on that particular day.

3. Use the following formula to calculate how long a particular sprinkler setup must run to deliver 13 mm (½ in) of water to the turf:

$$\text{Operating time in minutes} = \left(\frac{\text{Target quantity (e.g., 13 mm)}}{\text{Accumulated depth of water}} \times 60 \right)$$

Note that the delivery time established with this test will change significantly if a hose is added or removed from the setup. Because pressure drops due to friction loss in hoses, adding a second hose can cut sprinkler delivery volume in half, as well as reducing the area covered. If a second hose is required to reach some areas, the setup should be recalibrated.

The second stage: Find out how long the sprinkler can be left running in a particular spot before water runs off. Sprinkler operating times may vary for different locations within a particular site, because of different slopes, soil textures, traffic patterns and compaction. Some areas will require less water than others because they are less exposed to sun and wind. Reducing the sprinkler operating times in these areas conserves water.

On heavy soils or slopes, two or three applications separated by several hours, may be needed to deliver the target amount of water without causing runoff. Sprinklers with slower delivery rates are better in these situations (but are generally only available through irrigation supply outlets). Reducing delivery rates by adding a second hose is another option.

When to Water

A great deal has been written about the proper time to water. It is logical to water when evaporation losses would be lowest and coverage patterns most uniform—meaning in cool, high humidity, windless conditions. These conditions are common in nighttime or early morning. Watering at these times, however, may mean less attention is paid to controlling the timing and efficiency of the application; this may result in a great deal of wasted water.

To put the potential for wasting water into perspective, consider that:

- watering to runoff can use two or three time more water than the lawn requires,
- leaving sprinklers running an hour longer than necessary can waste 50% of the water applied,
- allowing too much overlap on sprinkler patterns, or watering driveways and walks, can waste 30-50%, and
- loss to evaporation in hot, windy mid-day conditions may only be 10 to 20% higher than on cool, calm mornings.

In short, if the decision is made to irrigate, it is generally better to do it when work schedules permit. Applications should be postponed in extremely dry, hot, windy conditions. Monitor the areas closely to eliminate runoff, avoid applying excess water, and arrange delivery patterns to minimize over-spray onto non-turf areas. A sprinkler system with a timer (if it is managed correctly) is a wise, water conserving investment.

Water Conservation Tips

Allow the turf to turn brown. This normally doesn't hurt the turf, and conserves water.

Rather than promote growth, consider watering just enough to keep the turf green; this takes about 15 mm (⅝ in) per week (reduced by amounts of natural rainfall).

Water deeply, once or twice a week, to develop deep roots and stronger turfgrass plants. Avoid light sprinkling.

Use water efficiently: check delivery rates, apply just enough and stop watering before runoff occurs; water the turf, not the driveways and other hard surfaces.

MOWING

Mowing is the most frequent maintenance operation carried out on turfgrass. It has both a functional and an aesthetic purpose, providing a neatly groomed, and sometimes patterned, appearance. It also provides an enjoyable surface for recreation, a safe, playable surface for various sports, and reduces fire hazards around buildings.

How you mow affects the health of the turfgrass. The following section covers mowing height and frequency and well as mower safety and maintenance tips.

Mowing Height

The height of the mower setting largely controls the depth of roots. Using higher mower settings leads to a deeper, more extensive root system. This improves the ability of the plant to obtain moisture and nutrients from deep in the soil (*see* Figure 6-2). The result is a healthy turf, better able compete with weeds, resist insect attack and withstand environmental stress, such as drought and temperature extremes. Recent research at the University of Guelph shows, even more strikingly, the effect of mowing on root depth in Kentucky bluegrass; it found roots were more than 2.5 times longer than mowing heights.[7] Generally, a mowed height of 6.5 to 7.5 cm (2½ to 3 in) is acceptable for lawns and amenity turf. As well as encouraging healthy plants, the increased height reduces the number of mowing operations needed for the season. Lower mowing heights create the illusion of a neater turf, but turf mowed at 7.5 cm (3 in) will look as neat as one mowed at 2.5 cm (1 in), provided the mower is sharp. A lawn with an uneven surface can even look better at the higher setting because there will be less scalping.

Figure 6-1. Stressed turf caused by close mowing.

The photo above shows severe drought stress from close mowing. The stressed area is surrounded by green turf that was mowed at normal height.

Using sharp mower blades is very important. This ensures a clean cut, which improves the appearance and is better for the health of the grass plants. Using a dull blade tears the leaves, leaving a jagged or frayed wound that stresses the plant. This, in turn, increases moisture loss and gives the lawn a brownish cast for several days after mowing. Dull mower blades also require more power to drive them, increasing fuel consumption.

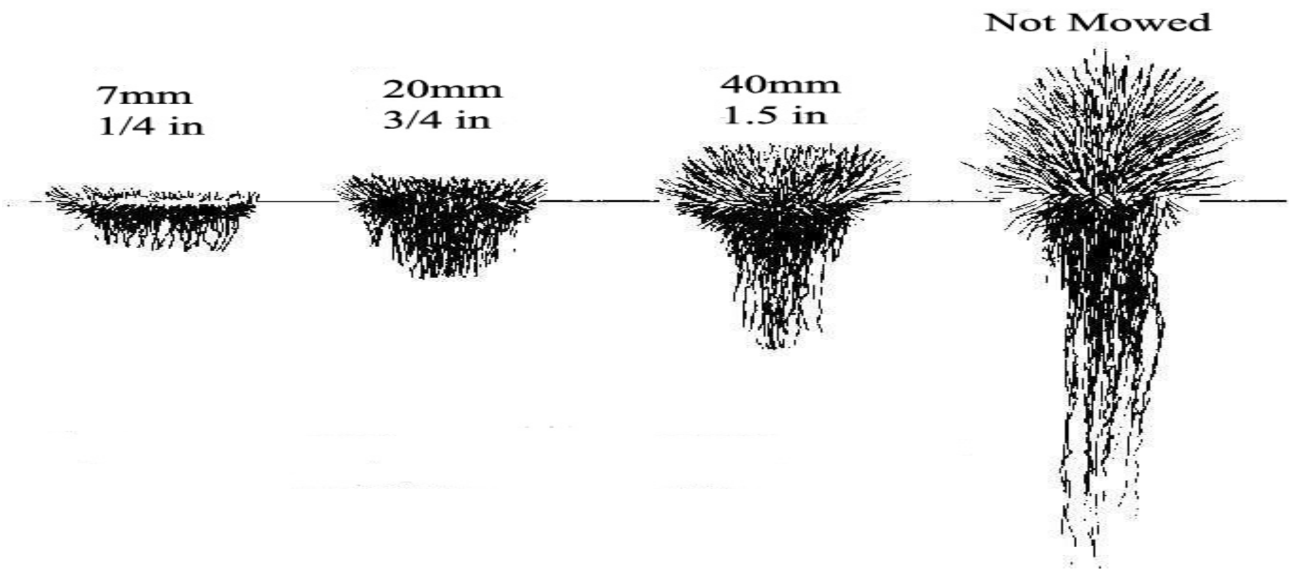


Figure 6-2. Root depths of grasses at various mowing heights. ***Adapted from Emmons.***[8]

Does higher mowing cause later green-up in the spring?

There have been reports of slow green-up in the spring on lawns cut at higher settings. This is particularly noticeable when the lawn is beside a closely mowed lawn.

Lawns turn green in the spring when the new growth appears above the layer of dead leaf blades left from the previous season. This means that the new grass blades will appear above a 7.5 cm (3 in) layer a few days later than above a 4 cm (1 ½ in) layer.

The problem is one of perception, since the turf is actually healthier at the higher mowing height. If the slightly slower green-up is an issue, the time can be shorted by lowering the mower cutting height setting for the last two or three cuts in the fall. As seen in Figure 6-3, growth processes are quite slow at that time of year so the lower height will have little impact on overall root growth.

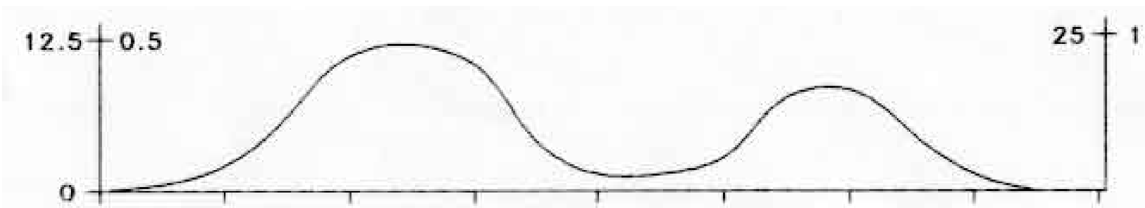
Mowing Frequency

To minimize the stress on turf plants, no more than one third of shoot growth (the portion of the grass blades above the surface) should be cut at any one mowing.[9] This is often referred to as the "⅓ rule" for mowing. Following this rule means that we should mow according to the rate of growth, rather than the calendar.

Growth rates differ widely throughout the season, depending on the temperature and availability of moisture. Figure 6-# illustrates a typical pattern of growth in non-irrigated turf. The daily growth rate peaks in June, and there is a second, lower peak in late September or early October. About two-thirds of the growth occurs during the spring, and the remainder through the summer and fall. The summer low is the result of the normal 8-12 week dry period that occurs in much of the Atlantic Region. While the seasonal pattern is the same for all non-irrigated lawns, the daily growth rate for a particular lawn depends on the underlying soil conditions and nutrients.

Moderate Fertility
mm inches

High Fertility
mm inches



Apr May June July Aug Sept Oct Nov Dec

Figure 6-3. Typical daily turf growth in New Brunswick without irrigation. (Adapted from Emmons[10] with growth data collected in NB research.[21])

The daily growth of shoots at the June peak can be 12.5 mm (0.5 in) or more. This applied to lawns on a good soil base with a moderate fertility program. Under a heavy fertilizer program, daily growth may approach 25 mm (1 in). Ryegrasses have a higher daily growth rate; as much as double that of bluegrass and fescues. Growth can be limited by lack of soil moisture and may actually stop when the turf becomes dormant during a dry, summer period. Under these conditions, water is the limiting factor and only the deep-rooted, non-turf species may show growth. The top growth of these plants will then dictate the timing of mowing. Each lawn will exhibit different growth characteristics for the summer, depending mainly on the moisture storage capacity of the underlying soil foundation.

Table 6-2. Number of days to allow between each mowing to cut ⅓ of the leaf growth, at different growth rates.

Daily Growth (mm)	Mower cutting height (mm)			
	40	50	62.5	75
	Mow when turf reaches (mm)			
	60	75	95	110
	Days between mowing			
3	7	8	11	12
6	3	4	5	6
10	2	3	3	4
15	2	2	2	3
20	1	1	2	2
25	1	1	1	2

Daily Growth (inches)	Mower Cutting Height (inches)			
	1½	2	2½	3
	Mow when turf reaches (inches)			
	2¼	3	3¾	4½
	Days between mowing			
1/8	6	8	10	12
1/4	3	4	5	6
3/8	3	3	3	4
1/2	2	2	2	3
3/4	1	2	2	2
1	1	1	1	1

Weekly mowing has been a normal practice throughout the region. However, during peak growth periods, this practice would remove more than a third of the shoot, particularly on heavily fertilized lawns. Not only does this stress the turf, but it also produces heavy clipping deposits that are too thick to leave on the lawn. The lawns loses the benefit of nutrients and organic matter from the recycled clippings, it takes more labour to transport and dispose of the clippings, and it places a strain on municipal landfills (*see* Grasscycling, below).

Reducing Mowing Frequency

Mowing frequency can be reduced dramatically by:
raising mowing heights, and
reducing the growth rate.

Mowing frequency can be nearly cut in half by raising mowing height from 40 mm (1½ in) to 75 mm (3 in) – *see* Fig. 6-2, above.

Reducing the nitrogen rates will reduce daily growth significantly. Waiting to apply spring fertilizers until after the growth peak also reduces the rate of growth. This may also improve the health of the turf: some evidence suggests that spring nitrogen applications actually deplete nutrient reserves in the plants and weaken the turf.[11] (*See* Chapter 3, for more information on fertilization timing). Heavily fertilized lawns may require mowing almost daily at peak growth periods to follow the ⅓ rule.

What if the lawn gets too tall?

Occasionally we get behind in our mowing schedule due to periods of wet weather, vacations, mower breakdowns, etc. Cutting at the regular height following these delays will remove considerably more than ⅓ of the plant and leave large volumes of clippings.

The preferred approach is to raise the mower cutting height, if possible, to remove only a third of the growth. Then repeat the cut within a few days, at successively lower heights until the normal mowing height is reached. This avoids excessive shock to the turf, and allows the clippings to be left on the lawn.

Mowing Pattern: Varying the direction of mowing in successive mowing operations promotes upright shoot growth. This reduces the formation of a horizontal growth orientation (‘grain’) and wheel tracks.

Mulching Mowers?

Mulching mowers are becoming more popular. While they may improve the appearance of the lawn when mowing taller grass, there seems to be little advantage over a regular mower. They do not handle wet grass as a well as a regular mower, which means a reduced mowing ‘window’. They also generally have higher horsepower, with higher fuel consumption, than regular mowers.

Mower Safety

Mowers can cause serious injury or property damage – either from direct contact with the blades, or from debris (rocks, sticks, cans) thrown by the blades. Operators should be aware of such hazards and protect themselves and others when mowing.

Important safety precautions:

- Keep hands and feet away from rotating mower blades.
- Keep bystanders – particularly children and pets - away from mowing equipment and operations.
- Always push a push mower. Never walk backward, pulling it with you – your feet can easily slide under the deck.
- Aim the mower discharge away from buildings, people and cars to reduce the risk of damage from thrown objects.
- Aim the clipping discharge onto lawn surfaces, not onto sidewalks or streets where they can wash into storm drains and river systems.
- Allow a gasoline mower unit to cool before refueling, to reduce the risk of fire.
- Avoid fuel spills. Partially filled fuel jugs are easier to control, reducing the chance of a spill.
- Wear safety glasses and footwear when using string line trimmers.
- Keep mowing equipment away from trees. Damage from mowers and string line trimmers causes serious injury to trees in landscape settings.

Mower Maintenance Tips

- Maintain sharp blades to produce healthy, attractive turf and save energy. Rotary mower blades should be sharpened after 10-15 hours of operation in normal conditions. It is a good idea to keep a spare set of sharpened blades on hand.
- Balance the blades after sharpening to reduce vibration and prolong equipment life.
- To extend mower life, clean the grass off the underside of the mower deck after each mowing. A thorough cleaning and repainting at the end of the season also helps. Grass clippings are high in nitrogen; their corrosive action speeds up the rusting process.

GRASSCYCLING

Grass clippings are a perfectly balanced, pollution-free lawn fertilizer. Leaving them on the lawn feeds the soil, not the landfill, and saves money in the process!

Lawns generate a lot of clippings. Although bagging and removing the clippings is a common practice, it adds time and costs to lawn care operations and contributes to the waste disposal problem for municipalities. In contrast, leaving the clippings on the lawn, 'grasscycling', has many advantages. It has been shown to:

- reduce fertilizer needs by 25 to 50%,[12, 13]
- cut labour for mowing and disposal of clipping in half,[12]
- substantially reduce demands on landfills,[14]
- improve overall colour of lawns,[15] and
- reduce weed populations.[16]

Studies show that the wet weight of lawn clippings ranges from 3.73 tonnes per ha annually (in a low fertility regime)[15] to 27.17 tonnes per ha annually.[17] This is equivalent to between 200 and 2700 garbage bags of clippings from one hectare of lawn (about 20 average sized home lawns). The burden this places on landfills is enormous—for example, before Michigan passed a law banning clippings in 1994, yard waste accounted for 20 - 25% of the trash disposed in landfills.[18] If clippings are removed from 10% of the turf area in our region, they represent a handling and disposal problem in excess of 100,000 tonnes annually.

A study[18] comparing plots with bagged clippings to grasscycled plots, reported:

- Grasscycled plots greened up earlier in the spring, grew faster, and stayed greener in the fall.
- Grasscycled plots had fewer broadleaf weeds than bagged plots.
- Bagging clippings nearly doubled the total mowing time compared to grasscycling.
- Bagging generated between 6 and 11 tons wet weight (1000 to 3800 cu ft) of clippings per acre per year.
- Neither the bagged nor grasscycled areas developed any thatch build-up.

Nutrient Content of Clippings

The fertilizer value of clippings is an important reason for leaving them on the lawn.

- One report found that a year's clippings contained 2.4 kg (5.3 lb.) of nitrogen, 0.8 kg (1.8 lb) of phosphorous, and 2.2 kg (4.8 lb) of potassium per 93 m^2 (1000 ft^2) of lawn.[19]

- The nutrient ratio in clippings is about 5:1:3 (N:P:K), which is similar to that of high quality turf fertilizers. The nitrogen is in organic form, thus is released slowly with no potential to leach off site.

- Where clippings were removed, Beard found that the annual nitrogen fertilization rate had to be increased by about 1 kg per 100 m^2 (2 lb/1000 ft^2) to maintain the desired colour and density of turf in Michigan.[13]

- A Guelph study reported that up to 40% of applied nitrogen is removed with clippings.[15] Based on this data, clippings removed from one hectare of lawn area may contain the equivalent of 17 to 56 bags of high quality turf fertilizer.

Clippings also add organic matter to the soil. This has been shown to improve the infiltration rate of water in comparison to sites where clippings were removed.[20]

Grasscycling vs. Thatch

Research has shown that clippings do not contribute to thatch accumulation in a healthy lawn.[21, 22] With their high water content (87 to 88% in Fredericton tests[21]), they shrink rapidly and filter down through the turfgrass to the surface. Soil organisms (fungi and bacteria) decompose them quickly. Thatch can build up, however, in conditions where the activity of soil micro-organisms and earthworms has been suppressed. This can be caused by low soil pH, applications of fungicide, insecticides or excessive fertilizer, compaction or poor drainage.

When is grasscycling not appropriate?

If more than ⅓ of the grass plant is removed in mowing, it takes longer for the heavier clippings, with their higher proportion of coarse stem material, to break down. In some cases, this can be overcome by running the mower over the area again to chop them more finely. In other cases, especially in wet weather, the excessive clippings may need to be removed.

Recycling Tree Leaves

Leaves, too, can be recycled on to the lawn with the same benefits as grasscycling. Chop them up with the mower in the fall and allow them to compost into the root zone as an alternative to raking and bagging. A couple of passes with a mower will break down normal accumulation of leaves satisfactorily, and return valuable organic matter to the soil. Michigan studies reported that there were no adverse effects from mowing up to 15 cm (6 in) of different types of leaves into lawns.[22]

MANAGING THATCH

Thatch is the dark brown mat of undecomposed plant tissue that lies above the soil. It is made up of stems, rhizomes, stolons, leaves, and roots. These products are high in lignin, which is tough for soil microorganisms to break down.

A moderate thickness of thatch (up to 2 cm or about ¾ inch) is a necessary and beneficial part of a lawn. It:

- creates a cushion effect, binding individual grass plants together and helping to resist wear from foot traffic,
- mulches the soil, which reduces the potential for erosion and water evaporation,
- provides an important source of natural food for soil microorganisms.

Figure 6-2. 25 mm Thatch Layer.
Photo courtesy of Dan Dinelli.

When the thatch layer is deeper than 2 cm (¾ in) it becomes a problem that can lead to declining turf health, shallow root systems, and reduced performance of pesticides.[23]

Thatch and Chinch Bugs: Is There a link?

Excess thatch has been suggested as a contributor to chinch bug infestations. However, research at Laval University found no correlation between the thickness of thatch and chinch bug populations.[24] There was also no correlation found in New Brunswick studies in the summer of 2002.[25]

Potter[26] notes that excessively fertilizing turf results in higher than normal levels of nitrogen in plants. This makes them more attractive to insects because insects have a high need for nitrogen in their diet. Leaf-feeding insects grow faster, live longer and lay more eggs on heavily fertilized plants. Since excessive fertilization also favours thatch buildup, this may have led to the perceived connection between excess thatch and chinch bug infestations.

Causes of Excessive Thatch

Excess thatch is a man-made problem. It develops when the dead organic matter from the actively growing turf accumulates faster than it decomposes. Any cultural or environmental factor that stimulates excessive shoot growth or impairs the decomposition process increases the rate that thatch accumulates.[27] Since earthworms and soil microbial activity decompose thatch, any practice that depresses this activity will result in thatch accumulation.

Thatch problems are not seen in turf where healthy earthworm and microbial populations exist in the soil. While we cannot see the soil micro-organisms, indicators that they are healthy would be:

- healthy turf growth,
- good levels of organic matter (2% or more) in the soil, and
- significant earthworm populations.

Factors that can suppress the earthworm and microbial activity needed to decompose thatch include:

- high fertilizer rates that stimulate rapid turf growth,
- low soil pH,
- applications of fungicides, some insecticides, and to a lesser extent, herbicides,
- compaction,
- poor drainage, and
- excessive irrigation.[28]

Preventing Thatch Problems

Sound maintenance practices that encourage a healthy soil microbial population are the best approach to preventing thatch problems. These include:

- taking soil tests to determine pH, P and K levels and correcting any deficiencies,
- following moderate nitrogen application programs,
- using pesticides only when and where required, and
- correcting compaction or drainage problems if these are contributors.

Grass clipping are easily broken down and do not by themselves contribute to a thatch problem. If mowing schedules are adapted to the growth rate of the turf (and nitrogen fertilizer is used in moderation) there won't be an excessive quantity of clippings to overburden the decomposer micro-organisms.

Little correlation has been observed in New Brunswick conditions between excess thatch accumulation and poor lawn construction (i.e., on shallow topsoil layers or poor soil). Thatch becomes a problem on these lawns when intensive management programs, using high fertilizer rates and regular pesticide sprays, are followed in an attempt to overcome deficiencies in the soil. Such intensive practices have been shown to suppress earthworm and microbial activity.[29, 30]

Excess thatch accumulations have not been observed to date in New Brunswick in those lawns that stay green naturally through the summer drought, or in biodiverse lawns (e.g., lawns with significant clover populations).

Correcting Excess Thatch

"Compost eats thatch" – Don Legacy

The key to correcting a thatch problem is to determine the source of the problem—then fix it. In most cases, excessive or overzealous fertilizer and chemical applications, combined with low soil pH, cause the problem. Moving to a sound maintenance program as described in the manual will stop further build-up of thatch. It is not clear, however, whether this measure alone will reduce an excessive thatch layer over time. If it works, this not only provides valuable organic matter to the soil, but it saves the cost and disposal problems associated with removing thatch mechanically.

Topdressing with properly matured compost has been shown to be an effective remedial measure.[31] Presumably, topdressing works by stimulating the soil microbial population, while also providing nutrients to the turf. Where thatch accumulations are very heavy, the process can be hastened by light aeration. This means just breaking the soil layer beneath the thatch to improve penetration of the compost into the thatch layer.

Avoiding insecticides that kill earthworms contributes to natural control of thatch. One study[32] reported that earthworm activity in moving soil into and above the thatch layer provided benefits comparable to topdressing with soil.

Mechanical practices, such as using a dethatcher or vertical mower to mechanically remove the bulk of the thatch, also correct a thatch problem. While it is economically attractive, mechanical dethatching removes a large amount of excellent, soil-building organic material from the turf. This also becomes a disposal problem and disturbs the seed bank in the soil, leaving sparse areas that are easily invaded by weeds.

Core aeration has also been used as a remedial practice. When done properly, so that tines penetrate fully, the thatch layer is somewhat broken up. Some of the soil is also moved to the top of the thatch layer. If there is healthy microbial activity in the soil, the soil organisms help break down the thatch. As with dethatching, this approach also disturbs the seed bank and encourages weeds.

AERATION

"Compaction is not a problem on home lawns, except maybe where the postman walks." *Dr. Bob Sheard*

Aeration (or aerification) is a mechanical cultivation method that allows selective tilling of existing turf, without destroying the sod. This usually involves removing hollow cores or open spoons of soil from the lawn and placing them on the surface. The term may also refer to using equipment with solid spikes or blades to punch holes in the underlying soil.

Aeration is normally done to relieve soil compaction or to improve infiltration of air and moisture. It may also be used to help reduce the build-up of thatch. Using aeration after overseeding or topdressing can improve results by increasing the contact between the seed or topdressing and the underlying soil.

"A Quality Aeration Job…"

Ken Pavely, currently the IPM program coordinator for Landscape Ontario after decades of field work, notes: "In my experience of thousands of lawns, a quality aeration job provides benefits by increasing soil oxygen, warming soils in the spring (which allows turf to thicken up), and, of course, bringing soil to the surface for thatch control."

When aerating to reduce compaction, the soil must be moist enough to enable plugs to be completely removed. This usually requires soil moisture conditions close to field capacity. Most commercial equipment is designed to penetrate 75 to100 mm (3-4 in). If the tines penetrate to the full depth, the operation will help alleviate compaction. It is difficult, however, to reach this depth in dry, compacted loam and silt loam soils. Under these conditions, even the heaviest equipment will penetrate only 25 to 50 mm (1-2 in). In effect, this is only about 1% of the soil volume in the 100 mm targeted depth, so results are likely to be disappointing.

To determine whether adequate moisture is present, check the length of the cores. If the cores are short, or tines are penetrating only part way, it would be better wait until the ground is softer after rainfall or irrigation.

Shallow penetration is acceptable when using an aerator after overseeding or topdressing operations. This is because the objective is only to push a portion of the applied seed or amendment material down into the soil.

The cores may be left on the surface to break down with normal traffic and mowing, or they may be broken up with a drag mat. After aeration operations, there is likely to be some weed invasion, caused by disturbing the seed bank that exists in topsoil. Weed invasion will be more pronounced in areas where turf is sparse or there are bare areas.

In this region, our winter freeze-thaw cycles do an excellent job of soil aeration. It is far more effective than all but the most exhaustive mechanical aeration efforts (e.g., triple or quadruple passes to full tine depth). To preserve the effect of natural aeration, restrict traffic on structurally weak soils (loam and heavier textures), for a week or two during spring thaw. In most home lawn and general turf, this – along with root growth activity - can largely eliminate compaction as a problem.

A healthy root system in turf alleviates compaction. If the plants are growing well, it indicates that the roots are doing their job and that there will be little benefit from mechanical aeration. This was clearly demonstrated in July 2003 at a topsoil recovery test site in Moncton. Tests with a soil compaction tester (*see* Chapter 2, page 8) in areas with bare spots showed root-restricting soil density or compaction at only 25 to 50 mm (1 to 2 in) deep. In contrast, probe tests in grassed areas, only 30 cm (1 ft) away, showed roots were not restricted by compaction even at 100-150 mm (4 to 6 in) in depth.

KEY POINTS

Watering

Use efficient irrigation practices:
- water deeply, once or twice a week,
- monitor applications to make sure all water soaks in, rather than runs off, and
- control the operating time for each sprinkler so that it delivers no more than the desired amount.

Mowing

- Mow safely to protect yourself and others.
- Cut turf grass at a height between 6.5 and 7.5 cm (2½ -3 in).
- Remove no more than ⅓ of the leaf at any one mowing.
- Keep mower blades sharp for best results.
- Lower mower settings in the late fall to shorten spring green-up time.

Grasscycling

- Leave the clippings on the lawn whenever possible; this reduces nitrogen fertilizer requirements by 25-50%.
- Cut no more than ⅓ of the total leaf height at one time.
- Recycle leaves as an additional source of organic matter for the soil.

Managing Thatch

- Prevent thatch build-up with sound cultural practice.

- Check maintenance practices, and correct those that may impair the activity of earthworm and soil micro-organisms:
  - test and correct deficiencies in soil pH, P and K levels,
  - use moderate, properly timed applications of nitrogen, and
  - use spot treatments of pesticides, only where they are needed and at the right time to be effective.
- Correct compaction or drainage problems, if these are contributing to thatch build up.
- Correct excess thatch problems by natural rather than mechanical methods where possible.

Aeration

- Protect natural aeration by restricting traffic during spring thaw.
- Ensure mechanical aeration operations are effective: carry out aeration operations for compaction relief when soil moisture conditions permit full tine depth penetration.

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CHAPTER 7. MANAGING PESTS

INTRODUCTION

The following section describes IPM programs for common turf pests found in the Atlantic region. It covers weed control and hairy chinch bug in depth because they are the most widespread and common problems; notes are also included on white grubs, which are less of a problem. Turf diseases are not covered because disease problems are rare in residential lawns and general use turf in this region. Each section follows the 6 main steps of an IPM program as outlined in the IPM/PHC of Canada definition (*see* Chapter 1).

MANAGING WEEDS

"Healthy grass is the best weed control." *Anon*.

A weed-free lawn is an artificial concept in nature. It requires significant amounts of energy, labour and materials to maintain. When lawns are on an inadequate soil base (which is common), the inputs required to maintain a weed-free appearance are even higher. This has environmental and economic costs—and suggests that we should consider other possibilities, such as growing biodiverse lawns better suited to the soil conditions existing under most lawns.

Figure 7-1. Healthy turf, on the left, suppresses weeds.

At the same time, we should recognize that there is a place for weed-free turf as a landscape design element (as there is for formal gardens and topiary). It is essential that we, as professionals, incorporate design and management practices that help achieve this while using fewer chemical inputs. We must promote new standards that focus on long-term management rather than just on annual pesticide and fertilizer applications. We must also work with municipal and provincial authorities to influence the public's perception of what constitutes an ideal lawn. This would allow us to move away from weed-free turf standards towards more environmentally benign models.

What is a Weed?

A weed is a plant in the wrong place. In a weed-free turf, both broadleaf plants and some off-colour turf species, like annual bluegrass, rough-stalked bluegrass, crab grass, or some creeping bent grasses, are considered weeds (for descriptions and control of these grasses, see Eggens[1]).

Some weeds, such as grasses with fine seeds, can come with the grass seed. While broadleaf plants may also come with the grass seed, most are from the 'seed bank' already in the topsoil. This is the accumulation of many years' worth of seeds that have blown in or dropped to the soil, remaining dormant until conditions are right for germination. Seeds that blow in from adjacent sites after the turf is established can also take root where the grass is thin enough to let the seeds drop to the soil surface.

The most common broadleaf plants in the region are dandelion, plantain, and clover (dandelions attract the most attention!) Less common are daisy, yarrow, devil's paint brush, creeping Charlie, buttercup, wild strawberry, stitchwort and creeping Jenny. These are all biennial or perennial plants meaning they survive from year to year. Annuals, such as mustard, lambs quarter, and pigweed, and some grasses, such as timothy, barnyard and couch (or quack) grass, are also often present in newly seeded lawns in good topsoil. (For descriptions of these plants, see publications listed under Further Reading at the end of chapter.)

Are Weeds Really a Problem?

The answer is…. yes…. no…. or maybe, depending on your point of view!
Some folks don't want any, while others could care less. More people are developing an appreciation for biodiversity in their lawns as well as a tolerance for higher broadleaf populations.

Natural Suppression of Weeds in Turf

Some weeds just disappear as turf becomes established. Annual weeds, as well as timothy and barnyard grass, normally disappear as mowing and competition from the turf plants eliminates them. If annual weeds persist, it is a clear indication of sparse turf. Over time, couch or quack grasses also blend with turf grasses in both colour and texture; they, too, seems to disappear in healthy turf.

Healthy, dense turf prevents light from reaching the soil and keeps dormant seeds in the seed bank from germinating. It also resists invasion by seeds blown in from adjacent sites. This is why turf management practices are key to the success of weed management programs. The photograph in Figure 7-1 was taken three years after weed-free sod was placed on a 'sustainable' soil base (it does not 'brown out' in midsummer). The weed-free appearance of the sodded turf to the left has been maintained for three years with no treatments, other than mowing. The area on the right, which was a turf seeding operation that failed, is a weed patch. This highlights the fact that healthy turf dramatically suppresses germination of the seed bank and blown-in weed seeds. Competition from healthy, vigorous turf also suppresses perennial weeds that have become established, as shown in Figure 7-2.

These examples show that where growing conditions suppress weeds, weed numbers are so low that removing them mechanically can be practical and cost effective, which would eliminate the need for herbicides.

Spring Summer Fall

Figure 7-2. Suppression of the same weed over the season, as health of the turf is improved. ***Photos courtesy of Bob Wick, Western Canada Turfgrass Assn.***

IPM PROGRAM FOR WEEDS

The basic steps in an IPM framework are described in Chapter 1. The following sections describe each step as it applies to managing weeds.

To make it easier to plan work and made treatment decisions, consider separating turf areas into Class A, B and C facility categories[2] (*see* Chapter 1).
Examples of the types of turf that might be included in each category are:

- **Class A –** High level of service: fine ornamental lawns, golf and bowling greens, irrigated sports fields.
- **Class B –** Moderate level of service: residential and commercial lawns, boulevards, recreational areas, golf fairways.
- **Class C –** Low level of service: Meadows, picnic areas, rough grass, undeveloped and naturalized areas.

1. Manage landscapes to prevent pests from becoming a threat.

First and foremost, it is important to remember that the presence of weeds is most often the result of poor turf, not the cause: **Weed invasion is the symptom of a weakened lawn**.

The main objective of an IPM program for weeds in lawns should be to create and maintain favourable growing conditions for turfgrass plants. When establishing new lawns, attention to the underlying soil foundation is critical in providing sustainable growth, while reducing the need for water and other inputs for the life of the site (*see* Chapter 5).

Since most turf management deals with existing sites, the first step is to assess site conditions and look for factors that affect the health and vigour of the turfgrass. Probably the foremost indicator is an area that browns out in midsummer, showing that the underlying soil profile is deficient in moisture storage capacity. This is a signal that it will require higher levels of inputs to produce healthy, vigorous growth. It may also mean that, unless underlying soil conditions can be improved, that it may be more realistic to classify such lawns as Category B or C. Achieving Class A standards on such soil will require supplemental irrigation as well as additional nutrients and chemicals.

Other factors to look for during the assessment, include:

- soil nutrient deficiencies,
- areas with compacted soil or poor drainage,
- patterns of wear from foot traffic or other encroachments, and
- shaded areas.

High weed populations generally indicate unfavourable growing conditions for turfgrass. The presence of particular weed species in a lawn may also be an indicator of a specific soil problem (*see* Table 7-1). Test the soil for pH and fertility; testing for organic matter levels also provides important information on soil health at little added cost.

After assessing the site conditions, determine the expectations of the owner or client. Use the information to develop a program of cultural practices that will provide the type of turf desired. Cultural practices include:

- taking soil tests (*see* Chapter 3),
- adjusting soil pH to 6.5 by adding lime (*see* Chapter 3),
- checking fertilizer rates, amounts and timing (*see* Chapter 3),
- raising mower heights to encourage deep roots (*see* Chapter 6), and
- recycling grass clippings (*see* Chapter 6)

2. Identify potential pests.

Some IPM training puts considerable emphasis on identifying weeds and knowing their biology, however, in practice, this may not be necessary for those managing general turf. It is important to be able to identify which are the objectionable grass species, and to be able to tell those that disappear under normal maintenance practices from those that usually persist and may require control. (For weed identification resources, see Further Reading at the end of the chapter and Appendix II for web sites).

3. Monitor environmental conditions, pest populations and pest damage.

A simple visual inspection of the type of weeds growing on site may indicate a specific problem with the underlying soil (*see* Table 7-1).

Table 7-1. Weed species as possible indicators of poor soil conditions.

Weed Species Present	Possible Soil Problem
Knotweed or plantain	Compaction
Sedge or buttercup	Poor drainage
Clover	Low nitrogen
Sorrel or wild strawberry	Low pH or poor fertility

Adapted from K. McCully.[3]

Weed Monitoring Methods

The transect method of monitoring and the grid method are the most common methods cited in the literature for counting weed populations.

Transect method: Walk along a series of lines or transects across a lawn, observing and recording the type and number of each visible weed at intervals. A commonly recommended method[2, 4] is to lay out a 10 m (30 ft) rope or line, then walk along it; at 10 places along the transect, observe the weeds in a 10 cm^2 (4 in^2) area. These observation points can be marked ahead of time on the line or you can take large strides along the line, noting the plants in the small area near your toe at each stride. By repeating the process on a series of transects, the percentage of each transect that was covered by weeds can be calculated. For example, if 1 transect is walked and weeds were found in 2 of the 10 observation points, that lawn area would have 20% weeds (80% turf). If enough transects are counted on a lawn, the average of the transect counts can be assumed to apply to the rest of the lawn. Although the number of transects may vary with the size of the lawn, it is advisable to walk at least 10 transects per site to make sure that the average of the counts reflect the real situation.

Grid Method: Place a 0.5- or 1-metre square frame randomly on the lawn; count the number of weeds inside the frame. Identify them if possible; this will be helpful in comparing results from year to year. Count at least 10 different locations on the lawn and average the results of the 10 counts. In this case, the counting method gives an average number of weeds per 0.5 m^2 (or per m^2), rather than the percentage of weeds in the lawn.

It is very important to realize that these two methods give two different measures. This means that the numbers from transect counts (percentage of weed cover) cannot be compared with counts from the grid method (number of weeds per m^2). To compare results from one year to the next, or between sites, the same monitoring method must be used each time.

4. Decide whether treatment is needed on the basis of population and damage thresholds.

In some regions, recommended weed tolerance and treatment (action) thresholds have been published for broadleaf weeds. Making decisions based on numbers, rather than on ‘eyeballing’ the weed infestation, moves the decision-making process away from subjective judgement to a more rational basis.

The following suggestions for treatment thresholds include both the percentage weed cover as used in British Columbia[5] as well as counts per square metre from research at the University of Laval[6]:

- **Class A Sites**-With an objective of relatively “weed free”; note that users often accept turf with 5 to 10% weed cover as “weed free”. Action threshold: 10 to 15% weed cover, or 5 dandelions per m^2.
- **Class B Sites**- Action threshold: 20 to 50% weed cover or 10 dandelions per m^2.
- **Class C Sites**- Action threshold: >50% weed cover or >10 dandelions per m^2.

It is important for the professional turf manager to discuss these action thresholds with owners.
Most property owners are realistic in their expectations and want to take an environmentally responsible approach. This means that public is becoming more tolerant of higher broadleaf

populations (i.e., using Class B and C thresholds), especially since this substantially reduces maintenance costs and chemical use.

5a. Use biological and mechanical control methods to reduce pest populations to acceptable levels.

Biological Controls: At present, there are no biological controls for weeds in turf. A biological control for dandelion (a strain of the fungus *Sclerotinia minor*) has been selected by researchers at McGill University but is some time away from being generally available.

Mechanical controls:

Removing weeds by hand may be practical if dandelions are the main problem, or other weed numbers are relatively low. Hand weeding is easier when the soil is moist. Experience shows that dandelions can be removed at a rate of 5 to 10 plants per minute, using simple tools that cut the taproot (*see* Figure 7-3). This means that on a site that has an average of 5 weeds per m^2, one person can weed over 100 m^2 per hour, at a cost comparable to spraying.

It is a good idea to drop turfgrass seeds, or a mixture of soil and seed, into each hole created by weeding to speeds closure of the turf and prevent weeds from germinating.

Figure 7-3. Manual weeders.

Weeding with Heat

Two types of weeders that work by applying heat to the target plants are available. As they are relatively new tools, the turf industry has not yet enough experience to judge how well they work, or the best timing for using them. However, it might be worth trying out smaller, less expensive models to determine whether they could be useful.

Flame Weeders: Small hand held flamers, with backpack propane tanks, are available from suppliers for use in landscapes. Broadleaf weeds are more easily damaged by heat than grasses, which have their growing tips protected by a heat resistant sheath. This means that, with care and (lots of) practice, flamers can be passed quickly over weedy areas in turf without damaging the grasses. Heat is more effective at killing weeds if the plants are only slightly damaged (i.e., by a very quick pass of the flamer), than if they are fried on the spot. It is thought that this may be because the injured plant exhausts its root reserves attempting to recover from the injury, whereas a plant with the top crisped uses less energy by sending up new shoots from the roots.

Infrared Weeders: Hand-held infrared weeding tools are also sold in Canada for control of dandelions and other weeds. They work by burning propane fuel from a backpack tank to produce radiant heat. They have a probe tip that is inserted into the growing point to kill the weed.

5b. When necessary, use targeted applications of pesticides.

It is not normally necessary to apply blanket treatment with herbicides on general use turf. Broadleaf weed populations, particularly in Class A and B categories of turf, are often localized, therefore it is only necessary to treat the affected areas. Treating only where monitoring shows it is necessary is a key principle of IPM. One of the commitments made by IPM accredited firms (under the IPM/PHC Accreditation Program) is that when chemicals are required, they will be applied to 50%, or less, of the managed area.

Although applying herbicides twice a year controls broadleaf weeds, this practice is becoming less desirable because of concern about health and environmental impacts. If maintaining a lawn to a Class A standard is important, then any underlying conditions for poor turf performance must also be corrected so that the turf can suppress broadleaf weeds.

The Herbicide Treadmill

The use of herbicides alone, without attention to building up healthy turf, merely opens up the soil for re-infestation as the broadleaf plants collapse and leave bare soil areas behind.

This is particularly apparent when the target is dandelion and the turf is sprayed after the plants begin to flower. The treated dandelions are still able to go to seed, which then take root in the bare spots left by the herbicide. More herbicide is applied next year to control those new plants….which re-seed…..and the cycle continues.

Control of Grasses: Chemical controls for persistent grasses (crab grass, annual bluegrass, rough bluegrass and bent grasses) have shown erratic results in Fredericton. Glyphosate (e.g., Roundup™) works on these species, but kills all vegetation in the area treated. This means that overseeding is required, with follow-up watering, to quickly fill in the killed area and prevent weeds in the seed bank from becoming established.

Control of Broadleaf Weeds: A properly timed application of selective herbicides, such as 2,4-D blends (e.g., "Killex"™ and other products), will remove broadleaf weeds. After this, experience shows that a healthy, vigorous turf can usually keep the weed population low enough to maintain a Class A standard for several years. When supplemented with hand weeding for dandelions (which is efficient because weed numbers are so low), a Class A quality turf growing on a sustainable soil base can be maintained without herbicide applications for five to ten years.

Tips for using 2,4-D blend herbicides:

- The products are most effective when the plants are growing rapidly: late May to late June, and late September to mid October.
- Products are more effective if applied in conditions of high temperature and high humidity. Under these conditions, the leaf pores have the largest openings and take in the most herbicide.
- Hot, dry weather increases plant resistance to herbicides because the pores close to conserve water and less herbicide is taken in.
- Rain shortly after an application will wash the product off the leaves and reduce the effectiveness of the application.

- Timing is particularly sensitive for dandelion control. For maximum effect, applications should be completed before the first flowers appear. Spraying when the flowers are in bloom doesn’t stop seeds from forming and germinating in the bare ground left behind.

Tests with 2,4-D blends in Fredericton shows that broadleaf weeds can be controlled using half the label rates, when applied under optimum conditions. This suggests that label rates were established to assure control over a broad application-timing window, when the plants may be more resistant to the products. While using reduced rates is a way to reduce chemical use – and reduce risk - the practice violates federal pesticide label regulations. Given the current public concern over pesticide usage, this area of labeling needs attention.

There have been instances of pesticide resistance developing from reduced use of products in other areas (agricultural, and medicine). The authors have seen no evidence to suggest that this factor is a concern in this particular application.

A note about combined fertilizer and herbicide products:

Products that combine fertilizer and herbicides (commonly called ‘weed-and-feed’ type products) are popular with the public,[7] and can provide some weed control when applied under optimum conditions. When such products are used as the primary fertilizer for turf, as is common, they are out of step with IPM principles and lead to a significant overuse of herbicides.

This is because the product is being applied:
- over the entire lawn at each use, often on weed-free lawns, so the herbicide component is being used where it will have no effect,
- at times of the season when the herbicide component is ineffective,
- more frequently (because of the fertilizer timing), and
- at rates that are higher than liquid formulations.

Research at Guelph has shown that combination fertilizer-herbicide products are only about half as effective as liquid formulations.[8] This is probably because when they are applied, only a small proportion of the granules stay on the leaf surfaces. Granules must dissolve while still on the leaf so that the active ingredients can be absorbed through pores in the leaf surfaces; from there they move into the plant’s system. Product labels shows that when applied at the manufacturers’ recommended rates, the amount of active ingredients in granular 2,4-D formulations are 50 to 150% higher than liquid formulations.

4 annual applications of these products to a turf area, at label rates, applies 10 to 20 times more 2,4-D than a blanket liquid application every 2 years.

The overuse problem with these products is serious enough that the PMRA considered legislating the product off the shelves.[9] This approach was withdrawn after the industry argued that the problem lay with uninformed users rather that the products. At this point, federal efforts have been redirected toward consumer education.

Corn Gluten Meal Pre-Emergent Herbicide: One product (TurfMaize™) containing corn gluten meal has just been registered in Canada for use as pre-emergent herbicide and a slow release organic fertilizer. Corn gluten meal is a natural product derived from corn and commonly fed to cattle. Natural chemicals in the gluten kill seeds, just as they germinate, but do not affect growing plants. It is important to note that gluten only prevents seeds from germinating—it does not remove existing plants. Correct timing of application is key: if it is applied after weed seeds germinate, the product will not contribute to weed control.

The product is labeled for control of dandelion and smooth crabgrass on residential lawns, where Kentucky bluegrass is the predominant grass. TurfMaize™ has received temporary registration, with full registration, pending receipt of additional efficacy data. Further research is also required to determine the tolerance of other turf species. Data are not available on the appropriate interval between overseeding or re-sodding operations and application of TurfMaize™. Therefore, labels say not to use the product in spring if over-seeding or sodding is done in spring; if over-seeding or sodding in fall, the product is not be used in the fall.

6. Have a built-in evaluation process.

After any type of treatment, whether cultural method or herbicide, the lawn should be checked for results. This should be done at intervals appropriate to the type of treatment. For example, turf should be inspected one to two weeks after a herbicide application to check whether it was effective; results of cultural methods may take months to show effects.

This follow-up information will be valuable, along with monitoring records, feedback from customers, budget records, etc., for assessing how well the IPM program worked and what to improve. After several seasons, a long-term trend toward better quality turf and low weed populations should be noticeable.

MANAGING HAIRY CHINCH BUG

The hairy chinch bug *(Blissus leucopterus hirtus*) is a major pest on turfgrass in the Atlantic region. The following section describes the insect, its biology and damage, as well as an IPM program based on the most recent research for Eastern Canada.

Description: In the Atlantic Region, the adult is about 3 mm (3/16 in) long, with folded white wings that extend almost to the tip of the abdomen. The first and second stage immature bugs (nymphs) are bright red with a distinct white band across the middle and are wingless. As they mature, the nymphs darken in colour to brown and, finally, to black just before becoming adults.

Life cycle: Adults over-winter at the base of trees, under hedges or shrubs, at the edge of lawns, and probably in the turf. They emerge in the spring when the temperature reaches about 20^0C and mate. Over a month, each female lays 200-300 eggs in small batches on the inside the base of lower parts of the leaves or in the root crowns of turf. Adults may fly from lawn to lawn to lay eggs.

Nymphs hatch from the eggs in about 30-40 days, depending on the temperature. The nymphs grow and molt five times; the stage between each molt is called an instar. With the final molt, they become adults, which occurs in July or August. Their development is closely related to growing degree-days (GDD) – data compiled by Environment Canada related to temperature and its impact on plant growth. These adults become the overwintering population.

There is only one generation per year in Southern Ontario[10] and Quebec.[11] It is unclear whether there are one or two generations in a season for the entire Atlantic region. A partial second generation was found in the Saint John area in 2002 studies in New Brunswick,[12] but these had not matured, and would not likely survive the winter.

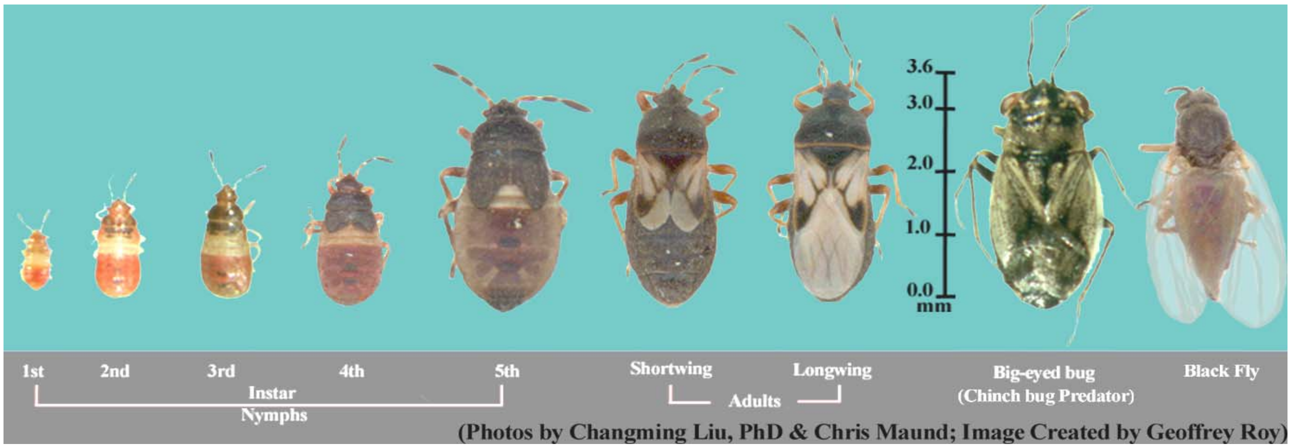

Figure 7-4. Chinch bug growth stages, with a Big Eyed Bug, an important chinch bug predator, to the right. (The black fly picture is included for size comparison.)

Damage: The nymphs damage the turfgrass by inserting their slender beak into the crown or stem of the leaves, then sucking the sap. They also inject a toxin in their saliva into the plant, which causes a blockage of the plant's vascular system and eventually kills it. Damage first appears as irregular yellowing patches in the turf that increase in size as more turfgrass is affected. If left unchecked, the turf in these patches turns brown and finally dies several weeks later.

In lawns allowed to go dormant (turn brown naturally) through the dry summer period, severe damage from chinch bug feeding may occur, but not be noticed, until the turfgrass fails to turn green with the fall rains.[10] Re-seeding or renovation may be required for areas that have moderate to extensive damage.

The actual numbers of lawns infested to damaging levels is unknown. Studies based on counts in southern Quebec showed that 60% of lawns in the study were infested, but only 11% had high enough counts to warrant a treatment.[11] Although there have been no similar studies undertaken in this region, the situation is likely to be similar.

Habitat: The nymphs are found in patches throughout the lawn, and seem to prefer open, sunny, dry areas. High soil moisture is believed to increase the mortality of early nymph stages and could be a barrier to their movement. Carriere, et al,[13] reported that nymphs are rarely present on aerial plant parts, being more abundant in the thatch. The 3rd instar stage is found on the surface of the soil between the plants. Recent studies in Quebec by Majeau, et al,[14] and in New Brunswick,[12] found no correlation between thatch thickness and chinch bug populations. This contradicts a widely held idea, as well as earlier work by Kortier Davis and Smitley[15] that showed the insects were more common in thicker thatch. It is reported that the adults seek out thatch in which to overwinter.[10, 16]

It is not clear whether chinch bugs prefer some species of turfgrass over others. Majeau[14] found that population density was more closely associated with perennial ryegrass, but not creeping bentgrass. Kentucky bluegrasses are the main target in most of the Atlantic region, with fescues showing less damage.

IPM PROGRAM FOR CHINCH BUG

The basic steps in an IPM framework are described in Chapter 1. The following sections describe each step as it applies to managing chinch bugs, based on what we know of it's biology and the factors that appear to make turf more or less resistant to invasion.

1. Manage landscapes to prevent pests from becoming a threat.

There is no practical way of eradicate this pest, but sound turf management practices will produce a healthy turf that is better able to withstand high populations without showing damage. Good management practices start with establishment of the lawn on a good soil foundation. Getting the turf off to a good start, by amending the soil organic matter, pH and nutrients as required, and choosing the most suitable varieties is important. Follow up with sound maintenance practices (*see* Chapter 6).

There is anecdotal evidence to suggest that stressed turf – both underfed and overfed with nitrogen, for example – show higher levels of damage, but research supporting this observation has not yet been done.

2. Identify potential pests.

See Description, above. It is important to correctly identify chinch bugs while monitoring because there are other similar looking insects. One of these is the big-eyed bug, which is a predator of chinch bugs. It looks similar to chinch bugs in shape and size, but has much larger, prominent, eyes. Both are quick moving insects, however, the smaller eyes of chinch bugs are unmistakable.

3. Monitor environmental conditions, pest and beneficial organism populations and pest damage.

Regular monitoring catches problems before chinch bug numbers and damage to the turf reach unacceptable levels. There are currently two useful monitoring methods for chinch bug: the flotation method and the quadrat method.

Flotation Method: Push a cylinder, such as a tin can with both ends removed, about 2-5 cm (an inch or so) into the soil and fill with water. In 10 minutes all stages of chinch bug will float to the surface and can be counted. If the area of the turf inside the cylinder is calculated, the count can be mathematically converted to a count per 0.1 m^2 (or per ft^2). This number can then be compared to treatment thresholds (see below) to determine whether control is required. Repeating the sampling process in 10 or more locations throughout the lawn will give an indication of the general level of infestation.

Quadrat Method: A Laval University research team has developed a faster sampling technique called "quadrat" sampling,[17] based on sequential sampling methods developed by Wald[18] and Iwao.[19] Cariere[13] refined the methods with field research, and this evolved to the current process described by Rochefort.[11] This method uses a 0.1 m^2 (1 ft^2) frame or "quadrat" – 33 x 33 cm, 20 x 50 cm, or 12 x 12 in.

Place the frame on the lawn and count all of the chinch bugs that can be found in 45-60 seconds. Sample weekly from the last week of June to mid August, counting 3 quadrats per 100 m^2 of lawn.

Figure 7-5. Monitoring for chinch bug, using a 20 x 50 cm quadrat or frame.

The process takes 10-15 minutes to sample an average home lawn, compared to several hours to use the flotation method.

It is important to note that counts from the flotation method cannot be directly compared to results from the quadrat method. While the Laval studies showed that counts using the quadrat method are about ¼ of the counts using the flotation process,[11] sampling in New Brunswick found that the quadrat counts were $1/10^{th}$ of flotation counts.[12] What is important is not the total number of insects counted, but that the sampling method is related to a treatment threshold. If thresholds are based on flotation counts they will be quite different than thresholds based on quadrat counts.

Sampling Locations: Hairy chinch bugs are not uniformly distributed in the turf.[11, 12] Populations are concentrated in "hot spots", and counts may drop to near zero less than 1m (3 ft) away. Therefore, monitoring should focus on likely sites, such as:

- known infested areas from previous years,
- dry, sunny slopes,
- areas with high counts from previous sampling programs, and
- areas with brown or wilting turfgrass in localized patches.

Sampling Frequency: The quadrat sampling method is based on taking 3 random samples per 100 m^2, repeated over the next several weeks, in areas of likely infestation. This provides one sample for every 33 m^2 on every sampling day. Given the localized nature of the chinch bug populations, this sampling frequency probably won't find many of them on any given sampling day. Monitoring for the full period of weeks, however, provides over 20 samples per 100 m^2, or one sample for every 4 to 5 m^2, which gives a reasonable probability of catching the hot spots.

If a quadrat sample shows a count of 10 or more bugs, indicating that it is a hot spot, it should be marked for checking the following week.

4. Decide whether treatment is needed on the basis of population and damage thresholds.

Although the insects are widely present in lawns, they only cause noticeable damage in some. (In the Laval research, while over 60% of the lawns were infested, only 11% required treatment.) Therefore, their visible presence alone is not necessarily an indication that treatment action is required. The damage threshold is the number of chinch bugs per area it takes to cause damage. Above this threshold there will be unacceptable damage to the turf if controls are not applied. Injury, or damage, thresholds are in the process of being developed and refined for Atlantic Canada. The following discussion gives examples of injury thresholds, but for the most recent information, consult extension or industry experts.

Based on the Laval research, it appears that a mean number of 10 chinch bugs or more per quadrat results in 5% damage to the lawn. An action threshold of 10 bugs per 0.1 m^2 quadrat seemed to work for New Brunswick conditions in 2002, and is useful as a starting point. Experience may show that action thresholds will vary slightly for other areas in the Atlantic Region and may be modified. Because a healthy lawn tolerates more feeding by chinch bugs than a stressed (under-fed or over-fed) turf, the damage threshold would be higher for a healthy lawn.

As described above, a New Brunswick study showed a ratio of 1 to 10 between quadrat counts and floatation counts. This means that a count of 10 bugs per quadrat may mean the actual population could be around 100 bugs per 0.1 m^2, which is much higher than previously published thresholds. This may be because the more favourable growing conditions found in the region enable the turf to withstand higher population pressures without visible damage. Flotation sampling in the Fredericton area in 2000 and 2001 found damage at counts of 50 chinch bugs per 0.1 m^2, while counts in "hot spots" ranged as high as 600 bugs per m^2. More detailed research in 2002[12] found there was little visible damage in biodiverse lawns with counts of bugs up to 1200 per m^2. Damage was apparent in 2002 in pure turf stands at flotation counts of 200 bugs per 0.1 m^2.

Table 7-2. Suggested treatment thresholds for two different sampling methods, based on the health of the lawn (New Brunswick data).

NUMBERS OF CHINCH BUGS		TREATMENT REQUIRED	
Flotation Method (count per 0.1 m^2)	Quadrat Method (count per 0.1 m^2)	Healthy Lawn	Stressed Lawn
0 – 50	0 – 5	None	None
50 – 99	6 - 9	None	None
100 – 199	10 – 19	Recheck, possible spot treatment	Spot Treatment
200 or more	20 or more	Spot Treatment	Spot Treatment

5a. Use biological, mechanical and behavioural control methods to reduce pest populations to acceptable levels.

Endophyte-Infected Grasses: Endophytes are naturally occurring fungi that live inside some grasses; the grass benefits because the fungi make the leaves toxic to insects that eat the shoots or sap. Ryegrasses and some fescues have been found with endophytes, but so far, no bluegrasses have been found - or successfully inoculated - with these fungi.

It is not known at this time, whether planting endophyte-infected grass cultivars can help manage chinch bugs. Studies at Laval[13] showed that endophyte-infected perennial ryegrass caused high mortality of 3rd instar nymphs of chinch bug. In mixed stands of endophyte-infected perennial ryegrass and Kentucky bluegrass, the nymphs showed a preference for the non-infected species. This may be because the highly mobile, 3rd instar stage can detect, and avoid, the toxic endophyte-infected cultivars. If perennial ryegrass in mixes used in the Atlantic region are really acting like annuals, then any benefit from planting the endophyte-infected perennial ryegrass would be lost after the first season.[20] Drawbacks to using endophyte-infected turfgrasses include:

- limited availability in the permanent species (some fescue varieties contain the fungus, but no Kentucky bluegrasses),
- loss of viability if not stored correctly,
- a demonstrated preference for non-infected species, and
- lack of a practical viability test.

Further discussion on endophytes may be found at the University of Rhode Island extension web site http://www.uri.edu/ce/factsheets/sheets/endophyte.html, and in *IPM for Turf Managers*.[32]

***Beauvaria bassiana*:** A biological control described in literature is the fungus, *Beauvaria bassiana*. This insect-attacking fungus occurs naturally in the soil under cool, wet conditions and is known to infect hairy chinch bugs. *Beauvaria* can be obtained commercially[21] although its use is likely to be limited since it must be kept moist to survive and be effective. More research is required to determine how effective this fungus is in Atlantic conditions.

In a study of manufactured topsoil at Fredericton in 2003, chinch bug infestations were only found in the plots of soil modified with peat.[22] It has been suggested that the low pH of the peat suppressed the naturally occurring *Beauvaria* populations in these plots, leading to the infestation.[23] Further investigation is underway to explore this possibility and its implications.

5b. When necessary, use targeted applications of pesticides.

If a monitoring program shows that the action threshold has been reached or exceeded, treatment may be required with insecticides. Treatments should be undertaken when the pest is most susceptible, using spot treatments on only those areas where monitoring has identified hot spots. It appears that to obtain control, it is sufficient to treat only an area 2 m (6 ft) or so around the hot spots. Treating the whole lawn is rarely justified; blanket insecticide sprays seem to be a significant factor in suppressing the soil life, and subsequent thatch build-up. Using this application approach, Laval researchers reduced insecticide use for chinch bug by 89%[9] (showing that 89% of the insecticide used in the past was unnecessary).

Lawns repeatedly treated with high levels of fertilizer and insecticides have fewer predators[24, 25] and more problems with hairy chinch bug.[24, 26] At the same time, many common insecticides have a debilitating impact on earthworms, leading to a rapid thatch build-up.[25] For example, in one case in this region, a sodded lawn, sprayed twice a year for chinch bug, had accumulated nearly 50mm (2 in) of thatch, three years after installation.

Insecticides are least effective if applied when the turf is very dry. Therefore, if possible, applications should be made during a gentle rain or the lawn should be lightly watered (at least 6 mm or ¼ in) before treatment. Soak the insecticide in, with an additional 6 mm of water, after treatment.[27] Insecticides should never be applied during a heavy rain as this might result in runoff of the chemicals. Follow all application conditions as required by Provincial permit or license conditions, with respect to posting the area, re-entry times, wind speed, and buffer zones.

Optimum Timing: According to Tashiro[10] and Majeau[14], insecticides are most effective when applied while the 3rd instar nymph stage is present. This is because most of the eggs will have hatched by that time and few of the insects have reached the 4th and 5th instar stages that appear to be more resistant to insecticides. Treatments applied too early or too late will not only be ineffective, but they will also reduce the numbers of beneficial insects that attack chinch bugs.

The rate that insects develop is correlated with temperatures above a certain minimum for growth, called temperature degree-days or growing degree-days.[28] Quebec studies[11, 29] found that calendar dates are correlated well enough with cumulative growing degree-days that it is practical to use calendar dates for monitoring chinch bugs. These studies reported that 95% of the 2nd and 3rd instars were found between July 8 and July 24; this was over the three-year period of the study. New Brunswick studies[12] and Newfoundland data[31] suggest that the peak period for these instars falls 10 days later than found in the Quebec studies. Given this observation, a recommended treatment window has been established as July 15 to August 15. A four-week window, rather than the shorter window in Quebec, is suggested at this time because:

- it provides a guide that improves control efforts significantly over current practice,
- it allows a margin of error for those becoming familiar with their first year of monitoring, and
- it provides a wider margin to take into account variations in chinch bug development around the region.

The recommended treatment window dates may be adjusted in the future as more data are collected.

6. Have a built-in evaluation process.

The final steps in any management program are the evaluation of the effects of the treatment and the documenting results for future reference. These contribute to the learning process and the evolution of the IPM program.

The New Brunswick Horticultural Trades Association has provided a coordinating role for this information. Reports forwarded to the NBHTA will be incorporated into future recommendations.

MANAGING WHITE GRUBS

Description: 'White grub' is the term used for the larva stage of several related species of beetles. The most common in the Atlantic region are May or June beetles (*Phyllophaga* spp.).
The adults are blocky, shiny reddish brown beetles, up to 2 cm (1.4 in) long with no distinctive markings on their wings or body. The larvae reach 8-12 mm (0.5-0.75 in) in length when full grown; they have six legs, a white to grayish body, and a dark brown head. They curl in a characteristic "C"-shape and are usually found within the top 5 cm (2 in) of the soil surface.

Life Cycle: Adults emerge in late spring, feed for a limited time, then mate. They fly at night and are often found around outdoor light sources. Females lay eggs about 12–50 mm (1–4 in) beneath the soil surface. Eggs hatch in about 3 weeks and the young larvae start feeding on roots and decaying matter. This continues until the fall, when they migrate deeper into the soil to spend the winter. The feeding sequence is repeated the following year, with the larvae again migrating deep into the soil for the second winter. The following spring they move up to just below the surface and feed on roots until May. Then they pupate in a cavity in the soil and remain there as a pupa through the fall and winter. The adults emerge from the pupae the following spring, completing a 3-year life cycle.

Damage: *The Gardener's Handbook*[30] suggests that 5 or more larvae per 0.1 m^2 (one square foot) is sufficient to warrant treatment. The larvae cut the turf roots so that it can be lifted like thick sod. This has rarely been observed in this region. The main damage is caused by skunks, raccoons and birds digging up the lawn to feed on the larvae.

Management: May or June beetles are not considered a pest in most turfgrass; homeowners rarely request treatment programs for the larvae. No control programs should be carried out for adults, although they are annoying, and pest control operators may get requests for their control. Naturally occurring predators, nematodes, bacteria, and fungi pathogens attack the eggs and larvae, usually keeping their numbers below aesthetically annoying levels in most areas.

Chemical Controls: Some products containing carbaryl are registered for control of white grubs. Note that diazinon and chlorpyrifos used for white grubs in the past can no longer be used in, or around, residential areas.

Jeff Morton, formerly the Provincial Horticulturalist with the NS Department of Agriculture and Marketing, provides the information in the following two sections – Managing Sod Webworm and Managing Crane Fly.

MANAGING SOD WEBWORM

Sod Webworms are occasional pests of turfgrass in the region. These are lepidopteran pests identified mainly as various species of the genus *Crambus* and *Chyrsoteuchia toparia* the cranberry root girdler.

Description: The sod webworm larvae are off-white or tan-coloured caterpillars, about 10-20 mm long with a brownish head when mature. The larvae have legs on each abdominal segment and move forward or backwards very rapidly when disturbed. The larvae move through a series of molts usually having 7 or 8 instars. The early instars are very tiny 2-3 mm and usually have black heads. The *Crambus* species have dark circular patches along their backs. A picture may be found on-line at: http://www.biologicco.com/newsletter/vol_1_5.htm.

The adults are most often observed as small whitish-brown moths flying low over the turf in the early evening from late June to early August. The adults are about 10mm long with a wingspan of 20mm. When at rest on turf leaves, they hold their wings close to their bodies giving a long narrow appearance further accentuated by two mouthparts, forming a shape like a snout, that protrude from their heads. The moths are weak flyers and the zigzag fluttering activity ceases quickly after they are disturbed resting on grass blades, weeds or neighboring trees.

Life Cycle: The sod webworms over winter as mature larvae in their ground burrows or in the soil. As the temperature increases the instar becomes active and feeds and begins to pupate with the onset of long days. The pupal stage is in a new burrow in the soil and lasts approximately 21-28 days. The adults emerge, mate and lay eggs within 10-12 days. Moths are nocturnal, resting on grass during the day or in shrubbery nearby. They drop their eggs on the grass by mid - June. Eggs hatch in a week, but dry out easily and many do not develop. The tiny webworm can eat only soft, succulent portions of the grass blade. If the grass blade is tough, it may starve. As it grows, it begins to eat the tougher parts of leaves and stems. At this stage, it lives in the thatch layer, constructing a woven tunnel reinforced with plant debris, soil particles and its own excrement. Eventually, it is large enough to chew grass blades off, dragging them into its burrow to be eaten.

If there is more than one generation in any one year, webworm damage will be more severe.

Damage: The first signs of sod webworm injury are small patches of yellow or brown grass on the lawn. If the infestation worsens, the brown patches join together, producing large, irregular areas of dying grass. The patches are noticeable in sunny areas, while weeds and shady areas of lawn usually remain green.

The most severe damage occurs is association with late summer drought. Severe damage may not be evident on drought stressed turf until the areas fail to green up in September.

Habitat: Sod webworms prefer sunny lawn areas protected from strong winds. Well-drained areas are also more prone to attack most likely due to the suitability for the larval burrows. Webworms prefer rapidly growing grasses with heavy thatch levels and are more evident in thick lawns receiving medium to high levels of fertility.

IPM PROGRAM FOR SOD WEBWORM

The basic steps in an IPM framework are described in Chapter 1. The following sections describe each step as it applies to managing sod webworms, based on their biology and development in Eastern Canada.

1. Manage landscapes to prevent pests from becoming a threat.

Sod webworms are pests in more aggressively growing turf areas later in the season. Turf managers should prevent thatch levels from becoming heavy as it causes stresses on the turf and provides more suitable habitat for the insect to grow to damaging levels. Managing the pH at levels above 6.0, and minimizing pesticide usage, will encourage more soil microorganisms and insects that help to break down thatch and/or prey on the larvae. Fertility management is critical especially ensuring that nitrogen levels are reasonable and available in low amounts throughout the season. Removing excess thatch may be required by mechanical means or through regular aeration and topdressing to mix soil through the thatch layer.

2. Identify potential pests

Sod webworms are caterpillars that damage lawns by feeding upon the grass blades.
The Cranberry girdler tends to feed more heavily on root portions and often cause more severe types of damage.

Make sure you identify the pest as sod webworm and assess how much damage it may do before you decide to apply a control. Many of the moths and caterpillars on your property are part of a healthy ecosystem, providing food to birds and other predators.

Turf injury resembling sod webworm damage can result from many different causes such as heat stress, other insects such as chinch bug and grubs, and - rarely - disease problems. Insufficient soil depth or surface rocks may also appear like the injury from webworms.

3. Monitor environmental conditions, pest and beneficial organism populations and pest damage.

Identify potential high levels of adult flights in late June and record potentially damaging populations. Initiate sampling 20-30 days later. Extreme dryness and heat in this period may severely limit the survival of the hatching larvae.

Check the thatch layer just above the soil surface. You may see signs of webworm feeding. Early in the season (July), small webworms eat only the tender parts of the grass blades, so that the blades appear skeletonized. Larger webworms will chew off the entire blade and drag it away. Observe carefully while teasing the turf and thatch apart looking for signs of green excrement and silk-lined tunnels. Generally the tunnels point downward, and the caterpillar is found inside. If you do not see signs of feeding, perhaps something else, such as poor drainage, a gas spill or the over-application of a pesticide, fertilizer or herbicide has injured the lawn.

Estimate the webworm population by drenching areas where webworms are likely to be found, such as the edges of damaged areas, with a lemon detergent solution. This will cause the larvae to become active and crawl to the surface. Mark off several squares measuring 30 cm by 30 cm. Using a rate of two liters of water for each 15 ml of detergent (2 tablespoons per gallon); apply as much solution as you need to saturate each test square. Watch each square for about 10 minutes. If no webworms appear, check other areas of the lawn. Although webworms may have injured the lawn, if they are no longer feeding upon the grass any controls you undertake will be ineffective.

4. Decide whether treatment is needed on the basis of population and damage thresholds.

Low numbers of webworm may not need to be controlled. Injured grass can recover if feeding is not severe. A lawn growing from a fertile, well-aerated soil that has received moderate amounts of fertilizer or nutrients will be best able to withstand an infestation. A wet summer will reduce the damage. Watering a dry lawn will help keep the grass growing (*see* Watering, Chapter 6).
As a general guideline, a range of 8-10 webworms in the test area will cause some damage to a previously healthy lawn. A lower number (3-4) in the area sampled can damage a lawn in poor condition before the outbreak.

5a. Use biological, mechanical and behavioral control methods to reduce pest populations to acceptable levels.

Thatch control is a key management technique in the reduction of sod webworm infestations. Management processes such as reduced pesticide usage, pH adjustment, moderate fertilization, proper irrigation, compost topdressing and core aeration result in lower levels of thatch and thus reduced potentials for webworm outbreaks.

Avoid stresses on the turf especially in hot conditions. Manage mowing practices to leave turf about 6-7.5 cm. This encourages deeper rooting and a more stress resistant plant able to recover from some defoliation.

Natural enemies including certain microorganisms, parasitic wasps and flies, and predators such as beetles, ants and birds reduce sod webworm populations. A good long-term strategy for pest control is to maintain an area where these webworm enemies can find the mixture of foods they require and shelter. Avoid repeated use of insecticides that can suppress natural enemies. Webworm outbreaks will often occur on areas treated for control of other insects earlier in the season. Leave room on your property for nectar sources such as daisies, Queen Anne's lace, black-eyed Susan, dill, caraway and fennel.

Turfgrass infected with endophytes---natural fungi that grow inside grass and affect the animals chewing it--- are resistant to sod webworms that chew on the leaves. Types of perennial ryegrasses, tall fescues and fine fescues are available with this resistance (*see* Chapter 4, Seed Containing Endophytes). Perennial ryegrass and tall fescue are marginally hardy in most areas and may require reseeding after periods of prolonged snow cover or ice. These grasses may be utilized as a portion of an overseeding mix to help diluted the population of susceptible turf in a specific area.

5b. When necessary, use targeted applications of pesticides.

The microbial product Bt (*Bacillus thuringiensis*) can be used to control webworm, and should be the first choice for a control product in this application because of its environmentally benign characteristics. This naturally occurring bacterium acts as a stomach poison when it is eaten by caterpillars, but does not damage other insects.

Application timing is important: Bt is not effective on moths, nor on larger webworms. Large numbers of moths signal the start of the monitoring period in the control cycle, not the time to start spraying. There is no point in applying control products at this time, because the product will not kill the moths. The best time to apply Bt is two weeks after observing moths – typically late July to early August. By this time, most of the resulting eggs should have hatched and the webworms are small and easily killed.

Remember that Bt will kill all caterpillars, including the caterpillars of butterflies, so avoid spraying it on any plants where pest control is not needed.

Parasitic soil nematodes are microscopic organisms that kill sod webworm larvae. Two species of nematodes *Heterorhabditis spp.* and *Steinernema* spp. are introduced predators that will reduce population levels. *Heterorhabditis* is a more aggressive predator actively moving through the top 15 cm of soil. Both types of nematodes move in the film of water in soil or plants. They are most effective when applied in warm conditions when water is freely available on the surface of the plant. Applying the product on a warm evening followed by a light irrigation improves the effectiveness of the application. Cold-hardy strains are available that promise better activity where a past history of infestation has occurred and/or high levels of adults have been detected; a fall treatment may be warranted.

Eliminate thatch if it is over 1.5 cm thick so that the nematodes will reach the soil. Avoid using chemical fertilizers or pesticides for at least one week after applying nematodes. These nematodes will not overwinter in Nova Scotia, so the product must be reapplied if you want control the following season.

If other management techniques have been found ineffective, a few chemical products are registered for use in controlling sod webworm infestations. If you decide chemical control products are necessary, treat only the affected area, so that predators and other insects can repopulate the area. The choice of products may also have an influence on the non-target effects to the general soil insect population. Always choose the least harmful product for the given situation.

6. Have a built-in evaluation process.

Pest management programs should monitor the effectiveness of the treatments and control strategies. Treated areas should be re-inspected in late August or early September to determine the extent of the damage and subsequent repair activities that may be required in the spring. Often undetected levels of infestation in the fall are misreported as winter injury the next spring.

EUROPEAN CRANE FLY

The European crane fly (*Tipula paludosa)* is an occasional pest of turfgrasses in Atlantic Canada.

Description: In Eastern Canada, the adult is 15-40 mm in length and has one pair of membranous wings equivalent to the length of the body. The adult is often described as an oversized mosquito with a grey-green slightly translucent abdomen. The adult is most often observed in flight low over turf and grass areas in the early evening and resting on building window screens. The larva known

as leatherjackets cause damage to turf and pasture areas. The name comes from the tough pleated grayish green skin that is covered with various black specs of different sizes. The larva are 20-40 mm in length and 5-8mm in diameter slightly tapering at each end. The insect was introduced to Sydney, Nova Scotia from Europe in 1955 and has since spread to the rest of the province. Pictures of adults and larvae may be seen at:
http://www.ent3.orst.edu/smartkey/display.cfm?pagename=Crane%20flies&groupname=nogroup

Life Cycle: The adult stage is the European crane fly, *Tipula paludosa*. It looks like a giant mosquito, but does not bite or sting. Crane flies emerge from the soil in late summer. They do not eat, but mate, lay eggs and die soon after emergence. The eggs, which are laid in the upper 3 cm of soil, are black, oval and about 0.1 cm long. Dry soil conditions may cause the eggs to die; otherwise they hatch into larvae, known as leatherjackets, within two weeks. The first two instars feed heavily for 6-8 weeks and the larva overwinter as third stage instars. The larva move deeper into the soil for the winter, and many die if the winter soil temperatures are low or conditions are dry. Heavy snow cover usually increases survival rates. As the soil temperature increases in the spring they move to the surface and resume feeding and molt to a fourth instar (most damaging stage) stopping in early summer to form pupa. The pupa can move up or down in their burrows, through the use of spines depending on environmental conditions. The pupae hatch in late summer or early fall, emerging as adult crane flies.

Damage: Leatherjackets may damage a variety of landscape plants with turf grasses most frequently attacked. Injury in turf becomes noticeable in slopes and stress prone areas in late spring to early summer as the over wintered larvae begin to mature. Weak or thin lawn areas marked by a large number of small holes are indicators of the presence of European crane fly larvae. Holes from the burrows are noticeable and usually spaced 25 mm to 100 mm apart in damaged areas. The damage is often localized to small patches but can encompass several hundred m^2 when infestations become severe.

Often the damage can be more severe in protected areas where good snow cover has been experienced. The population reaches a peak between mid-June and early July. Larvae may be noticed first after a heavy rain, when they are washed out of the soil and onto sidewalks and driveways. The pest may exist in large numbers with several thousand larvae observed on driveways and walkways in the evening. While these high population levels may not damage lawn areas, the slippery surfaces may become a problem when the larvae are crushed on smooth asphalt or concrete.

During the day, leatherjackets feed on grass roots near the surface of the soil. Dry soil conditions cause the larger larvae to migrate deeper in the soil to depths of 150 mm. The larvae crawl to the surface in the evening to feed on grass leaves crowns and stems.

Habitat: The European crane fly prefers a climate with high rainfall and low winter temperatures. Much of the Atlantic Provinces are suitable for potential infestation. Adult Crane fly is present in abundant numbers as s each fall and feed on a variety of grasses both in pastures and on turf areas. The larva is often present in shady areas where slightly higher soil moisture is expected and on slopes from the north and east sides of buildings.

IPM PROGRAM FOR EUROPEAN CRANE FLY

The basic steps in an IPM framework are described in Chapter 1. The following sections describe each step as it applies to managing crane fly, based on its biology and development in Eastern Canada.

1. Manage landscapes to prevent pests from becoming a threat.

Crane fly rarely causes severe damage to turf areas that are growing very vigorously. The first step is to employ sound turf management techniques to prevent injury in turf from reaching damaging levels. The major effect of the larval feeding is thinning of the turf causing the area to be more susceptible to weed invasion and other turf stresses such as drought, potentially discouraging the growth of desirable species.

2. Identify potential pests

See the description above. The pest may be confused with a variety of cutworm species in both planting beds and turf areas. Cutworm larvae are usually more solitary and do not occur in the numbers that crane fly often do. Cutworm larvae also have small feet on each abdominal segment while crane flies have none.

Large numbers of crane fly adults are often present in the fall but do not necessarily lead to severe infestations. Identification of the potential pest stage and resulting control strategies should be based on sampling for the larval stages in Mid-June.

3. Monitor environmental conditions, pest and beneficial organism populations and pest damage.

Turf areas suspected of potential infestations or showing early symptoms such as turf thinning or burrow holes should be sampled for the presence of larva. Examine several areas of soil underneath the grass. Cut three 30 cm (one foot) sides of a square of turf about 7.5 cm (3 inches) deep. Carefully fold the square back, using the uncut edge as a hinge. Scrape the soil from the roots to expose the leatherjackets and count them. When you have finished, firmly press the grass back in place, and water it.

Adult populations may be sampled in August and September but are poor indicators of potential pest infestations because of the susceptibility of the eggs and larva to death from poor environmental conditions. High levels of rainfall in late August and Early September will encourage good egg hatch. Dry surface and soil conditions will also contribute to death of the newly hatched larvae or eggs. Monitoring environmental and soil conditions will aid in predicting potential damaging pest levels.

4. Decide whether treatment is needed on the basis of population and damage thresholds.

Low numbers of leatherjackets do not need to be controlled. A lawn growing from a fertile, well-aerated soil that has received moderate amounts of fertilizer or nutrients will be able to withstand a mild infestation. If higher numbers (over 25) are found in the sampling area, expect that the lawn will be damaged. A lower number, 15 in the area sampled, will likely cause damage to a lawn that was in poor condition before the outbreak.

Damaging levels are often measured by the severity of the thinning of the turfgrass. Turf can tolerate significant injury before an entire area is destroyed. Often infestations are limited to very small areas and only those areas may need increased levels of management.

Direct control measures should only be considered in the spring as late summer drought or severe winter temperatures may significantly reduce the populations of the young larva in the preceding fall.

5a. Use biological, mechanical and behavioral control methods to reduce pest populations to acceptable levels.

Predator populations are generally insufficient to handle large infestations of European crane fly. Predatory arthropods, birds, and snakes all feed on the larvae in their burrows or as they emerge to feed in the evening.

Egg laying preference has been noted in the past where infestations occur on property boundaries where two different types of grass exist. While this may not be currently used for control strategies it does indicate that infestations may be limited due to preference of egg laying sites and species bio-diversity will reduce large-scale infestations.

Physical removal is possible in the evening as the insects are exposed on the surface of the soil. Large numbers can easily be intercepted at this time and disposed of in soapy water. Heavy rainfall events also drive the insects from the soil area lessening the populations in a specific area.

Large numbers of crane flies in late summer indicate a possible infestation of leatherjackets in the spring. However, eggs are sensitive to soil moisture, and quickly collapse if it is dry. Newly hatched larvae also require moisture; drought during late August and September will kill them. Since both eggs and larvae dry out easily, avoid irrigating a dry lawn in the fall if you suspect a leatherjacket infestation.

5b. When necessary, use targeted applications of pesticides.

Parasitic soil nematodes are microscopic organisms that kill leatherjackets. Two species of nematodes *Heterorhabditis spp.* and *Steinernema spp.* are introduced predators that will reduce population levels. *Heterorhabditis* is a more aggressive predator, actively moving through the top 15 cm of soil. Both types of nematodes move in the film of water in soil or plants. They are most effective when applied in warm conditions when water is freely available on the surface of the plant. Applying the product on a warm evening followed by a light irrigation to improve the effectiveness of the application. Cold hardy strains are available that promise better activity where a past history of infestation has occurred and/or high levels of adults has been detected a fall treatment may be warranted.

The effective treatment window for crane fly is early June as the fourth instar larvae are beginning to feed. Eliminate thatch if it is over 1.5 cm thick so that the nematodes will reach the soil. Avoid using chemical fertilizers or pesticides for at least one week after applying nematodes. These nematodes will not overwinter in Nova Scotia, so the product must be reapplied if you want control of crane fly the following season.

Most effective control of leatherjackets is achieved by making applications so the insect may intercept the products as they emerge for the evening feeding. Irrigating 2-3 days prior to treatments also encourage the pest to be close to the surface.

If other management techniques have been found ineffective, a few chemical products are registered for use in controlling grub infestations. Many control products will also destroy natural predators of lawn pests; an infestation of another insect, such as sod webworm or chinch bug, may follow. If you decide pest control products are necessary, treat only the affected area, so that predators and other insects can repopulate the area. The choice of products may also have an influence on the non-target effects to the general soil insect population. Always choose the least harmful product for the given situation. The effectiveness of most products is dependent on application techniques and timing.

6. Have a built-in evaluation process.

Pest management programs should monitor the effectiveness of the treatments and control strategies. Treated areas should be re-inspected in late August or early September to determine the effectiveness of the management strategies and identify future schemes to manage the areas.

KEY POINTS

Managing Weeds

- Consider growing a biodiverse lawn and raising tolerance levels for broadleaf weeds.
- Provide the best growing conditions so that the healthy turf suppresses weeds.
- Monitor weed populations, using transect or grid counting methods and keep records.
- Make treatment decisions based on monitoring results and treatment thresholds.
- Where weed numbers are low, use mechanical removal methods.
- If herbicides are used, target the use to the areas with the weed populations; avoid routine herbicide applications and mixed herbicide-fertilizer products.
- Evaluate the effect of any treatments and the overall IPM program.

Managing Insects

- Investigate the problem. Is it really insect damage?
- Identify the insect.
- Monitor population levels. Are damage thresholds exceeded?
- If control measures are needed, apply when they are most effective.
- Use spot treatments where possible.

Review the program annually to determine whether sampling procedures, locations and threshold levels need adjustment.

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APPENDIX I

Aspergillus fumigatus in Compost

Aspergillus fumigatus is a naturally occurring, fast-growing fungus that thrives at temperatures as high as 45-50°C. Thus, it is capable of growing profusely in compost. It lives on dead organic matter in soil and on plants (particularly trees). It is widespread in nature, and under the right conditions it can cause serious respiratory diseases in poultry as well as humans [1].

A. fumigatus is what is known as a secondary pathogen, which means that it cannot invade healthy lungs. It only affects persons whose lungs are already damaged by some other, primary disease. One researcher reports that people with compromised immune systems are at risk of developing a lung infection from *A. fumigatus*, as are smokers working with compost [2]. If someone is debilitated, has another pulmonary disease, or has increased susceptibility due to medication with corticosteroids, the inhaled spores may germinate and the fungus may invade the lungs and cause the lung disease, aspergillosis [3]. Humans appear to become more susceptible if they are being treated with antibiotics and corticosteroids. The fungus can also cause severe allergic reactions, especially in people who are subject to asthma or hay fever.

Of note to landscape service industry is that there is a risk of infection for anyone working directly with the compost, such as turning it, bagging it, or incorporating it into soil. A major source of this fungus may be found in certain types of vegetable compost during early stages of decomposition. When green leaves and branches trimmed from the trees are passed through a chipper, the resulting coarse wood chips and green vegetation provide an excellent medium for the growth of *A. fumigatus*. If a pile of this material is exposed to rain, within a few days microbial fermentation produces a high temperature that supports luxuriant growth of this fungus. Gardeners who use this material for mulch are exposed to millions of spores[3].

Although the fungus does not appear to pose a risk for healthy people, it is advisable to wear a mask when working extensively with compost or decomposing chipped material. It may be possible to heat finish compost to a temperature which would destroy the fungus [1]. It is also desirable, when handling the products, to maintain moisture levels sufficiently high to reduce dust particles.

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APPENDIX II. Web Sites Resources (as of October 2003).

Starting with Soil

Soil Water Monitoring and Measurement. 1974. Washington State University.
http://cru.cahe.wsu.edu/CEPublications/pnw0475/pnw0475.html

Fertilizing the Soil

The first two sites discuss how to vary fertilizer rates with differing soil types:
University of Minnesota Cooperative Extension:
http://www.extension.umn.edu/distribution/horticulture/DG1731.html

University of Illinois Cooperative Extension: http://www.turf.uiuc.edu/extension/ext-fert.html

LILAC (Low Input LAwn Care). A web site for Maine:
http://www.state.me.us/agriculture/pesticides/lilac.htm

Mowing

The Urban Farmer in BC. An interesting discussion of mulching mowers:
http://www.cityfarmer.org/

Grasscycling

University of Rhode Island. http://www.uri.edu/ce/factsheets/sheets/lawnmow.html

Iowa State University: http://www.ipm.iastate.edu/ipm/hortnews/11994/mowyrbot.html

Turfgrass Information Center, Michigan State University: http://www.lib.msu.edu/tgif/

Weed Identification

University of California statewide IPM program. Turfgrass Weed Photo Gallery.
http://www.ipm.ucdavis.edu/PMG/r785700999.html

Horticulture Organizations and Institutes

Guelph Turfgrass Institute: http://www.uoguelph.ca/GTI/gtihome.html

New Brunswick Horticultural Trades Association: http://nbhta.ca/

Landscape Nova Scotia: http://www.landscapenovascotia.ca/

Landscape Ontario: http://www.horttrades.com/

The Canadian Nursery and Landscape Association:
http://www.canadanursery.com/canadanursery/index.lasso

Federal Government Healthy Lawn:
http://www.healthylawns.net/english/index-e.html

Ontario Government Turf Information Website:
http://www.gov.on.ca/omafra/english/crops/hort/turf.html#ipm

Ontario Government Site with specific turf IPM information
http://www.gov.on.ca/omafra/english/crops/facts/info_turfipm.htm

APPENDIX III. IPM for Municipalities and Institutions

Some municipalities and institutions across the country have officially adopted Integrated Pest Management (IPM) policies, while many have parks departments that are successfully applying IPM practices. The following tips are intended to help anyone in a municipality, institutional setting or other agency, work toward putting in place an IPM program for turf.

1. Understand the IPM Process

The first requirement is a solid understanding of the elements of IPM. It is essential that everyone involved in the issue is using the same definition.

The elements of IPM, as defined nationally,[1] are:

1. preventing organisms from becoming pest problems by planning and managing ecosystems,
2. identifying pest and beneficial species,
3. monitoring pest and beneficial species populations, pest damage and environmental conditions,
4. using injury and action thresholds to determine when to treat pests,
5. using treatments that usually include a combination of methods, such as cultural, biological, physical, mechanical, behavioural, or chemical methods, to achieve acceptable control with minimal impact on the environment, and
6. evaluating the effects and efficacy of pest management strategies.

At the core of any IPM definition are two important concepts: IPM is based on preventing pest problems, and IPM is a decision making process for determining what actions to take when pest problems occur. A common misunderstanding about IPM is the idea that it necessarily means a pesticide based control program. Pesticides may or may not be used as treatments in an IPM program depending on the situation. For example, organic landscape services would only use products approved for organic practitioners. Where pesticides cannot be used, it is even more important to follow an IPM program to achieve good results.

2. Get Support From Decision-Makers

Adopting an IPM policy boosts the image of the municipality as environmentally responsible and complements other environmental initiatives such as composting and recycling programs. To obtain approval and support from municipal councils and managers it is important that they know the benefits of an IPM approach.

Promote the many benefits from using an IPM approach, including:

- protecting the environment,
- reducing or eliminating pesticide use[2],
- reducing use of fertilizers and other inputs,
- reducing the risk of groundwater contamination,
- improving pest management results and appearance of turf, and
- short- and long-term savings in materials and labour.

Knowing that an IPM approach incorporates sound turf management practices and provides a scientifically sound system for making decisions can reassure citizens that are concerned about turf management practices. For a particularly informative handout to use for public education, see Beard and Green.[3]

Is IPM a Fad?

Jim Moore, Supervisor of Parks and Grounds for the City of Moncton, comments:
"The combined efforts of Health Canada, the New Brunswick Department of Environment and Local Government, the New Brunswick Horticultural Trades Association, the Federation of Canadian Municipalities and Communities in Bloom reassure all involved that IPM is fact, not fad.
Citizens and staff fully endorse these new common sense approaches to gardening and turf management. Now is the time to give everyone involved with gardening activities in our city the opportunity to learn more about IPM."

Water Conservation Benefits: When IPM practices are used by homeowners to produce healthy, deep root lawns, it can substantially reduce the demand on municipal water supplies for summer watering. Where water comes from wells, the water savings that can be achieved may help defer, or avoid altogether, the need for the major expense of expanding the water system.

Most lawns established over the past 50 years have construction deficiencies in the underlying soil that make it necessary to irrigate turf to maintain the green colour throughout the summer. At the municipal level, this takes a lot of water. Irrigating 100 average (500 m^2) home lawns through the summer consumes over 14,000 m^3 of water, assuming no waste (poor irrigation practices can easily double this figure). With changes in watering practice, the green colour in turf can be maintained through the summer with half this consumption.

Healthy turf can also be allowed to go dormant, which eliminates the need to water and does not normally harm established turf.

3. Review Turf Management Practices

Review all current turf management practices to ensure that they encourage deep root growth, which is the foundation of healthy turf. Every aspect should be reviewed, questioned and improved, including the design of upcoming construction projects: there is no room for "that's the way we've always done it".

A striking example is questioning the normal practice of fertilizing in the spring. Consider that this additional fertilizer is being put on when spring growth is naturally vigorous. Fertilizing with nitrogen just increases this growth, at a time when workloads for mowing in May and June are usually a problem. Why compound the problem, when research[4] has shown that September or late June nitrogen applications are more beneficial to turf than spring feeding?

One way to start on the review is to list key problems and pest concerns. These may be divided into cultural problems and pest management problems (though these may also be related to cultural problems). Cultural problems are generally a result of poor construction or maintenance practices, foot traffic and wear, or a combination of these factors. Explore each problem or concern, discuss them with other managers and resource people and develop possible solutions. Some of these will be short-term and immediate, while others are intended to make long-term improvements in turf health. Begin making the changes where possible and keep good records of results. Review these records over the winter to make plans for the next season. Over time, incorporate the improved practices into a coordinated IPM program.

The following notes outline areas of turf management that may require improvement (for more information, consult the relevant chapters in this manual).

Categorize Turf: As a way to focus management activities, consider separating turf areas into Class A, B and C categories according the maintenance levels.[5] Each of these categories would have different thresholds for treatment decisions. Using such categories to allocate maintenance work and inputs helps turf managers provide a reasonable compromise between aesthetics and economics.

Examples of Turf Areas in Each Category

Class A – High level of service: *fine ornamental lawns, golf and bowling greens, irrigated sports fields.*
Class B – Moderate level of service: *residential and commercial lawns, boulevards, recreational areas, golf fairways.*
Class C – Low level of service: *Meadows, picnic areas, rough grass, undeveloped and naturalized areas.*

Fertilizing: Take soils tests and choose fertilizers based on plant needs. Maintain soil pH around 6.5 so that nutrients are available to the plants and the soil microbial population is healthy.

Review whether too much nitrogen is being applied annually (i.e., more than 0.5 to 1.5 kg/100 m^2 may be excessive). Use the uniformity of green colour, rather than depth of colour, as a criterion for turf appearance. Reducing nitrogen rates results in a lighter green, healthier turf—and saves both money and labour. It also reduces the risk of nitrate leaching into the groundwater.

Mowing. Cut at a 6.5 to 7.5 cm (2 ½ to 3 in) mowing height to encourage deep root growth. Manage mowing operations based on plant growth rates rather than the calendar, and cut no more than ⅓ of the plant growth at each mowing. This fosters healthy plant growth, and can reduce the number of mowing operations required per year. Sharpen mowers every 10 to 15 operating hours to improve appearance of the turf and reduce plant stress, while reducing fuel consumption.

Recycle clippings to reduce fertilizer and labour requirements, improve soil organic matter and reduce the disposal burden on landfills.

Watering: If the decision has been made to water the turf through the dry period, then it should be done as efficiently as possible to conserve water and obtain the best results. Rather than promote growth, consider watering just enough to keep the turf green; this generally takes about 15 mm (⅝ in) per week (reduced by amounts of natural rainfall). Water deeply, once or twice a week, to develop deep roots and stronger turfgrass plants.

Use water efficiently. Each irrigation setup should be carefully evaluated to maximize both irrigation efficiency and water conservation. Irrigation systems must be calibrated to determine how long to it takes the system to deliver a given quantity of water. Check delivery rates, apply just enough and stop watering before runoff occurs.

An alternative to watering is allowing the turf to turn brown. This normally doesn't hurt well established, healthy turf, and it conserves water.

Weed Management: Weeds, particularly dandelions, probably create the most controversy in turf pest management. Maintaining healthy, vigorous turf can reduce the size of established weeds, and dramatically reduce invasion of new ones. Selective herbicide use may be the most practical approach at present to restore a site to, and maintain, a Class A status. However, if dandelions are the only problem, hand weeding, using a well-designed weed tool can be done efficiently and cost-effectively. Experience shows that 5-10 plants can be removed per minute; where there are 5 weed per m^2, this means that around 100 m^2 can be weeded per hour.

The use of herbicides alone, without building up the turf in advance, merely opens up the soil for re-infestation as the broadleaf plants collapse and leave bare soil areas behind.

Tolerating a variety of plants in lawns (a 'biodiverse' lawn) is the most environmentally responsible and cost-effective approach. For example, uniformly distributed populations of white clover are attractive and can supply more than half of the nitrogen requirements for the turf grasses.

Insect Management: Pest insects, notably hairy chinch bug, are not often a problem in municipal turf. This may be because due to reduced budgets, less nitrogen is applied and a greater diversity of plants is tolerated in the turf. The most visible damage from chinch bugs seems to be correlated with high fertility, weed-free turf.

Where infestations have caused damage in the past, begin a monitoring program using the Laval quadrat method of counting chinch bugs. Where counts exceed a threshold of 10 chinch bugs per 0.1 m^2 (ft^2), insecticides may be required. Using spot applications, in the July 15 to August 15 window, is effective. Recent research in New Brunswick, however, suggests that considerably higher insect counts may be tolerable without visible damage. For example, some Class C turf with population counts of 600 to 1200 per 0.1 m^2 (ft^2) had little visible damage.[6]

New Construction: For any new construction, it is quite practical to establish lawns that stay green through the summer with natural rainfall, without increasing construction costs. Such sustainable turf is achievable with a soil foundation that makes adequate soil moisture available throughout the season. This usually means providing at least 60 cm (2 ft) of subsoil material (soil textures could range from sandy loam to a silt loam rocky subsoil) without barriers to capillary movement of moisture. At the same time, this increases the absorption of water and reduces runoff. This reduces the load on drainage systems and reduces contamination of ground water from silt, fertilizer and other chemicals.

Construction of playing fields should ensure that the soil has sufficient structural strength to reduce compaction from traffic.

4. Take Advantage of Training

IPM training and seminars are frequently held in the province. If budgets permit, have key staff attend as many as possible, including one or both of the major trade shows: Hort Congress in New Brunswick and Hort East in Halifax (held in alternate years). There is also a Turf Seminar held annually in Halifax.

Read key references, including the *Integrated Pest Management Manual for Landscape Pests in British Columbia*[5] and *Understanding Turf Management.*[7] An excellent primer in ecological management approaches is *Ecologically Sound Lawn Care Practices for the Pacific Northwest*[8], although the fertility rates and turf species must be adjusted for our climate. *Turf Management – Principles and Practices Study Guide*[4] provides a more in-depth scientific treatment of all aspects of turf behaviour for real fine-tuning.

5. Keep Citizens Informed

Spread the word. Keep management and the public informed of your approaches and successes. When they see the municipality taking the lead, the public is encouraged to participate in environmentally friendly turf care practices.

6. Consider IPM Accreditation

Consider enrolling in an IPM Accreditation program and introducing the IPM Accreditation requirement for contractors hired for turf management operations within the municipality.

The IPM Accreditation program is an independently audited industry certification program similar to the ISO 9000 concept. It has been developed by the IPM/PHC Council of Canada. The program began in Ontario and is now being implemented in some provinces. NBHTA (1-866-752-6862), Landscape Nova Scotia (1-877-567-4769), and Landscape Newfoundland and Labrador (709-726-2000) are provincial contacts for the program.

IPM/PHC of Canada Definition of IPM

The IPM/PHC (Plant Health Care) Council has re-stated the national IPM definition for use in its Industry IPM Accreditation program, as the following steps:

- manage landscapes to prevent pests from becoming a threat,
- identify potential pests (weeds, diseases and insects),
- monitor environmental conditions, pest and beneficial organism populations and pest damage,
- decide whether treatment is needed on the basis of population and damage thresholds,
- use biological, mechanical and behavioural control methods (such as resistant plant varieties, physical barriers and traps) to reduce pest populations to acceptable levels,
- when necessary, use targeted applications of pesticides, and
- have a built-in evaluation process.

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[5] Gilkeson, L. and R. Adams. *Integrated Pest Management Manual for Landscape Pests in British Columbia*. 2000. BC Ministry of Environment, Lands, and Parks. 128 pp. Available on-line: http://wlapwww.gov.bc.ca/epd/epdpa/ipmp/ipm-manuals.htm

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[8] McDonald, David K. *Ecologically Sound Lawn Care for the Pacific Northwest*. 1999. Seattle Public Utilities. Seattle, WA. Available on-line: http://www.ci.seattle.wa.us/util/lawncare/LawnReport.htm; Hard copies from New Brunswick Horticultural Trades Association (address on the website http://nbhta.ca/). Cost $15 ppd.

GLOSSARY

Action threshold: is the point at which treatment should take place to prevent a pest population from reaching the injury threshold.

Active ingredient (ai): the portion of a chemical product that actually does the work. For example, Killex 500™ has an ai of 500 g of 2,4-D per l of product.

Aeration (aerification): is a mechanical cultivation method that allows selective tilling of existing turf, without destroying the sod.

Amended subsoil: is subsoil amended with organic matter and possibly other products (lime, fertilizer) for use as a topsoil replacement.

Annual plant: describes a plant that germinates from seed, then flowers, produces seed, and dies in the same year; it has a one-year life cycle.

Application rate: is the amount of a product (fertilizer, lime, compost) or active ingredient applied to control a pest. It is usually expressed as amount per area (e.g., 10kg/100 m^2 or 30 ml per 10 m^2), per length of crop row (e.g., 40 g per 10 m length of row) or as a dilution (e.g., mix 50 ml in 4 L of water and spray to thoroughly wet foliage).

Biennial: describes a plant that completes its life cycle in two years.

Biological control: is the use of beneficial species, such as predatory and parasitic insects, birds, nematodes, or disease organisms to suppress populations of pests.

Broadcast application: is an even application of a product over an entire area, as opposed to treating part of the area or only individual plants in the area.

Broadleaf plants: most annual and perennial plants, shrubs and trees with wide leaves. Does not include grasses, conifers or other plants with needles or grass-like leaves.

Blotter test: is a germination test for seed viability, placing a number of seeds on a moist paper towel and keeping it moist for a week or two to see how many sprout. The name is a carry-over from the time when ink blotters were in general use.

Cation exchange capacity (CEC): is the measure of capacity of the soil to attract cations or to release elements, such as calcium, magnesium, and potassium, into soil solutions. In good soil, CEC tests commonly shows ranges of 10 to 20 meq/100 g.

Class A facility category: are turf areas expected to receive a high level of service (e.g. fine ornamental lawns, golf and bowling greens, irrigated sports fields).

Class B facility category: are turf areas expected to receive a moderate level of service (e.g. residential and commercial lawns, boulevards, recreational areas, golf fairways).

Class C facility category: are turf areas expected to receive a low level of service (e.g. meadows, picnic areas, rough grass, undeveloped and naturalized areas).

Clay soil: soil is classified as ‘clay’ when more than 40% of the content (material) is clay.

Compost seeding: is a blower type applicator process of seeding that mixes the required amount of seed with compost material.

Cultivar: is the name applied to a selection of a plant species (e.g., *Jamestown* Chewing’s Fescue.)

Damage threshold: is the number of pests per given area above which there will be unacceptable damage to the turf if controls are not applied.

Dethatching: is the process of removing an excess build-up of thatch. This is commonly done mechanically with a dethatcher, vertical mower.

Dormant/dormancy: is the seasonal halt to visible growth in plants or activity in animals, usually for the winter season. It may also occur during periods of drought.

Ecosystem: is an ecological system that includes a community of interacting living organisms along with the environment they live in.

Endophytes: are fungi that live inside the grass plant, benefiting the host plants by providing protection from insects that attack the shoots.

Fast release nitrogen: is water-soluble nitrogen present as nitrate (NO_3^-) or ammonium (NH_4^+) that is readily available for uptake by the roots.

Flotation sampling method: is the method of determining the number of insects on the surface of the ground per given area. An open ended cylinder 2-5 cm is pushed into the soil, filled with water and the number of insects that float to the surface after an appropriate interval - a 10 minute period for Chinch Bugs – are counted. Populations per unit area are calculated mathematically after determining the area of the can.

Friable seedbed: is a soil surface prepared for seeding with at least 25 to 50 mm (an inch or two) of fine loose soil.

Fungi: are a group of often-microscopic organisms lacking chlorophyll (green colouring); they grow from microscopic spores. Many are beneficial, forming part of nature’s food chain, and others cause diseases that suppress insects. Some are harmful, causing plant diseases, such as rots, rusts, mildews and blights. (Singular: fungus)

Grasscycling: is the mowing process that leaves the grass clippings on the lawn to recycle into the soil.

Grid weed monitoring method: is the process of calculating the average number of weeds per m^2 of lawn by placing a 0.5- or 1-metre square frame randomly (or along a “W” path) on the lawn and counting and identifying the number of weeds inside the frame.

Hydraulic seeding: is the method of pumping a seed-water (and often a mulch) mixture through a hose or gun onto a prepared surface. It was originally developed as a quick method for seeding slopes, hard to reach areas, and large areas like roadside rights-of-way.

Infiltration rate: is a measure of the speed that soil absorbs surface moisture from a rain event or irrigation.

Injury threshold: is the level at which pest numbers are high enough to cause unacceptable injury or damage.

Instar: describes the different moulting stages (or stages of development) of an immature insect as it grows.

Integrated pest management (IPM): is a decision making process for managing pest populations that uses a combination of techniques; it includes preventing pest problems through cultural practices, pest identification, monitoring, and the use of population thresholds for chemical control decisions, a combination of controls (cultural, physical, mechanical, biological, chemical, etc., preferably in spot treatments) and an evaluation step.

Life cycle: is the time path an organism follows from birth through juvenile development to adulthood, reproduction and death. It also deals with the habitat in these stages, with specific attention to the time periods and locations for effective control of pests.

Loam soil: soil is classified as ‘loam’ when all three particle sizes (sand, silt and clay) are represented in more or less 40% - 40% - 20% proportions.

Micro-organisms: are living organisms, including fungi, viruses, and bacteria that can only be seen with a microscope.

Mowing height: is the height of the mower setting. The recommended height is 6.5 to 7.5 cm (2 ½ to 3 in) for lawns and amenity turf.

Nutrient ratio: is the ratio (expressed as percentages) of nitrogen, phosphate and potash (N:P:K) in fertilizers.

Overseeding: is the application of seed to an existing lawn.

Percolation rate: This is the rate that moisture entering the soil moves downward through the soil pores due to gravity**.**

Perennial plant: describes a plant that has a life span of more than two years. The top may die back in winter or in drought, but the roots or rhizomes persist to resume growing in favourable conditions.

Plant available moisture: is the amount of moisture in the soil that is actually available for use by plants.

Plant succession: is the term to describe the adaptation (and dominance) of the plant species best adapted to site soil and maintenance conditions.

Quadrat insect sampling method: is the method of determining the number of insects per given area by placing a 0.1 m^2 (1 ft^2) frame or "quadrat" on the lawn and counting the number of insect pests that can be found within 45-60 seconds.

Renovation: is a more drastic approach to correcting turf problems. It involves getting rid of the existing turf, cultivating the surface and reseeding to remedy sparse turf, or to repair a surface that has become too uneven to mow or to use as intended.

Rhizomes: are plant stems growing horizontally beneath the soil. They help spread the plant by producing shoots above the stem, and roots below. Couch grass roots are the most commonly visible example.

Rough grading: the process of removing as much construction debris, tree stumps, and rocks as practical, installing any service, drainage, or lighting conduits, and levelling the surface for the application of topsoil.

Sandy soil: is a term to describe soil containing more than 45% (in high clay percentages) to 52% (in low clay percentages) of sand.

Seed bank: describes the seeds that have accumulated over the years in the top layer of soil.

Slow release nitrogen: is the insoluble chemical or organic form of nitrogen that must be first broken down by soil micro-organisms into a water-soluble form before it can be taken in by the roots.

Sod: is the term used to describe strips of turfgrass, with soil attached, used to establish new turf vegetatively. It comes in a variety of lengths, widths, and thickness. These include 1 yd^2 rolls or about 0.6 yd^2 slabs for manual handling, and large rolls (up to 30 yds^2) for mechanical laying. Normal widths are 16, 18 and 24 inches.

Soil air exchange: is the process where oxygen moves into the soil zone in exchange for carbon dioxide diffusing out of the soil.

Soil amendments: are products added to soil in an effort to improve growth characteristics.

Soil capillary action: is the upward movement of moisture between soil particles, even against gravity.

Soil microbial community: is the living component in topsoil that is essential for healthy, sustainable plant growth.

Soil moisture reservoir: is the soil foundation that stores moisture, and makes that moisture available to the plant roots either by direct contact or by capillary action.

Soil moisture storage capacity: is the calculated amount of water stored in a given depth of a soil.

Soil organic matter (OM): also called humus, is the decaying plant matter in soil. It is the organic matter that feeds the soil micro-organisms, improves the soil structure, the capacity of the soil to hold plant nutrients and water, and is a key indicator of the capability of soil to grow plants.

Soil pH: is the measure of hydrogen ion activity (or concentration) in a soil solution. The pH value determines how available most nutrients are, both to plants and to the soil micro-organisms. A pH of 6.5 is recommended for turfgrasses.

Soil structure: is a term that describes the clumping or agglomeration of soil particles in healthy soils. It contributes significantly to healthy plant growth.

Soil texture: is a term that describes the proportion of sand, silt, and clay particles found in a particular soil. It is the major factor in determining the size of the pore spaces between the soil particles and (along with organic matter content), the air, the moisture, and nutrient holding capacity of the soil.

Soil triangle: is a graphic tool used to classify soil type by plotting the percentages of sand, silt and clay and establishing the boundaries that define soil texture classifications (e.g., loam, silty loam).

Spot pest treatment: refers to an application of a pesticide to localized or restricted areas (e.g., individual plants) as opposed to a broadcast treatment that involves a uniform application over an entire field or area.

Subsoil: is that soil layer below the ‘topsoil’ or ‘A’ soil horizon and is considered to be a poor growing medium. With effective amendment, it can be a better growing medium than much of the purchased topsoil available.

Sustainable lawn management: is the development of a management regime for a turf site that reduces the need for water, fertilizer and herbicides.

Thatch: is the dark brown mat of un-decomposed plant tissue lying on top of the soil. It typically consists of stems, rhizomes, stolons, leaves, and roots with a high lignin content that are difficult for soil microorganisms to break down.

Topdressing: is the placing of properly matured compost or topsoil on turfgrass to stimulate soil microbial populations and provide additional nutrients to the turf.

Topsoil: is generally accepted as the top layer of soil on the ground in which most plant root activity occurs, is generally 10-30 cm (4-12 in) deep and often referred to as the "A" soil horizon.

Transect weed monitoring method: is the process of calculating the percentage of area covered by weeds by walking along a series of lines or transects across a lawn, observing at fixed intervals the type and number of each visible weed.

Water holding capacity: (see soil moisture storage capacity).

Weed treatment action threshold: is the value of the percentage of weed cover or the weed counts per m^2 at which a weed treatment program can be considered. The action threshold value will vary depending on the facility class category.

Weed: is a plant in the wrong place. In a weed-free turf, both broadleaf plants and some off-colour turf species, like annual bluegrass, rough-stalked bluegrass, crab grass, or some creeping bent grasses, are considered weeds.

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