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EDMONDS ENVIRONMENTAL SERVICES DIVISION

THE OAKS EXPERIMENTS ON ORGANIC MANAGEMENT OF TURF

Edmonds' Sustainable Economic Development Project

SUMMARY of a Report by:

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Contents: **Page:**

The Organic Approach

FORWARD

This Greenfacts is a summary of a 380 page research report titled *The Oaks Experiments on Organic Management of Turfs*. The research report documents in detail the results of a four year project developing an organic approach to turf management. This summary provides the context in which The Oaks Experiments were conducted and describes the experimental design and some of the key results. Further, the Greenfacts provides practical guidelines and specific recommendations so that those wishing to apply organic approaches to turf may do so. The Greenfacts is not a detailed summary. Some of the statements are not supported with statistical data or literature references, however, all of this supporting information is contained within the original research report. We hope that you find this Greenfacts informative and useful. A copy of the complete research report is available from Edmonds Landscape and Construction Services Limited, 2065 Clifton St., Halifax, Nova Scotia, B4K 1V4 (CDN$38 for black/white version and CDN$54 for color version). It is also available in major libraries in Nova Scotia.

I. INTRODUCTION

The landscape management industry in North America - of which turf management for golf courses, parks, commercial, institutional and residential properties is a major component - is a multibillion dollar industry (Watson, et. al., 1992). Acreage of turf is larger than for any other single crop species in the U.S. (BOX 1). For many people, "the lawn" is the most immediate contact they have with plants and nature.

Golf course and "high end" residential turf receive chemical inputs equivalent to or exceeding those in intensively managed agricultural crops (Bormann, et. al. 1993). Organic products and services account for less than 10% of total expenditures on turf management. However, this is a rapidly growing sector, driven by public concern about chemicals, increasing regulation of their use, and the necessity to find uses for unprocessed and processed organic wastes.

A high level of interest in organics notwithstanding, over the past few years, inconsistency in supply and quality of organic amendments, lack of experience with organic approaches, and a dearth of scientific research into the organic approach (BOX 2) have limited its development. The organic sector of the turf management industry is therefore still in its infancy and there remains much skepticism about the efficacy of organic methods.

In 1989 Edmonds Landscape and Construction Services Ltd. created Edmonds Environmental Services Division to begin addressing chemical usage within the company. With the use of organic fertilizers, mulch mowers, and aerators, Edmonds found that they were able to maintain or even increase turf quality without any use of synthetic fertilizers or pesticides (Photo 2a). In 1991, Edmonds received a Canadian Award for Business Excellence, Environment Division, in recognition of their innovations it pioneered in organic landscape practices. Edmonds was also the first Service company, and the first Landscape Management Company, to be awarded the "Eco-Logo" seal of approval by the National "Environmental Choice" Program

In making the transition to organic landscape management, Edmonds had to rely largely on informal (non-scientific) literature, as there was little scientific literature available, or it was hard to find, and almost no testing had been done locally. Initially, there was a dearth of organic fertilizing materials available. Following local and national recognition, however, numerous requests came in for Edmonds to purchase or test new organic products. Some of these products met with a high degree of success from the beginning, although how to use them most efficiently still required testing. Others proved deleterious in some applications, and beneficial in others. "Composts" were found to be highly variable even between different batches from the same supplier.

Such inconsistencies, or interruptions in supply of the most effective fertilizers, or in some cases, high weed levels or consumer skepticism, have prevented complete conversion of operations to organic management. However, complete conversion remains the company's goal. To achieve that goal - and for others to do likewise - inefficiencies in the system need to be reduced so that organic management is more predictable, and more efficient ecologically and economically.

The "Oaks Experiments" were the public demonstration component and the major research component of a larger project on "Total System Organic Management for Turfs", which was supported by the Canada-Nova Scotia Sustainable Economic Development Agreement. The experiments were designed to address two practical questions for which there was a shortage of information:

BOX 1: Urban Agro-Ecosystems.

Urban areas are not often thought of in an agricultural context. They are and always have been, however, sites of some of the most intensive agricultural or horticultural activity.

In the past, food production in urban areas contributed significantly to the urban diet, and turned the major potential transport pollution problem (stable manure) into an asset. It has been estimated for example that "in energy, mass and monetary terms the inputs and outputs of the [19th century] Parisian urban agroecosystems exceeded those of most examples of present-day, fully industrialized crop production... the volume of fresh salads, vegetables and fruits produced was equivalent to 50 kg per annum per capita, more than the present-day levels of consumption of these food." (Stanhill, 1977).

These intensive, organic, vegetable production systems waned with the advent of the automobile. Since the 1970's, these has been a resurgence of interest in urban vegetable gardening using mostly chemical methods of production; more recently a wide variety of organic fertilizers has become available as a result of recycling programs.

It is the horticultural components that most distinguish today's urban agroecosystems: shrubbery, trees, flower beds, and lawns around residential, institutional and commercial properties, and public playing fields, golf courses and parks beautify our cities, absorb noises and chemical pollution, provide recreation, and create jobs to care for them.

These horticultural systems consume immense quantities of agrochemicals. For example, lawn care pesticides alone account for 8% of pest control products sold in the U.S. (GAO, 1990). Per unit area, the rate of usage of pesticides in urban areas has been estimated as 3 to 10 or more times the rates used in corn and soybean (Ginsburg and Osborne, 1984), which are pesticide intensive crops. Higher levels of pesticide residues have been found in soils from urban regions than in agricultural soils (Carey, 1979). Fertilizer use is equally intensive; on the substantial turf areas in the urban environment, rates of N use can be as high as 200 - 300 kg N/ha per year which are equivalent to or greater than those for the most heavily fertilized crops such as potatoes; otherwise, rates are equivalent to or greater than those used on typical farm crops such as small grains (Dynisveld, 1992).

There is growing concern over potential health and environmental hazards associated with the intensive use of agrochemicals in urban areas. For example, an epidemiological study which linked neural tube defects in New Brunswick to pesticides (Hatcher and While, 1985) noted that "data on home and garden pesticides were inadequate for any type of analysis although this could represent the most significant direct exposure of all categories considered." A recent study revealed more lymphoma type cancer in dogs from residences where 2,4-D was used on lawns than in dogs from residences where herbicides were not used (Hayes, et.al., 1991); another study indicated a higher incidence of child leukemia in homes where pesticides were used (Lowengart, et.al., 1987). In the U.S., the Environmental Protection Agency banned use of diazinon on golf courses following definitive evidence that it kills birds, but it remains one of the most commonly used pesticides in urban areas (US GAO, 1990).

Runoff of pesticides and fertilizers contribute to pollution of surface and ground waters in urban regions (Flipse et.al., 1984). This is well known locally: in spite of the many remedial measures taken to protect lakes in the Sackville/Dartmouth region of Nova Scotia, there is evidence of continued decline in lake quality, and runoff of fertilizers is suspected to be a major factor (Hart and Waller, 1990).

Concurrent with the rising concern over agrochemicals in urban areas, the relatively high priced urban market is being looked upon as the major potential consumer of organic fertilizers produced from organic waste stream materials, i.e. as the economic driver for recycling of organics.

We appear to be coming full circle, from and to the practice of intensive organic agriculture and horticulture in urban regions. According to Stanhill (1977), the marais production systems of Paris developed slowly from the walled gardens of medieval Paris reaching maximum sophistication and importance in the second half of the 19th century. Today we don't have that length of time to resolve our waste disposal problems; further, the variety of materials we deal with, the fluctuations in supply, the possibilities for industrial contaminants, and the stringency of public health standards are very much greater. Developing this new urban organic agriculture and horticulture must be approached using all of the tools of science at our disposal, and enlist the collaboration of business, institutions and individuals. It is not an issue of whether "organic is better" as has been debated so vehemently in the past, but rather one of making the organic approach work.

BOX 2: What is *organic* management?

The essence of organic horticulture is the achievement of high aesthetic and functional quality by enhancing natural processes, rather than by using substitutes for them.

The word organic comes from "organismic" meaning pertaining to the whole, thus it is a whole system or holistic approach. The approach emphasizes:

Recycling to conserve resources, and add organic matter to the soil.

Diversification of habitat and species composition to give a good balance of nature for pest control, water conservation, etc.

Feeding the soil: a healthy soil, it is maintained, provides balanced nutrition and produces healthy, pest resistant plants.

Using legumes to provide inputs of nitrogen.

The organic approach discourages the use of substitutes for natural materials and processes, such as synthetic or highly processed fertilizers, synthetic pesticides and genetically engineered organisms. Under strict organic management, these substitutes are prohibited. Even natural pesticides such as rotenone are discouraged; they are seen only as a last resort and necessary to use only during the transition to organic management when there are still many imbalances in the system.

Following are some of the do's and don'ts of organic turf management which follow from the general principles of the organic approach (the do's) and in the case of don'ts, from requirements for strict organic management. Some of the rationale for the "don'ts" are provided.

FERTILITY

Do's

- Use organic amendments to fertilize soil and composts to increase humus.
- Use grass species and mixtures that do not require high N.
- Use a mulch mower to recycle clippings in place.
- Encourage clover (fixes N_2 gas from air, brings minerals up from depth).
- Assess N needs by greenness (visual), and % soil organic matter (lab test).
- Assess needs for P, K, and lime by soil tests in fall or spring.

Don'ts

- Do not use synthetic or processed fertilizer salts, especially highly soluble N fertilizers. They acidify soil, and in excess, cause rank growth which encourages pests.
- Do not use muriate of potash (KCl). The Cl ion is slightly toxic. Use potassium sulfate, sul-po-mag or other K source (wood ash, granite dust).

WEED CONTROL

Do's

- Mow high (2.5 - 3.0 inches or 6 - 8 cm) to favor grasses over weeds.
- Use complex seed mixtures.
- Practice timely manual weeding followed by overseeding and mulching with compost.

Don'ts

- Do not use herbicides: they have sub-lethal effects on non-target plants which make them more susceptible; they kill clover; they add to the pesticide load on the environment.

PEST AND DISEASE CONTROL

Do's

- Focus on ensuring a healthy turf; it is more resistant to pests and diseases.
- A healthy turf is more resistant to pests and diseases.
- Avoid over- or under-feeding grass with nutrients or water.
- Use complex mixtures.
- Dethatch and aerate as appropriate.
- Water regularly but not excessively, allow natural mid-summer dormancy or water regularly...not in between.
- Monitor pests.
- Use broad spectrum biological pesticides only when absolutely required.

Don'ts

- Do not use any synthetic insecticides or fungicides: they kill beneficial organisms; they treat symptoms rather than causes; they add to the pesticide load in the environment.
- Do not create stress by mid-season fertilization and then not watering sufficiently to support the growth demand.

1. How do we use organic fertilizers and soil-building amendments on turf for maximum aesthetic benefit without overusing them?

2. What turf species and mixtures are most suitable for organically managed turfs?

The experiments were established in the spring of 1992, and ran over four seasons. In an effort to realize both scientific credibility and a high degree of realism, replicated experimental treatments were superimposed on turf at an urban site which was maintained by company personnel using their normal practices for strict organic management.

II. THE OAKS EXPERIMENTAL SITE

Many visitors to "The Oaks" site recognized it as once the site of the Maritime Conservatory of Music (leased from St. Mary's University), and between 1945 and 1968, the residence of Premier Robert L. Stanfield and family. Currently, it houses the Gorsebrooke Institute and offices for several projects at St. Mary's University. The property encompasses approximately five acres including woodland, gardens, and lawns.

Once well known for its beauty, the grounds deteriorated after Premier Stanfield sold the property, and it served as a fraternity house. During that period, many exotic plants were taken, and parts of the wooded area became littered. St. Mary's began restoring the building and grounds in the late 1980's. The turf areas provided a convenient urban site for Edmonds to conduct field trials in organic turf management, while at the same time, renovating them.

There were two large turf areas at The Oaks; the "B field" behind the house, and the "F field" in front of the house (Figure 1). The F field was established in the spring of 1992 on top of fill by leveling it and adding a six inch (15 cm) layer of ordinary grade topsoil that had been enriched with lime and soluble nutrients.

In the spring of 1992, the existing turf on the B field was in poor condition. It had been completely devastated by chinch bug (Photo 1a) and the soil was strongly acidified (pH 4.6) and nutrient poor. The field was rotovated on May 3 and limed on May 12 with a mixture of coarse and fine dolomitic limestone. Soil depth varied between three and nine inches.

Thus, the F and B field soils could be considered representative respectively of the "instant" topsoil found in new developments, and of older, severely run down soil often found at older sites.

III. DESIGN OF THE EXPERIMENTS

The Oaks Experiments were experiments in strict organic management: we were not using banned materials except for use of synthetic NPK fertilizer on some reference plots. The results, however, have applications to "conventional" and "functionally organic" systems as well as to strict organic systems. By "conventional", we mean systems in which synthetic fertilizers and pesticides are used routinely. Even in those systems natural processes are still very important, and enhancing them can reduce the needs for expensive inputs, or complement the inputs to give better quality. By "functionally organic" we mean systems in which most of the material flows are organic, and pest control natural, but there may be some spot or one time use of pesticides, or use of very modest amounts of certain fertilizers such as superphosphate.

Amendments were made to the soil on May 16 - 21, 1992 and grass seeded on May 22 - 25. Fifty-seven different treatments were distributed in a patchwork through the turfs, most of them replicated three or four times (Figure 2; Appendix 2). Observations were made through the ensuing three field seasons (1992, 1993, 1994). A restricted set of observations were also made in 1995. Plots were marked with buried posts, and except for the application of fertilizers, conducting scientific observations, and bag mowing of sixteen 2 x 2 m plots separately from the rest of the area (which was mulch mowed), the site was maintained by normal commercial cultural practices used by Edmonds. That involved weekly mowing (grass cut at 2.5 inches), aeration and dethatching (both in the spring of 1993 plus aeration in early November, 1993), manual weeding, and overseeding (1992, 1993). No herbicides or other pesticides were applied over the four years of the experiments.

The experimental design, while efficient in use of resources, created a particular problem that entailed some risk. We anticipated that certain treatments would be more susceptible than others to pests and diseases. By not using pesticides, we would be able to learn how the fertility treatments and turf mixtures affected turf resistance to pests. However, at the same time, the susceptible

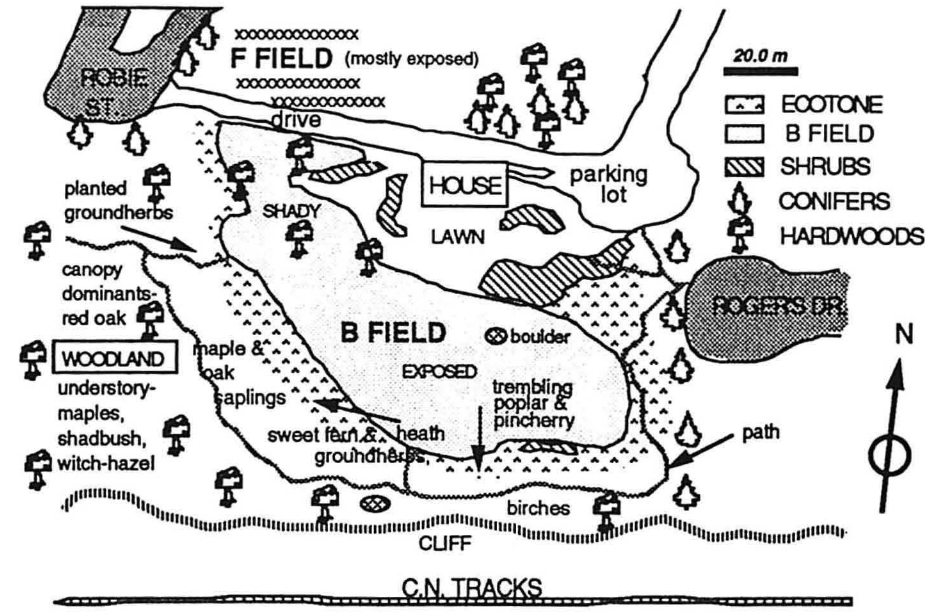


Figure 1. Diagrammatic illustration of major vegetation types surrounding the B (back) field at The Oaks, and location of the F (front) field. The area of the B field is approximately 2000 m^2, that of the F field (not detailed in the diagram), 1200 m^2.

treatments might allow reservoirs of the pests to build up which could overwhelm even the more resistant treatments. If we then resorted to use of pesticides, we might save the experiments, but we could no longer maintain that they were strictly organic. We had some periods of concern: with chinch bug in years one and two, and with a fungus (red thread) in years two and three. In both cases, at the height of our concern, we applied a mild soap solution to set the pests or disease back and hoped that the organic regimes would do the rest. They did, and we were able to learn how the different regimes and treatments affected resistance.

There were two major sets of experiments: the Fertility Experiments, and the Mixture Experiments (BOX 3).

The Fertility Experiments

In these experiments, we examined (i) the influence of bulky soil amendments applied to the soil before seeding, on the need for annually applied organofertilizer and, (ii) the influence of both types of amendments on turf quality and soil properties. The amendments were ones which were readily accessible locally. The bulky amendments, which were applied to "main plots" were:

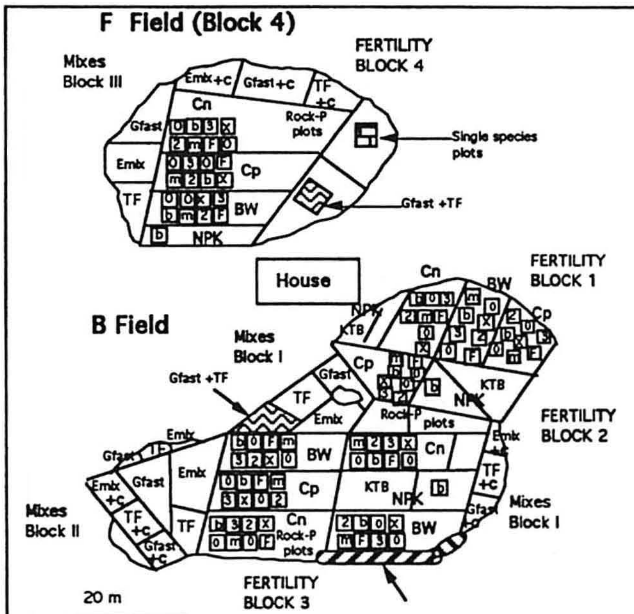


Figure 2. Diagram of plots at The Oaks. Main plots are NPK (synthetic fertilizer), Cn (Control), Cp (Compost), and BW (Brewery Waste). Small squares are the organofertilizer subplots with treatments as modified in 1993/4: 0 = no organofertilizer; m = 1 lb N per 1000 sq ft per year; b = 1 lb N, bag mowed; 2 = 2 lbs N; F = 2 lbs N, liquid fish used in place of organofertilizer in the fall of 1993; 3 = 3 lbs N; X = 3 lbs N but no fertilizer applied in 1994. Mixes are TF (tall fescues), Gfast (Greenfast), Emix (Ecomix); +c refers to clover overseeded. Ktb refers to areas seeded with Kentucky bluegrass. Scale bar applies to Blocks and main plots. Subplots are 2 m x 2 m.

BOX 3. Experiments conducted at The Oaks: background.

THE FERTILITY EXPERIMENTS

In the Maritimes, hundreds of thousands of tons of waste are produced each year in the fishery, forestry and agricultural industries, most of which now goes into landfills or directly into rivers and the sea. Alternatively, these wastes could be processed for use or used directly as soil building materials and fertilizers. The waste products from the region's natural resource industries therefore provide a tremendous opportunity to produce high quality organic fertilizers and soil-building materials, while solving some critical environmental problems.

A major impediment to these alternatives is the limited experience and research in using organic waste stream products (OWPs) in the place of synthetic fertilizers. Analyzing the total nutrient content does not indicate what is available to plants because some or most of the nutrients are bound up in organic materials which must decompose for the nutrients to be released. The intensity of the decomposition process is a function of the types of organic compounds, the types and numbers of organisms in the soil and the microclimatic conditions. There is considerable information on these topics in the scientific literature, but that information has to be calibrated for the specific types of OWPs and for local conditions. Resolving these limitations is critical to realizing the full benefits of organic amendments.

For organic materials to become more competitive with NPK fertilizers it is especially required:

(1) to improve predictability of their fertilizing qualities so that they will be used as alternatives to NPK, and so that when used, they are not overused resulting in adverse side effects such as pollution of aquatic systems and stimulation of pests;

(2) to document and improve predictability of their other beneficial attributes, such as their effects on pests, so that users can make appropriate calculations of real costs and benefits;

(3) to popularize the understanding of how organic amendments work, together with (1) and (2), this will reduce skepticism about organic approaches.

The fertility experiments at The Oaks were designed to provide fundamental, scientific information related to these issues, while at the same time addressing immediate real questions posed by users of organic materials as fertilizers.

THE MIXTURE EXPERIMENTS

In the Northeastern U.S. and in Canada, the traditional mainstay of turfs is Kentucky bluegrass. When managed with fertilizer and pesticides and irrigated as required, this species produces early greening, dark green turfs of uniform quality. Some difficulties with Kentucky bluegrass, even with conventional management, are high levels of pests (particularly chinch bug), a tendency to build up thatch, and low drought tolerance. Most cultivars of Kentucky bluegrass require a high level of N fertilization to achieve desired greenness (about 3 - 5 lbs N/1000 sq ft or 150 - 250 kg N/ha) which is expensive, and can contribute to nitrate pollution of groundwater. The heavy use of synthetic nitrogen acidifies soil, and extra lime has to be applied to maintain a favorable pH; also it encourages pests, which is one reason these turfs require a lot of pesticide for top quality.

It is well documented that the success of different species or varieties grown in monoculture or in mixtures can be strongly influenced by the fertilization, mowing, water, pest and weed control regimes, as well as by site specific variables. Thus it is to be expected that varieties, species and mixes that have been selected for use under conventional, chemically intensive turf management will not be the best under organic management, and further that they may even perform poorly under organic management. Research to identify mixtures of different grass species for organic management is lacking both locally and elsewhere.

The mixture experiments at The Oaks were developed to identify mixtures that might perform well in a Maritime climate under two different organic maintenance regimes (see BOX 4).

(1) Unprocessed brewery waste. (5% N, 0.5% P, 0.4% K, 78% OM on dry weight basis). This material was provided fresh from a local brewery and applied to give an intended N application of 300 kg N per ha; the actual rate was 469 kg N per ha.

(2) Potato compost. (0.6% N, 0.5% P, 0.7% K, 32% OM on dry weight basis). The compost had been prepared in PEI in 1991 from potato culls, farmyard manure, sawdust, and wood ash, using a windrow method with turning two to four times. It was applied to give a one inch cover of the soil (before incorporation), which is a fairly typical rate of application for composts. This corresponded to a N rate of 589 kg per ha.

These were compared with:

(3) Synthetic NPK fertilizer. Urea (44-0-0), superphosphate (0-20-0), and potassium sulphate (0-0-50) were applied to give 2, 3, and 6 lbs N, P_2O_5, K_2O per 1000 sq ft respectively.

(4) No amendment. The control treatment.

After spreading the bulky amendments, all plots were rototilled.

The annually applied organofertilizer was "Seagreen" (NPK: 7-9-7), a pelleted fish based fertilizer from National Sea Products Ltd., applied at rates of 0, 1, 2, and 3 lbs N per 1000 sq ft per year to 2 x 2 m "subplots". Initial applications at these levels were spread on soil in the subplots just before seeding, and incorporated to a depth of 10 - 15 cm using shovels. Then the whole area was seeded with "Ecomix". Subsequent top-dress applications were made two or three times annually beginning in the fall of 1992 (see Appendix 3). The NPK main plots were top-dressed with 3 lbs N annually as synthetic fertilizer; 1 lb was applied in spring, 1 lb in mid-summer, and 1 lb in the fall, per 1000 sq ft.

The Mixture Experiments

In these experiments (which are probably better termed trials), we compared three turfgrass mixtures for their performance under two organic management regimes. The mixtures selected were ones that we considered before hand were likely to perform well under organic management. They were:

(1) "Greenfast", an off-the-shelf, general purpose mix, sold by Halifax Seed Co. containing 40% Kentucky bluegrass, 15% chewing fescue, 15% creeping red fescue, and 30% perennial ryegrass.

(2) "Ecomix", a custom blend which essentially followed a recipe recommended by ecological turf managers in the U.S., modified as suggested by Tim Tregunno, Halifax Seed Co. Ecomix contained 15% chewing fescue, 10% creeping red fescue, 35% hard fescue, 20% Kentucky bluegrass, and 20% perennial ryegrass.

(3) Tall fescues: a blend of two tall fescue cultivars. This mix was recommended by Tim Tregunno as one that might perform well under ecological management, also because the tall fescues were receiving increasing interest within the landscape industry.

The three mixtures were seeded with and without clover (BOX 4). Where they were grown with clover, compost was incorporated in the soil prior to seeding but no fertilizer top-dressings were made subsequently. Where they were grown without clover, compost was incorporated, and plots received 2 or 3 lbs N as organofertilizer in top-dressings each year. The concept was to use clover based mixes as low maintenance mixes, and regularly fertilized mixes without clover as high end mixes.

Other Experiments

For the purpose of researching questions raised by Edmonds personnel after the start of the experiments, one of the two subplot replicates at each of the 1, 2, and 3 lbs organofertilizer-N levels was subsequently utilized for another experiment. In relation to fertility questions, experiments included:

- comparison of dormant feed and early fall feed of fertilizer on spring greening up;
- comparison of mulch mowing and bag mowing;
- comparison of a liquid fish silage product with organofertilizer as a dormant feed
- comparison of deleting and not deleting organofertilizer application at the 3 lb N level in the third year;
- comparison of mid-summer versus late summer application of 1 lb N at the 3 lb N per annum organofertilizer level.

In addition, separate experiments or trials were established to:

- compare a Kentucky bluegrass blend with Ecomix;
- test a mixture of 35% tall fescues with 65% Greenfast.

BOX 4. Clover: To be or not to be included in ecological turfs?

Before the advent of broad leaf herbicides, white clover (*Trifolium repens*) was a common component of turfs, whether seeded or invading naturally. With the advent of regular herbicide use in the 1950's, it was the first to disappear, and promptly became labeled a weed.

Potential advantages of clover are its nitrogen-fixing ability, greater drought tolerance than grasses, and that as a broad leaf, it competes with other (less desirable) broad leaf herbs. A study of clover in Nova Scotian pastures and in a turf on the Dalhousie University campus, revealed that white clover fixes up to 100 kg N per hectare annually under Nova Scotian conditions (Vessey and Patriquin, 1984). The drought tolerance is evident in mid-summer when clover patches on unwatered turfs remain dark green while clover-free grass browns.

Disadvantages or undesirable features that have been cited are its white flowers, that its leaves can stain white clothing, and that bees attracted to its flowers may sting children. D.G. Hessayon (1994) noted, "...clover is a major headache for many lawn owners. During the dry days of midsummer the bright green patches stand out against the dull and pale grass. This patchy effect is an eyesore, and control was difficult until the discovery of the newer-type selective weed killers".

We considered clover to be a desirable component of ecological turfs under low maintenance regimes, such as might be used in municipal grounds and large commercial tracts of land. In the mixture experiments, we compared mixes established with and without clover. The minus clover mixes were seeded on plots that received compost, and 2 - 3 lbs N of organofertilizer annually (corresponding to higher maintenance regimes). The plus clover mixes were seeded on plots that received compost initially, but no organofertilizer supplements (corresponding to lower maintenance regimes).

It turned out that there was a heavy seedbank of clover throughout the B field, and clover appeared in abundance on the B field in 1993 (Photo 3a). On the F field, it developed as it typically does on new turfs by radiation out from a few initial plants, forming the unsightly patches as described by Hessayon (Photo 3b). This development complicated our observations, but allowed us to document the effects of the different fertility regimes in the fertility experiments on the development of clover in turf. This information provided a basis for formulating strategies for managing clover in turfs to either avoid it or to encourage it.

Other experiments included:

- comparison of P nutrition between plots receiving and not receiving rock P amendments prior to seeding, and seeded with and without white clover; the concept was to test the proposition that clover plus rock P would effect improved P nutrition while maintaining low levels of soluble P in the soil - the objective was to develop a low P, low N system for use adjacent to lakes or estuaries that are sensitive to nutrient inputs,
- comparison of turf quality and soil characteristics on plots established on chronically poor turf area with and without commercial humates incorporated in the soil and seeded with four different mixtures or blends.

Observations

Detailed observations on turf and soil were conducted over 1992, 1993, and 1994. Selected observations were conducted in 1995. Observations on the different plots included standard soil tests, measures of soil biological activity, and various measures of turf quality, including greenness ranked visually and with a chlorophyll meter, clippings, verdure (top biomass below clippings), compression resistance, nutrient content, cover by clover and weeds, turf species composition and ratings for diseases.

IV. SOME HIGHLIGHTS OF RESULTS AND IMPLICATIONS FOR MANAGEMENT

An important but difficult aspect of The Oaks project was to handle the combination of private interests, documentation of results for the open scientific literature, and dissemination of results to the public and industry. Set out in these pages are some of the key requirements for achieving high turf quality under organic management, many of them learned by costly experience to Edmonds. The regional industry has first chance to capitalize on the results and individuals from the industry will also have much to contribute towards assessing them.

Hill (1985) and MacRae et. al. (1990) describe the transition to sustainable agriculture as occurring in three phases:

1. efficiency, in which increased efficiencies result in reduced inputs and waste,

2. substitution, in which benign inputs are substituted for toxic or ecologically disrupting inputs, and,

3. redesign, where the internal structure is redesigned so that there are less needs for inputs of any kind.

The research conducted at The Oaks focused on the efficiency and redesign aspects of the conversion towards more sustainable turf management. Our research does not eliminate the need for users to experiment. These are not recipes, rather what we are able to provide, based on the improved understanding of these systems that was gained from the research, and on specific experimental results, are *provisional guidelines* for users who want to reduce inputs to their systems and make greater use of alternative materials.

In this section, we discuss the results in the context of their potential use in organic management of turfs. They are discussed in categories in which they are commonly placed, and in a sequence which we suggest is a logical way to think about management of turfs: soil audits, bulky soil amendments, species and mixtures, top-dressing, and other maintenance factors (disease, mowing, weed control).

Soil Audits

In principle, organic systems should operate with the lowest levels of soluble nutrients that allows near maximum productivity or quality. Data from soil analyses are relied on to predict requirements for nutrient supplements, usually with the exception of nitrogen. Yet rarely are the recommendation protocols calibrated for particular situations, and recommendations for nutrient supplements can vary widely between labs (Donald and Warman, 1992).

In general, ratings are applied to a wide range of conditions with bias towards overestimating actual requirements in order to ensure that no crops are underfertilized. Thus one would anticipate modifying a rating upward when site specific calibrations are made, i.e. that a given level of a particular nutrient will be rated higher when the user has site specific and crop specific information.

As a preliminary examination of this question, we used data on tissue nutrient concentrations to rate adequacy of P, K, Mg and Ca in turf grass, and compared those assessments to the soil ratings provided by a commercial lab. Based on this comparison, and taking into consideration mobility of the nutrients in the soil, we make some provisional recommendations on interpretation of soil tests when ratings are applied to organic turf systems in which there is a mixed sward and clippings are recycled by mulch mowing.

Phosphorus Soil P levels varied from 2 to 445 ppm Mechlich-III P; remarkably, even at the site of near-zero soil P, leaf P levels were in the sufficient range (Figure 3). We infer that a lot of P cycles through the organic P fraction, which is not included in the Mechlich-III method. There is as yet no organic-P test which has been widely adopted by soil testing labs. In lieu of that, ***we suggest that low or no P be used on established turf and/or that clippings be analyzed for P in cases where P limitation is suspected.***

Potassium Potassium is highly mobile in soil, and inevitably, a significant amount is likely to be lost by leaching. ***Our provisional calibration suggests that at The Oaks, K would become limiting when soil K drops below about 40 ppm.*** This value is considerably lower than the commercial lab's upper limit, approximately 100 ppm for a "low" rating.

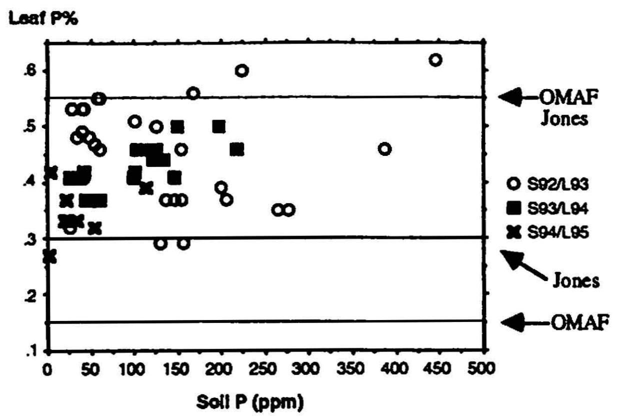


Figure 3. Plot of leaf P vs soil P for three data sets. Arrows indicate the sufficiency levels for P in turfgrass as given by OMAF (1992) and Jones (1980). S92/L93 denotes data point for P levels in soil sampled in fall 1992 and leaves sampled in summer of 1993. The commercial lab's ratings for P levels for The Oaks soil samples were: Very Low- 2-9 ppm; Low- 10-19 ppm; Medium- 20-29 ppm; High- 30-49 ppm; Very High- >50-ppm.

Magnesium and Calcium ***We found that 5% Mg in the soil CEC corresponded to the approximate critical concentration in grass tissue,*** as predicted by the commercial lab's rating of soil Mg. For Ca, there was no evidence for Ca limitation, or overall for general quality problems on the B field, even though many soil values were less than 60% of Ca in the CEC and were ranked "low" or "very low" by the commercial lab. ***For a mixed sward such as Ecomix, at least, it appears that Ca per se was not limiting at percent saturation values well below 65%. It is probably more critical to maintain higher saturation when the sward is predominately Kentucky bluegrass (Watschke and Schmidt, 1992). Low values could also be more critical for clover (Blue and Carlisle, 1985).***

Nitrogen Soil tests, such as the release of nitrate when soil is incubated or the amount of $NH4^{+}$-N extracted after boiling, have been developed that can predict N supply fairly accurately, however, they require at least annual sampling and the predictions are dependent on good calibration data. When one is dealing with different soil types, this is a serious limitation. ***Our data suggest that soil organic matter can be used as a first approximation in estimating soil N supply for turf*** (see page 18).

Soil electrical conductivity (EC) as a measure of soil-plant coupling Patriquin et. al. (1993) suggested on theoretical grounds that EC might be used under non-saline conditions to monitor the coupling and decoupling of the plant-soil system. In closely coupled systems, free ions (and EC) are reduced to very low levels. ***Observations from The Oaks and the theoretical considerations suggest that EC could be used as a diagnostic tool in organic systems***, for example, to indicate sites of over fertilization.

Bulky Amendments

Potato compost Benefits or potential benefits of the potato compost that were documented in this study include:

1. ***Provision of the equivalent of 1 - 2 lbs** N* in second and third years, on the B field.
2. ***Provision of large amounts of P and K.***
3. ***It increased resistance to red thread*** (Figure 4).
4. There was some indirect evidence that ***it improved water status*** of the soils.
5. ***It increased pH on acid soil.***

Problems encountered with the particular compost were primarily:

1. ***It was very hydrophobic***, resulting in some difficulties in maintaining moisture in the seedbed in 1992.
2. ***It appeared to immobilize N and/or have phytotoxic effects*** on the B field in the first year.
3. ***By the second and third years, it stimulated excessive growth*** on the B field.
4. ***It did not have a strong fertilizing effect on the F field.***

Before the experiment began, we expected the compost to have pronounced, positive effects on a low fertility soil such as the F field. It didn't, which we believe, was due to the compost, as received, being immature and to the F field soil having low biological activity. ***These***

observations suggest that for composts to be most beneficial on soils of low biological activity, the compost should be fully mature.

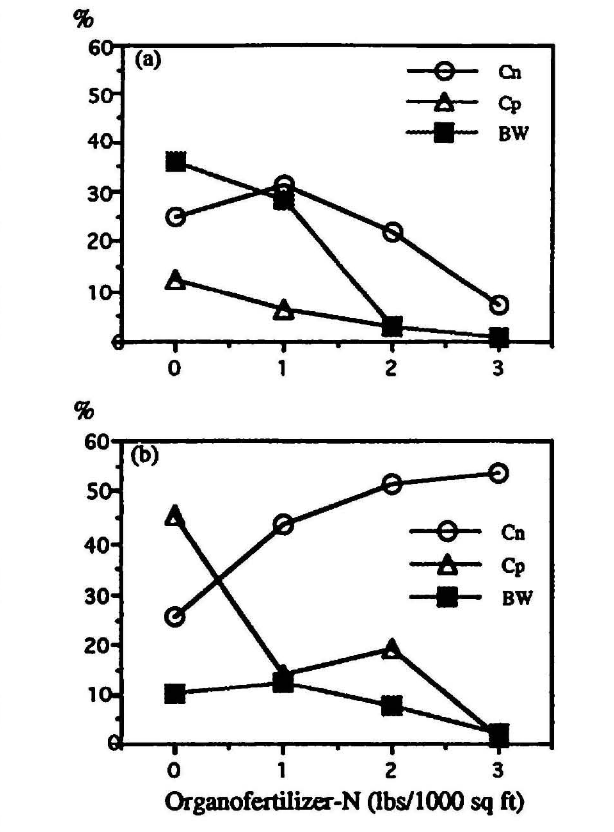


Figure 4. Percent red thread on (a) August 9, 1993 and (b) July 1994 for organofertilizer subplots within each main plot on the F field. Cn = Control; Cp = Compost; BW = Brewery Waste.

On soils of higher biological activity (such as the B field), immature compost might have some benefits for a site being planned for the long term. ***To avoid excessive turf top growth, the application rate of compost to soils of high soil organic matter (>5%) should be reduced to circa 50 t per ha, or less.***

Brewery waste For both the Brewery Waste and NPK treatments, there was evidence that by the end of the third season, they had lower soil quality (lower pH, organic matter, biological activity and increased bulk density; Figure 5), and lower productive capacity in comparison to the Control treatment. Two important conclusions in regard to the brewery waste are:

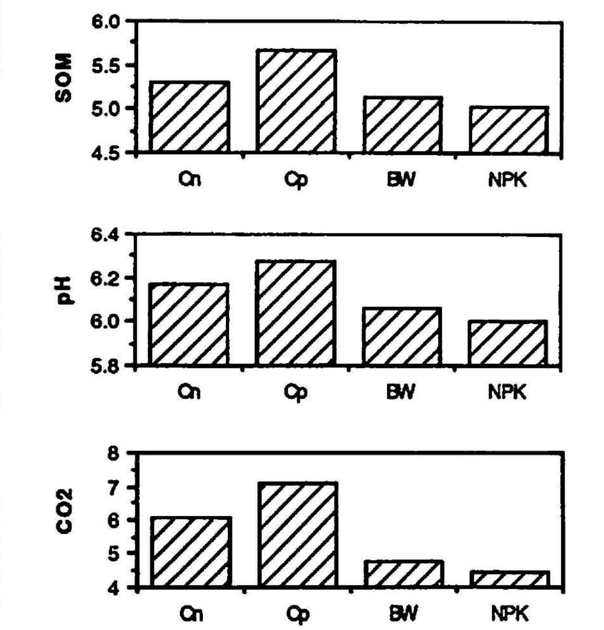


Figure 5. Soil organic matter, pH, and respiration of soil sampled from the B field in the fall of 1994. Units are percent for soil organic matter (SOM) and mg CO_2-C $kg^{-1}hr^{-1}$ for respiration (CO_2). Cn = Control; Cp = Compost; BW = Brewery Waste; NPK = NPK.

1. ***Brewery waste behaves like an organofertilizer rather than like a bulky amendment***, releasing a lot of N over a short period and not building up soil organic matter.

2. The documented detrimental effects of applying brewery waste were a result of an ***excessive rate of application compared to the capacity of the system to take up N***. This was an example of over fertilization using an organic material.

Grass Species and Mixes

Kentucky Bluegrass Kentucky bluegrass has generally been the species of choice of the turf industry in temperate climates. At The Oaks, this species proved to the most susceptible to diseases, which included red thread, anthracnose and two leaf spot diseases. On the plus side, Kentucky bluegrass exhibited very good winter survival (Figure 6), and the Kentucky bluegrass plots were the darkest green in early spring. Curiously, the Kentucky bluegrass subplots in the NPK main plots proved to be highly susceptible to clover invasion (Figure 6); the subplots were also heavily invaded by *Agrostis* sp. in the second year (Photo 3c).

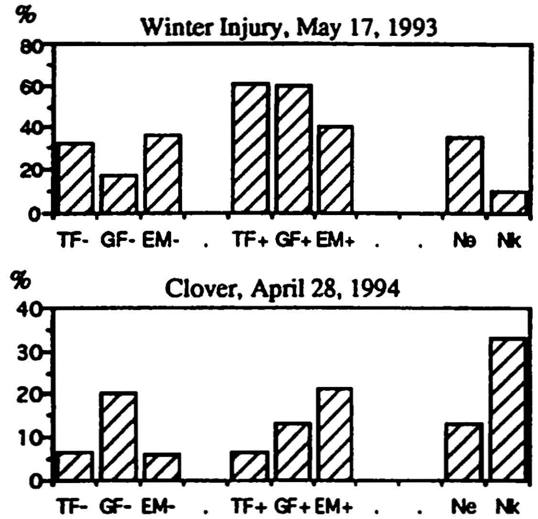


Figure 6. Winter injury (percent bare patches) and clover frequency for the mixture plots. TF = tall fescue; GF = Greenfast; EM = Ecomix; +/- = seeded with and without clover; Ne = NPK$_{Ecomix}$; Nk = NPK$_{Kentucky\ bluegrass}$.

We conclude that ***pure stands of Kentucky bluegrass are very unsuitable for organic systems because of their high susceptibility to invasion by competing species, and their susceptibility to diseases at levels of N and lime that do not render other species susceptible.***

Perennial ryegrass This species suffered no peculiar diseases, and was not the focus of initial infestation of several diseases as was Kentucky bluegrass. It maintained greenness better than Kentucky bluegrass during droughty periods and overall blended well with clover.

Perennial ryegrass performed exceptionally well in these organic systems, growing rapidly in the first year as is its reputation, and, unexpectedly, exhibiting high survival into the fourth season (1995).

Fine fescues The fescues appeared not to be affected by fertility levels. In pure stands, the Reliant hard fescue exhibited very poor winter survival and that likely accounted for the large winter injury in Ecomix in 1992/1993. ***This illustrates that regardless of the type of management, it is probably unwise to seed any cultivar in a high proportion without some knowledge of winter hardiness.***

Tall fescues. The tall fescues produced a turf that even at 80% purity, attracted favorable comments from visitors to The Oaks, who liked its texture, thickness, and color. However, the tall fescues suffered high winter injury, late fall bleaching of leaves, susceptibility to pink snow mold (Figure 7), and poor overall appearance for the first month of spring. ***Presently, tall fescues cannot be recommended for use in pure stands under organic management.***

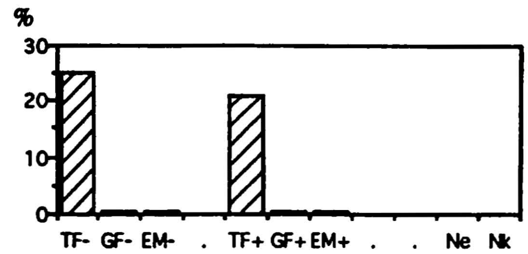


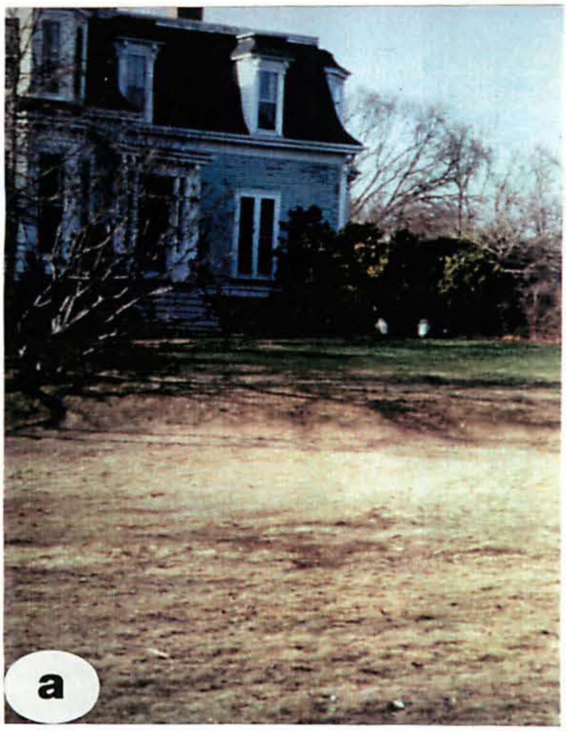
Figure 7. Percent cover by pink snow mold on April 28, 1994. TF = tall fescue; GF = Greenfast; EM = Ecomix; +/- = seeded with and without clover; Ne = NPK$_{Ecomix}$; Nk = NPK$_{Kentucky\ bluegrass}$.

Mixtures Based on the above observations, for organically managed turf locally, ***we recommend a mixture of 20% Kentucky bluegrass, 30% perennial ryegrass, and 50% fine fescues, with 25% each of the creeping and chewing varieties***. A mix of this nature with 35% tall fescue also appears to be a good one, but some further trials would be appropriate.

Clover

A major decision in organic turf management is whether to include or encourage, or not to include or discourage white clover. ***There can be little doubt that clover offers many benefits for organically managed turfs***; features that we documented or have inferred from The Oaks experiment include:

1. ***Presence of clover conferred greater disease resistance*** to associated grasses (Figure 8).
2. ***Clover provided the equivalent of up to 1 - 2 lbs N per 1000 sq ft per year.***
3. ***Clover was probably an important factor in the effective control of broad leaf weeds at The Oaks.***



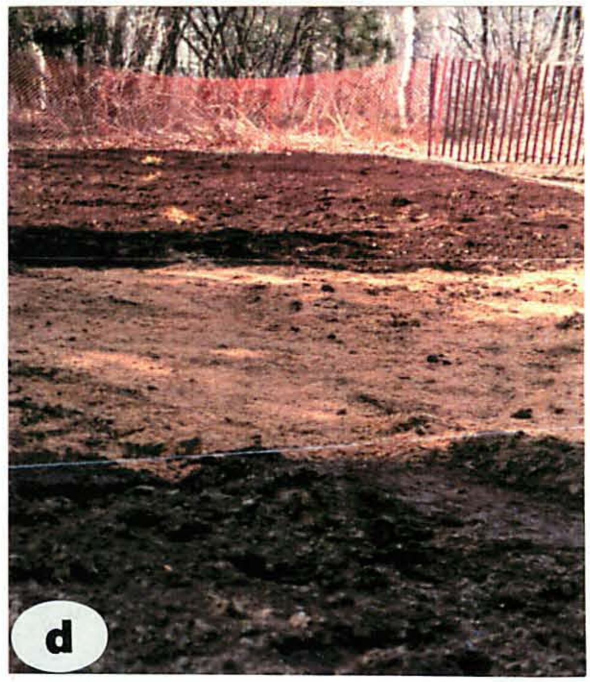
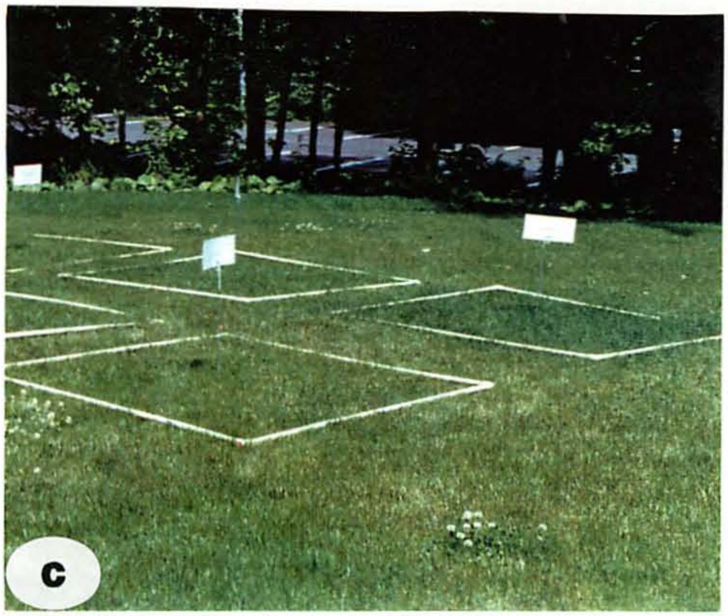
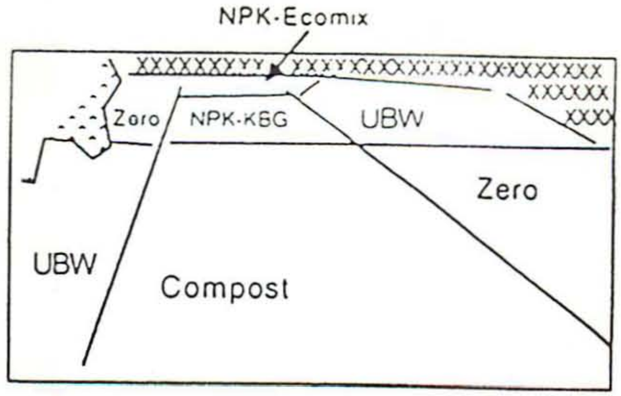


PHOTO 1: Establishment

a. In the foreground, the experimental turf before renovation in April, 1992. Turf had been totally destroyed by chinch bug.
b. Renovated turf in September, 1992.
c. Spent grain being distributed on a Brewery Waste Main Plot; subsequently it was incorporated by rotovating.
d. Control (foreground), Brewery Waste and Compost Main Plots in Block 1, after spreading brewery waste and compost.
e. Compost Main Plot, Block 2 on April 26, 1993. Plot in foreground that had received a dormant feed of organofertilizer in 1992 exhibited the least winter injury. The other plot outlined by a quadrat received no organofertilizer.
f. Single species plot of Reliant hard fescue, June 27, 1993. It suffered the most winter injury of all single species plots. Clover and weeds filled in the spaces created by winter kill of grass.





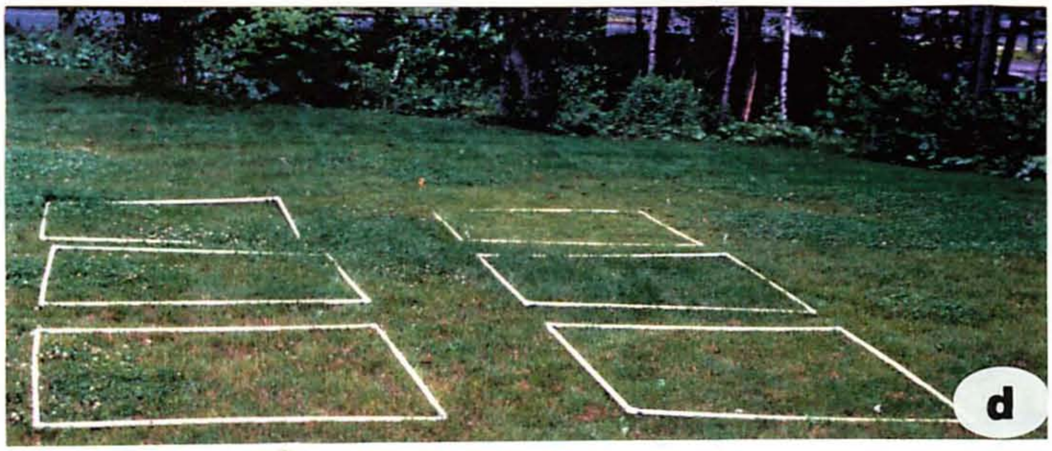
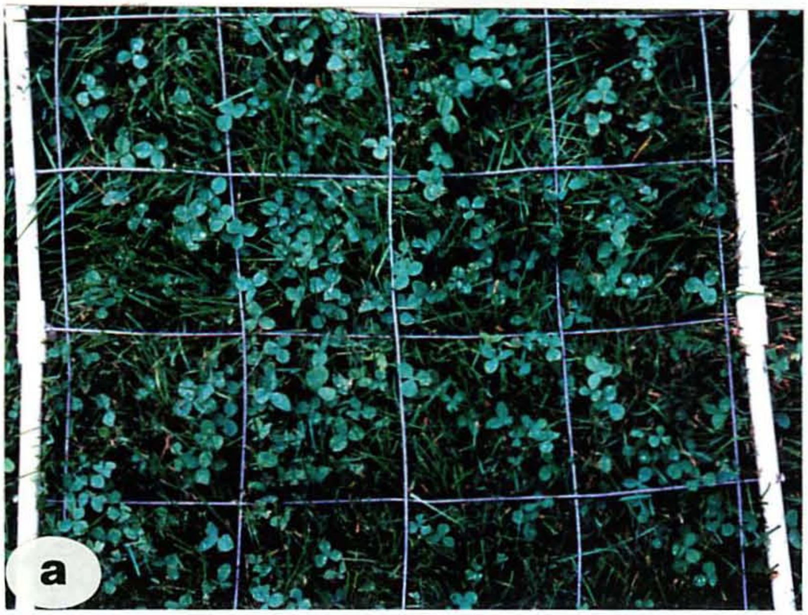


PHOTO 2. Greenness

a. Commercial property in full sun maintained with Seagreen organofertilizer at 3 lbs N per 1000 sq ft per annum.
b. Plots at The Oaks on August 15, 1992. The figure below identifies the different Main Plots in the photo. Note the Compost plot and the NPK-Kentucky bluegrass plots are lighter green than the Control Main Plot, and the Brewery Waste Main Plots are darkest green. The Main Plots are readily distinguishable, but the subplots are not.

c. Organofertilizer subplots on the Control Main Plot, F field, June 27, 1993. Plot at top right received the highest level of organofertilizer (3 lbs N per 1000 sq ft); plot at bottom right received none.
d. Subplots on Control Main Plot, F field, July 14, 1994. Plots proceeding from background to foreground are:

OF1 (mulch)	OF1 (bag)
OF2	OF3
OF0	OF3X



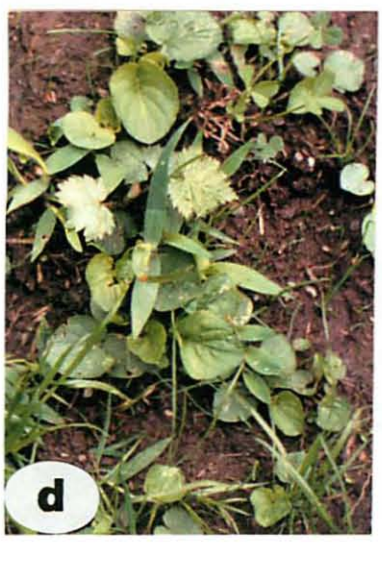


PHOTO 3. Clover/Weeds

a. Diffusely distributed clover on the B field. The quadrat was placed on a plus clover region on Cn2 subplot on Block 1, July 14, 1994. Frequency of clover cover is 100%, cover is approximately 30%. Note that clover color and density blends more evenly with grass than in photo 3b.
b. A clover patch on the F field, July 23, 1993. The patch contrasts sharply with the clover-free area outside the patch. Frequency of clover within the patch would be 100%, cover approximately 80%.
c. *Agrostis* spp. patches in NPK-Kentucky bluegrass plot, October 5, 1993.
d. Weeds typical of the B field in early June, 1992 - blackberry, violets, and witch grass.
e. Lambsquarter and grass seedlings on the F field in early June, 1992.

PHOTO 4: Diseases

a. Patches of red thread on the F field, July 1993.
b. Closeup of anthracnose on blades of Kentucky bluegrass.
c. Diseases on clover. Photo illustrates the three categories we used in describing patterns of fungal infection on clover: "spots" (distinct black spots on leaf at left margin of photo), "blotches" and "whole leaf necrosis".
d,e. Leaf spot (probably *Drechslera* spp) on Kentucky bluegrass, May 1993.
f. Two side by side plots of tall fescues (one Rebel Jr. and one Tribute) stand out because of intensity of pink snow mold and bleaching of leaves.

4. ***Clover was probably a factor contributing to maintenance of greenness through the entire growing season in 1993, 1994, and 1995***, with no auxiliary watering in 1994 and 1995.

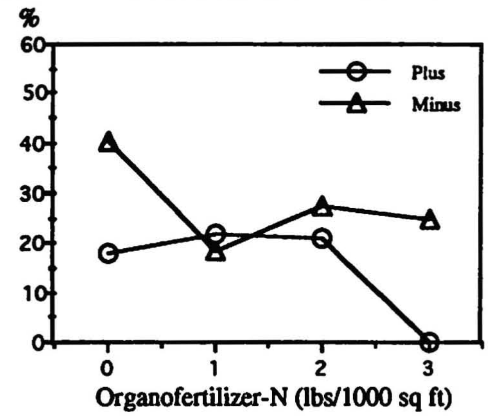


Figure 8. Percent red thread in plus and minus clover areas in July 1994 in organofertilizer subplots on the F field.

The disadvantages of clover appear to be mostly aesthetic. The unsightly patch problem (as on the F field; Photo 3b) results from clonal growth of clover from isolated individual clover plants. When the clover is well dispersed, as it was on the B field, it does not have the unsightly appearance. Other factors contributing to a better blending of the clover were: (i) the abundance of perennial ryegrass which appeared to blend better with clover than Kentucky bluegrass, and (ii) the B field did not go into mid-summer dormancy, perhaps due in large part to the abundance of clover itself.

The benefits of clover not withstanding, it may still be desirable or be the preference of the consumer, not to include clover, or to keep it at relatively low abundance. ***The observations on clover in different treatments illustrated marked effects of fertility management on clover abundance. The most critical factor, for keeping clover low, we deduced, was maintenance of high soil inorganic N through the establishment year.***

Top-dressing of Organofertilizers

Provision of P and K and problems of balance With synthetic fertilizers, it is relatively simple to apply specific amounts of each of N, P, and K. This is more difficult under organic management because of limited availability of materials that are high in one element but low in the others, and significant imbalances can result (i.e. excess P and deficient K relative to N). ***Under organic management, the key to minimizing imbalance problems is to manage the system to minimize the need for nitrogen. Suggested default values (values suggested in the absence of soil tests or budgets) for P and K are 1/6 and 1/2 of the amount of N for P_2O_5 and K_2O respectively.***

Minimizing need for nitrogen The major factors involved in minimizing needs for N are:

1. recycling within the system (mulch mowing in the case of turfs);
2. maintaining cover and root density to minimize losses by erosion and leaching;
3. inclusion of N_2-fixing plants;
4. handling supplements and amendments in such a way that minimizes the possibility for a surge in the nitrate pool in the soil;
5. taking into account differences in supply of N from the soil and in accumulation of N in soil as soil organic matter.

For an organically managed turf in which clippings are recycled, and clover is a component, the first three conditions are met quite well. What then becomes very important is to avoid increasing nitrate to levels that would result in significant loss of N by leaching, or denitrification.

Thus a critical issue is to identify real N requirements so as not to overfertilize. In a turf system in which clippings are recycled, the need for N supplements is potentially, very low. ***In principle, turf has amongst the highest potential of all agricultural and horticultural crops to maintain high quality with very low nutrient supplementation as it is a perennial crop in which there is no product that must be taken out of the system.*** In practice, however, "high-end" turf is one of the most heavily fertilized systems, receiving 150 - 250 kg N per ha (3 - 5 lb N per 1000 sq ft equivalent) or more annually.

Without clover in the system, there will be a requirement for N inputs to make up for losses by leaching and volatilization, however, for a recycling, sod type system not receiving large N supplements, such losses should be very low. Plant uptake systems are saturated at very low concentrations of soil solution nitrate and ammonium (< 1 ppm N). Thus, providing there is a continuous supply of inorganic N by continuous mineralization or organic materials, the grass will have adequate N even though there is never a large amount in the soil solution. By the end of 1994 on both the B and F fields, nitrate and electrical conductivity had dropped to very low values, while productivity had stabilized at high values (Figure 9). Under such conditions, leaching losses of nitrate should probably be less than 5 - 10 kg N per ha, i.e. in principle, one would have to add only 5 - 10 kg N per ha to maintain the system.

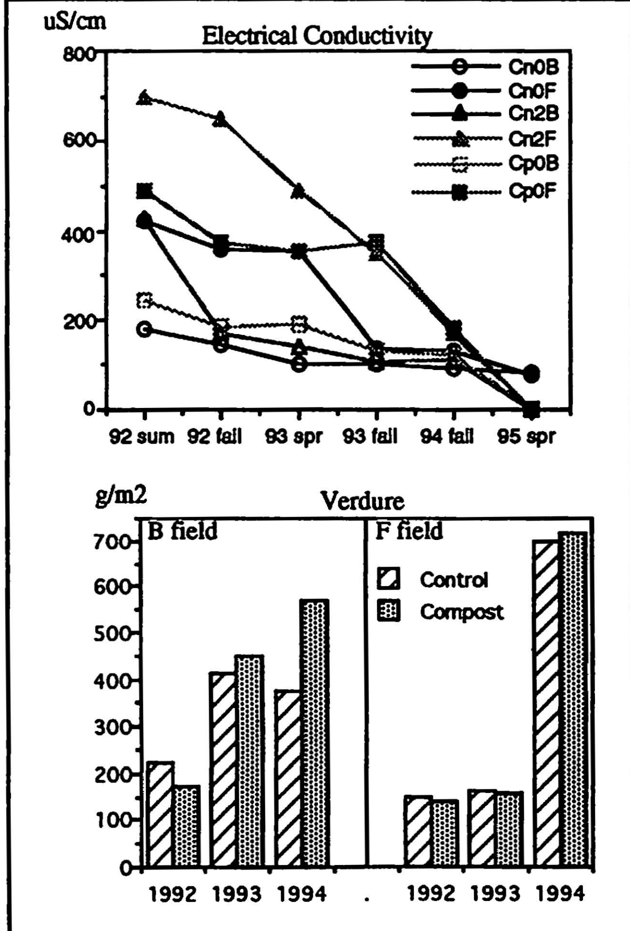


Figure 9. Electrical conductivity (uS/cm) and verdure (g/m^2) for selected treatments. Cn0B denotes Control main plot @ 0 lb N organofertilizer level on the B field. Reported verdure values are averaged for organofertilizer subplots at the 3 lb N per 1000 sq ft level.

That is the potential. In practice, to maintain high quality turf given less than ideal starting conditions, real N needs could be considerably higher. ***If a system has low soil organic matter initially, e.g. 2%, then under an organic regime in which the equilibrium soil organic matter value is in the area of 6%, accumulating soil organic matter will be a sink for some of the added N, possibly as much as 2 - 3 lbs N per annum. Likewise, until root systems build up, losses may be higher than the values suggested above, and the accumulating roots will sequester some of the added N.***

We are suggesting then, partly on theoretical grounds, and partly from the documented responses at The Oaks, that ***real N needs for high quality organically managed turfs with mixed grass swards are likely to be in the range of 0 - 3 lbs N per 1000 sq ft per annum.*** In order to predict real N needs, we offer the following provisional guidelines based on results at The Oaks and of Vessey and Patriquin (1984) for input of N via clover:

The needs for a mulch mowed turf with a mixed sward will be in the range of 0 to 3 lbs N per 1000 sq ft., calculated as follows:

1. Requirements will be towards the lower end of this range where soil organic matter is >5%, and towards the higher end where it is <3%, provisionally the following:

Soil Organic Matter (%)	Organofertilizer-N (lb per 1000 sq ft per annum)
1-2	3-4
2 - 3	3
3 - 4	2
4 - 5	1.5
5 - 6	1 - 0.5
> 6	0.25 - 0

2. Bag mowing can be assumed to increase requirements by 1 - 2 lbs N.

3. If clover in mid-summer is present at >50% cover, assume 1.5 lbs of N is added by clover, and proportionally less with proportionally less cover by clover.

4. For a new turf, established by seeding or sod, adding a mature compost to the soil at a rate of 100 t per ha (1 inch) will supply 1.5 or more lbs N the first year, and 1 lb N annually for the next two years.

5. If turf is 40-80% Kentucky bluegrass, increase requirements by 0.5 to 2 lbs N. Overseed with perennial ryegrass and fescues to reduce proportion of Kentucky bluegrass.

An example of how the calculation of N requirement is made follows:

Given a mulch mowed system with:

Soil organic matter of 2.5%, needs = 3 lbs N.
Kentucky bluegrass at 45%, additional need is 0.5 + 1.5*(45-40)/40 = 0.69 lbs N.
Clover 35% cover; contribution is 35/50 x 1.5 = 1.05 lbs N.
Net requirement: 3+0.69-1.05 = 2.64 lbs N.

When should applications be made? In the last 10 years, the turf industry in Canada has been shifting from a heavy early fall feed to a late fall or "dormant" feed of fertilizer. The dormant feed is applied when top growth has ceased but photosynthesis and root uptake are still active. It is commonly assumed that a dormant feed would not work with organofertilizers because temperatures would be too low to allow release of inorganic N. At The Oaks, a trial dormant feed in 1992 proved to be highly effective; applying organofertilizer on Nov. 6, 1992 resulted in substantially better greening up (Photo 1e), earlier onset of growth, and reduced winter injury in 1993 (Figure 10) compared to early fall fertilization. In 1993, all fall fertilizer applications were made on Nov. 17 and there was excellent greening up in spring of 1994. ***We suggest that the dormant feed of N is the most critical application, with up to 1 lb of organofertilizer-N being applied approximately one month before onset of effective winter dormancy***. For Nova Scotia, the timing is likely to be mid-October to mid-November.

Provisional recommendations for the yearly organofertilizer application follow (units are lbs N per 1000 sq ft).

Total N Applied Over the Year	Dormant Feed	Applied in Late May or Early June	Applied in Late June*	Applied in Late Aug. or Early Sept.
3	1	1	0.5	0.5 or 1
2.5	1	1	0	0.5
2	1	1	0	0
1	0.5	0.5	0	0
0.5	0.25	0.25	0	0
0.25	0.25	0	0	0

*Apply in late June only if turf is being watered in mid-summer to prevent grass from going into summer dormancy.

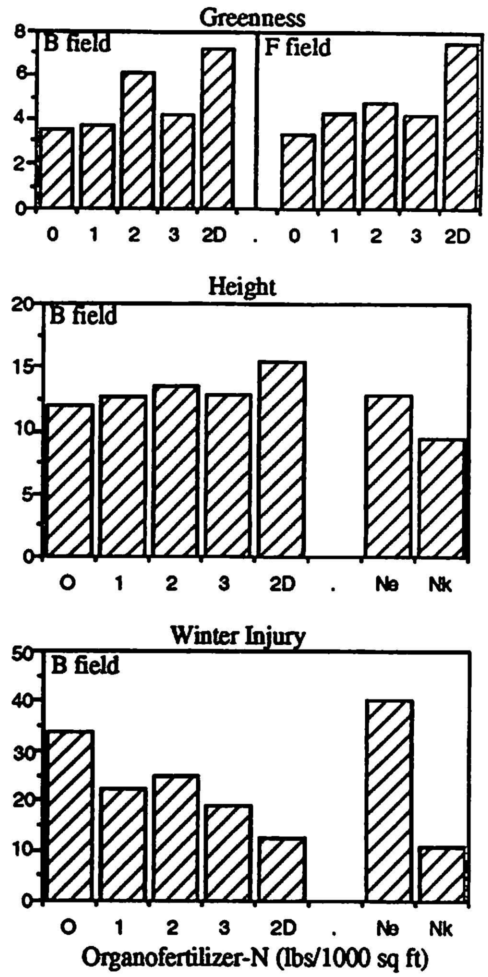


Figure 10. Visual greenness rankings (0-8), grass height (cm), and winter injury (percent bare patches) for subplots on May 17, 1993. N = NPK; e = Ecomix; k = Kentucky bluegrass; D = applied as a dormant fertilizer.

Other Management Factors

Pests and diseases ***Insect pests did not become problematic in The Oaks experiments***. There were, however, several diseases that reached levels resulting in noticeable effects on turf quality. ***Four diseases developed at The Oaks: red thread, anthracnose, leaf spot, and pink snow mold. The first three were observed initially on Kentucky bluegrass; pink snow mold occurred primarily on tall fescues***. Red thread and anthracnose are diseases commonly associated with low N, thus ***N stress experienced by Kentucky bluegrass (but not other species) may have been a critical factor in the initial establishment of red thread and anthracnose in the turfs***.

Red thread was first observed in 1993. Changes in the pattern of distribution and intensity of the disease suggested ***provisional strategies for control of diseases associated with N deficiency***.

To maximize resistance to initial infestation:

1. Ensure the predominance of turf species and cultivars that are not strongly N stressed at moderate levels of N.

2. Ensure that grass species receive adequate but not excessive N; the level of augmentation required will increase with the proportion of Kentucky bluegrass in the turf.

3. Incorporate compost before seeding or sodding new turf, or topdress compost in established turf. Compost appears to have suppressive effects that are independent of N effects.

4. Include clover in the system. It improves N nutrition of associated grasses and provides a natural regulation of N that minimizes likelihood of N deficiencies.

5. Mulch mow. This reduces water stress and improves N nutrition.

To control established infestations:

1. Rake (or dethatch) infected areas to remove debris, followed by (2) below.

2. Apply dilute soap solution to set back active inoculum remaining, followed by (3) below.

3. Apply organofertilizer at 1/2 - 1 lbs N per 1000 sq ft.

4. Finally, bag mow until the disease appears well under control.

Mowing Bag mowing increases N needs by 1 - 2 lbs N per 1000 sq ft per annum, and removes large amounts of other nutrients. Furthermore, compared to the equivalent mulch mowed plot, bag mowing reduced verdure, clipping yield, and increased susceptibility to disease (BOX 5). ***Thus mulch mowing must be considered an essential component of organic management, however, bag mowing is appropriate when disease builds-up***.

Weeds Weed control is often regarded as the "Achilles heel" of organic turf management. The Oaks experiments were not designed to address factors affecting weed pressure, as weeds were controlled by manual weeding. Beyond the establishment year, ***manual weeding focused primarily on dandelion, violets, and plantains; time requirements were not large and overall weed cover was less than 2%.***

Optimal timing of weed removal was very important, which was well illustrated by a sharp increase in the problem weeds in 1995 when weeding was interrupted for the first six months of the season. This interruption allowed the weed pressure to be expressed. We observed significant differences between the different fertility treatments, suggesting overall lower weed pressure under the higher fertility regimes (Figure 11).

In conclusion, the following ***strategies for managing weeds under organic management are suggested***:

1. As possible, when new topsoil is introduced, conduct some weed germination tests on the soil before hand to determine weed potential.

2. If the seedbank is large, then before seeding new turf, plan for a fallow period with time for at least one harrowing to reduce weeds in the seedbed.

3. Manual weed systematically in late spring and late summer.

4. Where larger gaps are created from weed removal, overseed with at least 50% perennial ryegrass, and introduce other species as desired. Mulch with compost or mineral soil.

5. Focus on problem and controllable weeds, particularly the broadleaf varieties.

6. If plantain is not present initially, it can be kept out by practicing vigilance in removing new plantain plants; seeds do not disperse far from parent plants, but seedbanks are persistent and once established, create a recurring weed problem.

7. Dandelion produces light seed that is widely dispersed, but is non persistent, thus it can repeatedly invade in large numbers from outside sources. Removing dandelion in adjacent areas can reduce that; plan to remove seedlings a few weeks after the major seed rains in late spring.

Box 5: Benefits of mulch mowing (compared to bag mowing)

Beginning in July of 1993, half of the organofertilizer plots receiving 1 lb organofertilizer N per season were bag mowed, while the others were mulch mowed, as before. Bag mowed plots were also set up in the NPK Main Plots, and in strips on Compost Main Plots that received 3 lbs organofertilizer-N per season.

Mulch mowing recycled nutrients; bag mowing removed them

In 1994, clipping production and nutrient content was measured through the season in bag mowed and mulch mowed subplots receiving 1 lbs organofertilizer-N per season, in the Compost Main Plots:

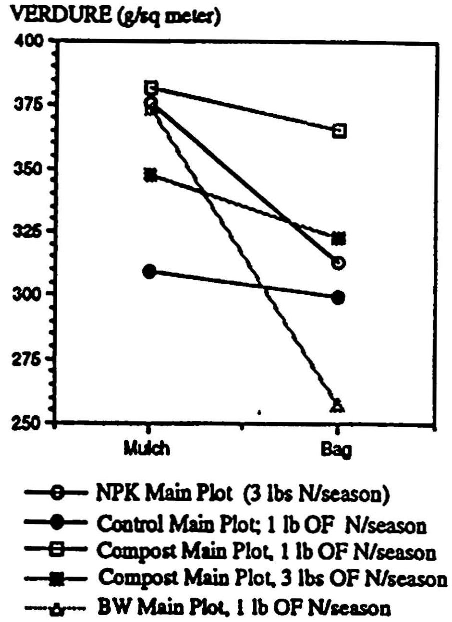
Clipping yields, and quantities of nutrients recycled in mulch mowed plots, or removed from bag mowed plots in 1994.

Component	Field	Recycled in Mulch Mowed Plots	Removed from Bag Mowed Plots
		(grams per	square meter)
Clippings	B	701	414
	F	367	167
Nitrogen	B	29.9	17.7
	F	11.7	4.1
Phosphorus	B	3.8	2.1
	F	2.1	0.7
Potassium	B	15.9	8.9
	F	7.6	3.0

Clipping production was much higher on mulch mowed than on bag mowed plots. Large quantities of nutrients were removed by bag mowing - in the case of N, equivalent to approximately 3 lbs N per 1000 sq ft per season on the B field, and 1 lb N on the F field. (5 g/m^2 = 1 lb N/1000 sq ft).

Bag mowing versus mulch mowing under different fertility regimes.

It was postulated that the effects of bag mowing would be less pronounced at higher levels of fertility, than at lower levels, because nutrient removal would be more critical in the low fertility regimes. However verdure, (see Figure below) and the ratio of clippings to verdure (data not shown) measured July 14, 1994, were lower in bag mowed plots than in mulch mowed plots by about the same degree under both low and high fertility regimes; verdure in NPK plots was reduced more by bag mowing than it was in other Main Plots. The differences in verdure at high fertility levels may be related to effects of bag mowing on soil mositure; measurements of soil water showed that mulch mowed plots retained higher levels of soil moisture than did bag mowed plots, in dry weather.



Bag mowing reduced susceptibility to diseases

Bag mowed plots receiving 1 lb N per season exhibited higher levels of red thread, leaf spot and anthracnose than did mulch mowed plots, when the diseases were first noted. These diseases affected mostly Kentucky bluegrass ; red thread and anthracnose were greatest on plots receiving lower levels of organofertilizer. However, after red thread innoculum reached high levels overall at the site, due to proliferation on Kentucky bluegrass on low N plots, bag mowed plots had less red thread than mulch mowed plots.

Thus grass on mulch mowed plots thus appears to be less susceptible to initial infection by fungal pathogens than grass on bag mowed plots, but once an inoculum builds up, bag mowing helps to reduce it.

8. Certain weeds if abundant, may indicate soil imbalances or physical problems.

9. A major benefit of clover is that it competes effectively with broadleaf weeds; including clover in the system and managing it appropriately will greatly reduce manual weeding requirements in the long run.

10. Mow high and frequently; with clover, lower mowing heights can be tolerated, but increase the clover component.

11. Maintain adequate but not excessive fertility, and other conditions favoring a strong grass sward.

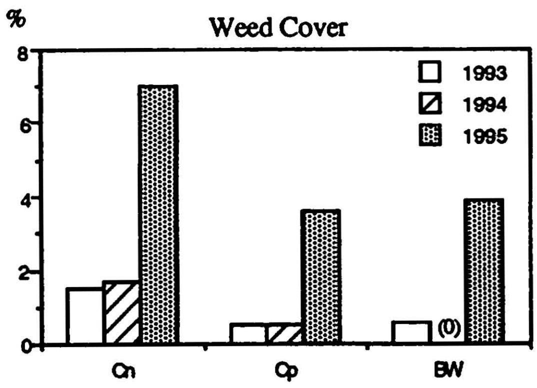


Figure 11. Visually estimated percent cover by weeds averaged for main plots on the B field. Cn = Control; Cp = Compost; BW = Brewery Waste.

V. THE TOTAL SYSTEMS APPROACH: OTHER COMPONENTS

The Oaks Woodlands

Turfs are usually components of larger property units. Other components of those units may impact upon turfs and vice versa, and ideally all are managed together.

The woodlands surrounding the turfs at The Oaks play important ecological functions in relation to the turf:

- as windbreaks, which lessen water stress in summer and help to maintain a protective cover of snow in the winter;
- the deep rooted trees draw nutrients from great depths, reducing to an a minimum the potential for contamination of groundwater from fertilization of the turf;
- they diversify the habitat, providing a reservoir of natural enemies of turf pests.

While not a formal part of The Oaks Experiments, the woodland itself attracted our interest. In 1992, an ecological survey of the woodland was conducted by Ann Li Huestis, supported by a Sarah Lawson summer scholarship from Dalhousie University. Her studies made us aware that the estate management had extended into the woodland, with many beautiful plantings in the understory at its periphery complementing the naturally seeded species. The introduced species had been well chosen and placed within the landscape to fill particular ecological niches. Hence they have survived for 25 years with virtually no attention. Ann Li's description of the site follows.

The Forest Garden

This forest garden, situated in a shallow topographic depression hidden from the back lawn, has had no management for 25 years or more. Still, it retains its basic character because the species selected fill an ecological niche and they continue to provide aesthetic value.

The garden is tucked under an overstory of red oaks, maples and hemlocks. A small stand of hemlocks provides protection for the garden by deflecting cold winter winds and trapping insulating snow for a range of herbaceous plants species in this garden. The shrubbery of Japanese barberry and Japanese knotweed help create a mystique as to what lies beyond the lawn in this shallow basin. Though the barberries are fearsomely prickled, their arching twigs provide scarlet berries for birds in the winter months. Their leaves turn red in the fall complementing the yellow and orange or the overstory plants. Japanese knotweed, although regarded as a rampant nuisance in many gardens today, was originally introduced as a garden screen or a hedging barrier that required no formal trimming. Other shrubs that provide interest to this garden are a rhododendron with fuchsia blooms, an elderberry with panicles of while flowers and red berries and a small mountain ash with scarlet fruits that are especially attractive to birds.

BOX 6. Cultural practices for *organic* management of turfs.

Below, we have combined the lessons gained from experiments with practical experience to provide seasonal *guidelines* for organic management of turfs.

GUIDELINES FOR FALL

1. ***Best time for dethatching*** (if it needs it): sometime during the first 2 - 3 weeks after active fall growth begins. To test for thatch: cut 1 inch (2.5 cm) squares or take samples with a soil corer. Thatch is the layer of coarse fibrous material above soil. Dethatching is advisable if that layer is thicker than 1/2 inch (12.5 mm).

2. If a major ***weeding*** is needed and you are dethatching, do weeding before the dethatching and overseed after dethatching. Use compost to mulch larger bare patches after seeding.

3. ***Apply potassium*** fertilizer (1/2 - 1 lb K_2O per 1000 sq ft), if soil test indicates K is low, in early fall to give good hardening off of grass. It is best to use potassium sulfate or Sul-po-mag rather than the usual muriate of potash (potassium chloride). Add a little N at the same time (i.e. 1/4 lb N).

4. ***A good time to add lime***: do it a few weeks after any use of K (lime can inhibit uptake of K) and according to needs.

5. ***Reduce cutting height*** as grass growth decreases over the fall to 2 inches (5 cm) and avoid leaving mats of grass or tree leaves to overwinter (encourages mold).

6. ***Soil sample*** in mid-October, before dormant feed; or in early spring.

7. ***Best time to aerate***: mid to late October (after first two frosts), and before dormant feed fertilization. Aeration opens up soil for organic fertilizers. You should aerate if you are unable to push a screwdriver down to its handle without hammering on it.

8. For early spring green up, apply a ***dormant*** feed of fertilizer. Dormant feed is after the first two frosts, generally mid-October to mid-November (in Nova Scotia). Typically 1/2 to 1 lb N in products with more than 5%N is applied. It's important to add phosphorus (P) or use a P-rich organic fertilizer at this time if soil is low in P (based on soil or leaf tissue test).

GUIDELINES FOR SPRING & SUMMER

1. Conduct spring ***clean-up*** in mid-April (old leaves raked up).

2. ***Aerate early*** as needed and if not done in the fall, to accelerate warming of soil and green-up; do it before fertilizing (holes provide conduits to move insoluble fertilizers into root zone).

3. If ***dethatching*** in the spring, do it after the first cut (about mid-May).

4. If a dormant feed was NOT applied in the fall, ***fertilize*** in the early spring using a balanced NPK organic fertilizer, or according to soil tests. If a dormant feed was applied, do not fertilize until late May or early June.

5. Early spring is a good time to ***apply a layer of compost.***

6. ***Weed out the first flush of dandelions.***

7. ***Fertilize*** in late May or early June for the summer period.

8. ***Major weeding*** in late May/early June, followed by overseeding and mulching with compost.

9. ***Start mulch mowing at 2 inches height, increase it to 3 inches by June, and maintain 3 inches*** (typically mowed 1x/week) through the summer. Mowing high and regularly creates stronger grass and helps to keep weeds down.

10. ***Keep mower blades sharp*** for neater and cleaner cut; it also reduces fungal infections.

11. ***Avoid aerating or dethatching during the summer period.***

12. ***Fertilize in late July*** only if grass is losing its greenness, and only if prepared to water regularly through the dry period.

13. For strongly ***shaded areas***: use a shade mix, mow at longer intervals.

The ground herbaceous species nestled in this garden are made up of native and exotic species. Japanese spurge and periwinkle carpet the ground under the shrubs and trees giving a dense evergreen cover with early spring or summer blooms, at the same time serving to control soil erosion. Mayapple, like many woodland floor species, emerges very early in spring through the thick mat of leaf litter. It takes advantage of the leafless period of shrubs and trees maximizing its photosynthetic potential and storing the energy in its underground portions. The mayapple has only two umbrella-like leaves and a nodding waxy white flower borne on the axil of the leaves. The ripe yellow fruit is edible while all other parts of the plant are poisonous. Solomon's seal, with its long arching leaf-stalks and greenish flowers provides a different dimension to the carpet of ground herbs and seemingly "lifts" the floor of this forest. Lily of the valley (and wild lily of the valley), clintonia, wood asters and creeping Jenny wander about the periphery of this forest garden.

These ground herbs species are successful in this garden because of their physiological and morphological adaptations for exploiting different light intensities either through tolerance or avoidance. Their adaptive strategies have allowed them to thrive under the stress of considerable shade from large overstory plants.

The plant species in this forest garden play different ecological roles. Some act as windbreaks helping to minimize temperature and moisture fluctuations, some serve to control erosion during the spring run-offs and heavy rainstorms, or conserve nutrients that otherwise might be leached away. They all provide organic matter to the forest floor, maintaining soil fertility and moisture-retentive capability. Trees and shrubs provide either nesting cover or food for birds and small mammals, while fallen branches become substrates and habitats for a succession of micro and macro organisms, fungi and mosses, that assist in the recycling of organic material in this all-organic garden.

VI. TOTAL SYSTEM ORGANIC MANAGEMENT (TSOM): A 21ST CENTURY TECHNOLOGY

In the past, "pollution" was something we blamed on big industries. As we move into the 21^{st} century, we are beginning to appreciate that the activities of each one of us, when taken collectively, have profound effects on the environment at large and that some of those effects are threatening our air, soil, water, and the diversity of the earth's inhabitants. As we become more sophisticated in our understanding of these effects and in monitoring them, more and more legal restrictions are being placed on the types and quantities of materials that enter the environment, and of our methods of physically interacting with the environment.

Currently, there are two general approaches to lessen the impact of humans and their technology on the environment:

(1) **isolating the systems**; this is an approach being used, for example, on some golf courses in the US: the whole drainage pattern is constructed to divert all runoff and leachates into special treatment areas;

(2) **lessening the negative impacts**; by using non-toxic materials such as biological herbicides, manual weeding and more closely matching fertilizer application with requirements.

The organic approach goes beyond protection to nurturing: by intensifying natural processes, it nurtures the environment, thereby increasing biodiversity and increasing the resistance and resilience of the ecosystem. The organic approach uses scientific techniques and knowledge, but the model is always nature.

TSOM is an organic approach to land management in urban regions and in watersheds with large urban components. It makes use of detailed scientific knowledge, systems analysis, and the principles of ecology to ensure that the landscapes involved fulfill their ecological functions while serving the socioeconomic needs of society. It also seeks to foster a better understanding of nature at large by urban residents.

There are five basic tenets to the principle of TSOM:

1. **Diversify the environment** (for pest control, nutrient cycling, windbreaks, educational purposes).

2. **Use well adapted species and varieties, including native species** (to minimize needs for inputs).

3. **Maintain a healthy soil** (for plant health, pest control, water retention).

4. **Practice Total System Recycling (TSR)** (to minimize needs for inputs, and process wastes naturally); TSR refers to processing and recycling as much of the waste as possible in a unit, within that same unit. The unit could be a home, an institution, a watershed, or region.

5. **Monitor water and soil** (including nutrients, acid-buffering capacity, contaminants, biological activity); if there are changes in the ecosystems, they will be reflected in the water and soil first.

An Example: TSOM for Turfs

TSOM begins with diagnosis; in the case of the turf, this diagnosis includes consideration of three components:

1. the **desired role of the turf** within the larger socioeconomic and ecological units;

2. the **site requirements or limitations**;

3. **economic constraints.**

The larger ecological unit is the watershed. **Turfs have three important roles to play in watershed ecology:**

- to cover the ground, reducing erosion of soil;
- to impart good infiltration qualities and high water-holding capacity to soil thereby reducing runoff and flooding;
- to purify water as it moves through the turf into ground water.

Major **roles within the larger socioeconomic units**, are often one or more of the following:

- to function as sites of recycling of organic waste stream products from the larger urban area;
- to contribute towards an aesthetically pleasing environment;
- to serve recreational needs (parks, golf courses, playing fields).

Diagnosing site **requirements or limitations** requires analysis of factors such as soil type/profile, infiltration characteristics, slope, intensity of use, exposure to wind and sun, soil chemical characteristics, availability on site of organics and facilities for processing them, proximity to water bodies.

Finally, there are the **economic constraints**; dealing with those is basically a matter of determining what intensity of management can be afforded or is necessary to achieve the minimum requirements.

Drawing on the basic tenets, actions are formulated that address the identified roles, site limitations and economic constraints. For example, for a public turf located near a lake, it might be concluded that:

(a) Ecological functioning: *Diagnosis*: the site is near a lake, with possibility of surface runoff. *Suggested Action:* mow higher, mulch mow, topdress with compost and aerate to improve infiltration, use poorly soluble rock P with clover; construct vegetative barriers, use other types of covers (not requiring fertilizers) on the steeply sloping areas. Use sand instead of road salt in winter on access roads (the salt contributes to eutrophication).

(b) Use: *Diagnosis*: limited recreational use, but aesthetically important: here there may be some tradeoff with (a), as the turf would contain clovers which some people may not like. *Suggested Action*: provide educational material on the role of clover, and the special care needed to protect lakes; keep other broadleaf weeds to a minimum; establish some perennial flower beds.

(c) Site limitations: *Diagnosis*: some shaded areas. *Suggested Action*: overseed with adapted grass cultivars; use alternative ground covers.

(d) On site organic waste: *Diagnosis*: grass clippings, minimal other yard waste, some food waste. *Suggested Action*: mulch mow; compost yard wastes on site and apply compost to flower beds in fall as a mulch; collect food wastes separately and process them in protected areas (from rodents) or in municipal composting facility.

(e) Economics: *Diagnosis*: need to minimize drain on "The Public Purse". *Suggested Action*: maintenance cost will be relatively low in this case because of use of Low Input Management System (clover/grass), and perennial species in flower beds.

Applying TSOM to a larger unit involves estimating the total production of organic wastes within that unit, the potential for using them within that unit, and the peculiar requirements and sensitivities of each individual property and ecological entities (i.e. a stream, lake). Then a mosaic of landscape management plans for individual properties is generated which makes best use of the total resources within the unit, ensuring that the functioning of ecological entities in conserved, and addressing needs at the individual property level.

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David Patriquin

IX. APPENDICES

Appendix 1. Table of Contents From Scientific Report Titled *The Oaks Experiments on Organic Management of Turf.*

Appendix 2. A List of All Experimental Treatments at The Oaks.

IA. Organic fertilizers (set-up in 1992; 4 reps).
1-4. Nothing incorporated & organofertilizer @ 0,1,2,3 lbs N.
5-8. Compost incorporated & organofertilizer @ 0,1,2,3 lbs N.
9-12. Brewery waste incorporated & organofertilizer @ 0,1,2,3 lbs N.
13. NPK incorporated & NPK-N @ 3 lbs N/season - Ecomix.
14. NPK incorporated & NPK-N @ 3 lbs N/season - Kentucky bluegrass.

IB. Comparison of early fall with dormant application of organofertilizer (conducted 1992/93; 4 reps).
15. Nothing incorporated.
16. Compost incorporated.
17. Brewery waste incorporated.
All with 2 lbs organofertilizer-N/season, dormant (November) application in 92 (compared with #3,7,11 - fall application in Sept.92).

IC. Comparison of mid-summer versus late summer application of organofertilizer (1993 only, 4 reps).
18. Nothing incorporated.
19. Compost incorporated.
20. Brewery waste incorporated.
All with 3 lbs organofertilizer-N/season, 93 mid-season application in late Aug. (compared with #4,8,12 mid-season application in early July).

ID. Comparison of bag mowing versus mulch mowing (set-up July, 1993; 4 reps).
21. Nothing incorporated.
22. Compost incorporated.
23. Brewery waste incorporated.
All with 1 lb organofertilizer-N/season, bag mowed from July 93 on (compare with 1 lb N/season, mulch mowed treatment #2,5,9).
24. NPK incorporated & NPK-N @ 3 lbs N/season - Ecomix (compare with #13, mulch mowed).
25. Compost incorporated, 3 lbs organofertilizer-N/season, bag mowed; compare with #26.
26. Compost incorporated, 3 lbs organofertilizer-N/season, mulch mowed.

IE. Comparison of liquid fish silage product with organofertilizer "Seagreen" as dormant feed (set-up Nov. 1993).
27. Liquid fish applied at 3/4 lb N to one of the duplicate 2 lb N organofertilizer plots in each of the Control, Compost, and Brewery Waste main plots (compare with 1 and 2 lbs N/season plots).

IF. Comparison of no addition of organofertilizer in 3rd year to organofertilizer subplots, with regular addition (set-up spring 1994).
28. Conducted on one of the replicate 3 lb N/season organofertilizer plots - no fertilizers applied in 1994 (compare with sister plots).

IIA. Mixture comparisons (set-up in 1992).
Set 1: Compost in seedbed; organofertilizer applied annually, 3 reps.
29. Ecomix.
30. Greenfast.
31. Tall fesuces.
Set 2: Compost in seedbed; no subsequent organofertilizer, 3 reps.
32. Ecomix + clover.
33. Greenfast + clover.
34. Tall fescues + clover.
Set 3: One set of plots with no soil amendments.
35. Ecomix.
36. Greenfast.
37. Tall fescues.

IIB. Demonstration plots (one set in the shade and one set in the sun; the shade set was eliminated in 1993).
38. Dutch white clover.
39. Reliant hard fescue.
40. Fortress red fescue.
41. Rebel Jr. tall fescue.
42. Tribute tall fescue.
43. Wilma chewing fescue.
44. Koket chewing fescue.
45. Haga Kentucky bluegrass.
46. Gnome Kentucky bluegrass.
47. Palmer perennial ryegrass.

IIC. Mixture/humates (set-up in fall 1993 in area where soil dried rapidly).
48. Greenfast + Tall fescue plus humate (1 rep).
49. Greenfast + Tall fescue minus humate (1 rep plus 2 other demo plots).
50. Ecomix plus humate (2 reps).
51. Ecomix minus humate (2 reps).
52. Tall fescues plus humate (2 reps).
53. Tall fescues minus humate (2 reps).

IIIA. <u>Rock phosphate/clover</u> (set-up in 1992; 4 reps).
54. Grass minus RP.
55. Grass plus RP.
56. Grass + clover minus RP.
57. Grass + clover plus RP.

Appendix 3. Levels of Organofertilizer and Other Treatments Applied to Subplots. Numbers Represent lbs of Organofertilizer-N/1000 sq ft.

			1993			1994	
Sub plot	**Inc.**	**Fall 92**	**Spr**	**Sum**	**Fall**	**Spr**	**Sum**
OF0	0	0	0	0	0	0	0
OF0	0	0	0	0	0	0	0
OF1	1	0.5	0.5	0	0.5	0.5	0
OF1	1	0.5	0.5	0B	0.5B	0.5B	0B
OF2	2	1	1	0	1	1	0
OF2	2	1D	1	0	0.75F	1	0
OF3	3	1	1	1	1	1	1
OF3	3	1	1	1A	1	0X	0X

Letters designate subsidary treatments as follows:

B = bag mowing from July 17, 1993 onwards.
D = dormant feed, applied in November versus September for others.
F = liquid fish silage substituted for organofertilier.
A = applied on Aug. 17 versus earlier.
X = no organofertilizer applied in 1994.
Inc. = incorporated in soil before seeding in spring of 1992.