University of Colorado at Boulder

Integrated Turf Management
At the
University of Colorado at Boulder

February, 2008

A view from Kittredge recreation fields looking west to Boulder's famous Flatirons.

Introduction

Turfgrass management since 1940 in the U.S. has been characterized by intensive use of synthetic chemicals including water-soluble fertilizers, herbicides, insecticides, and fungicides. Conventional practices also generate solid waste (through removal of grass clippings) and hazardous waste (leftover chemicals), and use large amounts of irrigation water, which may be wasted through over watering or runoff. A review of current science suggests that these practices may be harmful to human and wildlife health, and also negatively impact the turfgrass ecosystem, contributing to significant declines in populations of beneficial soil organisms, soil acidification and compaction, thatch accumulation, and diminished resistance to diseases. (1)

Turf professionals and technical literature indicate that a proven alternative approach exists. It is based on observation of the entire soil and grass ecosystem, appreciation that turfgrasses are sustained by the activities of soil-dwelling organisms, and understanding that this grass community is a dynamic equilibrium among many plants, invertebrates, and microbial organisms. This equilibrium can then be shaped to support the natural vigor of the grass plant and the beneficial soil organisms, and to minimize pest problems, by application of proper cultural practices. (2)

Like forests or prairie grasslands, lawns are dynamic ecosystems: communities of plants, soil, and microbes; insects and earthworms and the birds that feed on them; and humans who mow, water, fertilize, and play on the lawn. The interactions of all these community members shape the dynamic equilibrium we see as a lawn. Understanding and working within the natural processes that shape the lawn and its soil community can yield a durable, beautiful lawn that is easier to care for. As it turns out, these ecologically sound methods will also help reduce water use, waste generation, and water pollution. (3)

A lawn composed of a mix of locally adapted grass species growing in well-drained, fertile soil on a site with adequate sun will have few disease or pest problems, and can out-compete most weeds with proper management. The first step in maintaining a healthy lawn is to avoid practices that diminish the natural vigor of the turf ecosystem, such as broadcast applications of pesticides (which kill beneficial soil organisms as well as target species), over-watering (which promotes shallow rooting and fungal diseases), over-fertilization (which promotes thatch buildup, decreases soil biodiversity, and forces lawns to grow too fast), and improper mowing (mowing at the wrong height or too infrequently). (4)

(1) (2) (3) (4). Seattle Public Utilities, 1999, Ecologically Sound Lawn Care for the Pacific Northwest: Findings from the Scientific Literature and Recommendations from Turf Professionals

Recommended lawn care practices include:

- The selection of site-adapted and disease-resistant grasses.
- Avoiding over-watering: watering deeply, to moisten the whole root zone, but infrequently, *to limit disease and build deeper roots*; and watering dormant lawns at least once a month during the dry season, *to improve post-drought recovery.*
- Moderate fertilization with natural or natural/synthetic-slow-release combination fertilizers, *to build soil nutrient reserves and biodiversity.*
- Mulch-mowing (also called "grasscycling") whenever possible.
- Mowing regularly (remove only 1/3 of grass height each time), and mowing a little higher, at 2 to 21/2 inches on most lawns.
- Renovation/improvement practices that include aeration, compost topdressing, and over seeding, *to reduce compaction, increase water infiltration, improve soil structure and natural disease control, and crowd out weeds.*
- An integrated approach to pest problems (weeds, insects, and diseases) that includes:
    1. Setting realistic expectations for lawn appearance, tolerating a few weeds and setting realistic thresholds of acceptable damage to the lawn from pests
    2. Correctly identifying the cause of the problem
    3. Understanding the biology of the pest organism and its natural predators
    4. Monitoring for pest problems at appropriate times of the year, and
    5. Treatment of over-threshold problems with methods that support the turfgrass ecosystem and have the least non-target impacts on beneficial soil organisms, wildlife, pets, or humans. *Repeated broadcast or calendar-based applications of pesticides should be avoided because they may damage the diversity and stability of the grass/soil ecosystem.* (5)

Goals

The goal of ecological turfgrass management is to:

- support diverse populations of beneficial soil organisms: bacteria, fungi, protozoa, and invertebrates (such as earthworms, and many other species of soil animals) that make loose, fertile soil and recycle nutrients to the grass plant
- create conditions that favor the preferred grass species over "weed" competitors
- avoid stressing the grass with improper mowing, fertilizing, or watering practices
- avoid providing ideal growth conditions for disease or pest organisms, and
- maintain healthy populations of organisms that compete with, eat, or parasitize disease or pest organisms (everything from the beneficial fungi that parasitize disease-causing fungi, up to birds that eat pests). That seems like a lot to keep track of, which may be why people are often tempted to apply a chemical quick fix to stop or prevent problems. The bad news is that broadcast or calendar-based use of chemicals often kills the beneficial organisms (such as earthworms, or fungi that attack disease fungi, or birds that eat pests) and contributes to soil compaction, acidity, thatch build-up, disease susceptibility, and extreme nutrient swings that favor weeds and diseases over healthy turfgrass. The good news is that for the most part those chemicals are unnecessary, and a simple, common-sense approach will prevent most problems. It is easy to maintain healthy turfgrass by focusing on building healthy soil and providing for the grass plant's needs, using the practices described in this report. (6)

(5), (6). Seattle Public Utilities, 1999, Ecologically Sound Lawn Care for the Pacific Northwest: Findings from the Scientific Literature and Recommendations from Turf Professionals

The largest single problem contributing to the dandelion and other broadleaf weed infestation on the UCB campus is specifically turf health. The goal of this document is to describe a predictable and well-documented turf management plan that will be utilized by the Outdoor Services Division (a.k.a. Outdoor Services) of the Facilities Management Department at the University of Colorado at Boulder (UCB). This document addresses current turf management practices, proposed changes to these practices, short and long-term goals, and the role of organic and synthetic chemicals, in the form of fertilizers and pesticides, in this program.

Outdoor Services Turf Professionals

The UCB turf management program formally started in March 2002, beginning with the hiring of a new turf manager/irrigation officer (with a turfgrass management degree), the subsequent hiring of an assistant turf manager in September 2003 to oversee and implement the turf maintenance practices, and the purchase of some very specialized pieces of equipment, such as slit seeders and deep tine aerators. In the fall of 2006, the turf management program will be hiring a full-time, in the field, "turf tech." These turfgrass professionals for lawns and recreational fields use various methods of turf management to improve the health and appearance of the turf on campus.

Irrigating for Lawn Health and Water Conservation

The first issue Outdoor Services addressed was watering practices. Changing the irrigation practices from a methodology of light and frequent watering, to one of deep and infrequent, allows the plant to improve root depth. This revised irrigation practice will allow for greater stress tolerance, which in turn will help keep the turf density and reduce the loss of turf due to traffic and heat. Reducing the frequency of watering days also allows the top layer of the soil profile to dry out somewhat. This creates less favorable conditions for weed-seed germination.

Fertilizing for Lawn Health

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

One of the largest issues on the UCB campus is the lack of soil nutrients. In the past there has been minimal granular fertilizing. This has led to a serious deficiency in many nutrients that are essential to a good growing medium for the turf. The current program has begun to address this issue through a combination of granular synthetics and organics as well as irrigation system delivered (water-soluble) fertilizers.

Fertilizer Use: One of the immediate goals for the ecological turf management program is to reduce the use of synthetic chemicals, primarily fertilizers. Most of the products used by chemical lawn care companies contain water-soluble nitrogen and are derived from fast release nitrogen or synthetic sources like ammonium nitrate, ammonium sulfate, and urea.

Since most synthetic fertilizers have a fast release nitrogen source they green up a lawn very quickly but do not keep them green or build a healthy root system. Synthetically fertilized lawns depend on frequent feedings of fertilizer and therefore, weaken the turf and never develop a beneficial microbial ecosystem.

The heavy use of soluble synthetic nitrogen sources is associated with decreased populations of earthworms and other beneficial soil organisms, decreased soil pH (increasing acidity), increased

thatch accumulation, increased soil compaction, and increased incidence of certain turf diseases, as well as rapid shoot growth which requires more frequent mowing and can exhaust the plant's carbohydrate reserves. It is easier to grow grass in biologically active soil, where earthworms and other organisms recycle the nutrients from thatch, grass, and other organic material into non-leachable forms that are adsorbed and slowly released by *humus* (decomposed organic matter) in the root zone. Soil amendment and fertilization practices should aim at building the structure, organic content, natural nutrient cycling processes, and nutrient reserves in the soil, which then provides complete nutrients to the grass plant during its annual growth cycle. (7)

In addition to the failure of the fast release nitrogen to provide the needed nutrients to the plants over the long term, there is also the concern of excess nitrogen run-off. Because the nitrogen is so abundant in these synthetic fertilizers, there is too much for the plant to absorb at once and the majority of this nitrogen is washed away into gutters and storm drains. This accumulation of nitrogen causes damage to fish and the aquatic ecosystems.

A preferred form of nitrogen supplement is called "slowly soluble." This form of nitrogen includes organic materials (or less preferable synthetic organic materials). Slowly soluble nitrogen either has a low degree of solubility or requires some breakdown or conversion by native soil microorganisms.

Making a move to more slowly soluble organic fertilizers will help promote plant growth by adding naturally derived nutrients to the soil, which in turn will stimulate root development and density, reduce topsoil compaction, balance pH, and increase potash and iron levels.

This approach to fertilizer use tends to be more in line with the principles of an integrated program, as well as some of the health and safety goals of the policy. Outdoor Services has begun experimenting with fertilizers with higher organic content and has also begun to test the efficacy of a true non-synthetic fertilizer.

Granular fertilization: Using a combination of different fertilizers the Outdoor Services Division is providing the turf with much needed nutrients to provide intense growth to thicken the turf stand and improve color. The fertilization plan involves 6 granular applications during the year; one in the winter for a quick green up in the spring, another during spring break and then every six weeks throughout the growing season. The recreation fields will receive fertilizer applications once a month during the growing season. (**See Attachment A**)

Outdoor Services had a special fertilizer blend made for the university with an analysis of 26-5-12 (5.81% slow release or PSCF) as well as a minor nutrient package incorporated into the blend. At this time the situation requires the use of a slow release fertilizer to create a steady growing medium and also provide good color. In the future once turf health and density are restored there will be a shift to the use of organic fertilizers, which do not have as much nitrogen but will still provide even results. Further testing will be conducted to determine the best approach to organic fertilizer use for this region's climate and soil.

(7). Seattle Public Utilities, 1999, Ecologically Sound Lawn Care for the Pacific Northwest: Findings from the Scientific Literature and Recommendations from Turf Professionals

***P**olymer **C**oated **S**ulfur **C**oated **U**rea (PCSCU), also known as Polymer/Sulfur-Coated Fertilizers (PSCF), are hybrid products that utilize a primary coating of sulfur and a secondary polymer coat. These fertilizers were developed to deliver controlled-release performance approaching that of polymer-coated fertilizers but at a much-reduced cost. Sulfur is employed as the primary coating because of its low cost. Low levels of a polymer topcoat control the nutrient release rate. Unlike the soft wax sealants of SCUs (Sulfur Coated Urea), the polymers of PSCFs are chosen to provide a continuous membrane through which water and nutrients must diffuse. The water permeability characteristics of the polymer controls the rate of water diffusion in and out of the particle. The combination of the two coatings permits a positive cost/benefit value over products with single coatings of either sulfur or polymer. PSCFs possess excellent abrasion resistance and handling integrity. Because the outer coating is a hard polymer, the products do not leave waxy residues on application equipment.

The nutrient-release mechanism of PSCFs is a combination of diffusion and capillary action. Water vapor must first diffuse through the continuous polymer layer. The rate of diffusion is controlled by the composition and thickness of the polymeric film. At the sulfur/polymer interface, the water penetrates the defects in the sulfur coat through capillary action and begins to dissolve the fertilizer core. The dissolved fertilizer then exits the particle in reverse sequence.

This mechanism provides greater uniformity in nutrient release compared to typical SCU fertilizers. The agronomic advantages of this are reduced surge growth after application and longer residual; up to 6 months. In addition, the combination coating renders the nutrient release rate much less temperature sensitive than most polymer-coated fertilizers. (8)

Fertigation: This process utilizes the irrigation system to deliver fertilizer to the turf; applying organic components including sea weed extract, fish emulsion and humic acid to help improve the growth of microbial life in the soil. The microbes feed on the high organic content existing in campus soils to release nutrients in a form the turf plants can use. The fertigation system also distributes a wetting agent to help prevent hydrophobic conditions that can occur from high clay content and compaction. The wetting agent is Ammonium Lauryl Sulfate which is commonly used in household products such as shampoo. The desired end result is to create a living, breathing soil profile that will be able to sustain itself with minimal to zero synthetic fertilizer applications. The fertigation process is applied during an irrigation cycle every 4 to 6 weeks during the growing season.

(8). Sartain, J.B. "Food for turf: Slow-release nitrogen." *Grounds Maintenance* 1 Apr. 2002. http://www.groundsmag.com/mag/grounds_maintenance_food_turf_slowrelease/

Mowing Practices for a Healthy Lawn

In the past, many areas of campus were not mowed weekly due to budget constraints. This caused the turf to lie down and get "lazy". Regular mowing is a key practice for lawn health. The worst mowing scenario is to mow an overgrown lawn down to 2 inches all at once, just before the start of the summer drought. This can shock and seriously weaken a lawn. Instead, proper mowing practices should try to remove only 1/3 of the grass height at each mowing. With current equipment and a designated mowing crew Outdoor Services is poised to accomplish this recommended practice. In the past it took an entire week to mow the campus lawns. In addition the mowing height and mowing cycle were inconsistent. Current practices allow the mowing crew to start on one end of campus and mow about 95% of the main campus lawns in 2 days, with the smaller areas of campus touched up on Wednesday. With the implementation of the fertilizer program, and especially during the summer months, all areas of campus will be mowed twice per week. The turf manager has also lowered the mowing height on campus from 3 inches to 2 inches to help promote lateral growth of the plant, thereby promoting turf density.

Grasscycling is a key practice utilized by Outdoor Services. Grasscycling means leaving the clippings on the lawn, where they break down quickly and provide free fertilizer. Grasscycled plots grow faster, green up earlier in the spring, and stay green longer in the fall. Grasscycled plots also have fewer broadleaf weeds than practices that collect clippings. It improves the organic content of the lawn's root zone (through the activities of earthworms, bacteria, and fungi mixing and decomposing the clippings). It reduces the frequency and amount of fertilizer applications needed. It may reduce disease outbreaks. And it reduces compaction and enhances natural aeration, infiltration, and drainage, through the movement of earthworms between the deep soil layers and the surface. (9)

Soil Maintenance

Aerification: Outdoor Services uses various types of aerifiers to relieve compaction of turf areas and to improve the movement of oxygen, water and nutrients in the soil. Most of the campus was never aerified with any regularity prior to 2002. The current plan is to aerify all turf areas on campus to a depth of 2-3 inches depending on soil type and compaction. The turf tech position will be responsible for regular aerification across campus. **(See Attachment B)**

Topdressing: Outdoor Services uses an 80/20 sand/peat mix that is top-dressed on the recreation fields. Topdressing increases organic contents of the soil and also improves infiltration and percolation of water. Due to the impact on the habitat associated with peat harvesting, the use of a compost mix for top-dressing is also being researched.

(9). Seattle Public Utilities, 1999, Ecologically Sound Lawn Care for the Pacific Northwest: Findings from the Scientific Literature and Recommendations from Turf Professionals.

Soil Testing: The use of soil sample testing will allow for more targeted and effective treatments of fertilizers and other soil amendments. As previously stated, the presence of many weeds is due to poor soil conditions. For example, the presence of clover is often due to the lack of nitrogen in the system. In keeping with sound IPM principles and addressing the cause of the problem, it is more logical to adjust nitrogen levels in an attempt to reduce clover coverage before resorting to the use of a synthetic herbicide. While the herbicide may kill the existing clover, it does nothing to prevent it from coming back in the future. Certain weeds also thrive in high nitrogen conditions. By more closely monitoring nutrient levels as part of a fertilization and soil amendment program, Outdoor Services can avoid over fertilization, thereby reducing conditions that favor weeds.

Outdoor Services tests 20-30 locations across campus on an annual basis. Ten locations will be selected every year to monitor changing soil conditions in each specific location. Ten to twenty other locations throughout campus will be selected to monitor changing soil conditions throughout the year. The soil reports show many nutrient levels but the most important are Phosphorous (P2O5), Potassium, Organic matter and pH.

Overseeding

In the past overseeding, especially after Aerification, was not a common practice. Introducing new varieties of turf species by overseeding will increase the drought resistance and shade tolerance to promote healthier turf, as well as fill in bare patches. This will be accomplished by introducing a combination of a perennial ryegrass and Kentucky bluegrass seed mixture. For the next few years there will be aggressive seeding through out the growing season to try to improve the turf quality. Over the long term the frequency will be reduced to follow the spring and fall aerification schedule. **(See Attachment B)**

Addressing the Seed Bank

It is estimated that one Dandelion (Taraxacum officinale) plant can produce up to 15,000 seeds. Furthermore, it is estimated that these seeds can survive up to six years in undisturbed soil. Recognizing these facts allows one to understand the importance of managing the seed bank as part of a successful turf grass management program. By not addressing the seed bank, a maintenance program opens itself up to repeated and scheduled use of post emergent herbicides.

The seed bank can be dealt with using various approaches. One option is to rely exclusively on the extensive use of both pre- and post-emergent herbicides. While considered effective in the short term, this approach does not address the root cause of the problem. This is particularly true due to the addition of seeds to the campus system from the surrounding region by both wind and water borne transmission. If one looks at the areas directly west of campus (i.e., the Hill area) it is clear that they are a significant source of additional weed seeds. These seeds are carried to campus by wind but also by the raw water in the Anderson ditch. This water fills the campus ponds which are ultimately used to irrigate campus turf.

Another option to control the seed bank is the use of aggressive cultural practices such as good fertilization, aerification, over seeding, proper irrigation (deep and infrequent), and mowing at a height that will encourage lateral growth of the turf grasses. The combination of these cultural practices works to negatively impact the seed bank by eliminating the voids that seeds need to germinate and take hold. A weed is a plant of opportunity. Robbing weed seeds of the opportunity to germinate and

grow by removing necessary input, primarily sun light and water, effectively reduces the favorable conditions under which weeds thrive. Lastly, mowing crews will reduce the mechanical spread of weed seeds by more frequently cleaning mowers and mower decks.

A successful turf grass program must always try to stay ahead of any potential problems with voids in the turf. Typical causes of voids are poor irrigation coverage, construction damage, vehicle damage, and scalping from mowers. Knowing that weed seeds can stay viable for multiple years, an effective turf management program must strive to reduce the conditions that allow them to germinate in the first place. It is for this reason that support for aggressive cultural practices must remain consistent.

Integrated Pest Management

"Integrated pest management, or IPM, is an approach to pest control that uses regular monitoring to determine if and when treatments are needed, and employs physical, mechanical, cultural, and biological tactics to keep pest numbers low enough to prevent intolerable damage or annoyance. Least-toxic chemical controls are used as a last resort."

Daar, Olkowski, & Olkowski: IPM Training Manual for Landscape Gardeners

The Integrated Pest Management Process: The most common turf and lawn pest problem on the UCB is weed invasion; and primarily dandelions and other broad leaf "weeds". True IPM is a powerful approach that anticipates and prevents most problems through proper cultural practices and careful observation and knowledge of the life cycles of both beneficial and pest organisms. The IPM process for lawns includes the following steps:

1. Setting realistic expectations for lawn appearance, tolerating a few weeds and setting realistic thresholds of acceptable damage to the lawn from pests
2. Correctly identify problem pests and understand their life cycle
3. Monitor to detect and prevent pest problems
4. Modify the maintenance program to promote vigorous grass and discourage pests
5. If pests exceed the tolerance thresholds, use cultural, physical, mechanical or biological controls first; if those prove insufficient, use the chemical controls that have the least non-target impact
6. Evaluate and record the effectiveness of the control, and modify maintenance practices to support lawn recovery and prevent recurrence (10)

Step one: Establish tolerance thresholds

Every lawn has a few weeds, root-eating larvae, and fungal disease organisms present all the time, and this is good because it keeps populations of beneficial organisms that attack those pests present, too. The problem arises when the pest gets out of control. Tolerating a certain number of small mowable broadleaf plants (like clover) and concentrating on larger, easier-to-control dandelions may yield an overall "weed" threshold that is easier to attain. Weed tolerance thresholds are mostly subjective. The long term goal is to keep pest populations below the levels at which they would have unacceptable impacts on lawn appearance. (11)

(10), (11). Seattle Public Utilities, 1999, Ecologically Sound Lawn Care for the Pacific Northwest: Findings from the Scientific Literature and Recommendations from Turf Professionals.

Outdoor Services has established the acceptable tolerance levels for weeds as: **(See Attachment C)**

1. Injury Level is at 15 weeds per 25 square feet of lawn area
2. Action Level is at 30 weeds per 25 square feet of lawn area.
3. Damage Level is at 45 weeds per 25 square feet of lawn area.

Step two: Correctly identify pest problems and understand their life cycle

This step includes:

1. correctly identifying problem pests,
2. deciding that they are enough of a problem to pay attention to, and then
3. observing and reading about their life cycle to know how to prevent or control them effectively. (12)

Outdoor Services Turf Professionals are proficient in this area.

Step three: Monitor to detect and prevent pest problems

Monitoring is a key practice to anticipate and prevent major pest outbreaks. It begins with a visual evaluation of the lawn's condition. (13)

Outdoor Services will perform audits by walking around, observing and looking for problem areas in the lawn on a regular and ongoing basis. Outdoor Services will maintain a logbook, recording daily events such as high and low temperatures, precipitation, mowing, fertilizing, irrigation problems, vandalism, thresholds, actions taken, etc.

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

The lawn maintenance and improvement practices recommended in this report will prevent most pests from ever becoming a problem. Some practices are particularly helpful to prevent a particular pest problem. For example, aeration and over seeding along with proper mowing height, fertilization, and irrigation will help the grass out-compete weeds. Correcting drainage problems and letting the soil dry between watering cycles in the summer will also improve the health of the lawn ecosystem. (14)

Outdoor Services is committed to the maintenance program and practices described earlier within this report.

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

When a pest outbreak strikes (or monitoring shows one is imminent), first review the best cultural practices for grass to see if something may have been left out or needs to be added. Then consider the control options that are least toxic, or have the least non-target impact. (15)

If the previously described tolerance thresholds are exceeded Outdoor Services may need to resort to further actions including chemical controls. As noted, the goal of this program is to minimize the use of chemical herbicides; however the use of chemical herbicides may be required at times. The use of chemical herbicides will be discussed later in this report.

(12), (13), (14), (15). Seattle Public Utilities, 1999, Ecologically Sound Lawn Care for the Pacific Northwest: Findings from the Scientific Literature and Recommendations from Turf Professionals

One additional mechanical option would be removal by hand or by the use of poppers or diggers. Outdoor Services continues to test new devices to find the most effective approach. In this case, Student labor would be used to remove established weeds in an effort to improve the immediate aesthetic in particularly high visibility areas or difficult areas such as along curbs and edges. This will help reduce the pressure to conduct additional spot spraying in advance of the scheduled spring application. This option will be reserved for very small areas where the weed density is not too high.

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

Keep a notebook log of when, where, and what symptoms or monitoring revealed a pest problem, what controls were applied when, and the effectiveness of the control (whether by observing lawn condition, or direct monitoring techniques like re-counting number of crane fly larvae per square foot). Mark next year's calendar to monitor at the appropriate time to anticipate the problem. Review your lawn maintenance and cultural practices to see if they can be modified to prevent or reduce the problem. (16)

Outdoor Services and the Facilities Operations IPM program are committed to this process.

Herbicide Use

Continued *broadcast* or calendar-based applications of synthetic herbicides or use of chemicals to target patches of weeds often kills the beneficial organisms (such as earthworms, or fungi that attack disease fungi, or birds that feed on harmful insects) and contributes to soil compaction, acidity, thatch build-up, disease susceptibility, and extreme nutrient swings that favor weeds and diseases over healthy turfgrass. (16) By taking guidance from the campus IPM policy, the potential benefits of these applications can be met in a more targeted and safer fashion (if synthetics are chosen), as well as using organic alternatives, such as corn gluten meal, as a broadcast application. **(See Attachments D and E)**

Overall, one of the goals of the ecological turf management program is to follow an organically based program as much as possible. At present, research indicates there are effective pre-emergent non-toxic herbicides available. If it is determined that synthetic pesticides are to be used for the control of weeds in turf areas, it is recommended that several courses of action be taken to assure compliance with the IPM policy. In making this decision, it is important to recognize that "Of the 40 most commonly used lawn chemicals, 12 are linked to cancer, 21 are linked to liver, kidney and nervous system damage, and 36 cause irritation (National Institute of Health)."

Although corn gluten meal (CGM) is more expensive than some common synthetic pre-emergent herbicides (i.e., Gallery™ (Isoxaben), Pendulum), benefits of CGM include additional nitrogen in the form of organic matter, and the ability to re-seed treated areas within 30 days (vs. 60-90 days w/ synthetic products). Most importantly, due to the fact that CGM is an organic product, it can be applied to campus turf areas even when classes are in session. This allows the turf crew to use it when it is most effective (March & Aug.-Sept.). Commonly, synthetic products are considered too hazardous to apply during the regular semester schedule. This can result in applications that are poorly timed and therefore less effective.

(16). Seattle Public Utilities, 1999, Ecologically Sound Lawn Care for the Pacific Northwest: Findings from the Scientific Literature and Recommendations from Turf Professionals

Outdoor Services will be conducting a test of Corn Gluten Meal vs. Pre-emergent synthetic (yet to be determined). This will be a side by side study in a test plot directly south of Duane Physics. This area will be closely monitored throughout the growing season and will receive the same cultural and irrigation practices. The plot will be divided into three equal parts with the center 1/3 as a control plot.

In addition to this specific product, Outdoor Services will continue to research similar products for cost, efficacy and toxicity, with a preference toward non-toxic or organic based controls.

The Case for Replacement:
Certain locations that are small, have very high weed densities, and are difficult to maintain equipment at times do not qualify for herbicide applications. The first decision to be made in these cases is whether the plot should remain as turf. The campus landscape architect is currently involved in designing a comprehensive plan to address many edge and corner areas such as these. Goals of this effort include eliminating cow paths, tire ruts, sharply sloped turf, and turf areas notoriously difficult to maintain, especially those that can not accommodate key maintenance equipment such as aerators and slit seeders.

Once the decision has been made to keep an area as turf, it may prove to be more cost- and time-effective to rip out the old turf and start fresh. In addition to creating the opportunity to add needed soil amendments such as compost, sod replacement provides an immediate aesthetic improvement. Although the same plot could be sprayed with multiple applications of pre- and post-emergent herbicides, given the maintenance challenges presented by these areas, true restoration could take years.

Use of Synthetic Pre- and Post- Emergent Herbicides:
Where areas have been neglected or proper turf maintenance practices have not been utilized, turf professionals acknowledge and recommend a one-time broadcast spraying with a broad-leaf selective herbicide, to reduce major weed populations. However it is critical that this practice is followed by over seeding and proper maintenance to fill in the turf with grasses. Where as the current turf management program may require an aggressive broadcast application for the first year or two the long term goal is to reduce chemical herbicide applications by over 80%. As mentioned earlier, by monitoring and recording the use of synthetic chemical use on the UCB campus Outdoor Services can monitor the accomplishment of this aggressive goal.

In researching effective times to use a synthetic post-emergent herbicide for broadleaf weeds one would only find a suggested time range. For example, the suggestion for a spring application is when the weed is actively growing. This time varies greatly depending on soil temperature, recent precipitation (rain and snow), use, and other specifics of a particular area such as slope and orientation (north or south facing). There is no magic date and timing is best left up to the end user. There will never be a “perfect” time to apply chemicals for broadleaf weeds since there is such a long window of germination. **(See Attachments D and E)**

Another consideration for the use of synthetic chemicals is the amount of contact by the community and the potential for subsequent exposure to the product. In addition to increased health risks, over exposure to a fresh application of an herbicide can also diminish its efficacy as the product can be tracked off site on the sole of people’s shoes while it is still wet. This is of particular concern at the

university as it is very difficult to keep students off the grass following a pesticide application, despite extensive efforts to notify the population.

With these considerations in mind, the decision has been made to avoid applying synthetic *post-emergent* herbicides until after Spring commencement in early to mid May. This time frame should be acceptable since the weeds are still actively growing and will be for another month or so, and there should be good control from an herbicide applied at that time. The bigger problem that needs to be addressed is the weeds that have already gone through their life cycle and have produced seed. A post-emergent control will not be able to control the release of those seeds.

This is where the use of a pre-emergent herbicide comes in to play. Assuming large-scale reduction of established weeds is the desired goal, typically large scale applications of both a pre- and post-emergent herbicides may be required in the first year or two. The use of the pre-emergent the first year is to hold back the seed bank during the first summer in order to make up for previous turf management practices. The post-emergent is needed to kill the existing plants that remain from the years prior. Using this method gives the program time apply aggressive cultural practices in an effort to improve turf health. The second year will probably still need a relatively large-scale application of a pre-emergent; however this will lead to the reduction in areas requiring annual post-emergent herbicides.

There is another germination period for dandelions in the fall but it is far less aggressive than the spring germination. Some believe that conducting a fall application of a post-emergent is needed. Once the program is fully implemented Outdoor Services does not anticipate the need for this fall application. In fact, fall applications may actually require another large application of a post-emergent in the spring. The main result of using a post-emergent is to open up the turf canopy to grow more healthy turf. A fall application may impact the ability of the new grass seed to germinate and become strong enough to make it through the winter, thereby creating a new void for the seed bank to be able to produce a new weed come spring time. To state it another way, it does not make sense to spend the time and money to do a post-emergent application since it may impact the opportunity to follow up with aggressive re-seeding. Essentially, you can do more harm than good.

This is an important point to consider when doing a spring application. Given the timing of the spring application on campus, the weeks directly following a spring application are critical. During this time, it is important to follow-up immediately with good cultural practices, especially re-seeding. To fix a weed problem may take years and does not happen overnight. There needs to be the agreement that further applications may need to be added to the list and focused on the next year. To make changes to the appearance of the campus lawns will need focused efforts to regenerating a healthy turf system.

Conclusion

In conclusion it is important to recognize that in order to improve the appearance of the campus lawns the new turf management program will have to address current conditions that resulted from decades of overuse and improper maintenance. In some cases, the damage goes as far back as when turf areas were flood irrigated using the old concrete ditch system. The compaction caused by this practice alone has yet to be mitigated. The long-term goals for improvement in the campus appearance as well as a safe and healthy campus can be accomplished by utilizing an ecological turf management program. This approach will combine strong cultural techniques, organic based fertilizers, and the safest and least use of synthetic pesticides possible, while yielding superior turf quality, fewer weed problems, and a healthier ecosystem.

Summary of Cultural Practices

As we pointed out earlier, healthy soils will result in a healthy turf. The following practices will help achieve both healthy soils and turf areas:

- Effective use of the Outdoor Services resources
- **Water** less often, more **deeply** – keeps area where weed seeds lay dry, while keeping turf roots deep.
- **Fertilization and fertigation**; replenish nutrients, move to organic based, slow release fertilizers for supplemental applications.
- **Mowing height** lowered to 2"; keeps roots "active."
- **Grasscycling** adds nutrients and organic matter to the soil
- **Aggressive aeration**; deep-tine aeration, core aeration, and "slicing."
- **Top-dressing** with compost or sand.
- **Over-seeding** bluegrass, rye; start introducing some newer varieties of turf that are more suited to the environment on the UCB campus- some strains on campus could be over 20 years old.
- **Hand popping** – new ergonomic "twisters" and poppers being tested for difficult and obvious areas like along curbs.
- **Careful rotation** of uses; designate high impact areas.

These practices will generally be applied to all turf areas around campus. In particular, Outdoor Services will measure the success of the various weed control techniques while keeping cultural techniques at a constant. In keeping with IPM practices, extensive data collection and record keeping of results will be well maintained for review and evaluation.

Credit and Acknowledgment is given to Seattle Public Utilities for the use and reference of the publication Ecologically Sound Lawn Care for the Pacific Northwest: Findings from the Scientific Literature and Recommendations from Turf Professionals, 1999.
http://www.seattle.gov/util/stellent/groups/public/@spu/@csb/documents/webcontent/ecological_20031202125539 4.pdf

ATTACHMENT A

Fertilization Schedule

The dates that will follow are for designated timing of fertilizer applications for the growing season. Outdoor Services will be using a synthetic fertilizer for the short-term future to allow for vigorous growth through the entire season. It will be a 26-5-12 analysis with a minor nutrient package incorporated in the fertilizer. There will also be some foliar nutrient applications done to Rec. Fields, Duane Lawn, Benson Lawn and the Norlin quad for added microbial growth. Other areas may be added in the future. Also, there will be four injections of soil amendment nutrients through the irrigation system over the course of the growing season.

These dates are of course subject to change due to inclement weather. Outdoor Services has established two distinct routes for the application of fertilizers. The routes will vary in frequency due to the demands of the area:

Route 1 is the recreational field route; these areas will be done every month.
Route 2 is a bulk application of fertilizer on the majority of the turf areas on campus.

Late January	All turf areas on the Boulder Campus will receive a Urea application
Early March	Corn Gluten Meal at South UMC lawns and Duane test plot
Late March	Route 1
Early April	Foliar application to Franklin, Business, Farrand and Williams Village fields
Mid April	Route 2
Late April	Route 1
Early May	Foliar application to Franklin, Business, Farrand and Williams Village fields
Early May	Foliar application on Norlin Quad
Late May	Route 1
Late May	Foliar application on Duane & Benson lawns
Late May-Early June	Route 2
Early June	Foliar application to Franklin, Business, Farrand and Williams Village fields
Mid June	Route 1
Early July	Foliar application to Franklin, Business, Farrand and Williams Village fields
Mid July	Route 1
Mid July	Route 2
Early August	Foliar application to Franklin, Business, Farrand and Williams Village fields
Mid August	Route 1
Mid August	Corn Gluten Meal at South UMC lawns and Duane test plot
Late August	Route 2
Early September	Foliar application to Franklin, Business, Farrand and Williams Village fields
Mid September	Route 1
Early October	Route 2
Early October	Foliar application to Franklin, Business, Farrand and Williams Village fields
Mid October	Route 1

ATTACHMENT B

Aerification and Seeding Schedule

This upcoming year will be the first aggressive aerification and seeding across campus in two years. Spring and fall will be the two major times during the year where we will be pushing hard to aerate and seed the campus. Outdoor Services will begin to aerate and seed during spring break and continue until the end of April. There will also be a more concentrated effort from the beginning of September until the end of the month.

Although spring and fall will be the main times to focus on, there will also be cultural practices completed in areas around campus throughout the growing season. These areas will each require a different method of renovation. However, Outdoor Services will use all of the available equipment to continuously keep seeding and aerating the campus in order to improve the aesthetics of the campus.

Outdoor Services will increase the amount of turf work after large events such as event parking on a field or concentrated activity on an area.

At this point Outdoor Services plans to use close to 10 tons of seed this year alone. Plans are to increase this number over time as continuous reseeding is the single best way to combat the damage the university grounds receive during the year.

The following are the few dates that can be planned ahead with regards to the recreational fields. As stated before, there will be aerification and seeding throughout the year.

Late March	Aerate the Norlin quad, Benson & Duane lawns & Rec Fields
Mid-Late May	Field work including aerification
Late May-Late June	**Start spring aerification of campus**
Late May	Aerate Benson & Duane lawns **(or Franklin Field Work)**
Mid August-Late September	**Start fall aerification of campus**
September-November	Field repair after football on Franklin

******* Aerification will be done following summer athletic camps **(Dates vary)**

ATTACHMENT C

Weed Thresholds

The University Integrated Pest Management Plan requires that pest tolerance thresholds must be established and may vary by pest, specific location or type of land use. Each department having facility and land use responsibility will establish the pest threshold levels for their area of responsibility. Three distinct levels should be determined: *Injury Threshold*, at the point some injury begins or is noticed initially; *Action Threshold*, requires that action be taken to prevent a pest population from causing aesthetic, functional or economic damages; *Damage Threshold*, the level where unacceptable damages are already occurring. Regular monitoring is essential to determine the pest levels relative to the established thresholds. The Outdoor Services section has developed the following thresholds for weeds in turf areas:

"Pristine"

-Generally these are recently restored areas

-Have few or no visible weeds

- **Apply aggressive cultural practices (see pg. 14)**
- **Potential for pre-emergent to be applied to soil before installation of new sod**

Injury Threshold (See Figure 1)

-Greater than 15 weeds per 25 sq. ft.

- **Apply aggressive cultural practices (see pg. 14)**
- **Pre-emergent application**

Action Threshold (See Figure 2)

-Greater than 30 weeds per 25 sq. ft.

- **Apply aggressive cultural practices (see pg. 14)**
- **Possible replacement**
- **Pre-emergent application (if replaced or not)**
- **Post-emergent application (spot treatment) if not replaced**

Damage Threshold (See Figure 3)

-Greater than 45 weeds per 25 sq. ft.

- **Apply aggressive cultural practices (see pg. 14)**
- **Emphasis on replacement**
- **Pre-emergent application (if replaced or not)**
- **Post-emergent application (broadcast treatment) if not replaced**

Targeted Weeds:

- Dandelion
- Plantain (Narrow & Broadleaf)
- Mallow

Figure 1
15 weeds in a 25 square foot patch
Injury Threshold

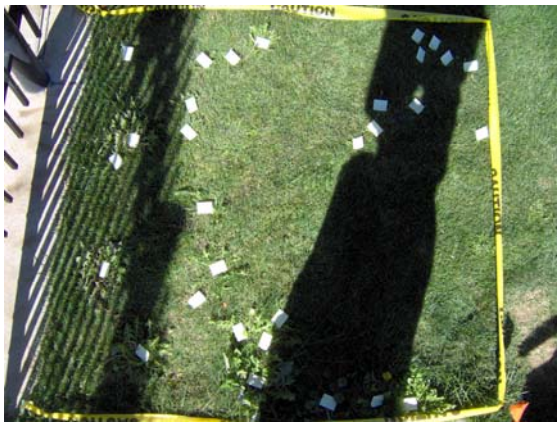

Figure 2
30 weeds in a 25 square foot patch
Action Threshold

Figure 3
45 weeds in a 25 square foot patch
Damage Threshold

ATTACHMENT D

Herbicide Use Guidelines

The information to follow is designed to guide decisions made about herbicide use. Specifics include weather restrictions, target pest, timing of the year, and other considerations.

CORN GLUTEN MEAL

Target pest: Broadleaf weeds – dandelions

Timing: Before seed set. Ideally two applications/yr.: early March & mid August to early Sept.

Preparation: Charge irrigation system (perhaps)

Weather Restrictions: Wind conditions of less than 10mph.

Mode of action: *Pre*-Emergent. Kills feeder/starter roots of emerging plant. Does not kill established plants.

Toxicity: EPA Toxicity Level 4 (Caution). Non-toxic, organic product. No environmental or health risks.

Other Considerations: Can be applied while students present. Able to target application when most effective. Must apply 60 days before re-seeding grass.

ISOXABEN (GALLERY 75 DF)

Target pest: Broadleaf weeds (95 total) – Dandelion, Plantain, Clover, Thistle, Black medic, Purslane.

Timing: Before germination. Identify germination times of target weeds. Apply Gallery 75 DF in late summer to early fall, in early spring, or anytime prior to germination of target weeds, or immediately after cultivation. Prevents growth of labeled weeds for up to 8 months.

Weather Restrictions: Wind conditions between. 3-10 mph (depends on granular vs. liquid). Label does not list temperature restrictions.

Mode of action: *Pre*-Emergent. Disrupts and halts root development of the weeds…seedlings gradually die before they break the soil surface.

Toxicity: EPA Toxicity Level 3 (Caution). Considered 'an immediate health hazard,' and a delayed health effect. LD50 for skin is >5000 mg/kg. Oral LD50 for rats is >5000 mg/kg. Isoxaben shown to interfere with reproduction in animal studies. 'This mixture contains a component which , is listed as a carcinogen for hazard communication purposes under OSHA…'

Other Considerations: Must be activated by ½ inch of rainfall or sprinkler water to set up a solid control area around weed seeds within 21 days of after application.

MCPP-p 4 AMINE

Target pest: Broadleaf weeds – Bindweed, Clover, Dandelion, Plantain

Timing: "Apply when the weeds are growing vigorously." "To obtain best results…must be applied when the weeds are most susceptible and conditions are such that no damage to the grasses will occur. Before seed set. One application/yr.: mid April to mid May. It is recommended that applications be made during a dry, eight hour period, since rain can wash off the material and reduce control. Fall application is not recommended as discussed earlier.

Preparation: "Do not mow lawn 2-3 days before or after treatment so that maximum uptake and translocation can occur."

Weather Restrictions: "Do not spray if rain is likely, otherwise the chemical may be washed off before absorption has taken place. For the same reason, do not water lawn for at least 24 hrs after application." Do not use of temp. Exceeds 90 degrees F.

Mode of action: *Post*-Emergent. Does kill established plants. "Absorbed by the foliage and is translocated throughout the whole plant and roots."

Toxicity: EPA Toxicity Level 1 (Danger). Significant environmental or health risks.

Other Considerations: Should NOT be applied while students present. Requires use of surfactant or synergist; these items not typically considered in overall toxicity rating of product.

ATTACHMENT E

Herbicide Applications

The following information is provided to demonstrate ideal times for specific herbicide applications. This schedule does not commit Outdoor Services to any particular application or product.

Pre-Emergent Applications

Early March	Organics: Organic herbicides typically require a longer time to become active after being applied (2-4 weeks). This requires that they be applied earlier in the season than synthetic products.
Mid March	Synthetics: Micro-climates (south facing slopes, south sides of buildings, areas intensified by the sun, etc.). These areas tend to warm up earlier in the season, which causes weeds to begin their reproductive cycle earlier (i.e., seed dispersal).
Late March	Synthetics: Non micro-climate areas.

Post-Emergent Applications

Mid May	All designated areas that meet the action level threshold.
Fall	Fall application of post-emergent herbicides is not recommended for reasons discussed earlier in this document

ATTACHMENT F

Weed Life Cycles

Most Prevalent Weeds	Life Cycle & Description	Most Effective Timing	Control Methods	
			Chemical	Cultural
Dandelions in Turf **Emerge:** mid spring to early fall **Pre Control Timing:** early spring **Post Control Timing:** mid-late spring & mid-late fall	(Taraxacum officinale) is a deep-rooted, stemless perennial weed. It has a long taproot and a basal rosette (circular cluster of leaves radiating from the stem of a plant at ground level) of slightly to deeply cut leaves with lobes that point back towards the base. The rosette remains green year-round. Yellow flowers appear mainly in the spring on long, smooth, hollow stalks. A second bloom occurs in the fall. The leaves and flower stalks exude a milky juice when broken. The flowers give rise to a "puff" ball or globe of parachute like brown seeds. Seedlings emerge from late spring to early fall, with most emerging in early summer, several weeks after the seeds are shed. Dandelion will grow in almost any soil type and is most commonly found in sunny areas. It reproduces by seed and from new plants that develop from pieces of broken taproots.	Dandelions are winter perennials which germinate in the early to mid spring and continue to germinate through fall. Post emergent herbicide applications will be most effective at this time. Use a selective post emergent application timed after germination when plants are young and actively growing.	Dandelions are readily controlled by 2,4-D, or products containing 2,4-D, if applications are made in fall or early spring before the plants begin to flower. Other useful post emergent herbicides include glyphosate, triclopyr, MCPA, MCPP, and mecoprop. Pre emergent herbicides are isoxaben and oxyfluorfen.	Dandelions can be physically removed, but it is very important to remove the taproot, in its entirety if possible, as new plants can sprout from root sections. Do not try to remove dandelions by hand; use the appropriate digging tool which is designed to penetrate deep with minimum damage to surrounding turfgrass plants. Good insect and disease control and a sound fertility program will help to prevent the open spaces that allow dandelion seeds to take root. A healthy dense lawn should be promoted. The manual removal of problem weeds can sometimes become impractical depending on density of the problem weed or the general size of the area. When this occurs, other control methods may need to be explored and/or implemented.

Most Prevalent Weeds	Life Cycle & Description	Most Effective Timing	Control Methods	
			Chemical	Cultural
Plantain in Turf **Emerge:** late spring through mid summer and early fall **Pre Control Timing:** None **Post Control Timing:** mid spring and mid fall	Narrow-leaved plantain (Plantago lanceolata), and broadleaf plantain (Plantago major) are perennial weeds that reproduce by seeds. Both produce a rosette or cluster of leaves at ground level and have fibrous root systems. The leaves of buckhorn plantain are narrow and lance-shaped (2 to 10 inches long – about five times as long as wide), often twisted or curled. Raised, parallel veins can be found on the underside of the leaf. As the name suggests, the leaves of broadleaf plantain are broad and egg-shaped – 1½ to 7 inches long – with main veins running parallel to the leaf margins. The petioles are sometimes tinged with red at the base. Both plantains produce erect flower stalks from June to September. Plantain produces a cone-like spike of white flowers perched at the top of the leafless flower stalk. Broadleaf plantain produces white-petaled flowers along the length of a leafless flower stalk that may be 2 to 18 inches long. Seed germinates in late spring through midsummer and sporadically in early fall.	Apply a selective broadleaf herbicide in mid-spring after seed germination in the rosette to flower stage. Post-emergence herbicides can be applied in midautumn when active growth has resumed.	Plantain has no preemergent herbicide. Post emergent herbicides can include any combination of these products: 2,4-D, 2,4DP, dicamba, and MCPP	Hand pulling is an option for small areas. Care should be taken to assure that roots are thoroughly removed. Good fertility and proper soil pH will help to prevent infestations. Soil testing which reveals high pH levels should be acidified, to a pH level of 6.5 to 7. The turf management staff gathered soil samples from various areas of campus and had them tested. Test results showed that, in general, the pH levels to be in the 7.5 to 8.3 range on the Boulder campus. Assuming funding for turf management is secured, the turf management staff would do a campus-wide acid injection through the fertigation system to help lower the pH level of the soil. Plantain also establishes itself well in compacted soils. Aerification can help prevent heavy infestation. Close mowing prevents seed head formation and helps to prevent spread. Proper watering will also help control. The manual removal of problem weeds can sometimes become impractical depending on density of the problem weed or the general size of the area. When this occurs, other control methods may need to be explored and/or implemented.

Most Prevalent Weeds	Life Cycle & Description	Most Effective Timing	Control Methods	
			Chemical	Cultural
Mallow in Turf **Emerge:** mid spring to late fall **Pre Control Timing:** early-mid spring **Post Control Timing:** mid-late spring & early-mid fall	Common mallow (Malva neglecta) ranges from a winter annual to a perennial depending on the location. The spreading stems of mallow grow prostrate with leaves borne on long petioles. Common mallow grows from a thick straight tap root. The leaves are lobed and can be confused with ground ivy. Mallow leaves are attached to the stem at the back of a rounded leaf. Mallow does not spread from nodes on stems. The flowers of common mallow are present from May to October. The flowers are white to lavender and have dark violet veins. The fruit resembles a cheese wheel. Mallow spreads by seed.	For optimum timing of post emergent herbicide, make application to mallow that is actively growing and in the seedling to flower stage of growth. Preferment should be applied in early to mid spring before seed germination.	Mallow can be controlled by spraying with a post emergent broadleaf herbicide containing 2,4-D, MCPP, *and* dicamba, or an herbicide containing triclopyr and cloypralid. Preemergent herbicide is isoxaben.	Weekly mowing and low mowing heights will help prevent infestations of mallow. Dense turf stands resist mallow invasion, so good turf management is key to controlling this weed. Hand weeding is extremely effective for mallow as long as the tap root is completely removed. The manual removal of problem weeds can sometimes become impractical depending on density of the problem weed or the general size of the area. When this occurs, other control methods may need to be explored and/or implemented.

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