4.5 Pest Infestation Thresholds

There will be four major factors, excluding climate, that will determine the thresholds of the anticipated turfgrass pests. They include water quality, soil conditions, pH and the turfgrass species.

Close monitoring of turfgrass during the establishment or grow-in phase will track the existence of potential pathogens. It will be very important to note the baseline information when sufficient crown, leaf stem, and thatch layers have developed. During this early stage, an evaluation of turf quality will be necessary. The evaluation should include a cross check for each Preliminary Threshold that has been established in the IGCBMP. The evaluation of pest occupancy for the project site should also be completed and the potential levels of anticipated pest outbreak established.

Following the grow-in period, the project may be required to close the Golf Course to traffic or play on specific days or time-frames as designated by the management of the Golf Course. In order to maintain consistent quality and achieve the standards outlined in this IGCBMP, it may be necessary to complete specific cultural or best management practices outlined in this report. Thus, reducing the impact of players on the existing turfgrass conditions will help the Golf Course maintenance staff to complete the necessary tasks on schedule that have been identified as cultural programs necessary for low-input management.

The Golf Course will maintain the greens as a consistent, weed-free turf that is of the highest playing quality, aesthetically appealing, and not impacted by the presence of deleterious pests. "Insect damage to the greens must also be at an absolute minimum but the greens need not be totally free of insects. Allowing limited damage (weeds or insect damage) does carry a risk that the above pathogen may spread which would force the use of a broader control." (Vittum, 1986). To produce high quality turf it is not necessary to have absolute control over insects and weeds. For example, healthy turf can be sustained with as many as five white grubs per square foot if traffic (wear) is not excessive (Brandenburg, 1989).

A similar level of quality will be required for the tees. Rotation of tee markers is necessary to maintain turf recovery. Therefore, the entire tee must be in a playable condition. Fairways may have a slightly greater amount of pest damage than tees. In the roughs and natural areas outside the fairways, a lower level of maintenance activity, compared to the tees, greens, and fairways, is proposed for insects and fungi.

Once the level of acceptable impairment is defined and the corresponding level of management is instituted, a regular program of inspections is required. The Golf Course superintendent or assistant Golf Course superintendent will make daily inspections of the course. This frequency is essential to identify the type and presence of pests early and to keep damage to an insignificant level with the lowest level of response.

4.5.1 Preliminary Threshold Guidelines

Site-specific turf pest thresholds identify the standard of management and establish that BMPs are functioning within the Golf Course operation. Suggested action levels for different Golf Course areas are presented in this section.

The suggested thresholds and action levels presented will be refined as actual data from the Golf Course becomes available. Data collection will begin during the grow-in period as soon as sufficient crown, leaf stem and thatch layers have been developed. During this early stage, the level of pest occupancy for the site should be determined, so that future pest outbreaks can be recognized with a degree of confidence. This is a process that will take approximately three years of data to refine the preliminary threshold guidelines and recognize the maximum tolerable levels of damage.

Historical pests and related patterns of existing golf courses are often a good indication of pest density and activity. Existing courses generally provide the turf agronomist the necessary confidence that certain levels of pests are natural and acceptable. To assume otherwise might be considered over-managing, disrupt the true causal agent, and lead to misdiagnosed turf problems.

Table 19 provides preliminary thresholds for weed grasses. Preliminary threshold guidelines have been established for the turfgrass pests anticipated to occur on each playing surface relative to the turfgrass cultivar. Grasses are easier to control in the lower heights of tees and greens. Simple hand removal will often prevent further spread of these grasses. Sedges are more difficult to identify and control and grow closer to the thatch canopy. Under well-established turfgrass conditions, these pests should pose minimal problems.

Table 20 lists the probable broadleaf weeds and the recorded levels of density in bentgrass and fine leaf fescue turf. Research will be needed to verify that the levels presented are not only tolerable but obtainable when managing these grasses. Many dicot weeds can be easily removed by hand. For those broadleaves difficult to control in groups or clusters, spot treatment with a wick applicator utilizing a post emergent herbicide will provide excellent control.

Tables 21 and 22 present management techniques once preliminary threshold guidelines are reached for weeds.

Table 23 presents timing for management techniques once preliminary threshold guidelines are reached for turfgrass disease.

Table 24 presents threshold guidelines for insect occurrence. Currently, there are no established industry thresholds for insect and mite pests found on this site. The thresholds for insects and mites are established as a preliminary guide. Local experience will also play a role in the refinement of these threshold guidelines.

Table 19. Suggested Action Levels for Grass Weeds in Different Golf Course Areas in New Jersey

Number of Weeds per 1,800 sq. ft.

Weed Species	Tees	Greens	Fairways	Roughs
Grasses				
Annual bluegrass	10	1	10	20
Barnyardgrass	5	1	10	10
Dallisgrass	3	1	5	10
Goosegrass	5	1	10	20
Green foxtail	5	1	10	20
Large crabgrass	5	1	10	20
Purpletop	5	1	10	20
Quackgrass	5	1	10	20
Small crabgrass	1	1	5	10
Timothy	5	1	10	20
Yellow foxtail	5	1	10	20
Sedges				
Purple nutsedge	5	1	10	50
Yellow nutsedge	5	1	10	50

Table 20. Suggested Action Levels for Broadleaf Weeds in Different Golf Course Areas in NJ.

Number of Weeds per 1,800 sq. ft.

Broadleaf				
Black medic	5	1	20	50
Broad-leaved plantain	3	1	10	20
Common chickweed	3	1	10	20
Common speedwell	5	1	20	50
Clover	3	1	10	20
Curly dock	3	1	10	20
Dandelion	3	1	10	20

Note: This table was developed from suggested guidelines by the University of Hawaii and an IPM program written for Lihi Lani by Holtzmann et al., 1991. The IPM plan was later summarized and rewritten by ETS to include this methodology as a means to establish baseline weed threshold counts

Table 21. Preliminary Threshold Guidelines - Turfgrass Weeds^ (Monocotyledons)

Pest	Area	Cultural Management	Chemical Control
Annual bluegrass	Tees/Greens Fairways Roughs	seed head control seed head control seed head control	post emergence post emergence post emergence
Barnyardgrass	Tees/Greens Fairways Roughs	seed head control seed head control seed head control	spot treat spot treat spot treat
Dallisgrass	Tees/Greens Fairways Roughs	mechanical removal mechanical removal mechanical removal	spot treat spot treat spot treat
Goosegrass	Tees/Greens Fairways Roughs	mechanical removal preventive preventive	spot treat spot treat spot treat
Green foxtail	Tees/Greens Fairways Roughs	mechanical removal preventive preventive	spot treat spot treat spot treat
Large crabgrass	Tees/Greens Fairways Roughs	mechanical removal preventive preventive	spot treat spot treat spot treat
Purple nutsedge	Tees/Greens Fairways Roughs	preventive preventive preventive	spot treat spot treat spot treat
Purpletop	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat preventive preventive
Quackgrass	Tees/Greens Fairways Roughs	mechanical removal preventive preventive	spot treat spot treat spot treat
Small crabgrass	Tees/Greens Fairways Roughs	mechanical removal preventive preventive	spot treat spot treat spot treat
Timothy	Tees/Greens Fairways Roughs	mechanical removal preventive preventive	spot treat spot treat spot treat
Yellow foxtail	Tees/Greens Fairways Roughs	mechanical removal preventive preventive	spot treat spot treat spot treat
Yellow nutsedge	Tees/Greens Fairways Roughs	preventive preventive preventive	spot treat spot treat spot treat

* Control of annual grass weeds on bentgrass or bluegrass tees and fairways are best obtained with the use of a preemergent herbicide. Under well established turfgrass conditions these pests should pose minimal problems.

Table 22. Preliminary Threshold Guidelines -Turfgrass Weeds* (Dicotyledons)

Pest	Area	Cultural Management	Chemical Control
Black medic	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Broad-leaved plantain	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Common chickweed	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Common speedwell	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Clover	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Curly Dock	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Dandelion	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Ground ivy	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Heal-all	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Henbit	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Knotweed	Tees/Greens Fairways Roughs	mechanical removal mechanical removal spot treat	mechanical removal mechanical removal spot treat
Lambsquarter	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Mallow	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat

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Table 22 (continued). Preliminary Threshold Guidelines - Turfgrass Weeds* (Dicotyledons)

Pest	Area	Cultural Management	Chemical Control
Mouse-ear chickweed	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Nodding spurge	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Oxalis	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Pearlwort	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Plantain	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Poison ivy & oak	Tees/Greens Fairways Roughs	N/A spot treat spot treat	spot treat spot treat spot treat
Purslane speedwell	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Prostrate spurge	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Prostrate pigweed	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Ragweed	Tees/Greens Fairways Roughs	mechanical removal mechanical removal mechanical removal	mechanical removal mechanical removal spot treat
Red clover	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Sheep sorrel	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Shepherd's purse	Tees/Greens Fairways Roughs	mechanical removal mechanical removal spot treat	spot treat spot treat spot treat

* Many dicot weeds can be easily removed by hand. For those broadleaves difficult to control in groups or clusters, spot treatment with a wick applicator utilizing a post emergent herbicide will provide excellent control.

Table 22 (continued). Preliminary Threshold Guidelines - Turfgrass Weeds* (Dicotyledons)

Pest	Area	Cultural Management	Chemical Control
Spotted spurge	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Stitchwort	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Thistle	Tees/Greens Fairways Roughs	mechanical removal mechanical removal mechanical removal	mechanical removal mechanical removal spot treat
Yarrow	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	post emergence spot treat spot treat
Yellow wood sorrel	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence

* Many dicot weeds can be easily removed by hand. For those broadleaves difficult to control in groups or clusters, spot treatment with a wick applicator utilizing a post emergent herbicide will provide excellent control.

Table 23. Preliminary Threshold Guidelines - Turfgrass Disease & Non-Infectious Biological Agents*

Pest	Area	Cultural Management	Chemical Control
Algae	Tees/Greens Fairways Roughs	upon detection 24-48 hours 48-72 hours	spot treat 72 hours 120 hours
Anthracnose	Tees/Greens Fairways Roughs	upon detection 48-72 hours 48-72 hours	spot treat 96 hours 96 hours
Bacterial wilt	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	72 hours 96 hours 120 hours
Brown Patch	Tees/Greens Fairways Roughs	upon detection 24-48 hours 48-72 hours	spot treat 72 hours 96 hours
Copper spot	Tees/Greens Fairways Roughs	upon detection 24-48 hours 48-72 hours	spot treat 72 hours 96 hours
Crown and root rot	Tees/Greens Fairways Roughs	upon detection 24-48 hours 48-72 hours	spot treat 72 hours 96 hours
Dollar spot	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat 72 hours 96 hours
Downy mildew	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	72 hours 96 hours 120 hours
Fairy ring	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	72 hours 96 hours 120 hours
Fusarium patch	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat 96 hours
Helminthosporium leaf spot	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat 96 hours
Leaf rust	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat 96 hours
Melting out	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat spot treat

Table 23. (continued) Preliminary Threshold Guidelines -Turfgrass Disease & Non-Infectious Biological Agents*

Pest	Area	Cultural Management	Chemical Control
Moss	Tees/Greens Fairways Roughs	rake out rake out improve drainage	spot treat spot treat spot treat
Necrotic ring spot	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat 96 hours
Nematodes	Tees/Greens Fairways Roughs	sample counts sample counts sample counts	needle> 200/100 cc Soil lance> 200/100 cc Soil stunt> 800/100 cc Soil spiral> 3,000/100 cc Soil Soil ring> 3,000/100 cc Soil
Pink patch	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat preventive preventive
Powdery mildew	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat spot treat
Pythium blights	Tees/Greens Fairways Roughs	upon detection upon detection 24-48 hours	preventive 24-48 hours 48-72 hours
Red thread	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 120 hours	72 hours 96 hours spot treat
Slime molds	Tees/Greens Fairways Roughs	upon detection 24-48 hours 48-72 hours	spot treat spot treat spot treat
Snow molds	Tees/Greens Fairways Roughs	upon detection upon detection rake out	preventive preventive spot treat
Summer patch	Tees/Greens Fairways Roughs	24-48 hours 48-72 hours 48-72 hours	spot treat spot treat spot treat
Take all patch	Tees/Greens Fairways Roughs	upon detection upon detection upon detection	spot treat spot treat spot treat
White patch	Tees/Greens Fairways Roughs	upon detection upon detection upon detection	preventive spot treat spot treat

* Currently there are no established industry standards for pest threshold guidelines. The following thresholds for insects, weeds and disease are established as a preliminary guide to assist the golf course superintendent in deciding when to choose the appropriate form of control. We fully expect that local experience will result in the refinement of these threshold guidelines. Hand removal of weeds in fairways and roughs can be accomplished by constructing a tool designed to remove the plant and taproot completely.

Table 24. Preliminary Threshold Guidelines - Turfgrass Insects

Area	Pest	Insect Density: Cultural Controls	Insect Density: Curative Controls
Greens/Tees Fairways Roughs	Annual bluegrass weevil	3-5/sq. ft. 5-8/sq. ft. 5-8/sq. ft.	6/sq. ft. 8/sq. ft. 8/sq. ft.
Greens/Tees Fairways Roughs	Ant mounds	1-2/yd^2 N/A N/A	3/yd^2 N/A N/A
Greens/Tees Fairways Roughs	Black cutworm	1-2/sq. ft. 2-3/sq. ft. 3-4/sq. ft.	3/sq. ft. 4/sq. ft. 5/sq. ft.
Greens/Tees Fairways Roughs	Bluegrass billbug larvae	N/A 3-4/sq. ft. 4-8/sq. ft.	N/A 6/sq. ft. 10/sq. ft.
Greens/Tees Fairways Roughs	Hairy chinch bug	10-15/sq. ft. 16-25/sq. ft. 26-30/sq. ft.	12-16/sq. ft. 25-30/sq. ft. 30-35/sq. ft.
Greens/Tees Fairways Roughs	Sod webworms	1-2/sq. ft. 3-4/sq. ft. 5-6/sq. ft.	3/sq. ft. 5/sq. ft. 7/sq. ft.
Greens/Tees Fairways Roughs	Black turfgrass ataenius	20-25/sq. ft. 30-35/sq. ft. 50-60/sq. ft.	30/sq. ft. 40/sq. ft. 60/sq. ft.
Greens/Tees Fairways Roughs	Japanese beetle, Asiatic beetle, May/June beetles & other annual grubs	3-4/sq. ft. 5-8/sq. ft. 8-10/sq. ft.	4/sq. ft. 8/sq. ft. 10/sq. ft.
Greens/Tees Fairways Roughs	Winter grain mite	30-40/sq. ft. 40-50/sq. ft. N/A	50/sq. ft. 60/sq. ft. N/A

4.5.2 Nematodes

High populations of certain species of nematodes may indicate that the turf root system is in danger or has already been debilitated to a significant extent. A simple count of nematodes, however, is not enough to make an informed determination of whether the threshold has been crossed and what, if any, action should be taken. The threshold levels which justify the implementation of control measures are dependent on the depth of the sample, the species of grasses present, the depth of the root system, soil texture, symptoms and extent of damage, presence of other stresses to the turf, and potential contamination of the environment by the nematicide chosen if action is taken (Wick, 1994).

Nematode populations are estimated most accurately with a composite sample. A three quarters of an inch to one inch diameter soil probe, or something similar, should be used to sample a depth of four inches throughout the site. This depth is a compromise but represents the population distribution of different species well.

Distribution: Nematodes are unequally distributed in the soil both vertically and horizontally, For example, if assays were done in a transect across a putting green, a series of high and low counts would result. Populations also vary according to the depth at which the sample was taken. A sample at a two-inch depth may have twice the concentration of stunt nematodes as a sample taken at four inches.

Time of Year: During winter months, nematode populations decline. As the grass begins to resume growth in the spring, nematodes begin feeding on roots. The reproductive potential of the nematodes increases as the soil temperature rises.

Assay Procedure: It is not possible to extract all of the nematodes from the soil sample. The soil (at least 1/2 pint) should be placed in a container, such as a plastic bag, to prevent desiccation. The sample number should be clearly identified on the outside of the container as paper tags placed in contact with the soil quickly deteriorate. The sample should be refrigerated or processed as soon as possible after collection.

At this time there is very little experimental data to establish threshold levels for nematodes in turfgrasses in this area. The numbers of nematodes per 100 cc of soil presented in the Table 25 are based on research from other states as well as from case-history information and survey results. They serve only as a guide.

Table 25. Threshold Levels for Nematodes in Turf

Nematode	Number/100 cc Soil
Needle	> 200
Lance	> 400
Stunt	> 800
Spiral	> 3000
Ring	> 3000

Cyanobacteria and Chlorophyte microalgae in a Kalonite clay base (Turftech II) and a biological liquid inoculum (Precep/Nemastop) are preferred as alternative control measures when populations of nematodes indicate only one or more species have specific high threshold counts. These products biologically increase root zone mass and dispense an irritant within the root that dislodges feeding nematodes.

Nematicide should not be used where contamination of water may occur and should be used only in accordance with the label and local regulations.

4.6 Pest Control Strategies

Once a pest has been located through routine inspection (whether visual, or with aid from disclosing solutions, trapping or disease immunoassay kits) and found to exceed threshold levels, the Golf Course staff has the information necessary to take action. Even when the infestation is found to be significant, the first corrective action is to evaluate environmental corrections. These include:

- Maintaining balanced nutritional levels;
- Improving microclimates through subsurface drainage, aerification, and increasing air movement and sun penetration;
- Reducing cultural management stresses by limiting scalping of turf, keeping mower blades sharp, and adjusting or raising mowing heights when necessary; and
- Calibrating replacement of water in order to control the build-up of total dissolvable salts in soils and minimize leaching.

If environmental factors have been optimized but infestation(s) still exceed acceptable thresholds, an incremental approach is indicated, starting with measures that have the smallest overall impact on the environment. Simple ideas often achieve desirable results. Hand removal of weeds or

spot application with a wick-type applicator are two examples of minimalist response. The Golf Course superintendent might reexamine fungicide management and develop new IPM strategies as needed to reduce disease pressure. New approaches might also assist in reducing fungicide resistance in turfgrass. Other approaches include maintaining insect populations within tolerable levels through the use of biologically synthesized insect and mite controls, or establishing populations of natural enemies, including microbial endophytes, insect parasites and other predatory nematodes. Natural enemies such as birds, mammals, and amphibians can also be supported, often through simple means.

4.6.1 Biological and Organic Controls

The turfgrass environment usually contains a large number of beneficial biological micro-organisms, insects, mites and spiders. If these organisms are not destroyed by insecticides or other chemicals, they can often control the insects and mites which damage the turf. In some cases, these beneficial insects look like pests and inexperienced managers may actually apply a pesticide. Therefore, it is important that one learn to differentiate the "good" bugs from the "bad" bugs. A number of diseases that attack turf insects can also be useful. These biological controls often take longer to do the job and may provide a reduced level of control. This should be acceptable, however, because of the reduction in the use of pesticides and lack of harm to non-target insects.

The release of parasitic organisms without the proper agency approval is strictly prohibited. The Golf Course superintendent must obtain the necessary permits and/or authorization as required by regulatory authorities before applying any experimental biological, parasitical or predatorial defenses. The regulatory authorities will also be consulted about known successes or failures with the use of these products for turfgrass control.

4.6.2 Common Predators and Parasites

The Golf Course IPM program is designed to preserve native insects that prey on pest populations. Unfortunately, most of these predators and parasites are very susceptible to many conventional pesticides. Caution must therefore be used when applying turf insecticides since these treatments can kill beneficial predators and lead to outbreaks of other pests.

On this site, earwigs, ground beetles, rove beetles, and lady beetles are expected to be significant predators.

Earwigs: Earwig nymphs and adults attack sod webworms and cutworms as well as a variety of other soft bodied insects. Earwigs require plant material or other cover in order to hide during the day and can be encouraged through provision of proper shelter.

Ground Beetles and Rove Beetles: These voracious predators feed on eggs and any insect they can subdue. Both adults and larvae are predators and are probably the most common natural control for caterpillars that attack turf. The primary means of encouraging beetles is through limiting insecticide applications or using spot treatments of insecticides in lieu of broadcast spraying. Recent studies indicate that these beetles rapidly reestablish into an area after pesticide usage if refuge sites are provided.

Lady Beetles: Lady beetles, like green lacewings, commonly inhabit trees and shrubs although they are occasionally found feeding on aphids and mites in turf. Releasing lady beetles is not recommended, however, since the commercially available species do not prefer turf habitat.

4.6.3 Common Pathogens

Most turf insect pests have natural diseases which periodically control their populations. A few of these pathogens require some special handling or application technique in order to be fully effective. It is imperative that the instructions for their use are carefully followed.

4.6.4 Insect Parasitic Nematodes

Microscopic nematodes which attack grubs have been recognized since the 1930s. Until recently, however, no one had identified an easy method to propagate or apply these parasites. Nematodes are now being produced in large quantities and several strains have been identified which will kill sod webworms and cutworms, billbugs, and the white grubs. These nematodes search out insects and enter their bodies through natural openings or by drilling through the cuticle. Once inside the body, the nematodes release a bacterium which kills the pest within hours. The nematodes then complete their development and produce new infective juvenile nematodes. Fortunately, these biological control agents only infect insects and will not harm the turf or other larger animals, including humans.

Exhibit® is a commercially available source of parasitic nematodes. It should be applied to the greens at a rate of 3.4 gallons per 1,000 square feet. As with all biological controls, care must be exercised to get the best results with parasitic nematodes. The active juveniles are very susceptible to drying and sunlight. Therefore, they should be applied to the turf with considerable water, preferably in the predator defenses. Regulatory authorities will also be consulted about known successes or failures with the use of these products for turfgrass control.

Dethatching, vertical mowing, sand topdressing, biologically active enhancers (described on the following page), grooming and brushing are the primary methods used to control and maintain the desired thatch levels. Vertical mowers and/or groomers will be installed on green and tee mowing equipment allowing the course to be dethatched on a regularly scheduled basis. In addition, aeration of the surface soils will be used to reduce thatch by relieving compaction and helping in the exchange of gases and fluids to the turf. Aerification is a process of opening passageways from the surface of the turf cover through the soil and into the root zone. In turfgrass, it is the equivalent of cultivation (plowing/discing) in agriculture. Since golf courses are subject to traffic (walkers, carts tractors, etc.), the upper soil profile has a tendency to compact and create inadequate soil pore space. Often, this will restrict the passageway of air and water into the root zone.

4.7.2 Biostimulant/Stress Management

Biostimulant/stress management products will be considered for use on an as-needed basis. Many products are available and will be used when soil testing and monitoring details the need for alternative strategies. Some serve to increase the turfgrass plants' ability to resist disease pressures and

environmental stress. Others will be useful for enhancement of soil microbes and/or drainage. Reducing stress and activating beneficial soil microorganisms, in turn, serve to increase the turfgrass' ability to counter disease, weeds, and insects, reducing the need for pesticides.

The following materials are intended to provide stress-specific assistance in the management of turfgrass, and to assist the Golf Course superintendent in the reduction of pesticide usage. These alternative materials are particularly useful in the maintenance of high traffic areas such as tees and greens. As time progresses and the soil ages, the use of these modification materials may prove to be particularly beneficial for turfgrass hardiness.

"**AquaTreat**" is a balanced blend of selected natural bacteria, bacterial enzymes, nutrients and synergists developed specifically to enhance water quality. They use only non-living organic matter as food sources. They have not been genetically altered or manipulated in any manner. The cultures are completely safe, and will not harm humans, plants, animals, birds, or the environment. The product alleviates odors, digests sludge, and keeps water algae free. It is manufactured by TerraBiotics L.P.

"**Bovarnura**" is a liquid organic manure fertilizer that promotes deep root development and encourages tillering. It may be used for root development on newly sodded areas. It supports the development of soil microorganisms and transforms nutrients to usable plant food. It is manufactured by the PBI Gordon Corporation.

"**Bio.Trek 22G**" with the active ingredient *Trichoderma Harzianum* is the first commercially available biological disease control agent for• turfgrass in the United States. The product is registered and suitable as a partial substitute for some turfgrass fungicides. The product is produced by Wilbur-Ekkils in Fresno, California and is currently undergoing a label change for registration as RootShield.

"**Bio-Safe Organic 3 in 1**" attacks insects by plugging their breathing tubes and causing asphyxiation. The product is registered for fleas, ticks, cockroaches, ants, scorpions, aphids, and beetles. The material is produced by American Wellness, Inc. in Carrollton, Georgia.

"**Cruiser**" is a bio insecticide containing the host seeking *Heterorhabditis bacteriophora (Hb)* nematodes for effective control of Japanese beetle larvae and other white grubs in turf and flower beds. The product is produced by Ecogen, Inc. Eco Soil Systems, Inc. produces a bioject Golf Course program for disease management, plant growth enhancement, sodium reduction and nematode suppression. The Bioject BioReactor is rented on an annual basis to inject large quantities of beneficial microbes directly into the Golf Course irrigation system. A developed strain of *Pseudoinonas aureofaceans* plays an important role in the reduction of fungal diseases. Tx-I plays an important role in the reduction of fungal disease. *Azospirilium brasilense* microorganisms are used to incorporate N_3 and release ammonia (NH_4) and nitrate (NO_3). The presence of *Azospirillurn* provides for healthier turf through nitrogen fixation, production of plant growth regulators, and colonization on the rhizoplane.

"**Epoleon**" is an organic deodorizer and neutralizer. This product stabilizes compounds so they are not re-released into the atmosphere. It is manufactured by the Epoleon Corporation of America.

"**Essential**" contains a high percentage of carbon-rich organic materials and humic acid. The product contains intermediate metabolites, metabolites, simple sugars, peptides, amino acids, enzymes and amides, humate, lignin, organic chealates and cellulose fiber, all found in the natural stages of organic matter decomposition. The product is manufactured by Growth Products®.

"**Green-Releaf**" produces a group of natural microbes that form a symbiotic relationship with plant roots. Plant performance is enhanced by facilitating the uptake of nutrients and water while simultaneously aiding in pathogen defense. The products assist with reducing traditional fungicide applications.

"**GroZone**" is a calcined clay soil conditioner for the root zone. The material retains moisture to minimize stress from prolonged droughts and reduces watering requirements. It helps to increase nutrient retention, prevent compaction and creates a strong environment for healthy roots. It is manufactured by the American Colloid Company.

"**Isolite porous ceramic**" is a root zone modification material designed to improve water conservation and increase capillary porosity. It provides a low cation exchange capacity that will not tie up nutrients and helps to leach salts. It is typically used as a soil amendment during construction or aerification. It is manufactured by the Innova Corporation, an affiliate of Sumitomo Corporation of America.

"**Netlon**" mesh element may be used to increase macro-pores. The mesh is used to increase strength and provide increased stability on slopes. The filaments also open continuous pore space and may be a potential amendment that may be rototilled into the soil. It is manufactured by Netlon, Ltd. England.

"**NoburN**" is an organic wetting agent that loosens compacted soils. It helps to alleviate localized dry spots and hydrophobic conditions but does not have to be watered in, unlike synthetic wetting agent materials. It is derived from the desert Yucca plant and is manufactured by Roots Inc.

Organica, Inc. produces plant growth activators, insect control agents, humic acids, insecticidal soaps and seaweed and kelp activators. The products are designed to assist turfgrass managers with alternative control agents. The company furnishes substantial information on product evaluation and field trials, with evaluations and test results for agricultural and greenhouse pests. The company is actively seeking expansion within the turfgrass industry and has been working in California for specific pest controls in agriculture and related food crop activity.

"**PanaSea and PanaSea Plus**" utilize liquefied sea plant extract to stimulate root growth and aid in the reduction of thatch. Natural growth hormones (cytokinin) work to make the turfgrass more resistant to stress. The product works to speed release of the lemma during seed germination. It is manufactured by Emerald Isle Ltd.

"**P2**" is a synthetic polymer which acts as a water absorbent and retention material. This can be used to help raise the water holding capacity and help lower the bulk density of the soil. It is distributed by Broadleaf Industries.

"**Pro²/Oxygen Plus**" provides oxygen to control stress encountered with anaerobic soils. There are several groups of anaerobic microorganisms which are pathogenic in plants. These organisms thrive in the absence of oxygen. The release of oxygen into the soil environment is a practical method for control. It is manufactured by Plant Research Laboratories.

"**Profile**" is a ceramic product engineered to solve and prevent soil problems. Profile increases water retention and nutrient holding because of the capillary pores and the cation exchange capacity. The product improves root zones by adding water, nutrient, and air holding capacity. It is designed to be used during construction, after aerification or to improve topdressing blends.

"**Sand-Aid**" is a natural organic sea plant soil conditioner. It may be used to decrease nutrient leaching and increase fertilizer efficiency. It may be incorporated into the soil mix of new green construction or applied as a topdressing constituent. It is also manufactured by Emerald Isle Ltd.

"**Spectrum**" is a mix of 24 species of live micro-organisms containing beneficial acids and amino acids that assist with reducing toxicity levels in soil and allow the plant to create greater resistance to pathogens and pests. The product is produced by Tainio Technology & Technique, Inc. in Cheney, Washington. The company produces a series of biological soil amendment and turf care products.

"**Turftech II**" utilizes nitrogen fixing bacteria (cyanobacteria) and may contribute as much as one pound of nitrogen per 1,000 square feet over a 60 day period. It may help to suppress disease causing fungi and bacteria and reduce the need to apply additional forms of nitrogen. Normal phosphorous and potassium is still required. It is manufactured by Soil Technologies Corporation.

While each of the products above offers important contributions to biostimulation and stress management, they are useful only within an overall testing and conditioning program. Soil, plant tissue and water quality will be tested at least twice a year to obtain an ongoing evaluation of the nutrient and electrolytic balance. Testing will also provide answers on sodium content, pH, etc., of the soil which will guide the maintenance staff on the use of soil enhancements.

For example, the presence of a pH imbalance can make nutrient supplies unavailable through chemical insolubility or fixation. When this condition is found, the proper answer may be to address the pH level rather than to increase nutrients. Similarly, adequate nitrogen is needed to produce rapid enough growth to recover from traffic associated with play. Too much nitrogen, on the other hand, can increase thatch and create thin cell walls resulting in susceptibility to certain fungus. In the spring and fall, higher quantities of phosphorous are needed to increase root depth and mass. Higher potassium is needed in the summer to increase cell wall thickness. Too little nitrogen, potassium, phosphorous, micronutrients, etc., can lead to disease. All of these factors influence the selection of soil enhancements just as they determine the choice of fertilizers or other management chemicals.

4.8 Mechanical Control Program

Mechanical controls are often the most easily instituted and followed techniques for improving the turfgrass environment. Suggested mechanical controls include the use of some or all of the following types of equipment and practices:

- Core aerification
- Shatter-Core aerification (shallow and deep tine with solid tines)
- High pressure water injection aerification
- Spiking/Slicing
- Dethatching (heavy thatch removal)
- Vertical mowing (light thatch removal)
- Grooming
- Brushing
- Proper mowing heights
- Proper mower blade sharpening
- Proper equipment repair

Poor turfgrass growth is often due to imbalances in water, carbon dioxide, and oxygen exchanges. Aerification typically remedies this.

Appropriate aerification can alleviate compaction and alter soil bulk density which inhibits root development. Historically, shatter core aerification has been used when persistent compaction problems warranted deeper aerification. With shatter core aerification, the presence of soil/sand on the canopy of the leaf surface must be minimized. The recent advent of high pressure water injection provides an increased safety margin for aerification on greens and tees during summer months.

Comparative field testing is currently underway to determine the benefits derived when choosing this form of aerification. One minor disadvantage from hydro-injection aerification is the disturbance of lower profile particle fines or sand or gravel displaced onto the putting green surface. While no form of aerification is trouble free, the machine currently produced by the Toro or Cushman/Ryan Corporation allows aerification to be completed with the least amount of disturbance to the playing surface.

Aerification should be performed in the late spring (April-June), and again in the early fall (September-October) to manage routine problems. This timing is important. If aerification is performed too late in the summer, it can cause heat related stress, resulting in slow recovery which can encourage weed infestation and insect pest pressure. Summer aerification with traditional core aerifiers will increase direct sun exposure along with elevated evapotranspiration values. This may result in desiccation, turf damage, and a plant more susceptible to disease or pest invasion.

Consistent mowing heights and proper bedknife adjustments must be maintained throughout the growing season. No more than one third of the leaf blade should be routinely removed in any single mowing. Alternate mowing equipment will be used during periods of excessive soil wetness to maintain these consistent mowing heights. Mowing frequency will increase during the spring, generally following 7-21 days after fertilizer applications. During cooler conditions and hot and dry periods, mowing frequency may decrease. Mowing frequency will also be reduced during inclement weather to keep mechanical damage to a minimum.

Clippings will not accumulate adjacent to play areas. This policy will minimize cross contamination of grasses near wetlands and encourage composting of the turfgrass clippings.

The commercial turfgrass equipment purchased for the Golf Course will be certified to meet the American National Standard Institute's (ANSI) voluntary safety specifications, B71.4-1984 and applicable regulations based thereon. Mowers will be adjusted, sharpened and inspected according to the manufacturer's specification in order to provide optimum cutting performance. The use of Wiehle rollers may be included on equipment used to mow tees, fairways, and greens. This will aid in the control of excessive thatch and promote underground shoots or tillers of the seeded bentgrass. Solid rollers should be used during the grow-in period. All turfgrass will be maintained at a cutting height which produces an optimum playing surface.

The range of heights listed in Table 26 is typically maintained for Kentucky bluegrass, fescue and bentgrass surfaces. A range of optimum heights has been provided to adjust for periods of dormancy and stress.

Table 26. Turfgrass Maintenance for the Lamington Farm Golf Course

Area	HEIGHT OF CUT	MOWING FREQUENCY	(X) WEEKLY
TEES	3/8"-5/8" (for bentgrass) (9.53 - 15.88 mm)	M W TH F	(3-4) with baskets
FAIRWAYS	½" - 3/4" (12.70 - 19.05 mm)	M T TH F	(3-4) with baskets
GREENS	7/64"-7/32" (2.78 - 5.56 mm)	(M) T W TH F S S	(6-7) with baskets
ROUGH	1.50"-3.00" (38.10 - 76.20 mm)	M T (W) TH F	(1-2) no baskets use vacuum rotary decks

The Golf Course will use electric mowers where they are deemed practical. These newly introduced machines provide operator comfort, improvements in air quality, and noise abatement. The Ransome E-Plex is now available for maintaining greens and tee mowing. The Smithco Company provides an electric trap rake for projects that are located near residential or urban areas addressing noise abatement issues. Most major turfgrass companies provide electric transportation vehicles for Golf Course employees including golf carts and golf shuttles convertible for such use.

A variety of mowing equipment will be used to prevent matting, compaction and/or frequency marks. Equipment used to mow tees will be low compaction, light-weight mowers. They will be provided with optional grooming attachments, five to eight blade reels, and grass catchers. A combination of triplex mowers and lightweight five-gang mowers will be used on fairways. High frequency, eight to eleven blade cutting units with hydraulically driven reels will be used to maintain the fairway playing surface. Walk-behind mowers causes less compaction, improve the quality of cut, and reduce turfgrass stress when compared with continual use of triplex mowers. Clean up passes around the edge of the green will be altered to allow upright growth and prevent what is known as tracking. Two types of mowers (reel-type and rotary) will be used to maintain roughs and general use turf. Ground driven or hydraulic reel mowers will be used to maintain areas adjacent to the secondary roughs. Areas adjacent to bunkers, greens, and tees may require the use of a hydraulic rotary or reel driven mower. The mowers selected will provide a uniform cut with a minimum of wear and compaction damage. They will maintain quality playing conditions and remove a maximum one third of the total leaf blade during each mowing.

The most critical part of the mechanical control section of this IGC1VIPO is proper mowing height adjustment and mower cutting quality. Mowers must be maintained so that leaf blades are cut and not torn off. Mower blades must be sharp. Lacerated leaf ends will increase the possibility of pathogen invasion. Extensive irregular separation of leaf tissue gradually increases a process known as chlorosis. Proper mowing heights are also paramount to the management of healthy turf. Table 27 establishes reel adjustment and the minimum frequency schedule to follow prior to mowing. With the advent of variable clip control reels and reverse reel backlapping features installed on the latest hydraulic lightweight mowers, the following schedule should be part of the normal mechanical and maintenance mowing operations.

Table 27. Turfgrass Mower Reel Adjustment and Tuning Frequency

Mowers	Periodic Adjustments	Minimum Backlapping	Minimum Grinding
Greens	Daily	As Needed	As Needed
Tees	Daily	As Needed	As Needed
Fairways	Daily	As Needed	As Needed
Roughs	Daily	As Needed	As Needed

4.9 Summary of Cultural/Mechanical Controls

The following will be used as interrelated cultural practices:

- Mechanical spikes will be used to promote root growth, reduce the incidence of water puddling, and provide beneficial oxygen to the crown area;
- Vertical mowers will be used to control excessive areas of thatch (more than approximately one inch or 2.5 cm on fairways/roughs; more than approximately 3/8 of an inch or 1.25 cm on tees; more than 1/4" or 1 cm on greens);
- Brushes will be used to provide upright shoot growth and prevent matting;
- Coring machines or an aerifier will be used to eliminate compacted soils and prepare the site for topdressing or overseeding;
- High pressure water injection aerifier will be used in periods of stress or when the practice may help reduce the need to apply a pesticide;
- Mechanical renovator will be used to control excessive thatch on fairways and roughs. Seeding or sodding will be used as a preventive means to control unwanted species of weeds wherever possible;
- Topdressing will be applied periodically to all tees and greens, depending on the growth and thatch conditions of the respective areas. Wear patterns (divots) on tees will be topdressed and seeded. Markers will be moved daily to allow sufficient time for the surfaces to recover. This practice will help to eliminate the establishment of weeds that are the result of continual wear;
- Greens will be topdressed as deemed necessary by the Golf Course superintendent. The rate of top-dressing will be directly proportional to the need to control thatch or achieve smoothness;
- Topdressing material will be of the same material as indicated in the original specification plan for new construction of the Golf Course greens. The use of identical sand as supplied for original construction is preferred. The lack of an organic matter is permissible as long as the material is of the same particle size distribution; and
- Topdressing will be used to level playing surfaces, to improve root structure when coring, to control thatch, and to protect new seedlings. Spot topdressing will be the practice for those areas in fairways with exposed native soils.

The proposed mitigation for leaf blowers, chainsaws, and weed trimmers include the following recommendations:

- Limit activity near residential homes from sunset to 8:00 am in the morning.

- Prioritize clean-up and trimming tasks in areas away from residential properties and focus on alternative methods of maintenance to minimize clean-up and trimming (i.e., apply growth retardants on areas requiring frequent weed trimming, remove debris with larger pieces of equipment during later parts of the day).

- Provide a balance of noise abatement equipment to facilitate general maintenance practices and supplement traditional pieces of hand/trim/clean-up and mowing equipment; and

- Use more passive control methods whenever and wherever possible.

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CHARTING A SUSTAINABLE FUTURE

GOLF & THE ENVIRONMENT

Environmental Principles *for* Golf Courses in the United States

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Salt Lake City, Utah 84106

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INTRODUCTION

The document which follows stands on it own as a summary of recommendations for better, more environmentally sensitive golf courses in the United States. There is however, a story that goes with this document we feel may help readers and users of the principles better understand their origin, development and purpose.

Heightened public awareness of environmental impacts and demand for environmental quality has affected all of our communities and our lives. Golf has been no exception. Like many of the other environmental debates taking place in this county in the previous decade, questions regarding golf's impact on the environment were increasingly being asked by citizen and environmental advocacy groups. In 1994, in response to this circumstance, the Center for Resource Management, Golf Digest Magazine, the National Wildlife Federation and the Pebble Beach Resort Company, concluded that the time was right to bring representatives of many of the country's most influential golf and environmental organizations together to address issues related to "golf & the environment."

A first meeting was held at the Pebble Beach Resort in January, 1995. This meeting which began as a tense and tentative exchange of views, ended with an overwhelming consensus that the shared interests and values of the golf and environmental communities should be the basis for future collaborative work. At that meeting, it was determined that an important priority of this collaborative agenda must be the development of a set of national principles to provide guidance on matters relating to environmental considerations in golf course planning & siting, construction, operation and maintenance.

In the year that followed, a committee of approximately 25 golf, environmental and government representatives worked together to develop these principles. The first few months were spent discussing just what we wanted to achieve with the principles, what their scope would be, what would and would not be included. Time was also spent researching examples of other "golf & environment" principles. About a dozen documents were reviewed for style, scope and level of detail. Many excellent examples of principles, prepared by various sponsors (nations, states, counties, even individual golf clubs) served as useful templates for our effort. Looking at these documents helped us conclude that, rather than creating a regionally specific document, this set of principles should

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...cribe a broad philosophy of approach and intent, one that would provide environmental guidance appropriate to new and existing courses in a wide variety of geographic areas.

The process of writing and reviewing the principles was highly collaborative and iterative. Many relevant issues were discussed for inclusion in the document, but it was decided that the purpose of the principles should be to focus on environmental considerations in the planning & siting, construction, maintenance and operation of golf courses. As multiple drafts were prepared and reviewed, the importance of language, the precise way in which a principle was stated, also became evident. Careful deliberation was given to word choice, whether or not to include a qualifying phrase, etc. "Majority vote" wasn't sufficient to decide an issue - consensus had to be reached. Overcoming early skepticism about each others motives and depth of commitment took time, but was perhaps the most important ingredient in an ultimately successful process.

After a last successful draft was reviewed and approved by this group, as well as an expanded circle of organizational constituents, the principles were introduced at a second meeting of the "Golf & the Environment" consortium. In the weeks preceding this conference; held in March, 1996, at the Pinehurst Resort in Pinehurst, North Carolina, endorsements were sought from the many organizations which worked on the document, and other important, interested groups. Endorsing organizations include:

American Society of Golf Course Architects
Arizona Golf Association
Audubon International
Center for Resource Management
Club Managers Association of America
Friends of the Earth
Golf Course Builders Association of America
Golf Course Superintendents Association of America
Ladies Professional Golf Association
National Association of Counties
National Club Association
National Coalition Against the Misuse of Pesticides
National Golf Foundation
National Wildlife Federation
North Carolina Coastal Federation
Pamlico-Tar River Foundation
Save the Bay
Southern Environmental Law Center
United States Environmental Protection Agency
United States Golf Association

We hope that this document, endorsed by the many interests listed above, will play an important role in the development or operation of your golf course and that they will help you preserve the beauty, integrity and health of your local environment.

- The "Golf & the Environment" Project Steering Committee

I. PREAMBLE

A group of leading golf and environmental organizations have jointly developed a set of principles which seek to produce environmental excellence in golf course planning and siting, design, construction, maintenance, and facility operations.

What are the Principles?

These principles are envisioned as a tool of universal value, for national use under a variety of circumstances. However, it should be up to local communities, based on local values, and others involved in the regulatory process, to assess the environmental compatibility of golf courses.

These principles are meant to provide a framework for environmental responsibility in developing goals for existing courses and for considering issues associated with new courses. They are designed to educate and inform the public and relevant decision makers about environmental responsibility, and to help set goals for environmental performance.

These principles are voluntary. They are not intended for use in making judgments about socio-economic issues. These principles assume regulatory compliance and are designed to provide opportunities to go beyond that which is required by law.

These principles were developed through a collaborative research and dialogue process, and represent a consensus of all endorsing organizations. They represent areas of agreement but do not resolve all environmental issues related to golf. The dialogue and process is ongoing, as is the implementation of these principles.

How Should They Be Used?

Good environmental practice and design is the result of a multitude of factors and a thorough understanding of how these factors interrelate on a specific site in a specific locale. The principles are meant to be used as a guide to making good decisions relative to the planning and siting, design, construction, maintenance and operation of a golf course. They are voluntary, and should be interpreted as representing a whole philosophy of good environmental design and management rather than specific dictates, each of which must be met in all cases. It is hoped that the principles will be widely adopted and used to improve the level of environmental awareness, practice, dialogue, and quality achieved within the game of golf.

For further information you are encouraged to contact any or all of the following organizations that participated in the development of these principles. A contact person for each organization is listed in the Appendix.

American Farmland Trust
American Society of Golf Course Architects
Audubon International
Center for Resource Management
Friends of the Earth
Golf Course Superintendents Association of America
Golf Digest
National Coalition Against the Misuse of Pesticides
National Wildlife Federation
North Carolina Coastal Federation
Rain Bird - Golf Division
Royal Canadian Golf Association
SENES Oak Ridge, Inc. - Center for Risk Analysis
Sierra Club
United States Environmental Protection Agency
United States Golf Association

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II. PRECEPTS

The participating organizations are committed to the following basic precepts which provide a foundation for the environmental principles:

- To enhance local communities ecologically and economically.
- To develop environmentally responsible golf courses that are economically viable.
- To offer and protect habitat for wildlife and plant species.
- To recognize that every golf course must be developed and managed with consideration for the unique conditions of the ecosystem of which it is a part.
- To provide important greenspace benefits.
- To use natural resources efficiently.
- To respect adjacent land use when planning, constructing, maintaining and operating golf courses.
- To create desirable playing conditions through practices that preserve environmental quality.
- To support ongoing research to scientifically establish new and better ways to develop and manage golf courses in harmony with the environment.
- To document outstanding development and management practices to promote more widespread implementation of environmentally sound golf.
- To educate golfers and potential developers about the principles of environmental responsibility and to promote the understanding that environmentally sound golf courses are quality golf courses.

III. VOLUNTARY PRINCIPLES FOR PLANNING AND SITING, DESIGN, CONSTRUCTION, MANAGEMENT, FACILITY OPERATIONS AND WHAT GOLFERS CAN DO TO HELP

A. Planning and Siting

1. Developers, designers and others involved in golf course development are encouraged to work closely with local community groups and regulatory/permitting bodies during planning and siting and throughout the development process. For every site, there will be local environmental issues and conditions that need to be addressed.

2. Site selection is a critical determinant of the environmental impact of golf courses. A thorough analysis of the site or sites under consideration should be completed to evaluate environmental suitability. It is very important to involve both the designer and a team of qualified golf and environmental professionals in this process.

3. Based on the site analysis and/or regulatory review process, it may be determined that some sites are of such environmental value or sensitivity that they should be avoided. Other less environmentally sensitive or valuable sites may be more suitable or even improved by the development of a golf course if careful design and construction are used to avoid or mitigate environmental impacts.

4. The presence and extent of some types of sensitive environments may render a site unsuitable or, in some cases, less suitable for golf course development. Examples include, but are not limited to:

   - Wetlands
   - Habitat for threatened or endangered plant or animal species
   - Sensitive aquatic habitats

5. There may be opportunities to restore or enhance environmentally sensitive areas through golf course development by establishing buffer areas or by setting unmaintained or low-maintenance areas aside within the site.

6. Golf course development can be an excellent means of restoring or rehabilitating previously degraded sites (e.g., landfills, quarries and mines). Golf courses are also excellent treatment systems for effluent water and use of effluent irrigation is encouraged when it is available, economically feasible, and agronomically and environmentally acceptable.

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B. Design

1. When designing a golf course, it is important to identify existing ecosystems. Utilizing what nature has provided is both environmentally and economically wise. Emphasizing the existing characteristics of the site can help retain natural resources, allow for efficient maintenance of the course and will likely reduce permitting and site development costs.

2. A site analysis and feasibility study should be conducted by experienced professionals. The identification of environmentally sensitive areas and other natural resources is important so that a design can be achieved that carefully balances environmental factors, playability, and aesthetics.

3. Cooperative planning and informational sessions with community representatives, environmental groups and regulatory agencies should be part of the initial design phase. Early input from these groups is very important to the development and approval process. This dialogue and exchange of information should continue even after the course is completed.

4. Native and/or naturalized vegetation should be retained or replanted when appropriate in areas that are not in play. In playing areas, designers should select grasses that are best adapted to the local environmental conditions to provide the necessary characteristics of playability yet permit the use of environmentally sustainable maintenance techniques.

5. Emphasis should be placed upon the design of irrigation, drainage and retention systems that provide for efficient use of water and the protection of water quality. Drainage and stormwater retention systems should, when possible, be incorporated in the design as features of the course to help provide for both the short and long term irrigation needs of the maintained turf and the unmaintained areas of the course.

6. Water reuse strategies for irrigation should be utilized when economically feasible and environmentally and agronomically acceptable. It is important that recycled water meets applicable health and environmental standards and that special consideration be given to water quality issues and adequate buffer zones. Water reuse may not be feasible on some sites that drain into high quality wetlands or sensitive surface waters. Suitable soils, climatic conditions, groundwater hydrology, vegetative cover, adequate storage for treated effluent and other factors will all influence the feasibility of water reuse.

7. Buffer zones or other protective measures should be maintained and/or created, if appropriate, to protect high quality surface water resources or environmentally sensitive areas. The design and placement of buffer zones will vary based on the water quality classifications of the surface waters being incorporated into the course. Regulatory agencies and environmental groups can assist in the planning of buffer zones.

8. Design the course with sustainable maintenance in mind. The design should incorporate Integrated Plant Management and resource conservation strategies that are environmentally responsible, efficient, and cost effective. Integrated Plant Management includes integrated pest management and emphasizes plant nutrition and overall plant health.

9. The design of the course should enhance and protect special environmental resource areas and when present, improve or revive previously degraded areas within the site through the use of plants that are well adapted to the region. Seek opportunities to create and/or preserve habitat areas that enhance the area's ecosystem.

C. Construction

1. Use only qualified contractors who are experienced in the special requirements of golf course construction.

2. Develop and implement strategies to effectively control sediment, minimize the loss of topsoil, protect water resources, and reduce disruption to wildlife, plant species and designated environmental resource areas.

3. Schedule construction and turf establishment to allow for the most efficient progress of the work while optimizing environmental conservation and resource management.

4. Retain a qualified golf course superintendent/project manager early in the design and construction process(es) to integrate sustainable maintenance practices in the development, maintenance and operation of the course.

D. Maintenance

Plant Protection and Nutrition

1. Employ the principles of Integrated Plant Management (IPM), a system that relies on a combination of common sense practices of preventing and controlling pests (e.g., weeds, diseases, insects) in which monitoring is utilized to identify pests, damage thresholds are considered, all possible management options are evaluated and selected control(s) are implemented. IPM involves a series of steps in the decision-making process:

   a. Through regular monitoring and record keeping, identify the pest problem, analyze the conditions causing it, and determine the damage threshold level below which the pest can be tolerated.

   b. Devise ways to change conditions to prevent or discourage recurrence of the problem. Examples include: utilizing improved (e.g., drought resistant, pest

resistant) turfgrass varieties, modifying microclimate conditions, or changing cultural practice management programs.

c. If damage thresholds are met, select the combination of control strategies to suppress the pest populations with minimal environmental impact, to avoid surpassing threshold limits. Control measures include biological, cultural, physical, mechanical, and chemical methods. Biological control methods must be environmentally sound and should be properly screened and tested before implementation.

Non-chemical control measures should focus on practices such as the introduction of natural pest enemies (e.g., parasites and predators), utilizing syringing techniques, improving air movement, soil aerification techniques, and mechanical traps. The selection of chemical control strategies should be utilized only when other strategies are inadequate.

When chemical and nutrient products need to be applied the following practices should be utilized:

2. Always read and follow label directions when using any plant protectant products. Strive to treat problems at the proper time and under the proper conditions to maximize effectiveness with minimal environmental impact. Spot treatments may provide early, effective control of problems before damage thresholds are reached.

3. Store and handle all pest control and nutrient products in a manner that minimizes worker exposure and/or the potential for point or non-point source pollution. Employ proper chemical storage practices and use suitable personal protective equipment and handling techniques.

4. Use nutrient products and practices that reduce the potential for contamination of ground and surface water. Strategies include: use of slow-release fertilizers, selected organic products, and/or fertigation.

5. Test and monitor soil conditions regularly and modify practices accordingly. Choose nutrient products and time applications to meet, not exceed, the needs of the turfgrass.

6. All plant protectant products should only be applied by or under the supervision of a trained, licensed applicator or as dictated by law.

7. Maintain excellence in the continuing education of applicators (including state licensing, professional association training and IPM certification). Training for non-English speaking applicators should be provided in the worker's native language.

8. Facilities should inform golfers and guests about golf course chemical applications. Common methods include permanent signs on the first and tenth tee boxes and/or notices posted in golf shops and locker rooms.

Water Usage

1. Use native, naturalized or specialized drought-tolerant plant materials wherever possible. For areas in play (greens, tees and fairways), using plant materials that are: well-adapted to local environmental conditions; can be efficiently managed; and provide the desired playing characteristics.

2. Plan irrigation patterns and/or program irrigation control systems to meet the needs of the plant materials in order to minimize overwatering. When feasible, use modern irrigation technologies that provide highly efficient water usage. Inspect systems regularly for leaks and monitor water usage.

3. Water at appropriate times to minimize evaporation and reduce the potential for disease.

4. Consider converting to effluent irrigation systems when available, economically feasible and agronomically and environmentally acceptable.

5. Manage water use effectively to prevent unnecessary depletion of local water resources.

Waste Management

1. Leave grass clippings and other organic materials in place whenever agronomically possible. If clippings are removed, compost and, if possible, recycle them.

2. Dispose of chemical rinsate in a manner that will not increase the potential for point or non-point source pollution. Methods include rinsate recycling or "spraying out" diluted compound in previously untreated areas.

3. Dispose of chemical packaging according to label directions (e.g., triple rinsing, recycling or returning to manufacturer).

4. Other waste products, such as used motor oil, electric batteries and unused solvents, should be recycled or disposed of according to the law and available community disposal techniques.

5. Seek to reduce waste by purchasing products that minimize unnecessary packaging.

Wildlife Management

1. Habitat for wildlife species that help control pests (e.g., bats, bluebirds, purple martins, etc.) should be protected. Additional habitat for these beneficial species should be created whenever feasible and environmentally desirable.
2. Manage habitat to maintain healthy populations of wildlife and aquatic species.
3. Species such as skunks, non-migratory Canada geese, and deer, when they become damaging, should be managed through non-harmful means whenever possible. Non-harmful control methods could include dogs, noisemakers, repellents, and trapping and removal. Managed hunting may be appropriate where legal and safe.

E. Facility Operations

1. Facilities should conduct an environmental assessment in order to develop and implement an overall environmental policy and/or long-range plan that reflects or expands upon these principles.
2. Maintain ongoing records to measure and document progress towards environmental improvement.
3. The environmentally responsible practices adopted for the maintenance of the golf course should extend to all areas of the overall facility grounds.
4. Facilities should adopt practices and technologies that conserve natural resources, including water and energy.
5. Facilities should develop and initiate comprehensive programs for recycling, reuse and waste reduction.
6. Facilities should properly store and dispose of solvents, cleaning materials, paints and other potentially hazardous substances.
7. Facilities are urged to join programs that help to foster effective environmental management and policies.
8. Facilities should take active steps to educate golfers, neighbors and the general public about their environmental policies and practices.

F. What Golfers Can Do To Help

The American golf community is dedicated to preserving the game's treasured links to nature. As a result, golf courses are now being developed, designed and managed more responsibly than ever before. However, we who play the game also have a responsibility to help ensure that golf remains compatible with nature and that our courses are well-managed and in harmony with the environment.

As golfers we should:

1. Recognize that golf courses are managed land areas that should complement the natural environment.
2. Respect designated environmentally sensitive areas within the course.
3. Accept the natural limitations and variations of turfgrass plants growing under conditions that protect environmental resources (e.g., brown patches, thinning, loss of color).
4. Support golf course management decisions that protect or enhance the environment and encourage the development of environmental conservation plans.
5. Support maintenance practices that protect wildlife and natural habitat.
6. Encourage maintenance practices that promote the long-range health of the turf and support environmental objectives. Such practices include aerification, reduced fertilization, limited play on sensitive turf areas, reduced watering, etc.
7. Commit to long-range conservation efforts (e.g., efficient water use, Integrated Plant Management, etc.) on the golf course and at home.
8. Educate others about the benefits of environmentally responsible golf course management.
9. Support research and education programs that expand our understanding of the relationship between golf and the environment.
10. Take pride in our environmentally responsible courses.

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APPENDIX

The "Environmental Principles for Golf Courses in the United States" were developed through a collaborative research and dialogue process managed and facilitated by the Center for Resource Management. The following individuals participated in this process and can be contacted for further information.

1. American Farmland Trust
   Ed Thompson, Jr.
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   Washington, DC 20036
   202-659-5170

2. American Society of Golf Course Architects
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   PO Box 510
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   302-345-1510

   Mike Hurdzan, Ph.D.
   1270 Old Henderson Road
   Columbus, OH 43220
   614-457-9955

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   518-767-9051

4. Center for Resource Management
   Paul Parker
   1104 E. Ashton Ave., #210
   Salt Lake City, UT 84106
   801-466-3600

   Meredith Miller
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   Denver, CO 80203
   303-832-6855

5. Friends of the Earth
   Courtney Cuff
   1025 Vermont Ave., NW
   Washington, DC 20005
   202-783-7400, ext. 207

6. Golf Course Superintendents Association of America
   Joe O'Brien
   1421 Research Park Drive
   Lawrence, KS 66049
   913-841-2240

   Pat Jones
   1421 Research Park Drive
   Lawrence, KS 66049
   913-832-4435

7. Golf Digest
   Andy Nusbaum
   5520 Park Avenue
   Trumbull, CT 06611
   203-373-7127

8. National Coalition Against the Misuse of Pesticides
   Jay Feldman
   701 E Street, SE, #200
   Washington, DC 20003
   202-543-5450

9. National Golf Foundation
   Rick Norton
   1150 So. U.S. Highway 1, #401
   Jupiter, FL 33477
   407-743-1556 ext. 42

10. National Wildlife Federation
    Sharon Newsome
    529 14th Street, NW, #452
    Washington, DC 20045
    202-233-9533

11. North Carolina Coastal Federation
    Todd Miller
    3609 Highway 24
    Newport, NC 28570
    919-393-8185

12. Rain Bird - Golf Division
    Eric Bescoby
    145 N. Grand Avenue
    Glendora, CA 91741
    818-812-3649

13. Royal Canadian Golf Association
    Teri Yamada
    1333 Dorval Drive
    Oakville, Ontario L6J4Z3
    Canada
    905-849-9700

14. SENES Oak Ridge, Inc. - Center for Risk Analysis
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15. Sierra Club
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    Far Hills, NJ 07931
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EXHIBIT 38

ABOUT THE NATIVE PLANTS FOR CONSERVATION, RESTORATION AND LANDSCAPING PROJECT

This project is a collaboration between the Virginia Department of Conservation and Recreation and the Virginia Native Plant Society. VNPS chapters across the state helped to fund the 2011 update to this brochure.

The following partners have provided valuable assistance throughout the life of this project:

The Nature Conservancy – Virginia Chapter • Virginia Tech Department of Horticulture • Virginia Department of Agriculture and Consumer Services • Virginia Department of Environmental Quality, Coastal Zone Management Program • Virginia Department of Forestry • Virginia Department of Game and Inland Fisheries • Virginia Department of Transportation

FOR MORE INFORMATION

Virginia Department of Conservation and Recreation
Natural Heritage Program
804-786-7951
www.dcr.virginia.gov/natural_heritage/nativeplants.shtml

FOR A LIST OF NURSERIES THAT PROPAGATE NATIVE SPECIES, CONTACT:

Virginia Native Plant Society
400 Blandy Farm Lane, Unit 2
Boyce, VA 22620
540-837-1600 | vnpsofc@shentel.net
www.vnps.org

FOR A LIST OF NURSERIES IN A PARTICULAR REGION OF VIRGINIA, CONTACT:

The Virginia Nursery and Landscape Association
383 Coal Hollow Road
Christiansburg, VA 24073
540-382-0943 | vnla@verizon.net
To search for species in VNLA member catalogs, visit:
www.vnla.org/search.asp

ILLUSTRATIONS COURTESY OF THE FLORA OF VIRGINIA PROJECT.

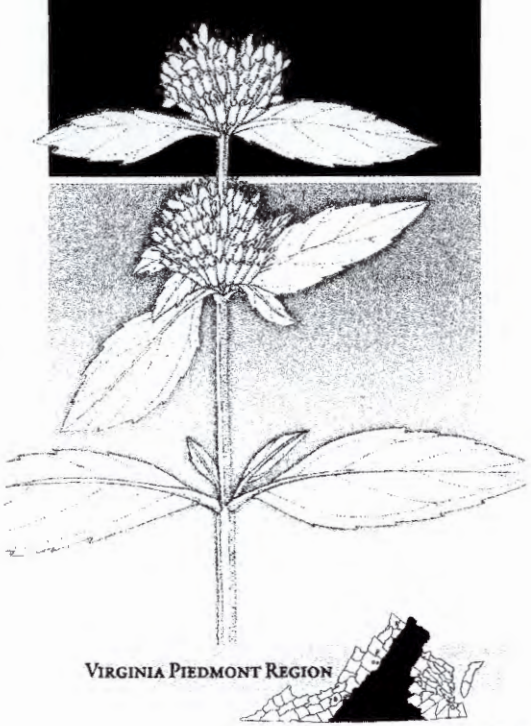
Illustrators: Lara Gastinger, Roy Fuller and Michael Terry. To learn more, visit:
www.floraofvirginia.org

DCR

9/2011

Native Plants

FOR CONSERVATION, RESTORATION & LANDSCAPING



VIRGINIA PIEDMONT REGION

WHAT ARE NATIVES?

Native species evolved within specific regions and dispersed throughout their range without known human involvement. They form the primary component of the living landscape and provide food and shelter for native animal species. Native plants co-evolved with native animals over many thousands to millions of years and have formed complex and interdependent relationships. Our native fauna depend on native flora to provide food and cover. Many animals require specific plants for their survival.

BENEFITS OF NATIVE PLANTS

Using native species in landscaping reduces the expense of maintaining cultivated landscapes and minimizes the likelihood of introducing new invasive species. It may provide a few unexpected benefits as well.

Native plants often require less water, fertilizer and pesticide, thus adding fewer chemicals to the landscape and maintaining water quality in nearby rivers and streams. Fewer inputs mean time and money saved for the gardener.

Native plants increase the presence of desirable wildlife, such as birds and butterflies, and provide sanctuaries for these animals as they journey between summer and winter habitats. The natural habitat you create with native plants can become an outdoor classroom for children, or a place for you to find peace and quiet after a busy day.

Native plants evoke a strong sense of place and regional character. For example, live oak and magnolia trees are strongly associated with the Deep South. Redwood trees characterize the Pacific Northwest. Saguaro cacti call to mind the deserts of the Southwest.

BUYING AND GROWING NATIVE PLANTS

More gardeners today are discovering the benefits of native plants and requesting them at their local garden centers. Because of this increased demand, retailers are offering an ever-widening selection of vigorous, nursery-propagated natives.

Once you've found a good vendor for native plants, the next step is choosing appropriate plants for a project. One of the greatest benefits of designing with native plants is their adaptation to local conditions. However, it is important to select plants with growth requirements that best match conditions in the area to be planted.

If you're planning a project using native plant species, use the list in this brochure to learn which plants grow in your region of Virginia. Next, study the minimum light and moisture requirements for each species, noting that some plants grow well under a variety of conditions. Many of the recommended species are well-suited to more than one of these categories.

For more information, refer to field guides and publications on local natural history for color, shape, height, bloom times and specific wildlife value of the plants that grow in your region. Visit a nearby park, natural area preserve, forest or wildlife management area to learn about common plant associations, spatial groupings and habitat conditions. For specific recommendations and advice about project design, consult a landscape or garden design specialist with experience in native plants.

WHAT ARE NON-NATIVE PLANTS?

Sometimes referred to as "exotic," "alien," or "non-indigenous," non-native plants are species introduced, intentionally or accidentally, into a new region by humans. Over time, many plants and animals have expanded their ranges slowly and without human assistance. As people began cultivating plants, they brought beneficial and favored species along when they moved into new regions or traded with people in distant lands. Humans thus became a new pathway, enabling many species to move into new locations.

WHAT ARE INVASIVE PLANTS?

Invasive plants are introduced species that cause health, economic or ecological damage in their new range. More than 30,000 species of plants have been introduced to the United States since the time of Columbus. Most were introduced intentionally, and many provide great benefits to society as agricultural crops and landscape ornamentals. Some were introduced accidentally, for example, in ship ballast, in packing material and as seed contaminants. Of these introduced species, fewer than 3,000 have naturalized and become established in the United States outside cultivation. Of the 3,500 plant species in Virginia, more than 800 have been introduced since the founding of Jamestown. The Virginia Department of Conservation and Recreation currently lists more than 100 of these species as invasive.

In the United States, invasive species cause an estimated $120 billion in annual economic losses, including costs to manage their effects. Annual costs and damages arising from invasive plants alone are estimated at $34 billion.

NATIVE PLANTS VS. INVASIVE PLANTS

Invasive plants have competitive advantages that allow them to disrupt native plant communities and the wildlife dependent on them. For example, kudzu (*Pueraria montana*) grows very rapidly and overtops forest canopy, thus shading other plant species from the sunlight necessary for their survival. A tall invasive wetland grass, common reed (*Phragmites australis ssp. australis*), invades and dominates marshes, reducing native plant diversity and sometimes eliminating virtually all other species.

Invasive species can marginalize or even cause the loss of native species. With their natural host plants gone, many insects disappear. And since insects are an essential part of the diet of many birds, the effects on the food web become far reaching. Habitats with a high occurrence of invasive plants become a kind of "green desert." Although green and healthy in appearance, far fewer native species of plants and animals are found in such radically altered places.

Exhibit 39

Virginia Piedmont Region

Rocky falls and rapids on the Potomac, Rappahannock and James rivers mark a transition from the softer sediments of the Coastal Plain to the resistant bedrock underlying the Piedmont. Moving west, the rolling hills of Virginia's Piedmont Plateau steadily climb from the fall line to the foothills of the Blue Ridge Mountains, which form the western boundary of the Piedmont. The hills of the Piedmont become steeper to the west, where monadnocks — remnants of ancient mountains — rise above the farms and forests. The Piedmont is known for moderately fertile but highly eroded clay soils that formed from deeply weathered bedrock. Most of this land was converted to farmland during European settlement. Today, however, mixed pine-oak-hickory forests arising from abandoned farmlands are found throughout the region.

Recommended Uses
W = Wildlife
H = Horticulture & landscaping
C = Conservation & restoration
D = Domestic livestock forage

Minimum Light Requirements
S = Shade
P = Partial sun
F = Full sun

Moisture Requirements
L = Low moisture
M = Moderate moisture
H = High moisture

Some species are marked with the following footnote symbols:

+ May be aggressive in a garden setting

* Due to the rarity and sensitivity of habitat in Virginia, these species are recommended for horticultural use only. Planting these species in natural areas could be *detrimental* to the survival of native populations.

Scientific Name	Common Name	Uses W	H	C	D	Light S	P	F	Moisture L	M	H
Herbs											
Achillea millefolium	common yarrow		•				•	•	•		
Ageratina altissima	white snakeroot	•				•	•			•	
Amsonia tabernaemontana	blue star		•			•	•			•	•
Anemone quinquefolia	wood anemone		•			•	•	•		•	
Anemonella thalictroides	rue anemone		•			•				•	
Antennaria neglecta	field pussytoes		•	•			•	•	•	•	
Aquilegia canadensis	wild columbine	•	•				•	•	•	•	
Arisaema triphyllum	Jack-in-the-pulpit		•			•				•	
Aruncus dioicus	goatsbeard		•			•	•			•	
Asarum canadense+	wild ginger		•	•		•				•	•
Asclepias incarnata	swamp milkweed	•	•	•			•			•	
Asclepias syriaca+	common milkweed		•	•				•	•		
Asclepias tuberosa	butterfly weed		•	•				•	•		
Baptisia australis*	blue wild indigo		•				•	•	•	•	
Baptisia tinctoria	yellow wild-indigo		•				•	•	•		
Bidens cernua+	nodding beggar-ticks	•	•	•			•	•	•	•	•
Chamaecrista fasciculata+	partridge pea			•				•	•	•	
Chelone glabra	white turtlehead			•	•	•	•				•
Chrysogonum virginianum	green and gold			•	•	•					•
Chrysopsis mariana	Maryland golden aster	•	•	•			•	•	•		
Cimicifuga racemosa	black cohosh			•		•	•				•
Clitoria mariana	Maryland butterfly pea			•	•	•	•		•		
Conoclinium coelestinum	blue mistflower	•	•	•			•	•			•
Coreopsis lanceolata	longstalk coreopsis	•	•					•			•
Coreopsis tinctoria	golden tickseed	•	•				•	•			•
Coreopsis tripteris	tall coreopsis			•	•		•	•			•
Coreopsis verticillata	threadleaf coreopsis			•	•		•	•			•
Delphinium tricorne	dwarf larkspur			•		•	•				•
Desmodium paniculatum	narrow-leaf tick trefoil	•		•	•			•			•
Dicentra cucullaria	Dutchman's breeches			•		•					•
Dicentra eximia	wild bleeding heart			•			•	•	•		
Doellingeria umbellata	flat-top white aster			•	•		•			•	•
Equisetum hyemale	horsetail				•	•	•	•		•	•
Eupatoriadelphus fistulosus	Joe-pye weed	•	•	•			•	•		•	•
Eupatorium perfoliatum	common boneset				•		•	•		•	•
Eurybia divaricata	white wood aster		•	•			•	•	•	•	
Geranium maculatum	wild geranium			•		•	•			•	
Gillenia trifoliata	bowman's root			•		•	•			•	
Helenium autumnale	sneezeweed		•	•	•		•	•			•
Helianthus angustifolius	narrow-leaf sunflower		•	•	•		•	•		•	•
Helianthus decapetalus	ten-petaled sunflower		•	•	•		•	•		•	
Helianthus divaricatus	woodland sunflower		•	•	•		•		•		
Heliopsis helianthoides	oxeye sunflower		•	•	•		•	•	•	•	
Hepatica nobilis var. obtusa	round-lobed hepatica			•		•				•	•
Heuchera americana	alumroot			•		•				•	
Hibiscus moscheutos	Eastern rosemallow	•	•	•				•			•
Iris cristata	dwarf crested iris			•		•	•				•
Iris virginica	Virginia blue flag			•			•	•			•
Lespedeza capitata	round-head bush clover	•		•				•	•		
Liatris pilosa var. pilosa	grass-leaf blazing star	•	•	•			•	•	•	•	
Liatris squarrosa	plains blazing star	•	•	•			•	•		•	
Lilium canadense	Canada lily			•			•	•		•	•
Lilium superbum	Turk's cap lily			•			•	•		•	•
Lobelia cardinalis	cardinal flower	•	•	•			•	•			•
Lobelia siphilitica	great blue lobelia	•	•	•		•	•				•
Lupinus perennis	lupine			•			•	•	•		
Maianthemum racemosum	false Solomon's seal		•	•		•	•			•	
Mertensia virginica	Virginia bluebells		•	•		•	•			•	•
Mimulus ringens	monkeyflower			•	•			•			•
Monarda fistulosa	wild bergamot	•	•	•			•	•	•	•	
Monarda punctata	Horse-mint		•	•				•	•		
Nymphaea odorata	American water lily		•	•				•			•
Oenothera fruticosa	sundrops		•	•				•		•	•
Opuntia humifusa	Eastern prickly-pear		•	•			•	•			•
Packera aurea+	golden ragwort	•		•		•	•			•	•
Peltandra virginica	arrow arum	•	•	•			•	•			•
Penstemon canescens	gray beardtongue		•			•			•		
Penstemon digitalis	foxglove beardtongue	•	•				•	•	•	•	•
Penstemon laevigatus	smooth beardtongue					•	•	•			•
Phlox divaricata	woodland phlox			•	•		•	•		•	
Phlox paniculata	summer phlox			•	•			•	•		
Phlox subulata	moss phlox			•	•			•	•		
Physostegia virginiana+	obedient plant			•	•		•	•			•
Podophyllum peltatum+	mayapple	•	•	•			•	•			•
Polemonium reptans	Jacob's ladder			•		•	•				•
Polygonatum biflorum	Solomon's seal			•		•	•			•	•
Pontederia cordata	pickerel weed		•	•	•			•			•
Pycnanthemum incanum	hoary mountain mint	•		•		•		•		•	
Pycnanthemum tenuifolium	narrow-leaved mountain mint	•	•	•			•	•	•	•	
Rhexia virginica	Virginia meadow-beauty	•		•				•			•
Rudbeckia fulgida	early coneflower		•	•			•	•	•	•	
Rudbeckia hirta	black eyed Susan		•	•			•	•	•	•	
Rudbeckia laciniata	cut-leaved coneflower	•	•	•			•	•		•	
Rudbeckia triloba	three-lobed coneflower	•	•	•			•	•		•	
Sagittaria latifolia	broadleaf arrowhead	•	•	•				•			•
Salvia lyrata+	lyre-leaf sage			•			•	•	•		
Sanguinaria canadensis	bloodroot			•		•					•
Saururus cernuus	lizard's tail			•	•		•	•			•
Saxifraga virginiensis	early saxifrage			•		•	•	•	•	•	
Sedum ternatum	wild stonecrop			•		•	•			•	
Senna marilandica	Maryland wild senna			•	•			•		•	
Silene virginica	fire pink			•				•	•	•	
Silphium perfoliatum	cup plant	•		•		•	•	•			•
Solidago caesia	bluestem goldenrod	•	•	•		•	•				•
Solidago odora	sweet goldenrod	•	•	•				•	•		
Solidago pinetorum+	pineywoods goldenrod		•	•				•	•		
Solidago puberula	downy goldenrod	•	•	•				•	•		
Solidago rugosa+	rough-stemmed goldenrod	•	•	•				•			•
Symphyotrichum concolor	Eastern silvery aster	•	•	•				•	•		
Symphyotrichum cordifolium	heart-leaved aster		•	•				•			•
Symphyotrichum pilosum	frost aster		•	•				•	•		
Thalictrum dioicum	early meadowrue			•		•					•
Tiarella cordifolia	foamflower			•		•					•
Tradescantia virginiana+	Virginia spiderwort		•	•		•	•				•
Trillium grandiflorum	white trillium			•		•					•
Verbena hastata	blue vervain	•		•			•	•		•	•
Vernonia noveboracensis	New York ironweed		•	•			•	•			•
Viola cucullata	marsh blue violet		•	•			•	•			•
Viola pedata	bird's foot violet		•	•				•	•		
Viola pubescens	yellow violet		•	•		•	•				•
Yucca filamentosa	common yucca		•	•				•	•		
Ferns & Fern Allies											
Adiantum pedatum	maidenhair fern			•	•		•				•
Asplenium platyneuron	ebony spleenwort			•			•	•			•
Athyrium asplenioides	Southern ladyfern			•	•		•				•
Botrychium virginianum	rattlesnake fern			•		•	•			•	•
Dennstaedtia punctilobula+	hay-scented fern				•			•	•	•	•
Dryopteris intermedia	evergreen wood-fern			•	•		•	•		•	•
Dryopteris marginalis	marginal shield-fern			•	•		•	•			•
Onoclea sensibilis+	sensitive fern			•	•		•	•			•
Osmunda cinnamomea	cinnamon fern			•	•	•	•				•
Osmunda regalis	royal fern			•	•			•			•
Polystichum acrostichoides	Christmas fern			•	•	•					•
Thelypteris palustris	marsh fern			•			•	•			•
Grasses, Sedges & Rushes											
Agrostis perennans	autumn bentgrass				•	•	•	•	•	•	•
Andropogon gerardii	big bluestem	•	•	•	•			•	•	•	
Andropogon glomeratus	bushy bluestem			•	•			•	•		•
Andropogon virginicus	broomsedge			•	•			•	•	•	•
Arundinaria tecta	switch cane	•		•	•	•	•	•		•	•
Carex crinita	long hair sedge	•	•	•			•	•		•	•
Carex lurida	sallow sedge	•		•			•	•		•	•
Carex pensylvanica	Pennsylvania sedge	•		•		•	•	•	•	•	
Carex plantaginea	plantain-leaved sedge			•	•		•				•
Carex stricta	tussock sedge	•		•			•	•			•
Chasmanthium latifolium+	river oats, spanglegrass			•	•	•	•	•			•
Danthonia sericea	silky oatgrass	•		•			•	•	•	•	
Danthonia spicata	poverty oatgrass	•		•		•	•	•	•	•	

Scientific Name	Common Name	Uses W	H	C	D	Light S	P	F	Moisture L	M	H
Dichanthelium clandestinum	deer-tongue		•		•		•	•		•	•
Dichanthelium commutatum	variable panicgrass		•	•			•	•		•	•
Dulichium arundinaceum	dwarf bamboo		•		•	•				•	
Elymus hystrix	bottlebrush grass		•	•			•	•		•	•
Elymus virginicus	Virginia wild rye		•		•		•	•		•	•
Juncus canadensis	Canada rush			•				•	•		•
Juncus effusus	soft rush			•				•	•		•
Leersia oryzoides	rice cutgrass			•				•	•		•
Panicum virgatum	switch grass		•	•				•	•	•	•
Saccharum gigantaeum	giant plumegrass		•	•				•		•	•
Schizachyrium scoparium	little bluestem		•	•	•			•		•	•
Scirpus cyperinus	woolgrass bulrush		•	•				•	•		•
Sorghastrum nutans	Indian grass		•	•	•			•		•	•
Sparganium americanum	American bur-reed			•				•	•		
Tridens flavus	redtop		•	•	•			•		•	•
Tripsacum dactyloides	gama grass		•	•	•			•	•		•
Typha latifolia	broad-leaved cattail		•	•				•	•		•
Vines											
Bignonia capreolata	crossvine		•	•			•	•		•	•
Campsis radicans	trumpet creeper		•	•				•	•	•	
Celastrus scandens	climbing bittersweet		•	•			•	•	•		
Clematis virginiana	virgin's bower			•			•	•			•
Lonicera sempervirens	trumpet honeysuckle			•	•			•			•
Parthenocissus quinquefolia	Virginia creeper		•	•				•	•		•
Passiflora incarnata	Purple passionflower		•	•				•	•	•	
Shrubs & Small Trees											
Alnus serrulata	hazel alder		•	•	•		•	•			•
Aronia arbutifolia	red chokeberry			•	•		•			•	•
Aronia melanocarpa	black chokeberry			•	•		•	•	•	•	
Castanea pumila	Alleghany chinkapin		•	•			•	•	•		
Ceanothus americanus	New Jersey tea		•	•			•	•			•
Cephalanthus occidentalis	buttonbush			•	•			•			•
Cornus amomum	silky dogwood		•		•		•	•		•	•
Crataegus crus-galli	cockspur hawthorn		•	•	•			•	•	•	
Eubotrys racemosa	fetterbush			•	•			•		•	
Euonymus americanus	American strawberry-bush		•	•				•			•
Gaultheria procumbens	wintergreen		•	•			•	•		•	•
Gaylussacia baccata	black huckleberry		•	•	•		•	•		•	•
Hamamelis virginiana	witch hazel			•	•		•	•		•	•
Hydrangea arborescens	wild hydrangea			•			•	•			•
Hypericum prolificum	shrubby St. Johnswort		•	•			•	•			•
Ilex decidua	deciduous holly		•	•	•		•	•			•
Ilex verticillata	winterberry		•	•				•			•
Kalmia latifolia	mountain laurel		•	•		•	•				•
Lindera benzoin	spicebush		•	•			•				•
Physocarpus opulifolius	ninebark		•	•			•	•	•	•	•
Rhododendron catawbiense	Catawba rhododendron			•	•		•	•			•
Rhododendron maximum	great rhododendron		•	•	•		•	•			•
Rhododendron periclymenoides	pinxter flower			•	•		•	•			•
Rhododendron viscosum	swamp azalea			•	•			•	•		•
Rhus aromatica	fragrant sumac			•			•	•	•		
Rhus copallinum	winged sumac		•	•	•			•	•		
Rosa carolina	pasture rose		•	•				•	•	•	
Rubus allegheniensis	Alleghany blackberry		•	•				•	•		
Salix humilis	prairie willow			•				•	•		
Salix sericea	silky willow			•	•		•	•		•	
Sambucus canadensis	common elderberry		•	•				•		•	•
Staphylea trifolia	bladdernut		•			•				•	
Vaccinium corymbosum	highbush blueberry		•	•			•	•	•	•	•
Vaccinium stamineum	deerberry			•				•	•	•	
Viburnum dentatum	Southern arrow-wood viburnum		•	•			•	•	•	•	
Viburnum nudum	possum-haw viburnum			•	•		•				•
Viburnum prunifolium	black-haw viburnum		•	•			•	•		•	
Medium Trees											
Amelanchier arborea	downy serviceberry		•	•				•	•		•
Amelanchier canadensis	Canada serviceberry		•	•				•	•		•
Aralia spinosa	devil's walkingstick		•	•			•				•
Asimina triloba	paw paw		•	•	•		•	•			•
Carpinus caroliniana	American hornbeam		•	•			•	•			•
Cercis canadensis	Eastern redbud			•	•		•	•			•
Chionanthus virginicus	fringetree			•			•	•			•
Cornus alternifolia	alternate-leaf dogwood		•	•	•		•	•		•	•
Cornus florida	flowering dogwood		•	•	•		•	•		•	•
Crataegus viridis	green hawthorn		•	•	•			•			•
Ilex opaca	American holly		•	•	•		•				•
Magnolia virginiana	sweetbay magnolia			•	•		•	•			•
Morus rubra	red mulberry		•	•	•		•	•			•
Ostrya virginiana	Eastern hop-hornbeam			•	•		•	•			•
Prunus americana	American wild plum			•	•			•			•
Rhus glabra	smooth sumac		•	•	•				•	•	•
Rhus typhina	staghorn sumac		•	•	•				•	•	•
Salix nigra	black willow			•			•	•		•	•
Large Trees											
Acer negundo	ash-leaf maple		•	•				•		•	
Acer rubrum	red maple			•	•			•		•	•
Acer saccharum	sugar maple		•	•	•		•	•		•	•
Aesculus flava	yellow buckeye			•				•		•	
Betula lenta	sweet birch		•	•	•		•	•		•	•
Betula nigra	river birch		•	•	•			•		•	•
Carya cordiformis	bitternut hickory		•				•	•		•	•
Carya glabra	pignut hickory		•	•	•		•	•	•		
Carya ovata	shagbark hickory			•	•		•	•	•		
Carya tomentosa	mockernut hickory			•	•		•	•		•	•
Diospyros virginiana	persimmon		•	•	•		•	•	•	•	•
Fagus grandifolia	American beech		•	•			•	•	•		
Fraxinus americana	white ash		•	•				•	•		•
Fraxinus pensylvanica	green ash		•	•				•	•		•
Juglans nigra	black walnut		•	•				•	•		•
Juniperus virginiana	Eastern red cedar		•	•				•	•	•	•
Liquidambar styraciflua	sweetgum			•	•		•	•	•		•
Liriodendron tulipifera	tulip poplar		•	•				•	•		•
Nyssa sylvatica	black gum		•	•				•	•		•
Oxydendrum arboreum	sourwood			•				•	•		•
Pinus echinata	shortleaf pine			•				•	•	•	
Pinus rigida	pitch pine		•		•				•	•	
Pinus strobus	white pine			•	•				•	•	•
Pinus taeda	loblolly pine		•	•	•				•	•	
Pinus virginiana	Virginia pine			•					•	•	
Platanus occidentalis	sycamore			•				•	•		•
Prunus serotina	wild black cherry		•		•			•	•	•	
Quercus alba	white oak		•	•	•			•	•	•	
Quercus bicolor	swamp white oak			•	•		•	•			•
Quercus coccinea	scarlet oak		•	•				•	•	•	
Quercus falcata	Southern red oak		•	•			•	•		•	
Quercus ilicifolia	bear oak			•	•			•	•	•	
Quercus michauxii	swamp chestnut oak		•	•				•	•		•
Quercus muehlenbergii	chinkapin oak			•				•	•	•	
Quercus palustris	pin oak			•	•		•	•			•
Quercus phellos	willow oak		•	•	•		•	•			•
Quercus prinus	chestnut oak		•	•			•	•			
Quercus rubra	Northern red oak		•	•	•			•	•	•	
Quercus stellata	post oak		•	•	•			•		•	
Quercus velutina	black oak		•	•	•		•	•			
Robinia pseudoacacia	black locust			•				•	•	•	
Sassafras albidum	sassafras			•				•	•	•	
Tilia americana	American basswood			•				•	•		
Tsuga canadensis	Eastern hemlock		•	•				•	•		

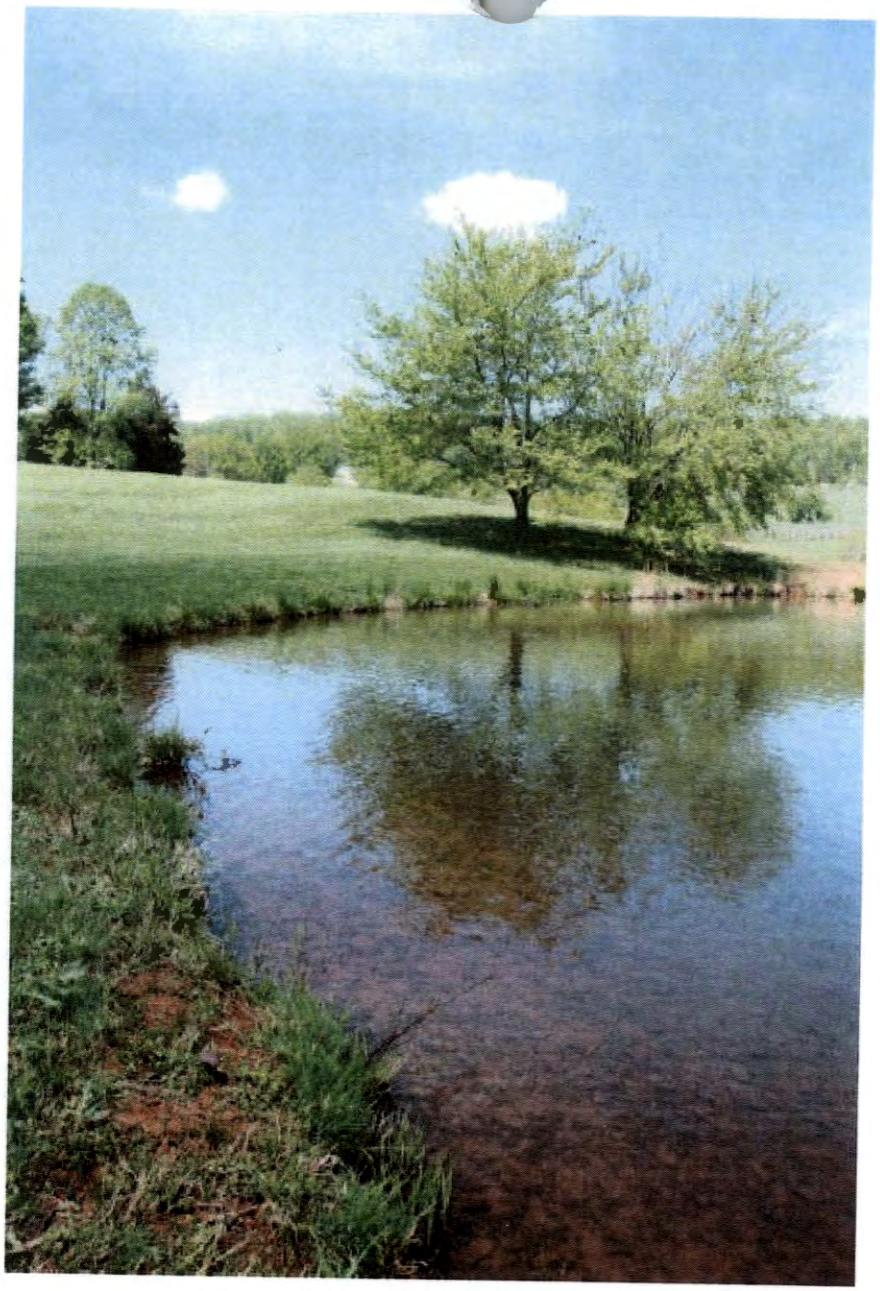


Exhibit 40

Exhibit 41

Exhibit 42