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The first section (white pages) includes lecture notes of papers presented at the 1997 New Jersey Turfgrass Expo. Publication of the New Jersey Turfgrass Expo Notes provides a readily available source of information covering a wide range of topics. The Expo Notes include technical and popular presentations of importance to the turfgrass industry.

The second section (green pages) includes technical research papers containing original research findings and reviews covering selected subjects in turfgrass science. The primary objective of these papers is to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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PLAN BEFORE YOU PLANT
A 5-STEP PROCESS FOR DEVELOPING A LANDSCAPE WEED MANAGEMENT PLAN

Dr. Joseph C. Neal[1]

Supplemental hand weeding accounts for the majority of landscape bed maintenance costs. When used exclusively, it can cost 10 to 100 times as much as an effective herbicide or mulching program. However, many of the costly and unsightly weed problems can be avoided or at least minimized with a little planning. Developing a landscape weed management plan involves five basic steps.

(1) **Site assessment.** Survey the site for cultural aspects as well as weed species.
(2) **Define the type of planting.** The type of planting, woody shrubs vs. bedding plants etc., will define the post-plant weed management options available.
(3) **Selection of ornamental species and compatible weed management options**; based upon design, cultural, and weed management criteria.
(4) **Site preparation.** Control weeds that cannot be controlled after planting.
(5) **Installation and implementation;** of the plants and the plan.

These steps will be discussed separately, but keep in mind that each step relates to, and is dependent upon, the decisions made in the other steps. The goal is to provide a process by which an effective and economical weed management plan may be developed.

STEP 1. SITE ASSESSMENT

Adequate site assessment will allow proper species selection based upon design criteria, cultural suitability, and management regime, including weed management. Take soil samples for pH and nutrient analysis. Note soil type and physical condition, drainage patterns, exposure and edaphic aspects, and potential maintenance problems such as gutter down-spouts, chlorine from the pool, or traffic patterns. Identify the weeds in the area, with particular emphasis on perennial weeds. Ask yourself: “Can these weeds be controlled after planting?” Some species that are difficult or impossible to control after planting include: bindweed, nutsedge, mugwort, Canada thistle, goldenrod, bamboo, Japanese knotweed, wild violet, and field horsetail. Also, inspect the surrounding areas for weeds that may encroach, such as: ground ivy, wild strawberry, yarrow, buffalograss, bermudagrass, creeping speedwell, quackgrass, or other creeping perennials.

The best time to scout for weeds is in mid- to late summer, when annual and perennial weeds can be identified. Scouting in late fall or early spring, is likely to miss many of the important species. Also, scouting in the summer will allow adequate time for decision-making and site preparation before planting.

STEP 2. DEFINE THE TYPE OF PLANTING

The species to be planted will define the intensity of management required and, to a large degree, govern your future weed management options. A planting of woody trees and shrubs will allow the most post-plant weed management options. In contrast, a mixed planting of woody and herbaceous plants will have fewer post-plant options. Where herbaceous perennials or annuals are included in a permanent landscape bed, geotextiles often cannot be used and herbicide choices are limited. Table 1 provides an overview of the weed management limitations

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and options for the different types of plantings. Tables 2 and 3 list the herbicides registered for use in landscape ornamentals and the suggested types of plantings where they can be used. Understanding these limitations and options will help guide you in the following steps toward developing an effective weed management plan.

Table 1. Weed management options and limitations for the five types of landscape plantings.

Tree and Shrub Beds: Densely shaded plantings exclude weeds.

- Geotextiles and mulches are useful.
- Many broad-spectrum herbicides are available for pre- and postemergent control.
- Spot or directed applications of non-selective herbicides, like Roundup, are possible.
- Therefore: species selection is flexible and pre-plant weed control is not as critical as in other types of plantings.

Recommendations: Control perennial weeds before planting (although control may be possible after planting), use geotextiles with a shallow layer of mulch, use a preemergent herbicide if needed, and supplement with spot applications of postemergent herbicides and/or hand weeding.

Woody Ground Cover Beds: The ground cover should ultimately exclude most weeds.

- Limited uses for non-selective herbicides; therefore, control perennial weeds before planting.
- Do not use geotextiles where ground covers are expected to root and spread.
- Control annual weeds with mulching, hand weeding, and/or herbicides.
- Several preemergent herbicides are available.
- Few uses for postemergent herbicides.
- Postemergent control of annual and perennial grasses is possible.

Recommendations: Control perennial weeds before planting, use geotextiles where possible; else use mulches with a preemergent herbicide and supplement with hand weeding.

Annual Flower Beds: A closed canopy will shade-out many weeds.

- Periodic cultivation (annually or between display rotations) will suppress many weeds.
- Very limited use of non-selective herbicides; control perennial weeds before planting.
- Geotextiles generally are not useful (due to the short-term nature of the planting).
- Few preemergent herbicides are safe; careful species and product selection are required.
- Mulches will suppress many annual weeds.

Recommendations: Control perennial weeds before planting, carefully select species for weed management compatibility, use mulches and a preemergent herbicide, and supplement with hand weeding.

Table 1 (continued).

Herbaceous Perennial Beds: Similar to Annual Flower Beds except:

- Lack of periodic cultivations will encourage perennial weed encroachment.
- Fewer herbicides are labeled; check the labels carefully.
- Geotextiles may be useful in clump-type plantings or to restrict growth of spreading-types.
- Very limited use of non-selective or postemergent herbicides.

Recommendations: Control perennial weeds before planting, use geotextiles where possible, use mulches with a preemergent herbicide, and supplement with hand weeding.

Mixed Plantings (of woody and herbaceous plants):

- More complex due to the diversity of species.
- Different areas of the bed could receive different treatments.
- Site preparation is usually critical.
- Few herbicides are registered for a wide spectrum of ornamental plant types.
- Geotextiles may or may not be useful.

Recommendations: Maximize the number of weed control options by compatible species selection. Control perennial weeds before planting, use geotextiles where possible, use mulches with a preemergent herbicide where possible, and supplement with hand weeding.

Tree and Shrub Beds

Two options set tree and shrub beds apart from the rest; one is the possibility of post-plant perennial weed control, the other is the use of geotextile fabrics for annual weed control. Perennial weeds may be controlled by manual removal, spot applications of glyphosate (Roundup), or, in some instances, dormant-season applications of diclobenil (Casoron). Care should be taken not to contact desirable foliage with Roundup; also, use diclobenil only on labeled species as injury is likely to result if applied to other plants. Annual weeds may be controlled using geotextile fabrics, organic or inorganic mulches, and/or herbicides. It is often necessary to combine these treatments for complete weed control. Geotextile fabrics are somewhat expensive to install but become cost-effective if the landscape bed is to remain in place for more than four years. Preemergent herbicides are less expensive and equally effective, but must be reapplied annually (usually two applications per year). Escaped weeds may be controlled manually or with spot applications of postemergent herbicides.

Woody Ground Covers

Ultimately, woody ground covers should exclude most weeds; however, weed encroachment during establishment is likely. After planting, it is difficult to make spot applications of Roundup or other nonselective herbicides without injuring desirable plants; therefore, perennial weeds should be eliminated before planting. An exception are perennial grasses, which can be selectively controlled after planting with sethoxydim (Vantage) or fluazifop-p (Ornamec). Annual weeds may be controlled with mulch plus a preemergent herbicide, supplemented with some hand weeding.

Annual Flower Beds

Weed control in annual flower beds can be simple if perennial weeds are eliminated before planting. Perennial grasses can be selectively controlled with sethoxydim or fluazifop-p, but

Table 2. Preemergent herbicides registered for use in landscape plantings.

Common Name	Trade Name(s)	Suggested Use-sites			
		Trees & Shrubs	Ground-covers	Annual Flowers	Herbaceous Perennials
bensulide	Betasan, Lescosan, Pre-San, Others	✔	✔	✔	✔
diclobenil	Casoron, Dyclomec, Norosac	✔	few	no	no
EPTC	Eptam	✔	✔	no	no
isoxaben	Gallery	✔	✔	no	no
napropamide	Devrinol	✔	✔	✔	✔
metolachlor	Pennant	✔	✔	no	few
oryzalin	Surflan	✔	✔	✔	✔
oryzalin + benefin	XL	✔	✔	✔	✔
oxadiazon	Ronstar	✔	✔	no	no
oxyfluorfen	Goal	✔	few	no	no
oxyfluorfen + pendimethalin	Scotts Ornamental Herbicide 2 (OH2)	✔	✔	no	no
oxyfluorfen + oryzalin	Rout	✔	✔	no	no
pendimethalin	Ornamental Weedgrass Control, Pendulum, others	✔	✔	no	few
prodiamine	Barricade, Factor	✔	✔	no	few
pronamide	Kerb	✔	no	no	no
simazine	Princep, Caliber 90, Simazine, others	✔	few	no	no
trifluralin	Treflan, Preen, others	✔	✔	✔	✔
trifluralin + isoxaben	Snapshot TG	✔	✔	no	no

NOTE: always check the herbicide label for list of registered species, directions for use, and precautions.

Key to Symbols: ✔ = registered for numerous species; few = registered on a few species; no = not recommended as most species in this category would be injured.

other perennial weeds cannot be selectively controlled after planting. Nonselective herbicides will kill or severely injure annual bedding plants and should be avoided after planting. Geotextiles are generally not used in annual flower beds but can be useful if no other options are available. Annual weeds may be controlled with mulches, preemergent herbicides, and/or hand weeding.

Herbaceous Perennial Beds

Weed management options in herbaceous perennial beds are similar to those for annual flowers, except (1) it is more important to eradicate perennial weeds, as there will be no opportunity to cultivate or renovate the bed for several years; and (2) fewer species are included on herbicide labels. Geotextile mulches may be used around clump-type plants, but not around spreading species.

Mixed Plantings

In mixed plantings of woody and herbaceous ornamentals, site preparation is as critical as for herbaceous perennials because post-plant choices are few. One option for such areas is to plant the woody species first; control the perennial weeds in the first two growing seasons, then introduce the herbaceous species. Another option may be to define use-areas within the bed

Table 3. Postemergent herbicides registered for use in landscape plantings.

		Suggested Use-sites			
Common Name	**Trade Name(s)**	**Trees & Shrubs**	**Ground-covers**	**Annual Flowers**	**Herbaceous Perennials**
bentazon	Basagran T/O	directed	few	no	no
clethodim	Envoy	✔	✔	✔	✔
diclobenil	Casoron, Dyclomec	✔	some	no	no
diquat	Reward, Spectracide	directed	no	no	no
fenoxaprop	Acclaim	✔	✔	✔	✔
fluazifop-p	Fusilade, Ornamec, others	✔	✔	✔	✔
glufosinate	Finale	directed	no	no	no
glyphosate	Roundup, Kleenup, others	directed	no	no	no
halosulfuron	Manage	directed	no	no	no
oxyfluorfen	Goal	few	few	no	no
pelargonic acid	Scythe	directed	no	no	no
pronamide	Kerb	✔	no	no	no
sethoxydim	Vantage	✔	✔	✔	✔

NOTE: always check the herbicide label for the list of registered species, directions for use, and precautions.

Key to Symbols: ✔ = registered for over-the-top or directed applications on many species within the category; directed = do not contact desirable foliage; few = registered for use over only a few species in the category; no = not recommended as most species in this category would be injured.

that will receive different weed management programs, such as a section devoted to annual flowers in an otherwise woody tree and shrub bed.

STEP 3. SELECTION OF ORNAMENTAL SPECIES AND COMPATIBLE WEED MANAGEMENT OPTIONS

Based upon the type of planting desired and the site assessment, we can now select the species for planting. The criteria for species selection should include design and site suitability, and maintenance aspects including disease and insect resistant species/varieties, as well as weed management option compatibility. Selecting the proper weed management option(s) will depend upon weed species present, your flexibility in planting design and species selection, economics, as well as some personal choice. Generally, **it is best to control perennial weeds before planting** (see" Step 4, Site Preparation"). If perennial weeds cannot be controlled before planting, carefully evaluate the type of planting and species selection to ensure that weeds can be selectively controlled after planting. Geotextile fabric mulches are generally not used in annual flower beds, but may be useful if no other options are available. Annual weeds may be controlled after planting using mulch, preemergent herbicides, by hand weeding, or a combination of these options.

Mulches

Many types of **mulches** are available including barks, various hulls (pecan, cocoa, buckwheat, etc.) municipal composts, crushed rocks, and others. All types suppress annual weeds by excluding light, which is required for seed germination. When mulches are too fine, too thick, or begin to decompose, they stay wet between rains, allowing weeds to germinate and grow directly in the mulch. Therefore, for weed control, a mulch which is fairly coarse-textured with a low water-holding capacity would be preferred. To effectively suppress weeds, organic mulches should about 4 inches thick. Inorganic mulches should be 3 to 4 inches thick, as they do not decompose or settle as quickly. Plan for periodic replenishment. When used alone, mulches rarely provide 100% weed control. Supplemental hand weeding or spot spraying are generally necessary. In many situations, the amount of supplemental weeding required can be burdensome and expensive; therefore, most landscapers will choose to use geotextiles and/or preemergent herbicides with a thin layer of a decorative mulch.

Geotextiles are synthetic fabrics which allow water and air to pass, but prevent weed seedling emergence. Although these materials are relatively expensive and time-consuming to install, they become cost-effective if the planting is to remain in place for 4 or more years. These fabrics are as effective as a good preemergent herbicide, but, in contrast to herbicides, without the need to reapply or the worry of potential herbicide injury to non-labeled species. Geotextiles are not suggested where the area is to be replanted periodically, as in annual flower beds, or where the fabric would inhibit rooting and spread of ground covers. Geotextiles must be covered by a mulch to prevent photodegradation. Use a shallow layer of mulch, as roots of weeds germinating on top can penetrate the fabric. Many perennial weeds can grow through plastic or geotextile mulches; therefore, those species must be controlled during site preparation. If weeds do grow into or through the geotextile, remove them when they are small to prevent holes in the fabric.

Herbicides

Herbicides are relatively inexpensive and effective, and, when properly chosen and applied, can be used in nearly any type of planting. If you decide to use a herbicide, consider the following selection criteria:

(1) select one which controls most of the weeds present (no herbicide will control all weeds);
(2) be sure the ornamental species are on the herbicide label;
(3) proximity of susceptible species, and the likelihood of exposure;
(4) potential residual effects on subsequent plantings (such as an annual flower bed);

(5) type of application equipment (granular or spray); and
(6) economics (don't forget the cost of supplemental hand weeding).

Consider using the ornamental species listed on the label as a selection criteria, for the herbicide as well as for the ornamental species. In this way you can obtain maximum weed control and avoid injury to desirable plants.

Preemergent herbicides are applied after planting but before weeds germinate. Some of the more popular preemergent herbicides used in the landscape plantings include trifluralin (Treflan), oryzalin (Surflan, XL), and metolachlor (Pennant). Treflan and Surflan control annual grasses and many broadleaf weeds, but can be used safely around many woody and herbaceous ornamentals. Metolachlor has become popular because it controls yellow nutsedge as well as most annual grasses. Table 4 provides information on the effectiveness of preemergent herbicides on several common landscape weeds.

When weeds escape the preemergent herbicides or geotextile fabrics, **postemergent herbicides** are often used. There are selective and non-selective types. Roundup, Diquat, and Scythe are non-selective and injure any vegetation contacted. Roundup is systemic, translocating to the roots, thereby killing the entire plant. It is effective on annual and perennial weeds. Diquat and Scythe are contact-type herbicides, controlling small annual weeds but only "burning-back" perennial or large annual weeds. The other postemergent herbicides listed in Table 3 are selective, that is, they kill or injure some species but not others. Before using these products, carefully check the lists of weeds controlled and the ornamentals species over which the herbicide may be safely used. For example: Casoron will control many perennial weeds but will injure most herbaceous and some woody ornamentals. Oxyfluorfen (Goal) can be used over many conifers but will injure many other ornamentals. Ornamec and Vantage selectively control annual and perennial grasses, but check the labels for species and varietal differences in plant safety. Manage and Basagran can be applied as directed sprays to the base of many woody species for nutsedge control, but check the label for recommended species and cautions.

For more detailed and extensive information on herbicides registered for landscape uses, contact your local Cooperative Extension office. Also, two good references on herbicides used in landscapes are the "Weed Management Guide for Herbaceous Ornamentals" and the "Weed Control Suggestions for Christmas Trees, Woody Ornamentals, and Flowers" (see suggested readings).

When selecting planting types and species to be included, use the weed control options as one of the selection criteria. The following two examples demonstrate how this can result in improved weed management.

Example 1. In a potential planting bed you identified yellow nutsedge as a major weed. Since yellow nutsedge is not controlled by mulches, geotextiles, or most preemergent herbicides, and postemergent herbicides applied in late summer or fall would have little or no effect on tuber emergence in the spring, your options are limited. Preemergent applications of metolachlor (Pennant) can provide adequate control, but this herbicide will injure many annual flowers and ornamental grasses. For example, Pennant should not be applied to begonia or impatiens, but it is safe on many woody species and herbaceous perennials. Therefore, an important species selection criteria would be to choose from those listed on the Pennant label. If you must plant begonias, then you would have to fumigate the site to eliminate nutsedge tubers.

Example 2. In a new landscape, a *Pachysandra* bed interplanted with daffodils for spring color was specified. Site analysis shows *Oxalis* (woodsorrel) and common groundsel to be the predominant weeds in the area. Since geotextiles would prevent spread of the *Pachysandra*, they should not be used. Additionally,

Table 4. Effectiveness of preemergent herbicides on common landscape weeds.

Herbicides	Annual grasses	Chick-weed	Galin-soga	Ground-sel	Morning-glory	Oxalis	Purslane	Spurge	Nut-sedge
Barricade	G	G	N	P	?	F	P-F	F	N
Betasan	G	F	P	?	N	N	F	P	N
Casoron	F-P	G	P	F	P	P	F	P	F
Devrinol	G	G	F	F	P	P	G	?	P
Eptam	G	G	N	?	P	?	G	?	P
Gallery	F	G	G	G	F	G	G	G	N
Goal	G	G	G	G	G	G	G	G	N
Kerb	G	?	G	G	?	?	G	?	N
Scotts OH2	G	G	G	G	F	G	G	F	N
Pennant	G	F	G	P	N	P	F	P	G
Princep	F	F	F	F	G	G-F	G	G	N
Ronstar	G	P	F	F	F-G	G	G	F	N
Rout	G	G	G	G	F	G	G	F	N
Snapshot	G	G	G	G	F	G	G	G	N
Surflan	G	G	F	F	N	G	G	F	N
Pendulum, others	G	G	F	P	P	F	F	F	N
Treflan	G	G	F	P	P-N	F	F	F	N
XL	G	F	P	P	N	F-P	F	F-P	N

Weed control rankings based on label information and author's experiences: G = good; F = fair; P = poor; N = no control expected; ? = unknown.

both of these weeds grow quite well in organic mulches and are difficult to hand weed (particularly the woodsorrel). The only herbicides labeled for both *Pachysandra* and daffodils do not control these weeds. Switching to *Vinca* as the ground cover species would allow the use of Surflan (oryzalin), which controls both weeds and is labeled for both ornamental species.

Once the species selection and weed management options have been chosen, you are ready to prepare the site for planting.

STEP 4. SITE PREPARATION

The best time to control perennial weeds is before planting. There are basically three options: repeated cultivation, fumigation, or Roundup. Table 5 provides guidelines for controlling several perennial weeds which are difficult or impossible to control after planting. Note that spring applications of Roundup are less effective than fall applications on several species. Therefore, where possible, plan ahead and do your site preparation in the fall. Note also that even Roundup does not control all weeds. For species like nutsedge, field horsetail (Equisetum), and wild violet, other measures may be necessary, such as fumigation. Fumigation is also useful if annual weeds are present which cannot be controlled after planting.

If the site is to be amended with top soil or organic matter, inspect the sources of these materials for weeds. Top soils from farm land or stream banks are notorious sources of nutsedge tubers and weed seed. Inspect piles of compost or mulch for signs of weeds. In par-

ticular, improperly composted municipal yard waste is often full of weeds, although, properly composted organic materials are typically fairly weed free. Some species frequently found in mulch piles include mugwort, thistle, and bindweed. If these weeds are present, find an alternate source!

STEP 5. INSTALLATION AND IMPLEMENTATION

Once you have gone to so much trouble to prepare a weed-free planting area, don't introduce weeds. Many perennial weeds are introduced in soil balls of field-grown nursery stock. Look for signs of mugwort, bindweed, field horsetail, or nutsedge. Again, inspect your source of mulch for weeds. If geotextiles are to be used, install them properly. If herbicides are to be used, apply them carefully. In short, implement the plan that you have developed.

No single weed management strategy will control all weeds. An integrated approach, utilizing all options at your disposal is the most economical and effective means of controlling weeds. To achieve this, remember to **PLAN BEFORE YOU PLANT.**

Table 5. Effectiveness of pre-plant weed control measures on certain hard-to-kill perennial weeds.

Species	Roundup-Fall	Roundup-Spring	Fumigation	Cultivation
Bindweed	Fair	Fair	Good	Poor
Japanese knotweed	Very Good	Poor	Good	Good
Mugwort	Good	Poor	Good	Poor
Canada thistle	Good	Fair	Good	Fair
Wild violet	Fair	Fair	Excellent	Fair
Goldenrod	Very Good	Fair	Excellent	Good
Nutsedge	Poor	Poor	Very Good	Poor
Bamboo	Poor	Poor	Fair	Fair
Quackgrass	Good	Good	Very Good	Poor
Bermudagrass	Good	Fair	Very Good	Poor
Buffalograss	Poor	Poor	Very Good	Poor
Field horsetail	Poor	Poor	Good	Poor

NOTE: This publication contains pesticide recommendations. Changes in the pesticide regulations occur constantly and human errors are still possible. Some materials mentioned may no longer be available, and some uses may no longer be legal. All pesticides distributed, sold or applied in New York State must be registered with the New York State DEC. Questions concerning the legality and registration status for pesticides should be directed to the appropriate Cornell Cooperative Extension specialist or your regional DEC office. Read the label before applying any pesticide.

SUGGESTED REFERENCES

Cornell Pest Management Recommendations for Commercial Production of Trees and Shrubs. Available from your local Cornell Cooperative Extension office.

Weed Management Guide for Herbaceous Ornamentals, by Andrew Senesac and Joseph Neal. Available from the Dept. of Floriculture and Ornamental Horticulture, Plant Science Bldg., Cornell University, Ithaca, NY 14853. ($1.25)

Weed Control Suggestions for Christmas Trees, Woody Ornamentals, and Flowers, by Skroch, Neal, Derr, and Senesac, Available from the Agric. Publications, N.C. State University, Raleigh, NC 27659-7609. ($7.50)

Nursery and Landscape Weed Control Manual, by Robert P. Rice, Jr., Thomson Publications, P.O. Box 9335, Fresno, CA 93791.

OTHER TITLES IN THE WEEDFACTS SERIES...	**PRICE**
Weed management Guide for Herbaceous Ornamentals, Senesac and Neal	$1.25
Greenhouse Weed Control, Neal and Senesac*	stamped, self-addressed envelope
Conducting a Bioassay for Herbicide Residues, Neal	stamped, self-addressed envelope
Woody Weeds of Nursery and Landscape, Uva and Neal	$1.00
Weedy Grasses of Turf, Nursery, and Landscape, Uva and Neal	$2.00
Annual Bluegrass Biology and Control, Williams and Neal	$0.75
Turfgrass Weed Management - An IPM Approach, Neal	$1.00

For copies send check (payable to Cornell University) or envelope to: Weed Facts - Department of Floriculture and Ornamental Horticulture, 20 Plant Science Building, Cornell University, Ithaca, NY 14853.

*Updated version available on-line from NC State University, Department of Horticultural Science, Horticulture Information Leaflet # 570 at http://www.ces.ncsu.edu/depts/hort/hil/flowers-index.html.