

CHECKLIST
BMPs FOR CONTAINER NURSERIES AND DISTRIBUTION CENTERS
REGULATIONS, SITE SELECTION, WATER MANAGEMENT

Regulations

For information on the Wetlands Protection Act or the Water Management Act, contact Massachusetts Department of Environmental Protection (<http://www.mass.gov/dep/water/approvals/wmgforms.htm>). See also “Site Selection Considerations: Wetlands Protection Act and Water Management Act” in this manual, page 4.

- ✓ Considerations

Site Selection

- ✓ Choose a site with an adequate source of clean water. Container-grown plants need to be irrigated frequently, often daily, throughout the growing season.
- ✓ Choose a site with a firm surface and good surface drainage.
- ✓ Ideally, choose a site that slopes slightly and offers water drainage to a pond or retention basin for recycling back to the crop.
- ✓ Consider the proximity of wet areas and the drainage patterns to minimize the efforts needed to curb water and soil contamination through runoff.
- ✓ Consider operating procedures and practices to control site runoff which can result in the discharge of nutrients and pollutants to waters.

Water Quality and Quantity

- ✓ Plan for 1 acre inch (approximately 27,000 gallons) of irrigation storage per acre of nursery stock per day for irrigation supplies.
- ✓ Plan for water storage for irrigation for 30 days.
- ✓ Provide a water source that is free of sediment and mineral deposits like iron and calcium bicarbonate.

Runoff Water Management

- ✓ Develop a plan for erosion and sediment control for each container nursery.
- ✓ Seed, sod, or stabilize in some manner newly constructed or barren areas to prevent erosion and sediment loss.
- ✓ Address unsuitable site-specific topographical characteristics before establishment of vegetation.
- ✓ Use temporary vegetation when bare areas will exist for 30 days or longer.
- ✓ Establish permanent vegetation to stabilize disturbed areas and reduce erosion and sediment loss.
- ✓ Use mulch to control erosion on disturbed land prior to vegetation establishment.
- ✓ Use erosion control blankets or netting to hold mulch in place as necessary during vegetation establishment.
- ✓ Use filter strips to prevent erosion.
- ✓ Use ground covers to provide means of erosion and sediment control on slopes where mowing is not feasible or grass establishment is difficult.

Grassed Waterways

- ✓ Provide grassed waterways for the uniform movement of water resulting in reduced sediment and other substances delivered to collection basins.
- ✓ Do not use grassed waterways as travel lanes; maintain vegetation.
- ✓ Use lined waterways to reduce erosion in concentrated flow areas.

Management of Stormwater

- ✓ Use stormwater management to minimize erosion.
- ✓ Never discharge stormwater runoff directly into surface or ground waters. Route runoff over a long distance, through grassed waterways, wetlands, vegetative buffers and other places designed to increase overland flow.

Irrigation

- ✓ Apply irrigation water uniformly over the growing area and apply the correct amount of water for the desired crops.
- ✓ Determine the correct amount of water to use while irrigating by measuring the leaching fraction from containers.
- ✓ Use low-pressure/low-volume irrigation systems, which use drip emitters or spray-stakes for container (5 gallon and greater) production.
- ✓ Use cyclic irrigation to decrease the amount of water and nutrients exiting the container.
- ✓ Periodically check the nozzle orifices for wear or plugging.
- ✓ Install a backflow prevention valve at the water source or pump to prevent cross-contamination of water supplies.
- ✓ Recycle subirrigation water that contains fertilizer to prevent discharge of contaminants to the environment.
- ✓ Space containers under fixed overhead irrigation to maximize amount of water striking plants and reduce water waste between containers.

Growing Media and Water Management

- ✓ Choose components of container growing media that are best adapted to plants and management.
- ✓ To prevent leaching of pesticides and nutrients, avoid media with a high proportion of coarse particles and air space, and a relatively low water holding capacity.

Water Quality for Irrigation

- ✓ Monitor irrigation water quality to ensure pollutants are not discharged.

Management

Strategies for Water Conservation

- ✓ Do not over-water. Do not water if the soil is still wet. Irrigate according to the requirements of the plants, not on a fixed schedule. The duration of irrigation is typically what needs to be modified based on evapotranspiration.
- ✓ Use rain shutoff devices to prevent irrigation system operation and minimize nutrient runoff.
- ✓ Collect irrigation and rain runoff and use for irrigation.
- ✓ Manage irrigation runoff to minimize the possibility of polluting surface or ground

waters.

- ✓ Keep B&B stock and container stock out of the wind in holding yards.
- ✓ Cover B&B stock with moisture-retaining materials such as sawdust or wood chips.
- ✓ Plug sprinkler heads that are not watering plants, keep sprinkler heads as close as possible to the plants, and use larger water droplet size to reduce irrigation time.
- ✓ Group plants according to water needs for efficient irrigation.
- ✓ Water early in the morning or between the hours of 6 PM and 10 AM when temperatures and winds are at their lowest levels to reduce water loss. Watering at night will also minimize leaf wetness period to prevent foliar diseases.

Overwintering Structures

- ✓ Use BMPs for plastic disposal, energy use (heated structures), water use, nutrient management, rodent and pest management, drainage, and runoff.

CONTAINER NURSERIES AND HORTICULTURE DISTRIBUTION CENTERS

Site Selection Considerations

Growing plants in containers presents different challenges than growing plants in field soil. Container plants are grown in media that contain a limited amount of water, retain small quantities of nutrients, and confine roots in a limited space. Consequently, inputs like irrigation and fertilizer applications must be precise and properly timed in quantities to maximize benefits to the container plant production system, while minimizing negative effects on the environment. An opportunity exists to use the best possible management strategies, even with the site-specific nature of nursery production facilities. BMPs include operating procedures and practices to control site runoff which can result in the discharge of nutrients and pollutants to waters.

Since container production entails growing plants above ground using customized soilless growing media, the type of native soil at the site is not as important as it is with field-grown crops. Generally, container production requires a firm surface with good surface drainage. The ideal site has a slightly sloping topography for proper air movement and offers water drainage to a pond or retention basin for recycling back to the crop. Container nurseries are best sited on soils with low permeability. Consider the proximity of wet areas and drainage patterns to minimize the efforts needed to curb water and soil contamination through runoff. The site should also be chosen to minimize the loss of quality native soil in accommodating the production area. An adequate source of clean water is important.

Water Quality and Quantity for Container Nurseries

Water is the most important consideration for growing nursery crops in containers. Most container nurseries irrigate daily or every other day during the growing season.

Professionals who design irrigation systems for container nurseries suggest using a figure of no less than 1 acre inch (approximately 27,000 gallons) of irrigation storage per acre of nursery stock per day when planning irrigation supplies. Nurseries should have storage capacity at least a 30 day irrigation supply.

High quality water, free of sediment and mineral deposits like iron and calcium bicarbonate, is necessary to avoid clogging drip, spray stake, or mist nozzles. Water treatment to remove such elements is expensive. Groundwater from deep wells usually provides the highest quality irrigation water.

Irrigation water should be tested each year for pH, alkalinity, sodium (Na), chloride (Cl), and electrical conductivity (EC). More information about these tests can be found in the section [Nutrient Management – Container Nurseries: Irrigation Water Testing](#).

Runoff Water Management

Container nurseries are especially susceptible to erosion (the process by which the land surface is worn away by the action of water, wind, ice, or gravity) and sedimentation (the process where soil particles settle out of suspension as the velocity of water decreases) after new development and prior to filling empty container beds. Water flowing over exposed soil picks up detached soil particles and debris that may possess chemicals harmful to receiving waters. As the velocity of flowing

water increases, additional soil particles are detached and transported. Water flows have a tendency to concentrate, creating small channels and eventually gullies of varying widths and depths. Larger and heavier soil particles carried in these water flows—sand and gravel—settle out more rapidly than fine silt and clay particles. Totally eliminating the transportation of these fine particles is difficult, but managing runoff from both irrigation and stormwater to minimize erosion and sedimentation—and protect water quality—is critical.

Drainage Channels and Grassed Waterways

Drainage channels can be established with permanent vegetation such as fescue grass or even aquatic plants. Permanent vegetation in drainage channels slows water velocity, reduces erosion, and reduces sediment and nutrients in runoff water. Permanent vegetation located at outlets of drainage channels also traps organic material, solids, soil, nutrients and other dissolved pollutants in runoff before the water returns to irrigation supplies.



Jeff Vanuga, USDA NRCS

Grassed waterways are natural or constructed channels, shaped or graded to required dimensions and established with suitable vegetation for the stable conveyance of runoff. These structures are used to reduce erosion in a concentrated flow area, such as in a gully or in temporary gullies. They are also used to reduce the amount of sediment and substances delivered to collection basins, nearby waterways, or sensitive areas. Vegetation may act as a filter in removing some of the sediment delivered to waterways, although this is not the primary function of grassed

waterways. Do not use grassed waterways as travel lanes. Maintain vegetation to prevent erosion and control runoff.

Water and Sediment Control Basins

The use of water and sediment control basins may be a primary means of reducing water quality problems. The goal of each operation is to prevent irrigation water from leaving the property. Evaluation of each site will determine if collection basins are necessary or possible.

Basins or other structures must have all necessary state and local permits prior to construction. Collection basins are constructed with clay-like materials with good scaling characteristics or lined with an acceptable membrane liner. Basins should have emergency overflows to prevent dike damage in the event of overtopping. If rainwater is allowed to discharge from the property, it must be considered in the design of water collection basins.

More information is available on the NRCS National Handbook of Conservation Practices Web site (<http://www.nhq.nrcs.usda.gov/CCS/Buffers.html#Anchor-Benefits>).

Underground Collection

The use of systems where irrigation water is collected underground and re-used in outdoor sub-irrigation facilities should be considered. Such systems are commercially available but not widely used due to the expense. Collection/storage structures would not only serve to reduce nursery runoff, but also provide a renewable water supply and provide buffering capacity for reclaimed water and rainfall.

Management of Stormwater

Stormwater runoff is water flowing over the land, during and immediately following a rainstorm. On-site storage of stormwater can reduce peak runoff rates; provide for settling and dissipation of pollutants; lower the probability of downstream flooding stream erosion, and sedimentation; and provide water for other uses. Never discharge stormwater runoff into surface or ground waters. Route runoff over a longer distance, through grassed waterways, wetlands, vegetative buffers and other places designed to increase overland flow. These components increase infiltration and evaporation, allow suspended solids to settle and remove potential pollutants before they are introduced to other water sources.

Whenever possible, construct the components of stormwater management systems on contours following the topography. This will minimize erosion and stabilization problems caused by excessive velocities. It will also slow the runoff allowing for greater infiltration and filtering. If systems are not constructed on contours, their components must be stabilized to prevent erosion (e.g. outlet terraces and grade stabilization structures).

The NRCS National Handbook of Conservation Practices Web site provides standards for at least three types of irrigation, water and sediment, and tailwater structures (www.nrcs.usda.gov/technical/standards/nhcp.html).

Irrigation for Container Nurseries

Irrigation application efficiency is relative to irrigation system design and management. While some irrigation systems are more efficient than others, it is important to recognize that poor management of a relatively efficient system can reduce or negate system efficiency and increase pollutant discharge to runoff or percolating waters. When evaluating irrigation efficiency, take into consideration the uniformity of application; the amount of water retained within the media following irrigation; and, for overhead irrigation, the amount of water that enters containers compared to that which falls between containers.

Measuring Uniformity and Amount

Two BMPs to irrigate efficiently are making sure all irrigation is applied uniformly over the growing area and checking that the correct amount of water is applied for the desired crops. One way to measure uniformity is to place plastic bags within empty pots throughout a block or zone before an irrigation cycle, collect the water applied, and measure the amounts in each container. If the volume collected among containers is highly variable, risers and nozzle orifices should be inspected. Risers should be straightened so that they are perpendicular to the ground and nozzle orifices should be replaced if they appear irregular in shape or larger than new orifice openings. If wind frequently interferes with water distribution, consider creating a windbreak.

Determine the correct amount of water to use while irrigating by measuring the leaching fraction from containers. A leaching fraction is the amount of water which drains from containers after irrigation divided by the total amount of water applied to the container during irrigation. It can be multiplied by 100 to obtain the percent leachate:

$$\frac{\text{Volume of leachate}}{\text{Total volume irrigation entering container}} = \text{Leaching fraction} \times 100 = \text{Percent leachate}$$

To collect the amount of water that drains from a plant's container after irrigation, place another plastic bag in an empty pot. This time, place a containerized plant inside the plastic-bag-lined container. Do this for each crop in different-sized containers. After the last irrigation cycle of the day, compare the amount of water collected in the bag placed in the empty pots to the amount of water collected in the bags below various crops. The amount of water in bags under crops should be approximately 10 to 20% of the amount collected in the empty container. If it is considerably more than 10 to 20%, plants may be receiving more irrigation than necessary. This is one way to determine if plants are over-watered and enables growers to conserve water during the production period.

Leaching fractions can be affected by the plants' canopies. Canopies can gather, repel, or have little effect on the amount of water entering containers. Plants can be removed from containers and the degree of uniform wetness in the container media can be observed. If irrigation is adequate, there will be no dry spots in the container root zones and it will be obvious that water has moved through the entire depth of the container profile. Increasing irrigation efficiency (by correcting water distribution uniformity and maintaining a 10 to 20% leaching fraction) is the

best water-conservation practice that growers can adopt if they are facing water shortages or want to reduce water runoff.

Methods of Application

Most nursery crops grown in 1- to 5-gallon containers are irrigated by overhead-impact sprinkler irrigation. Each sprinkler nozzle may need a supply of up to 15 gallons of water per hour for proper performance.

In recent years, nurseries have adopted several water-conserving application practices. Low-pressure/low-volume irrigation systems, which use drip emitters or spray-stakes, are being used for both field production and larger container (5 gallons and greater) production. These emitters often require only 10 to 20 pounds per square inch (psi) pressure and 0.5 to 15 gallons per hour of water. Where there are long distribution lines or uneven terrain, pressure-compensated emitters are available to ensure even distribution of water.

Drip irrigation provides a consistent, direct application of water to the root zone during production. Another advantage of low-volume/low-pressure systems is direct injection of fertilizers within the irrigation water. Applying nutrients directly to the root zone increases nutrient use efficiency because nutrient application is more closely controlled by the grower. When nutrients are applied in granular form as a top-dress, there is always the possibility of losing nutrients in the runoff after periods of heavy rains.

During the growing season most nurseries irrigate on a daily basis in which the daily water allotment is applied in a single application (continuously). An alternative to continuous irrigation is cyclic irrigation in which the daily water allotment is applied in more than one application with timed intervals between applications.

Cyclic Irrigation

Cyclic irrigation is a BMP that applies the necessary daily amount of irrigation in more than one application with timed intervals between applications. Several 15-minute applications of water are used, with a pause of 30 to 60 minutes between applications. Using this method, runoff is minimized and water use is reduced by about 25% compared to one long, single application from an overhead sprinkler. For example, if 0.6 inches of water are required per day within an irrigation zone, 0.2 inches will be applied three separate times with approximately 1 hour between irrigation cycles. Cyclic irrigation requires automated irrigation controllers, which schedule irrigation between nursery container blocks throughout the day. After all blocks are irrigated once, the rotation begins again.

Many nurseries have adopted cyclic irrigation over a daily, single irrigation cycle to conserve water and nutrients. A single irrigation cycle commonly distributes water over a growing block for an hour, and in most nurseries 0.5 to 1 inch of water is applied. Similar to a downpour, water applied continuously to a container can move through the media quickly collecting nutrients in the leachate. Very little lateral wetting of the media occurs, while a large portion of the water and nutrients are lost through the bottom of the container. If the nursery is near surface water like a stream or river, production area runoff can potentially impact surface water quality. In other locations, particularly areas with sandy soils and shallow aquifers, high volumes of irrigation can leach nutrients.

In contrast, during the first application of water in cycled irrigation, the foliage canopy and the surface medium are moistened but not saturated. Because only one-third of the total water is applied, water moves laterally and downward into the media slowly. More water moves into small pore spaces between media particles, resulting in greater wetting and moisture retention than effected by one long irrigation application. The second irrigation cycle continues moving the wetting front (the arc of water moving downward and laterally from the surface of the container) slowly down the container column. Ideally, the third irrigation cycle pushes the wetting front to the bottom of the container.

Effects of Growing Media Characteristics on Water Management

The predominant potting media components in nurseries are pine bark, sand, and sphagnum peat moss. Some alternative materials being used are shredded coconut husks (coir), composted yard wastes and animal wastes, composted hardwood bark, and other composted materials. Pine bark media require frequent irrigation and have very high unavailable water content. Screened pine bark used alone as a potting media has a water-holding capacity of approximately 65% water (by volume), but only about 32% is available for plant use.

During drought, a 4-to-1 ratio blend of pine bark and sand is better, since the blend's water-holding capacity is equal to bark alone and approximately 41% of the water held is available to plants. The mixture of pine bark and sand also wets faster and more uniformly during irrigation, since the infiltration rate (downward movement) of water is slowed and better lateral wetting occurs. The trade-off is that this substrate weighs over twice as much as pine bark alone, and some plants may not grow as rapidly if water is never limited because much of the air space in the pot is replaced by sand particles. A 10% addition of peat moss increases water retention even more than sand, but does have the potential of becoming waterlogged and it is difficult to wet when dry.

Horticultural wetting agents are effective in retaining water in potting media without creating waterlogged conditions. These characteristics can be very useful for enhancing root growth and establishing newly potted liners. However, one application of a wetting agent may lose effectiveness before the end of the growing season. In most cases, newly potted plants are well established in containers by that time, and reapplication is not necessary.

Synthetic hydrogels have been shown to enhance growth of established plants in containers in very coarse media such as pine bark. They appear to have little effect on newly potted plants. The water absorption of hydrogels is affected by fertilizers and compounds in organic potting media, but they still retain significant quantities of moisture that are available as established plants extend roots into and adjacent to the cubes in the potting mix. In effect, they act as miniature oases for roots. Since they must be incorporated to be effective, the need for these materials must be anticipated prior to drought for them to be beneficial.

A substrate's absorption capacity is related to the pre-irrigation substrate water content. The wetter a substrate is, the less water it will hold, so adjust the daily irrigation volume according to the substrate water content in order to minimize leaching.

Water Quality

Irrigation water quality is a critical factor for production of container-grown nursery plants. Poor water quality applied with overhead irrigation can result in damage to foliage, change substrate pH, or result in unsightly foliar residues or stains. Use of poor quality water in irrigation systems can also clog mist nozzles and micro-irrigation emitters. Irrigation, fertilizer, and pesticide efficacy are more easily managed when using good quality water. To ensure water has desirable qualities, monitor the irrigation water constituents. Monitor water quality at least twice a year (summer and winter); more frequent monitoring is needed to alter production practices in response to changes in water quality.

Reclaimed water, runoff water, or recycled water may require some reconditioning before using since disease organisms, soluble salts, and traces of organic chemicals may be present. Water quality should be tested to ensure it is acceptable for plant growth and to minimize the risk of discharging pollutants to surface or ground water.

Grouping Plants for Efficient Irrigation

To apply irrigation more uniformly, growers can group stock based on container size, substrate, plant type, plant water requirements, plant leaf type, and plant canopy. Because small containers will be saturated before large container plants receive enough water, most growers group containers by size in separate irrigation zones. Likewise, plants growing in very different potting media should not be grouped under the same irrigation regimes. This can be the case when plants are brought in from other nurseries. Nursery crops such as azaleas, rhododendrons, and camellias are often grown in mixes containing peat moss and may require less frequent irrigation.

Different cultivars of one type of plant, like juniper or holly, should be grouped and irrigated according to container size. It is more difficult to determine how to group different types of plants for most efficient irrigation. Various published lists do indicate which plants will tolerate similar moisture conditions in the landscape: dry, moist, or wet. These lists can help growers decide how to segregate plants in nurseries for similar irrigation needs.

Some nursery studies have also compared plant water use. Generally, plants with thick, waxy cuticles or thick, fleshy leaves can be grouped together and watered less frequently than plants with thin leaves. Deciduous plants usually require more water than broadleaved evergreens during the growing season but less when they are dormant. In general, junipers and conifers require less frequent irrigation than do broadleaved evergreens. Depending on winter protection provided, most container plants require occasional irrigation during winter months.

Summary of BMPs for irrigation efficiency

- ✓ Do not over-water. Do not water if the soil is still wet. Irrigate according to the requirements of the plants, not on a fixed schedule. The duration of irrigation is typically what needs to be modified based on evapotranspiration.
- ✓ Water early in the morning or between the hours of 6 PM and 10 AM when temperatures and winds are at their lowest levels to reduce water loss.
- ✓ Use cyclic irrigation instead of a long single application of water from an overhead sprinkler.
- ✓ Space containers under fixed overhead irrigation to maximize plant irrigation and reduce water waste between containers.
- ✓ Use drip tubes or spray sticks for individual containers, when reasonably practical.
- ✓ Plug sprinkler heads that are not watering plants, keep sprinkler heads as low as possible to the plants, and use larger water droplet size to reduce irrigation time.
- ✓ Group plants together that have the same water requirements.

Overwintering Practices

Nursery B& B and container grown plants require winter protection to protect them from desiccation and root damage due to freezing. Plants can be consolidated in an area of the nursery and covered with a protective covering, or placed in unheated or heated polyhouses/greenhouses, or lower and narrower structures called polyhuts. These structures are usually temporary structures used to provide protection from wind and cold. The temperature in most overwintering structures is kept below freezing but above 25° F to prevent damage. A source of water for irrigation is needed. When planning for overwintering nursery stock, growers should consider BMPs for plastic disposal, energy use (in heated structures), water use, nutrient management, rodent and pest management, as well as drainage and runoff which can result in the discharge of nutrients and pollutants to waters.



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The ideal site for overwintering has a slightly sloping topography for proper air movement and offers water drainage to a pond or retention basin for recycling back to the crop. Subsurface drainage may also be needed. Proximity of wet areas and drainage patterns should also be considered to minimize the efforts needed to curb water and soil contamination through runoff.

The type of overwintering technique used is determined by the plant species and the ability of their roots to withstand cold temperatures during winter. Growers must first determine the extent

of winter protection required for the plants being grown. Plants whose roots are killed at higher temperatures than the average low temperature in their geographic area will need some type of protection. Plants with roots that can withstand colder temperatures may need less protection. Table 2 lists killing temperatures for roots of selected woody ornamental plants.

Plants develop the ability to survive winter temperatures following exposure to shortening days and lower temperatures (acclimation). In order to develop maximum tolerance to cold the plants must be exposed to freezing temperatures. Ultimately, if exposed to consistently lower temperatures, without sudden damaging drops or swings up and down, many plants are able to tolerate very cold temperatures. Cultural practices, such as fertilizing, watering, and pruning impact a plant's ability to acclimate. Any practice that stimulates late season growth should be avoided.

Covering Plants

Do not cover plants before they have acclimated to cold temperatures. This is usually sometime in November around Thanksgiving for much of Massachusetts.

Watering

Before covering, consolidate plants as close as possible and water well. Moist media freezes more slowly than dry media and releases heat, offering root protection. Check moisture level of the media during the winter and irrigate if necessary.

Rodent Management

The final step prior to covering plants is to provide some type of rodent control. Many growers use commercially available baits while others have reported that human hair or cut up deodorant soap works for them. In addition to using baits, make overwintering greenhouses rodent tight. Use fine mesh screen wire like hardware cloth around the perimeter of the greenhouse. Bury it under ground to a depth of 8 to 12 inches, creating a subterranean barrier. Leave about 6 to 8 inches of extra hardware cloth at the bottom, and bend it outward at a 90° angle to form an L-shape. This will help to keep pests from burrowing under. Mow and clean up the natural vegetation close around the greenhouses to eliminate protected areas for rodents.

Managing Temperature Extremes

Temperature extremes are often managed with timely ventilation and supplemental heat. Depending on daytime winter temperature, overwintering structures may be ventilated to reduce rising temperature inside the structure. For certain plant species, supplemental heat may be

Methods of Overwintering

Massachusetts has six hardiness zones representing a wide range of temperatures. As a result, growers here use many different methods for overwintering plants. Some experimentation will be necessary to determine which method works best for your situation:

1. Push pots together with protection at the edges
2. Mulching
3. Microfoam with a poly cover directly over plants placed on the ground
4. Greenhouse with single-layer poly (white poly)
5. Greenhouse with double-layer poly
6. Greenhouse with double-layer poly and a poly blanket
7. Greenhouse with double-layer poly and a microfoam blanket
8. Greenhouse with double-layer poly and heat

necessary to avoid rapid temperature drop and prolonged cold. Uncover plants when temperatures begin to rise in early spring but after the danger of subfreezing temperatures has passed. In early spring, holes can be cut in the poly to ensure adequate ventilation while still providing adequate protection from frosts.

Plastic Disposal

The poly film used to cover overwintering structures and the microfilm used to protect overwintering plants present a disposal problem at the end of every winter season. In Massachusetts, the Department of Environmental Protection open burning regulations do not permit burning of agricultural plastic. Burning plastic can release toxic and potentially cancer-causing chemicals into the air. If you have plastic waste for disposal, first check with your local municipal recycling center or a plastic recycling company. The second option for proper disposal is to hire a commercial waste hauler.

Table 2. Average killing temperatures for roots of selected species of woody ornamental plants.

Scientific Name	Common Name	Killing Temperature °F*
<i>Magnolia soulangiana</i>	Saucer Magnolia	23
<i>Magnolia stellata</i>	Star Magnolia	23
<i>Cornus florida</i>	Flowering Dogwood	20
<i>Daphne cneorum</i>	Garland Flower	20
<i>Ilex crenata</i> ‘Convexa’	Convex Japanese Holly	20
<i>Ilex crenata</i> ‘Hetzi’	Hetz Japanese Holly	20
<i>Ilex crenata</i> ‘Stokesii’	Stokes Japanese Holly	20
<i>Ilex opaca</i>	American Holly	20
<i>Pyracantha coccinea</i>	Fire Thorn	18
<i>Cryptomeria japonica</i>	Japanese Cedar	16
<i>Buxus sempervirens</i>	Common Boxwood	15
<i>Cotoneaster horizontalis</i>	Rock Cotoneaster	15
<i>Cytisus praecox</i>	Warminster broom	15
<i>Euonymus fortunei</i> ‘Carrierei’	Carrier Euonymus	15
<i>Euonymus fortunei</i> ‘Argenteo-marginata’	Variiegated Euonymus	15
<i>Hedera helix</i> ‘Baltica’	Baltic Ivy	15
<i>Ilex glabra</i>	Inkberry Holly	15
<i>Pachysandra terminalis</i>	Japanese pachysandra	15
<i>Pieris japonica</i> ‘Compacta’	Compact Pieris	15
<i>Vinca minor</i>	Common Periwinkle	15
<i>Viburnum carlesii</i>	Korean Spice Viburnum	15
<i>Acer palmatum</i> ‘Atropurpureum’	Bloodleaf Japanese Maple	14
<i>Cotoneaster adpressa praecox</i>	Nan-Shan Cotoneaster	10
<i>Pieris japonica</i>	Japanese Pieris	10
<i>Rhododendron</i> ‘Gibraltar’	Gibraltar Azalea	10
<i>Rhododendron</i> ‘Hinodegiri’	Azalea hybrid	10
<i>Taxus media</i> ‘Nigra’	Black Anglojap Yew	10
<i>Euonymus fortunei</i> ‘Colorata’	Purple Leaf Wintercreeper	5
<i>Leucothoe fontanesiana</i>	Drooping Leucothoe	5
<i>Pieris floribunda</i>	Flowering Pieris	5
<i>Juniperus horizontalis</i>	Creeping Juniper	0
<i>Juniperus horizontalis</i> ‘Douglasii’	Waukegan Juniper	0
<i>Rhododendron carolinianum</i>	Carolina Rhododendron	0
<i>Rhododendron catawbiense</i>	Catawba Rhododendron	0
<i>Picea glauca</i>	White Spruce	-10
<i>Picea omorika</i>	Serbian Spruce	-10
<i>Potentilla fruticosa</i>	Shrubby Cinquefoil	-10
Rhododendron P.J.M. hybrids	P.J.M. Rhododendron	-10

*Highest temperature that killed more than 50% of root system and reduced top growth.

Source: Havis, J.R. 1964. Root hardiness of woody ornamentals. *HortScience* 11(4):385-386.

