

**National Ornamental Research Site at Dominican University CA (NORS-DUC) and  
California Department of Food and Agriculture (CDFA)  
Best Management Practices Manual  
to reduce the risk of introducing Soil-borne Plant Pathogens into Horticultural Nurseries  
and  
Managed Wildland Landscapes**

The following voluntary recommended Best Management Practices (BMPs) are designed for ornamental and native plant nurseries and restoration projects where the final planting destination is in managed wildland landscapes. This document is intended to reduce the risk of introducing soil-borne plant pathogens into nursery operations and managed wildland landscapes through a systems approach to production. These BMPs are organized according to Nursery Critical Control Points (CCPs). Individual nurseries are encouraged to review these practices, assess their risks and voluntarily apply some or all of the BMPs, depending upon their production systems, physical location, nursery type, regional climatic conditions, geographical location and the plants grown. Comprehensive, thorough sanitation and BMPs need to be followed so the nursery environment is non-conducive to pathogen establishment.

The BMPs are a major component of a successful Nursery Pest Risk Plan which should include: a map of the operation identifying supply chain flow from start to finish, employee training records, internal systems review procedures and documentation of their implemented BMPs.

The Nursery CCPs focus on the following areas:

- I. Plants
- II. Soil
- III. Water
- IV. Containers
- V. Field Layout
- VI. Sanitation
- VII. Scouting
- VIII. Training
- IX. Documentation/Record Keeping
- X. Disclaimer
- XI. Acknowledgements



If requested, nurseries will be given guidance in the creation of their Nursery Pest Risk Assessment Plan by the authors of this document.

Updated April 2021

## **I. PLANTS**

### **BMP 1**

**Collections of cuttings and seeds from wildland habitats must be taken from healthy plants during non-rainy weather and, where possible, should be collected at approximately two feet or more above the soil surface.**

Rationale: Pathogens can be transmitted on seeds and cuttings taken from diseased plants. They also can be acquired from infested soil that may have splashed up from the ground.

### **BMP 2**

**Cuttings and seeds collected from wildland habitats must be placed and stored in clean containers (see Sanitation).**

Rationale: Avoid contaminating healthy cuttings; place them in clean or new bags or collection bins.

### **BMP 3**

**Confirm buy-ins are received from nurseries that are licensed and operating under a clean stock production plan according to all applicable phytosanitary laws and regulations.**

Rationale: The first line of defense – know your supplier. Grower priority should be to ensure that potentially contaminated stock is not purchased or allowed to enter the production site.

### **BMP 4**

**All incoming nursery buy-ins should initially be placed in an area where leafy debris can be easily cleaned up and safely disposed of, such as on the loading dock.**

Rationale: Leafy debris can harbor pathogens and serve as a source of pathogen introduction into the nursery.

### **BMP 5**

**Do not commingle incoming plants with existing stock for a period of six weeks..**

Rationale: Avoid contamination of clean stock with potentially diseased material. Plants that have been treated with *Phytophthora*-specific fungicides may not exhibit symptoms of disease for at least six weeks after treatment and may “mask” the disease. Isolation or quarantine of the incoming plants is recommended prior to introduction and may be released after inspection.

### **BMP 6**

**Trained and authorized personnel should visually inspect all incoming seed, cuttings and nursery stock buy-ins, regardless of origin, for symptoms of disease prior to introduction into the nursery facility.**

Rationale: Visual evaluation of incoming propagative materials can detect and screen out pathogen infected material early. After a six-week hold, suspect materials should be closely re-evaluated before introduction into the nursery or discarded.

### **BMP 7**

**When taking cuttings from existing nursery stock, collect only from healthy plants and, if necessary, dip cuttings in an approved disinfectant solution before sticking. For plants that are prone to diseases, chemically treat crop in the field prior to taking cuttings.**

Rationale: Treatment of stock plants with registered disinfectant(s) before cutting of the propagation material can reduce the possible introduction of contaminated plant material into the propagation cycle and will also protect the open wounds from possible pathogen infections.

#### **BMP 8**

**Avoid product returns of nursery stock. If unavoidable, isolate the material from other plants for at least six weeks and inspect for disease symptoms. Test a portion of the returned product for *Phytophthoras* by pear baiting or other accepted diagnostic method.**

Rationale: Avoid possible disease introduction from the returned stock which may have been exposed to pathogens. If disease is found on returned stock, contact your county agricultural commissioner or cooperative extension office.

#### **BMP 9**

**When delivering to a job site for your own installation, place plants on a suitable barrier (such as plastic sheeting), to protect them from soil substrate contamination.**

Rationale: The soil substrate can harbor pathogens and plants returned from the job site can introduce pathogens into the nursery.

#### **BMP 10**

**Thoroughly inspect all plant material bound for shipping or planting at habitat restoration sites.**

Rationale: Visual evaluation of outgoing materials provides a final screening for pathogens. Suspect materials should be held and tested for pathogens.

#### **BMP 11**

**Dispose of unsalable plant material no longer actively managed.**

Rationale: Aged or unsaleable product can serve as a source of inoculum for pathogens and weeds.

## **II. SOIL**

#### **BMP 12**

**Ensure that growing media is purchased from a reliable source and the components are low risk for containing pathogens.**

Rationale: Given that *Phytophthora* and other pathogens can survive in potting media, it is critical for the grower to exclude sources of contamination in components, such as peat, bark and other organic components. Know your supplier and tour their operation to ensure they do not employ potentially risky practices. When growing for restoration or managed wildland installations, to ensure freedom from pathogens, heat treatment or fumigation of potting mix may be necessary.

#### **BMP 13**

**Ensure growing media is stored in an area known to be free from pathogens or on a surface which can be sanitized and is not exposed to contamination by the soil substrate, surrounding environment or workers' activities.**

Rationale: Clean potting media can become contaminated by external sources such as infested leaf debris, contaminated water, or contaminated soils. Install a barrier between the soil substrate and the potting media, such as a pond-liner or a concrete pad.

#### **BMP 14**

**Avoid re-use of potting media or if used media must be recycled, properly disinfest prior to usage.**

Rationale: Used media can harbor pathogens. Heat treatments or other proven methods of disinfestation must be employed. See appendix.

#### **BMP 15**

**Avoid movement of potentially contaminated soil/mud through the nursery on tires, shoes, and equipment. Employ the use of boot scrubbers, foot and tire baths.**

Rationale: Soil borne pathogens are known to be transmitted in mud stuck to tires, shoes etc.

### **III. WATER**

#### **BMP 16**

**Irrigate in a manner that enables leaves to dry quickly which avoids periods of prolonged leaf wetness. Where possible, reduce plant density to enable better air movement in the plant canopy to promote faster drying of leaves**

Rationale: Properly time irrigation events to reduce conditions favorable for disease development. Extended leaf wetness periods due to late afternoon or nighttime irrigations (such as sprinklers, hand watering, or misters) are conducive to infection by pathogens.

#### **BMP 17**

**Monitor and annually test untreated irrigation water from any source other than a well or municipal water supply to confirm that it is free from pathogens.**

Rationale: For growing operations that utilize recycled water or open irrigation water sources, such as ponds, lakes, streams, or well-water blended with surface water, proper water treatment is recommended (ozonation, chlorination or other water disinfection program).

#### **BMP 18**

**Avoid or minimize accumulation of standing surface water in planting beds and roads.**

Rationale: When plants sit in standing water, *Phytophthora* zoospores can swim from pot to pot. The pathogen may potentially enter plants through the roots or by splashing onto leaf surfaces. Standing water puddles in the nursery provide optimum conditions for *Phytophthora* to thrive and to be splashed onto plants. Roads and pathways should be properly graded. Excessively wet roads provide the potential for infested mud or water to splash onto plants.

#### **BMP 19**

**Insert a barrier (such as gravel layers, or preferably raised benches with drainable bench tops) between native soil and containers to reduce splash and dispersal of pathogens from the potentially infected ground. This can be easily accomplished by using raised benches with drainable bench tops that prohibit lateral movement of water from pots.**

Rationale: Soil-borne pathogens such as *Phytophthora*, can inhabit the soil substrate and potentially be a source of contamination.

### **IV. HORTICULTURAL CONTAINERS AND SUPPLIES: plant stakes, irrigation emitters, plant protectors (Tubex tubes), etc.**

#### **BMP 20**

**Use new or clean and properly disinfested pots and horticultural supplies, including irrigation emitters and drip line.**

Rationale: Pathogens can be carried in residual soil and potting media adhering to used pots and has been shown to transmit pathogens to the newly potted plant. Research has demonstrated that *Phytophthora* are killed when products are held for 30 minutes at 50<sup>0</sup> C (122<sup>0</sup> F). (See addendum Solarizing and Steaming)

#### **BMP 21**

**Do not store dirty containers in or near clean areas of the nursery.**

Rationale: Avoid contamination of clean areas with dirty pots.

#### **BMP 22**

**Ensure pots are stored off the ground and are not exposed to contamination by the surrounding environment.**

Rationale: Clean pots can become re-contaminated by external sources such as infested leaf debris, contaminated water, or contaminated soils.

#### **BMP 23**

**Hose nozzles must be kept off the ground.**

Rationale: Dirt adhering to hose nozzles can harbor pathogens.

### **V. FIELD LAYOUT**

#### **BMP 24**

**Design and manage the nursery layout and work flow to ensure no cross contamination occurs (e.g. used, dirty pots are not carried through a clean production area of the nursery).**

Rationale: Soil-borne pathogens can easily be moved from place to place on dirty items and cause contamination of clean areas.

#### **BMP 25**

**Restrict entry to propagation areas. Allow entry to essential personnel only.**

Rationale: Field workers can introduce pathogens into the propagation area on their clothing, boots and tools.

#### **BMP 26**

**Nursery layout should ensure that service trucks (deliveries, portable toilets, will-call) do not travel through the production areas.**

Rationale: Dirt adhering to wheel wells, tires and undercarriage of vehicles can be shed onto roads in production areas and contaminate the nursery.

#### **BMP 27**

**Divert soil and water movement from adjacent properties away from the nursery.**

Rationale: The surrounding environment (forest, grassland, watershed, etc.) can harbor pathogens. Install a berm or a trench to redirect soil and water from adjacent properties.

#### **BMP 28**

**Break up long sections of large groupings of the same plant species (monoculture) with alternate species or physical barriers.**

Rationale: When a pathogen is introduced to a large grouping or expanse of one species of plant, a disease can rapidly spread through the lot from plant to plant. A vertical physical barrier or a two-meter gap between lots may provide protection from the disease spread.

#### **BMP 29**

**When transporting material for disposal, ensure the load is securely contained.**

Rationale: Plants destined for disposal are likely to be diseased and must be safeguarded to prevent the spread of pathogens while in transit through the nursery.

#### **BMP 30**

**Ensure cull piles are located on the lower perimeter of the nursery and runoff from all cull piles is directed away from media components, media mixing area, and growing beds to prevent contamination. When possible, use a metal dumpster for culled plants.**

Rationale: Pathogens from cull piles can infest media and plants growing in the nursery. A dumpster provides containment and protection from spread by wind and rain.

#### **BMP 31**

**Visitor and employee parking lots should be located downhill from and/or away from production beds to prevent water or soil run-off into the nursery.**

Rationale: Soil borne pathogens are known to be transmitted in mud stuck to tires and the undercarriage of vehicles.

## **VI. Sanitation**

#### **BMP 32**

**Remove and dispose of leaf debris from within plant production areas.**

Rationale: Leafy debris can harbor pathogens which can be transmitted to growing plants. Many *Phytophthora* root pathogens are also foliar pathogens (e.g. *P. cactorum*, *P. nicotianae*.)

#### **BMP 33**

**All vehicles entering the nursery (delivery trucks, service trucks, will-call trucks, employees vehicles) should be free of mud and dirt.**

Rationale: Reduce the potential introduction and spread of pathogens within the nursery.

#### **BMP 34**

**Do not sweep out or clean trucks in or near production areas.**

Rationale: All trucks have the potential of carrying debris and soil inside the trailer that can harbor pests. Dirty trucks should be directed to a truck washing station. Ensure the truck is not swept out at your nursery.

#### **BMP 35**

**All visitors and employees must have clean footwear before entering the nursery.**

Rationale: Soil carried on footwear can harbor pathogens and be introduced into the production beds. Utilize signage to educate visitors on sanitation practices employed by the nursery.

#### **BMP 36**

**Boot scrubber stands and footbaths should be placed in critical locations in the nursery (e.g., the entrance to the nursery, the propagation area, greenhouse entrances, etc.)**

Rationale: Soil carried on footwear can harbor pathogens and be introduced in to the production beds. It is necessary to utilize the boot scrubber to remove dirt clods and dust from shoes prior to stepping into the footbath.

#### **BMP 37**

**Carts and vehicles used within the nursery should be cleaned of mud and debris at the end of each day in a designated location that is dedicated for this purpose.**

Rationale: Reduce the spread of pathogens within the nursery.

#### **BMP 38**

**Adequately control weeds on the nursery site.**

Rationale: Maintaining a weed-free production site and surrounding area may eliminate possible reservoirs of pathogens.

#### **BMP 39**

**After every crop rotation, disinfect propagation mist beds, sorting areas, cutting benches and equipment.**

Rationale: In order to reduce potential introduction and minimize the spread of pathogens throughout the nursery, basic sanitation practices should be followed using registered products in accordance with label instructions.

#### **BMP 40**

**All tools and gloves used in the nursery, at landscape installations and at habitat restoration sites must be cleaned between uses at different locations.**

Rationale: Soil carried on tools and gloves can harbor pathogens and be introduced into the production beds, and restoration and managed wildland planting areas.

#### **BMP 41**

**Tools required for nursery practices, such as propagation or potting, need to be restricted to that specific task and not shared. Dedicated tools must be stored in a manner that ensures their cleanliness and prevents usage for other tasks.**

Rationale: Dirty tools can harbor pathogens and cross contamination occurs when tools are shared.

### **VII. Scouting/Inspection**

#### **BMP 42**

**Routinely inspect landscape plants within the growing grounds and the surrounding area for symptoms of disease.**

Rationale: Plants of the same or related species that are growing adjacent to nursery stock can harbor pathogens that could potentially be transmitted to nursery stock. These same plants can be monitored for the presence of disease symptoms and serve as a sentinel plant for early warning of disease presence. If they become infested, remove and dispose of them properly.

#### **BMP 43**

**Conduct a regular (weekly, monthly) scouting program of all nursery stock for the signs of pests and diseases.**

Rationale: Early detection is critical for successful pest and disease management. Nursery protocols regarding the discovery and reporting of symptomatic plants must be established. See BMP 46 for an example of a pest reporting program.

### **VIII. Training**

#### **BMP 44**

**Nursery personnel should attend training sessions to learn the symptoms and signs of pests and diseases, in addition to staying abreast of the most current research and findings.**

Rationale: Training on horticultural practices is available to the public and is regularly provided by UCNFA. Other training is occasionally provided by California Department of Food and Agriculture (CDFA), Pesticide Applicators Professional Assoc. (PAPA), among other professional associations.

#### **BMP 45**

**Display photographs and posters of the disease symptoms caused by soil-borne pathogens in appropriate employee gathering areas. (i.e break areas, lunch and conference rooms, etc.)**

Rationale: Continual exposure to educational materials and photos of plant disease symptoms is instrumental for employee training.

**BMP 46**

**Educate nursery personnel on your pest reporting program.**

Rationale: Nursery protocols regarding the discovery and reporting of symptomatic plants must be established and symptomatic plants must be flagged and left in place. Pest management supervisor must be notified and brought to the flagged location to understand the extent of the spread so the appropriate actions can be taken.

**BMP 47**

**Educate the appropriate employees and managers about the organization's implemented BMPs.**

Rationale: It is essential that all employees are familiar with the best management practices and ensure that they are carried out.

## **IX. Documentation/Record Keeping**

**BMP 48**

**Maintain, for a minimum of two years, accurate shipping documentation identifying products sold, amount, date and receiver for the purpose of tracking plant shipments.**

Rationale: In the event that a pest or pathogen is found by the receiver, documentation will provide the necessary information to track down all other associated plants. (ie. Same lot, same propagative source, etc.)

**BMP 49**

**Maintain records on source of buy-ins, seed source locations and other sources of propagative material such as cuttings or divisions.**

Rationale: In the event a disease or pest is discovered, tracking the origin of the material is essential to address the problem. If the problem is discovered on materials collected from the native environment, further investigations can be carried out to determine the nature of the problem and the area can be avoided for future collections. Records may also be beneficial for potential future collections.

**BMP 50**

**Maintain thorough records in order to track the completion of the various sanitation practices employed at the nursery. (i.e. documentation of when propagation bench is sanitized, scouting schedule, etc)**

Rationale: Records can be used to demonstrate that the practices are being completed as per the requirements of your BMP program and can also be used to improve training programs. The records will provide an opportunity to look back at practices to see what may have gone wrong when plants are not thriving.

**BMP 51**

**Establish a tracking system for movement of plants within the nursery, from propagation (or buy-in) to sales.**

Rationale: this will help to facilitate the delimitation survey if one is required on the production site. Once disease is identified in the nursery, it is critical to clean up any contaminated area.



## **X. Legal Disclaimer**

Although the information in these BMPs is believed to be reliable and accurate, they are provided without warranties of any kind, either expressed or implied. These BMPs seek to identify ways in which the introduction or spread of *Phytophthoras* may be minimized or controlled.

## **XI. Acknowledgements**

If you have questions or comments, please contact:

Kristina Weber, CDFA [Kristina.Weber@cdfa.ca.gov](mailto:Kristina.Weber@cdfa.ca.gov)

Karen Suslow, NORS-DUC Program Manager [KarenSuslow@gmail.com](mailto:KarenSuslow@gmail.com)

Kathy Kosta [katfish@frontiernet.net](mailto:katfish@frontiernet.net)

NORS-DUC and CDFA BMP Manual to reduce the risk of introducing soil-borne plant pathogens into horticultural nurseries and managed wildland landscapes

IMPLEMENTATION DATE

PROCEDURES FOLLOWED


BMP **1**


BMP **2**


BMP **3**


BMP **4**


BMP **5**


BMP **6**


BMP **7**


BMP **8**

**IMPLEMENTATION DATE    PROCEDURES FOLLOWED**

**9**  
BMP


**10**  
BMP


**11**  
BMP


**12**  
BMP


**13**  
BMP


**14**  
BMP


**15**  
BMP


**16**  
BMP


**IMPLEMENTATION DATE      PROCEDURES FOLLOWED**


**BMP 17**


**BMP 18**


**BMP 19**


**BMP 20**


**BMP 21**


**BMP 22**


**BMP 23**


**BMP 24**

IMPLEMENTATION DATE	PROCEDURES FOLLOWED
---------------------	---------------------

<b>25</b> BMP		

<b>26</b> BMP		

<b>27</b> BMP		

<b>28</b> BMP		

<b>29</b> BMP		

<b>30</b> BMP		

<b>31</b> BMP		

<b>32</b> BMP		

<b>33</b> BMP		

<b>34</b> BMP		

IMPLEMENTATION DATE	PROCEDURES FOLLOWED
---------------------	---------------------


**BMP 35**


**BMP 36**


**BMP 37**


**BMP 38**


**BMP 39**


**BMP 40**


**BMP 41**


**BMP 42**

IMPLEMENTATION DATE	PROCEDURES FOLLOWED	
		BMP <b>43</b>
		BMP <b>44</b>
		BMP <b>45</b>
		BMP <b>46</b>
		BMP <b>47</b>
		BMP <b>48</b>
		BMP <b>49</b>
		BMP <b>50</b>

IMPLEMENTATION DATE	PROCEDURES FOLLOWED
---------------------	---------------------


**BMP 51**


**BMP 52**


**BMP 53**


**BMP 54**


**BMP 55**


**BMP 56**


**BMP 57**


**BMP 58**