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PLANT MATERIALS TECHNICAL NOTE

DORMANT HARDWOOD STEM CUTTING PROPAGATION: SELECTION, STORAGE, AND PREPARATION

INTRODUCTION

Cuttings offer a low-cost, quick, and easy technique to propagate plants for horticulture, conservation, and restoration uses. Cutting propagation uses vegetative portions of a plant (e.g. stem, root, leaf) to produce a new independent plant that is a clone of the parent plant (Figure 1). Dormant hardwood stem cuttings are made from mature, dormant stem tissue after the leaves have fallen off. Stem cuttings are classified according to the part of the plant from which they are obtained, the time of year harvested, and the physiological condition of the tissue at the time of cutting (Table 1).

Hardwood cuttings are the preferred type of perennial woody plant cutting because they are inexpensive and easy to grow, store well, are less perishable than actively growing tissue, and can be shipped long distances. This document provides a basic outline of sequential steps in the preparation of dormant, hardwood stem cuttings to be used for adventitious rooting under controlled greenhouse conditions and direct field planting.

Table 1. Stem cutting types commonly used in conservation and horticulture work.

Stem Cutting Type	Description	Species Examples (common names)
Hardwood	Mature, dormant stems of woody species	Dogwood, snowberry, willow (see Table 2)
Semi-hardwood	Partially mature, current season growth cut in spring and early summer	Buffaloberry, serviceberry, ceanothus
Softwood	New, succulent spring growth of woody species	Aspen, chokecherry, caragana
Herbaceous	Stems of non-woody plants	Pussytoes, goldenbanner

Figure 1. Greenhouse propagated hardwood conifer cuttings, photo by T. Dougher, MSU.

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I. SPECIES SELECTION

Species propagated by dormant hardwood cuttings are selected for their ease-of-rooting, the desired use, and the planting location. Deciduous and evergreen species can be propagated from cuttings, but the techniques may differ by species (Table 2). When selecting species for conservation or restoration uses make sure they are suited to the site conditions (i.e. moisture, climate, soils).

II. TIMING OF COLLECTION

In northern temperate climates, dormant, hardwood cuttings are taken from stems after leaves have fallen off and before bud expansion in the spring, usually in the late fall to late winter (January and early February). Cuttings taken in late winter or early spring when buds are fully vernalized and are ready to grow often result in reduced adventitious rooting success. If source plants are leafed-out when harvested, the establishment success is reduced by 50 to 60%.

Do not use cuttings with:

- Swollen buds
- Expanding buds
- Bud scale separation

III. PARENT OR DONOR PLANT SELECTION

The propagating source (donor or parent plants) material for hardwood cuttings should be taken from healthy, vigorous stock plants. Avoid coarse wood, stems with long internodes, discolored wood, weak interior shoots, yellow or dark cambium, wrinkled or withered bark, or splintered wood. Make sure cuttings are alive by scraping off the bark layer to expose the green cambium below.

Figure 2. Silver buffaloberry cuttings from central parts of parent plant stem with tips removed, photo by NRCS.

Ideal source material should be:

- Wood of the previous season's growth since adventitious root formation declines with the age of parent stock.
- Free of viruses, bacteria, fungi, serious insect damage, and other pathogenic organisms.
- Central and basal stem parts (Discard stem tips that are low in stored energy; Figure 2).

IV. COLLECTION

The dormant cutting size will determine the appropriate tool for harvesting. Ensure the tool is sharp for clean cuts and sterilized to reduce the spread of disease. Tools may include a:

- Lopping or pruning shears
- Small saw
- Brush cutter
- Chainsaw

When cutting stock:

- Do not harvest more than one-third of an individual source plant or 40% of a rhizomatous woody species (e.g. streambank willow).

- Spread harvesting activity throughout the stand.
- Select branches that will not affect the health or appearance of the parent plant; for example, select cuttings from inside the crown instead of visible exterior branches.
- Mark the terminal and basal ends for planting orientation by making the lower cut at a 45-degree angle and the top a right angle or dip the top 1 to 2 inches of a cutting into a grafting glue which may also reduce transpiration.
- Tie cuttings in convenient-sized bundles of approximately the same length, placing the tops in one direction, and label the bundle by species and count.

The size and handling of cutting stock can vary somewhat based on whether it will be used in a greenhouse or field application, species, storage options, and other factors. Hardwood cuttings used in greenhouse production often vary considerably in length and diameter depending on the species. Long cuttings may be taken in the field, stored under refrigeration, and trimmed later just prior to striking. Deciduous hardwood cuttings are typically 4 to 30 inches long while evergreen cuttings are 4 to 8 inches in length. Dormant hardwood stock used in greenhouse propagation is sometimes trimmed at the propagation facility for more efficient cold storage.

Cutting length of woody riparian species (e.g. willow, cottonwood, dogwood) for direct field planting and bioengineering treatments, is determined by conditions at the planting site including the depth to the mid-summer water table, the erosive force of stream, periods of inundation, and competitive herbaceous vegetation. The cutting should be long enough for 6 to 8 inches to be in the mid-summer water table while two to three buds are above ground. The cutting should extend 6 to 12 inches above the highwater level and herbaceous growth. A cuttings diameter of 1 to 3 inches has been found to have the highest survival rate for riparian species. In general, the smaller the cutting diameter, the longer the cutting.

V. TRANSPORT AND STORAGE

Cutting material needs to remain moist, not excessively wet, and protected from wind to prevent desiccation. Temperatures in the dormant cutting and planting seasons should be cool enough (45°F) to transport cuttings inside a vehicle, a covered truck bed, or a trailer for a relatively short transport period. During transport:

- Minimize transport time as much as possible.
- Wrap the cuttings in heavy paper, damp burlap, heavy-duty plastic bags, or place in a cooler (Figure 3).
- Add moistened peat moss, shredded newspaper, or wood shavings to the packaging.
- Mist plants prior to transport.
- Prevent cuttings from warming inside a vehicle and do not place them in direct sun.

Figure 3. Keep cuttings wrapped, moist, and out of direct sun when transporting, photo by NRCS.

Ideal storage is in a controlled environment with temperature at 33 to 40°F and relative humidity at 80 to 95 percent. Cutting viability and planting success are dependent on maintaining these ideal temperatures and humidity. Under the ideal temperatures and humidity, cuttings can be stored for 3 to 4 months. A refrigerator or walk-in cooler provides ideal storage environment but an unheated, dark, storage shed, garage, or cellar may also work well for storage.

During storage:

- Do not allow cuttings to freeze.
- Minimize storage time prior to use.
- Place cuttings in a large plastic bag.
- Place long cuttings in a bucket and covering them with a plastic bag to maintain humidity.
- Examine frequently for mold, drying, and leaf development.
- Apply fungicide as needed to prevent damage.
- If buds begin to swell or develop, lower storage temperatures or plant the cuttings.

VI. CUTTING PREPARATION

Dormant hardwood cuttings to be used in greenhouse propagation must be trimmed after removal from refrigeration. Begin by removing all side (lateral) branches so the cutting is a single stem (Figures 4 and 5). Then remove branch ends (apical buds plus several inches) and trim cuttings to size or make into multiple cuttings. In general, cuttings should be sufficiently long to host two to three buds above ground when struck and enough material below ground for rooting and plant support. Greenhouse cuttings should be ¼ to 1-inch diameter, especially at the basal end to be inserted into the propagation media (Figure 4). Re-cut the basal end of the cutting at a 45-degree angle using a sharp grafting knife in order to optimize the smoothness of the surface and water uptake. Avoid using crushing type pruning shears that create a rough, irregular basal surface that can harbor disease. Include at least two nodes in the cutting with the basal end cut approximately ½ to 1 inch below a node. Placing a sharp grafting knife tangential to the cutting surface, pulling the knife downward in a slicing motion in order to remove a thin layer of bark and expose the green cambium layer (Figure 5f). This is called “wounding” the cutting, and this technique has been shown to enhance adventitious rooting in many species. The resultant wound is typically ¾ to 1 inch long and approximately ⅛to ¼ inch wide.

Prior to treating trimmed cuttings with rooting hormone, they may be stored for short periods of time on the propagation bench or in a flat if wrapped in moist paper towels. Prior to applying powdered hormones, lightly mist the base of each cutting with water, shake off excess moisture, dip in rooting hormone, and tap the base of cutting on a hard surface (such as the edge of a beaker), to remove excess powder.

Figure 4. Deciduous hardwood cuttings approximately 10 inches long and ¼ to 1-inch diameter inserted into a peat and perlite media on a greenhouse propagation bench, photo by NRCS.

Table 2. Species commonly propagated from hardwood dormant cuttings.

Common Name	Scientific Name	Origin[1]	Use[2]	Cutting Time	Rooting Ease	Growth Stage	Growth Medium	Growth Hormone[3]
Arborvitae	*Thuja* spp.	I	H	Winter	Moderately easy	2 year wood	Well drained soil	0.3% to 0.9% IBA
Aspen	*Populus tremuloides*	N	C, H	Early spring	Difficult	1 year wood	Moist well drained soil	0.30% IBA
Burning bush	*Euonymus alatus*	I	H	Late winter	Moderate to difficult	1 year wood	Moist well drained soil	0.2% IBA
Cottonwood	*Populus* spp.	N	C, H	Early spring	Easy	1 and 2 year wood	Moist well drained soil	-
Dogwood	*Cornus sericea*	N	C, H	Late fall, early winter, spring	Easy to moderate	1 year wood	Moist soil	-
Elderberry	*Sambucus racemosa*	N	C	Mid to late winter	Easy	1 year wood	Moist well drained soil	-
Forsythia	*Forsythia suspensa*	I	H	Fall to late winter	Easy	1 year wood	Moist well drained soil	-
Mtn. mahogany	*Cercocarpus ledifolius*	N	C, H	Fall to late winter	Moderate to difficult	1 year wood	Sand	1.6% IBA
Ninebark	*Physocarpus capitatus, P. opulifolius Physocarpus* spp.	N, I	C, H	Mid to late winter	Easy	1 year wood	Moist well drained soil	-
Rocky Mtn juniper	*Juniperus scopulorum*	N	C, H	Early dormancy	Moderately difficult	3 - 5 year tip wood	Perlite, sand, vermiculite	1.6% IBA
Snowberry	*Symphoricarpos albus*	N	C	Mid-winter	Easy	1 year wood	Vermiculite	0.10% to 0.30% IBA
Spirea	*Spiraea douglasii, S. splendens, Spiraea* spp.	N, I	C, H	Winter	Moderately easy	1 year wood	Moist well drained soil	0.5% IBA
Viburnum	*Viburnum* spp.	I	H	Spring, fall or winter	Easy	New or 1 year wood	Moist well drained soil	-
Willow	*Salix* spp.	N	C	Fall to early spring	Easy	1 and 2 year wood	Moist soil, water edge	-
Woods' rose	*Rosa woodsii*	N	C	Late winter	Moderately difficult	2 year wood	Perlite	-

[1]N= Native, I = Introduced; [2]C = Conservation or Restoration, H = Horticulture; [3]IBA = indole-3-qbutyric acid

VII. GREENHOUSE and FIELD PROPAGATION

Greenhouse propagation of dormant cuttings provides a controlled environment to produce plants. Greenhouse equipment can be used to optimize the environment and soil media for plant establishment, and physically or chemically prepare cuttings before planting. Field propagation is the direct planting of dormant cuttings into the ground prior to root formation and bud break. While environmental factors cannot be controlled, the conditions for planting can be selected to improve establishment success (Table 3 and Figure 5).

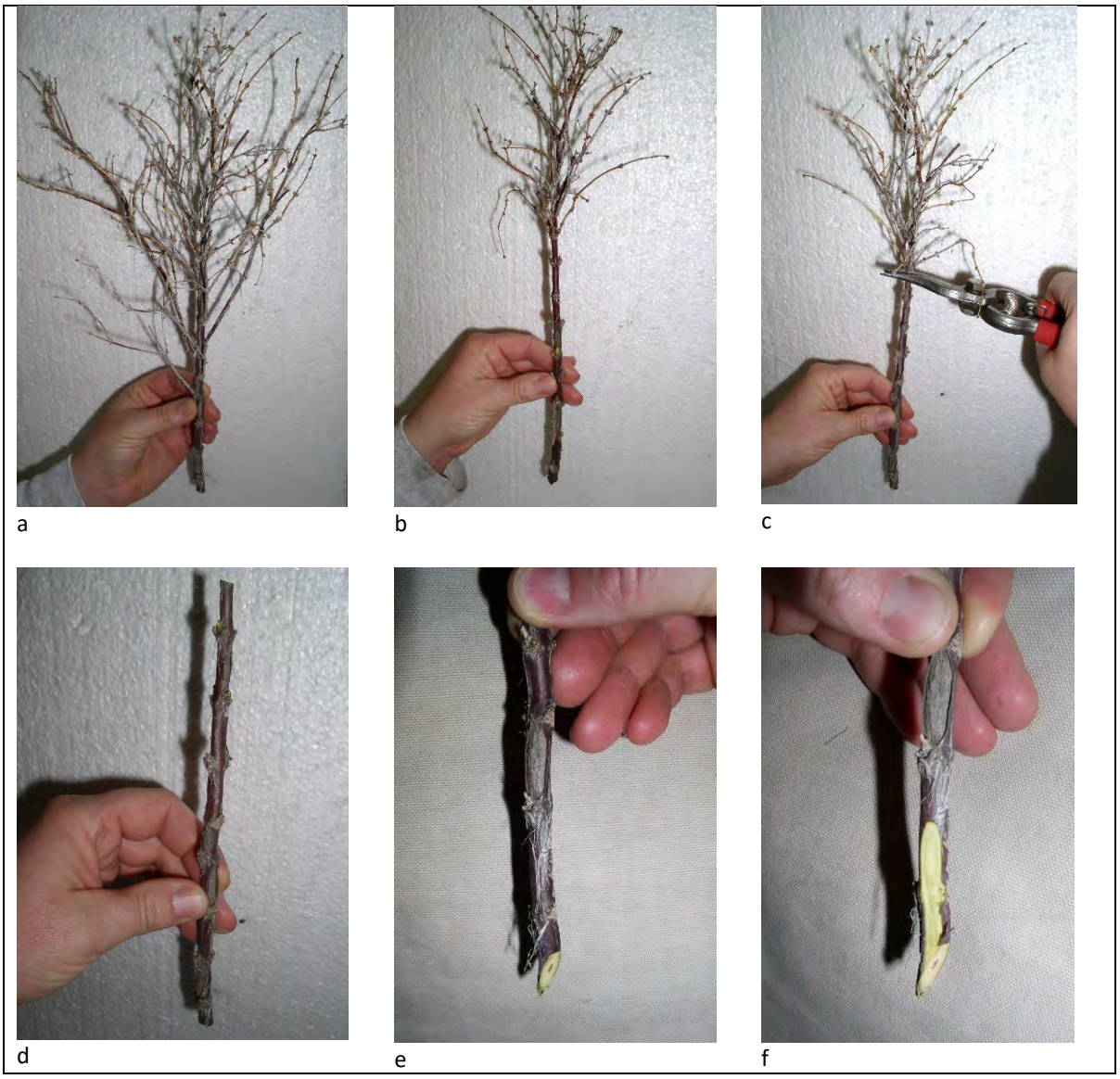

Figure 5. Steps for preparing a dormant hardwood cutting for greenhouse propagation. Take long cuttings in the field (a), remove all side branches (b), and remove branch ends and trim cuttings to size (c). Cutting should have two to three buds above ground (d), cut basal end at a 45-degree angle (e), and wound cuttings with a 1 to 1.5-inch shallow cut along stem (f).

Table 3. Sequential description of propagation activities for greenhouse and field propagation from dormant hardwood cuttings.

	Greenhouse Propagation	Field Propagation
Timing	Getting hardwood cuttings to produce roots is a balancing act between proper heat to spur rooting while maintaining cooler shoot temperatures to hold off bud break. Root zone heating can be accomplished with heating mats, hot pipes, or dark color provided the soil can be heated with sunshine. Cuttings can be propagated at any time in tightly controlled greenhouses. Cold frame, Quonset hut, or hot bed relies on natural temperature cycles and propagation should occur in the spring.	Plant dormant cutting stock prior to spring runoff. Avoid freezing temperatures.
Handling	Only remove cutting material from cold storage as will be needed that day. Check stored cutting for health and size.	Remove only enough plant material from cold storage for the planting period and minimize transport time.
Preparing	Deciduous – Remove lower lateral branches, recut at an angle with a sharp grafting knife or bypass pruners. Wound cuttings with a 1 to 1.5-inch, shallow, tangential cut along the stem at the basal end of the cutting. Evergreens (particularly conifers) – new growth is typically short on conifers, so second year's growth is included giving the cutting an extra 'mallet' shape. Remove the lower 'needles' to keep the foliage out of the rooting media. Wound cutting, drawing the point of a knife along base of the current season's growth.	Always keep cuttings covered with a moist substrate until they are placed in the ground. Avoid over-heating during transport and planting especially for cuttings wrapped in plastic. The planting site should be prepared and all equipment in-place well before cutting delivery. Carefully open bundles, and then cautiously remove individual cuttings to avoid damage. Cuttings should be fully dormant with little to no evidence of bud scale separation or green, actively growing tissue.
Chemical Treatment	Most cuttings require the addition of a liquid or powder rooting hormone called auxin. Auxin comes in several forms labelled as KIBA, IBA (most common), and NAA. For easier-to-root species (willows, poplars, fast-growing species), 1,000 to 3,000 ppm will enhance the vigor of rooting. For harder-to-root species (conifers, maples, oaks, slower growing species) 3,000 to 10,000 ppm may be required. To apply, lightly mist the cutting base with water, shake off excess water, and dip in the preferred rooting hormone. If using powder, tap off excess hormone.	Pre-treat stored unrooted cuttings prior to planting by soaking the base or entire cutting in water for 24 to 48 hours. A willow extract made from soaking short willow shoots in water for 24 hours and soaking cuttings in the extract for 24 hours has benefited the rooting of dogwood cuttings. Field cuttings may need to be treated with auxin as with greenhouse cuttings.

	Greenhouse Propagation	Field Propagation
Rooting Media	The key to a good rooting media is the balance between holding moisture and good aeration. Hardwood cuttings require moisture to establish but also need oxygen to form the roots. The needed ratio between moisture holding and aeration depends on species (Table 4).	Plant dormant cuttings when good soil moisture conditions exist. Avoid frozen or excessively dry soil conditions.
Planting	Strike cuttings basal end down, into a pilot hole so that about 2 to 3 inches of the base of the cutting is buried. Firm propagation media around cutting base to ensure good media to cutting contact. One to three buds should remain above the media. Pot size depends on species, cutting size, and greenhouse structure utilized. Air-pruning pots and smaller pots are acceptable, so long as they allow for 2 to 6 inches of the cutting to be buried. Tall skinny or air-pruning pots are generally more desirable for transporting and transplanting to keep the media intact, but if you are utilizing a cold frame or hot bed, a propagation bed is more appropriate though plants must be kept moist once removed from the planting bed (Figures 4 and 6).  **Figure 6.** Hardwood cuttings in propagation trays and 10 cubic inch cone-tainers, photo by NRCS.	Plant in permanently moist zones along streams and wetlands at the water line, on the bank, and on dry upper banks if they can reach the summer water table. Cuttings planted up to 6 feet deep to ground water have been successful for willows and cottonwood. At least 75% of the dormant cutting must be placed below ground to provide adequate opportunity for rooting. Aim for 6 to 8 inches of the cutting to be planted in the mid-summer water table with 3 to 4 buds remaining above the ground. If long periods (> 30 days) of inundation are likely, the cuttings should extend 6 to 12 inches above the expected high-water level. When planting for bank stabilization, cuttings should extend 2 to 3 feet above ground for immediate bank erosion protection. Plant cuttings with the top end up and pointing downstream at 45 to 60-degree angles to the soil surface. Along streams, plant cuttings in rows perpendicular to the stream channel. It is recommended that holes be made for the cuttings with a probe to avoid damaging the buds when the cuttings are inserted into the ground. Always firm each cutting solidly around hole.

	Greenhouse Propagation	Field Propagation
Environmental Conditions	Root zone temperatures should be maintained at 70 to 85°F depending on species while shoot zone should be kept around 45 to 55°F. Lighting is not necessary since there are no leaves. Keep at low levels by shading or utilizing fluorescent or LED lighting if plants are illuminated. Rooting media should be kept moist, not damp or wet. Hand watering hardwood cuttings is adequate to maintain moist soil. Water every few days when media dries. If atmospheric humidity is very dry or a highly aerated rooting media is used, then cuttings and media should be misted regularly throughout the day.	Direct planting is best on cool, cloudy, humid days with little or no wind. Do not handle stock at below freezing temperatures.

TABLE 4. Rooting media type and properties.

Rooting Media	Rooting Properties	Species commonly adapted to Media
Sand	Fast drainage, good aeration, easily removed from cuttings	Willows, poplars, some conifers, mountain mahogany
Peat	High moisture holding capacity, moderate aeration	blueberry
Perlite	Highly aerated, low moisture holding capacity, easily removed from cuttings	Maples for epicormic bud cutting formation
Peat and Perlite Mix	High moisture holding capacity, good aeration, most commonly used in cuttings	Junipers, many deciduous species

VIII. RECORD KEEPING

Keeping detailed records is essential for learning from dormant hardwood cutting successes and failures. Record keeping can also be used to schedule cuttings, facilities, planting dates, labor needs, production costs, and more.

Written, digital, or photographic records may include the:

- Species, condition, and source of cutting materials
- Type of cutting used (i.e. hardwood), cutting date, and cutting size
- Environmental conditions at time of cutting
- Storage duration, temperatures, and humidity
- Cutting treatments (wounding, stripping), growth hormones, rooting medium, and environmental requirements (bottom heating, temperatures, mists, light) used in a greenhouse
- Percent rooted, number of days to rooting or leaf-out, and percent survival

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