Materials Plant Program

TECHNICAL NOTES

US DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE
PORTLAND, OR
NOVEMBER 1999

PLANT MATERIALS NO. 24

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Producing Pacific Northwest Native Trees and Shrubs in Hardwood Cutting Blocks or Stooling Beds

Introduction:

There is increasing interest in the establishment and use of cutting blocks to produce unrooted, hardwood (dormant) cuttings of easy-to-root woody plants for direct insertion along stream banks and in wetlands. Other names include stooling beds or coppice beds. This high yielding method consists of closely planting individual species in groups or rows and repeatedly cutting new, vigorous shoots from live stumps or lower stems. While there may be a sufficient supply of certain native willows from nearby natural stands, other species of importance are often less readily available in the wild. Therefore, one of the better ways to address this shortage is for nursery growers, public agencies or individuals to establish and grow mother plants as cutting blocks or manage "borrow areas" as a source of hardwood cuttings, whips, poles, posts, or live stakes.

The purpose of this Technical Note is to offer general guidelines and present some considerations to those wishing to produce trees and shrubs from hardwood cutting blocks. Fast growing species such as willows and cottonwood may take only to 2-3 years to produce significant numbers of harvestable cuttings, depending on length of growing season, intensity of management and other factors. Slower growing shrubs may take 3-4 growing seasons to become highly productive. The use of these open-ground, stock plant beds is common practice in the nursery trade, particularly for further multiplication of true-to-name clonal material in mist benches, containers and rooting beds. In a similar or less intensive fashion, it is also possible to produce native species of known origin for ecosystem restoration and rehabilitation plantings, erosion control along streams and shorelines, and soil and water bioengineering practices.

Economic and Management Considerations:

These considerations are complex and beyond the scope of this outline. For example, if the material is to be grown for profit, one must consider the typical risks of a wholesale grower or similar business. The individual, farmer or landowner must have the right resources and be financially prepared. They should possess skills or be knowledgeable in basic woody plant science and propagation, business economics and management, as well as environmental, labor, health, land use, and related legal issues or practices. Markets for native plants have continued to expand as of late, but risks may be higher than for more traditional nursery commodities with a more predictable and well-established customer base.

Select Management Options:

Low, medium or high input systems are all options. Lower input systems may consist of greater randomization of species and spacing for a more natural appearance, little or no pest management with chemicals, less fertilization or use of other soil amendments, and no supplemental irrigation. Lower input systems cost less and take less time and skill to manage, but will produce less and yield lower quality material. Such an option may be more suitable as a secondary use of enhanced wetlands and revegetated riparian zones as "borrow areas" where minor, select extraction of material might be permitted if it doesn't negatively impact the site's primary functions. Inorganic versus organic inputs may be considered for nutrient, soil quality, or plant pest management. Potential runoff, surface and ground water contamination, and negative fish, wildlife and other environmental impacts must all be carefully accounted for and minimized. Permits for earth moving, collecting, planting and/or cutting in sensitive areas may be required.

Equipment and Facilities:

Although the minimal requirements may appear to be hand pruners, loppers, labels, saws, twine and tarps or plastic, it is unlikely any significant quantity of material can be produced, stored, hauled and shipped at reasonable cost without greater mechanization. Some probable needs include: 4x4 tractor(s), 4x4 ATV, brush cutter, chain saw, hand saws, circular, radial arm, band or table saw, weed eater, mower(s), sprayer(s), refrigeration unit such as an 8x10 or larger walk-in cooler, trailer(s), sheltered work, storage and handling area(s), tiller(s), and 4X4 truck or pickup. A large cooler is particularly useful for holding material in a dormant state until it is shipped or planted. Stationary power saws can be used to efficiently cut and size raw material into equal length cuttings, stakes, poles or whips.

Site Selection, Planning and Layout:

The actual land or site required for establishing and maintaining cutting blocks depends on many factors. However, the number and kind of species chosen, their soil and moisture requirements or tolerances and growth habit, the type of mechanization used, and the potential yield and market are among the most important considerations. While low lying wetlands and floodplains appear to be attractive locations for deciduous water-loving trees and shrubs, winter floods and mud may restrict or prohibit timely mechanical harvest and management when the plants are

dormant. Low areas may also be natural frost pockets in certain situations. Soil is easily compacted by heavy farm equipment when wet, but ATV's with wide tires can reduce the problem. Upland sites have the advantage of better year round accessibility and easier soil quality and moisture management. Water can be applied when desired and winter access is not as limited by site hydrology.

Random or haphazard layout of beds may provide the most natural appearance but is not suitable for most mechanization. At a minimum, permanent grass or mulched footpaths should be maintained between blocks or rows for access and the same species/source planted in small groups or clumps. Straight, uniform hedgerow formations are usually the most efficient for maintenance and harvesting. Rows are usually orientated north south for maximum utilization of sunlight by the plants. On wetter sites, it may be useful to plant along the contour of the slope so that upper rows can still be harvested as soil moisture and standing water fluctuates. Harvest can proceed down slope over time as water levels recede and soils drain. If the site allows, plants can also be grouped by similar management, soil or growth requirements or growth habits. Leave enough space between different clones/sources of the same species within the same row to easily tell them apart. Other considerations affecting layout include aesthetics, adjacent land uses, neighbors, hydrology and runoff, proximity of farm buildings and roads, and future room for expansion.

Selection of Species and Genetic Stock:

Pacific Northwest native tree and shrub species with the greatest potential for hardwood cutting blocks are listed and described in table 1. Willows and certain poplars are by far the easiest and most productive species for this type of increase and propagation, but other species should be considered where plant and wildlife diversity, aesthetics, and special needs are project goals. Certain non-native (exotic) or hybrid species could also be utilized, but their end use is primarily urban, pulpwood (hybrid cottonwood plantations), ornamental, or farmstead windbreak plantings. Urban or homeowner use may warrant the use of male poplar and willow clones because of the undesirable cotton (seed) shed in the spring by female clones. Species selection will largely depend on market demand, applicability to end uses, and adaptation to the cutting block site.

Besides what species to plant, the issue arises of what and how many clones or genetic sources within a species should be selected for the cutting blocks. Genetic diversity between clones and between and within populations, and their "source" or natural "origin", are important concepts for ecological restoration plantings, but not well defined or understood for most native woody species other than the major timber trees. Guidelines or restrictions for seed (and clone) transfer between locations or "zones" of different climate, soils or elevation are often "best guesses" based on personal observations, the species natural range, plant community surveys, or taxonomic differences below the level of species. Until more information is available, Major Land Resource Areas, Ecoregions, ecological or floristic provinces or "Seed Zones" are all useful in making determinations of where to obtain and where to plant native species. Even when area of adaptation for specific cultivars, clones or species are known, good goals are still to: (1) try and obtain seed or cuttings for cutting block establishment from wild specimens within each region for outplanting by customers within the same region and within the species natural

range, and (2) try and incorporate genetic diversity within each block of the same species for the same zone. For broadleaf riparian and adjacent upland species, the Oregon Department of Forestry (Kendall 1996) also suggests the use of 1000 foot elevation bands from 0-3000 feet and 500 foot bands above that.

Site Preparation and Planting:

For the best establishment, cutting blocks or stooling beds require site preparation and planting techniques similar to other managed landscape situations. Soil testing for macro and micronutrient and pH status, preplant incorporation of organic matter (peat is weed free, manure is not) or fertilizer, and deep cultivation to break up soil or plow pans are recommended. Gentle grading to create raised and lowered beds or paths might be an option to create microenvironments of better or poorer drained areas for access or planting, depending on the species and drainage needs. These same methods may not be applicable to wetter sites or revegetation plantings. Topsoil should be of good depth. It may be necessary to fallow the site mechanically or with chemicals for one year or more to control weedy species and reduce the number of weed seeds in the soil bank. Planting is best in the fall or winter if the soils are not frozen. Cuttings can be rooted in containers first then transplanted, or stuck directly into the bed, or seedlings can be planted. Regular irrigation will be needed during the establishment year.

Plant and Row Spacing:

Suggested spacing between plants within a row, block or clump is listed by species in Table 1. If production is needed in 1-2 years rather than 2-4, the spacing should be cut in half. Then after 3-5 years, it may be useful to thin out every other plant, especially dead, diseased or weaker ones.

For poplars and willows, some growers have used the "Miller Bow Technique" (Harrington, McGrath and Kraft 1999, Miller personal communication) named after Rob Miller of Jefferson Farms in Salem, OR. It uses a spacing of 5-9 ft within row, which is wider than traditional stool beds. The method consists of first sawing a notch through the cambium and part way into the wood on one side of the trunk, 6-12 inches above the base when it is 3-4 inches thick. The trunk and branches are bent over (not snapped) so they rest horizontally on the adjacent stump like a railing. This process is continued down the row in a linear fashion. Uniform, vigorous, new sprouts proliferate along these trunks and from the notched root collar which can then be mechanically cut when they reach appropriate size and length.

Instead of single row beds, another good method is to plant a double row within the beds using the suggested spacing for within and between rows. Use a staggered arrangement for plants in adjacent rows.

Beds should have an alley between them for maintenance and harvesting access. The alley should be wide enough to mow with equipment and drive up and down with a small tractor or ATV with a trailer for picking up and hauling branches to a processing site. Alleys between beds can be seeded to grass for ground cover, weed control, access and trafficability. Appropriate grasses on uplands may include hard fescue, chewings fescue, sheep fescue (east of Cascade Mountains) or native fine fescues such as Roemer's or Idaho fescues.

Irrigation/Soil Moisture Management:

Trickle irrigation on automatic timers is desirable for new and established cutting blocks, especially for drier soils and upland sites. Soaker hoses or flood irrigation may work in some situations. Irrigation water should be tailored to the species being grown. Soil moisture measuring devices such as gypsum moisture blocks, tensiometers or other meters can assist in scheduling and conserving water.

Weed Management:

Weed barrier cloth can work well for non-rhizomatous woody species. Some are impregnated with herbicides. A 2-4 inches thick layer of bark mulch conserves moisture and reduces weed competition, regardless of growth habit. Herbicides cleared for weed control in trees and shrubs may be useful in less sensitive areas, but the label and all applicable laws must be followed. Mowers and weed eaters provide mechanical suppression. Tillage is usually not done after establishment. Consult the local county Extension Agent, pesticide consultant, chemical dealer, or PNW Weed Control Handbook.

Insect and Disease Management:

A monitoring program for insects and diseases is the first step in good pest management, even for low input systems. If pests are a problem, some type of integrated pest management (IPM) or integrated plant protection (IPP) program that combines chemical, biological and mechanical control is usually recommended. It is also wise to practice good sanitation, such as periodic sterilization of cutting tools, removal of dead or infected limbs, and disposal of leaf litter which can harbor over-wintering insects and diseases or their inoculum.

For willows, among the most common insect pests are scales, willow/poplar borers, aphids and tent caterpillars. Scales can be controlled with dormant oil spray. Willow/poplar borers must be controlled as adult beetles. Borers (the larvae) seldom kill the entire plant or live stump, but will reduce production. Removal of infested branches or stumps may be needed. Caterpillars may be controlled with BT, a biological control agent (bacteria) specific to Lepedoptera (the butterfly family). In terms of diseases, scab and black canker of willow are common and sometimes serious pests. Symptoms for both are similar, including rapid blighting or “firing” of new shoots and young leaves. Both infections may occur simultaneously (Sinclair, Lyon and Johnson 1987). The susceptibility among willow species and even clones of the same willow can vary widely. Leaf rusts and other cankers are common also.

Other trees and shrubs will have their own set of insect and disease problems. Consult the local county Extension Agent, chemical dealer, PNW Insect Control Handbook or PNW Plant Disease Control Handbook for control methods.

Wildlife Control:

Fencing (8 feet tall or higher) for exclusion of deer may be needed. Newer, longer lasting, foliar applied repellents are on the market. Other techniques to reduce deer predation may include seeding a small area to legumes or other "favorite" food plant to attract deer away from cutting beds. Monitor for signs of voles and mice. If stem girdling is excessive, control or protection may be necessary. Small rodent control may require mowing between rows, weed/vegetation management to reduce hiding cover, installing protective sheathing around the base of the stems, and possibly baiting. Several useful publications are listed in the reference section.

Fertility Management:

High input systems usually involve a fertilization program, beginning with possible lime application to raise soil pH, and a starter fertilizer based on recent soil tests. Starter fertilizers are often low in nitrogen (N) but high in phosphorous (P) and potassium (K) or "balanced," such as 16-16-16 (N-P_20_5-K_20). Sulfur, potassium, and micronutrients may be needed if foliar signs and symptoms of nutrient deficiency develop and/or if soil tests or foliar analysis indicate a deficiency. The use of organic fertilizers is a good option, as are foliar nutrient applications (foliar feeding).

Recent research at Oregon State University appears to indicate that for deciduous woody perennials, early spring soil applications of N provide little benefit and should be delayed until May. Furthermore, foliar applications of N as urea in September apparently are beneficial to the plant and, unlike fall soil applications, do not delay dormancy nor increase the risk of damage from an early frost. Both methods have the added benefit of reducing the potential for water quality degradation from fertilizer runoff that can occur with abundant, early winter or early spring rains.

Harvest and Handling Techniques:

Harvest methods vary from using simple hand tools to the use of custom fabricated or special modified machinery. Manual methods include the use of hand pruners, pruning shears, pruning saws, loppers, and lopping shears. Mechanized techniques utilize brush cutters, power pruners, or hydraulic harvesters that are PTO driven and side-mounted on a tractor or pulled over or along side the cutting blocks. In the last method, branches and whips are severed with a rotating blade or other cutting device. In some cases, the material may also be transported by belts to a person who catches it and places it in large boxes (Morgenson 1992).

Harvesting for hardwood material can take place anytime the plants are winter dormant, usually after natural defoliation in late October until bud swell begins in early spring (Feb, March or early April depending on the climate). Cutting is usually done anywhere from 6-12 inches above the ground, depending on the species and the age of the stumps. Once the raw branches or shoots are cut, they are collected and transported back to an unheated processing area with high humidity. For production of uniform cuttings and live stakes, side branches are pruned off and small groups cut to length by a band saw or other stationary saw. It is important that all cutting tools be sterilized before and during use to prevent the spread of diseases. In dry environments, it

may be necessary to keep the material covered or wrapped before and during processing to prevent desiccation. For live stakes, the top ends are usually cut flat (90 degree angle) while the basal end is cut at an angle (45 degrees or less) for easier insertion. Finally, the material is organized into bundles and tied by a machine or manually bound with twine, string or even large rubber bands, then labeled with color codes of paint or tagged.

Before being placed in cold storage, some growers dip the bundle in fungicide mixes to control diseases. Others dip the distal (top or upper) ends with non-toxic latex paint or paraffin wax to identify which end is up for planting and reduce transpiration losses. Storage should be in a cool, moist place or refrigeration unit. Temperatures of 24-28 degrees F are sometimes used to minimize fungal growth and bud break, but temperatures from 34-40 degrees F are often adequate for short term storage (1-8 weeks). It may be necessary to wrap the bundles in plastic or surround them with slightly moist (not wet) wood shavings, sphagnum moss, or other media to prevent dehydration in storage or shipping. For some species, storage in moist media can stimulate callus formation or even root development if left for long periods. This may or may not be desirable. Chances increase the higher the moisture content of the media and the warmer the storage conditions.

Depending on the species, growth rate of the sprouts, and caliper of material required, shoots can be cut annually or at 2-4 year intervals. Some species do not root as well from cuttings of wood older than 1-2 years, necessitating frequent crown removal to force sprouting of vigorous new shoots. Young, even aged material is usually the most desirable. If row spacing permits, rotation lengths can be longer if larger poles or even post size material is needed. Separate beds or sections can be managed as uneven aged stands to supply stock in a wide range of diameters. Most cutting blocks will remain highly productive for many years, but short-lived, disease prone willows and poplars can decline in growth rate after 10-15 years and may need to be replaced, or the beds rotated.

Alternate uses:

Cutting blocks can be arranged and managed for aesthetic and landscape purposes, such as screens, borders, and hedges. Because some of the same species listed in table 1. root from softwood or hardwood cuttings, the beds could provide a source of this and other vegetative material as well (refer to table 1.). Raw, unprocessed branches, canes, and whips can be bound immediately as wattles (fascines) or transported directly to stream bank and shoreline stabilization projects for use in soil bioengineering practices such as brush mattressing, brush layering and branch packing. By coppicing, larger pole and post size material can provide a source of firewood. Finally, select harvesting of low input systems may be a secondary use of revegetation or restoration projects that provide wildlife habitat and other environmental benefits.

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Table 1. Select PNW Native Trees and Shrubs with Potential for Hardwood Cutting Blocks

Species name/ Common name	Spacing Within Rows	Commercial availability as cuttings	Mature height X width	Rooting ability of hardwood cuttings	Growth rate of sprouts	Other methods of vegetative propagation	Risk of establishment by cuttings	Remarks
Baccharis pilularis Coyote brush	1-2	Rare	6 x 4	Fair to good	Moderate	Root cuttings	3	Evergreen, dioecious shrub. PNW range restricted to coastal Oregon, but more common in California.
Cornus sericea Redosier dogwood	2-4	Common	16 x 10	Good	Fast	Layering, softwood cuttings	3	Consistent rooting under favorable moisture. Stores well under refrigeration for several months.
Lonicera involucrata Black twinberry	2-3	Rare	10 x 6	Good	Moderate to fast	Layering, semi-hardwood and softwood cuttings	3	Cuttings require consistent good moisture first growing season. Roots in saturated soils.
Oemleria cerasiformis Indian plum	2-4	Rare	16 x 10	Poor to good	Moderate	Layering, root cuttings	5	Variable results from hardwood cuttings. Use vigorous 1-yr old wood and take cuttings early in winter prior to bud swell for best results.
Pachistima myrsinites Oregon boxwood	2	Rare	3 x 3	Good	?	Layering	?	Small evergreen shrub. Good rooting results from cuttings taken in the early fall. Rooting hormone may help.
Physocarpus capitatus Pacific ninebark	2-4	Rare	14 x 8	Good to very good	Moderate to fast	Softwood cuttings	2	Common in wetlands. Good soil binding traits. Cuttings root very easily from young or old wood without any special treatment.
Physocarpus malvaceus Mallow ninebark	2-3	Rare	8 x >>	Fair to good	Moderate	Softwood and root cuttings, rhizomes	?	Thicket forming from rhizomes. Mostly east side of Cascade Mountains.
Philadelphus lewisii Lewis mock orange	2-3	Rare	10 x 8	Fair	Moderate	Rooted suckers, softwood cuttings	5	Adventitious roots from cuttings are weak and may not penetrate compacted, clay soils. Hormonal treatment of hard and softwood cuttings may help.
Populus trichocarpa Black cottonwood	3-9*	Very common	150 x 30	Fair to very good	Very fast	Layering	3	May not establish well in saturated soil conditions. Variable results from cuttings. Best from 1-2 yr old wood.
Ribes sanguineum Red-flowering currant	2-3	Rare	8 x 6	Poor to Fair (+)	Slow to moderate	Softwood cuttings w/ heel, layering	5	Hardwood cuttings are slow to root but hormonal treatments can help. Species is susceptible to root rot, so provide good drainage and don't overwater.
Rosa gymnocarpa Baldhip rose	2	Rare	6 x 6	Poor to Fair (-)	Moderate	Semi-hardwood cuttings, softwood cuttings	5	Straight, dense thorns on stems require handling with thick gloves. Found on droughty, upland sites. Cuttings benefit from hormonal treatment.
Rosa nutkana Nootka rose	2-3	Rare	6 x >>	Fair to very good	Moderate	Root cuttings, suckers, softwood cuttings	4	Thicket forming. Has pair of large thorns at the base of each leaf. Flowers large, singular. Tolerates saturated soils during growing season.
Rosa pisocarpa Clustered rose	2	Rare	8 x >>	Poor to Fair	Moderate	?	5	Has pair of large thorns at base of leaf but flowers borne in clusters. Wet to dry conditions.

Table 1. continued.

Species name/ Common name	Spacing within rows	Commercial availability as cuttings	Mature height X width	Rooting ability of hardwood cuttings	Growth rate of sprouts	Other methods of vegetative propagation	Risk of establishment by cuttings	Remarks
Rosa woodsii Woods rose	2-3	Rare	8 x >>	Poor to Fair	Moderate to fast	Root cuttings, suckers, layering, softwood cuttings	5	Thicket forming. Has thorns and showy pink flowers borne in clusters. Mostly east of Cascade Mountains.
Rubus spectabilis Salmonberry	2-4	Rare	10 x >>	Good	Moderate	Root cuttings, layering, basal sprouts	3	Spreads by rhizomes and provides good erosion control once established. Weak thorns. Important wildlife food and cover. Tolerates shade, wet soils.
Salix amygdaloides Peachleaf willow	3-9*	Common	50 x 20	Excellent	Very fast	Layering, most stem cutting types	1	Similar to Pacific willow.
Salix drummondiana Drummond willow	3-9*	Common	12 x 10	Excellent	Fast	Layering, most stem cutting types	1	Shorter statured willow. Younger branches are yellow.
Salix prolixa Mackenzie willow	3-9*	Common	20 x 15	Excellent	Fast	Layering, most stem cutting types	1	Smaller statured willow. Persistent stipules.
Salix exigua Coyote willow	3-9*	Common	26 x >>	Very good	Fast	Root cuttings, layering, most stem cutting types	2	Thicket forming. Needs more moisture than other willows.
Salix fluviatilis Columbia River willow	3-9*	Occasional	20 x >>	Very good	Fast	Root cuttings, layering, most stem cutting types	2	Spreads by rhizomes. Small natural range (Lower Columbia River basin and tributaries). Rapidly colonizes sandbars. Related to Northwest willow.
Salix hookeriana Coast or Hooker willow	3-9*	Very common	25 x 20	Excellent	Very fast	Layering, most stem cutting types	1	Coarse stems are more brittle than most willows. Wild clones with silvery leaves have ornamental value. Most common within 5 miles of west coast.
Salix lasiolepis Arroyo willow	3-9*	Occasional	35 x 25	Excellent	Very fast	Layering, most stem cutting types	1	Grows well on moist upland sites, in gulches and along streams.
Salix lemmonii Lemmon's willow	3-9*	Occasional	20 x 25	Excellent	Fast	Layering, most stem cutting types	1	Only found east of the Cascade Mtns. Grows in well-drained coarse-textured soils in upper riparian zones. Closely related to Geyer's willow. Deciduous stipules.
Salix lucida ssp. *lasiandra* Pacific willow	3-9*	Very common	50 x 25	Excellent	Moderate to Fast	Layering, most stem cutting types	1	Very common, but may be more disease prone than certain other native willows. Some can be large.
Salix scouleriana Scoulers willow	3-9*	Very common	25 x 16	Good to very good	Very fast	Layering, semi-hardwood cuttings	2	Common in forests and upland areas. Has moderate shade tolerance and often a single trunk. Cuttings sometime benefit from dilute hormonal treatments.
Salix sessilifolia Northwest willow	3-9*	Occasional	26 x 18	Excellent	Fast	Layering, most stem cutting types	1	Closely related to Columbia River willow.

Table 1. continued.

Species name/ Common name	Spacing within rows	Commercial availability as cuttings	Mature height X width	Rooting ability of hardwood cuttings	Growth rate of sprouts	Other methods of vegetative propagation	Risk of establishment by cuttings	Remarks
Salix sitchensis Sitka willow	3-9*	Very common	30 x 20	Excellent	Very fast	Layering, most stem cutting types	1	Produces long unbranched sprouts that are easy to process into whips and cuttings.
Sambucus racemosa Red elderberry	3-5	Rare	25 x 15	Fair to very good	Moderate	Layering, softwood cuttings	5	Variable results from hardwood cuttings. Best from vigorous 1-yr old wood. Hormones can help. Do not confuse with blue elderberry which is rated poor.
Spiraea betulifolia Birchleaf spirea	2-3	Rare	3 x >>	Fair to good	?	Root cuttings, layering	?	Spreads by rhizomes. Dry foothills of Willamette Valley, otherwise mostly east of Cascades.
Spiraea douglasii Douglas spirea	2-3	Occasional	7 x >>	Very good	Fast	Root cuttings, layering	2	Spreads easily by seed; can volunteer into adjacent areas so grow separately or remove seed heads.
Symphoricarpos albus Snowberry	2-3	Seldom	5 x >>	Very good	Fast	Root cuttings, softwood cuttings	2	Rhizomatous. Establishes in saturated soils. Has shade tolerance. Good soil stabilizer.

***Note**: Wider row spacings recommended when using "Miller Bow Technique" (see text).
Table Definitions: All spacings and plant sizes are expressed in feet. Risk of establishment based on scale of 1 = lowest to 5 = highest for direct sticking of unrooted hardwood cuttings at outplanting site. The symbol ">>" used instead of width for species that spread readily from underground shoots, suckers or rhizomes. Data based on compilation of information from various sources (publications, personal experience and interviews with native plant propagators), but will be updated as needed. Results can vary substantially between clones even under the same growing conditions.