NUGGETS OF KNOWLEDGE

A Budded Clone of *Carpinus betulus*©

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The subject tree (Fig. 1) is a budded clone, propagated from a seedling rootstock and a bud from a street tree in Davis, California.

The seedling rootstock was produced from seed harvested in September 1984, from a symmetrical, globe-headed tree in Davis, California. The seed was cold-stored under moist conditions over winter (1984–85) and sown in spring 1985. It germinated by May 1985 and thereafter the seedlings were container-grown, lastly in so-called tube containers (6 in. diameter × 36 in. depth).

On 23 March 1987, when the seedlings were about 2 years old, I chip-budded some of them, using budwood collected that same day from the aforementioned parent tree. This parent tree was vase-shaped with strongly ascending branches, and now is about 50 ft tall and broad. It is one of numerous European hornbeam trees that were planted along Whittier Avenue in 1965 as bare-root nursery stock of about 6 ft height. Being of seedling origin, these trees now vary in size and shape, with each tree annually producing typical catkins of either male or female flowers.

In contrast, with the other hornbeam trees in the area, the subject tree had had only male flowers initially, but since year 2000 has had a meager amount of female flowers also. The fruit or winged nutlets that have developed from these few female flowers have been similar to those on the other trees, which are somewhat like small, shriveled peas.

The unique dual trunk of this clone is the result of simultaneously planting a seedling European hornbeam tree 3 ft from the clone and later splicing a ⅜-inch

Figure 1. This tree, with Phil Barker standing beside it for scale, is a cloned European hornbeam (Carpinus betulus). Barker propagated the tree, planted it at his home in Davis, CA, and created the dual trunk. Trees of this species typically have a critical visual flaw when the leaves turn brown in autumn and remain on the tree until spring. This tree was uniquely propagated to defoliate in autumn, as occurred in December 2006 when this photo was taken. An exception is the cluster of brown leaves at about 2 feet above ground. They are on shortened branches that arise at the top of the rootstock, just below the bud union of the clone and have been kept for demonstration purposes only. On 12 May 2009, the respective height and spread of the tree was an estimated 40 ft and 25 ft. Likewise on this date, the circumference of the trunk of the clone at 15 in. (38 cm) below and above the center of the cross arm, measured 16.5 in. (42 cm) and 18.5 in. (47 cm), respectively. This greater circumference above the cross arm (18.5 in. above vs. 16.5 in. below) apparently is because leaves only are on the clone, whereas water and nutrients feed into the trunk of the clone, above the cross arm, from both root systems. A potted plant hangs from the cross arm of the dual trunk for visual interest.

diameter branch from this seedling tree onto the trunk of the clone, at a height of about 7 ft. To do this splicing, I drilled a small hole through the branch, inserted a small, flat-headed screw into the hole and screwed it into the trunk of the clone; after first shaving off bark down to the cambium at the contact points of the branch and the trunk to promote their healing together. Two years later I pruned the end of the branch that extended beyond the trunk back to the trunk. About 10 years later, bark had callused over the scar where the branch had been pruned off. The screw that initially held the branch and trunk tightly together remains imbedded in the wood of the knitted union and is no longer visible (Fig. 1).

The two positive traits of this clone are: (1) prompt defoliation in autumn and (2) like the parent tree, I expect it will produce primarily male flowers and therefore meager fruit or seeds, above and beyond the tree's novel, dual trunk. These two positive traits also typify a neighboring sister clone that has a single trunk.

Stem Cuttings of *Romneya coulteri* ©

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- In October I cut green leafy stems with firm pencil-size laterals from irrigated plants of *Romneya coulteri*.
- Mallet cut: cut lateral stem above the axil of the main stem and below the axil of the main stem at a angle.
- Remove the stem tip. The cutting should have 3–4 green leaves.
- Prepare cutting: dip in diluted Clorox®. (8 cups of water to 1 teaspoon Clorox) and rinse in clear water.
- Apply Dip'N Grow® at a 1 : 5 ratio.
- Add RootShield® to cutting mix at a rate of 3 tablespoons per 1 ft^3 of soil.
- Put cuttings under mist with bottom heat set at 70 °F.
- In 2–3 months, pot rooted cuttings into 4-inch containers with Sunshine® Mix #4 and RootShield. Place back into greenhouse and continue on bottom heat.
- In 2 months the *R. coulteri* liners are ready to be potted up. A large saleable plant is ready in May.

Impact of Oil on the Horticultural Industry©

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We are a green industry have a major issue that we need to face. This deals with the different plastic products used in the industry, and their recyclability.

Although many container corporations put a recycle symbol on the bottom of their containers with the number of the kind of plastic it is made from, there are still areas where we need to make recycling expedient. The cell pack and the light-weight 4-inch pot industries as well as the house-plant industry often do not have numbers or a recycling marks at all. Flats to carry these containers and the round-holed flats

also don't have any numbers. In addition, all the plastic labels for the plants have no recycling marks.

Californians are often thought of as the crazy environmentalists, but many of our communities have excellent recycling programs which allow us to recycle all identifiable materials. I believe other states also have programs like these in place. The nursery industry, while well underway to providing easily identifiable recyclable containers, still has a way to go before it can claim to have closed the recycling loop.

As far as labels are concerned there is no reason why in the printing of the label the recycling symbol cannot be added, at very little additional cost. The cell packs would probably require rebuilding the molds which would be more costly. However, I assume over time those molds break down and at those times the next molds should have the symbol marked on them.

I would like to suggest that growers begin to request recyclable containers for their products. People in the landscape industry tend to be aware of the waste they need to dispose of especially since they are being charged more and more to do so. It would help to reduce their costs of doing business and, perhaps, motivate them to use your product if you provide them with a cheaper cost alternative to their waste issues.

Vegetative Propagation of Old Growth Conifers©

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In three separate experiments, vegetative propagation of old-growth Monterey pine (*Pinus radiata* D. Don), Great Basin bristlecone pine (*Pinus longaeva* D.K. Bailey), and coast redwood [*Sequoia sempervirens* (Lamb. ex D. Don) Endl.] was conducted to determine optimum cutting type, rooting hormone concentration, and formulation required to successfully produced rooted cuttings.

Results from limited experiments indicate that for both Monterey pine and Great Basin bristlecone pine, needle fascicle cuttings treated with a 2000 ppm IBA and 1000 ppm NAA solution produced the best rooting of old growth specimens. For coast redwood, stem cutting treated with 8000 ppm IBA talc or 16,000 ppm IBA talc produced the best rooting of old growth specimens.

INTRODUCTION

Vegetative propagation of forest trees is commonly used to establish clones for heritability studies, breeding stock in seed orchards, and the replication and preservation of selected genotypes. Grafts and cuttings are used for cloning physiologically old trees to establish seed orchards and clonal archives. Cuttings are preferred over grafts since grafts often present problems with delayed incompatibility. However, cuttings taken from old parent ortets rarely root satisfactorily, necessitating grafting as an initial step in propagating procedures for newly selected trees (Menzies, 1995).

The time of maturation and longevity of species in this study vary considerably. Monterey pine (*Pinus radiata* D. Don) bears seed when 5 to 10 year old and is short lived. It attains full size in 80 to 100 years and rarely lives beyond 150 years.

Great Basin bristlecone pine (*P. longaeva* D.K. Bailey) begins to bear seed when 20 to 40 years old. The oldest known bristlecone pine "Prometheus," determined by growth ring counts, was about 4,900 years old when it was felled in 1964 (National Park Service 2008). Coast redwood [*Sequoia sempervirens* (Lamb. ex D. Don) Endl.] bears seed when 5 to 15 years old. The oldest redwood found so far, determined by growth ring counts, is nearly 2,200 years old (Burns and Honkala, 1990).

Vegetative propagation of juvenile Monterey pine has been well documented for over 70 years since the first cutting was successfully rooted in 1929 by J.F. Field at a New Zealand nursery (Libby, 1964). Techniques have been developed to obtain reliable rooting of cuttings from trees up to 40 years old. More typically, cuttings are taken from donor trees that generally range from 1 to 5 years of age and stock plants are retained for up to 8 years. Juvenility is a key variable in successful rooting rates. It has been reported that a strike rate of 90% from a 1-year-old seedling stock could be expected to drop to about 80% by age 5 and to only 15% by age 15 (i.e., full maturity) (Thomas and Spurway, 1998).

There is apparently no literature documenting vegetative propagation of Great Basin bristlecone pine, though seed propagation has been done by conservation and commercial nurseries.

Vegetative propagation of coast redwood has been done for over 80 years and as early as 1924 it was noted that young vegetative wood roots better than older vegetative wood (Metcalf, 1924). More recently, cuttings of selected cultivars are typically collected from stock plants under 5 years old. Rooting percentages up to 90% have been reported, but extensive trials revealed that 40% to 70% is more typical for many cultivars (Blythe, 1984).

This study outlines the methods and results used to successfully propagate old growth Monterey pine (*P. radiata*), Great Basin bristlecone pine (*P. longaeva*), and coast redwood (*S. sempervirens)* from semi-hardwood stem cuttings and fascicle cuttings (pine species only).

MATERIALS AND METHODS

Plant Material.

Experiment 1. Semi-hardwood stem cuttings and unexpanded needle fascicle cuttings of the national champion Monterey pine (*P. radiata*) were collected on 29 Nov. 2001 from an estimated 150-year-old tree in Carmel, California.

Thirty-six cuttings of semi-hardwood terminal shoots had dense, fully elongated healthy needles, with a cutting length between 10.2 and 15.2 cm (4 and 6 in.) and a basal stem diameter between 3.2 and 7.9 mm (⅛ and 5/16 in.). All secondary needles (short shoots) were removed from the lower half of the each cutting. A straight cut was made at the basal end of the stem with sharp propagation shears and the cuttings were immersed for 5 min in a 1.2 $g \cdot L^{-1}$ (0.16 oz/gal) solution of dimethyl-4-4'-o-phenylenebis-3-thioallophanate (Cleary's 3336® WP; Cleary Chemical Corp., Dayton, New Jersey). Following the fungicidal soak, 36 cuttings were recut at the basal end. Eighteen cuttings were dipped to a 1.3 to 2 cm (½ to ¾ in.) depth for 5 sec in a 2000 ppm indole-3-butyric acid (IBA) and 1000 ppm 1-napthaleneacetic acid (NAA) solution. Eighteen cuttings were lightly wounded with a single slice wound 1.3 to 2 cm (½ to ¾ in.) long, and dipped to a 1.3 to 2 cm (½ to ¾ in.) depth in 8000 ppm IBA talc. Treated cuttings were then firmly inserted 3 to 4 cm (1 to 1½ in.) into rooting medium filled into 43.0 cm × 43.0 cm ×

6.4 cm (17.0 × 17.0 × 2.5 in.) propagation flats (Dillen Products, Middlefield, Ohio) and placed on a bench with intermittent mist.

One hundred eighty unexpanded needle fascicle cuttings were removed from semi-hardwood terminal shoots with an X-ACTO™ knife and all were treated with the same fungicidal soak and hormone solution as the semi-hardwood terminal shoots. Treated fascicle cuttings were then firmly inserted 6.4 mm (¼ in.) into rooting medium filled into 43.0 cm × 43.0 cm × 6.4 cm (17.0 × 17.0 × 2.5 in.) propagation flats and placed on a bench with intermittent mist.

Experiment 2. Semi-hardwood stem cuttings, fascicle cuttings, and two cones of the 'Methuselah' bristlecone pine (*P. longaeva*) were collected on 8 Oct. 2002 from an estimated 4,786-year-old tree in the Inyo National Forest, California. Expanded fascicle cuttings derived from 2-year-old seedlings were collected on 4 Nov. 2004.

Six cuttings of semi-hardwood terminal shoots had very dense, fully elongated healthy needles, with a cutting length between 7.6 and 10.2 cm (3 and 4 in.) and a basal stem diameter between 6.4 and 9.5 mm (¼ and ⅜ in.). All secondary needles (short shoots) were removed from the lower half of the each cutting. A straight cut was made at the basal end of the stem with sharp propagation shears and the cuttings were immersed for 5 min in a 1.2 $g \cdot L^{-1}$ (0.16 oz/gal.) solution of dimethyl-4-4'-o-phenylenebis-3-thioallophanate. Following the fungicidal soak, 6 cuttings were recut at the basal end. Three cuttings were dipped to a 2 to 3 cm (¾ to 1 in.) depth for 5 sec in a 2000 ppm IBA and 1000 ppm NAA solution. Three cuttings were lightly wounded with a single slice wound 1.3 to 2 cm (½ to ¾ in.) long, and dipped to a 1.3 to 2 cm (1.2 to ¾ in.) depth in 8000 ppm IBA talc. Treated cuttings were then firmly inserted 3 to 4 cm (1 to 1½ in.) into rooting medium filled into 43.0 cm × 43.0 cm × 6.4 cm (17.0 × 17.0 × 2.5 in.) propagation flats and placed on a bench with intermittent mist.

Twelve needle fascicles were removed from semi-hardwood terminal shoots with an X-ACTO™ knife and all were treated with the same fungicidal soak and hormone solution as the semi-hardwood terminal shoots terminal shoots. Treated needle fascicles were then firmly inserted 6.4 mm (¼ in.) into rooting medium filled into 43.0 cm × 43.0 cm × 6.4 cm (17.0 × 17.0 × 2.5 in.) propagation flats and placed on a bench with intermittent mist.

Ten seeds from an open-pollinated (half-sib) cone were sown fresh (no cold stratification required), one seed per cell, to a depth approximately twice the seed width in growing medium filled into 3.8 cm diameter × 14 cm deep (1.5 in. diameter × 5.5 in. deep) UV stabilized Ray Leach Cone-tainers™ "Stubby Cell" (Stuewe and Son Inc., Corvallis, Oregon) and placed into trays on a bench without intermittent mist. Seedlings were grown for approximately 2 years. Growing medium was kept moist throughout the establishment phase.

Seedlings were fertilized with a 150 ppm nitrogen solution of Scotts® Peters® Excel® 21N–5P–20K water-soluble fertilizer (The Scotts Company, Marysville, Ohio) during the rapid growth phase and reduced to a 50 ppm nitrogen solution during the hardening phase. Seedlings were grown for approximately 2 years to achieve target specifications with a height of 6.4 to 7.6 cm (2.5 to 3 in.) and a stem caliper of 3 to 5 mm (⅛ to 3⁄16 in.). Once this size, 10 expanded needle fascicle cuttings were removed from 2-year-old seedlings with an X-ACTO™ knife and all were treated with the same fungicidal soak and hormone solution as the semi-hardwood terminal shoots. Treated expanded fascicle cuttings were then firmly inserted ⅓ their length into rooting medium filled into 43.0 cm × 43.0 cm × 6.4 cm (17.0 × 17.0 × 2.5 in.) propagation flats and placed on a bench with intermittent mist.

Experiment 3. Semi-hardwood stem cuttings of old growth coast redwood (*Sequoia sempervirens*) were collected on 30 Oct. 2007 from three selected trees, each estimated over 1000 years old, at Roy's Redwoods Open Space Preserve, Marin County, California.

Nine hundred cuttings of semi-hardwood terminal shoots had dense, varied healthy needle structure, with a cutting length between 7.6 and 12.7 cm (3 to 5 in.) and a basal stem diameter between 3.2 and 4.8 mm (⅛ and 3⁄16 in.). All primary needles were removed from the lower third of the each cutting. A straight cut was made at the basal end of the stem with sharp propagation shears and the cuttings were immersed for 5 min in a 1.2 $g \cdot L^{-1}$ (0.16 oz./gal.) solution of dimethyl-4-4'-o-phenylenebis-3-thioallophanate. Following the fungicidal soak, 300 cuttings from each tree were recut at the basal end and 100 cuttings were dipped to a 1.3 to 2 cm (½ to ¾ in.) depth in either 3000 ppm IBA talc, 8000 ppm IBA talc, or 16,000 ppm IBA talc. Treated cuttings were then firmly inserted 3 to 4 cm (1 to 1½ in.) into rooting medium filled into 43.0 cm × 43.0 cm × 6.4 cm (17.0 × 17.0 × 2.5 in.) propagation flats and placed on a bench with intermittent mist.

Propagation Medium.

Cuttings. Medium consisted of perlite : peat (9 : 1, v/v) and incorporating Scotts® Osmocote® 18–6–12 controlled release fertilizer (The Scotts Company, Marysville, OH) at 1.8 $kg \cdot m^3$ (3.0 lb/yd^3) and Scotts® Micromax® Micronutrients (The Scotts Company, Marysville, Ohio) at 0.7 $kg \cdot m^3$ (1.0 lb/yd^3).

Seedlings. Medium consisted of peat : perlite (3 : 1, v/v) incorporating Scotts Osmocote 18–6–12 controlled release fertilizer at 3.8 $kg \cdot m^3$ (6.0 lb/yd^3) and Scotts Micromax Micronutrients at 0.7 $kg \cdot m^3$ (1.0 lb/yd^3). After sowing, seeds were covered with a 6 mm (¼ in.) layer of perlite to maintain moisture and prevent growth of cryptogams.

Propagation Environment. Greenhouse air temperature controls were set at 18 to 24 °C (65 to 75 °F) during the day and 13 to 18 °C (55 to 65 °F) at night. A 16-h photoperiod was maintained during winter months. Overhead intermittent mist for cuttings was set at 6 sec every 15 to 30 min (depending on weather conditions) during the hours 0700 to 1600. No bottom heat was provided.

RESULTS

Experiment 1. The results from Experiment 1 indicate that only 1 stem cutting and 3 fascicle cuttings produced roots. It should be noted that only 1 of 3 fascicle cuttings developed a terminal leader after initial rooting (Table 1).

Experiment 2. The results from Experiment 2 indicate that no stem cutting or fascicle cuttings from the donor tree produced roots. However, 7 expanded fascicle cuttings derived from 2-year-old seedlings produced roots (Table 2).

Experiment 3. The results from Experiment 3 indicate that all 3 selected trees produced roots (Table 3). Tree #1 produced the fewest number of rooted cuttings and only with 16000 ppm IBA, the highest IBA concentration tested. Tree #1 was likely the oldest donor tree of the 3 trees in this experiment. Tree #2 produced the most number of rooting cuttings and with both 8,000 and 16,000 ppm IBA. Tree #3 produced rooted cuttings with both 8,000 and 16,000 ppm IBA. None of the three selected trees produced roots with 3,000 ppm IBA, the lowest IBA concentration tested.

DISCUSSION

The capacity of cuttings to root is influenced by many factors including cutting genotype, cutting physiology, cutting pre- and post-treatment, rooting hormone treatment, rooting medium, and the rooting environment. Eliminating as many variables as possible is important when conducting rooting trials and evaluating optimal propagation protocols.

While few direct correlations can be made between the three separate experiments with old growth conifer species, some general observations can be made. It is known that adventitious root formation declines with the chronological age of the donor tree. Rarely has vegetative propagation been attempted on extreme adult phase trees as in these experiments. Not surprisingly, rooting percentages were far below what might be expected from commercially propagated juvenile material of the same species. It should also be noted that only a limited number of cuttings were made available for propagation of these old growth conifers. Therefore, rooting hormones and concentrations used in these experiments were based on previous rooting experience with juvenile stock plants of the same or similar species.

For both Monterey pine and Great Basin bristlecone pine, it appears fascicle cuttings present the best option for initial propagation of old growth specimens. Not all needle fascicles cuttings that root will develop desired tree form; thus it is best to select needle fascicles that exhibit signs of early shoot development. Needle fascicles are far more abundant than tip cuttings and fascicle meristems possess juvenile characteristics. This reduction in physiological age (phase change) promotes potentially better rooting than stem or tip cuttings.

For coast redwood, it is apparent that higher concentrations of rooting hormones are necessary to induce rooting of stem cuttings from old growth specimens.

Initial vegetative propagation of old growth conifers allows for the multiplication of rare or unique individual genotypes and a means of genetic conservation by the subsequent establishment of clonal archives through hedging. The identification of successful propagation methods and nursery production of unique specimens can provide unique plant material resources for repositories at research facilities, arboretums, and botanic gardens and for commercial use.

Table 1. Response of Monterey pine (*Pinus radiata*) cuttings to selected rooting hormone concentrations and formulations.

Cutting type	Treatment	Cuttings stuck (no.)	Rooted cuttings (no.)[x]	Rooting (%)
Stem cutting	2000 ppm IBA + 1000 ppm NAA solution	18	0	0
Stem cutting	8000 ppm IBA talc	18	1	5
Fascicle cutting	2000 ppm IBA + 1000 ppm NAA solution	180	3	2

[x] Rooting data was collected on 2 Feb. 2002.

Table 2. Response of bristlecone pine (*Pinus longaeva*) cuttings to selected rooting hormone concentrations and formulations.

Cutting type	Treatment	Cuttings stuck (no.)	Rooted cuttings (no.)	Rooting (%)
Stem cutting	2000 ppm IBA + 1000 ppm NAA solution	3	1[1]	0
Stem cutting	8000 ppm IBA talc	3	1[1]	0
Fascicle cutting	2000 ppm IBA + 1000 ppm NAA solution	12	1[1]	0
Expanded fascicle cutting	2000 ppm IBA + 1000 ppm NAA solution	10	7[2]	70

[1]Rooting data was collected on 8 Feb. 2003. [2]Rooting data was collected on 4 Feb. 2004.

Table 3. Response of coast redwood (*Sequoia sempervirens*) cuttings to selected rooting hormone concentrations and formulations.

Cutting Type	Treatment	Cuttings stuck (no.)	Rooted cuttings[1] (no.)	Rooting (%)
Tree #1				
Stem cutting	3000 ppm IBA talc	100	0	0
Stem cutting	8000 ppm IBA talc	100	0	0
Stem cutting	16000 ppm IBA talc	100	2	2
Tree #2				
Stem cutting	3000 ppm IBA talc	100	0	0
Stem cutting	8000 ppm IBA talc	100	5	5
Stem cutting	16000 ppm IBA talc	100	8	8
Tree #3				
Stem cutting	3000 ppm IBA talc	100	0	0
Stem cutting	8000 ppm IBA talc	100	2	2
Stem cutting	16000 ppm IBA talc	100	2	2

[1]Preliminary rooting data was collected in 30 Mar. 2008. As of 10 Sept. 2008, the experiment remained in progress to allow cuttings ample time to root.

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Bag Technique

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When I'm grafting I like to put the freshly grafted plants in a tray, cover them with a plastic bag, and store in the shade with bottom heat till they are leafed out.

SUPPLIES

- Anderson Die & Mfg Co 14⅜ × 18⅜ in. trays which holds 30, 2⅞ in. or 20, 3⅝ in. band pots.
- Kirkland 33 gal clear garbage bags $22.99/200.
- GT Bag Co. has bags of all sizes (www.gtbag.com or 800-735-3950).
- Use permanent marker pens for plant labels and bags.
- Two different fungicides and water.
- Bottom heat: 70–75 °F.
- Alternate: bags for individual band pots or bags for individual grafts

SUGGESTIONS

- Understock should rise above graft.
- Avoid eye pokes — keep understock tops toward tray center.
- Avoid lost labels — keep away from outside edge of tray.
- No vegetation below any graft.
- Pots should be free of weeds and leaves — nothing rotting.
- Lightly water with fungicide before covering with bags; do not over water!
- Always keep grafts facing same light orientation.
- Never let bags be in direct sun, period.
- Check random sample daily.
- Easy to see all bags fogged up — if bag is clear then pull and correct problem.
- Do first culling 2 to 3 weeks after grafting.
- Get rid of all mold and dead stuff in pot and all vegetation under grafts.
- Re-apply fungicide, but use one from different group than original.
- Turn bag inside-out before recovering grafted plants after inspections.
- Temperature is perfect for growing both the good and bad so must monitor.
- Bags will keep any problem contained if you are careful not to mix bags.
- Remove bags in stages after plants are callused, not all at once, to acclimate plants.