Wood Shrub Propagation: A Comprehensive Approach[1]

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Abstract: The demand for increased biodiversity of species in forest revegetation projects has resulted in a renewed interest in native, woody shrub propagation. This paper presents a comprehensive approach for incorporating the vast amount of propagation information that is already available on specific treatments for woody shrubs into existing nursery programs.

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1.0 INTRODUCTION

"Facts are meaningful only when they can be attached to ideas. Unless students (people) are taught a system for learning or processing information, facts are of little use to them." (Wurman 1990, parentheses inserted by author.)

The demand for increased biodiversity in the revegetation of western forest habitats has resulted in a renewed interest among nursery growers in how to develop propagation programs for a wide variety of native, woody shrubs. The last major period of interest in native shrub propagation occurred in the late 1970's and 1980's as land management agencies responded to the challenge of revegetating lands disturbed by mining related activities. In the process of developing the propagation techniques of these native species a vast amount of information was compiled from both public and private sources. The greatest challenge to today's growers, more than discovering specific propagation treatments or techniques for different species, is to find an effective way of incorporating the information that is available into their own propagation programs. The objectives of this paper are:

1) To present in the context of the paper the sources of information that is already available for propagating native, woody shrubs; and

2) To present a comprehensive approach for growers to apply the information that is available to their own propagation programs.

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Before proceeding, it is important to make the distinction between propagation treatments and propagation programs in the context of this paper. Propagation treatments describe specific treatments for inducing germination of seeds or rooting of cuttings. Propagation programs describe the use of specific propagation treatments in an overall propagation plan for a species, and are based on the overall objectives and resources of the grower.

2.0 THREE KEY STEPS TO SUCCESSFUL PROPAGATION

"We need to know how to make connections from one subject or interest to the next." (Wurman, 1990)

Three key steps for initiating a successful program are: (1) know your plants, (2) planning and scheduling, and (3) good recordkeeping. These steps should be used before any propagation work is actually begun, and then modified over time in response to the different degrees of success or failure of the individual programs.

2.1 Know Your Plants

2.1.1 Ecological Factors

Identify the native range of the species, the elevation that it is normally located at, its natural habitat, and miscellaneous information that may be of interest to a grower. A basic understanding of the ecological factors that influence the growth and survival of the species in its native environment may provide important clues about propagating a species without knowing its specific cultural requirements. Consider the following example of *Ceanothus velutinus:*

Range: Intermountain West and northern Great Plains (Sutton and Johnson 1986; Van Dersal 1938)

Elevation: 6000-10,000' (Van Dersal 1938)

Habitat: Dry; full sun (Sutton and Johnson 1986; Van Dersal 1938)

Miscellaneous: Pioneer species after fires; food for deer and birds (Van Dersal 1938).

As you might expect, the recommended treatments for this particular species include the following:

Field planting: Sow in the fall or summer at a soil depth at least twice as deep as the seed diameter. Optimum temperature is between 45-100°C. (Vories 1981)

Pretreatments: Soak in hot (79- 90°C) water until cool and cold stratify for 2-3 months at 1-5°C; or, scarify in sulfuric acid for 30-60 min and cold stratify for 2-3 mos at 3-5°C (Vories 1981).

Seeds of plants that have fruit eaten by animals frequently have a scarification requirement to improve germination.

Just because different species thrive under similar ecological conditions you should not automatically assume that they will have the same requirements for germination. Huckleberries, *Vaccinium* species, are a desirable food source for birds and mammals and readily establish themselves in clearcuts and burned areas. Based upon that description, one might expect the propagation treatments to be similar to those recommended for *Ceanothus.* However, light and alternating temperatures are recommended for these species (Ellis et al 1985). A light requirement has not been reported for *Ceanothus* (Schopmeyer 1974). The point is that all of the environmental and ecological conditions must be examined when considering propagation treatments.

2.1.2 Plant Characteristics

Some specific plant characteristics that are important for propagation purposes include growth habit, fruit type, fruit and seed ripening dates, seed viability, and transplantability of the plants.

Growth habit. Is it upright *(Acer circinatum)* or prostrate *(Arctostaphylos uva-ursi)?* Spreading *(Ceanothus velutinus)* or compact *(Pachystima myrsinites)? Is* it fast growing *(Shepherdia argentea),* or slow growing *(Amelanchier alnifolia)?* What type of root system does it have: coarse *(Quercus gambelli),* fibrous *(Purshia tridentata),* shallow *(Rosa woodsii),* or deep *(Cercocarpus montanus)? Is* it rhizomatous *(Mahonia repens)* or suckering *(Prunus virginiana)?* (Sutton 1986; Wasser 1982; Van Dersal 1938).

Fruit type. Specific information about fruit type will help enable growers to make predictions about possible seed treatments, as well as plan collection, cleaning and storage activities. (For specific details about the collection and storage of woody shrub seeds refer to Young et al. 1983, or Schopmeyer 1976).

Ripening dates. Because of the effect of age on seed germination and viability, it is important to know the ripening periods of fruits and seeds for scheduling collection periods, and for purchasing seeds. Ripening dates may also give some indication of the best time to collect cuttings. For example, *Purshia tridentata* grows fastest between flowering and seed ripening (Wasser 1982). The best time for collecting soft cuttings for this species would be in this time period.

Seed viability. Seed viability must be considered because of its direct effect on the ability of seeds to germinate. Seed viability declines over time and varies between species. Some species, such as *Artemisia tridentata tridentata* have a very short period in which seed remains viable, 1-2 years, compared to 3-12 years for *Ceanothus velutinus* (Vories 1981). Seed storage conditions will have a significant impact on the viability of seed, but a detailed discussion on seed storage is beyond the scope of this paper.

Transplantability. Transplantability of a species is important whether you are growing bareroot or container crops. Species with taproot systems normally do not transplant as easily as plants with more fibrous root systems (Sutton and Johnson 1986). Activities such as root pruning, may have to be scheduled in the propagation program.

2.1.3 **Cultural requirements**

Cultural requirements refer to all of the factors that affect plant growth, including pretreatments for seeds or cuttings, potting or rooting media, greenhouse or field conditions, and fertilizing and water regimes. The main focus of this paper will be on the primary types of dormancy that influence germination of woody shrub seeds, and techniques for growing these shrubs, primarily, in containers.

Types of dormancy. Most shrubs in the temperate regions of the United States require some type of pretreatment, or combination of pretreatments before they will germinate. What type of pretreatment a grower chooses to use will depend upon the **type of dormancy** that prevents the seeds from the germinating, and the **propagation program** that best meets the grower's needs and abilities. Seeds of most plants experience innate dormancy. **Innate dormancy** is a general term which describes the mechanism seeds use to avoid viviparous germination. The specific types of dormancy common to most woody shrubs are described in the following passages, with recommended treatments and examples of species affected.

After-ripening. One source describes this as a maturation period of the seed embryo before it will respond to pregermination treatments (Young et al 1983); and another describes it as an actual treatment where seeds are stored in an air-dry state under optimal storage conditions (high temperature and humidity without reducing viability) to decrease dormancy (Ellis et al 1985). Treatments: time, stratification, optimal storage conditions (Ellis et al 1985; Young et al 1983). Species affected: *Acer, Artemisia, Dyssodia, Ilex,* and *Prunus* (Young and Young 1992; Schopmeyer 1974).

Seed coat dormancy. Elements in the seed coat of an imbibed seed prevent the seed from germinating. Treatments: after-ripening, removal of seed coat, acid and mechanical scarification, hot water soaks, leaching, and stratification (Ellis et al 1985; Young et al 1983.) Species affected: *Acer, Comus, Juniperus, Prunus,* and *Rosa* (Young and Young 1992; Schopmeyer 1974).

Hard seedcoat dormancy. Distinguished from seed coat dormancy by an impermeable seed coat that prevents imbibition of water (Ellis et al 1985). Treatments: acid or mechanical scarification (Young and Young 1992; Ellis et al 1985; Schopmeyer 1974). Species affected: *Acacia, Arctostaphylos, Ceanothus, Mitts,* and *Shepherdia* (Young and Young 1992; Schopmeyer 1974; Heit 1970).

Embryo dormancy. The seed fails to germinate after the seed coat has been removed. Treatments: stratification, leaching, chemical treatments (Hartmann et al 1992; Ellis et al 1985). Species affected: Most temperate species including *Amelanchier, Artemisia, Mahonia, Quercus (black oak species),* and *Vaccinium* (Hartmann et al 1992; Young and Young 1992; Ellis et al 1985; Schopmeyer 1974).

Double dormancy. Any combination of embryo dormancy with hardseededness or seed coat dormancy. Treatments: combined treatments for both types of dormancy. Species affected: Numerous woody species in the temperate areas. A specific example is *Acer glabrum* which has an after-ripening requirement in addition to seed coat and embryo dormancy. Treatments include sowing in the field in the fall or spring after suitable pretreatments; pericarp removal followed by cold stratification at 3-5°C for 2-3 mos; warm stratification for 180 days at 20-30°C (Vories 1981); or stratify in seedflats outdoors and overwinter.

There are two types of dormancy responses more specifically related to environmental conditions than to physiological or anatomical features of the seeds. **Enforced dormancy** is a response to environmental conditions such as light, soil temperature, or oxygen availability. Weed seeds are the classical examples of seeds that exhibit an enforced dormancy response. When soil is disturbed and seeds that were buried are exposed to light and alternating (day and night) temperatures, germination occurs (Ellis et al 1985). Species in the genuses *Artemisia, Betula, and Vaccinium* exhibit an enforced dormancy response, and germinate best when sown near the soil surface and are exposed to light and alternating temperatures (Young and Young 1992; Ellis et al 1985; Wasser 1984; Vories 1981).

Induced dormancy occurs when seeds that have begun to germinate go into a deeper, secondary dormancy in response to some environmental stimulus (such as high or low temperatures), and fail to germinate even when environmental conditions are optimal (Ellis et al 1985). The failure of the seeds to germinate when the negative environmental influence has been corrected is what distinguishes induced dormancy from enforced dormancy (Ellis et al 1985). It is possible that many plants are susceptible to induced dormancy, but a specific example might be *Acer* species.

The first author worked at a nursery in Utah where maple seeds were stratified in seed flats placed outside for the winter. After several months the seed flats were brought into the greenhouse where the seedlings that did emerge were transplanted after several days into containers. The seed flats were then set aside to be discarded later. However, after several days a prolific amount of germination occurred inthose flats that had been set aside. It is the author's opinion, that the seeds were in the process of germinating when the flats were brought into the greenhouse, but the immediate exposure to the warmer greenhouse temperatures caused an induced dormancy response that gradually declined over time. This could be an inherent response in species that inhabit areas like the Great Basin where precipitation is a limiting factor during the warmest time of the year. The solutions to this problem might be to: (1) lower the initial greenhouse temperatures close to the outdoor temperatures and gradually increase them over time when this method of stratification is used; or, (2) use a different type of pretreatment when it is not feasible to change the greenhouse environment.

<u>Propagation Methods.</u> Landis and Simonich (1983) describe four different propagation methods for woody shrubs: **direct seeding, transplants, germinants,** and cuttings. The advantages and disadvantages of each method are listed in table 1, along with examples of species that are grown using each method. The propagation method selected will depend upon a number of factors including the pretreatments prescribed for the species, space, cost, convenience, and scheduling.

Direct seeding refers to the practice of directly sowing seeds into the containers that will be used for liner stock or finished plant material. This method works well for species that have a high percentage of germination in a short period of time; and for larger, readily germinating seeds that can be easily sown in individual containers. When pretreatments are required they are initiated prior to the scheduled sowing date. Otherwise seeds are soaked in water for 24-48 hours at room temperature and air-dried before sowing. (Author's comment: aerating the seeds during soaking with aquarium pumps or compressors may improve germination performance.)

Emergents, (previously defined as "transplants" by Landis and Simonich), is the practice of direct sowing seeds into seed flats and then transplanting seedlings from the flats into larger containers. This method is normally used for species that have complex dormancy requirements, for species with very small seed, or for species where the seed viability is poor or unknown. Pretreatments are completed prior to sowing; or, when stratification is the only pretreatment used, seeds are sown into the flats, irrigated, and placed outside for overwintering.

Sprouts, (previously defined as "germinants" by Landis and Simonich), is the practice of planting sprouts into containers. This technique is normally used for species that have simple dormancy requirements (usually stratification), large seeded species that require stratification, and high value crops such as *Mahonia repens* that have a prolonged germination period and are planted as sprouting occurs. Seeds are soaked for 24-48 hours and then stratified in refrigerators at -1 to 4°C, or at room temperature for a predetermined period of time. Some species, including *Acer* and *Junipenus,* may require a combination of warm and cold stratification. Stratification methods include mixing the seeds in moist peat moss in plastic bags; "naked" stratification where seeds are soaked prior to stratification and stratified in plastic bags without adding peat moss; or put in mesh bags and placed between layers of peat moss in seed flats. Because molding is a problem during stratification, a strong fungicide such as Captan is mixed with the seeds.

Table 1.--Four propagation methods for containerized production of woody shrubs.[1]

Method	Advantages	Disadvantages	Examples
Direct seeding	Quick Minimizes seed handling Mechanical seeding is possible Fewer labor steps	Hard to control cell occupancy and seedling density Requires thinning and consolidation of cells Waste of seed Inefficient use of greenhouse space for difficult to germinate species	*Arctostaphylos uva-ursi, Amelanchier alnifolia, Cornus sericea, Salix spp.*
Emergents	Control of cell occupancy and seedling density Efficient use of seed Efficient use of greenhouse space Allows adjustments for variable or unknown germination rates More uniform crop development Can use artificial or natural stratification	Transplanting is slow and labor intensive Requires additional time and expense associated with sowing into seed flats Seed may be over or under sown depending on the quality of the seed-lot Potential disease problems and loss of seedling vigor for seed flats with dense emergence	*Acer spp., Artemisia spp., Juniperus scopulorum Quercus spp., Rosa woodsii, Vaccinium spp.*
Sprouts	Control of cell occupancy and seedling density Efficient use of seed Efficient use of greenhouse space Allows adjustments for variable or unknown germination rates More uniform crop development	Sowing is slow and labor intensive Requires precise planning and scheduling to adjust for irregular germination Requires refrigerators or specialized stratification chambers Number of seedlings subject to seedlot quality Seeds may mold and rot during stratification	*Acer spp., Mahonia repens Quercus spp., Prunus spp., Purshia tridentata*
Cuttings	Control of cell occupancy and seedling density Eliminates cost of expensive seed Reduces dependence on seed crops Efficient use of greenhouse space More uniform crop development Faster production of some species Growers can preserve desirable genotypic and phenotypic qualities Growers can preserve sexual characteristics of dioecious plants	Cuttings may be difficult and expensive to store and collect Transplanting is slow and labor intensive Some species do not root well Timing is critical Requires special propagation facilities Contracts may restrict the use of cuttings Transplanting is slow and labor intensive	*Arctostaphylos uva-ursi Cornus sericea Populus trichocarpa, Salix spp., Symphoricarpos albus*

'Modified from Landis and Simonich 1983; used with permission.

YEAR	ACTIVITY	MONTHS J F M A M J J A S O N D
One	Planning	********
	Collect seed	****************
	Stratification	******
Two	Stratification	*****************
	Transplanting	****************
	Growing	************************************
Three	Growing	**********************
	Hardening	***************
	Shadehouse	*******************

Figure 1.--Production schedule for containers of *Juniperus scopulorum* started from emergents (modified from Landis and Simonich 1983; used with permission.)

Rooted cuttings, involves direct sticking vegetative cuttings into containers, or sticking cuttings in flats to initiate rooting before transplanting them into containers. Cuttings are usually used as a last resort for species that may be difficult to propagate from seed; or for species like *Juniperus scopulorum* (fig. 1) that require prolonged periods of stratification before germination occurs. Cuttings are also useful when seed is not available, or for reproducing plant selections or cultivars. However, if finished plants are to be used for revegetation projects, they should be collected from numerous plants at or near the site of the revegetation project to maintain genetic diversity and to enhance the chances for survival of the species at the site.

2.2 **Planning and Scheduling**

The primary questions that should be asked while developing your propagation programs are:

<u>Who?</u> Who are you growing the plants for? A government agency, or a private corporation or business?

<u>What?</u> Closely related to "who", is what are the plants being grown for? Are the plants for a revegetation project, or residential and commercial landscaping? Most plants grown for revegetation projects are grown as bareroot seedlings or tubelings from seeds; whereas landscapers and retail nursery people may desire plants produced from cuttings grown in large containers or as balled and burlapped stock. Most contracts will also include specific requirements such as where the seed or cuttings are collected from, the size of the finished product, and a hardening or acclimation period prior to shipping.

<u>When?</u> When do the plants need to be ready for shipping or transplanting?

<u>How?</u> How will you grow the plants? This will depend upon the specific cultural requirements for each species; and what is the best method to use based upon your resources (including space and labor), and the answers to the previous questions.

The following scenario is an example of why it is important to answer the previous questions before committing oneself to a particular propagation program. The Forest Service (Who?) is revegetating a ski resort in northern Idaho (What?) and needs two thousand tubelings, each, of *Mahonia repens, Arctostaphylos uva-ursi,* and *Corpus sericea.* The opening date for bids is January 1, 1993 with contracts awarded March 1, 1993. The plants must meet certain specifications, (including a two week, outside acclimation period), by April 1, 1995 **(When?).** Based upon the information that has already been compiled on each of these species in figures 2 through 5 (How?), you must decide if: (1) it is even possible to meet the demands of the contract; and (2) the propagation program you will use for each species to meet the conditions of the contract.

YEAR	ACTIVITY	MONTHS J F M A M J J A S O N D
One	Planning	********
	Collect seed	***************
	Stratification	******
Two	Stratification	**********************
	Planting	***************************
	Hardening	*************
Three	Shadehouse	*************************

Figure 2.--Production schedule for containers of *Mahonia repens* started from sprouts (modified from Landis and Simonich 1983; used with permission.)

YEAR	ACTIVITY	MONTHS J F M A M J J A S O N D
One	Planning	********
	Collect seed	***************
	Stratification	**************
Two	Stratification	************
	Growing	************************
	Hardening	*******
	Shadehouse	*******

Figure 3: -Production schedule for containers of *Arctostaphylos uva-ursi* started by direct seeding. (Information provided by Plants of the Wild, Tekoa, Washington.)

YEAR	ACTIVITY	MONTHS J F M A M J J A S O N D
One	Planning	******
	Collect seed	***************
Two	Stratification	************
	Growing	*******************
	Hardening	*******
	Shadehouse	********

Figure 4.--Production schedule for containers of *Cornus sericea* started by **direct seeding. (Information provided** by Plants of the Wild, **Tekoa, Washington.)**

YEAR	ACTIVITY	MONTHS J F M A M J J A S O N D
One	Planning	*******
	Collect cuttings	********
	Stick cuttings	********
	Growing	*******************
	Hardening	*******
	Shadehouse	********

Figure 5.-Production schedule for containers of *Cornus sericea* started from cuttings. (Information provided by Plants of the Wild, Tekoa, Washington.)

You can see, based upon this information, that it would be possible to meet the conditions of the contract for *Arctostaphylos uva-ursi* and *Comus sericea,* but not *Mahonia repens.* Figures 4 and 5 also illustrate how the most efficient method of producing a crop may not be the most expedient method; but, the most expedient method, if possible, may not be the most economical method or acceptable method to your client. Using cuttings for *Comus sericea* would save costs in terms of actual production time; but, as was mentioned earlier, cuttings are generally a more expensive method of production, and are used more as a last resort, or when the customer demands it. In this example timing is not so critical because plants started from seed will be ready well within the specified time frame. Also, the contract may prohibit the use of cuttings, or require that they be collected from the site--which may be an expensive or difficult option.

23 Good Recordkeeping

When working with such a broad diversity of species with so many different cultural requirements, it is essential that a good recordkeeping system be established at the beginning of the propagation program, and used over time to refine and improve techniques for different species. Keeping good records will also prevent the loss of valuable information due to employee turnover or attrition (Scott 1981). A good system should be easy to use with clear guidelines for what should be recorded. The information that should be recorded falls into four major categories: (1) general information about the plants, (2) propagation information, (3) scheduling, and (4) results.

2.3.1. **Plant Information**

Plant information should include the plant name, what the plants will be used for, and the cost of production. It should also include the information about the ecological factors and plant morphology that was previously described in this paper.

2.3.2 **Propagation Information**

In addition to the specific propagation treatments and methods used or recommended, this section should include: the source and location of the plant material; collection dates of seeds and cuttings; type of cuttings taken; seed viability and storage conditions. It should also include the cultural conditions that each species was grown under including: soil media, environmental conditions; and fertilizer and watering regimes.

2.3.3. **Scheduling**

Keeping scheduling records is beneficial for advance planning and for making readjustments in your propagation program over time.

2.3.4. **Results**

Results should include observations since what you are observing is the result of what you have put into practice. Specific things to record should include: the results of germination tests for different species and treatments; rooting success for different species and treatments; plant growth; problems ; failures; -and successes. Any other information that might be useful for improving the propagation program in the future should be recorded in this section.

3.0 SUMMARY

"Our adeptness at asking questions will determine how we reach solutions." (Wurman 1990)

There is already a large amount of information available on specific propagation treatments of native, woody shrubs. The challenge to today's growers is to successfully incorporate this information into their own propagation programs. By stepping back and looking at other factors related to plant growth and development; by carefully planning and developing their programs over time, and by asking the right questions, growers can more effectively use, and hopefully improve on, the information that is already available.

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