Red Alder Plantation Establishment: Site Selection, Site Preparation, Planting Stock, and Regeneration

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Abstract

The information to be presented is based on research results from experimentation done on red alder (*Alnus rubra* Bong.) from 1987 to 2001 by Weyerhaeuser Company, and anecdotal evidence from almost 20-years of experience growing red alder at an operational-scale on Weyerhaeuser lands in western Washington.

As with any tree species, the keys to successful red alder plantations establishment are: (1) site selection; (2) quality planting stock; (3) site preparation; (4) out plant timing; and (5) planting quality. However, red alder is generally less forgiving of sub-optimums for these factors than other commercial tree species grown in the Pacific Northwest.

Frost, very poor soil drainage, drought stress and exposure can negatively affect establishment success, site productivity and wood quality (from top-breakage and sun-scald) of red alder plantations. Sites with these characteristics are not suitable for growing of red alder commercially. Frost/cold is the number one killer of planted red alder—avoid frost prone sites and within-site frost pockets. Generally, the best sites biologically for growing red alder are also some of the best sites for growing Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco).

All stock types have been used to establish red alder plantations successfully. Seedling morphological characteristics and physiological readiness at time of planting, and site conditions over the first 3-years, determine field performance success. Seedling survival and early growth is predicted by the following factors: (1) stem basal caliper (measured 25-mm above the root-collar); (2) height; (3) height on the stem to the lowest healthy bud; (4) percent of the stem with healthy buds; (5) total vegetation ground cover in years 1 and 2; and (6) root system fullness. Basal caliper appears to be the most significant factor for seedling survival and growth—presumably because more stored carbohydrates are available for new root growth early in the growing season. This allows the tree to develop an active root system before the demands from rapid leaf growth begins. Seedlings with a basal caliper of 6-10 mm, height of 60-90 cm, a root mass that is dense enough to indicate a good balance with the shoot, and with abundant *Frankia* nodules throughout the root system will survive, grow fast and capture the site quickly.

Weed competition > 30% cover decreases growth and > 90% decreases survival. Currently there are few selective herbicides for release of planted red alder from weed competition—most broadcast vegetation control must be done prior to planting.

The spring planting period begins when the probability of a killing frost is low and ends before there is an appreciable seasonal drying of the soil. The recommended planting window for western Washington, at elevations less than 300 meters, is mid-March to mid-April.

Red alder plantation establishment can be very successful on “the right sites,” when the “correct” silviculture is practiced. Establishment success and subsequent tree growth can be highly variable on “sub-optimal” sites, or when sub-optimal silviculture is practiced.

Keywords: Red alder (*Alnus rubra* Bong.), site selection, planting stock, site preparation and planting.


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Introduction

Red alder (Alnus rubra Bong.) is a valuable hardwood tree species that competes with many other hardwoods in the marketplace (Western Hardwood Association 2005). Red alder is used principally for the production of lumber and veneer—high-grade lumber for fine furniture, cabinets, and turnings; lower-grade lumber for furniture frames/interior parts and pallets; face veneer for cabinets; and core veneer for high-quality paneling. When red alder is compared to other important North American hardwoods—yellow birch (Betula alleghaniensis Britton), black cherry (Prunus serotina Ehrh.), sugar maple (Acer saccharum Marshall)—its workability index reflects that it is very competitive for finishing, machining, sanding, polishing, color uniformity and gluing, and it has the lowest specific gravity/strength. A very important characteristic of red alder is that the wood readily accepts stain enabling red alder to mimic more expensive woods very convincingly. Lower grade alder logs have value as a desirable pulpwood species.

Because of the expectation of a continuing strong hardwood industry in the Pacific Northwest, some landowners are investing in growing red alder saw-logs to provide future raw material for that industry. This paper will focus on what we know about the requisites for successful red alder plantation establishment. The information presented is based on results from experimentation, and anecdotal evidence from almost 20-years of research and operational experience in red alder tree growing. The intent is to provide a practical guide to assist landowners in growing red alder plantations successfully.

As with any tree species, the factors to successful red alder plantations are: (1) site selection; (2) quality planting stock; (3) correct site preparation; (4) proper out plant timing; and (5) planting quality. The exception for red alder is that the species is generally less forgiving of sub-optimums for these factors than other commercial tree species grown in the Pacific Northwest.

Site Selection

Site selection for red alder requires evaluation of site characteristics relative to the risk of plantation failure from environmental factors, red alder productivity potential, and the need for herbaceous weed control. The objective is to exclude from consideration planting units that will have obviously low red alder productivity potential and/or obviously high risk of plantation failure due to poor soil drainage, frost, drought or inability to control weed competition.

Risk of Plantation Failure

Some characteristics of the better sites for red alder management are (Harrington 1986, Harrington et al. 1994):
- Elevation – Less than 300 m;
- Physiographic position – Flood plain, terrace, bench, lower slopes;
- Aspect – West to east slopes;
- Slope – 10-30%);
- Soil drainage – Well drained;
- Soil texture – Silt loam, silty clay loam, clay loam, silty, clay;
- Soil depth – Greater than 75 cm;
- Depth to summer water table – 2- to 3-meters; and
- Parent material – Sedimentary, sedimentary/volcanic, and volcanic.

Planting units with a combination of the following site characteristics are probably undesirable candidates for red alder production (site productivity will be low and the risk of plantation failure will be high):
- Bog or marsh areas;
- Upper slope positions;
- Ridge tops;
- S to SW exposures;
- Frost pockets (within site & “macro” cold air drainage);
- Exposed and windy sites;
- Droughty sites - sandy, excessively drained, soils;
- Poorly drained soils;
- Depth to summer water table less than 1-meter or greater than 4-meters.
- Highly weathered/leached soils.
- Elevation greater than 450 meters.
- Sites with expected very high levels of weed competition that can not be adequately controlled to low levels—i.e. salal (Gaultheria shallon).

Foresters need to use their judgment when determining the suitability of a site for growing red alder. Any single characteristic that would result in a high risk of plantation failure may be sufficient to exclude a unit from consideration for red alder production (e.g., a severe frost pocket). If a unit has an “undesirable” characteristic that does not increase the risk of mortality, it may still be acceptable for red alder production depending on the combination of other factors (e.g., S to SW Exposure). A site with multiple “undesirable” characteristics is probably unacceptable as a red alder management unit (e.g., S to SW exposure and excessively drained soils).
Select sites with a low risk of regeneration failure. Poor soil drainage, frost, drought and difficult to control weed communities can hinder successful plantation establishment considerably.

Although naturally occurring red alder can tolerate poorly drained soils, careful examination shows that it occupies only the better drained micro-sites within the irregular topography of a wet site. The establishment of a well-stocked plantation is significantly hindered on wet sites because suitable micro-sites occur infrequently and are poorly distributed.

Newly planted seedlings are adversely affected by poor drainage. Where saturated soils persist into the growing season, poor drainage induces seedling mortality and also severely restricts root growth of those seedlings that survive periodic soil saturation. The diminished root system can predispose newly planted seedlings to later summer drought stress. Given the heavy herbaceous weed communities that can develop on these sites and limited site preparation options, drought stress effects can be compounded, resulting in considerable seedling mortality. Red alder is a riparian and upland site species—not a wet-site species.

Areas of high frost hazard should not be regenerated to red alder. These sites are associated with topographic features having a high probability of cold air drainage from higher elevations in the spring and fall seasons (fig. 1). Vegetation condition and topographic features can be used to assess the likelihood that a site is in a cold-air drainage. Red alder and other naturally occurring woody vegetation can show evidence of previous frost events. Areas where fog hangs for long periods indicate potential for a frost pocket. Valleys exhibiting a gentle gradient from high elevation areas or topographic features that form blockages tend to slow the flow of cold air and be more frost-prone. Frost risk is increased if there is a cold-air dam such as a ridge of mature trees downhill or downwind (a planting unit that is surrounded by timber can create a frost pocket).

There is evidence that soils with a high summer water table may be more prone to frost risk. These soils provide a good supply of late-growing season soil moisture—prolonging red alder growth well into the early fall. Alder in this de-hardened state are very vulnerable to early frost. This type of an effect is usually very clustered within a plantation. Exposed sites in the Cascade foothills, that are prone to east-winds in the winter, also have a high risk of freeze related mortality and damage. The effects of cold associated with normal seasonal weather can be mitigated a considerable amount through site selection. However, young red alder plantations will always be vulnerable to the effects of arctic outbreaks in the early-autumn because red alder tends to grow late into the growing season and is usually not hardened-off by early-autumn.

Summer drought and heat stress contribute significantly to reduced performance of newly planted red alder seedlings. Regeneration difficulties have been particularly noted on droughty sites typified by south-southwest aspects, steep slopes, and coarser textured soils. Units with heavy textured soil that have been seriously compacted from ground-based logging tend to have excessive alder mortality on logging trails—root system development seems to be seriously impeded and moisture stress results as the crown foliage mass continues to develop.

There may be portions of a planting unit that is unsuitable for red alder—frost, wind, or drought prone. If these micro-sites are large enough to be identified and flagged-out, Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) or some other species should be planted. An example of this would be units in the Cascade foothills. The mid- and lower-slopes can be ideal for red alder and the ridge-top slope position unsuitable. Steep southwest slopes in a unit with predominantly moderate slope and favorable aspect are another example.

Red Alder Site Productivity

Site productivity for red alder is an important consideration for commercial production. Site index based on the heights of an appropriate sample of trees near index age (i.e., base-age 20 or 50-years for red alder) is a common practice for making this determination. Most often site index can not be estimated directly from tree height measurements because the tree species of interest is not presently growing in even-aged stands, of the correct age, in the vicinity of
sites to be regenerated. A useful estimate of red alder site productivity (base age 50-years, Worthington 1960) can be obtained in the absence of site trees to measure following the procedures given in, “A Method of Site Quality Evaluation for Red Alder” (Harrington 1986).

The evaluation process requires that the user score soil-site factors that pertain to geographic/physiographic characteristics, soil moisture/aeration, and soil fertility/physical properties. Applying the site quality evaluation method requires the soil survey/soil series profile descriptions, long-term meteorological data, local knowledge and on-site observation.

Soil survey and soil series profile descriptions provide information on the following: 1) elevation; 2) physiographic position; 3) aspect and slope; 4) soil texture; 5) soil depth; 6) soil rock and gravel content; 7) soil parent material; 8) soil pH; 9) soil organic matter, and 10) soil bulk density. Published long-term meteorological data from the recording station closest to the planting unit is used to determine growing season precipitation (April 1 through September 30). Local knowledge is used to assess special hazards (frost pockets, exposure, wind, etc.), internal soil drainage, and approximate depth to the summer water table.

On-site observation is required to: 1) confirm the soil-site factors taken from the soil survey; 2) determine site specific special hazards; 3) verify internal drainage and summer water table depth assumptions; 4) evaluate the character of red alder growing in the vicinity of the unit (frost or heat damage, health, stem form, etc.).

Experience has shown that this approach classifies sites accurately as to good, intermediate or poor sites for growing red alder. The accuracy of the method can be increased by giving more of a deduction in site-points for droughty sites, exposed windy sites, frost pockets, and when pH in the surface soil is 4.0 or less.

Lands selected for growing red alder should be good sites and have a very low risk of poor establishment success. Generally, the best sites biologically for growing red alder are also some of the best sites for growing Douglas-fir.

Planting Stock

All stock types (containerized plug, bare-root, plug+1/2 transplant) have been used successfully to establish red alder plantations (Radwan et al. 1992, Dobkowski et al. 1994). Research trials have shown that survival and early growth of bare-root seedlings is predicted by the following morphological characteristics and other factors: (1) basal caliper (measured 25 mm above the root collar); (2) height; (3) height to the lowest healthy bud or lateral branch; (4) percent of the stem with healthy buds or branch laterals; (5) total vegetation ground cover in years 1 and 2; and (6) root system fullness. Root System fullness for bare-root seedlings is classified as follows:

Good (fig. 2)—An abundance of fibrous, flexible, heavily branched roots, and an absence of heavy, stringy, non-branched roots; root mass is dense enough to indicate a good balance with the shoot; abundant Frankia nodulation present.

Fair (fig. 3)—One or several heavy, woody, non-branched roots, but a portion of the root system is fibrous and well-branched, shoot appears proportionately heavier than the root system (i.e., shoot and roots are not “well balanced”); Frankia nodulation present.

Poor (fig. 4)—Root systems are predominately composed of heavy, woody, non-branched roots, or if there are fibrous roots, they are too few to support the tree; the root system is clearly out of balance with the shoot. Frankia nodulation is rare.

Basal caliper appears to be the most significant factor for seedling survival and growth—presumably because more stored carbohydrates are available for new root growth early in the growing season. This allows the tree to develop an active root system before the demands from rapid leaf growth begins.

Figure 5 gives an example from one experiment showing the relationship between the probability of achieving an age-1 plantation-height target and seedling root system, basal caliper and height (A. Dobkowski, unpublished data 2004). This result from a logistic regression analysis indicates that seedlings with a good root system, basal caliper of 6 mm or more, and height of 60 cm has a 0.80 probability of achieving the age-1 height target.

Results from this and other field experiments, coupled with operational experience, suggests the following specifications for bare-root seedlings (Ahrens 1994, Dobkowski et al. 1994, Molina et al. 1994, Kendall et al. 2003):

• Height—range 45-100 cm—with approximately 70% of the seedlings between 60 and 70 cm;
• Basal caliper (measured 25 mm above the root collar)—5 mm minimum caliper—with approximately 70% of the seedlings between 6 and 9 mm;
• Root systems characterized by an abundance of fibrous, flexible, heavily branched roots, and an absence of heavy, stringy, unbranched roots, root mass dense enough to indicate a good balance with the shoot; many Frankia nodules;
• Healthy branches or buds along the full-length of the stem; and
• Free from disease and top-damage.
Bare-root seedlings with these attributes, when planted on good sites and with proper site preparation, will achieve survival and height-age targets most of the time. Generally, large seedlings (large caliper, balanced height and caliper, good root systems and *Frankia* nodulation) are preferred—even when taking into consideration that the logistics of handling and planting large stock is more problematic and can incur more cost. Smaller stock types and seedlings generally have a much greater risk of poor performance.

### Weed Control

Heavy first and second-year weed competition, particularly grass and herbaceous plant life-forms, has been shown to be detrimental to red alder survival and growth (Figueroa 1988, Dobkowski et al. 1994). Weed competition thresholds based on first-year cumulative ground cover of grass/sedge, forbs ferns, and woody plants:

- Minimal Effects – Below 20%;
- Growth Impacts – 30% to 80%; and
- Survival Impacts – Greater than 90%.

Weed competition occurring late in the first growing season, and in the second growing season, can have serious impacts on rapid tree growth. Effective control of weed competition can often be the difference between plantation success and failure (fig. 6).

Figure 7 (A. Dobkowski, unpublished data 2004) shows the probability of achieving plantation height age targets by seedling basal stem diameter and height at time of planting with heavy (80%+) cumulative vegetation.
ground cover) and very-low weed competition (10%-15% cumulative vegetation ground cover). This result indicates that even seedlings with larger basal caliper (7 to 9 mm) do not perform satisfactorily under heavy weed competition. Conversely, most seedlings large enough for operational out-planting (basal caliper greater than 5 mm and height of greater than 45 cm) perform well under low weed competition.

Weed control prescriptions need to consider weed communities that existed in the under-story of the harvested stand as well as weed invasion by forbs, grasses, and woody shrubs into newly harvested areas. There are currently a very limited number of herbicides for site preparation and the release of planted red alder from weed competition. For practical purposes, all broadcast herbicide control measures must be taken prior to planting. Atrazine 90 WSP™ (active ingredient, Atrazine; Helena Chemical Company 2005; Washington State only), Accord Concentrate™ (active ingredient, glyphosate; Dow AgroSciences 2005), and Escort™ (active ingredient, Metsulfuron methyl; DuPont 2005) are registered/labeled for use in red alder site preparation. Atrazine 90 WSP can be broadcast over the top of dormant red alder as a release treatment. Accord is labeled for the release of hardwoods from weed competition, but only as a directed spray—not as a broadcast application.

**Check regulations before applying these or any herbicides—read and follow herbicide labels very carefully when applying herbicides.**

Cumulative vegetation ground cover in the first growing of less than 10-15% is desirable for rapid stand establishment and growth and to maintain ground cover in the second growing season below competition thresholds for red alder survival and growth. If ground cover of herbaceous weeds is expected to exceed 30-40% in year two, it is advisable to use herbicides in late-winter/early-spring, when red alder are still dormant and weeds are active. A broadcast application of Atrazine 90 WSP™ in late-winter and/or a directed spray of Accord Concentrate™ applied in early-Spring can be effective as a release treatment.

Anecdotal evidence suggests soil scarification that exposes mineral soil (when combined with weed control) can increase survival and growth when heavy slash/forest floor is present.

**Planting**

**Out-plant Timing**

A planting date should be selected to balance the risks of freeze damage and drought stress. The spring planting period begins when the probability of a killing frost is low and ends before there is an appreciable seasonal drying of the soil.

The recommended planting window for elevations less than 300 m, is mid-March to mid-April. Planting in November through February can result in serious freeze damage (top-kill and diminished root growth potential). Planting in late April to mid-May may not allow enough time for an adequate root system to develop before the onset of summer drought stress. It is advisable to begin planting in early March (at sites with minimal risk of spring frost) rather than planting into late April or early May.

**Other considerations at time of planting**

Red alder seedlings should be lifted from the nursery beds or styro-blocks/plugs in early January, freezer stored (-2°C) until the spring planting time is reached. Seedlings should be defrosted slowly under cover at approximately 4 to 5°C. Once the seedlings have thawed they should be cooler stored (2°C) until planted. It is advisable to keep seedlings frozen until just before the planting date—minimizing cooler storage to a week or less. Because red alder can de-harden very rapidly when removed from cold storage, seedlings stored in the field on the day of planting need to be protected from heat to prevent premature de-hardening. On-site daily storage under an insulated truck...
canopy or in the shade of standing timber covered with a heat shield (i.e., Mylar™) seedling protection tarp is recommended. Take only the number of seedlings that can be planted in one-day from cold storage to the field.

Red alder seedlings are brittle and prone to breakage. Planting crews accustomed to handling conifers need to be cognizant that alder seedlings require more care. Careless loading of seedlings into planting bags can result in considerable breakage to roots and stems. Care needs to be taken when closing the planting hole to assure that the stem is not wounded by the planter’s boot.

To partially offset the effects of heat and drought on newly planted seedlings, deep planting (ground level approximately 25-50 mm above the root collar) is recommended. Minimizing the scalping of forest floor during the planting process can reduce heat girdling; exposed mineral soil at the base of the stem from scalping acts as a heat-sink, and the thin bark of alder is readily damaged. Similarly alder planted directly against logging slash or stumps is easily damaged by sun-scald and/or mechanical abrasion—make certain that the planting spot is clear of surface slash for approximately a 30-cm diameter around the stem.

Conclusion

It is essential that “Best Management Practices” for site selection, plantation establishment and silviculture be followed in order to achieve successful red alder plantations. Achieving uniform stocking and rapid early growth, so that the stand “captures the site” within the first 3-years, is critical. It is essential that early intensive silviculture be practiced in order to assure rapid site occupancy. Rapid site occupancy by the crop promotes full stocking, rapid growth and good stem quality.

Red alder can be difficult to grow successfully in plantations – generally the species is “less forgiving” than conifers when planted on the “wrong” sites, and/or with improper silvicultural practices. For example; planting frost-prone sites or ineffective herbaceous weed control may reduce growth of Douglas-fir, but can result in extensive mortality and very poor growth of red alder. Effective weed control is more difficult for red alder because of the limited number of herbicides available for use on red alder, particularly for release treatments following planting. Also, the planting window is much narrower for red alder than for Douglas-fir (March 15–April 15 for red alder, vs. early-winter to early-spring for Douglas-fir). The consequence of planting red alder too early or too late can be excessive mortality.

Though the risks of failure and difficulty of growing red alder may be higher than growing conifers, we have learned how to mitigate the risks (through site selection, nursery practices and silviculture). The uncertainties of growing red alder must be weighed against the demand for red alder in commercial applications in the world-wide lumber market. Plantation-grown red alder can produce quality saw-logs in a relative short rotation of 25 to 30 years (compared to 60-years plus for other important North American hardwoods). Some landowners think that red alder will continue to have increasing value potential because of its desirable commercial wood properties and relatively short rotation for saw-logs.

Literature Cited


Helena Chemical Company. 2005. Section 24 (c) Registration ATRAZINE 90 WSP HERBICIDE, EPA Reg. No. 19713-76-5905, EPA SLN No. WA-050010B.

