Cottonwood Complex

This operational summary provides information about vegetation management in the cottonwood complex. Interior versions of this complex are dominated by cottonwood (*Populus balsamifera* ssp. *trichocarpa*) and may contain significant components of black twinberry (*Lonicera involucrata*), red-osier dogwood (*Cornus stolonifera*), willow (*Salix* spp.), red elderberry (*Sambucus racemosa*), thimbleberry (*Rubus parviflorus*), green alder (*Alnus crispa*), mountain alder (*Alnus rugosa*), reedgrass (*Calamagrostis canadensis*), or drooping wood-reed (*Cinna latifolia*).

The coastal version of the cottonwood complex may contain significant components of red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), red-osier dogwood, devil's club (*Oplopanax horridus*), red elderberry, or thimbleberry. Other shrubby and herbaceous species that may occur with varying abundance are stink currant (*Ribes bracteosum*), vine maple (*Acer circinatum*), and sword fern (*Polystichum munitum*).

Topics covered in this summary include development of the complex and its interaction with crop trees; non-timber values and pre-harvest considerations; and management strategies for current and backlog sites.

Other Titles in this Series

Operational Summary for Vegetation Management:

- Bigleaf Maple Complex
- Dry Alder Complex
- Ericaceous Shrub Complex
- Fern Complex
- Fireweed Complex
- Mixed-shrub Complex
- Pinegrass Complex
- Red Alder–Salmonberry Complex
- Reedgrass Complex
- Salal Complex
- Wet Alder Complex
- Willow Complex

02/02

Operational Summary for Vegetation Management

Cottonwood Complex

British Columbia

Forest Practices Branch
Ministry of Forests

Forest Renewal BC

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Operational Summary for Vegetation Complexes
Cottonwood Complex

Foreword

Managing competing vegetation during reforestation can be challenging. Combinations of plants that thrive in seral ecosystems often dominate sites following harvesting or natural disturbance. While many treatment methods for limiting the growth and spread of these vegetation complexes have been explored, the effectiveness of these treatment methods varies widely. This is due to the effects of a widely varying mix of factors, including the number, health, and structure of the competing plants on site, site conditions, treatment timing, and impact of forestry activities. In addition, while some treatments may provide suitable control, the cost in terms of site degradation, hazard to surrounding habitat or crop trees, or the cost of the treatment itself, may be prohibitive.

Much work has been undertaken in recent years by ecologists, silviculturalists, and vegetation management specialists in identifying the characteristics of, and the range of treatment options for, major competing vegetation complexes. Until recently, however, knowledge about managing particularly challenging vegetation complexes was scattered. This series summarizes the key information needed to identify and manage important vegetation complexes in British Columbia.

Introduction

Each complex includes several plant species and may be found over a wide range of ecosystems. As a result, response to treatments will vary within complexes, and prescriptions should be developed on a site-specific basis. This operational summary provides information about vegetation management issues in the cottonwood complex, including the cottonwood–red alder complex. Topics include: complex development and interaction with crop trees; treatments that affect development of the complex; non-timber and pre-harvest considerations; and management strategies for current and backlog sites.

1. Description

Species Composition

Interior versions of the cottonwood complex are dominated by cottonwood (*Populus balsamifera* ssp. *trichocarpa*) and may contain significant components of black twinberry (*Lonicera involucrata*), red-osier dogwood (*Cornus stolonifera*), willow (*Salix* spp.), red elderberry (*Sambucus racemosa*), thimbleberry (*Rubus parviflorus*), green alder (*Alnus crispa*), mountain alder (*Alnus rugosa*), reedgrass (*Calamagrostis canadensis*), or drooping wood-reed (*Cinna latifolia*).

The coastal version of the cottonwood complex is also dominated by cottonwood and may contain significant components of red alder

(*Alnus rubra*), salmonberry (*Rubus spectabilis*), red-osier dogwood, devil's club (*Oplopanax horridus*), red elderberry, or thimbleberry. Other shrubby and herbaceous species that may occur with varying abundance are stink currant (*Ribes bracteosum*), vine maple (*Acer circinatum*), and sword fern (*Polystichum munitum*).

Occurrence

The cottonwood complex is predominantly found on nutrient rich, moist, well-drained loams or sandy loams of alluvial origin and is most often found on floodplain sites. The interior version of this complex is found in the Boreal White and Black Spruce (BWBS), Interior Cedar–Hemlock (ICH), Interior Dougls-fir (IDF), Montane Spruce (MS), and Sub-Boreal Spruce (SBS) biogeoclimatic zones. The coastal version is predominately found in the Coastal Douglas-fir (CDF) and Coastal Western Hemlock (CWH) biogeoclimatic zones.

2. Complex Development

Reproduction

The cottonwood complex contains a variety of species with differing reproductive strategies.

Cottonwood is dioecious, that is, male and female flowers occur on separate trees. Between the ages of 10 and 15 years, female cottonwood annually produces abundant, highly viable but short-lived wind-dispersed seed. Cottonwood seed will germinate on a variety of favourable substrates but the greatest abundance of germination occurs on moist exposed mineral soil. Establishment of germinants requires moist soil conditions for at least the first month. While the mortality of cottonwood seedlings is high, it is the primary means of reproduction.

Cottonwood can vegetatively reproduce from stump sprouts and to a lesser extent, from root suckers. It can also regenerate from broken stems, branches, twigs, or root fragments incorporated into moist mineral soil. Cladoptsis, the natural abscission of twigs, may result in the establishment of stems.

Green, mountain, and red alder annually produce abundant wind-borne seed that may remain viable in the soil for up to one year. While alder seed will germinate on moist organic material, the primary mode of regeneration is germination on moist mineral soil in full light conditions and moderate temperatures. Germination is poor under low light conditions or when seed is buried.

Alders do not produce root suckers but can vigorously sprout from the root collar or stump when young. However, after red alder reaches 10 to 15 years in age, its ability to successfully re-sprout decreases dramatically and few trees beyond this age will produce sprouts that live for more than two years. As well, the number and vigour of sprouts decreases when stump height is less than 10 cm.

Salmonberry produces large quantities of hard-coated seed every year that can remain viable in the forest floor for very long periods of time. Seedlings will germinate on a variety of substrates but mineral soil and high light levels appear to be required for successful establishment. Seedling production is not significant in perpetuating established colonies.

Vegetative reproduction is the primary means of expansion and perpetuation of established salmonberry colonies. The spread of new shoots is achieved through the lateral extension of rhizomes. However, adventitious shoots will form on existing stems if damaged or disturbed, and the rooting of buried shoot tips has been reported. Rhizome and root fragments can be expected to re-establish new shoots following soil disturbance.

Thimbleberry, red elderberry, and red-osier dogwood have similar reproductive strategies to that of salmonberry, although red-osier dogwood produces stolons instead of rhizomes.

Reedgrass is able to reproduce both through the production of seed and through the vegetative expansion of underground rhizomes. The ability of reedgrass to produce seed and rhizomes is influenced, in part, by the light level within which the plant is growing.

Rate of Development

Cottonwood is a shade-intolerant species that attains dominance over other species within this complex through rapid early and juvenile growth. Heights of 10 m can be achieved in as little as 5 years. The best growth is achieved on coastal sites, with growth decreasing toward northern and interior locations. Cottonwood normally matures in 60 to 70 years, after which the canopy begins to break up.

Red alder seedlings require full sun for normal development but can tolerate partial shade for several years. However, when grown under low light conditions, red alder has reduced growth and may eventually die. Under full light and adequate moisture, the indeterminate red alder seedling can grow to 1 m or more in the first year. On some sites, annual height growth can exceed 3 m during the first 5 years. This rate of growth slows after the juvenile stage with height growth generally stopping after the age of 50 years. In general, red alder trees reach half of their mature height by 15 years of age.

Green and mountain alder usually exist as understorey species in undisturbed stands. Upon release into full light, these species can gradually coalesce and develop into continuous thickets within 3 to 10 years. While branch length can exceed 10 m, the average height of these species rarely exceeds 5 m.

Salmonberry is a perennial l–3 m tall shrub that can grow as much as 1.5–2 m in a single season when grown on well-aerated moist soils under full sunlight. Salmonberry has been described as shade semi-tolerant and is able to inhabit sites too shady for other species, but it cannot survive under the very low light conditions of a dense coniferous canopy.

Under the reduced light levels of a closed forest canopy, the above- and belowground biomass production of reedgrass is severely reduced. When the forest canopy is removed, either through logging or natural disturbances, reedgrass rapidly expands. Tiller and rhizome production significantly increase under full light conditions, and ground coverage rapidly expands. Reedgrass can form continuous mats within 3 to 4 years following harvest when grown in optimum conditions.

Within the coastal version of the cottonwood complex, very dense young cottonwood–red alder stands have sparse, low-vigour, salmonberry-dominated understories. As the cottonwood and red alder component ages and canopy gaps begin to appear, understorey shrub cover increases and, in the absence of conifers, salmonberry and other shrubs may completely dominate the site after cottonwood and red alder begin to die or break up (after 60 to 100 years).

Similarly, in the interior version of the cottonwood complex, the very dense young cottonwood stands have sparse, low-vigour reedgrass and moderate vigour thimbleberry and green or mountain alder understories with minor amounts of black twinberry and red-osier dogwood. As the cottonwood component ages and canopy gaps begin to appear, understorey shrub and grass cover increases and, in the absence of conifers, green or mountain alder and other shrubs may increase in abundance.

Factors that Affect Development

Treatments that increase light levels and create ground disturbance can promote the development of the cottonwood complex. The complex is relatively long-lived, and few other plant species can readily colonize and out-compete it when established. Measures should therefore be taken to inhibit or delay the establishment of the complex. The desired crop trees should be established before full development of the cottonwood complex.

Treatments or factors that favour the development of the cottonwood complex include:

- increased light levels in the stand, resulting from natural disturbances or harvesting
- ground disturbances which expose mineral soil
- light to moderate burning
- removal of other vegetation (i.e., non-crop trees and shrubs)
- low- to moderate-impact mechanical site preparation.

Treatments or factors that can impede or delay cottonwood complex development include:

- complete or partial shading (may prevent or inhibit cottonwood and red alder growth)
- dry site or dry soil conditions
- thick organic layers
- vegetation control with herbicides, for example:
  - glyphosate applied as a foliar spray in late summer
  - basal application (cottonwood and red alder) of triclopyr ester
  - triclopyr ester in water applied as a foliar spray in spring or late summer
  - cut stump application of glyphosate, triclopyr ester, or 2,4-D.

Interactions with Crop Trees

An important beneficial effect of the presence of the cottonwood complex is an increase in forest soil organic matter content. The rapid development of leaf area index by cottonwood can help to reduce soil moisture excesses and flooding problems. When red, green, or mountain alder occur within the complex, additional positive impacts on the growth of crop trees result from their ability to increase nitrogen, decrease soil pH, and decrease soil bulk density. On nitrogen-poor or -medium sites, a component of red alder in the stand can increase biomass production of Douglas-fir once it overcomes the light competition impacts of the alder canopy. Beneficial effects of the shrub layer may be the control or reduction of soil surface erosion, the contribution of large amounts of soil organic matter to the site, and the exclusion of other competitive species.

Cottonwood and other species in this complex compete with slower growing conifers for light. Shade-intolerant species, such as Douglas-fir and lodgepole pine, cannot survive for long periods under dense to moderately dense cottonwood canopies. Light levels beneath vigorous young cottonwood stands of moderate to high density are generally very low. Once cottonwood canopies close, light levels below 5–10% should be expected. At such low light levels, survival and growth of even highly shade-tolerant conifers (e.g., western hemlock, western redcedar, and true firs) are likely to be very poor. When understorey vegetation is well developed, such low light levels can also be found, even when cottonwood densities are lower.

Because of its rapid rates of growth, growing cottonwood in mixture with shade-tolerant conifers will likely require maintaining cottonwood densities at very low levels, except on sites where growth of cottonwood is poor. A promising alternative is to grow cottonwood in strips or patches interspersed with conifer patches. This approach will involve planting and treating the conifer "clusters" (i.e., cluster planting). Cluster size and orientation should be planned to balance beneficial effects of cottonwood cover with its competitive effects. Contributions of cottonwood litter to soil organic matter are likely to extend about one tree length from the cottonwood.

A canopy of cottonwood may also reduce the frequency of spruce leader weevil (*Pissodes strobi)* attack on Sitka spruce and white spruce seedlings and saplings. Side shade from adjacent patches or strips of cottonwood may reduce leader weevil damage for a distance of 5–10 m north of the edge of young (10 m tall) stands. Influences on weevil damage are expected to extend northwards from strips or patches of cottonwood for about one tree (cottonwood) height. Such influences are not expected to extend southward from a patch or strip of cottonwood.

Both cottonwood and red alder are early successional species that require a major disturbance to replace themselves under an established shrub canopy. Dense shrub canopies can reduce volume growth of both cottonwood and red alder during initial growth periods. The growth of moderately shade-tolerant species, such as western redcedar, Sitka spruce, and white spruce, can be suppressed by the presence of cottonwood canopies. Mats of leaf litter from both the broadleaf and shrub canopies may also prevent germination or smother small seedlings of shade-tolerant crop trees.

Cottonwood may impair the ability of alder to fix nitrogen through competition for light, and cottonwood litter may have minor allelopathic impacts on the nitrogen-fixing capabilities of the alder root nodules.

3. Management Consideration for Other Resource Values

Cottonwood, living and dead, provides shelter, cover, feeding sites, denning sites, and nesting cavities for a variety of wildlife species. A substantial number of primary and secondary cavity nesters, such as pileated woodpeckers and tree swallows, utilize cottonwood of advanced age and decay. The large branches provide nesting sites for many species such as bald eagles and great blue herons. Several ungulates plus beavers forage on the branches and young saplings. Cottonwood also has a variety of craft, food, and medicinal uses; early spring catkins are a source of vitamin C; the cambium can be used as an emergency food; buds can be used to produce Balm of Gilead; salicin and populin can be extracted for pain relief.

Red alder is believed to support greater invertebrate biomass than other associated tree species. With advanced age it also provides short duration cavity nesting and feeding sites and, in younger stages, can provide nesting and breeding habitat for a variety of species. For example, deer, elk, beaver, and mountain beaver will forage on red alder leaves or twigs. However, red alder grows so rapidly that it is within the range of browsing animals for only a short period after the beginning of its second year. Red squirrels will feed on the catkins and deer mice, shrews, and red-backed voles will feed on the seed.

The shrub component of this complex provides important forage for many species: foliage and stems may be browsed; berries and flower nectar are consumed.

This complex is commonly found in riparian and moist areas. The rapid growth of cottonwood and alder can contribute to stream quality and the litter of complex constituents can contribute detritus to streams. However, the establishment and maintenance of a minor component of longer-lived conifers may be desirable in riparian zones to provide conifer woody debris and to contribute to diversity in the riparian zone. The rapid above-ground and belowground growth of this complex can also contribute to stream bank stability when disturbance results in a loss of bank integrity.

4. Pre-harvest Considerations

Silvicultural System

Most plant species potentially occurring in the cottonwood complex are photosynthetically most efficient under higher light levels such as those of forest clearings. In open canopy forests with moderate understorey light

levels, green alder, mountain alder, thimbleberry, red-osier dogwood, reedgrass, and salmonberry have moderate aboveground growth but salmonberry, thimbleberry, and reedgrass may have a significant amount of rhizome production. Cottonwood and red alder growth rates are significantly reduced under forest canopies. The creation of large openings, thus full light, in these stand types creates conditions that will lead to rapid full site occupancy by potentially any of the components of this complex. Where establishment of shade-tolerant conifers is the management objective, a shelterwood system should be used to favour establishment of conifers over intolerant cottonwood and red alder and to inhibit growth of shrub and herb layers. The shelterwood system must ensure that post-harvest understorey light levels are low enough to restrict aboveground biomass production of the shrub and grass species and the germination of cottonwood or red alder. At the same time, light levels must be sufficient for adequate survival and growth of the desired crop tree seedlings. Light levels (growing season average) should be maintained above 15–20% of those in the open to achieve consistent survival of shade-tolerant species. Light levels above 30% are desirable for reasonable growth rates, with growth reaching maximum at light levels above 60%. To minimize the potential for cottonwood or red alder ingress, the technique of harvesting should avoid excessive soil disturbance. If the main focus of site management is removal and reforestation with cottonwood, red alder, Douglas-fir, lodgepole pine, or other shade-intolerant species, manipulation of light levels may cause significant growth suppression of the desired crop species. Under these situations, complete removal of the overstorey may be required to set the stage for other site manipulation techniques to control the non-crop vegetation in this complex.

Under the reduced light levels of a closed forest canopy, aboveground and belowground biomass production of the shrub and grass species is severely reduced and usually cottonwood or red alder are non-existent. The presence of shrubs and grasses under these conditions is minimal. Thus, the number of plants surviving harvest may not lead to rapid full site occupancy through vegetative expansion. Excessive soil disturbance and mineral soil exposure following the harvest of a closed canopy forest may promote colonization and development of the cottonwood complex through re-growth from the rhizome, root, and stem fragments, and through the germination of wind-deposited seed or seed stored in the soil. If mineral soil exposure is kept low during harvesting, development of the cottonwood complex may be avoided.

When cottonwood forms a component of the pre-harvest stand structure, retention of all or a portion of the cottonwood stems may inhibit some root and stump sprouting and the avoidance of branch breakage during falling and yarding may aid in the avoidance of stem sprouting. As well, retention of cottonwood may have the beneficial effect of maintaining some vertical structural diversity through to the next rotation.

The silvicultural system chosen must therefore take into consideration the level of understorey light, the level of non-crop vegetation site occupancy existing prior to harvest, and the shade tolerance of the desired crop species. When an open canopy structure exists and shade-tolerant crop species are preferred, systems that promote some shading (i.e., shelterwood or selection) may reduce the level of competition that will occur on the site. When shade-intolerant crop species are preferred, or under closed canopies where low pre-harvest understorey light levels and low numbers of non-crop plants exist prior to harvest, large openings may be created through clearcutting, retention, patch clearcutting, or seed tree systems. In all cases, the exposure of mineral soil should be kept to a minimum.

Advanced Regeneration

The retention of advanced regeneration may reduce some of the competitive impacts of this complex. Advanced regeneration of sufficient size will not be subjected to early light competition, and taller advanced regeneration may be able to withstand or even extend the duration before light competition from cottonwood or red alder becomes significant. High levels of advanced regeneration may also provide some shading of the site, thus reducing the competitive effects of this complex.

Method of Reforestation

Reliance on natural regeneration of conifers is not recommended due to typical delays in seedling establishment that will allow the full development of the cottonwood complex before the majority of conifer tree seedlings are large enough to withstand its competitive impacts. Tree seed falling beneath the non-crop canopies may not have enough light to germinate, and any seedling that does germinate may be smothered by leaf litter.

In general, since the competition-free window for this complex is relatively short, the most effective means of rapidly establishing a crop of desired tree species is planting. Plantations should be established prior to site domination by any of the species within this complex. Even if the desired crop tree is cottonwood or red alder, planting should still be undertaken to ensure full site occupancy by the trees prior to full establishment of the non-crop component of this complex.

Natural regeneration of cottonwood can occur from both seed and vegetative sources. Successful regeneration from seed requires sufficient areas of exposed moist mineral soil during the flowering season. An adjacent seed source is also highly beneficial. New stems can also originate from intact and broken roots, stump sprouts, and from buried stems and branches. The successful establishment of vegetative sprouts can be enhanced if harvesting occurs early in the year after the ground has thawed and the soil is moist but before spring growth has started. Natural regeneration of cottonwood may result in uneven spacing of the stems across the site; some areas may have very low densities and other areas may have very high densities.

5. Vegetation Management for Current Sites

Site Preparation

General

A harvesting or mechanical site preparation method that causes mineral soil exposure provides an ideal seedbed for all components of this complex. Such a disturbance may also stimulate the germination of buried seed. Damage caused to existing plants may stimulate re-sprouting and the spread of rhizome and stem fragments. Vegetation management under the diversity of reproduction strategies in this complex is, therefore, relatively difficult. Caution must be exercised because control of one component of this complex may release another equally or more competitive component.

Mechanical

Since the majority of cottonwood complex sites occur on moist soils, extreme caution should be employed when using heavy machinery for mechanical site preparation.

The spread and colonization of cottonwood and the other constituents of this complex may be favoured by light- to medium-impact mechanical site preparation treatments. Treatments that expose and mix the upper mineral horizons will sever and spread reedgrass, thimbleberry, or salmonberry rhizomes and buried thimbleberry, red-osier dogwood, or salmonberry seed throughout the treatment area. These rhizomes and seed can quickly establish new plants, thus compounding their competitive impacts. Rhizome elongation from existing plants has been found to be greatest through soils with low bulk density. The exposed mineral soil can also create conditions that may allow for the germination of cottonwood, red alder, green alder, mountain alder, or reedgrass seed and the establishment of new plants. Thus, these treatments may effectively increase the rate of development of the cottonwood complex.

High- to very high-impact mechanical site preparation can control the establishment and growth of this complex if the stem fragments, roots, rhizomes, and buried seed are removed from the soil. However, in most cases, as with the low- to medium-impact site preparation, the freshly exposed and mixed mineral soil creates seedbed conditions that favour the establishment of non-crop seed. Mechanical spot cultivation (1.5 m × 1.5 m patches) to a depth of 45 cm may create enough of a competition-free window to aid in the establishment of the desired crop trees.

Non-crop vegetation densities on scarified sites can be higher than on unscarified sites. Retention of the organic layer may minimize the colonization and site occupancy by most of the non-crop plants within this complex.

Manual Scalping (Screefing)

Manually scalped planter spots (30 cm × 30 cm) does not usually provide enough of a competition-free window to allow sufficient establishment of desired crop trees. Like some forms of mechanical site preparation, scalping may promote the spread and establishment of non-crop vegetation by creating a favourable growing site and promoting spread through rhizome severing, stem fragment burying, and buried seed exposure. Such small patches may be ineffective in compensating for the rapid height growth, and its associated light competition, of non-crop vegetation.

Prescribed Fire

Less intensive (low to moderate) burns have been found to have little damaging impact on existing thimbleberry, green alder, mountain alder, red-osier dogwood, reedgrass, and salmonberry plants. The fire may remove the aboveground portion of these plants but has minor impact on the belowground rhizomes or buried seed. Shoot re-growth from the rhizomes and establishment of new plants from buried seed may increase the amount of these species over that which was present prior to treatment. Only very high intensity burns that destroy the majority of the organic layer, including rhizomes and seed bank, are effective in controlling the major species of this complex. Even when the cottonwood and red-alder seeds are destroyed by the burn, they are the first trees to become established through wind-dispersed seed on burned-over areas. Thus, burning may provide a very short competition-free window in which to establish the desired crop trees. Once the cottonwood complex is established, burning may be very difficult due to the very low flammability of cottonwood and red alder.

Chemical

Chemical treatments have successfully controlled all non-crop components of the cottonwood complex.

Foliar applications of glyphosate (1.5–2.1 kg ae/ha) during the growing season can control cottonwood, mountain alder, red elderberry, reedgrass, thimbleberry, salmonberry, red alder, and green alder. A late spring to late summer foliar application (1.0–2.0 ae/ha) of triclopyr ester can control red alder, red elderberry, and salmonberry. An early foliar application of triclopyr ester (3.0–4.0 ae/ha) can control thimbleberry and an early to late summer foliar application of triclopyr ester (2.0–3.0 ae/ha) can control green alder. Lower dosage rates run a high risk of being ineffective.

Basal application, stem injection, and cut-stump application of triclopyr ester, 2,4-D, or glyphosate (any season) have been found to be very effective in causing severe damage to mountain alder, green alder, red alder, and cottonwood stems. However, it should be noted that controlling one species component of this complex may cause the release of another component that can lead to an increase in competitive species density and canopy closure on the site.

Application of granular hexazinone (Pronone®) at 4 kg ai/ha in spring has provided excellent control of reedgrass for 5 years after treatment. However, the effectiveness of hexazinone for controlling cottonwood and red alder is highly variable. In most cases, good control can be achieved only on soils with low soil organic matter content and shallow surface organic horizons (<5 cm deep).

Seeding with Cover Crops

Where the site has been prepared by continuous mechanical site preparation or broadcast burning and existing non-crop plants or rhizomes are not present, seeding of agronomic grasses or legumes may prevent or reduce the establishment of most potential constituents of this complex. However, vigorous growth of agronomic species is likely on these sites and may seriously impact survival and growth of tree seedlings through competition, vegetation press, and providing ideal habitat for voles and other rodents. The seeding of agronomic species may be ineffective if established plants or their roots are alive in the soil following site preparation. In these situations, the non-crop vegetation may be able to out-compete the agronomic species and dominate the site.

Biological Control

Livestock Grazing

Most of the species of this complex, with the exception of red-osier dogwood and reedgrass, have moderate to low palatability and are not favoured by livestock. Trampling damage may provide some control by preventing significant height growth. Species shifts may occur as a result of grazing.

Red-osier dogwood has fair to good forage value but is not a preferred forage species. If plants are small enough (less than 1.5 m in height) and grazing pressure is high, utilization of the red-osier dogwood will occur. Repeated entries will be required.

Early growth of reedgrass is moderately palatable to sheep but becomes less favoured as the season progresses. When little other forage exists, sheep grazing appears to provide moderate to excellent control in the year of grazing if at least two grazing passes are made over the site. Several years of grazing on a site may actually increase the dominance of reedgrass. When the preferred forage are eaten more readily the growth and dominance of reedgrass is favoured.

Planting

Timing

Planting of preferred crop trees should occur immediately after harvest or site preparation in order to take full advantage of the competition-free window. The longer the cottonwood complex is allowed to establish following harvesting or site preparation the lower the success rate of reforestation efforts.

Stock Type

Stock types that exhibit little check in growth following planting will maximize post-planting height increment. They are able to exploit the competition-free window and successfully become established as desired crop trees. Large (415D or greater) vigorous planting stock with well-developed root systems improves seedling survival on cottonwood sites. Larger caliper seedlings may be better able to withstand any potential mechanical damage. Planting cottonwood whips, 1–2 m tall, results in the best potential for achieving desired stocking of this species if there is scarce cottonwood in the pre-harvest stand and adjacent area or if a dense shrub cover already exists.

Species Selection

In the CDF, grand fir (Bg), western redcedar (Cw), and Douglas-fir (Fd) are the preferred coniferous species and cottonwood (Act), red alder (Dr), and bigleaf maple (Mb) are productive broadleaf species for reforestation on most site series where the cottonwood complex has the potential for developing. On moist and wet CWH subzones, amabilis fir (Ba), Sitka spruce (Ss), and Cw are preferred coniferous species and Act and Dr are productive broadleaf species for reforestation on most site series where the cotton-wood complex has the potential for developing. On drier CWH subzones, Bg and Cw are the preferred coniferous species and Act, Dr, and Mb are productive broadleaf species for reforestation on most site series where the cottonwood complex has the potential for developing. In the BWBS, SBS, and MS zones on site series where the cottonwood complex has the potential for developing, spruce (Sw, Sx) and lodgepole pine (Pl) are the preferred coniferous species and Act and aspen (At) are productive broadleaf species for reforestation on most. On the site series of the ICH where the cottonwood complex has the potential for developing, Sx, Cw, or subalpine fir (Bl) are the preferred coniferous species and Act, At, and birch (Ep) are productive broadleaf species on most. In the IDF, Fd, Pl, and Sx are preferred coniferous species and Act and At are productive broadleaf species for reforestation on most site series where the cottonwood complex has the potential for developing.

If a silvicultural system which results in lower than full light levels in the understorey is employed or the cottonwood complex is well developed, Cw, Ss, Bg, spruce (Sw, Sx), Ba, or Bl may be the more suitable choices. Douglas-fir, Pl, Act, Mb, At, or Dr should be used only where there is full sunlight and the microsite of seedling establishment is relatively free of competition. Red alder, At, and Act seedlings have a very low tolerance to the competitive impacts of non-crop vegetation.

Spruce (Ss, Sx, Sw) should be used only if spruce leader weevil resistant genotypes are employed or in areas with low spruce leader weevil hazard.

Cluster Planting System

A cluster planting system can reduce the cost of post-planting vegetation management activity. The system can provide an option for growing mixtures of conifers and broadleaved species and can also integrate the needs of silviculture with those of wildlife habitat management.

The number of trees per cluster required to meet minimum and target stocking standards should be determined according to the site prescription, the conditions of the site, and the associated stocking standards. Factors to consider include the size of the available microsites and their distribution, species selection, anticipated post-free growing mortality, the ability of the trees to self-prune within the cluster, and the size and shape of coniferous and deciduous stocking.

Brushing

General

The need for brushing treatments will depend largely on the success and timing of the initial planting. Since most of the components of the cottonwood complex are able to rapidly re-occupy a site from underground rhizomes, stem base re-sprouting, and/or buried seed, few brushing techniques will provide anything but short-term competition relief for crop trees. Red alder, on the other hand, is susceptible to long-term control through brushing. In managing vegetation of this complex, it is important to know that removing the cottonwood and the red alder species can result in an increase in density and canopy closure of other non-crop components.

Manual

Manual cutting of cottonwood is not an effective method for reducing stem numbers or cover. Cottonwood will sprout vigorously regardless of the timing and frequency of treatment, and manual cutting may result in a 25-fold increase in the number of shoots or sprouts per stem. Thus, where manual cutting is the only option available, re-treatment may be required.

Spacing of young cottonwood to acceptable densities (800–1800 stems/ha), however, may provide a period of reduced competition while reducing the re-sprouting vigour of cottonwood and other components of the cottonwood complex (i.e., red alder and trembling aspen). The lower light levels associated with the spaced cottonwood canopy may also reduce the expansion of shrubs, forbs, and grasses. The reduced expansion and re-sprouting vigour of the competing vegetation may result in a lengthening of the period between re-treatments.

Alternatively, removing competing trees and shrubs within a 1–1.5 m radius of young crop tree seedlings may ensure desired crop tree establishment, with spacing of the deciduous overstorey planned to occur when its competition begins to impact the growth and vigour of the crop trees.

A double girdle, each at least 1.5 cm wide and 10 cm apart, removing only the bark and cambium on trees greater than 3 cm DBH, as low on the stem as possible, may be effective in killing cottonwood. Basal sprouting and girdle bridging may occur, however, allowing for tree survival. Death of successfully girdled cottonwood, depending on size, can take 2 to 3 growing seasons.

Red alder trees, older than 15 years, can be controlled effectively by manual cutting. Even if sprouts occur, they rarely live longer than 2 years. On the other hand, younger alder trees can sprout vigorously with the greatest amount arising on cut stems between 1 to 3 years old. The effectiveness of cutting increases when treatment occurs in mid-summer or when the cut stump is within partial or full shade. Stump heights below 10 cm have been shown to have lower numbers and less vigorous sprouts.

On red alder trees greater than 3 cm DBH, a single girdle (at least 1.5 cm wide), that removes only the bark and cambium as low on the stem as possible, has shown to be completely effective in killing red alder. Death of girdled red alder, depending on size, can take 2 to 3 growing seasons.

Manual cutting of salmonberry, thimbleberry, red-osier dogwood, and elderberry stimulates rapid re-sprouting from stem bases and rhizomes and can result in an increase in crown closure on the treated site. Manual cutting treatments of these shrubs should focus on maximizing the light available to the target crop tree during the bud elongation and bud setting phase of determinate conifer seasonal growth (late foliar to early summer) since removal of these shrubs from the site through manual cutting is unlikely.

Cutting of reedgrass manually has little impact. The re-growth from rhizomes and parental bases rapidly replaces the ground coverage of reedgrass lost to cutting. Manual cutting or bending of reedgrass late in the growing season prior to snowfall may prevent seedling damage by vegetation press.

Physical Barriers

Large (90 cm × 90 cm) plastic mulches, when firmly anchored to the ground, may provide a competition-free microsite during the first year if placed promptly after disturbance. Larger (2 m × 2 m or larger) mulches are required to provide more enduring (and effective) competition control in this complex. However, mulches are unlikely to be sufficient to control competitive effects of cottonwood or alder on conifers.

Chemical

As described under "Site Preparation (Chemical)," chemical treatment may control almost all competitive components of the cottonwood complex. A foliar application of glyphosate (1.5–2.0 kg ae/ha) during late summer may provide a sufficient competition-free window to ensure crop tree establishment and survival. In some cases, one or more re-treatments (2 to 3 years apart) may be necessary to provide sufficient levels of competition control to improve conifer performance. Care must be taken to ensure that damage to the desired crop trees does not occur during application.

Glyphosate application over plantations of Douglas-fir, Sitka spruce, white spruce, or true firs must be conducted in late summer or fall to minimize crop tree damage. Glyphosate herbicide will severely damage sprayed western redcedar, yellow-cedar, and western hemlock. Triclopyr ester applied in an oil carrier will severely damage oversprayed conifers. Foliar applications of triclopyr ester (in water) during dormant periods (late summer and very early spring) at rates below 2 kg ae/ha can be used for release of Douglas-fir, grand fir, and western hemlock.

Basal bark application of triclopyr ester to target cottonwood, red alder, mountain alder, or green alder stems will provide effective control, as will stem injection of red alder with triclopyr ester, glyphosate, or 2,4-D. Cut stump application of glyphosate, triclopyr ester, or 2,4-D will effectively control treated stems. If desired, these basal bark, injection, or cut stump treatments can be targeted to control trees to a specified residual density or

within a prescribed (1 m–1.5 m) radius of crop conifers. When using basal bark application of triclopyr ester in mineral oil, care is required to avoid herbicide application to conifers.

Livestock Grazing

As described under "Site Preparation (Biological)," most of the species of this complex, with the exception of red-osier dogwood and reedgrass, have moderate to low palatability and are not favoured by livestock. Trample damage may provide some control by preventing significant height growth, and browsing activities may cause species shifts towards other less competitive species. To avoid browsing damage, livestock grazing should not occur during active crop tree growth.

6. Vegetation Management Strategies for Backlog Sites

General

The cottonwood complex changes little over time; thus, there is little difference between the established complex on current and backlog sites. The same vegetation management strategies employed on current sites can be applied to backlog sites.

Planting

If the cottonwood or cottonwood–alder canopy is partially or fully closed, it may act as a nurse crop for any shade-tolerant crop species established in the understorey. Similar methods as described under "Vegetation Management For Current Sites (Planting)" should be used to establish the shade-tolerant crop trees underneath the cottonwood or cottonwood–alder canopy.

Brushing

A cottonwood or cottonwood–alder overstorey canopy may act as a nurse crop and reduce the density and crown closure of the shrub and grass layer components of this complex. If the broadleaf overstorey is acting in this manner, attempts to release the understorey crop trees should ensure that they are well established and able to withstand the competitive effects of the also-released shrub and grass layers.

7. Summary

The most effective methods for controlling cottonwood complex appear to be treatments that inhibit or remove the ability of non-crop competing vegetation to colonize the site. Reduction of the competitive impacts of this complex must begin with the choice of harvest system and reforestation methods employed. In addition, all subsequent treatments must consider the potential growth response of the complex under the resulting microsite environment. While one treatment alone may provide some control, the most effective control of the cottonwood complex should be viewed as a system or series of treatments.

If the cottonwood complex fully develops on-site before the establishment of the desired crop trees, the effectiveness of most available vegetation control methods decreases. Successful plantation establishment in this plant community is consistently associated with prompt initiation of reforestation activities after disturbance.

Where herbicide use is not an option, an effective cultural approach of managing the cottonwood complex appears to be the following:

- minimizing the exposure of mineral soil and retention of undisturbed organic layers during harvest
- an immediate mechanical spot cultivation (1.5 m × 1.5 m patches) to a depth of 45 cm
- planting of large vigorous stock types of fast-growing crop species as soon after site preparation as possible
- 2 to 5 years after harvest, manually brushing a 1–1.5 m radius around each crop tree in the mid-May to end of June period, for 1 or 2 years. This may provide for enough crop tree height growth to allow the seedlings to overtop the shrub competition
- girdle the cottonwood and red alder once the stems achieve DBH of at least 3 cm. An appropriately placed 1.5 cm wide girdle (two girdles 10 cm apart on cottonwood) that completely removes the bark and the cambium has been shown to be effective in removing these species
- spacing of young cottonwood stands to densities below 1800 stems/ha may also provide sufficient reduction in competition to achieve reasonable levels of growth on shade-tolerant conifers, and may reduce cottonwood re-sprouting vigour.

Among chemical treatments, a foliar application of glyphosate (1.5–2.1 kg ai/ha) can provide several years of control of a broad range of species found on these sites. Basal bark application of triclopyr ester, stem injection with triclopyr ester, 2,4-D, or glyphosate, or cut stump application of triclopyr ester, 2,4-D, or glyphosate also provide very effective control of cottonwood and red alder.

However, chemical and non-chemical treatments, used in combination, have been shown to be most effective in managing sites that currently have or have the potential to develop the cottonwood complex. Most effective is a series of treatments following this sequence:

1. the minimization of mineral soil exposure during harvest
2. an immediate mechanical spot cultivation (1.5 m × 1.5 m patches) to a depth of 45 cm
3. planting of a fast growing crop species
4. after approximately 2 to 3 years, a foliar application of glyphosate, if necessary.

If the cottonwood complex is already well established, a chemical site preparation with glyphosate would be required prior to planting.

Any treatment of these sites should be assessed for its impacts on all competitive species in this complex and stand management objectives. Control of only one competitor in the complex can potentially lead to site domination by one or all of the other competitors and result in higher

competition for resources with the desired crop species than existed prior to treatment. In all cases, monitoring the non-crop species growth on these sites is essential in effective management.

For More Information

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