GROWING BALSAM FIR CHRISTMAS TREES IN FIELD AND FOREST

by

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ABSTRACT

High quality balsam fir Christmas trees produced in natural forest sites and in field plantations are the result of several years of nurturing. This report discusses stand development, site preparation, planting, tending, and culturing procedures. Trees in natural stands must have adequate space, available nutrients, and protection for growth and development. Thinning (spacing) is necessary throughout the rotation on natural sites with abundant stocking; where stocking is sparse fill planting supplements natural regeneration. Fertilizers increase foliage production thus enhancing tree quality and shortening rotations. Control of insects, diseases, and competition from other vegetation, which often threaten the viability of a Christmas tree operation, require vigilance and the correct use of pesticides and good cultural practices. Establishment of a field plantation requires site preparation, suitable stock, and proper planting. Seedlings for outplanting may be nursery grown bareroot or container stock, or wilding transplants. Mowing and the judicious use of herbicides throughout the rotation protect the plantation trees from competition. Fertilizer may be of little importance during the first two years after outplanting, but when established, balsam fir usually responds to additions of fertilizer especially nitrogen. A shearing-pruning program should begin at outplanting to correct defects, such as double tops. When the crown is about 1.3-1.8 m (4-6 ft) in height, overall shearing to promote foliage build-up and tree symmetry should commence. Trees should then be sheared each year till harvested.

RESUME

Les sapins baumiers de qualité élevée produits comme arbres de Noël dans les forêts naturelles et les plantations sont le résultat de plusieurs années de soins. On examine dans ce rapport les méthodes utilisées pour le développement des peuplements, la préparation du terrain, la plantation et l'entretien. Les arbres dans les peuplements naturels doivent disposer de suffisamment d'espace, de substances nutritives et de protection pour croître et se développer. Des éclaircies (dépressages) doivent être pratiquées pendant toute la révolution dans les peuplements naturels où la densité est élevée; aux endroits où la densité est faible, des regarnissages sont effectués pour suppléer la régénération naturelle. Les fertilisants permettent d'accroître la production de feuillage et d'améliorer ainsi la qualité des arbres et de raccourcir les rotations. Il est nécessaire d'exercer une lutte vigilante contre les insectes, les maladies et la végétation concurrente qui souvent menacent la viabilité des plantations d'arbres de Noël, et d'employer à cette fin les méthodes chimiques et culturales appropriées. Pour l'établissement d'une plantation, on doit faire attention à la préparation du terrain, au matériel utilisé et à la plantation elle-même. Le matériel utilisé peut être constitué de plants à racines nues ou en récipients produits en pépinière ou encore de semis naturels. Pendant toute la rotation, on protège la plantation contre la végetation concurrente en tondant cette dernière et en appliquant de façon judicieuse des herbicides. On peut ne pas avoir besoin d'engrais au cours des deux premières années suivant la plantation, mais, une fois implantés, les sapins baumiers répondent ordinairement aux engrais, surtout à l'azote. Un programme d'émondage-élagage devrait être mis en oeuvre dès la plantation afin de corriger les défauts, surtout les pousses apicales doubles. L'émondage général pour favoriser la production de feuillage et une croissance symétrique devrait commencer lorsque l'arbre mesure environ 1,3 à 1,8 m (4 à 6 pieds) de hauteur. Les arbres devraient ensuite être émondés chaque année jusqu'à la récolte.

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INTRODUCTION

Of the many evergreens grown for Christmas trees none better fulfills the image of the traditional tree than balsam fir. In addition to its natural conical form, pliable branches, and good needle retention, fir emits a pleasant aroma unique to balsam.

Balsam fir Christmas trees reach prime marketability, a height of 1.8-2.4 m (6-8 ft) in about 10 to 15 years from seed. The needles, unlike the foliage of some evergreens, retain or intensify their green color throughout the fall season and hold firmly to the twigs after the tree has been harvested. Needles usually live at least six years and, on trees fully exposed to sunlight, grow spirally around the twig. Internodal shoot growth is profuse on healthy trees and contributes significantly to a full-foliaged crown. Fir responds well to the cultural practice of shearing, becoming a uniformly dense symmetrical cone under the practiced hand of the experienced grower. Seeds are usually produced on trees 20 or more years old; a few on the occasional tree most years and in great abundance at two to four year intervals. Until recently, this natural seed source has been the sole supply for stocking in cultivated wild stands.

This report provides guidelines for site selection and preparation, planting, tending, cultural procedures, and overall stand development.

Site Considerations

Balsam fir grows well over a wide range of soil and site conditions, especially in the Maritime climate of the Atlantic Provinces. Growth appears to be best in deep sandy loams on gentle slopes with good drainage (Bailey 1981). Because these sites are also highly valued as agricultural land, tree growers have traditionally settled for less optimal or marginally productive land. However, this practice has changed somewhat in recent years with the large-scale expansion in plantations. The high value placed on Christmas trees and the willingness of many producers to invest expertise and capital in Christmas trees as a crop have created a demand for land with high production capabilities. The quality of trees produced and the crop rotation period are important factors affecting profits and both are strongly influenced by site. Therefore, as crop values and production costs increase, the importance of site selection is magnified.

Although sites representing a wide range of soil characteristics and topography will produce satisfactory growth when correctly managed, some sites should not be considered for plantation establishment. Producers should avoid areas where the water table lies at or near the ground surface for even short periods each year. Seedling survival and growth are poor on such sites and frost heaving is often a perennial problem. Exposed gravelly hills with excessive drainage are the opposite extreme and are areas also to be avoided. Water stress is likely to result in high seedling mortality before the end of the first growing season and the growth rate of survivors will be poor. There are no practical corrections for over-drained areas, but ditching or agricultural tiles are sometimes used to drain wet areas. Mounding of the soil, usually about 15-22 cm (6-9 in.), on flat poorly-drained field sites or on soils with heavy clay content results in improved levels of moisture and soil aeration enhancing conditions for growth and survival of seedlings planted on the raised areas.

Avoid frost pockets. Damage by spring frosts is occasionally widespread in the Maritimes, but incidence is usually higher in valley bottoms or in sheltered areas where air flow is restricted. Some sites at relatively high elevations are also frost susceptible. Trees growing on south facing slopes where early spring development results in advanced shoot growth before the arrival of the frost free period are vulnerable to frost injury. Natural regeneration can serve as an indicator of frost susceptibility; frost injury results in brown twig tips throughout the summer and perennial frost injury results in deformed trees (Christie 1980).

Developing the Site for Christmas Tree Production

Establishment of boundaries and roadways and tree spacing are among the first considerations in developing a site for Christmas tree production. Surveyed property lines should be clearly marked. Ideally, all-weather roads should not be more than 60 m (200 ft) apart in either plantations or wild stands. Some growers wisely provide additional passageways through plantations by leaving two unplanted rows after each 12 or 15 rows planted. These provide access for moving equipment and materials and are especially useful when spraying for insect control.

A spacing of 1.5 x 1.5 m is adequate to produce quality Christmas trees in the 2 to 2.4 m (6 to 8 ft) height range (Table 1). Most growers however, prefer to plant at the more traditional spacing of about 1.8 x 1.8 m, while some use wider spacing only between the rows to accommodate small tractors or all terrain vehicles used for mowing. Rules for spacing wild stands are similar, but must be flexible to accommodate the various sized natural stock.

Table 1. Adequate spacing to produce quality Christmas trees

Spacing		No. of trees	
m	ft	ha	acre
1.52	5.0	4306	1742
1.68	5.5	3558	1440
1.83	6.0	2990	1210
1.98	6.5	2548	1031
2.13	7.0	2197	889
2.29	7.5	1914	774

PLANTATIONS - GENERAL

Interest in growing balsam fir Christmas trees in field plantations is increasing in the Maritimes. The high level of efficiency in producing Christmas trees in evenly spaced uniform stands makes plantations an attractive venture. Tree culture and the routine management practices of weed and insect control, fertilizing, and harvesting are more easily done under field conditions than on forest sites. Ready accessibility results in better stand surveillance and a short reaction time when conditions warrant a response. The even-aged character of plantations facilitates the selection of appropriate treatments and the timely application of optimum amounts of materials to control pests or to enhance growth. The utilization of many agricultural practices in the establishment and maintenance of plantations greatly reduces manual labor requirements, often making plantations of increased acreages a practical option. However, successful plantations require a long-term commitment of both capital and owner dedication. Returns on investments begin only with harvesting, usually 6 to 10 years after outplanting.

Site Preparation

Successful planting in fields requires some form of site preparation. This may range from weed killing on planting spots to tilling of the entire site. Plowing and harrowing are the standard way of breaking up sod and compacted areas in fields. This improves drainage and aeration, providing suitable conditions under which fertilizer and (or) lime may be applied (Hallett 1981). Some growers choose to raise the pH to about 6.0 by applying dolomitic lime in combination with tilling. Lime can be applied topically where the soil is not tilled, but because penetration through soil is slow it may take several years to reach the root zone. The pH is an indicator of acidity which in soils affects the availability of nutrients and microrganism activity. While pH 6.0 is sometimes purported to be optimum for balsam fir growth, evidence to support this position is lacking. Balsam fir grows on sites with a wide range in soil acidity (Bakuzis and Hansen 1965). Growth has been good, where weeds were controlled, in many plantations with pH near 5.0.

A soil analysis for potassium, phosphorus, magnesium, and pH is a logical step, especially if complete site preparation with amendments is being implemented. Recommendations can then be made to adjust the pH and nutrients to the desired levels Optimum soil nutrient levels for balsam fir plantations have never been clearly defined. However, Hallett's (1981) recommendations for nurseries can serve as a guideline although the nutrient requirements for field-planted seedlings may be less critical than those for seedlings in transplant beds.

Ground cover

Cover and catch crops *i.e.,* clover or buckwheat are sometimes grown and when plowed under or killed with herbicides add valuable organic and nutrient content to the soil. Varieties of short clover and grass restrict the growth of weeds and tall grasses if not plowed under, and, in the short term, provide good cover between the rows, thus reducing the need for mowing. Clover varieties are usually short-lived perennials and as they decline in density and vigor, the ground is exposed and weeds reestablish. For this reason, a low growing grass such as creeping fescue or kentucky blue grass is sown with the clover to provide a more stable cover crop (Clare *et al.* 1984).

While complete site preparation is done successfully by a few growers in the Maritimes, most plantations are established with little preplanting preparation. Many highly successful plantations have been established with the proper use of herbicides as the only means of site preparation (Fig. 1.).

Fig. 1. Site preparation using herbicides only.

Weeds

A weed is any plant that competes with a crop under management. Timothy in plantations or red spruce regeneration in natural stands are weeds when the crop is Christmas trees.

A wide variety of weeds found in the Maritimes is adapted to all site conditions of the Region. While many weed species grow best on fertile sites some, because of hardiness and growth habits or other characteristics, are particularly suited to poor sites.

Weeds compete for dominance with each other as well as with cultivated crops and any site disturbance or modification that disrupts or inhibits the growth of one species creates conditions conducive to the growth of others. Grass growth, for example, may be retarded by a single tilling or scarification while seeds of other weed species are stimulated to germinate. Thus, a different ground cover is established, but one no less competitive to young seedlings.

Herbaceous weeds differ in the length of their life cycle. Annuals and biennials complete their life cycles, after producing seeds, in one and two years, respectively. These groups reproduce only by seeds, some of which may remain viable in the ground for many years. Perennials persist for more than two years. Some perennials reproduce only by seeds while others, the most difficult to control, reproduce from both seeds and underground parts. Quack (couch) grass, one of the most common perennials in plantations, is a serious competitor that reproduces by seeds and rhizomes.

Trees, shrubs, and vines are woody perennials that reproduce by seed, and by basal sprouts or root suckers following cutting. Raspberry, blackberry, and dogwood are common shrubs troublesome both in plantations and natural stands. Red maple and oak are two of the most difficult tree species to control in natural stands; basal sprouting is stimulated when trees are cut. The aspens, when cut, reproduce prolifically by root suckers.

Weeds compete with crop trees for water, nutrients, light, and space, often overtopping young seedlings, causing poor quality foliage and deformed tops. Stress on a seedling is intensified by weed growth, especially during the first two years in the plantation. This results in slow seedling growth or can stop growth. Trees in this condition, which is sometimes referred to as planting shock, are unlikely to show an immediate growth response when weeds are removed; the usual "turnaround" period is two years. Also, stress by interference with physiological processes makes seedlings less winter hardy (Glerum 1985).

Ground vegetation has additional adverse effects on plantation establishment, maintenance, and tree growth. Weeds and grasses provide a habitat for small rodents that chew and burrow around the base of trees and in the root zone. This has a negative effect on tree growth. Pines are sometimes killed by girdling but damage is usually less severe to balsam fir.

The thought of fire in a plantation with the accompanying spectre of devastation and loss motivates producers to guard against fire hazards. Where weeds are allowed to grow undisturbed, dry dead weeds accumulate increasing the risk of fire, especially in early spring before new growth emerges.

Planting is difficult in fields with dense ground vegetation and heavy sod cover. The rate of planting is reduced and the effort is increased when planting in tightly bound sod. Planting slits in sod are difficult to close initially, and they have a tendency to reopen as the ground surface dries, thereby increasing the likelihood of a serious moisture deficiency in the root zone of the seedlings.

Weed and grass competition around established trees causes needles to drop from lower branches. This results in increased amounts of butt pruning and shortened crowns (Fig. 2). Whether the producer chooses to harvest trees of reduced size or continues the rotation to recoup lost crown height, profitability suffers.

Fig. 2. Extensive butt pruning; the result of weed competition.

A comprehensive weed control strategy should also address problems associated with soil conditions, topography, and the consequences of removal of vegetation from a site.

Frost heaving is largely limited by the amount of organic matter in the soil. Therefore, plant debris on the ground surface and in the plow layer as well as living vegetation inhibit frost heaving.

Erosion can be a serious problem resulting in significant losses of mineral soil. The elimination of ground vegetation over total areas or even in strips will contribute to erosion on some sites. Spot treatment of weeds is adequate for seedling establishment and is the appropriate method of treatment on sites subject to erosion.

Although on the short-term total vegetation control may be advantageous to growth of established trees, producers should consider both the short- and long-term implications of such a program. In addition to soil erosion and frost heaving is the long-term concern of soil degradation that results from the depletion of organic matter when total vegetation is controlled throughout the rotation. Furthermore, chemical costs are substantial and working condition on bare soil may be unsatisfactory at some times of the year, especially during harvesting.

CONTROL OF GROUND VEGETATION

The control of ground vegetation begins with preparation for planting and continues through to harvesting, often challenging both the ingenuity and resolve of growers. Strategies differ between sites and may change on any one site during the rotation. Control measures may involve cultivation and cover crops, and should include herbicides. Where cover crops are grown, seeding using standard agricultural practices is done a full year before tree planting. During this period a dense cover effectively eliminates other plant growth in the plantation; however, this cover must itself be eliminated in the area around the seedling.

Tilling, the fall before planting, temporarily eliminates competing plant growth for the newly planted seedling. However, recurring weeds and grasses will become strong competitors, overtopping many of the seedlings by the end of the first growing season, if a herbicide is not used. Machine cultivation, an option for controlling weeds between the rows in the early years of plantation establishment, is not commonly practiced in this Region.

Use of Herbicides

It is not the purpose of this report to give a detailed discription of herbicide useage. The herbicides discussed are used in Christmas tree production and are effective for most weed control programs. The manufacturers recommendations, which give instructions for application and precautions to be taken, should always be followed. In special cases, the recommendation for application presented here may be in addition to those given by the manufacturer, while in other instances specific rates are those of the manufacturer.

General considerations

Both preemergence and postemergence herbicides are widely used in Christmas tree plantations;

some herbicides are effective at both stages of plant development. The appropriate herbicide mix, for a given situation, is selected largely on the basis of time (season) of application, stage of plant development, the composition of plant growth, and, in established plantations, on tree susceptibility. Herbicides with different characteristics are often combined in one spray mix to control a broad spectrum of plant species. (The lower range of the recommended rates for each herbicide is usually adequate when two are combined.) No one herbicide will provide satisfactory control throughout the rotation, thus the need to alternate or combine herbicides.

Broad spectrum weed control can be pursued in Christmas tree plantations without the restrictions often encountered in agriculture where target weed species and cultivated crops may have identical life cycles and susceptibilities. Balsam fir exhibits various degrees of tolerance to many foliage herbicides and develops root systems deep enough to resist preemergent herbicides such as simazine.

Herbicides with water as the carrier are usually applied with hydraulic sprayers; mist blowers are also used especially in the initial weed control operations of wild stands. For particularly hard-to-kill shrubs, undiluted forms of certain herbicides may be applied by directed spot application. Granular forms of some herbicides are also available. They are not widely used in plantations, partly because of the difficulty in application. Mechanical applicators that are used in agriculture are not readily adaptable for most forestry situations. Hand application is labor intensive and uniform dosages are difficult to apply. However, granular herbicides are effective, and with the wider selection of products now available, and more field experience, herbicides in this form will probably find many specialized uses in the future.

A general improvement in soil conditions follows weed control. The breakdown of dead plants contributes nutrients and organic material to the soil. Also, the resultant increase in earthworm activity improves soil texture and aeration. The soil becomes more friable with better moisture retention capacity. This, combined with the elimination of moisture demanding vegetation, appreciably extends the drying out period of the soil, which is important especially to establishing seedlings.

Weed control covering strips 0.5 m (20 in.) wide or spots 0.5 m diameter are adequate to facilitate the planting operation and for seedling establishment in plantations (Appendix 1).

Specific considerations

Roundup and simazine are the two most important and widely used herbicides in Christmas tree production. Roundup controls a wide range of herbaceous and woody plant growth and is effective any time after leaves are fully developed until autumn coloration of foliage (Grosslard and Atkinson 1985). Early fall applications are especially effective against blackberry, raspberry, and other woody plants as well as grasses and late maturing weeds. When combined with simazine for spring or fall treatments, plant growth in fields is broadly controlled throughout the following growing season. Although the activity of Roundup may be reduced when mixed with simazine, the gain in residual control outweighs the loss. An alternative is to apply each herbicide separately a day or more apart.

Control is better when tall grass is mowed before fall applications of herbicides. Where Roundup is included in the spray mix, new grass growth should be allowed to reach a height of about 20 cm before spraying.

Kerb, used primarily for the control of grass also controls some broadleaved plants including chickweed. It must be applied in the fall in October or early November, before the ground freezes because it is active only under cold conditions. Simazine combined with Kerb increases the scope and duration of control. Kerb should not be used on first-year outplantings.

Velpar, which is effective against many herbaceous and woody weeds when used as a tank mix with water, is also used in undiluted form for spot treatments. Spot gun applicators are used to apply Velpar-L close to the root collar of shrubs to be controlled. Because balsam fir on most sites is moderately susceptible to Velpar, applications should not come within 1 m of the tree. Top sprays which should be applied in early May, may damage fir foliage.

Preplanting treatments - Fall. A fall application of simazine, Roundup or Kerb alone or in an appropriate combination gives good vegetative control for spring planting. Atrazine combined with simazine also is an effective spray.

While the manufacturers recommended rates generally should be followed, simazine at rates of 6-8 kg/ha (6-8 lbs/ac) can be safely used in most sod covered balsam fir plantations. Simazine should not be applied more than once in any one year. Where simazine and atrazine, two closely related chemicals, are used together the combined amount should not exceed the rates for simazine.

Preplanting treatments - Spring. While fall applications of simazine and atrazine are effective, some of the effect is lost during winter. Therefore, maximum control by these herbicides is obtained from early spring applications.

Simazine acts through the roots of plants with little, if any, foliar absorption. Efficacy is greatest at germination, therefore springtime applications should be made before plants emerge. If spraying is delayed until growth has begun, simazine should be combined with atrazine or a more readily absorbed foliar herbicide, *i.e.*, Roundup. Before spring growth commences apply simazine at a rate of 6-7 kg/ha (6 lbs/ac) and after growth has began add Roundup at the rate of 1-2 kg/ha (1-2 lbs/ac) or apply simazine and atrazine in equal amounts for a total of 6-7 kg/ha. Atrazine is more soluble in water than simazine and is therefore more susceptible to leaching (Aherns 1969). A lower rate of atrazine, *i.e.* a 2:1 simazine-atrazine combination would reduce the danger of injurious levels of the herbicide reach ing the root zone. This could occur on sandy soils or with excessive rainfall. Effective one-season control of vegetation in an abandoned field was obtained with a mix of 270 mL of Simadex L and 100 mL of Roundup per 14 L of water at a rate of about 560 L/ha (50 gal/ac). This translates to about 5.7 kg/ha (5 lbs/ac) of simazine and 1.5 kg/ha (1.4 lbs/ac) of Roundup. Plants must be actively growing for Roundup to be effective. Quack grass, as stated earlier, should be 15-20 cm (6-8 in.) high.

Planting, which may follow within a few days of such treatments, should be done by the slit method to avoid mixing the topmost layer of soil, containing simazine, with soil in the root zone of the seedling.

Although weeds and grass may have been killed by planting time in a spring weed control program, the sod will not have had time to break up; therefore, the difficulties of planting in sod remain.

Preplanting treatments - August planting. Roundup applied in July at the rate of 5 mL/L water per 560 L/ha kills plant growth resulting in the disintegration of sod, making conditions amenable for August planting. Tall grass should be mowed before spraying as described earlier.

Postplanting treatment. Simazine may be applied over newly planted seedlings if a preplanting treatment has not been possible, or on tilled sites. The planting slit should be tightly closed by at least one moderately heavy rain before simazine is applied to assure that none dribbles through to the root zone. The manufacturer's recommended rate of application should not be exceeded where sod cover is lacking or when top spraying recently-planted trees. There is a danger of root injury resulting from seepage through the disturbed ground surface of the planting area.

Atrazine or Roundup should not be used in top sprays over young seedlings, however, they can be applied as directed sprays. Both, especially Roundup, are effective on many weed species resistant to other herbicides. If plants are well established on uncultivated sites by planting time, the first postplanting spray with simazine will not give complete control.

Total vegetative control may not always be desirable. Some plant growth around seedlings helps to reduce erosion and frost heaving on susceptible sites.

Established plantations. Herbicide prescriptions for postplanting control can be used in established plantations to control competition around individual trees. Kerb may be applied over balsam fir as a late fall spray. As with preplanting treatments, there is broader spectrum control when simazine is combined with Kerb. However, some weeds may not be controlled by routine measures. For example, chickweed and vetch are early invaders after herbicide treatment and are very resistant to simazine. A directed spray, to avoid contacting fir foliage, of 2,4-D or Roundup in midsummer should provide control. A directed spray is difficult to accomplish on young plantations with advanced vetch growth; the young trees may be shrouded by the weed. Efforts should be made to treat vetch at an earlier growth stage; more than one treatment may be necessary. None of the herbicides presently registered for forestry use are fully satisfactory for vetch control. Hopefully some promising new herbicides will prove useful and be accepted for registration.

Balsam fir will usually tolerate Roundup at about 2.5 L/ha (1-1.25 L/ac), as a top spray in late August or September. This is an effective treatment especially for recurring grasses, perennial weeds, and most species resistant to simazine. Vetch, which produces seeds earlier in the season, is not eradicated.

Some between-the-row weed control should also be planned, especially on fertile sites. Although the seedlings are planted in treated strips, they can become overtopped by vigorous weed and grass growth between the rows (Fig. 3). Freeing the area between the rows from moisture and nutrient absorbing plant growth has the effect of increasing the tree's food supply; as trees mature their root systems extend throughout the area. This can be accomplished by extending the herbicide spray to full area coverage, but, as already noted, control that leaves the ground completely bare has disadvantages.

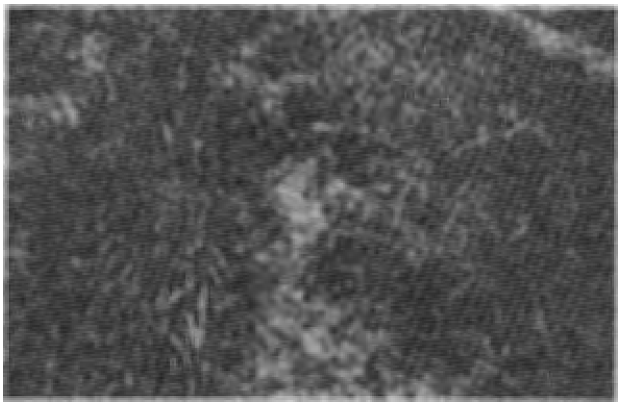

Fig. 3. Encrouching weeds and grass from untreated areas between the rows of seedlings.

Site management that results in a low ground cover may not require treatment to protect the young trees from competition. However, plant growth that creates food and a habitat for rodents and an eventual fire hazard should not be left unchecked. Repeated mowing is the preferred way of limiting plant growth between the rows. Annual weeds are largely controlled by mowing but most perennial weeds and grasses continue to grow. Although the roots of many plants remain active, mowing eliminates competition to tree foliage and reduces the fire hazard. One mowing gives inadequate control on most sites. It merely reduces competition between species allowing suppressed weeds, *e.g.,* vetch to flourish while recurring grass growth increases in vigor. Two or more mowings are usually necessary for satisfactory control.

NATURAL STANDS - GENERAL

Although field plantations are increasing in most parts of the Region, over 90% of current Christmas tree production comes from cultivated natural stands. Weed control is usually necessary in the early development of natural forest sites for Christmas tree production. Weeds, usually woody plants of many different species, as opposed to grass and herbaceous growth found in field plantations, establish quickly in most cutover sites in the Region. Hardwood sucker and sprout growth regularly follow clear-cutting of predominately hardwood or mixedwood sites while low shrubs, *e.g.,* raspberry, are usually the first to regenerate on softwood sites.

Competition (Weed) Control

Stump sprouting can be reduced or prevented by applying a mixture of 2,4-D and fuel oil to the stumps of recently cut trees. The rate of 1 kg, a.i. 2,4-D in 50 L (1 lb, a.i./5 gal) of fuel oil is recommended. Roundup at a concentration of about 10% in water will eliminate or reduce sprouting of many hardwood tree species. However, red maple, a prevalent species in most mixedwood stands in the Region, sprouts prolifically from stumps and may not be satisfactorily controlled except with a more concentrated spray. Roundup is more expensive than 2,4-D. Sprouting, usually profuse on untreated stumps, and other hardwood regeneration and shrubs can be controlled with foliar sprays, ideally, before the end of the first growing season after overstory removal.

Where the number of stumps producing sprouts is sufficient to warrant full area coverage, foliage sprays must be delayed until new balsam fir growth has hardened off. Roundup, the most widely used herbicide in wild Christmas tree stands, applied in late August or early September (before frost) at a rate of 3-5 L/ha (1.25-2 L/ac) in about 40 L/ha (16 L/ac) of water, controls most hardwoods. Although less effective than Roundup, 2,4-D at 3.4-5.0 kg a.i./ha controls many hardwood species, but not without injury to balsam fir. For this reason

2,4-D is not usually recommended for stand maintenance. However, it may be useful in early stand development where dense hardwood regeneration effectively shields the young balsam regeneration from direct spray contact and subsequent injury; minor injury at this early stage of development is unlikely to have long-term consequences.

Full coverage is usually accomplished by applying the herbicide as a mist. Aerial applications are highly efficient for large areas. Tractor-drawn mist blowers are also used with various levels of success. The relatively high concentration of herbicide used in mist sprays requires strict attention to rates of application to prevent damage to crop trees. On rough terrains, a constant speed and output angle of the tractor-drawn sprayers cannot always be maintained. Consequently, specific rates may be difficult to apply. Uniform coverage with backpack mist blowers is also difficult to accomplish. Any change in pace or hesitation by the backpack spray operator may reduce or increase the dosage severalfold in that location, resulting in either negligible control or injury to crop trees. Young balsam fir, especially recent outplantings, are most susceptible.

Tractor mounted or drawn hydraulic sprayers are also used for weed control operations on wild stands. The danger of injury to crop trees by this method of application is negligible when care is taken. Sprays are, as much as possible, directed to target weeds and, because of the dilute concentration of the herbicide, limited contact with crop trees is inconsequential. Hydraulic type sprayers require large amounts of water (upwards of 560 L/ha (50 gal/ac)), and spray time is much greater, making this method impractical for broad coverage of large areas. Usually, the amount of herbicide applied per hectare should be comparable to the amount used for mist application. However, with directed sprays the operator has the option of increasing the concentration where particularly resistant species are encountered, without endangering crop trees.

Backpack hydraulic sprayers are efficient for controlling brush, especially in established stands. As deciduous growth declines in vigor and prevalence, areas requiring treatment become smaller and more widely separated, thus making backpack sprayers practical even in moderately large operations. Total areas are sometimes sprayed with backpack sprayers equipped with an over-the-

balsam budbreak gives early season control of many herbaceous weeds, grass, and raspberry. Rates of 1-1.5 kg a.i./ha. (1-1½ lb/ac) are usually adequate. A higher rate *i.e.,* 2 lbs/ac gives better control of raspberry but, balsam fir has limited tolerance of Velpar and as rates increase the risk of injury increases, especially on sandy soils. Velpar-L at 5 L/ha (2 L/ac) equals 1 lb a.i./ac.

In early stand development, especially where scattered stump sprouts and clumps of shrubs regenerate, backpack sprayers are practical for applying weed controls. Roundup at 60 mL/5 L water (2 oz/gal) applied in late June, controls sprouts of resistant hardwood while they are still relatively small. If the sprouts are left uncontrolled, large clumps, 2 m or more in height, can develop around stumps in one growing season. Sprouts of this size compete with crop trees for space and, whether living or dead, should be cut (Fig. 4). In small operations or where sparse, brush can be controlled manually with hand tools or a brush saw.

Fig. 4. Both living and dead sprouts may compete for space.

Thinning

Thinning (spacing) is usually the first major task in the initial development of most natural stands. Where hardwood regeneration has established along with balsam fir, weeding and thinning are often combined. Of the advanced regeneration, trees up to about 2 m (6.5 ft) in height should be favored for Christmas tree production. Taller trees should be retained only when other regeneration is lacking or when the tall tree has marketable potential within two years (Estabrooks 1982). Tall trees is time consuming and hard work) are usually not good candidates for future Christmas trees.

Spacing must provide adequate growing space for each tree to maturity if trees with good form and high quality foliage are to be produced. The space between trees changes each year with annual growth, cultural practices such as shearing and butt pruning, and harvesting. Astute growers pursue stand management practices that utilize available space for maximum productivity of existing stock. Trees should have a spacing of 1.5-1.8 m (5-6 ft) at maturity. However, where natural regeneration is abundant, thinning may be done in stages to allow a crop of small trees to be harvested part way through the rotation. While growers must provide ample space for crown development, over-thinning depletes the stand's long-term potential for tree production, resulting in a corresponding reduction in profits. Because most natural stands are composed of various sized trees, spacing rules should remain flexible while adhering to the fundamental standard that insists on unobstructed growing space for each tree.

Young regeneration, spaced at an early age, has the greatest potential for Christmas trees: the entire tree can be developed. Where thinning has been delayed, crowding and shading cause the loss of foliage on the lower branches. This injury can be corrected only by additional butt pruning which results in valuable crown loss and trees with long handles (Fig. 5). An important objective of stand management is to keep the stand height at a convenient level for shearing. For example, a 2.1-m (7-ft) crown on a 1.3-m (4-ft) handle puts the top of the tree out of reach for shearing with standard length shears.

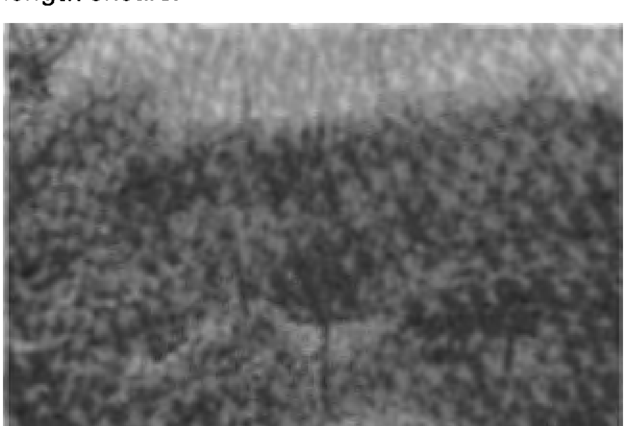

Fig. 5. Extensive butt pruning: the result of insufficient thinning.

Thinning, rather than a one-time operations, is an ongoing process in most natural stands. Nature's method of randomly scattering seeds tends to perpetuate a pattern of excessive or uneven stocking, typical of forest sites. While open areas should be planted, overstocked areas must be thinned to be productive.

All thinned trees should be cut at ground level, limbed, and cut into short pieces. This prevents or reduces regrowth, improves working conditions, and hastens the breakdown of waste material.

Combined with harvesting, thinning can become partly cost recoverable. Small, otherwise wasted trees may be marketable as table-top trees and other thinnings sold for wreathmaking.

Growers, endeavoring to use natural stock to its maximum, may butt prune to complement standard thinning. In some instances, butt pruning of advanced stock will provide adequate growing space for young seedlings without loss of stock and will achieve the same objective as thinning (Fig. 6).

Fig. 6. Butt pruning to provide space for new regeneration.

An early harvest of some trees may also constitute thinning. In natural stand operations, it is often better long-term economics to harvest a small or a low grade tree that is crowding vigorous young seedlings than to remove the seedling competition (Fig. 7). In a well managed stand the development of future crop trees is considered with every cultural practice.

Thinning is not a straightforward task. It must be practiced with the skill necessary to obtain optimum development of natural stock. Since productivity, tree quality, and profits are directly related to the level of proficiency in thinning, this task warrants the best efforts of all those producing Christmas trees in natural stands.

Fig. 7. Harvesting of a low grade tree will often improve development of young regeneration.

Fill Planting

The term "fill planting" refers to planting trees in understocked areas of natural regeneration to obtain full stocking throughout. The forest's natural tendency for self renewal is a most valued feature of Christmas tree stands on forest sites. Stock establishment, the first essential of all Christmas tree stands, is a natural phenomenon on forest sites and, under ideal conditions, is perpetuated over many crop rotations. However, stocking is not usually uniform in natural stands; even in the early years of operation, overstocked and unstocked areas are often interspersed. Furthermore, the rate of regeneration, especially where large areas are involved, usually decreases with time, resulting in sparsely stocked stands and low productivity.

Although many natural stands remain in operation after 30 years, productivity is often less than half the site's potential where natural seeding has been the only source of new trees. A natural all-aged Christmas tree stand, fully stocked, contains about 4900 trees/ha (2000/ac). Besides increasing the productivity of the land under management, fully stocked stands can be more efficiently managed than understocked stands, thereby reducing production costs. Management practices, such as insect control, are usually applied broadcast and are therefore most cost effective on fully stocked stands. Since most weeds are intolerant of shade, control problems are appreciably reduced with full stocking.

Soil conditions on natural forest sites are usually well suited to tree growth, and site preparation is unnecessary except for weed control which is routinely a part of stand management. When a sod cover builds up in open or sparsely stocked areas on long-standing managed sites, treatment similar to that for field plantations is necessary. The performance of planted seedlings on poorly drained forest sites is usually unsatisfactory. Although marginally wet sites produce some high quality trees, these areas should not be viewed as potential sites for fill planting. The number of "spots" capable of producing good tree growth is limited and not many are likely to be found by the planter. Nature seems to be much more adept at selecting these microsites than does the most experienced planter. A high level of mortality with great variability in the growth rate of survivors should be expected from seedlings planted under these conditions (Estabrooks 1985).

Natural seeding adds significantly to the value of a stand, and whether plentiful or sparse, should be protected and enhanced. Seedlings that have established naturally on a site, although smaller than planting stock, will usually grow faster at this stage than recently planted seedlings and should be regarded as an important source of new trees. Fill planters should allow equal spacing for naturally regenerated and planted seedlings. If natural regeneration is overlooked, fill planting will be excessive and, as trees develop, the stand will be overstocked.

Although planting under natural forest conditions offers many advantages, the actual planting may be an arduous task. Tree roots and other obstacles associated with forest sites usually add to the effort required for planting. This combined with the intermittent pattern of planting and uneven topography results in fewer trees planted by each planter per day on forest sites than in field plantations. Such difficulties should not deter growers in their efforts to obtain full stocking in natural stands. Christmas trees are a valuable short rotation crop and management practices that increase productivity and efficiency are sound investments.

For information on fertilizing natural stands see page 14.

PLANTING

Planting success depends upon planting procedures, stock quality, site conditions, care of stock between lifting and planting, and environmental conditions both during and following planting.

Some of these conditions can be only partially controlled by the operator. For example, the degree to which the planting schedule can be adjusted to avoid unfavorable environmental conditions is limited. Outplanting should take place as soon as possible after seedlings arrive from the nursery. Since all the seedlings usually cannot be planted the day they arrive, a holding area that provides a cool, shaded, and well ventilated environment should be located near the planting site (Murray 1979). An on-site transplant bed could alleviate these problems by providing a ready supply of planting stock, which allows for outplanting when environmental conditions are favorable to early survival.

Bareroot seedlings whether being planted in the field or in transplant beds must be protected from exposure and the roots kept cool and moist between lifting and planting. Container stock must be kept moist until planting.

Season

Trees planted in early spring usually establish better than those planted in August, the alternate time for planting. High daytime temperatures and drying winds are more prevalent during late summer, and ground moisture, the most important element for newly planted seedlings, is usually more limited in late summer than in springtime. However, with adequate moisture, balsam fir planted in August may outperform similar stock planted on the same site the following spring.

Stock

Plantation-grown balsam fir 2-2 stock (2 years each in a seedbed and transplant bed) is generally preferred by Christmas tree producers for outplanting. At this age, transplants should have a sturdy stem and a well developed "bunch" of fibrous roots. The likelihood of survival and establishment, because of their ability to withstand drought and winter drying throughout the first year, is greater (Fig. 8).

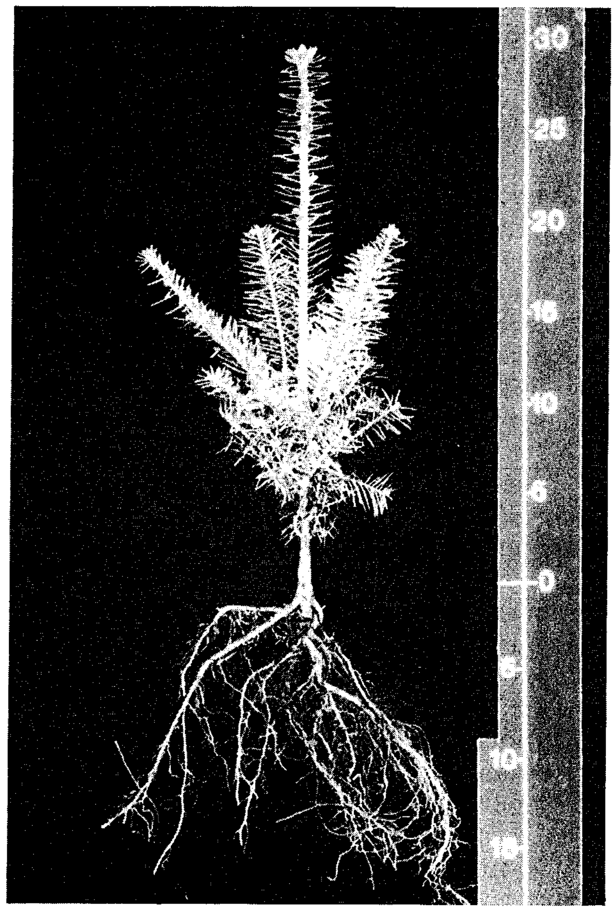

Fig. 8. A 2+2 bareroot seedling with well developed top and roots.

Container-grown balsam fir stock is increasingly being used as an alternative to bareroot stock. Both purchase and planting costs are substantially less and quality planting, especially in natural stands, is more easily attained. However, the susceptibility of small seedlings to suppression from competition is great and the rotation period is extended. Container-grown seedlings are sometimes grown 1 or 2 years in a transplant bed to produce hardy stock before outplanting. Two-year-old nursery grown bareroot seedlings are also used by producers with transplant beds.

Balsam fir wildlings are another source of stock. Wildling seedlings, grown two years in a transplant bed, develop strong root systems that are able to adapt readily and thrive as outplantings. Wildlings have an unknown history and are screened in the transplant bed. Those that do not produce well developed root and top growth are not outplanted. Direct outplanting of wildlings is not usually advised. Even under the most ideal conditions, some injury and loss of roots occur when the seedlings are pulled from their natural site. Except under highly favorable conditions during both pulling and outplanting, the stresses associated with establishment in the plantation are likely to result in a high level of mortality or planting shock.

A good wildling source is often difficult to find. Only young seedlings 15-25 cm in height, growing in the open are suitable for transplanting. Trees growing under a forest overstory should be avoided because although small, many are old trees and few respond well to cultivation. Wildlings can usually be pulled in bunches and should be carefully separated to minimize root loss and injury (Pinnock 1975).

Transplanting, should be in well tilled beds, gardenlike conditions, in rows about 15 cm apart at a spacing of 5 to 7.5 cm. Early August is sometimes regarded as the optimum time for transplanting: balsam fir, like other conifers, produce most of their roots during two periods of the year, late summer, after shoot elongation, and in spring before budbreak. Therefore, the roots of seedlings transplanted in late summer have two growing periods to become established before producing new shoot growth. However, the stress effects of moisture deficiencies, often associated with late summer weather conditions, can retard root growth and offset the theoretical advantage of August transplanting. August transplants should be shaded until fall unless regular watering is possible.

Most transplanting irrespective of stock is done in the spring. Transplanting of wildlings in early May has been successful in Canadian Forestry Service experiments (unpublished data). At this time of year, moisture is usually in good supply and, on suitable sites, transplants with a water source for root absorption can be expected to establish well.

Weeds in wildling transplant beds can usually be controlled with a top spray of simazine at about 2 lbs/ac in early spring (1 oz 80w/1.5 gal water for each 1000 sq ft).

Appropriate applications of fertilizer contribute to the growth and development of seedlings in transplant beds. First-year transplants are usually set out on sites to which phosphorus and potassium have been added, at least two weeks earlier. Ideally, amendments should be based on the results of a soil analysis (Table 2). Where a soil analysis is not available Hallett recommends 0-20-20 and 0-46-0 at 700 g and 225 g (1.5 and 0.5 lbs) per 100 sq ft, respectively.

The following rates, based on tree nursery experience at Canadian Forestry Service - Maritimes, are recommended for second-year transplants: for each 10 m^2 (100 sq ft), broadcast 10-10-10+ Mg at the rate of 225 g (0.5 lbs) in early May, and 450-675 g (1.0 to 1.5 lbs) in mid June. The same amount over the same time period, in more frequent and lighter applications, may result in a fuller utilization of the fertilizer. Fertilizing should be discontinued after mid June until bud set and dormancy. (Nitrogen fertilizer added late in the growing season may prolong top growth, delaying dormancy and the onset of frost hardiness, or promote a frost susceptible second bud flush). However, because root growth and nutrient storage continue into late fall, this fertilizing schedule may be insufficient to prevent late season nutrient deficiencies; such occurrences, because of leaching especially of nitrogen, are more likely in seasons with above average rainfall. An application of 10-10-10+Mg at 225 g in early August and/or late September should prevent autumn plant hunger; this option may be especially timely when climatic conditions or other indicators, *i.e.*, foliage color-yellowing- suggest a nitrogen deficiency. An analysis of a late-summer foliage sample would show, more definitively, if a fall fertilizer top dressing were needed.

The processes involved in the development of winter hardiness in seedlings are complex and not

Table 2. Guidelines for fertilizer amendments[1]

Organic matter		pH		Available phosphorus			Exchangeable potassium		
				Lab result		Req'd	Lab result		Req'd
Lab result %	Req'd applic. m^3/ha	Lab result	Req'd applic. kg/ha	MFRC* ppm P	Truro** kg/ha P_2O_5	applic. kg/ha TSP	MFRC* meq/100g K	Truro* kg/ha K_2O	applic. kg/ha KS
A. Lab results and recommended applications									
2.0	350	4.5	10 000	20	120	530	.15	160	280
2.5	275	4.7	8 000	30	180	450	.20	210	230
3.0	200	4.8	5 000	40	240	370	.25	260	180
3.5	130	5.1	4 000	50	300	270	.30	315	120
4.0	65	5.5	2 000	60	400	140	.35	370	50
B. Recommended levels									
4.5	-	6.0	-	75	500	-	.40	420	-

[1]Soil testing in Nova Scotia is conducted at the Nova Scotia Department of Agriculture and Marketing lab at Truro (Truro), and in New Brunswick at the Maritimes Forest Research Centre (MFRC), Fredericton. The results of analysis are expressed in different terms for some nutrients. For this reason the above guidelines for preparation of seedbed and transplant soil for balsam fir are related to results from both labs for phosphorus and potassium (from Hallett 1981).

Note: Beginning in late 1987 testing previously done at MFRC will be done at the soil and plant testing laboratory Hugh John Flemming Forestry Complex, UNB Building, Fredericton, N.B.

fully understood. However, the importance of an adequate supply of nutrients and moisture throughout the fall is well recognized (Glerum 1985). Fertilizers should not be applied during drought conditions.

Methods

Planting of bareroot stock on a small scale can be best accomplished with a round pointed shovel, preferably one with a reduced blade, *i.e.,* a fire shovel. The T-slit method is commonly used especially in uncultivated fields. Two vertical shovel cuts are made in the ground; first, the stem, and second, the top of an inverted T. With the shovel in the second cut, the soil is pried open and the tree planted in the slit. This method is usually the best planting method on forest sites. The two shovel cuts sever any roots in the planting spot and facilitate planting the seedling in a verticle position with its roots extending to the mineral soil (Fig. 9).

Planting on tilled sites may involve the removal of soil to form a pit large enough to accommodate the root system of the seedling. This method should not be attempted on untreated sod, but under suitable conditions provides the opportunity for proper placement of the roots in the best topsoil and should result in a vigorous seedling. Also, on tilled sites, the single shovel cut, where the roots are planted under the lifted shovel blade, is an efficient planting method (Fig. 10).

The planting pit, regardless of method, must be sufficient to accommodate the roots in their natural position with the root collar at ground level. The seedling should be planted with the stem vertical and the soil should be firmly packed around its base. Care should be taken to plant seedlings at the approximate depth at which they were grown in the nursery. Planting deeper than this has a smothering effect on the root system; seedlings become stunted and many may die. Shallower planting results in root damage caused by the combined effects of warmer than normal root temperatures and drying conditions.

Container-produced seedlings can be easily planted with a dibble or pottiputki on forest sites or in tilled fields. Under untilled field conditions, a shovel and the T-slit method of planting are recommended. Mechanical planters are successfully used in large plantations. A three or four man crew can plant 7000-10,000 seedlings per day.

Fig. 9. Planting a bareroot seedling using the T-slit method.

Fig. 10. Planting a bareroot seedling on a tilled site.

FERTILIZING

Fertilizers are applied to improve tree quality and shorten rotations. Appropriate applications produce dark green foliage, an increase in needle length and budding, and improved tree vigor. Factors such as time of application, material, rate, site, and stand age determine the level of fertilizer response.

Over-fertilizing, especially young seedlings, can cause serious root injury which adversely affects tree growth or survival, and creates entry points for lethal root fungi. Excessive nitrogen in larger trees may cause abnormal leader development, delay dormancy, or result in a second late season flushing of some buds. These new shoots may be intolerant of fall frosts. High nitrogen levels are also implicated in winter bud injury of seedlings. Fertilizer treatments may accelerate spring bud flush, thus increasing the risk of shoot injury caused by late spring frosts (Hallett 1984).

Fertilizer applied to small trees should be spread evenly in a band around the tree about 10-15 cm (4-6 in.) from the stem. For larger trees, the band should be beneath the dripline. A concentration of fertilizer near the base of the stem, especially of young trees, is a serious form of over-fertilization.

Plantations

The degree to which young trees in plantations respond to topical applications of fertilizer is questionable. Results of studies by Veilleux (1985) and Canadian Forestry Service - Maritimes (unpublished data) suggest that available nutrients on most agricultural sites where weeds are controlled are sufficient for the biotic potential of establishing seedlings. In Canadian Forestry Service experimental plantations, differences in growth between fertilized seedlings and controls (unfertilized) during the first three years have been negligible. Color, the most readily observed sign of response, possibly indicated fertilizer uptake by some trees. The likelihood of some responses occurring without immediate visual manifestations should not be overlooked. For example, root growth, hidden from view, probably is increased with fertilizer treatments to young trees. A stimulus in root growth at this stage of tree development should result in long-term growth benefits. Where fertilizer was applied annually, response by year 6 was usually apparent with significant improvements in foliage quality and density of most fertilized trees over that of unfertilized trees.

The minimum age at which fertilizing should begin for the greatest economic gains cannot be stated precisely. Topical applications of fertilizer in year 1 do not appear to provide growth gains. (Any additions of fertilizer following spring outplanting should be delayed for about three weeks and contain a low level of nitrogen. A mix, *i.e,* 5:20:10 + Mg at 20 g per tree spread in a band 10-15 cm (4-6 in.) from the stem is acceptable.) A fertilization program beginning in year 2 (one full year after outplanting) with a topical application of a complete fertilizer plus magnesium, *i.e.,* 10-10-10-3, appears to be adequate for seedlings that need supplementary nutrients. Some trees, because of physiological limitations or because of the nutrient sufficiency of the site in which they are growing, appear unable to use supplementary plant food applied in this manner and fail to exhibit a growth performance better than the control trees. This may partly explain the indefinite nature of response of young trees to fertilizer. Further testing of different fertilizers, rates, and methods and timing of application is required before strategies can be identified that will produce positive growth responses of young balsam fir.

Where fertilizer is applied once during the year, applications should be made in late May or early June. Heavy spring rains, which can cause leaching or the loss of nitrogen in surface run off, are less likely after this period. Furthermore, warm ground temperature combined with actively growing trees result in a greater uptake of added nutrients than under cold stagnant conditions. Two springtime applications, each at a reduced rate, result in a fuller utilization of fertilizer; the first of these should be made in early May and the second about 6 weeks later.

When starting in year 2, one application of fertilizer (10-10-10 +Mg) at the rate of 30 g (1 oz) per tree or two applications at 20 g each per tree are recommended. Nitrogen is invariably the limiting element in tree growth. At this age, seedlings can utilize only small amounts and inappropriate amounts can result in a negative growth response or a reduced rate of survival (Veilleux 1985). Addition of the other elements serves to correct the major nutrient deficiencies likely to be found in fields with an unknown history of agriculture.

In succeeding years, the proportion of nitrogen should be increased to a ratio of 18:7:7 or 22:5:5. These or comparable mixes can usually be purchased from suppliers, or they can be obtained by combining 10:10:10 and ammonium nitrate at the ratios 2:1 and 1:1. Rates may be gradually increased to about 120 g (4 oz) per tree for mature Christmas trees. On most sites, this amount of fertilizer will produce the luxuriant foliage necessary for top quality trees.

Container Stock

Container seedlings grown under controlled conditions with regular fertilizer treatments should be fertilized in the field after outplanting. Thirty grams of a complete fertilizer in a 10-cm dibble hole 10 cm from the stem is an appropriate nutrient supplement at this stage. Topical applications as recommended earlier can be made in subsequent years.

Natural Stands

Balsam fir on forest sites responds to additions of nitrogen fertilizer (Krause 1981). The lack of significant response to additions of phosphorus and potassium found by Canadian Forestry Service (Timmer *et al.* 1977) and other workers in the Maritimes suggests that these nutrients are unlikely to be growth limiting. Therefore, fertilizer applied to promote growth of balsam fir should have a high nitrogen content. Where ammonium nitrate or urea is used, annual applications should be alternated with a complete fertilizer, *i.e.,* 20:5:5 as a safeguard against deficiencies in phosphorus and potassium. Experiments have shown that rates of 50-60 kg/ha (50-60 lbs/ac) of actual nitrogen (250-300 kg/ha of 20:5:5) are optimum for many sites for a first time application and that the actual amount required can be estimated from the length of needles as an indicator of site (Embree and Estabrooks 1981). Depending on site and tree response, the rate of succeeding treatments can usually be reduced. Applications should be made in late May or early June when trees are actively growing and the dangers of nitrogen loss from leaching are reduced.

Some fertile sites produce good trees naturally, while in others few quality trees develop without a fertilizer supplement: variability between trees on the same site is common. Fertilizer rates and schedules can be fine-tuned on the basis of tree performance. Requirements differ between sites, and producers are wise to note site variations and adjust treatments accordingly. Small on-site experiments are useful for determining rates based on response differences. Trees, especially on course textured soils or marginally drained sites, may change from dark green in summer to yellow in the fall. This suggests a nutrient deficiency. Two treatments of a complete fertilizer, one in May and one early July, each at one-half of the usual rate, should help prevent this condition from occurring.

Foliar analyses are useful in some situations but should not be necessary on most sites. Where foliage is chlorotic and obviously nutrient deficient, a foliar analysis may be helpful in determining the best fertilizer amendment. Conversely, especially on long-established sites where fertilizer has been applied over many years, an analysis may show sufficiency in some elements resulting in a saving to the producer who then applies only the needed elements.

Foliar nutrient standards for balsam fir Christmas tree culturing and examples of fertilizer amendments are shown in Tables 3 and 4 (Krause and Hamilton 1981).

SHEARING AND BUTT PRUNING

Shearing

Shearing is a standard practice for enhancing tree quality and increasing the number of salable Christmas trees in balsam fir stands. Hedge shears, shearing knives, motorized backpack shearing machines and hand pruners are implements commonly used. Corrective shearing should begin with outplanting. Double stems, especially on 4-year-old bareroot stock, are frequently encountered and should be corrected. Double tops, equally damaging to young trees, are usually the result of leader injury. On a young tree, these similar abnormalities are easily corrected without seriously affecting development, by removing the less promising top.

In the absence of abnormalities, shearing to develop crown form and density should begin when trees are 1.4-1.8 m (4-6 ft) in height depending on leader growth and foliage density. Trees lightly foliated with long leaders should be sheared at an early stage but shearing of heavily foliated trees with moderate leader length, *i.e.*, superior trees, can be delayed until the tree is about 1.8 m (6 ft) in height. The latter produces mature trees in a shorter time with less shearing.

The first shearing should reduce the leader to about 30 cm (12 in.) and the current terminal shoots of whorl branches to 50 to 75% of their length. Symmetry and taper should be established in the first shearing, when possible. However, side shearing that removes more than the most recent shoot growth may be excessive and result in poor foliage production the next year. Therefore, when trees are severely lopsided or flaring, the development of symmetry or taper should extend over two or more years (Estabrooks 1986).

Top development is an important aspect of tree culturing and can be most challenging. The top section is especially vulnerable to many types of injury. Insects, birds, and extremes of weather conditions cause injury, especially to the buds of leaders. Terminal bud loss, or a leader broken during the time of shoot growth, usually results in upturned whorl branches. Early removal of all but the strongest branch, promotes alternate top development and maintains form with a minimum of deformity. When leader loss occurs near the end of or after shoot elongation, whorl branches are unlikely to turn upward. One or more latent buds will usually develop at the node, and the following year vertically oriented shoots develop from which a leader can be selected. The whorl branches should then be sheared to restore symmetry (Fig. 11). Internodal bud loss that results in a "bare" leader over 25 cm in length demands the removal of the previous years top growth. An internodal branch, the most promising alternative, will then develop as leader replacement. If this condition is untreated a goose neck forms and the tree is reduced to a cull (Fig. 12).

Sheared tops usually produce two or more competing leaders the following year. Subsequent top shearing should first select the leader with the strongest vertical alignment to the center stem, shear to the proper length, 20-25 cm, then remove the competing leaders (Fig. 13). Where the vertical alignment is unacceptable to good tree form or internodal growth is weak, the competing leaders should be partly retained to help maintain symmetry and taper and (or) top density (Fig. 14).

Abnormal tree development, usually the result of an injury, takes many forms and affects most trees. Often standard shearing, where the general outline of the tree is maintained, is the best treatment. Given time and proper shearing, trees demonstrate great capacity for foliage production that compensates for imperfections. While some conditions cannot be corrected within an acceptable time period, growers should not give up easily.

Table 3. Provisional foliar nutrient standards for balsam fir [*Abies balsamea* (L.) Mill.]Christmas tree culture

Condition	N* %	P/N#	K/N	Mg/N
Severely deficient	< 1.3	< 0.08	< 20	< 0.04
Moderately deficient	1.30 — 1.59	0.08 — 0.089	0.20 — 0.29	0.04 — 0.050
Critical	1.60 — 1.69	0.09 — 0.10	0.30 — 0.35	0.051 — 0.06
Adequate	1.70 — 2.00	> 0.10	> 0.35	> 0.06
Excessive	> 2.00	—	—	—

* N = nitrogen, P = phosphorus, K = potassium, Mg = magnesium.
# = Ratios based on foliar concentrations in percent of over-dry weight (from Krause and Hamilton 1981).

Table 4. Examples of fertilizer recommendations for balsam fir Christmas tree stands based on foliar analysis

	Test results				Recommended treatment					
Example	N* %	P/N	K/N	Mg/N	N (kg/ha)	P (kg/ha)	K (kg/ha)	Mg (kg/ha)	Carrier type	Amount
1	1.25	.13	.45	.08	100	—	—	—	34-0-0**	300
2	1.50	.12	.40	.07	75	—	—	—	34-0-0**	220
3	1.65	.12	.40	.07	50	—	—	—	34-0-0**	150
4	1.70	.09	.40	.07	—	40	—	—	0-46-0+	200
5	1.60	.07	.40	.07	50	80	—	—	34-0-0	150
									+ 0-46-0	400
									Or 11-48-0++	400
6	1.55	.14	.28	.07	75	—	100	—	34-0-0	220
									+0-0-61#	165
7	1.60	.14	.28	.04	50	—	100	80	34-0-0	150
									+0-0-22-18##	450
8	1.65	.09	.30	.07	50	40	50	—	10-10-10#	500

* N = nitrogen, P = phosphorus; K = potassium; Mg = magnesium
** Ammonium nitrate
\+ Triple superphosphate
++ Mixed fertilizer
# Muriate of potash

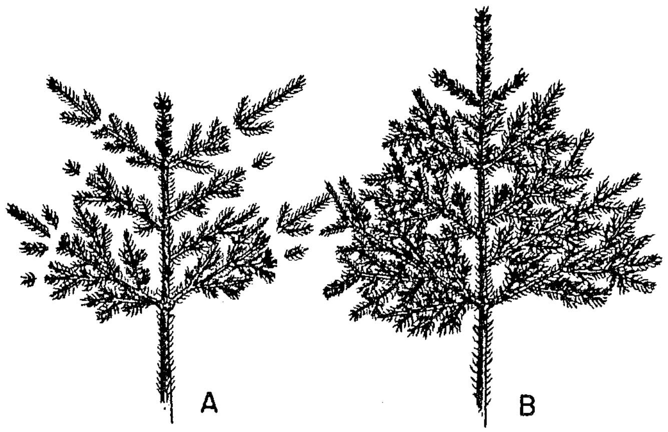

Fig. 11. Leader loss where an alternate leader grows from a latent bud. (A) Shear points. (B) Expected form after the next years growth.

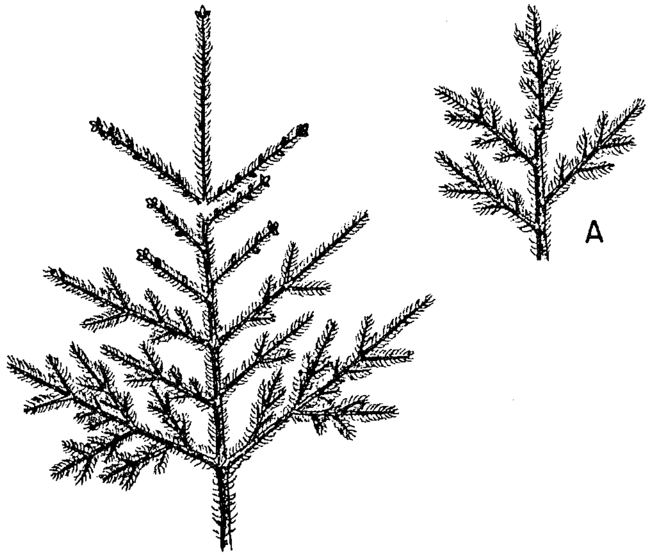

Fig. 12. Internodal bud loss on the leader results in a gooseneck. Remove the leader and top whorl branches. (A) An internodal branch should turn up during the next growing season and provide a new leader without seriously affecting tree form.)

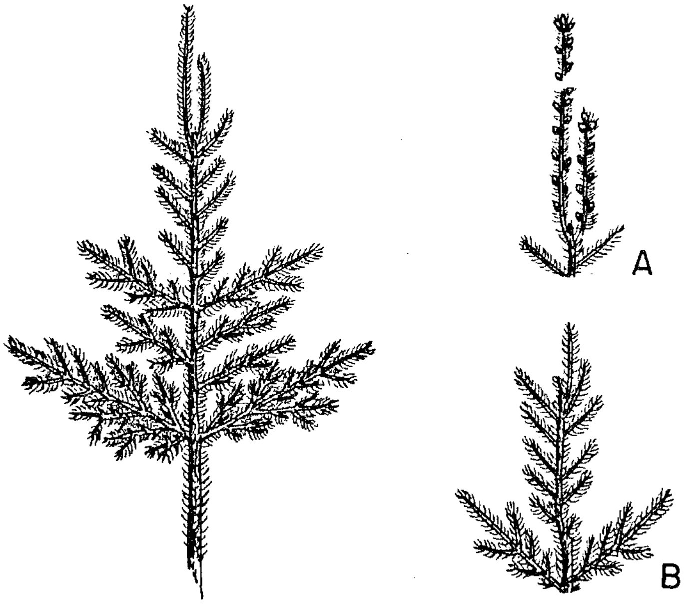

Fig. 13. Vertically oriented shoots following leader shearing. (A) Shear points for top development. (B) Expected top development at end of next growing season.

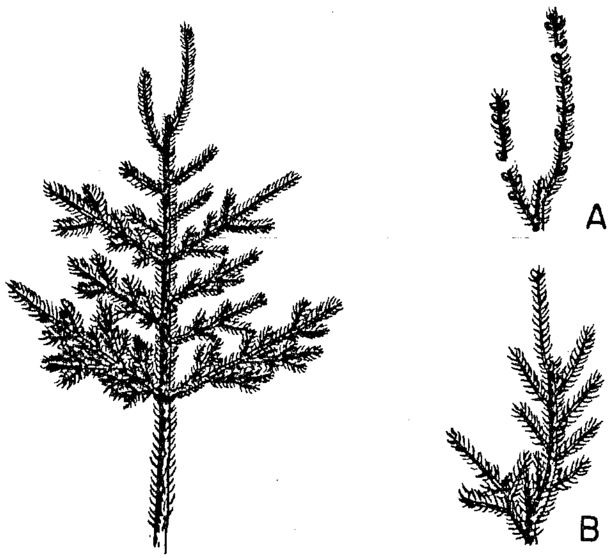

Fig. 14. Double tops with imperfect alignment. (A) Shear points for partial pruning of both tops. (B) Expected top development at end of next growing season.

The level of tree enhancement is partly determined by the time of year of the shearing. Balsam fir tolerates shearing anytime during the year and, from the point of view of Christmas tree culturing, usually responds positively. However, the best response is from shearing in late July after shoot elongation, but while other growth processes, especially bud development, continue. Trees sheared in the springtime just before budbreak are less responsive. Shearing would not be done during the shoot elongation period of early summer.

Butt Pruning

Butt pruning is usually done during thinning or just before or during the first shearing. Shearing to develop symmetry and taper is more easily done after butt pruning and inventories of trees by size and grade are more accurate and more easily obtained. While there are distinct advantages to early butt pruning it can be postponed till harvest time.

Butt pruning, which removes weak or unwanted bottom branches from the base of the stem ideally up to the first full whorl, should also provide a handle of at least 30 cm. Although internodal branches are not usually adequate in size and placement to form the crown's bottom ring of branches, one or more can sometimes substitute for missing whorl branches and allow greater utilization of the trees crown. Strict attention to pruning to the first full whorl often wastes the lower part of the crown which, with shearing, might come into shape by the time the tree reaches marketable size. Pruning should be done without damaging the bark of the tree stem; hand cutters are the safest implement.

The prevalence of suitable sites and the availability of both naturally regenerated and nursery grown seedlings combine to give the Maritimes immense potential for Christmas tree production. Although new information is steadily aiding growers in the development of effective cultural-management practices, present state-of-the-art technology is sufficient for highly successful operations over a wide range of conditions in both field and forest.

REFERENCES

Ahrens, J.F.; Flanagan, T.R.; McCormick, M.L. Jr. 1969. Chemical control of weeds in Christmas tree plantings. Bull. Conn. Agric. Exp. Sta., New Haven, No. 700.

Bailey, R.E. 1981. Site selection and Christmas trees. Pp. 1-14 *In* Balsam Fir Update: A Review of the Latest Research Findings Pertinent to Christmas Tree Culture. A. Dickson (Coordinator). Proc. of Seminar sponsored by U.N.B. Faculty of Forestry, Fredericton, N.B.

Bakuzis, E.V.; Hansen, H.L. 1965. Balsam fir. April 25, Univ. of Minnesota Press, Minneapolis.

Christie, C. 1980. Managing wild balsam fir for Christmas trees (revised). N.S. Dep. Lands For. Truro, N.S.

Clare, S.G.; Dykeman, B.W.; Smith, R.F; Simpson, J.D. 1984. A guide for establishing a permanent sod cover in forest tree seed orchards. Can. For. Serv., Marit. For. Res. Cent. Tech. Note No. 105.

Embree, D.G.; Estabrooks, G.F. 1981. Fertilizing balsam fir Christmas trees in wild stands. Can. For. Serv., Marit. For. Res. Cent. Tech. Note No. 25.

Estabrooks, G.F. 1982. Thinning wild stands of balsam fir for Christmas tree production. Can. For. Serv., Marit. For. Res. Cent. Tech. Note No. 52.

Estabrooks, G.F. 1985. A case for fully stocked Christmas tree stands. Can. For. Serv., Marit. For. Res. Cent. Tech. Note No. 138.

Estabrooks, G.F. 1986. Shearing balsam fir Christmas trees. Can. For. Serv., Marit. Inf. Rep. M-X-160.

Glerum, C. 1985. Frost hardiness of conifer seedlings: principles and applications. Pp. 107-120. *In* Duryea, M.L. (Ed.). 1985. Proc. Evaluating Seedling Quality: Principles, Procedures and Predictive Abilities of Major Tests. Workshop held October 16-18, 1984. Forest Research Laboratory, Oregon State Univ., Corvalis.

Grosslard, E.; Atkinson, D. (Eds.). 1985. The herbicide glyphosate. Butterworth & Co. (Publishers) Ltd., London.

Hallett, R.D. 1981. So you want to grow your own balsam fir planting stock. Can. For. Serv., Marit. For. Res. Cent. Tech. Note No. 24.

Hallett, R.D. 1984. Forest nursery practices in the Maritimes. Pp. 81-107. *In* Reforestation in the Maritimes, 1984. *Edited by* R.D. Hallett, M.D. Cameron, and T.S. Murray. Proc. Reforestation in the Maritimes, 1984 Symp. Moncton, N.B.

Krause, H.H. 1981. Factorial experiments with nitrogen, phosphorus and potassium fertilizers in spruce and fir stands of New Brunswick: 10-year results. Can. For. Serv., Marit. For. Res. Cent. Inf. Rep. M-X-123

Krause, H.H.; Hamilton W.N. 1981. Foliar analysis for fertilizer recommendations in balsam fir christmas tree culture. Pp. 42-53 *In* Balsam Fir Up date: A Review of the Latest Research Findings Pertinent to Christmas Tree Culture. A Dickson (coordinator). Proc. of Seminar sponsored by UNB Faculty of Forestry, Fredericton, N.B.

Murray, T.S. 1979. Storing bare root and container nursery stock on the planting site. Can. For. Serv., Marit. For. Res. Cent. Tech. Note No. 6.

Pinnock, D.F. [1975] Establishment and care of balsam fir for Christmas trees. N.B. Dep. Agric. Rural Develop. Plant Ind. Br., Fredericton, N.B.

Timmer, V.R.; Stone, E.L.; Embree, D.G. 1977. Growth response of young balsam fir fertilized with nitrogen, phosphorus, potassium, and lime. Can. J. For. Res. 7: 441-446.

Veilleux, J.M. 1985. Fertilisation de plantations de sapin baumier cultivé pour la production d'arbres de Noël. I-Essais au moment de la plantation. Gouv. du Québec, min, de l'Énergie et des ress., Serv. de la recherche. Mémoire No 87.

APPENDIX

Recommended rates of application for herbicides and insecticides usually refer to the active ingredient (a.i.) of the product exclusive of the inert material which serves as a carrier or filler. For example, Simazine 80W is a wettable powder 80% active and the Princep nine-T, water dispersible granule formulation is 90% active. Simadex L., a flowable form, contains 500 g (17.6 oz) a.i. per litre.

Pesticide labels always show the amount of active ingredient contained in the product (amounts may be shown in metric or American measure). With this information the amount of material needed for a specific rate can be obtained by a few simple calculations.

Example: For a rate of 5 kg a.i./ha of simazine using Simadex liquid.
(1 L of Simadex L. = 500 g a.i.; 2 L = 1000 g a.i. or 1 kg)
5 kg a.i./ha = (5 X 2 L)
= 10 L of Simadex L/ha

The amount of product per litre of water at a rate of 560 L/ha.
= No. of L/ha ÷ 560
= 10 L ÷ 560 L
= 0.018 L or
18 mL of Simadex L/litre of water

or Using Princep Nine-T (soluble granules 90% a.i.) at 5 kg a.i./ha
= 5 ÷ 0.9
= 5.5 kg of Princep Nine-T/ha

The amount of product per litre of water at a rate of 560 L/ha
= No. of kg ÷ 560
= 5.5 kg ÷ 560 L
= 0.0098 kg or
10 g of Princep Nine-T/litre of water

Example: A rate of 4.5 lbs a.i./ac of simazine using Princep Nine-T is to be made
4.5 ÷ 0.9
= 5 lbs of Princep Nine-T/ac

The amount of product per imperial gallon of water at a rate of
50 gal/ac = No. of oz (5 x 16) ÷ 50
= 80 oz ÷ 50 gal
= 1.6 oz of Princep Nine-T/gal of water

Guide to the amount of pesticide to be added to water to obtain specified dosages at four rates of application

Rate of application gal/ac	Dosage (lbs/ac) dry pesticide 1	2	3	4	5
			ounces per gallon		
25	0.6	1.3	1.9	2.6	3.2
50	0.3	0.6	1.0	1.3	1.6
75	0.2	0.4	0.6	0.8	1.1
100	0.16	0.3	0.5	0.6	0.8

Rate of application L/ha	Dosage (kg/ha) dry pesticide 1	2	3	4	5
			grams per litre		
250	4.0	8.0	12.0	16.0	20.0
500	2.0	4.0	6.0	8.0	10.0
800	1.25	2.5	3.75	5.0	6.25
1000	1.0	2.0	3.0	4.0	5.0

Rate of application gal/ac	Dosage (qt/ac) liquid pesticide 1	2	3	4	5
			fluid ounces per gallon		
25	1.6	3.2	4.8	6.4	8.0
50	0.8	1.6	2.4	3.2	4.0
75	0.5	1.1	1.6	2.1	2.7
100	0.4	0.8	1.2	1.6	2.0

Rate of application L/ha	Dosage (L/ha) liquid pesticide 1	2	3	4	5
			millilitres per litre		
250	8.0	12.0	16.0	20.0	24.0
500	4.0	6.0	8.0	10.0	12.0
800	2.5	3.75	5.0	6.25	7.5
1000	2.0	3.0	4.0	5.0	6.0

Other dosages can be calculated from combinations of the above rates.

Guide to spray coverage at four rates of application

Rate of spray application	Area covered	Strips Width	Strips Length	Spots Diameter	Spots Number
		Coverage per gallon of spray			
Gal/ac	sq ft	ft	ft	ft	
25	1742	2.0	871	2.0	554
	1742	2.5	697	2.5	355
50	871	2.0	436	2.0	277
	871	2.5	348	2.5	178
75	580	2.0	290	2.0	184
	580	2.5	232	2.5	118
100	435	2.0	217	2.0	138
	435	2.5	174	2.5	88
		Coverage per litre of spray			
L/ha	m^2	m	m	m	
250	40.0	0.6	66	0.6	141
	40.0	0.75	53	0.75	90
500	20.0	0.6	33	0.6	70
	20.0	0.75	26	0.75	45
800	12.5	0.6	20	0.6	44
	12.5	0.75	16	0.75	28
1000	10.0	0.6	16	0.6	35
	10.0	0.75	13	0.75	22

Useful Conversions

1 acre = 43560 sq ft
1 acre = 0.405 ha
1 ha = 2.471 acre
1 ha = 10 000 m^2
19 inch diam spot = 2 sq ft
0.5 m diam spot = 0.196 m^2
3.0 oz/19 inch diam spot = 4100 lbs/ac
45 g/0.5 m diam spot = 2300 kg/ha

gal/ac X 11.23 = L/ha
L/ha X 0.09 = gal/ac
fl oz/ac X 70 = mL/ha
mL/ha X 0.014 = fl oz/ac
lb/ac X 1.12 = kg/ha
oz/ac X 70 = g/ha
g/ha X 0.014 = oz/ac
kg/ha X 0.89 = lb/ac