Paper Birch Managers’ Handbook for British Columbia
Paper Birch Managers’ Handbook for British Columbia

by

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PREFACE

Hardwood and Vegetation Management Research Program

This publication was initiated by the British Columbia Hardwood and Vegetation Management Technical Advisory Committee (HVM TAC) as project B43. Funding for the project and publication was provided by the Canada–British Columbia Partnership Agreement on Forest Resource Development: FRDA II and by the British Columbia Ministry of Forests.

HVM TAC was established in 1990 under funding from the Sustainable Environment Fund – Forest Renewal Initiatives Program, to establish a co-ordinated research and extension program supplying relevant information to hardwood and mixedwood forest managers. Representatives on HVM TAC include the Ministry of Forests (Research Branch, Silviculture Branch, and forest regions), Ministry of Environment, Lands and Parks (Wildlife Branch), and the Canadian Forest Service. Since its inception, a total of 45 projects have been supported province-wide.

The current hardwood research goal of HVM TAC is to support the acquisition, communication, and application of information needed for the sustainable and integrated management of hardwood and mixedwood resources.

The 5-year strategic plan for hardwood research outlines four priority areas for investigation. They are:

1. **Hardwood Silviculture**, to provide information on the effectiveness of silvicultural treatments;

2. **Ecology**, including site selection, stand dynamics, and site productivity studies, to assist in operational decision-making;

3. **Integrated Resource Management**, to support the integration of hardwood harvesting and silviculture with other management objectives; and

4. **Forest Health**, including investigations into the nature, impacts, and control of organisms that damage hardwoods, and into the role of hardwoods in maintaining forest health.

Further information about the program may be obtained from the Ministry of Forests, Research Branch, 31 Bastion Square, Victoria, B.C. V8W 3E7.
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There was a decision to avoid author-date references in the text of this handbook and to end each section with a short list of key reference sources for that section’s information. This decision resulted in the use of ideas from many paper birch researchers and managers who are not identified in context when their suggestions are included in this handbook. The handbook would not have been possible without earlier ideas from persons who have thought about paper birch management or who have provided original data on this species. We thank them as the collective source of information published here. The general approach was to begin with information summarized recently for birch in British Columbia by Simard and Vyse (1992). This was supplemented by two additional steps. First, emphasis was given to birch information published since the latter review. Second, use was made of some of the very earliest documentation about paper birch management in North America, because this often involves reports that are difficult to obtain. An example is the 1954 manuscript by Russell J. Hutnik, then of the Northeastern Forest Experiment Station, USDA Forest Service, titled An Outline of the Silviculture and Management of Paper Birch.

The research for this handbook focused on a literature review, carried out mainly by personnel of Western Ecological Services Ltd., and on the field experience of Suzanne Simard, Kamloops Forest Region, Ministry of Forests, and Jian Wang, Red Rock Research Station, Ministry of Forests.

The manuscript was greatly improved as a result of review by several researchers in the Ministry of Forests (I. Cameron, P. Comeau, R. Kabzems, T. Newsome, A. Vyse), and by J. C. Zasada, USDA, Forest Sciences Laboratory, Rhinelander, Wisconsin. We also thank E. Allen, Pacific Forestry Centre, Victoria, for review of this handbook’s sections dealing with diseases of birch in British Columbia.

Many of the photographs in this handbook are by S. Simard. We also thank J. Mather, K. Enns, P. Comeau, M. Carlson, C. Li, and T. Berkhout for permission to reproduce their photographs. Most photographs are acknowledged in figure captions. No acknowledgement indicates that the photograph is by one of the two senior authors. We also thank the Royal British Columbia Museum for permission to re-publish art work by T. C. Brayshaw in Figure 10. The manuscript was greatly improved by editorial advice from Georgina Montgomery of G. Montgomery and Associates, Victoria. We also appreciate the layout, typesetting, and graphic expertise provided by D. Butcher, Dynamic Typesetting, Victoria.
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1 INTRODUCTION

This handbook summarizes existing information on the ecology and management of paper birch (*Betula papyrifera* Marsh.), which occurs through virtually all of British Columbia east of the Coast Mountains, and Alaska paper birch (*Betula neoalaskana* Sarg.), which occurs in the northeastern part of the province east of the continental divide. For simplicity, these two birches are referred to here collectively as paper birch. Together they are important components of forests in interior and northeastern British Columbia. Because paper birch occurs through most of British Columbia (Figure 1), there are many site series in nearly all of the province’s biogeoclimatic subzones where birch needs to be considered in silviculture prescriptions.

To emphasize the practical intent of this handbook, some of the key paper birch management techniques are summarized at the outset (Table 1). In most cases birch is likely to be managed as part of mixed-stand silviculture. The terminology used in this handbook refers to “mixed forest” and “mixedwood,” as defined in the Glossary. In some cases, the context requires variations of these terms, such as “birch–conifer mixture,” “mixed-species stand,” “mixed-broadleaf stand,” or “mixed broadleaf–conifer stand.”

The intent of this handbook is not to promote pure birch silviculture, but to encourage forest managers to recognize the importance of birch in silvicultural decisions. There are four fundamentally different ways for foresters to view birch management, each with a specific goal:

- manage birch in pure birch stands;
- manage birch as a component of birch–conifer mixtures;
- manage birch to assist stand re-establishment in areas where root diseases and frost damage are restricting conifers; or
- manage birch for special purposes related to biodiversity, wildlife habitat, or riparian-zone management.

Some fundamental decisions should be made before forest managers choose a particular management approach for paper birch (Figure 2). Options associated with birch stemwood production are suggested in Figure 3. For objectives to enhance birch-dominated ecosystems for wildlife, biodiversity, or other aspects of integrated resource management, Figure 4 lists other choices that can be made by a forest manager involved with ecosystems where birch is a significant component. While it is important to work with birch’s basic silvical characteristics, it is equally important to maintain a flexible and adaptive approach to birch management.
FIGURE 1. The timber supply areas in which paper birch is a leading species in some sites. Birch is distributed province-wide, except on the Queen Charlotte Islands and western slopes of the Coast Mountains where it is absent altogether. It has only a scattered occurrence on Vancouver Island (Massie et al. 1994). This map includes 18 timber supply areas (shown enclosed by heavy line) where paper birch is a potential leading species: Fort Nelson, Fort St. John, Mackenzie, Prince George, Kalum, Cranberry, Kispiox, Quesnel, Robson Valley, Williams Lake, 100 Mile House, Kamloops, Revelstoke, Arrow, Kootenay Lake, Okanagan, Fraser, and Soo.
<table>
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<tr>
<th>Management goal</th>
<th>Techniques available</th>
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<td>• regenerate fully stocked crop of birch</td>
<td>• clearing followed by scarification to provide seedbed for natural regeneration, given an adequate birch seed source (Section 5.1.2)</td>
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<td>• clearing followed by planting of high-quality birch seedlings at appropriate spacing (Section 5.5)</td>
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<td></td>
<td>• encouragement and management of birch stump sprouts (Section 3.5.2)</td>
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<td>• establish mixed stand of birch and conifers</td>
<td>• interplanting of birch among conifers or vegetation management that leaves a birch component (Section 5.5)</td>
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<td>• improve or maintain growth rate of birch crop trees</td>
<td>• spacing control in young birch stands (&lt;20 years) according to density management guidelines (Sections 5.3 and 5.7)</td>
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<td></td>
<td>• periodic thinning of seed trees or older trees left after partial cutting to avoid spread of disease (Sections 5.3 and 5.7)</td>
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<td>• maintenance of dominance and full stocking of birch from seedling to maturity; fertilization with phosphorus may also improve growth under some conditions (Section 5.7)</td>
</tr>
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<td>• ensure high-quality, decay-free birch stems and high-grade birch sawlogs</td>
<td>• thinning to produce uniform spacing to maintain stem form, with moderate crowding to optimize growth rate and crown-lift (Sections 5.3 and 5.7), and to prevent build-up of diseased or weakened trees (Section 5.8)</td>
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<tr>
<td>• facilitate or accelerate succession to shade-tolerant conifers in mature birch stands</td>
<td>• underplanting of conifers; thinning or girdling of birch overstorey; brush control in understorey (Sections 3.6.3, 5.2 and 5.3)</td>
</tr>
<tr>
<td>• convert mature birch stands to new crop of conifers</td>
<td>• commercial harvest of mature birch followed by site preparation, planting, or natural regeneration of conifers (Sections 3.6.3, 5.2 and 5.3)</td>
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<td>• maintain birch component in conifer-dominated stands for biodiversity and productivity</td>
<td>• precommercial or commercial thinnings to maintain top light for scattered birch (Sections 5.3 and 6.1)</td>
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<td></td>
<td>• encouragement of birch to develop in forest canopy gaps created by wind, disease, or insects (Sections 5.3 and 5.8)</td>
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<tr>
<td>• retain mature birch component for wildlife and biodiversity</td>
<td>• maintenance of top light for mature birch in conifer-dominated stands; adjacent conifers can protect birch from wind and prolong the retention of birch for wildlife and biodiversity purposes (Sections 3.6.3 and 6.1)</td>
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</table>
Begin by basing decisions for silvicultural options on paper birch market demands, accessibility of the paper birch resource, and dominant management goals (stemwood production, integrated resource management, or simply protection of this resource) until its use allocation can be assessed later.

**Is there now a market for paper birch in your management area?**
- **Yes**
- **No**

**Are there access restrictions for paper birch management in your area?**
- **Yes**
  - Re-assess access and market conditions in the future as market conditions change.
- **No**

**Is paper birch stemwood production your main objective?**
- **Yes**
  - See Figure 3
- **No**
  - **Are your main objectives to enhance paper birch systems for riparian-zone management (slope stability, protection of streamside habitats, streamside restoration), wildlife habitat, biodiversity, or integrated resource management?**
    - **Yes**
      - See Figure 4
    - **No**
      - **Is your area being managed for specific purposes involving paper birch?**
        - **Yes**
        - No action, but re-assess as forest management goals change, and protect the existing paper birch resource to retain all options.
        - **No**
          - Focus on conifer production on mixedwood sites and retain all options for future use of broadleaf species.

**FIGURE 2.** Preliminary decisions needed for selection of paper birch silvicultural options.
Begin planning for paper birch production by assessing which areas should be dedicated to that purpose.

- Have you identified sites that are optimal and sites that are unsuitable for paper birch production?
  - Yes: Map such sites; avoid unsuitable sites and place silvicultural effort on optimal sites. 
    - See Sections 2 and 3.4
  - No: Do you know the stem quality of paper birch in your management area?
    - Yes: Assess local variations in incidence of stem decay. 
      - See Section 3.7
    - No: Have you assessed the silvicultural implications of the age-class structure of the parent stands with which you will be dealing?
      - Yes: Very old stands may already be breaking up enough to allow new regeneration to develop; if not, encouragement of vegetative reproduction is needed. 
        - See Sections 5.1, 5.2, 5.6, and 5.8
      - No: Have you decided on the timing and method of harvest to promote maximum broadleaf regeneration?
        - Yes: In general, plan to clearcut and increase soil temperature by causing harvesting disturbance that promotes vegetative reproduction. 
          - See Sections 3.5, 5.1, 5.2, and 5.6
        - No: Have you considered other factors that would encourage maximization of paper birch stemwood production in the next rotation?
          - Yes: If stemwood piece size is not important, consider short rotations because mean annual increment of paper birch peaks earlier than in conifers. 
            - See Sections 3.7 and 5.9
          - No: Define special circumstances where fertilization or other silvicultural expenditures may be warranted because they are often not justified as an expenditure for paper birch stem biomass production; see Sections 5.3 and 5.7.

Defer allocation of any forest land base to paper birch stemwood production until all of these questions are addressed as part of long-range planning and silviculture prescriptions.

FIGURE 3. Silvicultural options for management of paper birch for stemwood production in natural stands.
If the answer to any of these questions is no, either focus on paper birch stemwood production (see Figure 3) or maintain broadleaf stands as sites for later emphasis on wildlife use, biodiversity, or integrated resource management.

**FIGURE 4.** Silvicultural enhancement of paper birch ecosystems for wildlife use, biodiversity, or integrated resource management.
1.1 Paper Birch in Contemporary British Columbia Forestry

- Birch is now a desired raw material, not only for high-value wood and veneer products, but also for pulp, oriented strandboard, and other fibreboard products.

- Paper birch continues to play an important role among British Columbia’s forest products, being used in the production of birch logs in the lower Fraser Valley and central Interior, birch sawnwood in the Fraser Valley, rotary veneer in the Fraser Valley and southern Interior, and sliced veneer in the Fraser Valley and central Interior.

An analysis that compared British Columbia’s 1995 industrial use of broadleaf species with that in 1990 (Hyslop and Massie 1996) indicates that the biggest increase occurred with aspen (up about 262%, from 0.59 million m³/year in 1990 to 2.13 million m³/year in 1995). Although birch remained at only 1% of provincial broadleaf biomass utilization from 1990 to 1995, it also experienced increased overall market demand in those 5 years. In 1990, about 17 000 m³ of birch was used in British Columbia. In 1995, birch utilization reached 29 000 m³, an increase of about 70% over 1990. In the same 5-year period, balsam poplar utilization in British Columbia increased about 64% from its 1990 level, black cottonwood dropped about 77%, and red alder dropped about 0.7%.

The same 1996 review indicated that, in 1995, British Columbia paper birch provided raw material to one plant processing chips from broadleaf species, five plants producing sawn material, two plants producing veneer or plywood, and two plants producing oriented strandboard or particleboard. As of March 1996, grade 1 paper birch logs that were 100% sound, with a top diameter inside bark of at least 25 cm (10 in) had a market value of $90/m³, and dry-sliced or rotary birch veneer (1/32 inch), mill-run grade, was worth $90 (US) per thousand square feet. Log sale summaries from Lumby, B.C., provide a general comparison of birch and conifer log values. In the 12 months ending 30 June 1996, for a total log sort of 56 498 m³, the overall average price was $90.81/m³. Paper birch made up 236.5 m³ of this total at an average price of $21.61/m³. In that period the highest log values ($158.80–169.21/m³) were for oversize spruce, spruce for acoustic products, and spruce and Douglas-fir building logs. Only cottonwood yielded a lower price ($18.49/m³) than birch. Firewood made up of mixed species sold for $43.36/m³ at Lumby in 1995–96.

The communities or local regions most favourably located for potential birch usage—that is, with sufficient birch resources available near the community to support a milling facility—are Fort Nelson, Fort St. John, Kamloops and the nearby North Thompson region, and the Salmon Arm–Vernon–Sicamous region. Recent inventory and economic analyses suggest that management of paper birch for commercial sawlog production has increasing potential in the Interior. However, more information is needed on the resource potential to support a birch milling facility in the West Kootenay region of the province.

A current management problem is how to ensure a local sawmill a steady supply of high-quality birch logs. Overall regional availability of sawlog-quality birch may be less of a restraint than the problems faced by operators and contractors who set out to obtain cutting rights and silvicultural approvals to deliver good-quality birch stems to mills.

In production of chemithermomechanical pulp (CTMP), partial replacement of coniferous pulp raw material with up to 30% of birch and/or aspen mixtures has shown
that it is possible to produce pulps bleached to the brightness required for specialized papers. Through the use of atmospheric refining and interstage peroxide bleaching birch is now being combined with aspen to produce ultra-high-yield pulps. Good-quality CTMP can be obtained from mixtures composed of equal amounts of each species. CTMP produced from birch can partially replace the high-cost softwood component that is diminishing in supply in some areas of the province, a circumstance that could alter the way forest managers approach birch silviculture.

Paper birch is also being used as core material for aspen oriented strandboard and waferboard, providing high-quality boards that are superior to all-aspen panels. The future role of paper birch is assured because it is a high-value raw material not only for specialty products such as lathe-turned items, mouldings, and furniture, but also for use as a veneer for covering other less valuable biomass sources. For example, Thompson River Hardwoods in Kamloops recently used aspen as the core for plywood sheets and birch as the surface veneer. Unusable material for this plywood-veneer operation goes to the oriented strandboard plant at 100 Mile House. A recent analysis of oriented strandboard and medium-density fibreboard production in British Columbia indicated that the raw material for these products would be from various conifers, plus aspen and balsam poplar, but not from paper birch. However, recent oriented strandboard mills in Alberta and Quebec are using birch for up to 50% of their raw material requirements. Economic feasibility studies in northeastern British Columbia have emphasized the importance of the integrated processing of aspen, balsam poplar, and paper birch. This realization is an important step forward from 2 decades ago when many hectares of boreal broadleaf species, including paper birch, were cleared and burned in that part of the province, at the same time as Canada was importing substantial amounts of veneer and plywood products made from birch.

Although not yet a prominent part of the botanical forest products industry, birch also offers some commercial potential for use in producing biochemical products. For example, sap tapped from paper birch in the spring is not a new product, but is one that offers further potential use in the production of syrup, wine, beer, and medicinal tonics. Its carbohydrate content is about 0.9% (consisting of glucose, fructose, and sucrose), which compares to 2–3% total sugar content in maple sap. Trials showed that sap flow in birch lasted for 23–29 days compared to 16–45 days in maples. Small-scale operations to tap birch sap currently exist in Alaska. In Russia, total sap production from birch has been reported to be as high as 11 000 t/year, with yields as high as 30 t/year in one season. The practice there is to tap birch trees over 20 cm dbh, with tapping done 5–10 years before felling. Birch bark also remains an often wasted product, but it has great value-added potential in the hands of skilled artisans. In parts of North America where it is now hard to find large birch trees that can yield the large pieces of bark needed for canoe construction, an artisan-produced birch bark canoe can sell for up to $2500. Birch has a potentially important role to play in the current province-wide project (supported by Forest Renewal BC) to promote woodworkers, artisans, and industrial manufacturers in the province’s value-added wood sector.

Information Sources:
1.2 Inventory of Paper Birch in British Columbia

- The largest concentration of birch is found in the northeast of the province, especially in the Fort Nelson Timber Supply Area (TSA).

- The six TSAs with the greatest volume of birch in the province, in descending order, are: Fort Nelson (7 869 000 m³); Okanagan (2 337 000 m³); Fort St. John (2 160 000 m³); Kamloops (1 681 000 m³); Prince George (1 109 000 m³); and Kispiox (798 000 m³).

If British Columbia foresters are to manage the province’s tree species on the principle that each species should be encouraged to produce biomass in the biogeoclimatic subzones where that species is already doing well without silvicultural intervention, then paper birch should receive the greatest forest management attention in the area shown in Figure 1 and in the most productive sites listed in Table 3. Forest land areas in which paper birch is the leading species are summarized in Table 2 for various regions of British Columbia. The table also lists the relative proportions of birch volumes in near-mature, mature, and overmature age classes.

British Columbia’s annual utilization of paper birch in 1992 was estimated at 22 000 m³ (2000 m³ on the coast and 20 000 m³ in the Interior); recent estimates of 20-year annual harvests indicate a potential birch utilization of 324 000 m³/year (7000 m³ on the coast and 317 000 m³ in the Interior).

There are currently about 527 000 m³ of paper birch in the Fraser and Soo TSAs. Birch stands in the Fraser and Soo TSAs, as currently inventoried, occupy about 1000 ha of good sites, 4025 ha of medium sites, and 3000 ha of poor sites. Of this inventory, 486 000 m³ is near-mature, 40 000 m³ is mature, and 1000 m³ is overmature.

Existing inventory maps in British Columbia do not provide detailed information on birch stands. The information that is available suggests that birch suitable for conversion to lumber is scarce. In both British Columbia and Alberta, recovery of clear birch lumber from existing stands is considered to be a financially risky undertaking, partly because birch stands of sawlog size often contain decay or other defects. Furthermore, there are not many stands of a size and total volume to permit efficient logging and sawing of birch. Alberta experience indicates that recovery of clear birch lumber is usually 25% or less of the volume cut.

**Information Sources:**
Jasper Millworks Ltd. and Woodland Resource Services Ltd. 1988; Massie et al. 1994; Massie 1996.
TABLE 2. Forest land areas in which paper birch is the lead species in British Columbia, and relative proportions of paper birch volumes in near-mature, mature, and overmature age classes (Massie 1996)

<table>
<thead>
<tr>
<th>Regional area&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Area (ha)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Volume (000s m&lt;sup&gt;3&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Near-mature&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Mature</td>
</tr>
<tr>
<td>Central</td>
<td>34 485</td>
<td>1 111</td>
</tr>
<tr>
<td>North-Central</td>
<td>22 385</td>
<td>437</td>
</tr>
<tr>
<td>Northeast</td>
<td>137 000&lt;sup&gt;d, e&lt;/sup&gt;</td>
<td>3 190</td>
</tr>
<tr>
<td>Northwest</td>
<td>12 962</td>
<td>476</td>
</tr>
<tr>
<td>South-Central</td>
<td>37 265</td>
<td>971</td>
</tr>
<tr>
<td>Upper Fraser</td>
<td>8 025</td>
<td>486</td>
</tr>
<tr>
<td>Total</td>
<td>252 122</td>
<td>6 671</td>
</tr>
</tbody>
</table>

<sup>a</sup> Regional areas defined by Timber Supply Areas:
- **Central**: Quesnel, Williams Lake, 100 Mile House, Robson Valley, Kamloops
- **North Central**: Prince George, Mackenzie
- **Northeast**: Fort Nelson, Fort St. John
- **Northwest**: Kalum, Kispiox
- **South Central**: Okanagan, Revelstoke, Arrow, Kootenay Lake
- **Upper Fraser**: Fraser, Soo

<sup>b</sup> Combination of good, medium, and poor sites; sites of low productivity are not included.

<sup>c</sup> Maturity-age definition:
- **Near-mature**: 41–80 years of age
- **Mature**: 81–120 years of age
- **Overmature**: 121 years of age or more

<sup>d</sup> In the northeast of the province, paper birch would also include Alaska birch.

<sup>e</sup> In the Dawson Creek TSA, the data were not adequate to report birch on private farm land. On public land, only 4 515 ha were reported with birch as the predominant species.
TABLE 3. Relative percentage occurrence of birch on good, medium, and poor sites (by land area) on 17 British Columbia Timber Supply Areas in which the current inventory identifies birch as a leading species (Massie et al. 1994)

<table>
<thead>
<tr>
<th>General region in British Columbia</th>
<th>Timber Supply Area</th>
<th>Percentage occurrence of birch (on a land area basis) as a lead species on different sites&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Good&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fraser Valley</td>
<td>Fraser</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Soo</td>
<td>0</td>
</tr>
<tr>
<td>Northeast</td>
<td>Fort Nelson</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Fort St. John</td>
<td>0</td>
</tr>
<tr>
<td>North-Central</td>
<td>Mackenzie</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Prince George</td>
<td>1</td>
</tr>
<tr>
<td>Central</td>
<td>Quesnel</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Williams Lake</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>100 Mile House</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Robson Valley</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Kamloops</td>
<td>1</td>
</tr>
<tr>
<td>South-Central</td>
<td>Okanagan</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Revelstoke</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Arrow</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Kootenay Lake</td>
<td>0</td>
</tr>
<tr>
<td>Northwest Interior</td>
<td>Kalum</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Kispiox</td>
<td>0</td>
</tr>
<tr>
<td>Provincial Total</td>
<td></td>
<td>1%</td>
</tr>
</tbody>
</table>

<sup>a</sup> If less than 0.5% of land area, relative percentages are recorded as zero.

<sup>b</sup> In the current inventory, site quality is a derived attribute in which interpreted height and age are related to a site index curve or equation to determine good, medium, poor (and low) site quality. These site quality estimates are based on stand height defined by average height of the dominant and codominant trees of the leading species in a stand, and age is defined as average age of the dominant and codominant major species in the stand canopy. The latter definition allows conifer data to enter into these site quality estimates even on land areas where birch is a leading species. The last two columns in the table above suggest that birch occurs mainly on sites currently defined as medium or poor. This may not be an accurate portrayal of site potential because there are many cases in British Columbia where birch is prominent in good sites. The fact that the present inventory does not show a high percentage occurrence of birch on good sites suggests the need to investigate the degree to which incorporation of broadleaf site index data would improve provincial forest inventory databases.
1.3 Applicability of Range-wide Paper Birch Information to British Columbia

- Although absent from some parts, paper birch is generally a component across the extensive boreal forests of North America, where it occurs with the dominant genera of *Picea, Abies, Larix, Pinus,* and *Populus.* In British Columbia, *Pseudotsuga* and *Thuja* are other genera often associated with birch.

- Foresters familiar with paper birch in their own districts will be the best judges of the applicability of range-wide birch information to their particular sites and silvicultural circumstances.

Paper birch, like any other tree species, has inherent genetic and physiological characteristics that apply to the species wherever it occurs. By itself, this implies that birch management experience gained from anywhere within the natural range of this species would be applicable to birch in British Columbia. If that were entirely true, there would likely not be a need for this handbook, as management guidelines exist for paper birch in the New England states (Safford 1983; Leak et al. 1987; Hornbeck and Leak 1992), the Lake states (Tubbs 1977; Tubbs et al. 1983), the Maritimes (Lees 1978), and the Pacific Northwest (Niemiec et al. 1995). However, there are several reasons why birch management experience is not applicable over all parts of the species’ natural range: sites defined by biogeoclimatic criteria vary greatly over the wide geographic range of paper birch; the early-succession and late-succession companion shrub and tree associates of paper birch vary throughout this tree’s natural range; and forest management practices, intensities of biomass utilization, priorities for various products that can be made from the stems of broadleaf species, economic factors related to use of paper birch, and interests in biodiversity and forest sustainability all vary geographically.

Therefore, existing information about birch management from anywhere in its natural range has been incorporated into this handbook wherever it is biologically defensible to do so. Where it was judged that ecological, silvical, or silvicultural circumstances in British Columbia *may* be different from the source area of particular advice about birch management, the geographic source of that information is identified. Foresters familiar with paper birch in their own area of work will be the best judges of how well the range-wide birch information applies to their particular site and silvicultural circumstances.

The degree to which silvicultural experience with silver birch (*Betula pendula*) in Europe can be applied to paper birch in British Columbia has not been well tested. However, this handbook does make occasional reference to *B. pendula* silviculture (for example in Section 5.3), where responses to various levels of stem density could be expected to be similar in paper birch and silver birch.
2 ECOSYSTEMS THAT SUPPORT PAPER BIRCH IN BRITISH COLUMBIA

Paper birch is adapted to a wide range of climates and tolerates wide variations in the amount and pattern of precipitation. The province-wide distribution of paper birch indicates the diversity of biogeoclimatic subzones and site series in which forest managers can be involved with this species.

2.1 Geographic Distribution of Paper Birch

• The northern range of birch follows closely the northern limit of tree growth; the southern range extends to northern Idaho–western Montana, the Great Lakes region, and through central New York to the Appalachian Mountains.

• Paper birch is found throughout British Columbia except on the Queen Charlotte Islands. It occurs sporadically on southeastern Vancouver Island and is somewhat more abundant in the lower mainland of coastal British Columbia, but it is predominantly an Interior species.

Paper birch is common in most low- to medium-elevation biogeoclimatic zones in the Interior. It is the most widely distributed broadleaf species in the ICH and the wet-belt portions of IDF zones in interior British Columbia (see Appendix 1 for definition of biogeoclimatic subzones that are abbreviated in the text). It also occurs in the BWBS, SBS, MS, CWH, CDF, PP, and BG zones. It is uncommon in the ESSF zone and absent from the MH and AT zones. In the Interior it is most abundant along rivers and lake shores, but does extend upslope to about 1000 m. It rarely occurs in subalpine forests, but is common in boreal forests across Canada. Appendix 2 lists the site series in which birch could be expected as a seral species in the Cariboo, Kamloops, Nelson, Prince George, and Prince Rupert forest regions.

The exceptionally wide geographic distribution of paper birch in British Columbia, which includes Alaska paper birch in the province’s northeast, is a result of several factors: its ability to be a prominent species on sites of poor quality where other British Columbia tree species have difficulty becoming established; its ability to regenerate on sites after fire and harvesting disturbances; its high resistance to growing-season frost and ability to begin early-season growth while temperatures are still below freezing; and its ability to tolerate solidly frozen ground in the dormant season. Also, birch trees are considered by some researchers to have a high tolerance to flooding, although seedlings are physiologically damaged by flooding. Another factor important to the prevalence of young birch in gaps of older conifer stands is the species’ greater resistance than conifers to root diseases such as Armillaria spp. and Phellinus weirii. Paper birch is often described as a species with very low shade tolerance, although it may have a wider range of shade tolerance than is reported in the literature. For example, in interior British Columbia birch often occupies small canopy gaps created by the loss of only a few overstorey conifers. Also, birch can persist for many years as a codominant with succeeding conifers, although it eventually drops out as a stand component. The typical landscape pattern of birch in southern British Columbia (Figure 5) is influenced by patterns of wildfires, rural settlement, forest harvest areas, riparian zones, and root disease patches.
Although paper birch is viewed as an Interior species, where it does occur in coastal British Columbia it can be a locally important component of broadleaf stands, particularly in the driest and coolest subzones of the CWH zone. Some taxonomists have suggested that the populations of birch that are restricted to southwestern British Columbia are a separate variety, _B. papyrifera_ var. _commutata_. While birch occurs on both upland and floodplain sites in interior British Columbia, it tends to be restricted to upland sites in coastal biogeoclimatic zones. It is also common as a successional species in the Richmond and Delta municipalities of the Fraser River delta, but the sites where it occurs are above recent historical flood levels.

Paper birch is a good example of an angiosperm that possesses high genetic variability and is evolving rapidly. Its transcontinental distribution gives this monoecious species a very large total population size. It is a typical pioneer species that is capable of sexual and asexual reproduction; birch flowers early and produces large quantities of seeds that can be blown some distance. Polyploidy, ranging from tetraploids (4n = 56) to hexaploids (6n = 84), is common in this species.

There has been very little experimentation to test geographic variation in paper birch, partly because birch plantation establishment is uncommon and birch tree improvement has had a low priority. However, tests in Maine and New Hampshire did demonstrate differences in height among provenances from different areas across an east–west range of those two states.

**Information Sources:**

**Figure 5.** Typical distribution of paper birch along the shore of Big Shuswap Lake near Eagle Bay, British Columbia. The landscape pattern of paper birch follows that of wildfires, rural settlements, forest harvesting, riparian zones, and root disease patches. (Photograph by J. Mather)
2.2 Ecosystems in Which Forest Managers Are Most Involved with Paper Birch

- Paper birch reaches its greatest productivity in the ICH zone, which occupies the warm, moist valleys of the southern Interior, but it also grows well in transitional climates, such as the coast–interior ecotone and between the dry and wet belts in the southern Interior. On an area basis, birch achieves its greatest abundance in the BWBS zone of northeastern British Columbia.

- Paper birch is an acceptable regeneration species, on certain site series, in seven of British Columbia’s biogeoclimatic zones (BG, BWBS, ICH, IDF, MS, PP, and SBS).

Paper birch can potentially occur in all of British Columbia’s biogeoclimatic zones except the MH and AT zones. However, it is a potential regeneration species on the greatest number of site series in the Prince George Forest Region, where the SBS zone has 34 of the region’s 56 site series where birch was considered by the Silviculture Interpretations Working Group (1994) to have silvicultural potential. Of the 209 site series where birch is considered to have a regeneration role in British Columbia, 45% are in the ICH zone and 32% are in the SBS zone (Table 4). Birch is not a recommended species for regeneration in the Vancouver Forest Region. In the five other forest regions, birch sites are most common in the SBS zone in the Cariboo and Prince George forest regions, and in the ICH zone of the Kamloops, Nelson, and Prince Rupert forest regions.

Across the province, birch is potentially associated with many other tree species (Table 5). This list of possible associations of birch with other tree species is based on judgements by the Silviculture Interpretations Working Group (1994), where site series in which birch is considered an acceptable regeneration species are also sites that support various combinations of other tree species. In Table 5, the lack of birch association with any other tree species in the Vancouver Forest Region results from birch not being regarded as a suitable regeneration species on any site series in that forest region. In reality, birch is common on disturbed sites of the Fraser River lowlands, where it can potentially occur with red alder, black cottonwood, bigleaf maple, western hemlock, western redcedar, or Sitka spruce. On a regional basis, paper birch can coexist with the greatest variety of other tree species in the Prince George and Prince Rupert forest regions (Table 5). There are eight tree species that can occur with birch in all five of British Columbia’s Interior forest regions (cottonwood, aspen, subalpine fir, western redcedar, Douglas-fir, western hemlock, lodgepole pine, and hybrid spruce).

Paper birch has silvicultural potential in 304 different combinations of site series and biogeoclimatic subzones/variants, compared to 496 for aspen and 284 for black cottonwood (see Table 4 and Appendix 2). On a province-wide scale, the two most common birch-dominated site associations in British Columbia are Paper birch with Starflowered Solomon’s seal and Paper birch with Aspen – Thimbleberry – Falsebox. In decreasing order, paper birch is a potential regeneration species in the following numbers of site series–biogeoclimatic unit combinations in the province’s six forest regions: Prince George, 103; Kamloops, 63; Nelson, 58; Cariboo, 44; Prince Rupert, 36; and Vancouver, 0. Paper birch can naturally regenerate on a broad range of sites and parent materials or microsites, including colluvial slopes (Figure 6), woody debris (Figure 7), crevices in rock outcrops (Figure 8), and productive riparian ecosystems (Figure 9).
**TABLE 4.** Number of site series in which paper birch is a potential regeneration species in British Columbia, by forest region and biogeoclimatic zone (Silviculture Interpretations Working Group 1994)

<table>
<thead>
<tr>
<th>Biogeoclimatic Zone</th>
<th>Cariboo</th>
<th>Kamloops</th>
<th>Nelson</th>
<th>Prince George</th>
<th>Prince Rupert</th>
<th>Vancouver</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWBS(^{a})</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>8</td>
<td>5</td>
<td>—</td>
<td>13</td>
</tr>
<tr>
<td>BG</td>
<td>—</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3</td>
</tr>
<tr>
<td>ICH</td>
<td>10</td>
<td>28</td>
<td>27</td>
<td>14</td>
<td>16</td>
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<td>95</td>
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<td>IDF</td>
<td>5</td>
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<td>—</td>
<td>22</td>
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<tr>
<td>MS</td>
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<td>4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>4</td>
</tr>
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<td>PP</td>
<td>—</td>
<td>2</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>SBS</td>
<td>21</td>
<td>—</td>
<td>—</td>
<td>34</td>
<td>11</td>
<td>—</td>
<td>66</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>36</strong></td>
<td><strong>45</strong></td>
<td><strong>40</strong></td>
<td><strong>56</strong></td>
<td><strong>32</strong></td>
<td>—</td>
<td><strong>209</strong></td>
</tr>
</tbody>
</table>

\(^{a}\) Biogeoclimatic zone abbreviations are identified in Appendix 1.
TABLE 5. Tree species potentially associated with paper birch on site series where birch is an acceptable regeneration species, by forest region (Silviculture Interpretations Working Group 1994)

<table>
<thead>
<tr>
<th>Species</th>
<th>Cariboo</th>
<th>Kamloops</th>
<th>Nelson</th>
<th>Prince George</th>
<th>Prince Rupert</th>
<th>Vancouver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acb&lt;sup&gt;a&lt;/sup&gt;</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Act</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>At</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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</tr>
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</tr>
</tbody>
</table>

<sup>a</sup> Tree species’ abbreviations are identified in Appendix 1.
FIGURE 6.  Successful establishment of paper birch on an active colluvial slope in the Liard River area of north-eastern British Columbia. (Photograph by K. Enns)

FIGURE 7.  Woody debris, in this case a cut stump, is also an acceptable medium for birch regeneration.
FIGURE 8.
At the extreme lower level of site productivity, birch often becomes established in crevices of rock outcrops.

FIGURE 9. At the upper level of site productivity, birch is a common component of riparian and alluvial ecosystems in interior British Columbia. (Photograph by J. Mather)
3 PAPER BIRCH BIOLOGY AND SILVICS

This section focuses on those aspects of paper birch autecology that are considered most relevant for management of this species. The emphasis is on soil and site relations, regeneration biology, responses to disturbance, succession, growth and yield, and agents that are damaging to birch.

3.1 Field Recognition of Paper Birch

- Paper birch is probably the most variable tree species in Canada. Many geographic varieties, including Alaska paper birch in northeastern British Columbia, have been described.

- Recognized varieties of paper birch in British Columbia include: the common var. *papyrifera*, which occurs across Canada and is found in the interior of British Columbia; var. *commutata*, the coastal form found in the Fraser Valley, on southern Vancouver Island, and at scattered locations along the coast; and var. *subcordata*, which results from the crossing of paper birch and water birch (*B. occidentalis)*.

Paper birch is a small- to medium-sized, small-crowned tree that ranges in height from 15–30 m. The crown of birch is oval-shaped and open, and is usually composed of many ascending branches that end with many branchlets. Its characteristically white to yellowish bark is smooth and marked with horizontal lines, and it peels readily into papery strips. Leaves of birch are egg- or diamond-shaped, usually between 4 and 8 cm long, occasionally longer to 10 cm, and greener on the top surface than on the undersurface. The undersurface has long hairs, seen as tufts in angles of larger leaf veins, and the leaf edges are sharply double-toothed. Typical leaf, twig, catkin, and fruit characteristics of paper birch are shown in Figure 10.

**FIGURE 10.** Typical leaf, twig, catkin, and fruit characteristics of paper birch: A, branch with fruiting catkins; B, winter twig with staminate catkins; C, underside of leaf showing axillary tufts of hair; D, fruit (Brayshaw 1996).
Flowers of paper birch occur as male and female forms in separate catkins (2–3 cm long) on the same tree and commonly on the same branch. Flowers appear in spring either during or before leaf burst. Genetic and environmental factors govern the numbers of male and female flowers produced by a tree and large variations can occur from year to year. Male catkins are formed and are readily identifiable at the end of the growing season, thus serving as a general indicator of potential seed crop in the coming year. Fruits of birch are oval nutlets with wings wider than the body.

The largest birches recorded to date in British Columbia are two trees on the lower mainland: a birch tree 22.56 m tall, with a breast height diameter of 1.42 m located on the east Pitt River dike, Pitt Meadows; and a birch tree 25.91 m tall and 1.09 m dbh, located on Skumalasph Island, Chilliwack Indian Reserve 16, near Deroche. By comparison, the 1996–97 National Register of Big Trees in the United States records a paper birch in Cheboygan County, Michigan, as 32.6 m high and 1.78 m dbh. A northwestern United States birch identified as *B. papyrifera* var. *subcordata*, from Minam River, Oregon, was listed as 20.1 m high and 0.38 m in circumference at breast height. A birch of above-average dbh, growing in association with balsam poplar, is shown in Figure 11.

**Information Sources:**


**FIGURE 11.** Paper birch is often the last of the early seral broadleaf species to die in boreal mixedwood stands, with the result that relatively large individual birch trees occur among their other early-seral partners, in this case balsam poplar.
3.2 Biological Features of Paper Birch That Distinguish Its Silvicultural Responses from Conifers and Other Broadleaf Species

- Compared to conifers, birch is a short-lived species, often with top dieback or other deterioration by age 70. In some cases, however, it survives to at least 140 years.

- Many birch trees are multi-stemmed, often as a result of disturbance that stimulates a parent tree to produce basal sprouts.

Paper birch is common as an overstorey tree in early seral plant communities, but because of its shade intolerance, usually survives only one generation as succession to conifers progresses. Although paper birch usually has signs of heartrot by 60–70 years, it is not uncommon to find intact old-growth birch that is 100–140 years old (Figure 12). Alaskan researchers have recorded good-quality birch stands 125–150 years old. In mature forests, it occupies openings and gaps created by blowdowns and other disturbances. There are indications that birch can tolerate more shade in stands on rich soils than on poor soils.

Important silvical and management differences between paper birch and the other main broadleaf species in British Columbia are summarized in Table 6. Biological features of paper birch that distinguish its silvicultural responses from conifers are summarized in Table 7, and the key silvicultural implications of birch’s ecological characteristics are listed in Table 8. Features summarized in these tables are discussed in greater detail elsewhere in this handbook.

There are major silvical differences between paper birch and the conifers with which it is commonly associated.

Information Sources:
FIGURE 12. Paper birch usually has signs of heartrot by age 60–70 years, but this tree at the north end of Adams Lake, British Columbia, is still healthy at age 80 years. It is not uncommon to find intact old-growth birch that is 100–140 years old. Many mature birch trees are multi-stemmed. (Photograph by S. Simard)
TABLE 6. Some silvical and silvicultural features of paper birch in comparison to British Columbia’s other main broadleaf species, black cottonwood–balsam poplar, aspen, and red alder (*** = predominant feature for the species; ** = applies to the species but not predominately so; * = does not apply to the species; ? = silvical or silvicultural aspects not well known)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Paper birch</th>
<th>Cottonwood–balsam poplar</th>
<th>Aspen</th>
<th>Red alder</th>
</tr>
</thead>
<tbody>
<tr>
<td>• vegetative reproduction almost exclusively by root suckers</td>
<td>*</td>
<td>**</td>
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<tr>
<td>• vegetative reproduction common from stump sprouts</td>
<td>***</td>
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<td>**</td>
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<tr>
<td>• vegetative reproduction common from broken branch or stem segments</td>
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</tr>
<tr>
<td>• readily reproduced by stem or root cuttings</td>
<td>*</td>
<td>***</td>
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</tr>
<tr>
<td>• frequently reproduces naturally from seedling origin</td>
<td>***</td>
<td>***</td>
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<tr>
<td>• very rapid early growth rate if of vegetative origin</td>
<td>***</td>
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<tr>
<td>• relatively rapid early growth rate if of seedling origin</td>
<td>?</td>
<td>?</td>
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<td>***</td>
</tr>
<tr>
<td>• when of clonal origin, very effective natural thinning</td>
<td>*</td>
<td>***</td>
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<td>*</td>
</tr>
<tr>
<td>• natural thinning in seedling origin stands is less effective than in stands of stump or root sucker origin</td>
<td>**</td>
<td>?</td>
<td>?</td>
<td>*</td>
</tr>
<tr>
<td>• ability to fix nitrogen</td>
<td>*</td>
<td>**</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>• nitrogen fixation leads to soil acidification</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>• significant role in riparian ecosystems</td>
<td>***</td>
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<td>***</td>
</tr>
<tr>
<td>• management for high-quality solid wood products is a high priority</td>
<td>***</td>
<td>**</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>• management for fibreboard, strandboard, pulp, and paper products is main priority</td>
<td>**</td>
<td>***</td>
<td>***</td>
<td>**</td>
</tr>
</tbody>
</table>
**TABLE 7.** Some biological features of paper birch that distinguish it from conifers or other British Columbia broadleaf species

- Paper birch is immune to several root diseases (*Phellinus weirii*, *Inonotus tomentosus*, *Heterobasidion annosum*, and *Loptographicum wageneri*) and has low susceptibility to *Armillaria ostoyae*. Birch can be planted on diseased sites to hold the effects of *Phellinus weirii* within acceptable limits, provided sites are suitable for birch. On sites infected with *Armillaria* or *Phellinus*, root disease spread may be reduced where birch is regenerated in mixture with susceptible conifers, although mortality among susceptible species can be expected.

- Birch stems decay differently than stems of most of birch’s companion tree species that lose their bark quickly; in contrast, bark is the last part of the stem to decay in birch. Intact cylinders of bark often remain long after the wood of downed birch stems has decayed, possibly because the bark is effective in keeping the water content of decaying wood high, thus promoting decomposition of the downed stemwood.

- Paper birch contains more total foliar and branch nutrients than conifers, a factor that makes birch foliage biomass a very important part of nutrient cycles. This is especially true because birch foliage decomposes much faster than wood or bark, and because of the relatively high proportion of birch’s above-ground nutrients contained in the foliage. In birch, the biomass of small roots (< 1 mm diameter) may be twice that of conifers, suggesting that birch can provide intense root competition to companion tree species.

- Unlike conifers, many paper birch are multi-stemmed. This adds to birch’s aesthetic appeal and coppice ability, but is not conducive to good stem production.

- Of the four main broadleaf species in British Columbia, paper birch is the least demanding in terms of soil nutrients and is the best adapted to soil drought.

- Paper birch does not exhibit the extremely rapid early growth characteristic of broadleaf species such as alder and black cottonwood, but early growth of birch is still faster than that in conifer species.

- Paper birch does not reproduce well in established forests. Once companion conifers are present in the late stages of forest succession, subsequent development of birch is highly dependent on disturbances that create gaps in the conifer or mixedwood canopy.

- Stand break-up in birch occurs earlier than in conifers. Stand deterioration in paper birch typically occurs between 75 and 100 years when tops start to die, leaving an uneven upper canopy. In the Lake states, many examples of widespread birch mortality are thought to be triggered by periods of drought, compounded by borer and leaf miner attacks.

**TABLE 8.** Silvicultural implications of paper birch’s ecological characteristics

- An important role of paper birch is improvement of soil quality by accelerating the cycle of mineral nutrients, carbon, and organic matter, characteristics shared with *Alnus*, *Populus*, and *Salix*.

- With the current abundance of paper birch seed sources, dense natural regeneration of paper birch may be expected on many sites, with relatively concentrated occurrence corresponding to areas of soil disturbance on a given site. Tightly clumped birch stems are common where birch is of sprout origin; stump sprouts can provide acceptable supplemental regeneration. In the best cases, every tree can be expected to sprout, thus providing long-term, tree-for-tree replacement, but the probability of this occurring declines with age.

- As with many other tree species, if a manager wishes to limit natural regeneration of paper birch, control methods could include minimizing soil disturbance, removing seed trees, and maintaining a groundcover of litter, woody debris, or vegetation (particularly grass). Relatively good control over initial spacing can be achieved by planting paper birch on sites where soil disturbance is minimized.

- Maintenance of a paper birch component can help maintain and enhance soil organic matter and nutrients, particularly where significant soil degradation has occurred.

- There can be various combinations of site preparation, planting, or dense natural regeneration to achieve early dominance of paper birch. Paper birch does not tolerate overtopping by shrubs; dense brushfields can quickly develop following harvest of birch stands, thereby impeding birch regeneration and often requiring some combination of intensive site preparation, planting, and vegetation management to establish adequate stocking of either paper birch or conifers.

- Commercial thinnings should aim for open, high-light conditions to promote rapid growth of birch stems.

- A component of paper birch in conifer stands can provide more diverse stand structure of wildlife and biodiversity value than would be provided in pure conifer stands.
3.3 Paper Birch Soil Relations

- Paper birch grows best in nutritionally rich sites, but is also adapted to a wide range of nutritional conditions. It requires moderate amounts of nitrogen and sulphur, and high levels of calcium and magnesium. It is also sensitive to phosphorus availability.

- Paper birch grows on soils ranging from acidic to highly calcareous. Best growth occurs on well-drained sandy loams and on silt soils, or on soils derived from limestone.

Paper birch occurs on a wide variety of parent materials and on soil textures ranging from gravelly sands to loams and organic soils. It is most abundant on rolling upland terrain or on alluvial sites, but also occurs on open slopes, rock slides, bogs, and swamp margins.

As with other tree species, height growth of birch sprouts and birch seedlings is greater as soil moisture increases. For example, in the ICHmw3 variant of the Kamloops forest region, 10-year-old birch sprouts have been recorded to be about 10 m tall on subhygric sites, but only 4 m tall on submesic sites. The same holds true on the geographic scale of subzones and variants, with 10-year-old birch averaging about 4 m tall in a dry variant in the Kamloops forest region (IDFmw2), but 7 m in a wet variant (ICHmw3).

Paper birch is important to nutrient cycling in British Columbia’s forests because of its deciduous growth habit, rapid litter decomposition rate, and high foliar nutrient concentrations. Preliminary research involving comparisons of nutrient concentrations of recently abscised paper birch and Douglas-fir foliage indicates that birch is richer than Douglas-fir foliage in nitrogen, phosphorus, sulphur, calcium, magnesium, and potassium (Figure 13). The superior ability of birch to sequester nutrients compared to Douglas-fir is partly due to birch’s more robust root system, which allows it to use

**FIGURE 13.** Mean nutrient concentrations of recently abscised foliage from 1-year-old field-planted paper birch and Douglas-fir seedlings. The ratio of paper birch to Douglas-fir for the macronutrients (sulphur, nitrogen, and phosphorus) was 1.5–1.7 and for the major cations (potassium, magnesium, and calcium) was 1.2–3.0. Deciduous trees typically are more nutrient-rich than conifers growing on the same site. (Simard 1995)
larger volumes of soil. Roots of birch seedlings have greater biomass and length than
do roots of Douglas-fir seedlings grown under the same conditions. Therefore, uptake
and annual turnover of the nutrients contained in birch roots and foliage are potentially
very important to conifers on the same site.

The high nutrient demand of paper birch enables it to grow fast and dominate
rich sites. Although birch prefers rich sites, it also tolerates acidic to calcareous soils
and can grow in soils with a pH as low as 4.4. Its nutrient requirements for nitrogen and
sulphur are moderate, while those for calcium and magnesium are high. High tissue
nitrogen concentrations in paper birch are associated with nitrogen fixation by
asymbiotic bacteria living in soils within the zone of birch roots. Extractable nitrogen
has been shown to be as much as 15 times greater beneath a birch forest than under
spruce stands.

Birch exploits soils efficiently by developing shallow feeder roots and deep sinker
roots. Birch roots penetrate deeper in warm soils than in cold soils. Roots grow propor-
tionately to light intensity; as shade increases, photosynthate in paper birch is allocated
to the stem at the expense of the roots, and the root-to-shoot ratio diminishes. Larger
roots and higher root-to-shoot ratios are produced by seedlings grown in full sunlight.

Several sources from the literature, summarized by Perala and Alm (1990b), have
noted that mycorrhizal birch seedlings survive and grow better than non-mycorrhizal
seedlings because they take up more nutrients, especially phosphorus. The soil activity
of mycorrhizal fungi improves seedling development, even before infection takes place,
by liberating nutrients from soil organic matter.

Association with diverse ectomycorrhizal fungi gives trees versatility to exploit a
range of soil microenvironments such as mineral soil, organic matter, and decaying
wood. Ectomycorrhizal fungi differ physiologically in their ability to transport water,
break down organic nutrients, absorb mineral nutrients, and provide protection from
pathogens at different periods in a season or over the period of a tree’s life. In a recent
field study, Jones et al. (1997a, b) showed that diversity of the ectomycorrhizal
community on 2-year-old Douglas-fir root systems was higher when grown in mixture
with paper birch than when grown in pure stands. They suggested that this increased
diversity resulted from: (1) the ready infection by colonized, neighbouring paper birch
because of a readily available carbon supply (from birch roots); and (2) the modification
of the soil, both chemically and biologically, by the presence of paper birch, and thus
alteration of the relative ability of different fungi to colonize Douglas-fir.

Different tree species can share in several common types of mycorrhizal fungi,
and thereby become physically and physiologically connected. The connecting
mycelium can serve as conduits for the exchange between trees of nutrients, carbon,
and water. Paper birch and Douglas-fir seedlings have been shown to share many
ectomycorrhizal fungi over a high proportion of their roots, and the two tree species
can exchange between them 4–7% of their fixed carbon. In mixed stands, there can be
a net gain in carbon by Douglas-fir, which increases as Douglas-fir is shaded by
neighbouring birch. This carbon is likely transferred in combination with nitrogen
after being converted to amino acids. Thus, paper birch is not simply a competitor for
resources with its conifer neighbours, but is important in co-operative processes
involving symbiosis and mutualisms.

Paper birch is known to accumulate comparatively high concentrations of storage
proteins in its bark at the time of leaf senescence. This autumn translocation of leaf
nitrogen (and its accumulation in the bark as soluble protein) has been hypothesized
to be one reason why birch is a fast-growing species. *Salix, Populus, Larix,* and *Betula*
all have major proteins present during winter, which may serve as available sources of
nitrogen for early spring growth. *Alnus* is missing from this list because some studies
indicate that it does not conserve leaf nitrogen through retranslocation to bark tissues.
This suggests that birch’s nutrient cycling and nutrient partitioning role within forest
ecosystems may be quite different from alder’s well-known role in nitrogen relations.

There is now substantial research to show that some tree species (such as spruce)
cause cycling of nutrients to slow down, whereas other species may improve soil fertility.
European silviculturists now recognize that nutrient release from heathland and
moorland soils accelerates after establishment of birch. Recent laboratory studies with
paper birch suggest that seedlings of this species can increase soil-available carbon, as
well as microbial acquisition of soil nutrients. The rapid uptake of nitrogen by paper
birch roots is considered to be a stimulus for microbial communities to acquire nutrients
from the soil.

### 3.4 Stand and Site Conditions of Diagnostic Importance to the Manager

- On a province-wide basis, birch occurs predominantly on poor sites. A
  recent analysis indicated that areas in which birch is the leading species
  in British Columbia totalled 148,948 ha of poor sites, 100,359 ha of
  medium sites, and only 2815 ha of good sites.

- Forest Practices Code guidelines stress that, to maintain biodiversity,
  the proportion and distribution of broadleaf stands should be maintained
  within the range of natural proportions and distributions found in
  unmanaged landscapes. This objective can only be met by actively
  managing some stands for pure or mixed broadleaf composition.

Encouragement of paper birch as a forest renewal crop or as a nurse crop often
involves poor and medium sites. On many of these sites, natural regeneration of paper
birch can be encouraged concurrently with the planting of conifers. Once a paper birch
stand is established, it can improve the site quality for conifers.

Regeneration with broadleaf species, especially paper birch, is now recognized
as an ecologically sound strategy for regenerating root-diseased sites. To meet this
objective, paper birch can either be grown in pure stands over short rotations, to reduce
inoculum levels, or grown in mixture with susceptible conifers to lower root disease
levels and regeneration risk.
3.5 Paper Birch Natural Regeneration Biology

- Sufficient seed dispersal, suitable microsites, lack of shrub competition, and opportunities to meet the germination requirements of birch are necessary for natural regeneration. Birch is also dependent on frequent natural disturbance.

- Natural regeneration by seeding is still prevalent for birch in British Columbia, and is preferred over artificial regeneration where cost is important for low-productivity sites or sites with poor access or low tolerance for heavy traffic.

As outlined in subsections below, paper birch has regeneration advantages over its companion conifers because it can effectively reproduce either from seeds or sprouts. Also, birch is very frost resistant and often begins growth early in spring when temperatures are still below freezing. Birch germinants can also tolerate high summer temperatures, provided sufficient moisture is available. If soil moisture is adequate, these high temperatures stimulate not only seedling development, but also the growth of birch sprouts. Successful regeneration requires very specific soil, light, moisture, and disturbance conditions, but these prerequisites are well known, giving the manager substantial opportunity to influence the timing, density, and success of birch re-establishment.

3.5.1 Seedling reproduction

- Paper birch reproduction is mostly from seed. This species begins to bear seed by age 15 and optimum seed production occurs between ages 40 and 70.

- Seed availability and surface conditions are key factors in birch regeneration. Seedling regeneration can be patchy and unreliable.

Reproduction in birch is mostly from seed (Figure 8), although adventitious buds vigorously sprout from the root collar following cutting or fire (Figure 14). Birch produces seeds annually, but good crops occur every 2–4 years. A single paper birch tree may produce 9–10 million seeds in a good seed year; each strobilus contains about 380 seeds. Solitary birches produce more seed (about 10 times more) than trees in closed stands. The bulk of birch seed is dispersed by water and by wind over snow surfaces in fall and early winter, but in Alaska there is evidence that some seed can fall each month of the year. Although birch’s winged nutlets are easily transported distances of over 200 m, most fall within two to three tree lengths (100 m) of the parent tree. However, birch trees isolated in equally tall spruce stands spread only about 25% of their seed within 40 m and the rest further afield. Seed is dispersed in the fall and early winter (August to January). The sites and circumstances where oversnow dispersal of birch seed may be important are not well understood. Opinion is divided on the role of snow surfaces as an aid to birch seed dispersal. To assess this question, local data are needed on periodicity of seedfall in relation to timing of snowfall and ice-crusted snow surfaces. Of the species with fall and winter seed dispersal (paper birch, white spruce, tamarack, and interior species of alders and willows), birch has a greater dispersal distance than does white spruce. Regardless of species, however, there are usually
FIGURE 14. Coppice sprouts are a common mode of regeneration in birch. (Photograph by S. Simard)
only very small quantities of seeds dispersed more than 100 m from the seed source. Germination normally occurs the following spring immediately after snowmelt. Paper birch seeds in the soil seed bank can remain viable for at least 2 years, with evidence that seeds of birch in Sweden have even greater longevity. Research in Alaska has shown that paper birch seed quality can vary greatly from year to year; in some years, even though total seedfall may be good, the amount of viable seeds may be far lower than total seedfall would suggest.

Female catkins of paper birch release large quantities of small, wide-winged seed. This species begins to bear seed at about 15 years of age and optimum seed-bearing years occur between 40 and 70 years. In northern Wisconsin, paper birch on average produced a good seed crop in 1 of 4 years. Average paper birch seed crops can provide about 250 seeds per square metre, and 9000 or more seeds per square metre is considered a bumper crop. A very high reported viable seedfall, from a study in Alaska, recorded 28 000 seeds per square metre. Even greater numbers were reported from a Finnish study (177 000 viable and unviable seeds per square metre) of paper birch, with even larger numbers in other birch species. Such heavy seed production can reduce flowering and radial growth the following year, and can induce crown dieback. Both birch and white spruce have a fall and winter seed dispersal pattern. This contrasts with aspen, black cottonwood, and balsam poplar, which disperse seeds in early summer. Moist, mixed mineral-organic soil is the ideal medium for birch seed germination. Such seedbeds are created following windthrow, fire, and mechanical site preparation.

Birch of seed origin grow much slower than those of sprout origin due to the smaller carbohydrate reserve in the expanding root system compared to the established root system. In British Columbia’s ICH zone, seedlings on mesic sites grew on average only 20 cm/year whereas sprouts grew on average 60 cm/year. In general, natural regeneration can be effective on small patch cuts or if seed trees are left in place. However, regeneration may be poor in large openings.

Direct seeding trials on 15-m wide, east–west clearcut strips in northeastern New York State indicated that seeding rates as low as 12 viable birch seeds per spot, or 1.24 million seeds per hectare for broadcast seeding on tractor-scarified areas, produced satisfactory birch stocking at the end of the second growing season. Shade became the major cause of mortality during the second growing season. Birch seedlings also had less height growth close to the south border of east–west clearcut strips, suggesting that trees producing the shade should be removed as soon as possible after the first growing season.

**Information Sources:**
3.5.2 Coppice and other forms of vegetative reproduction

- Fully stocked birch stands often cannot be achieved from coppice. Birch gradually loses its ability to regenerate by coppice after approximately 60 years.

- Coppice systems need to consider stand age and harvest season. Encouragement of coppice sprouts can be particularly appropriate on poor sites to supplement seedling regeneration and increase stand structural diversity.

Virtually all broadleaf trees and tall shrubs can produce basal sprouts at some time in their life, but the degree to which sprouting declines with age varies by species. For example, although aspen can vigorously produce root suckers in stands 100 or more years old, aspen’s ability to produce basal sprouts declines to near zero by age 100. In contrast, Alaska data indicate that in paper birch, 30–40% of stems 100–150 years old still have the ability to form basal sprouts. In places where there is deep organic matter, birch’s basal sprouts can originate from as deep as 10 cm below the upper surface of forest floor litter. Very severe fires that completely remove organic layers, leaving only charred roots, prevent further basal sprouting in birch, willows, and alders.

Birch sprouts from the root collar or stump following fire or cutting. This origin of birch stems is indicated where stands are made up of multi-stemmed clumps, often with sweeping boles (Figure 15). Numbers of birch sprouts per cut stem are commonly reported to range from 2 to 15 sprouts per stump. However, in the ICHmw3 variant, up to 200 sprouts per cut stump have often been recorded, but these sprouts rapidly thin to 3–7 per stump within 10 years of cutting. In the ICHmw and IDFmw subzones, birch sprouts are reported to grow as much as 2 m/year following parent-tree removal.

As a regeneration method, coppicing involves cutting near the base of the stem and allowing regrowth of a number of shoots from the cut stump. Cutting close to the ground encourages coppice shoots from the root collar, rather than from the stump, thereby

![FIGURE 15. The clumped distribution of birch stems of sprout origin can persist for many decades. (Photograph by S. Simard)](image_url)
improving the stability of the coppice stool. Sprouting is believed to be more vigorous if trees are cut in the dormant season. Prolific sprouting occurs when trees are young, but sprouting vigour declines with age. Birch begin to lose their ability to sprout at about age 60. Experience with birch coppicing in Britain has led to recommendations for 15- to 25-year rotations with 750–1100 stools per hectare. Coppicing can be done at any time of the year, but is easier when foliage is off the trees (which also avoids bird nesting times). The first coppice cut can be made at the end of the establishment phase, or it can be delayed if larger stems are desired for a particular product.

Most of the adventitious buds that form sprouts are located just below ground level, so stump height is not thought to be correlated with frequency of sprouts from the root collar zone. However, there is evidence that a greater frequency of lateral sprouts from the stump retards the growth of more vigorous root collar sprouts. Sprouting vigour of birch decreases with age, although in Alaska there are reports of considerable sprouting of older stems as tree vigour declines. In such cases, even if the stem dies the sprouts survive and can resprout after disturbance. Sprouting appears to be reduced when stems are cut in May-June, at the time that root carbohydrate reserves are minimal. It was observed in Alaska that trees cut after about mid-July did not sprout until the next growing season. High light intensity and high temperatures stimulate the growth of sprouts so that growth is faster after clearcutting than it is after thinning. Paper birch sprouts have more rapid growth than seedlings. Sprouts can reach 1 m in the first growing season and are often twice the height of seedlings by age 4. Birch of sprout origin that have height growth rates as great as 1 m/year are common in mesic and wetter sites. Comparative height growth curves of paper birch sprouts and Douglas-fir seedlings to age 15, based on data from the ICH zone in southern British Columbia, are shown in Figure 16.

Paper birch can also be vegetatively propagated by grafting, air-layering, rooting of cuttings, or tissue culture (micropropagation). Cuttings from seedlings root sooner and more reliably than cuttings from mature trees. Treatment with indolebutyric acid or other hormone treatment can enhance rooting response of cuttings.

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**FIGURE 16.** Comparison of early height growth, to age 15, for paper birch of sprout origin and Douglas-fir on mesic sites in the ICH biogeoclimatic zone of southern British Columbia (Simard and Vyse 1992).