BetulaceaeCBirch family

Betula L.

birch

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Growth habit, occurrence, and use. The birchesCmembers of the genus *Betula*Cconsist of about 40 to 50 species of deciduous trees and shrubs occurring in the cooler parts of the Northern Hemisphere (Weaver 1978). Several species produce valuable lumber. Other species are useful for ornamental plantings because of their attractive growth habit, foliage, and bark. Nearly all species provide food and cover for wildlife, and some are valuable because they seed-in promptly on harvested or burned lands. The 14 species native to the Unites States are listed in table 1, along with several species that are introduced or are referenced in the seed literature.

Flowering and fruiting. The flowers are monoecious and borne in catkins. Staminate catkins are formed in late summer or autumn, remain naked during winter, and open after considerable elongation in the spring (table 2). The pistillate catkins, which are cone-like with closely overlapping scales, are born terminally on short, spur-like lateral branches and appear with the leaves (table 2). When the female catkins (strobiles) ripen in late summer or autumn (table 2), they become brown and woody and are either erect or pendulous (figure 1). Each scale may bear a single small, winged nut (seed) (figures 2 and 3) that is oval, with 2 persistent stigmas at the apex. The seeds turn from greenish tan to light brown or tan when mature (Brinkman 1974). Seeds disperse from late fall until the following spring (Houle and Payette 1990; Matlack 1989). Although seeds can begin to disperse in late summer, these early-shed seeds may be of poor quality. Seeds of yellow birch shed in August were found to not be viable. Viable seeds were not released in meaningful amounts until September, with the maximum of good seeds being released in October (Houle and Payette 1990). After seedfall, the strobiles slowly disintegrate on the trees, with the axes persisting on the branchlets.

Seed production. Birch tends to flower at the relatively young age of 10 to 15 years (Lepisto 1973) (table 3). Some individuals are precocious in flowering and this appears to be under genetic control (Huhtinen and Yahyaoglu 1974). Clausen (1980) reported on a progeny test of 147 open-pollinated yellow birch families from 21 stands. He found that some female-flowering began at 6 years from seed, but this occurred in only 1% of the trees. By age 9, 14% of the trees were producing seeds. Male-flowering commenced 1 year later than female-flowering. Seedlings from northern sources tended to flower earlier than those from southern sources. In greenhouse conditions with irrigation, fertilization, and CO_2-enriched air, European white birch seedlings have produced male catkins as early as 9 months and commercial quantities of seed from 5-year-old trees (Lepisto 1973).

Birches are known to hybridize readily. These hybrids appear to be at least partially fertile, allowing for the production of second generation hybrids and backcrossing to the parent species (Barnes and others 1974).

The holartic lygaeidC*Kleidocerys resedae* (Panzer)Cfeeds on the seeds of European white birch and cause premature drop of catkins and seed failure. The feeding does not, however, affect the vigor of the parent plant even though the insects can be quite numerous and visible (Wheeler 1976).

Seed production is usually regular and abundant. Bjorkbom and others (1965) reported that paper birch produced a higher proportion of viable seeds in good seed years than it did during poor seed years. The percentage of viable birch seeds can be estimated by examining the seeds on a light table (Patterson and Bruce 1931). The seeds are primarily dispersed by wind as they are shed from the catkins. Wind can also blow seeds along the surface of the snow up to 80 m from the mother tree. This secondary dispersal may be the more effective method; it has been predicted to increase sweet birch seed dispersal by a factor of 3.3 over that of aerial dispersal alone (Matlack 1989). Ford and others (1983) trapped about 5% of the total seed-fall from round-leaf birch at nearly 100 m from the parent tree. Although an abundance of seeds can be found in the forest soil, these seeds are short-lived. Most seeds are nonviable after the second or third year (Granstrom 1987; Granstrom and Fries 1985; Johnson 1975; Moore and Wein 1977; Perala and Alm 1989; Steijlen and Zackrisson 1986). The abundance of seeds in the forest soil is, therefore, likely supported by regular replenishment from new crops (Komarova 1986). A rare case of excessive seed production has been observed to lead to crown deterioration and reduced growth of the parent trees (Gross 1972).

Seed collection. Birch seeds are collected by picking or stripping the strobiles from standing trees or shrubs or from trees recently felled in logging operations. This is best done while strobiles are still green enough to hold together. Because ripe strobiles shatter readily, they are usually put directly into bags rather than allowed to fall onto the ground or tarps, which can result in loss of seed. However, seeds can also be collected from paved surfaces in urban areas.

Seed extraction. Freshly collected strobiles can be subject to heating because they usually are at least somewhat green. They should be spread out to dry for several weeks until they begin to disintegrate. Low relative humidity is the most important factor in drying the strobiles. Matlack (1989) found that sweet birch strobiles released their seeds at low humidity anywhere in the temperature range of –14 to 16 °C. Once the strobiles begin to fall apart, they can be shattered by rubbing or shaking, and the seeds can be separated from most of the scales and debris by screening and fanning. Round-hole screens of the following sizes have proved satisfactory for the following species: glandulose birch, 2.38 mm; yellow birch, 3.2 mm; river birch, 4 mm; paper birch , 3.2 mm; European white and downy birches, 2.6 mm. The remaining scales can be removed by fanning (Brinkman 1974). Any stems can be removed with an indent cylinder. Very careful adjustment with a column blower or a specific gravity table can upgrade the seedlot. Birch seeds are very small and light, with the number per weight and yield per volume varying considerably among species (table 4).

Seed storage. Heit (1967) reported that birch seeds apparently stored best at 1 to 3% moisture content and temperatures of 2.2 to 3.3 °C. Other tests with sweet, paper, and gray birches are in basic agreement with this position, thus indicating that birch seeds are orthodox in storage behavior. Seeds of these 3 species were found to keep for 1 2 to 2 years at room temperature if the moisture content was between 1 and 5%. If the moisture content was much higher, germination dropped even though the seeds were stored at 1.7 to 4.4 °C (Brinkman 1974). Slightly higher moisture content seems possible if freezer storage is used. One lot each of yellow, sweet, and paper birches was successfully stored in the National Tree Seed Laboratory seed bank for about 15 years with moisture contents between 5 to 9% at –8 °C (table 5). A lower moisture content would probably have been better, because the paper birch seeds began to deteriorate at 15 years and were discarded at 17 years. Liquid nitrogen storage also appears to be an option for the birch seeds (Iriondo and others 1992).

Pregermination treatment. It has been known for over 50 years that prechilling (that is, stratification) improved germination of birch seeds (Brinkman 1974). Several sources (Brinkman 1974; Heit 1967; ISTA 1996) state that light during germination is able to reduce or replace the need for prechilling to obtain complete germination. The barriers to germination in European white birch are removed by light or stratification (Black 1956; Black and Wareing 1954, 1955). However, prechilling can still be an important procedure. For example, Vanhatalo and others (1996) found that not only did prechilling result in faster and higher germination, but it also improved the ability to germinate at temperatures below the optimum.

Furthermore, the birch genus is divided into 2 groups in regards to prechilling: those that will germinate in the dark with adequate prechilling and those that require light. For example, European white birch (Black and Wareing 1955, Vaartaja 1956) and paper birch (Bevinton and Hoyle 1981) can germinate in the dark, whereas monarch and Japanese white birches and Erman birch require light regardless of prechilling (Nagata and Black 1977; Nagata and Tsuda 1975; Odani and Anma 1986). Giberellic acid (GA_3) in concentrations of 50 to 100 ppm could substitute for the light with Erman birch (Odani and Anma 1986). However, in the light-obligatory group, the sensitivity to light is markedly increased by providing prechilling (Nagada and Black 1977). Therefore, prechilling can reduce the requirement for light when growing plants under artificial conditions. This might provide some cost savings during the germination phase by reducing lighting expense. Reducing the light requirement might also allow birch to be germinated in a greenhouse with other plants that had low light requirements. On the other hand, if there is not time for prechilling, then light sufficient to keep dark periods less than about 6 hours may fully replace the need for prechilling.

It is important to know a seedlot=s characteristics well when making the refined manipulations of light and prechilling suggested above because prechilling beyond 3 weeks can lead to increased dormancy and obligatory use of light in some sources of paper birch (Bevington 1986; Bevington and Hoyle 1981). Although light use was obligatory in these sources of paper birch, the seeds were well sensitized to the light and germination was prompt and complete. Bevington (1986) further found that seeds from different sources varied in the range of temperatures at which they would germinate. Seeds from northern sources were able to germinate over a wider range of temperatures than those from southern sources, mostly because they could germinate at cooler temperatures. Sensitivity to light did not seem to be related to geographic source but was universally enhanced in proportion to the length of prechilling, at least up to 6 weeks as demonstrated by faster and higher germination (Bevington, 1986).

Prechilling temperatures need to be close to 2 or 3 °C. A rise in temperature to even 5 °C can increase the time needed to effectively overcome the dormancy (Bevington and Hoyle 1981; Vanhatalo and others 1996).

Germination tests. The use of light during the test can reduce or eliminate the need for prechilling. However, because some seedlots may benefit from prechilling, a test with and a test without prechilling are frequently recommended (AOSA 1998; ISTA 1996). Tests should be made on germination paper or sand at alternating temperatures of 30 °C for 8 hours and 20 °C for 16 hours with light supplied during the 30 °C period. Testing by AOSA rules requires planting 4 dishes of 100 seeds each. Should the seedlot be less than 98% pure, then a partial purity analysis must be done to acquire the needed pure seeds for the germination test. Because catkin bracts are not removed from many seedlots, the seedlots have low purity and ISTA prescribes testing by weighed replicate. In the weighed replicate test, 0.10 g of seed are planted in each of the 4 replicates. The number of normal seedlings per weight of seeds is then reported instead of a germination percentage. The results of some published test data are presented in table 6.

Nursery practice. Birch seeds can be sown after collection in the late summer or fall, or in the spring after prechilling for 4 to 8 weeks. Seeds are broadcast and covered as lightly as possible, with about 3 mm (1/16 to 3/16 in) of soil. The seeds can be sown without covering (Brinkman 1974) if adequate irrigation can be supplied, which provides more light to the seed. Germination is epigeal (figure 4) and usually complete in 4 to 6 weeks after spring-sowing. Birch seedlings require light shade for 2 to 3 months during the first summer. Tree percent is low; only 15 to 20% of European white birch and downy birch seeds will produce 1+0 seedlings (Deasy 1954; Wappes 1932). A seedling density of 278 to 500/m^2 (25 to 45/ft^2) is desirable (Heit 1964). Stock usually is field planted as 1+0 or 2+0 seedlings. Birch seeds have shown marked sensitivity to herbicides and insecticides (Weinberger and others 1978; Weinberger and Vladut 1981).

In a study of open-pollinated families of yellow birch (Wearstler and Barnes 1977), heavier seeds produced taller seedlings immediately after germination. Seeds from mountain and more northern sources germinated earlier, but the seedlings tended to be shorter. The shorter seedlings and faster germination were generally associated with shorter growing season.

Cherry leaf roll virus is known to be transmitted through seeds. Transmission of this pathogen is highly variable and not generally strong. Two generations were estimated to be enough for the disease to be lost from a population of European white birch (Cooper and others 1984).

Germination on adverse sites. Environmental disturbances caused by mining operations and air pollution create conditions that have been suspected of interferring with normal seed germination for birch. The germination of European white and downy birches was found to be inhibited by high zinc concentrations (Brown and Wilkins 1986). Such heavy metal concentrations were thought to be a major reason for lack of colonization of these 2 species on mine spoil in Wales. On the other hand, Scherbatskoy and others (1987) found that heavy metals and low pH did not reduce germination of yellow or paper birch seed samples taken in Vermont. Reduced regeneration of these 2 species had been associated with low soil pH and increasing concentrations of heavy metals believed to be caused by air pollution. In fact, pH of 3 produced germinations higher than controls or pH values of 4 or 5. Growth of gray birch on coal mine spoils in Pennsylvania is likely to be inhibited by the high temperatures of the soil surface(Pratt 1986).

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Table 1C*Betula,* birch: nomenclature and occurrence.

Scientific name & synonym(s)	Common name	Occurrence
B. alleghaniensis **Britt.** *B. lutea* Michx. F.	**yellow birch**	Newfoundland to SE Manitoba, S to NE Iowa N Illinois & Delaware; mtns to Tennessee
B. borealis **Spach**	**northern birch**	Massachusetts, New Hampshire, Vermont, Maine, N to Nova Scotia, Newfoundland, &
	Quebec, & Labrador	
B. davurica **Pall.**	**Dahurian birch**	Temperate China, Japan, & Russian Federation
B. ermanii **Cham.**	**Erman birch**	NE China, Japan, Korea, Russian Federation in Chita, Kamchatka, Sakhalin, Yakutia-Sakha, & Bryansk
B. lenta **L.**	**sweet birch,** black birch, & cherry birch	S Maine to S Ontario, S to E Ohio & Delaware; mts to N Alabama & Georgia
B. mandshurica **var.** ***japonica*** **(Miq.) Rehder** *B. alba* var. *japonica* Miq. *B. japonica* Siebold ex H.J.P. Winkl. *B. japonica* var. *Kamtschatica* (Regel) H.J.P. Winkl. *B. platyphylla* var. *japonica* (Miq.) H. Hara *B. platyphylla* var. *kamtschatica* (Regel) H. Hara	**Japanese white birch** Asian white birch	Japanese islands of Hokkaido & Honshu; Russian Federation in Kamchatka, Magadan, & Sakhalin
B. maximowicziana **Regel**	**monarch birch**	Japanese islands of Hokkaido & Honshu; Kurile Islands in the Russian Federation
B. minor **(Tuckerman) Fern.** *B. saxophila* Lepage *B. papyrifera* var. *minor* (Tuckerman) S. Wats. & Coult.	**dwarf white birch**	New York, New Hampshire, Maine, New Brunswick, N to Ontario, Quebec, Newfoundland, & Labrador
B. murrayana **Barnes & Dancik**	**Murray birch**	Michigan
B. nana **L.** *B. gladulosa* Michx. *B. exilis* Sukatschev; *B. michauxii* Sarg. *B. glandulosa* var. *hallii* (T.J. Howell) C.L. Hitchc. *B. glandulosa* var. *sibirica* (Ledeb.) Schneid. *B. nana* ssp. *exilis* (Sukaczev) Hutten	**bog birch,** swamp birch, & dwarf birch	Newfoundland to Alaska, S to higher mtns of California, Colorado, & Maine

B. nana var. *sibirica* Ledeb. ***B. neoalaskana* Sarg.** *B. papyrifera* var. *neoalaskana* (Sarg.) Raup	**Alaska birch**	Alaska, Alberta, N British Columbia, Manitoba, W Northwest Territory, NW Ontario, Saskatchewan, & Yukon Territory
***B. nigra* L.**	**river birch,** black birch, & water birch	Connecticut to E Iowa & SE Kansas, S to E Texas, E to N Florida
***B. occidentalis* Hook.** *B. beeniana* A. Nels.; *B. fontinalis* Sarg. *B. papyrifera* Marsh. ssp. *occidentalis* (Hook.) Hulten *B. occidentalis* var. *inopina* (Jepson) C.L. Hitchc. *B. papyrifera* var. *occidentalis* (Hook.) Sarg.	**water birch**	Alaska, Canada, W US, E to the Dakotas, Nebraska, Colorado, & New Mexico
***B. papyrifera* Marsh.** *B. cordifolia* Regel *B. alba* var. *cordifolia* (Regel) Regel	**paper birch,** canoe birch, silver birch, & white birch	Newfoundland to Canada, S to Washington & E to North Dakota, NE Iowa & New England; locally in other states in N
***B. pendula* Roth** *B. verrucosa* Ehrh.	**European white birch**	Europe to Japan
***B. populifolia* Marsh.**	**gray birch,** white birch, & wire birch	Nova Scotia to S Ontario, S to N Ohio, Pennsylvania, & Delaware
***B. pubescens* Ehrh.** *B. alba* L. *B. tortusa* Ledeb.	**downy birch,** downy birch	N & central Europe to E Siberia
***B. pumila* L.** *B. pumila* var. *glandulifera* Regel (Gleason) *B. glandulifera* (Regel) Butler *B. nana* var. *glandulifera* (Regel) Boivin *B. glandulosa* var. *glandulifera* (Regel) Gleason	**swamp birch**, glandulose birch, bog birch, & swamp birch	W Quebec to British Columbia, S to Montana, E to North Dakota & N New York
***B. uber* (Ashe) Fern.**	**roundleaf birch**	Smyth County, Virginia
***Betula* × *utahensis* Britt. (pro sp.)** *B. andrewsii* A. Nels. *B. piperi* Britt. *B.* × *commixta* Sarg. *B. occidentalis* var. *fecunda* Fern. *B. papyrifera* var. *subcordata* (Rydb.) Sarg.	**northwestern paper birch**	Yukon Territory, S through British Columbia, Alberta, Saskatchewan, Washington, Idaho, Montana, Oregon, Wyoming, & Utah

Source: Brinkman (1974).

Table 2C*Betula,* birch: phenology of flowering and fruiting

Species	Location	Flowering dates	Fruit ripening dates	Seed dispersal dates
B. alleghaniensis	Midrange	AprBMay	AugBOct	SeptBSpring
B. davurica	Japan	May	Oct	C
B. lenta	Midrange	AprBMay	AugBSept	SeptBNov
B. nana	Midrange	JuneBAug	AugBOct	SeptBMar
B. nigra	Northern part of range	AprBMay	MayBJune	MayBJune
B. papyrifera	Midrange	AprBJune	AugBSept	AugBSpring
B. pendula	Russia & Finland	AprBJune	JulyBAug	JulyBSept
B. populifolia	Midrange	AprBMay	SeptBOct	Oct to mid-winter
B. pubescens	Germany & Finland	MayBJune	AugBSept	FallBWinter
B. pumlia	Midrange	MayBJune	SeptBOct	OctBMar

Sources: Ahlgren (1957), Brinkman (1974), Damberg (1915), Fernald (1950), NBV (1946), Sarvas (1952), Van Dersal (1938), Wappes (1932).

Table 3C*Betula,* birch: height, seed-bearing age, and seed crop frequency

Species	Height at maturity (m)	Year first cultivated	Minimum seed-bearing age (yr)	Years between large seed crops
B. allenghaniensis	30	1800	40	2
B. davurica	19.5	1883	C	2
B. lenta	24	1759	40	1B2
B. nana	1.8	1880	C	C
B. nigra	30	1736	C	C
B. papyrifera	21	1750	15	2
B. pendula	19.5	Long	15	2B3
B. populifolia	12	1750	8	1
B. pubescens	19.5	1789	15	2B3
B. pumila	3	1762	C	1B2

Sources: Brinkman (1974), Wappes (1932), Yelenosky (1961).

Table 4C*Betula,* birch: seed yield data

	Thousands of cleaned seeds/wt						
	Seeds/fruit vol		Range		Average		
Species	kg/hl	lb/bu	/kg	/lb	/kg	/lb	Samples
B. alleghaniensis	1.3B4.5	1.0B3.5*	612B1,995	278B907	990	450	24
B. davurica	C	C	1,518B1,672	690B760	1,595	725	2+
B. lenta	C	C	975B2053	443B933	1,421	646	13
B. nana	C	C	6,547B11,253	2,976B5,115	8,446	3,839	3
B. nigra	C	C	631B1,206	287B548	825	375	13
B. papyrifera	2.6B9.4	2.0B3.4*	1,342B9,064	610B4,120	3,036	1,380	28
B. pendula (de-winged)	C	C	3,332B11,088	1,510B5,040	5,317	2,417	154+
B. pendula (winged)	C	C	1,606B1,892	730B860	1,749	795	10
B. populifolia	C	C	7,878B10,846	3,581B4,930	9,363	4,256	2
B. pubescens	C	C	1,650B9,900	750B4,500	3,784	1,720	45
B. pumila	C	C	3,072B7,634	1,396B3,470	5,328	2,422	4

Sources: Brinkman (1974), NBV (1946), Rafn and son (1928).
* De-winged seed.

Table 5C*Betula,* birch: germination of 3 seedlots stored for 8 years at the USDA Forest Service=s National Tree Seed Laboratory, Dry Branch, Georgia

Species	Moisture content	Prechilling (days	Percent germination	
B. alleghaniensis				
1974	C	C	C	
1977	5.0	0	45	
1983	C	63	70	
1988	7.0	63	67	
1991	C	0	32	
1992	C	0	56	
	C		21	58
B. lenta				
1974	C	30	54	
1977	C	C		
1983	C	63	72	
1988	7.9	63	67	
1991	C	C	C	
1992	C	0	45	
	C	63	37	
B. papyrifera				
1974	C	C	C	
1977	7.0	0	76	
	C		63	82
1983	C	63	87	
1988	8.9	C	C	
1991	C	0	4	
		63	16	
1992	C	0	18	

Table 6C*Betula,* birch: germination and purity test data

Species	Prechill period (days)	Daily light (hr)	Medium	Temp. (°C) Day	Temp. (°C) Night	Duration (days)	Average germ. (%)	Samples	Purity (%)
B. alleghaniensis	30B0	8+	Sand	32	15	30B40	27	22	56
	None	8+	C	30	20	14B28	59	3	60
B. davurica	None	8+	C	30	20	14B8	18	4	C
B. lenta	40B70	8+	Sand	32	15	30	43	13	72
B. nana	(over winter)	C	Sand	30	20	30	24	1	C
	None	20	Perlite	24	18	30	3	5	C
B. nigra	30B60	8+	Sand	30	20	30	34	13	42
	None	20	Perlite	24	18	30	73	35	C
B. papyrifera	60B75	8+	Sand	32	15	30B40	C	C	24
	None	8+	Paper pads	C	C	40	47	6	C
B. pendula	30B40	8+	Sand	C		C	30	10+	68
	None	8+	C	30	20	30B40	36	143	C
B. populifera	60-90	8+	Sand	30	20	40	64	3	C
B. pubescens	30B60	8+	C	30	20	30	40	44	69
	None	8+	C	25	15	30	87	17	C
B. pumila var. *glandulifera*	None	20	Perlite	24	18	30	31	4	38

Sources: Black and Waring (1954, 1955), Brinkman (1974), Heit (1968), Gorshenin (1941), Yelenosky (1961).