N

Hydrophyllaceae—Waterleaf family

Nama lobbii Gray

woolly nama

Eamor C. Nord and Andrew T. Leiser

Dr. Nord (deceased) retired from the USDA Forest Service's Pacific Southwest Forest and Range Experiment Station; Dr. Leiser is professor emeritus at the University of California's Department of Horticulture Davis, California

Other common names. Lobb fiddleleaf.

Growth habit, occurrence, and use. There are 2 perennial species in this genus, both low-growing, suffruticose plants native to California, Nevada, and Utah. Only the sub-shrub woolly nama—*Nama lobbii* Gray—has potential for revegetation use, as it can provide a rather persistent, dense groundcover. The other species—Rothrock fiddleleaf, *N. rothrockii* Gray—furnishes only a sparse cover that dies back to the roots each year.

Woolly nama is native to the Sierra Nevada and Cascade ranges in east central and northern California, and western Nevada at elevations of 1,220 to 2,100 m within ponderosa (*Pinus ponderosa* Dougl. ex Laws.) or Jeffrey (*P. jeffreyi* Grev. & Balf.) pine and California red fir (*Abies magnifica* A. Murr.) forests. It occurs in sunny, exposed locations with slightly to moderately acid soils derived mostly from volcanic mud flows and decomposed granites. Plants 15 to 60 cm tall are generally sparse and widely scattered (McDonald and Oliver 1984). However, where the tree or associated shrub overstory is removed, such as by logging or other mechanical means, woolly nama spreads rapidly to form dense crowns up to 1.5 m in diameter on individual plants (McDonald and Fiddler 1995). Fast-growing roots that extend up to 5 m or more in a single year contain a profusion of adventitious buds that sprout to form new plants.

Woolly nama has many characteristics that make it desirable for revegetation on adapted sites. The low growth habit helps reduce fire hazards in brush-cleared areas, and its abundant, aggressive sprouting habit together with dense foliage provides good groundcover. It is known to offer strong competition and thus reduce growth of young conifers within plantations (McDonald and Oliver 1984). Although it is not regarded as a serious weed pest in areas where it occurs naturally, care should be exercised to prevent introduction and possible spread of this plant into cultivated croplands, mainly because of its aggressive rooting habits, which enable the plant to withstand cultivation.

Flowering and fruiting. The numerous small purple flowers are borne in reduced terminal cymes or in axillary angles along slightly erect stems; they appear from May to September. The fruit is a capsule containing 10 to 12 oval, angular, very dark brown seeds up to 1.5 mm long (figures 1 and 2). The capsules mature in late August, September, and October. In a test of a cleaned seedlot, seeds measured 1 to 1.3 mm in diameter; 85% of the seeds in the lot were filled and there were about 2,000 seeds/g (56,875/oz).

Collection, extraction, and storage. Mature seeds may be hand-stripped or flailed directly into containers, or seed heads together with some foliage may be harvested mechanically during late September and thereafter until snow covers the ground. One means is to use a rotary lawnmower equipped with a collection bag and set at maximum height that clips and gathers the material, which is later dried and threshed. The seeds may be extracted by threshers or hammermills, and cleaned with aspirators or air-screen cleaners. A collection made in the Tahoe basin, using this type of equipment, yielded over 1.8 kg (4 lb) of clean seeds from about 59 kg (130 lb) of dry clippings (Nord and Leiser 1974). Only half of the total number of seeds was released from capsules during clipping and drying, and the remaining seeds had to be extracted and separated by a hammermill and South Dakota Seed Blower. No precise data are available on longevity of woolly nama seeds, but they are presumed to be orthodox in storage behavior and should remain

Figure 1—*Nama lobbii*, woolly nama: seed.

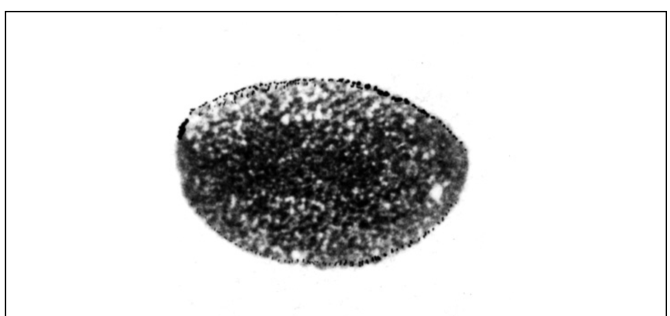
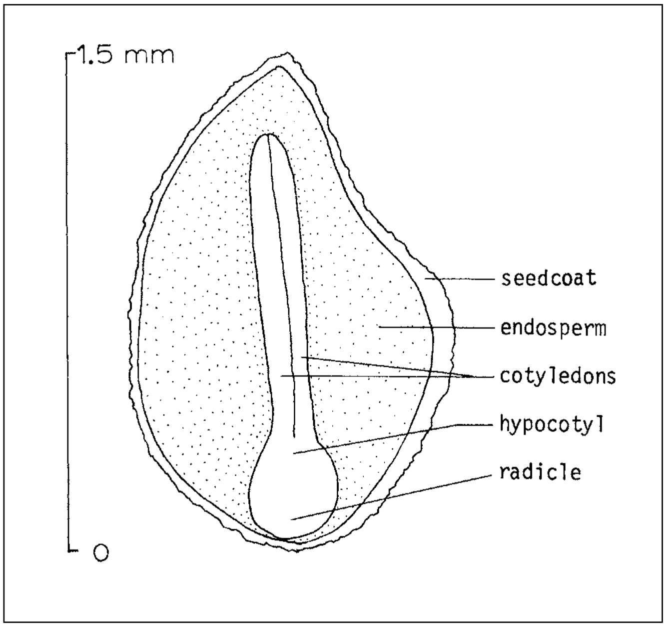


Figure 2—*Nama lobbii*, woolly nama: longitudinal section through a seed.



viable for a number of years when stored dry at low temperatures.

Germination. Woolly nama seeds exhibit what apparently is seedcoat dormancy. Stratification has no effect, but when the seedcoats are removed, up to 60% of the seeds will germinate. The dormancy may be due to a chemical that is found in the seedcoat. Extracts of the colored leachate obtained from seeds kept under intermittent mist contained an anionic polyphenol that may inhibit germination (Nord and Leiser 1974). Leaching woolly nama seeds for 3 days under intermittent mist for 3 seconds at 2-minute intervals, followed by soaking in 200 ppm gibberellic acid, yielded 39% germination. Other treatments in which gibberellic acid was used yielded as much as 30% total germination, but sulfuric acid, thiourea, hydrogen peroxide, and hot water treatments were not effective in improving germination. In laboratory tests , the first observed germination was at 12 days and germination continued intermittently thereafter throughout a 4-month period (Nord and Leiser 1974).

Because of the very low and slow germination, it is most unlikely that woolly nama can establish itself satisfactorily from direct field seeding unless seeds are treated in some manner to break dormancy. This appears to be the case even in native stands, where seedling plants are rarely found; presumably most natural establishment or spread of this species comes from root segments transported during some form of soil disturbance.

Nursery and field practice. The best method known to prepare the seeds for sowing calls for leaching the seeds under intermittent mist or running water for 2 to 3 days, soaking in gibberellic acid that is constantly agitated, and air-drying thoroughly. The seeds should not be rinsed or washed. Soaking for 2 hours in 200 ppm or stronger gibberellic acid solution is suggested if seeds are to be sown within a few days after treatment. If seeding is to be delayed for more than about 10 days and soil moisture conditions are unpredictable, stronger solutions and longer soak times (probably up to 500 ppm for periods up to 24 hours) should be used to reduce risks of leaching should rains occur before seeds germinate. Seeding should be done in the late fall or very early spring to take advantage of the most favorable moisture conditions for germination and seedling establishment. Seeds may be sown separately or mixed with rice hulls as a diluent and carrier at a depth of about 12 mm ($^{1}/_{2}$ in) on properly prepared, firm seedbeds where competing vegetation has been previously removed.

The plant makes its best development on medium-textured, well-drained soils that are neutral to moderately acid in reaction. The plants are susceptible to gopher damage to the roots in southern California, but they appear to be immune from damage to the foliage by animals, including rabbits, which often damage or destroy many other shrub or herbaceous species.

Rooting either stem cuttings or root sections of woolly nama has not been too successful. In several trials, only 30% of stem cuttings rooted, and none survived when transplanted into pots. Root cuttings failed to regenerate new plants, although some fresh shoots became green and grew slightly (Nord and Goodin 1970).

References

McDonald PM, Fiddler GO. 1995. Development of a mixed shrub–ponderosa pine community in a natural and treated condition. Res. Pap. PSW-224-web. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. 19 p.

McDonald PM, Oliver WW. 1984. Woody shrubs retard growth of ponderosa pine seedlings and saplings. In: Proceedings, 5th Annual Forest Vegetation Management Conference; 1983 November 2–3; Redding, CA. Redding, CA: Forest Vegetation Management Conference: 65–89.

Nord EC, Goodin JR. 1970. Rooting cuttings of shrub species for plantings in California wildlands. Res. Note PSW-213. Berkeley, CA: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 4 p.

Nord EC, Leiser AT. 1974. *Nama lobbii* Gray, woolly nama. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 551–552.

N

Berberidaceae—Barberry family

Nandina domestica Thunb.

nandina

Laura G. Jull and Frank A. Blazich

Dr. Jull is assistant professor at the University of Wisconsin's Department of Horticulture, Madison, Wisconsin; Dr. Blazich is alumni distinguished graduate professor of plant propagation and tissue culture at North Carolina State University's Department of Horticultural Science, Raleigh, North Carolina

Other common names. heavenly-bamboo, sacred-bamboo, *nanten*.

Occurrence, growth habit, and uses. *Nandina* is a monotypic genus indigenous from India to central China (Huxley and others 1992; Krüssmann 1985; Ohwi 1984). It was introduced into Japan from China before the sixteenth century (Coats 1992). The species is a broadleaf evergreen, upright, flat-topped shrub reaching a height of 1.5 to 2.4 m with a spread of 1.0 to 1.5 m that can spread by root suckers into large colonies (Dirr 1990; Whitcomb 1996). Plants are characterized by numerous, unbranched stems with horizontal branches. However, with age, they tend to become leggy and open, unless pruned properly (Flint 1997). The species is hardy to USDA Zone 6 (Dirr 1990) and will remain evergreen in USDA Zones 7–8. It becomes deciduous when exposed to colder temperatures (Gibson 1982).

In Japan, nandina is called *nanten*,"sacred-bamboo," as fruiting twigs are sold in winter to decorate altars, both in temples and private homes (Coats 1992; Krüssmann 1985; Richards and Kaneko 1988). There, nandina is planted close to the entrances of homes because the plant is used to comfort family members who have bad dreams. The wood is aromatic and very close grained; it is considered by the Japanese to be flavorful and suitable for toothpicks (Coats 1992). The plant is reputed to have medicinal properties effective in treatment of various ailments (Ikuta 1994).

Nandina is cultivated commonly in the United States because of several desirable landscape attributes. The new, finely dissected leaves are bronze to red, becoming blue-green with age, and turning a dull purple to bright red in winter (Flint 1997). Flowers occur in large panicles held above the foliage and are followed in the fall by showy, bright red berries produced in clusters that persist throughout the winter. The stems give the appearance of bamboo (Flint 1997). Plants are adaptable to many different soils; they tolerate sun, shade, and drought; and they are pest free (Dirr 1990; Whitcomb 1996).

Geographic races and hybrids. Nandina has been in cultivation for centuries. China and Japan are considered as sources of dwarf selections. Cultivars with fern-like foliage, distorted branchlets, and white, yellow, or crimson fruits occur in the nursery trade (Dirr 1990).

Flowering and fruiting. Nandina will flower and produce fruit in heavy shade to full sun (Dirr 1990). Plants fail to set fruit if planted singly, so it is best to plant groupings of several plants to ensure cross pollination (Gibson 1982). Inflorescences are erect, terminal, 20- to 38-cm-long white panicles that appear from May to June. Individual flowers are perfect, 6 to 13 mm across, and pinkish in bud, opening to white with yellow anthers. The fruits are globular, bright red berries that are 8 mm in diameter with 2 seeds; they ripen in the fall and persist through the winter (Dirr 1990).

Collection of fruits, seed extraction, and cleaning. Fruits should be harvested when mature in the fall. Removal of the fleshy pulp is recommended and is accomplished easily by maceration (Dirr and Heuser 1987; Gibson 1982). After fruits are soaked in water for 24 hours and macerated, the seeds (figures 1 & 2) can be separated from the fleshy pulp (Newman 1991).

Seed storage. Due to the presence of a rudimentary embryo, seeds should be stored under slightly moist conditions at 4 °C, then sown in late spring or summer to obtain uniform and rapid germination (Dehgan 1984; Hartmann and others 1997). Seeds held in cold storage for 9 to 10 months germinate as well as those sown immediately after seed extraction and do so without appreciable loss in viability (Afanasiev 1943; Dirr and Heuser 1987).

Pregermination treatments. Seeds exhibit delayed germination due to a rudimentary embryo and slow rate of embryo development (Dirr and Heuser 1987). The rudimentary embryo is formed after flowering in August and September and during fruit enlargement in winter. However, further development is arrested during spring and summer months (Afanasiev 1943), although embryo maturation can

Figure 1—*Nandina domestica*, nandina: seeds.

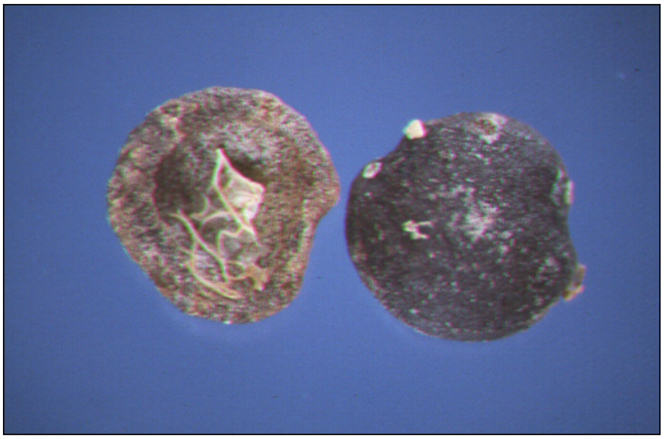
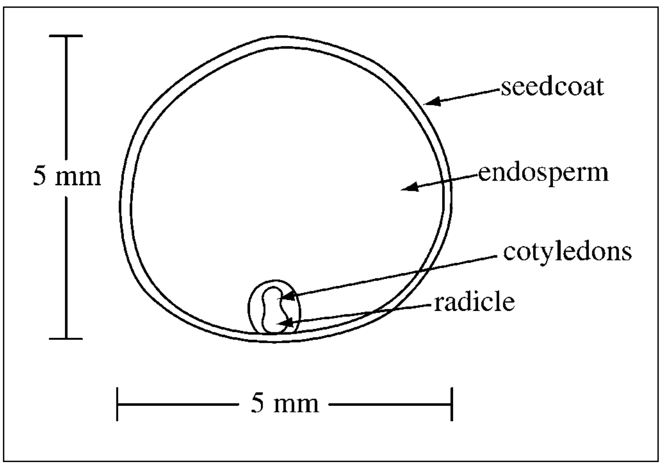


Figure 2—*Nandina domestica*, nanadina: longitudinal section of a seed.



occur during cold storage (Hartmann and others 1997). Embryo development also can occur regardless of whether seeds are stored at high or low temperatures or in moist or dry environments (Dirr and Heuser 1987).

Seeds of nandina have a tendency to germinate only during late fall or early winter, regardless of the sowing date (Afanasiev 1943; Hartmann and others 1997). Attempts to overcome this response—by cold stratification, treatment with various chemical compounds, increased oxygen pressure during germination, or varying the time of planting—have all been unsuccessful (Afanasiev 1943). Afanasiev concluded that cold stratification neither hastened embryo development nor improved germination. To speed embryo development, Dirr and Heuser (1987) recommend warm stratification of seeds for several months, followed by cold stratification for several months. In contrast, Hartmann and others (1997) reported that cold stratification was not necessary for seed germination.

Dehgan (1984) further investigated seed germination of nandina. Seeds were placed under dry or moist conditions at 4 or 30 °C for 0, 6, or 12 weeks. Another group of seeds was first treated with 1,000 ppm (0.1%) gibberellic acid (GA_3) for 24 or 48 hours followed by cold stratification at 4 °C or warm stratification at 30 °C for 0, 6 or 12 weeks. Results demonstrated that cold stratified seeds sown in a greenhouse in February had the greatest germination (78%) with the shortest germination time (3 weeks). Seeds that were cold-stratified for 12 weeks germinated more rapidly and uniformly compared to those stratified for 6 weeks. Neither GA_3 treatment nor warm stratification (30 °C) resulted in greater germination than nontreated seeds. Alternating periods of cold–warm, warm–cold, or warm stratification alone had little effect on increasing germination.

Germination tests. At present, optimum conditions for seed germination of nandina have not been defined. Two years are required for germination if seeds are sown in the fall (Dirr 1990). Dirr and Heuser (1987) reported 65% germination of seeds sown immediately following collection. However, time of actual germination was not reported.

Nursery practice. Although seeds can be germinated, commercial propagation of nandina is typically accomplished by vegetative means. If sexual propagation is desired, nandina seeds should be sown 6 mm ($^1/_4$ in) deep in a moist, sterile medium at 21 °C. The medium needs to be covered with polyethylene film and the container placed in bright light. Germination tends to be slow and generally occurs in about 60 days (Gibson 1982; Hartmann and others 1997). Seedlings tend to be relatively uniform (Whitcomb 1996).

Stem cuttings can be rooted anytime of year (except during the spring flush) with success rates of 80 to 90% (Barr 1987; Hartmann and others 1997). Auxin treatment of cuttings is beneficial (Barr 1987; Dirr and Heuser 1987). However, rooting tends to be slow (Bean 1976). Once stems have hardened, which is indicated by a reddening of the foliage, they become more difficult to root (Dirr and Heuser 1987; Gwaltney 1983). In addition, division of side shoots and removal of suckers that appear at the bases of plants have been successful, especially on dwarf cultivars (Dirr and Heuser 1987; Gwaltney 1983; Hartmann and others 1997). This is best accomplished in spring before growth begins.

Micropropagation protocols for nandina are currently being used commercially (Briggs and McCulloch 1983; Dirr 1990). *In vitro* techniques have been used to eliminate viruses from nandina (Smith 1983).

N

References

Afanasiev M. 1943. Germinating *Nandina domestica* seeds. American Nurseryman 78 (9): 7–8.

Barr B. 1987. Propagation of dwarf nandina cultivars. Combined Proceedings of the International Plant Propagators' Society 37: 507–508.

Bean WJ. 1976. Trees and shrubs hardy in the British Isles. 8th ed. Volume 3. London: John Murray Co. p. 1.

Briggs BA, McCulloch SM. 1983. Progress in micropropagation of woody plants in the United States and western Canada. Combined Proceedings of the International Plant Propagators' Society 33: 239–248.

Coats AM. 1992. Garden shrubs and their histories. New York: Simon and Schuster. 223 p.

Dehgan B. 1984. Germination of *Nandina domestica* seed as influenced by GA_3 and stratification. Proceedings of the Florida State Horticultural Society 97: 311–313.

Dirr MA. 1990. Manual of woody landscape plants: their identification, ornamental characteristics, culture, propagation, and uses. 4th ed. Champaign, IL: Stipes Publishing Co. 1007 p.

Dirr MA, Heuser CW Jr. 1987. The reference manual of woody plant propagation: from seed to tissue culture. Athens, GA: Varsity Press. 239 p.

Flint HL. 1997. Landscape plants for eastern North America: exclusive of Florida and the immediate Gulf Coast. 2nd ed. New York: John Wiley and Sons. 842 p.

Gibson G. 1982. The bamboo alternative. American Horticulturist 61(10): 4, 7–10, 36.

Gwaltney T. 1983. Propagation of dwarf nandina cultivars. Combined Proceedings of the International Plant Propagators' Society 33: 624–628.

Hartmann HT, Kester DE, Davies Jr FT, Geneve RL. 1997. Plant propagation: principles and practices. 6th ed. Upper Saddle River, NJ: Prentice Hall. 770 p.

Huxley A, Griffiths M, Levy M. 1992. The new Royal Horticultural Society dictionary of gardening. Volume 3. London: Macmillan. 790 p.

Ikuta A. 1994. *Nandina domestica* (heavenly bamboo): *in vitro* culture and the production of jatrorrhizine, berberine, and other alkaloids. In: Bajaj YPS, ed. Biotechnology in agriculture and forestry: Medicinal and aromatic plants VI. Volume 26. Berlin: Springer-Verlag: 259–268.

Krüssmann G. 1985. Manual of cultivated broad-leaved trees and shrubs. Volume 2. Portland, OR: Timber Press. 624 p.

Newman SE. 1991. Germination of doubly dormant woody ornamental seeds. Combined Proceedings of the International Plant Propagators' Society 41: 359–364.

Ohwi J. 1984. Flora of Japan. Washington, DC: Smithsonian Institution. 1067 p.

Richards BW, Kaneko A. 1988. Japanese plants: know them and use them. Tokyo: Shufunotomo Co.: 98–99.

Smith RH. 1983. *In vitro* propagation of *Nandina domestica*. HortScience 18(3): 304–305.

Whitcomb CE. 1996. Know it and grow it: 3. A guide to the identification and use of landscape plants. Stillwater, OK: Lacebark Publications and Research. 802 p.

Aquifoliaceae—Holly family

Nemopanthus mucronatus (L.) Loes.

mountain-holly

John C. Zasada and C. S. Schopmeyer

Dr. Zasada retired from the USDA Forest Service's North Central Research Station; Dr. Schopmeyer (deceased) retired from the USDA Forest Service's Research National Office

Growth habit, occurrence, and use. Mountain-holly is a deciduous, branchy shrub occasionally attaining small tree stature that occurs in swamps, bogs, and poor fens from Newfoundland to Minnesota and south to Virginia and Indiana. Heights at ages 5, 10, 20, 30, and 40 years for plants in a shrub-dominated peatland in New York were 1.4, 2.0, 3.5, 4.0, and 4.5 m, respectively (LeBlanc and Leopold 1992). It is regarded as an obligate wetland species: 99% of the plants grow in wetlands (Begin and others 1990; Curtis 1959; Reed 1988; Vitt and Slack 1975). It is typically found on acidic to mildly acidic soils in the shrub zone adjacent to bog mats (Cram 1988).

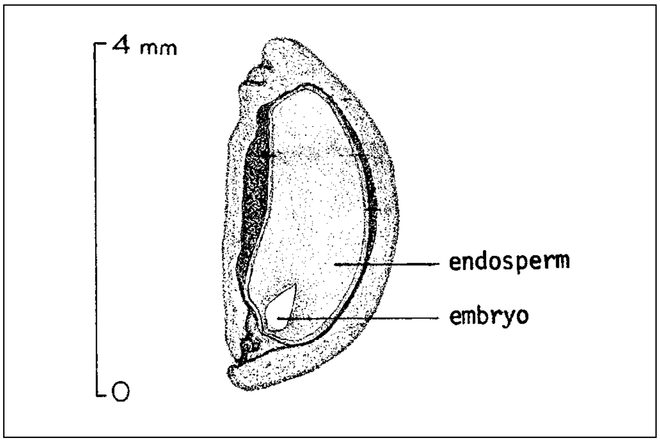
Nemopanthus is a monospecific genus and is closely related to *Ilex* spp. Similarities between *Ilex* and *Nemopanthus* in anatomical characteristics provide a basis for combining the 2 genera, but at this time it is maintained as a separate genus (Baas 1984). Information from Bonner (1974) for *Ilex* seeds is relevant to *Nemopanthus*. The species was introduced into cultivation in 1802.

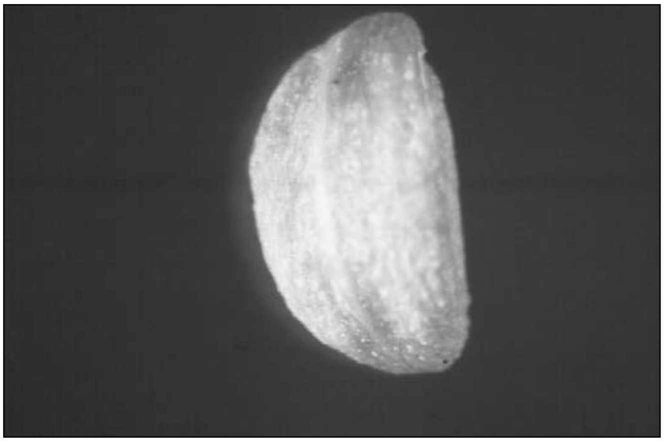
Flowering, fruiting, and seed collection. This species is mainly dioecious, with some monecious individuals (Farrar 1995). Flowering occurs in early May to June; fruits ripen as early as July, continuing into August; animals disperse the seeds (Gorchov 1990). The fruit is a scarlet, dull-red berrylike drupe, 0.6 to 2.5 cm in diameter, containing 4 to 5 bony nutlets (Rehder 1940), although Gorchov (1990) found a mean of 2.9 seeds/fruit. The latter are somewhat crescent shaped and are bone colored, with 1 rib on the back (figure 1). Because the fruits are somewhat persistent, they may be collected as late as mid-October (Schopmeyer 1974).

Extraction and cleaning of seeds. Seeds in small lots can be prepared by rubbing the fruits through a #10 soil screen (0.7mm) and then floating off the pulp and empty seeds. There are about 1,600 berries in 0.45 kg (1 lb) of fruit. The number of cleaned seeds per weight (3 samples) ranged from 68,355/kg (31,000 to 66,000/lb), with an average of 99,225/kg (45,000/lb). Seed purity in one sample was 96% and average soundness in 4 samples was 80% (Schopmeyer 1974).

Germination. Seeds are doubly dormant and require a period of after-ripening before the immature embryo will develop (figure 1) (Dirr and Heuser 1987). Consequently, germination is very slow. In 3 tests, germination began several months after sowing and continued for about 2 years, when germination capacities of 14 to 66% were observed

Figure 1—*Nemopanthus mucronatus*, mountain-holly: longitudinal section through a nutlet showing small immature embryo (**left**) and nutlet (**right**)





N

(Adams 1927; Schopmeyer 1974). Cold stratification alone did not increase germination rate (Adams 1927; Nichols 1934). Dirr and Heuser (1987) recommended 5 months of warm followed by 3 months of cold stratification. Propagation by greenwood cuttings is feasible (Bailey 1937; Dirr and Heuser 1987).

References

Adams J. 1927. The germination of the seeds of some plants with fleshy fruits. American Journal of Botany 14: 415–425.

Baas P. 1984. Vegetative anatomy and the taxonomic status of *Ilex collina* and *Nemopanthus* (Aquifoliaceae). Journal of the Arnold Arboretum 65: 243–250.

Bailey LH. 1937. The standard cyclopedia of horticulture. 3 vol. New York: Macmillan. 3639 p.

Begin J, Belanger L, Pfalzgraf J, Pineau M. 1990. Qualite de production dans les erablieres rouges de la plaine Drummondville, Quebec. Forestry Chronicle 66(4): 377–386.

Bonner FT. 1974. *Ilex* L., holly. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington DC: USDA Forest Service: 450–453.

Curtis JT. 1959. The vegetation of Wisconsin: an ordination of plant communities. Madison: University of Wisconsin Press: 655 p.

Cram H. 1988. A focus on peatlands and peat mosses. Ann Arbor: University of Michigan Press. 306 p.

Dirr MA, Heuser CW Jr. 1987. The reference manual of woody plant propagation: from seed to tissue culture. Athens, GA: Varsity Press. 239 p.

Farrar JL. 1995. Trees in Canada. Markham, ON: Fitzhenry and White. 502 p.

Gorchov DL. 1990. Pattern adaptation and constraint in fruiting synchrony within verterbrate dispersed woody plants. Oikos 58: 169–180.

LeBlanc CM, Leopold DJ. 1992. Demography and age structure of a central New York shrub-carr 94 years after fire. Bulletin of the Torrey Botanical Club 119(1): 50–64.

Nichols GE. 1934. The influence of exposure to winter temperatures upon the seed germination in various native American plants. Ecology 15: 364–373.

Reed PB JR. 1988. National list of plant species that occur in wetlands. Biol. Rep. 88 (26.1), Northeast Region (region 1). Washington DC: USDI US Fish and Wildlife Service, Northeast Region.

Rehder A. 1940. Manual of cultivated trees and shrubs. 2nd ed. New York: Macmillan. 996 p.

Schopmeyer CS. 1974. *Nemopanthus mucronatus* (L.) Trel., mountain holly. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington DC: USDA Forest Service: 553.

Vitt DH, Slack NG. 1975. An analysis of the vegetation of sphagnum-dominated kettle-hole bogs in relation to environmental gradients. Canadian Journal of Botany 53: 332–359.

Nyssaceae—Sour-gum family

Nyssa L.

tupelo

Franklin T. Bonner

Dr. Bonner is a scientist emeritus at the USDA Forest Service's Southern Research Station, Mississippi State, Mississippi

Growth habit and use. The 4 deciduous, arboreal species of tupelo—the genus *Nyssa*—native to North America (table 1) are valued for pulp, veneer, specialty wood products, wildlife food, and honey production. Water tupelo, black tupelo, and swamp tupelo were cultivated in North America before 1750 (Bonner 1974; Brown and Kirkman 1990).

Flowering and fruiting. The minute, greenish white flowers that appear in spring (table 2) may be either perfect or staminate and pistillate; flowers may be borne separately on different trees. Fruits of the tupelos are thin-fleshed, oblong drupes about 10 to 38 mm long (figure 1). Their colors range from red to blue-black when they ripen in the autumn (table 2). Each fruit contains a bony, ribbed, usually 1-seeded stone (figures 2 and 3). Seeds of water tupelo range in color from white to dark brown or gray, and some are pinkish white. Seeds of all colors have germinated equally well (Bonner 1974). Trees of Ogeechee tupelo will bear fruit when they are about 5 years old (Kossuth and Scheer 1990), and 2-year-old stump sprouts of both swamp

Table 1—*Nyssa,* tupelo: nomenclature, occurrence, and height

Scientific name & synonym(s)	Common name(s)	Occurrence	Height at maturity (m)
***N. aquatica* L.** *N. uniflora* Wangenh.	**water tupelo,** tupelo-gum, sourgum, cotton-gum, swamp tupelo	Coastal Plain from Virginia to N Florida & Texas N to Missouri & S Illinois	24–30
***N. biflora* Walt.** *N. sylvatica* var. *biflora* (Walt.) Sarg. *N. sylvatica* var. *ursina* (Small) Wen & Stuessy	**swamp tupelo,** blackgum, swamp, black-gum	Coastal Plain, chiefly from Delaware to S Florida & E Texas, N to W Tennessee	40
***N. ogeche* Bartr. ex. Marsh.** *N. acuminata* Small	**Ogeechee tupelo,** Ogeechee-lime, sour tupelo, sour tupelo-gum, white tupelo	Coastal Plain from South Carolina to NW Florida	12–15
***N. sylvatica* Marsh.**	**black tupelo,** blackgum, sourgum, tupelo-gum, pepperidge	Maine W to Michigan & Missouri, S to E Texas & S Florida	15–18

Source: Little (1978).

Table 2—*Nyssa,* tupelo: phenology of flowering and fruiting

Species	Flowering	Fruit ripening	Color of ripe fruits	Fruit drop
N. aquatica	Mar–Apr	Sept–Oct	Dark purple	Oct–Dec
N. biflora	Apr–June	Aug–Oct	Blue-black	Sept–Dec
N. ogeche	Mar–May	July–Aug	Red	Nov–Dec
N. sylvatica	Apr–June	Sept–Oct	Blue-black	Sept–Nov

Sources: DeBell and Hook (1969), Kossuth and Scheer (1990), Radford and others (1964), Vande Linde (1964).

N

Figure 1—*Nyssa*, tupelo: fruits of *N. aquatica*, water tupelo (**upper left**); *N. sylvatica*, black tupelo (**upper right**); *N. ogeche*, Ogeechee tupelo (bottom).

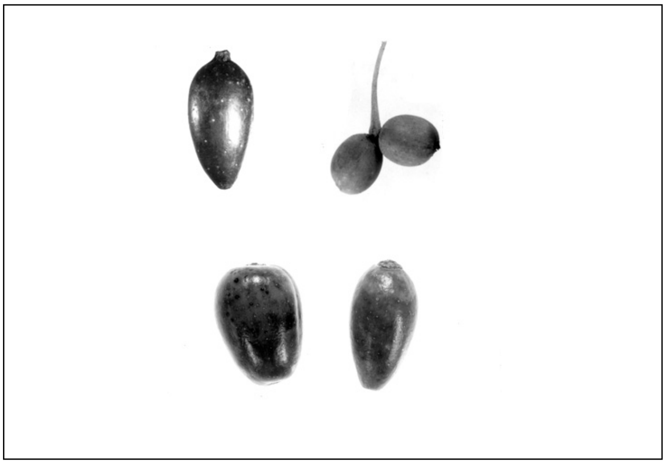
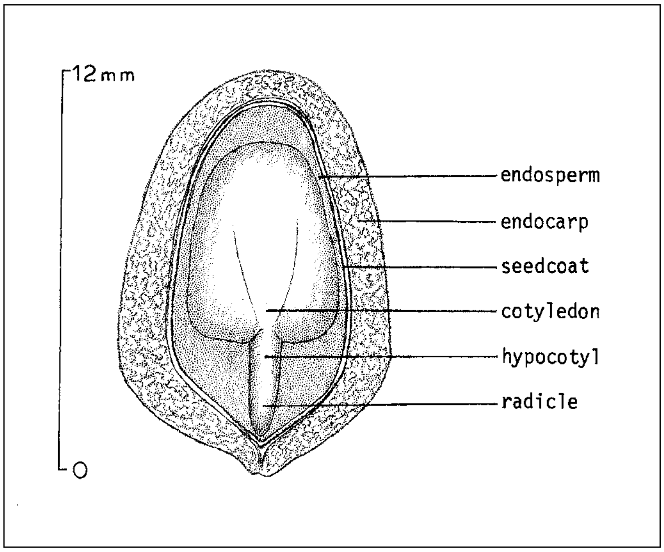


Figure 2—*Nyssa,* tupelo: stones (seeds) of *N. aquatica*, water tupelo (**upper left**); *N. ogeche*, Ogeechee tupelo (**upper right**); *N. sylvatica*, black tupelo (**lower right**); *N. biflora*, swamp tupelo (**lower right**).

Figure 3—*Nyssa sylvatica*, black tupelo: longitudinal section through a seed.



tupelo and water tupelo have produced viable seeds (Priester 1979). Major seed production can be expected when trees reach a dbh of about 20 cm, and all of the tupelos typically fruit abundantly each year (Johnson 1990; Kossuth and Scheer 1990; McGee and Outcalt 1990).

Collection, extraction, and storage. Ripe tupelo fruits may be picked from the ground, from standing trees, or from freshly felled logging tops. Newly shed fruits of water tupelo with exocarps intact will float for as long as 100 days, and they may be skimmed from the top of the water or picked from drift piles (Johnson 1990; Schneider and Sharitz 1988). Ogeechee tupelo fruits that are partially dried may float also (Kossuth and Scheer 1990), but fruits of the other tupelos do not (McGee and Outcalt 1990). External fruit color is the best index of maturity in the field (table 2). To extract the seeds, the fruits should be run through a macerator with running water to float off the pulp. Small samples may be de-pulped by rubbing the fruits over a large-meshed screen, such as hardware cloth. For water tupelo, observed numbers of fruits per weight have been from 340 to 600/kg (155 to 270/lb). Fifty kilograms (100 lb) of black tupelo fruits should yield 12 kg (25 lb) of cleaned seeds (Bonner 1974). Seed weights are listed in table 3.

Water tupelo seeds are orthodox in storage behavior. They can be stored for at least 30 months in polyethylene bags at either 3 or –10 °C, if seed moisture contents are <20% or <10%, respectively (Bonner and Kennedy 1973). Seeds of black tupelo can be stored satisfactorily over 1 winter in cold, moist stratification in sand or in just cold storage (Vande Linde 1964). Removal of the pulp did not appear to be essential for retention of viability in either condition. There are no published storage data for other tupelo species, but it is probable that the same methods would be successful for them also.

Pregermination treatment. Tupelo seeds exhibit moderate embryo dormancy, and they benefit from cold, moist stratification. Treatment in moist sand and in plastic bags without medium have been used successfully (Bonner 1974; DeBell and Hook 1969). Good germination has been reported after only 30 days of stratification, but periods up to 120 days may be needed for some seedlots (Bonner 1974; DuBarry 1963).

Germination tests. Official seed testing prescriptions for tupelos in North America (AOSA 1993) call for a temperature regime of 8 hours at 30 °C in light and 16 hours at 20 °C in the dark. Testing should be on moist blotters or creped cellulose wadding for 21 days (water tupelo) or 28 days (black tupelo). Stratification for 28 to 30 days should precede the test. Germination of stratified seeds has been tested in several other media (table 4), and each of these probably would be satisfactory for seeds of all tupelo species.

Nursery practice. Although untreated seeds may be sown in the fall (Heit 1967) spring-sowing of stratified seeds is recommended, particularly in the South. They may be broadcast or drilled in rows, with 50 seeds/m (15/ft) for water tupelo. Seeds should be planted 12 to 25 mm ($^1/_2$ to 1 in) deep or sown on the bed surface and rolled into the soil and mulched (Bonner 1974; Vande Linde 1964). Mulching with 2 to 3.5 cm (.8 to 1.4 in) of sawdust is recommended for water tupelo and with 6 mm ($^1/_2$ in) of sawdust or 1 cm (.4 in) of pine straw for swamp tupelo. After sowing, the seeds and mulch must not be allowed to dry excessively.

Table 3—*Nyssa,* tupleo: seed weights

		Cleaned seeds/weight				
		Range		Avg		
Species	Collection place	/kg	/lb	/kg	/lb	Samples
N. aquatica	—	—	—	1,000	456	—
N. biflora	South Carolina	—	—	5,320	2,415	10
N. ogeche	—	2,300–3,100	1,040–1,420	2,700	1,230	2
N. sylvatica	—	4,100–8,820	1,850–4,000	7,280	3,300	5
	North Carolina	5,750–8,500	2,610–3,860	7,450	3,380	10
	Midwest	—	—	5,500	2,492	2+

Sources: Bonner (1974), Earle and Jones (1969).

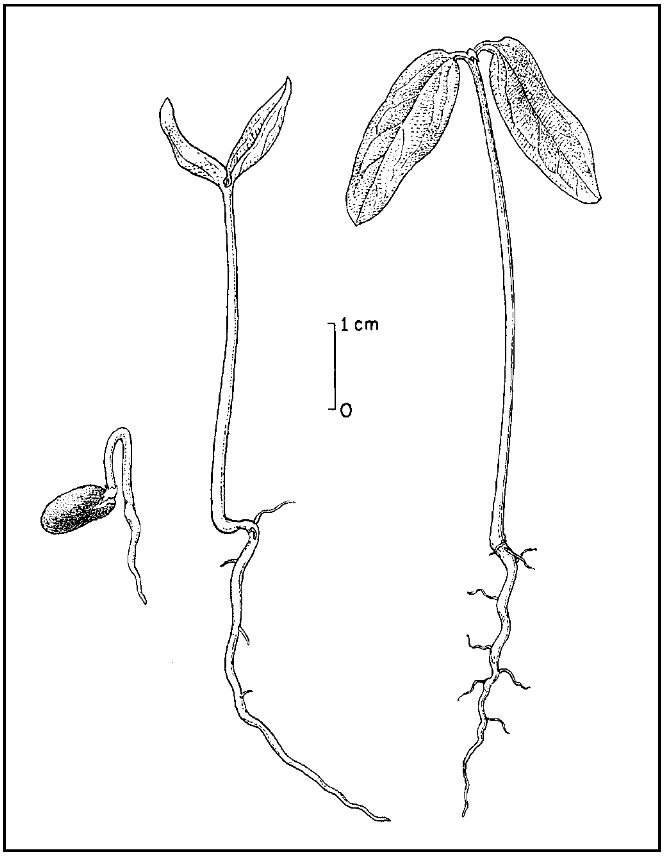
Table 4—*Nyssa,* tupelo: germination test conditions and results on stratified seeds

	Daily	Germination test conditions				Germination rate		Germination %		
	light		Temp (°C)			Amt		Avg		Purity
Species	(hr)	Medium	Day	Night	Days	(%)	Days	(%)	Samples	(%)
N. aquatica	8	Kimpak	30	20	27	87	18	97	5	100
	0	Water in petri dish	29	29	28	57	14	79	24	—
N. biflora	ND	Sand	—	—	60	—	—	51	—	—
N. ogeche	8	Kimpak	30	20	70	69	12	85	1	—
N. sylvatica var. *sylvatica*	8	Kimpak	30	20	27	—	—	71	8	99

Sources: Bonner (1974), Debell and Hook (1969).
ND = natural daylength in a greenhouse.

N

Figure 4—*Nyssa sylvatica*, black tupelo: seedling development at 1, 4, and 39 days after germination.



Shading with tobacco shade cloth can help keep beds moist and aid the newly emerged seedlings (Vande Linde 1964). Germination is epigeal (figure 4). Desirable seedbed densities for water and black tupelos are 100 to 150 seedlings/m^2 (9 to 14/ft^2) (Williams and Hanks 1976. Vegetative propagation of tupelos is possible by softwood cuttings and grafting (Dirr and Heuser 1987).

References

AOSA [Association of Official Seed Analysts]. 1993. Rules for testing seeds. Journal of Seed Technology 16(3): 1–113.

Bonner FT. 1974. *Nyssa* L., tupelo. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 554–557.

Bonner FT, Kennedy HE Jr. 1973. Storage of water tupelo seeds. Tree Planters' Notes 24(4): 7–8.

Brown CL, Kirkman LK. 1990. Trees of Georgia and adjacent states. Portland, OR: Timber Press. 292 p.

DeBell DS, Hook DD. 1969. Seeding habits of swamp tupelo. Res. Pap. SE-47. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station. 8 p.

Dirr MA, Heuser CW Jr. 1987. The reference manual of woody plant propagation. Athens, GA: Varsity Press. 239 p.

DuBarry AP Jr. 1963. Germination of bottomland tree seed while immersed in water. Journal of Forestry 61: 225–226.

Earle FR, Jones Q. 1962. Analyses of seed samples from 113 plant families. Economic Botany 16: 221–250.

Heit CE. 1967. Propagation from seed: 8. Fall planting of fruit and hardwood seeds. American Nurseryman 126 (4): 12–13, 85–90.

Johnson RL. 1990. *Nyssa aquatica* L., water tupelo. In: Burns RN, Honkala BH, tech. coords. Silvics of North America. Volume 2, Hardwoods. Agric. Handbk. 654. Washington, DC: USDA Forest Service: 474–478.

Kossuth SV, Scheer RL. 1990. *Nyssa ogeche* Bartr. ex Marsh., Ogeechee tupelo. In: Burns RM, Honkala BH, tech. coord. Silvics of North America. Volume 2, Hardwoods. Agric. Handbk. 654. Washington, DC: USDA Forest Service: 479–481.

Little EL Jr. 1978. Checklist of United States trees (native and naturalized). Agric. Handbk. 541. Washington, DC: USDA Forest Service. 375 p.

McGee CE, Outcalt KW. 1990. *Nyssa sylvatica* Marsh., black tupelo. *N. sylvatica* Marsh. var. *sylvatica*; black tupelo (typical), *N. sylvatica* var. *biflora* (Walt.) Sarg., swamp tupelo. In: Burns RM, Honkala BH, tech. coords. Volume 2, Hardwoods. Agric. Handbk. 654. Washington, DC: USDA Forest Service: 482–489.

Priester DS. 1979. Stump sprouts of swamp and water tupelo produce seeds. Southern Journal of Applied Forestry 3: 149–151.

Radford AE, Ahles HE, Bell CR. 1964. Guide to the vascular flora of the Carolinas. Chapel Hill: University of North Carolina Book Exchange. 1183 p.

Schneider RL, Sharitz RR. 1988. Hydrochory and regeneration in a bald cypress–water tupelo swamp forest. Ecology 69: 1055–1063.

Vande Linde F. 1964. Nursery practices for southern oaks and gums. Tree Planters' Notes 65: 24–26.

Williams RD, Hanks SH. 1976. Hardwood nurseryman's guide. Agric. Handbk. 473. Washington, DC: USDA Forest Service. 78 p.