

Nettleleaf giant hyssop (*Agastache urticifolia*)

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Nomenclature

Nettleleaf giant hyssop (*Agastache urticifolia* [Benth.] Kuntze) belongs to the Lamiaceae or mint family, Mentheae tribe, and Nepetinae subtribe (Drew and Sytsma 2012). The *Agastache* genus is comprised of two sections, *Agastache* (syn: *Chiastandra*) and *Brittonastrum*, which are geographically distinct. Nettleleaf giant hyssop is part of the more northerly distributed *Agastache* section (Lint and Epling 1945; Vogelmann 1985). Taxonomy for this review follows Cronquist et al. (1984).

Family

Lamiaceae – Mint family

Genus

Agastache

Species

urticifolia

NRCS Plant Code

AGUR (USDA NRCS 2019).

Subtaxa

There are two nettleleaf giant hyssop varieties: *A. u.* var. *glaucofolia* (A. Heller) Cronquist and *A. u.* var. *urticifolia* (Cronquist et al. 1984).

Synonyms

Lothophanthus urticifolia Benth., *Vleckia urticifolia* Raf., *Agastache glaucofolia* Heller var. *glaucofolia*.

Common Names

Nettleleaf giant hyssop, nettle-leaf horsemint, horsemint (USDA FS 1937; USDA NRCS 2019).

Chromosome Number

The chromosome number for nettleleaf giant hyssop is $2n = 18$ (Welsh et al. 2016).

Hybridization

Although natural hybrids are not described in the literature, viable pollen was produced from hybrids formed when plants of the *Agastache* and *Brittonastrum* sections were crossed in controlled greenhouse experiments. Pollen viability (pv), as determined from lactophenol + aniline blue staining, was greatest for crosses of nettleleaf giant hyssop with other western *Agastache* populations: × *A. foeniculum* (28% pv), × *A. cusickii* (52% pv), × *A. occidentalis* (96% pv), and × *A. parvifolia* (98% pv). Pollen viability was generally lower for crosses of nettleleaf giant hyssop with species of the *Brittonastrum* section, which occurs in Arizona, New Mexico, and Mexico: × *A. palmeri* (24% pv), × *A. rupestris* (21% pv), × *A. pallidiflora* (14–20% pv, depending on the subspecies). Pollen viability was much lower for crosses with *Agastache* populations from Indiana (*A. nepetoides* [4% pv], *A. scrophularifolia* [3% pv]), and Asia (*A. rugosa* [0.1% pv]) (Vogelmann 1985).

Distribution

Nettleleaf giant hyssop occurs in the western US and southern British Columbia. Populations occur from southern British Columbia near its international border with northeastern Washington; east to western Montana, Wyoming, and Colorado; south to California's Kern and Santa Barbara counties; and west nearly to the Pacific Coast in Oregon, California, and central Washington (USDA NRCS 2019). The species is widely distributed in California (Munz and Keck 1973) and considered widespread throughout the Intermountain West, except for the Kaibab Plateau (Cronquist et al. 1984). It occurs in all Utah counties except Daggett, Emery, Morgan, Summit, Uintah, and Wayne (Welsh et al. 2016).

Variety *urticifolia* is the most widely distributed of the two nettleleaf giant hyssop varieties, occurring throughout the range described for the species. Variety *glaucofolia* is narrowly distributed, occurring only in parts of California and Oregon (USDA NRCS 2019).

A study conducted in the East River Basin of Gunnison County, Colorado, suggests that nettleleaf giant hyssop is shifting its range with its climatic niche over time. Vegetation surveys of 125 sites occupying four communities (sagebrush [*Artemisia* spp.], spruce-fir [*Abies-Picea* spp.], subalpine meadow, and alpine) were conducted in 1948 and 1952 and compared to surveys conducted 65 years later. The constancy of nettleleaf giant hyssop in sagebrush vegetation was 52% in 1948 and 15% in 2014. Average elevation of nettleleaf giant hyssop populations in 1950 was 9,308 ft (2,837 m) (range: 8,340–10,203 ft [2,542–3,110 m]) and in 2014 was 9,928 ft (3,026 m) (range: 8,527–11,982 ft [2,599–3,652 m]) (Zorio et al. 2016).

Habitat And Plant Associations

Nettleleaf giant hyssop occupies dry to wet sites in canyons and mountain valleys from the foothills to high-elevation sites (Hitchcock and Cronquist 2018) in herbaceous-dominated communities, shrublands, woodlands, and forests (Munz and Keck 1973; Blackwell 2006; Welsh et al. 2016; USU Ext. 2017).

Herbaceous communities. Throughout its range, nettleleaf giant hyssop is common in a variety of herbaceous dominated communities, such as grasslands, meadows, and forb-dominated types from foothills to alpine zones. In eastern Washington, nettleleaf giant hyssop occurred in grasslands in the arid transition zone of ponderosa pine (*Pinus ponderosa*) forests on granitic soils (Piper 1906). It is characteristic and common in the poke knotweed (*Polygonum phytolaccifolium*)-nettleleaf giant hyssop-Nuttall's linanthus (*Linanthastrum nuttallii*) communities in the Blue Mountains of northeastern Oregon and adjacent Washington and Idaho, which occupy cool and dry sites (Powell et al. 2007). In the Bitterroot Mountains of western Montana, nettleleaf giant hyssop occurred in high-elevation grasslands dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*) and Idaho fescue (*Festuca idahoensis*). The grasslands occurred within the Engelmann

spruce-subalpine fir (*Picea engelmannii-Abies lasiocarpa* spp.) zone where tree establishment was restricted (Root and Habeck 1972). In the Wasatch Mountains of southern Idaho and northern Utah, nettleleaf giant hyssop occurred in 6 of 25 major plant communities and reached its maximum frequency in open alpine fellfield communities at an average elevation of 9,469 ft (2,886 m) (Ostler and Harper 1978). Cover of nettleleaf giant hyssop was up to 8% in Thurber's fescue (*Festuca thurberi*) grasslands scattered within other vegetation from 8,500 to 12,500 ft (2,600–3,800 m) in the Crested Butte area of Gunnison, Colorado. These grasslands were most common on steep south-facing slopes with deep soils (Langenheim 1962). In the Great Basin, nettleleaf giant hyssop was considered common in the tall forb rangeland type where shrubs are mostly absent and grasses or sedges rarely make up more than 10% of the composition. The tall forb type was found near springs, along streams, and in Douglas-fir (*Pseudotsuga menziesii*) and spruce-fir forest openings at 6,300 to 9,000 ft (1,900–2,700 m) (Shiflet 1994).

Shrublands. Nettleleaf giant hyssop occurs in big sagebrush (*Artemisia tridentata*) communities (Fig. 1), mountain brush vegetation, and in shrub-dominated thickets. In vegetation studies at the Craters of the Moon National Monument in south-central Idaho, nettleleaf giant hyssop was common in mountain big sagebrush (*A. t. subsp. vaseyana*)/bluebunch wheatgrass and riparian communities. Riparian vegetation occurred close to water and had dense woody vegetation and tall forb layers (Day and Wright 1985).



Figure 1. Nettleleaf giant hyssop growing in a roadside shrubland in Utah. Photo: USDI BLM UT931 SOS.

Shrub dominance varies in mountain brush or thickets where nettleleaf giant hyssop is common. In eastern Whitman County, Washington, and Latah County, Idaho, nettleleaf giant hyssop was characteristic of black hawthorn/common snowberry (*Crataegus douglasii/Symphoricarpos albus*) thickets 0.6 to 1 ft (0.2–0.3 m) tall on northern aspects (30–50% slope) at 2,500 to 2,600 ft (760–800 m) (McMinn 1952). It also occurred in common snowberry thickets growing within Idaho fescue meadows in the Columbia Basin Province (Franklin and Dyrness 1973). In the Lake Tahoe Region of Nevada and California, nettleleaf giant hyssop occurred in Geyer willow (*Salix geyeriana*) hedges that lined wet meadows along the

Truckee River (Smiley 1915). In Utah's Wasatch Mountains nettleleaf giant hyssop occurred in the canopy openings of tall bigtooth maple (*Acer grandidentatum*) shrublands on north and east slopes with highly fertile loam soils (Allman 1953). It was also abundant in the mountain snowberry (*Symphoricarpos oreophilus*)/forb community in the subalpine zone of the Wasatch Plateau. This tall shrubland occurred on south slopes exposed to extreme drying by full sun and southwest winds and had just 48% vegetation cover. Cover of rock was 16%, bare ground was 11%, and nettleleaf giant hyssop cover ranged from 10 to 25% (Ellison 1954).

Woodlands. Nettleleaf giant hyssop occurs in quaking aspen (*Populus tremuloides*) and Rocky Mountain juniper (*Juniperus scopulorum*) woodlands. It can be abundant in moist, rich soils within quaking aspen zones throughout its range (Fig. 2) (USDA FS 1937). In the Jackson Hole Wildlife Park, Wyoming, nettleleaf giant hyssop occurred in quaking aspen and big sagebrush communities. Two types of quaking aspen stands occurred in the Park: stands with open canopies growing on xeric hillsides and densely shaded stands on flatter terrain. Nettleleaf giant hyssop only occurred in the open hillside stands (Reed 1952). In quaking aspen woodlands near Salt Lake City, Utah, that were ungrazed for 50 years, nettleleaf giant hyssop was a dominant understory forb (Bartos and Mueggler 1982). In the Mink Creek area near Pocatello, Idaho, nettleleaf giant hyssop was common in the Rocky Mountain juniper/mountain big sagebrush-mountain snowberry/basin wildrye (*Leymus cinereus*) vegetation type. These woodlands were considered mid-seral and occurred on mixed carbonate substrates with less than 25% average tree cover (Rust 1999).



Figure 2. Large stand of nettleleaf giant hyssop growing in a quaking aspen woodland opening in Utah. Photo: USDI BLM UT931 SOS.

Coniferous forests. In ponderosa pine, Douglas-fir, and spruce-fir forests, nettleleaf giant hyssop occurs in both the understory and canopy openings (Fig. 3) (Franklin and Dyrness 1973). It is commonly found as scattered plants growing with lupines (*Lupinus* spp.), geraniums (*Geranium* spp.), bluebell (*Mertensia* spp.), snowberry (*Symphoricarpos* spp.), and chokecherry (*Prunus virginiana*) (USDA FS 1937). In southwestern Oregon, nettleleaf giant hyssop constancy was 67% in the Douglas-fir/salmonberry/western swordfern (*Rubus spectabilis*/*Polystichum munitum*) plant association,

considered the warmest of the Douglas-fir forest associations occurring on moist north slopes at a mean elevation of 520 ft (160 m) (Atzet et al. 1996). In Oregon's Umpqua National Forest, nettleleaf giant hyssop occurred in meadow openings in white fir (*A. concolor*) and Shasta red fir (*A. magnifica* var. *shastensis*) forests. These meadows were similar to the mesic tall forb community described for the Wasatch Mountains of Utah (Franklin and Dyrness 1973), where nettleleaf giant hyssop also occurs (Ostler and Harper 1978). In central Idaho, nettleleaf giant hyssop was a widespread species in several early seral, Douglas-fir forest types, many of which included an abundance of ponderosa pine (Steele and Geier-Hayes 1995). In Utah, nettleleaf giant hyssop occurred on high plateaus in Engelmann spruce (*Picea engelmannii*)-subalpine forests with low annual temperatures, high winds, and short growing seasons (Dixon 1935).



Figure 3. Nettleleaf giant hyssop growing in a subalpine meadow in Utah. Photo: USDI BLM UT931 SOS.

Elevation

The elevation range for nettleleaf giant hyssop is from about 1,300 to 10,800 ft (400–3,300 m) (Hickman 1993; Welsh et al. 2016). In California the range is 1,300 to 9,800 ft (400–3,000 m) (Hickman 1993), and in Utah it is 5,400 to 10,800 ft (1,650–3,330 m) (Welsh et al. 2016).

Soils

Nettleleaf giant hyssop grows in soils with a variety of textures and pH levels from 6 to 8. Although described as growing in wet and dry habitats, it is not exceptionally drought tolerant (USDA FS 1937; USU Ext. 2017; USDA NRCS cited in Tilley and Pickett 2019). It is considered a facultative upland (FACU) species, which means it normally occupies non-wetland sites, but it is occasionally found in wetlands (Crawford 2003; USDA NRCS 2019).

Several studies indicate that nettleleaf giant hyssop prefers or is more abundant on moist sites. In the Palouse region of eastern Washington, nettleleaf giant hyssop was associated with shrub thickets and other vegetation where soil moisture was greater than in surrounding grasslands (Skinner 2005).

In an evaluation of the relationships between landscape position and biotic and abiotic attributes of western juniper (*Juniperus occidentalis*) in the Steens Mountains of southeastern Oregon, nettleleaf giant hyssop was positively associated with soil moisture ($r = 0.798$). It was also strongly associated with north- and east-facing slopes with low western juniper cover (<1%), which had higher soil moisture content (Petersen and Stringham 2009). In an evaluation of soil moisture and vegetation characteristics in eastern Whitman County, Washington, and adjacent Latah County, Idaho, nettleleaf giant hyssop was characteristic of black hawthorn/common snowberry thickets on north slopes. The thickets remained above the permanent wilting percentage longer into the summer than most other grasslands, shrublands, and ponderosa pine forests in the area (McMinn 1952). When the vegetation and soil characteristics of 372 undisturbed sagebrush (*Artemisia* spp.)-dominated sites were evaluated in Nevada's Humboldt-Toiyabe National Forest, nettleleaf giant hyssop was associated with sites having the deepest soils, greatest effective rooting depth, and greatest water holding capacity (Jensen 1990).

Description

Nettleleaf giant hyssop is a tall, herbaceous, strongly aromatic, perennial with a deep, thick, extensive fibrous root system with creeping root stalks (USDA FS 1937; Hickman 1993; Welsh et al. 2016). Plants are robust and grow erect up to 6.5 ft (2 m) tall, although they are often less than 5 ft (1.5 m) tall (Craighead et al. 1963; Welsh et al. 2016). Those growing in full sun are often much shorter than those growing in shade (USU Ext. 2017).

Plants typically produce several, mostly glabrous leafy stems that are hollow and square in cross section (Fig. 4) (USDA FS 1937; Andersen and Holmgren 1996; Welsh et al. 2016). Leaves when crushed give off a strong minty/anise smell. Plant pubescence can vary. In California, plants growing in the Coast Ranges were more pubescent than those in the Sierra Nevada Mountains (Munz and Keck 1973). Stems are simple or branched near the top (USDA FS 1937).



Figure 4. Nettleleaf giant hyssop plant in flower. Photo: USDI BLM UT931 SOS.

Leaves are opposite, petiolate, and 0.4 to 2 in [1–5 cm] long. Leaves are triangular to egg-shaped, coarsely and irregularly serrate along the edges, and have heart-shaped bases (Fig. 5) (Munz and Keck 1973; Cronquist et al. 1984; Hitchcock and Cronquist 2018). Larger leaves are 1.6 to 4 in (4–10 cm) long and 0.8 to 3.2 in (2–8 cm) wide (Hitchcock and Cronquist 2018). Leaves are green on both surfaces, although the undersides can be slightly paler than the upper sides, and they are often purplish near the base (USDA FS 1937; Tilley and Pickett 2019).



Figure 5. Nettleleaf giant hyssop leaves are arranged opposite along the square stem. Photo: USDI BLM OR110 SOS.

Flowers are produced in a dense, spike-like inflorescence measuring 1.2 to 6 in (3–15 cm) long and 0.8 to 2 in (2–5 cm) wide (Fig. 6) (Spellenberg 2001; Welsh et al. 2016; Tilley and Pickett 2019). Flowers are sessile and arranged in a whorl around the inflorescence stalk (Munz and Keck 1973; Welsh et al. 2016). Flowers are bilabiate (Tilley and Pickett 2019). The upper corolla lip is erect with two lobes. The lower lip is spreading with three lobes, the middle one being largest (USDA FS 1937; Munz and Keck 1973). Corollas range from white to rose or violet (Welsh et al. 2016). The calyx is tubular, somewhat finely hairy, and up to 0.4 in (1 cm) long. It is slightly two-lipped with 15 ribs and five teeth, which are greenish white to purple at the tips (USDA FS 1937; Hitchcock and Cronquist 2018).

Flowers are perfect with four stamens protruding beyond the corolla (Hermann 1966; Hitchcock and Cronquist 2018; LBJWC 2019). The lower two stamens ascend under the upper corolla lip, and the upper two stamens thrust down between the lower lobes, such that on casual inspection the lower stamens appear longer than the upper stamens (Munz and Keck 1973; Cronquist et al. 1984; Welsh et al. 2016). The ovary is four-parted, and develops into a nutlet with four seeds. Nutlets are dull brown, striped, ovoid to elliptic, 1.7 mm long and 1 mm wide, and smooth to wrinkled with minute short hairs at the apices (Munz and Keck 1973; Moon et al. 2009).

Reproduction

Given the large number of flowers in each inflorescence and because each individual nettleleaf giant hyssop flower produces four seeds, high reproductive output seems likely for the species. Yet, seed production per plant is relatively small, and seed viability can be as low as 25% (USDA FS 1937).

Nettleleaf giant hyssop seed production was low for plants grown in an outdoor experimental garden at Waterloo University, Ontario, Canada. Plants were grown from seed collected in Klamath Falls, Oregon. When inflorescences were bagged and protected from pollinators, no seed was produced. Seed was produced, but production was low, when inflorescences were open-pollinated. Just 22 viable seeds were produced from 100 fruiting flowers. Meiosis and pollen formation were normal and all pollen was good, causing researchers to wonder if low seed production was due to a lack of suitable pollinators for the timing of flowering of the non-local seed source in the common garden (Gill 1979).



Figure 6. Close-up of nettleleaf giant hyssop inflorescence. Photo: University of California Botanical Garden.

Reproductive success of nettleleaf giant hyssop was also low when evaluated as part of a larger study of reproductive success in a common garden in Utah's Wasatch Mountains. For outcrossed nettleleaf giant hyssop plants, the mature fruit/flower ratio was 26% ($n=78$), and the seed/ovule ratio was 56% ($n=17$) for a pre-emergent reproductive success (PERS) of 17%. This PERS was considered low, and PERS reported for other outcrossing species in the study ranged from 8 to 100% (Wiens et al. 1987).

Pollination

Nettleleaf giant hyssop flowers require pollination for seed production (Pleasants 1977; Gill 1979). The rose to violet flowers attract a variety of insect pollinators, and the zygomorphic flower structure makes flower pollination an inevitable result of insects feeding on the nectar (Vansell 1933; Ostler and Harper 1978; LBJWC 2019). Flowers are generally available to pollinators from June through mid-September, but phenology varies with latitude and elevation (Allman 1953; Munz and Keck 1973). See Collection timing section.

No seed was set when nettleleaf giant hyssop flowers were protected from insects in studies conducted in meadows near Crested Butte, Colorado. Nettleleaf giant hyssop pollinators foraged for nectar, not pollen. Seed set with insect visitation was 90%. Bees visited 0.7 flowers per second in this area, and the longevity of individual flowers averaged 4.6 days. In one year of the study, nettleleaf giant hyssop produced 464 flowers/quadrate ($2.5 \text{ ft} \times 2.5 \text{ ft}$ [$0.75 \text{ m} \times 0.75 \text{ m}$]). In the following year, 1,992 flowers were produced per quadrate (Pleasants 1977). When bumblebee competition was evaluated in this same area, nettleleaf giant hyssop was visited by yellow-fronted bumblebees (*Bombus flavifrons*) (about 80% of bumblebee visits), white-shouldered bumblebees (*B. appositus*) (<20% of bumblebee visits), and two-form bumblebees (*B. bifarius*) (<5% of bumblebee visits). Visits were monitored in a year when nettleleaf giant hyssop produced an abundance of flowers ($1,992 \text{ flower-d/m}^2$) (Pleasants 1980).

Queen Alexandra's sulphur (*Colias alexandra*) also visits nettleleaf giant hyssop flowers. This butterfly species made an average of eight visits to nettleleaf giant hyssop flowers during the last quarter of its flight season. Visiting observations were made over about 50% of the butterfly's flight season in montane habitats in Gunnison County, Colorado. Nettleleaf giant hyssop in this area averaged just 0.3% cover and produced $1.1 \mu\text{l}$ of nectar/flower (Watt et al. 1974).

Ecology

Nettleleaf giant hyssop occurs in early and late-seral communities. Plants grow in full sun to partial shade, but seed germination is greatest in full sun (Hoffman 1985; Steele and Geier-Hayes 1995). In the few studies evaluating disturbances in nettleleaf giant hyssop communities, plants generally survived burning but were more abundant on unburned than burned sites (Zschaechner 1985).

Studies indicate that nettleleaf giant hyssop tolerates early seral conditions and can persist as communities become shaded and tree dominated. The species was common in one of the earliest successional herbaceous subalpine communities in the Wallowa and Blue Mountains of eastern Oregon, but this study did not compare nettleleaf giant hyssop abundance across seral stages (Ellison 1960). In the Owyhee Mountains of Idaho, nettleleaf giant hyssop was more common in mature western juniper woodlands than in herbaceous or shrubland-dominated communities within the same habitat type (Bunting et al. 1999).

Seed And Seedling Ecology

Nettleleaf giant hyssop produces a seed bank, but longevity of seed in the soil is unknown. In central Idaho, it is a widespread species in early seral Douglas-fir forests. It establishes in full sun from soil-stored seed, the viability of which was reported to be 67% by Steele and Geier-Hayes (1995). On the Payette and Boise National Forests of Idaho, seed was recovered from soil collected in grand fir (*Abies grandis*) and Douglas-fir forests that averaged 101 years old (Kramer and Johnson 1987). Soil was sampled from 48 stands at a volume of 74 in² (475 cm²) soil/stand. Five viable nettleleaf giant hyssop seeds were recovered for a maximum seed density of 678/ft² (63/m²). Nettleleaf giant hyssop occurred in the aboveground biomass of both the Douglas fir (13% constancy) and grand fir (6% constancy) forests (Kramer and Johnson 1987).

A proportion of seed is likely removed by seed predators, and some may be distributed by grazers. Seven nettleleaf giant hyssop seeds germinated from cattle feces collected from sites in northeastern Oregon (Bartuszebig and Endress 2008). Experiments in recently hayed fields across Switzerland, revealed that 42% of non-native nettleleaf giant hyssop seeds were removed after 3 days when they were made available to insects and rodents. The non-native nettleleaf giant hyssop seeds used in the experiments averaged 0.5 mg (Preukschas et al. 2014).

Under controlled conditions, nettleleaf giant hyssop seedlings grew larger with minimal shading and higher nighttime temperatures. Shading of 6% in the greenhouse in summer resulted in greater dry seedling shoot weight. Seed collected from quaking aspen stands in northern Utah was sown 0.25 to 0.5 in (0.6-1.3 cm) deep in loam soil filling 5-pint (2.3 l) containers. Shading treatments were initiated as seedlings emerged. After 2 weeks, containers were thinned to four seedlings. After 5 weeks, unshaded nettleleaf giant hyssop seedling leaves were sun burned at the margins and tips. After 2 months, the dry weight of seedling shoots with 6% shading (323 mg) was significantly greater ($P < 0.05$) than that of unshaded seedlings (277 mg) and those with 20% (248 mg), 30% (253 mg), and 40% shading (230 mg). Air temperature ranged from 61 to 94 °F (16-34 °C) and relative humidity from 32 to 78% in the greenhouse (McDonough 1969c).

In growth chamber experiments, nettleleaf giant hyssop seedlings were larger when nighttime temperatures were higher. Nettleleaf giant hyssop seed was summer collected at 2,300 ft (700 m) from aspen and mixed forb-grass vegetation in Utah's Uinta National Forest. Seeds were germinated on moist filter paper, and germinants were planted in containers filled with loam soil. Containers were exposed to 12 hours of light and 12 hours of dark. The temperature during the light phase was 68 °F (20 °C), but during the dark phase was 36, 41, 50, 59, or 68 °F (2, 5, 10, 15, or 20 °C). After 8 weeks, the dry weight of seedling shoots (0.29-0.35 mg at ≥ 59 °F [15 °C]) was significantly higher ($P < 0.05$) at the warmer than the cooler nighttime temperatures (0.14-0.19 mg at ≤ 50 °F [10 °C]) (McDonough 1969b).

Disturbance Ecology

Most nettleleaf giant hyssop plants survived clearcutting and fire in the few studies evaluating post-disturbance recovery. Clearcutting operations in a quaking aspen stand near Salt Lake City, Utah, did not result in large changes in the percent composition attributed to nettleleaf giant hyssop. This was even though clearcutting resulted in greater shrub dominance and increased abundance and size of quaking aspen sprouts for the first 3 years after cutting (Bartos and Mueggler 1982).

Three of four directly monitored nettleleaf giant hyssop plants survived fires in mixed shrublands near Jackpot, Nevada. Direct fire effects were evaluated after prescribed fires in late August and early October. The late August fire burned when live fuel moisture was 92%, air temperature was 74 °F (23 °C), relative humidity was 24%, and winds were 5 mi/hr (8 km/h). The early October fire burned when live fuel moisture was lower (77%), but air temperature, relative humidity, and wind speed were similar. All sagebrush and all aboveground nettleleaf giant hyssop biomass was consumed in each fire. Both nettleleaf giant hyssop plants tagged before the August fire and one of two tagged before the October fire sprouted in the first post-fire year (Zschaechner 1985). In the Gambel oak (*Quercus gambelii*) zone of Parley's Canyon in Utah's Wasatch Mountains, nettleleaf giant hyssop was not reported in a 9-year-old burned site but occurred with low frequency (5%) and cover (0.8%) on the adjacent unburned site. Observers of the fire described it as burning hot and for a long duration (McKell 1950).

Wildlife And Livestock Use

All classes of livestock, elk (*Cervus canadensis*), deer (*Odocoileus* spp.), and small mammals graze nettleleaf giant hyssop (USDA FS 1937; Okello 1993; Ogle and Brazee 2009). Birds feed on the seeds (Craighead et al. 1963), and a wide variety of insects visit the flowers for nectar (Bouseman and LaBerge 1978; Pleasants 1980; Adamson et al. 2018) .

Nettleleaf giant hyssop is utilized by horses, cattle, and sheep. Although sheep use may be heavier (USDA FS 1937; Hermann 1966), use by cattle is still often high. Plants are grazed until flowers begin to drop, then again after seed has matured, and in the fall if young green leaves are available (USDA FS 1937). Palatability to and use by sheep is considered greater in the drier portion of nettleleaf giant hyssop's range (southern Idaho, Utah, Nevada, and lava beds in northeastern California) than in northern Idaho and the Sierra Nevada of California (USDA FS 1937).

In a comparative cattle and sheep grazing study, use of nettleleaf giant hyssop was 16% by cattle and 26% by domestic sheep. Feeding observations were made for 6 years on adjacent allotments where the animals grazed separately. The allotments were in the mountains of northern Utah in vegetation that was 60% large meadows and 40% open aspen groves (Cook 1983). Cattle grazing occurred from July 1 through October 1 and sheep grazing from July 3 through September 26. Nettleleaf giant hyssop made up 0.3% of the vegetation composition (Cook 1954).

Sheep utilized 6% of the stems, 60% of the leaves, and 36% of the flower heads that made up nettleleaf giant hyssop's current year's growth (Cook and Stoddart 1953).

Deer, elk, and pronghorn (*Antilocapra americana*) feed on nettleleaf giant hyssop (Ogle and Brazee 2009). In an area of Utah's Wasatch Mountains closed to livestock grazing but used by many deer, nearly all nettleleaf giant hyssop plants growing in the canopy openings of bigtooth maple groves were clipped (Allman 1953). In subalpine summer range in eastern Oregon's Wallowa-Whitman National Forest, elk and domestic sheep fed on nettleleaf giant hyssop. In this range above the lodgepole pine (*Pinus contorta*) belt, production of nettleleaf giant hyssop was 2.5 lbs/acre (2.8 kg/ha) green weight. Use by sheep was 1 lb/acre (1.1 kg/ha) or 40%, and by elk was 0.5 lb/acre (0.6 kg/ha) or 20% (Pickford and Reid 1943).

In feeding trials, nettleleaf giant hyssop was a preferred food of northern pocket gophers (*Thomomys talpoides*). Northern pocket gophers were live-trapped in Douglas-fir forests on the Payette National Forest and fed known quantities of plants. Nearly 30% of the weight of nettleleaf giant hyssop fed was consumed and 15% was cached (Okello 1993).

Nettleleaf giant hyssop is a nectar source for many bees, moths, and butterflies, including monarch butterflies (*Danaus plexippus*) (Adamson et al. 2018). The mining bee (*Andrena pertristis caroliniformis*) has been collected from nettleleaf giant hyssop (Bouseman and LaBerge 1978).

Nutritional Value

Nettleleaf giant hyssop flowers on plants growing in a meadow in the Gunnison National Forest of Colorado averaged 0.38 µL nectar/flower/24 hrs and 48% sugar, or 0.182 mg sugar/flower. The average reward/flower for bumble bees was 0.03 J, and their net energy intake was 0.0075 J/s (Pleasants 1981). Nettleleaf giant hyssop seeds average about 30% oil and 20% protein (RBG Kew 2019).

Ethnobotany

Western Indian tribes used nettleleaf giant hyssop as a food (Chamberlin 1911; Craighead et al. 1963) and a medicine (Train et al. 1941; Turner et al. 1980). Gosiute Indians of Utah gathered nettleleaf giant hyssop seeds extensively. They were dried and ground into a meal and cooked as porridge, mush, or cakes (Chamberlin 1911). The Okanagan-Collville Indians of Washington and British Columbia drank an infusion of the leaves to treat colds and put the strong-smelling leaves in the blankets of babies to break fevers (Turner et al. 1980). In the Great Basin region, the Paiute took a cold water infusion of leaves to ease indigestion and stomach pains and a boiled infusion for colds. They mashed leaves into a poultice to treat swellings. The Shoshone used nettleleaf giant hyssop as a laxative or purging agent (Train et al. 1941).

Current Medicinal Use

Although a nonnative species in India, nettleleaf giant hyssop is used there to treat diarrhea and respiratory problems. Traditional indigenous healers in the Bandarban District of Bangladesh make a tea from the leaves to treat diarrhea. The tea is taken three times a day for 10 days (Faruque et al. 2018). In northern India, nettleleaf giant hyssop is known as zufa khushk. It is imported from Iran and Afghanistan and used to treat chronic obstructive respiratory diseases (COPD) (Zaidi et al. 2010).

Horticulture

There are nettleleaf giant hyssop cultivars available for native landscaping. Because nettleleaf giant hyssop grows in poor soils, has moderate water needs, and attracts bees, butterflies, and humming birds (Mee et al. 2003), it is desirable for landscaping. Although recommended for water-wise native landscaping, nettleleaf giant hyssop is only moderately drought tolerant. Plants require well-drained soils but tolerate rocky, low organic matter soils and soils lacking organic matter (Hickman 1993; Mee et al. 2003). Nettleleaf giant hyssop may also be useful to bee keepers. In 1 of 2 years of observations, a surplus 100 lbs (45 kg) of honey was harvested from honeybee colonies in Eldorado County, California. The surplus was attributed to heavy nectar secretion by nettleleaf giant hyssop. The honey was considered fine quality with a somewhat minty flavor, and showed no tendency to granulate for several months after extraction (Vansell 1933).

In a greenhouse experiment, growth differences for 'Honeybee Blue' nettleleaf giant hyssop bedding plants, were not significantly different when watered at medium moisture content (every 2-3 d) or at 18% of medium moisture content (every 3-5 d) (Niu et al. 2006).

Revegetation Use

Nettleleaf giant hyssop tolerates early to late-seral conditions (Ellison 1960; Bunting et al. 1999). It is highly valuable for livestock, wildlife, and pollinators (USDA FS 1937; Adamson et al. 2018), and is an attractive long-lived plant (Eldredge et al. 2013). These traits and values make it desirable for use in restoration of degraded rangeland sites, decommissioned roads, slash pile burn scars, logging skid trails, and other disturbances.

Developing A Seed Supply

For restoration to be successful, the right seed needs to be planted in the right place at the right time. Coordinated planning and cooperation is required among all partners to select appropriate species and seed sources; these are determined by current or projected revegetation requirements and goals (PCA 2015).

Developing a seed supply begins with seed collection from native stands. Collection sites are determined by current or projected revegetation requirements and goals as well as through consultation with land managers and

stakeholders. Collected seed is distributed for restoration or first increased in seed fields to provide a larger supply of seed (PCA 2015). Production of nursery stock requires less seed than large-scale seeding operations. Regardless of the size and complexity of any revegetation effort, seed certification is essential for tracking seed origin from collection through use (UCIA 2015).

Seed Sourcing

Because empirical seed zones are not currently available for nettleleaf giant hyssop, generalized provisional seed zones developed by Bower et al. (2014), may be used to select and deploy seed sources. These provisional seed zones identify areas of climatic similarity with comparable winter minimum temperature and aridity (annual heat:moisture index). In Figure 7, Omernik Level III Ecoregions (Omernik 1987) overlay the provisional seeds zones to identify climatically similar but ecologically different areas. For site-specific disturbance regimes and restoration objectives, seed collection locations within a seed zone and ecoregion may be further limited by elevation, soil type, or other factors.

The Western Wildland Environmental Threat Assessment Center's (USFS WWETAC 2017) Threat and Resource Mapping (TRM) Seed Zone application provides links to interactive mapping features useful for seed collection and deployment planning. The Seedlot Selection Tool (Howe et al. 2017) can also guide restoration planning, seed collection, and seed deployment, particularly when addressing climate change considerations.

On the Malheur National Forest, nettleleaf giant hyssop is seeded on a wide variety of habitats. Seed is collected from numerous wild populations at various elevations over several different watersheds. When seed is needed to restore a large area, seed is collected from as many populations as possible within the closest areas sharing similar environmental conditions to ensure genetically diverse, locally adapted seed (J. Rausch, USDA FS, personal communication, January 2020).

Occurrence Map

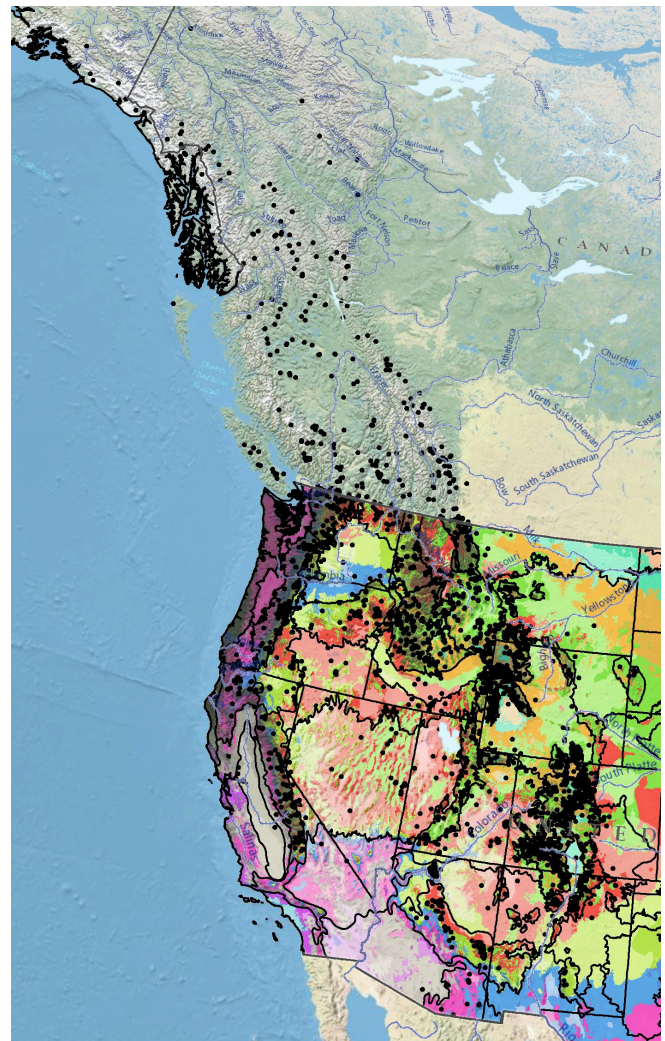


Figure 7. Distribution of nettleleaf giant hyssop (black circles) based on geo-referenced herbarium specimens and observational data from 1871-2016 (CPNWH 2017; SEINet 2017; USDI USGS 2017). Generalized provisional seed zones (colored regions) (Bower et al. 2014) are overlain by Omernik Level III Ecoregions (black outlines) (Omernik 1987; USDI EPA 2018). Interactive maps, legends, and a mobile app are available (USFS WWETAC 2017; research.fs.usda.gov/pnw/products/dataandtools/seed-zone-webmap). Map prepared by M. Fisk, USDI USGS.

Releases

Although seed is available through a limited number of commercial collectors and growers, as of 2019, there were no germplasm releases of nettleleaf giant hyssop for wildland restoration. There are horticultural cultivars including 'Honeybee Blue' (Niu et al. 2006).

Wildland Seed Collection

Seed can be collected by shaking or stripping it from the inflorescences or by clipping the inflorescences (Fig. 9) (Plummer et al. 1968). If using historical herbaria records to find collection sites, note that one study found nettleleaf giant hyssop populations shifted up in elevation over time (Zorio et al. 2016). This study is summarized in the Distribution section.



Figure 8. Dry, nettleleaf giant hyssop inflorescences on a plant growing on Black Mountain in the Caribou-Targhee National Forest. Photo: R. Lehman, USFS.

Wildland Seed Certification

Verification of species and tracking of geographic source is necessary whether wildland seed is collected for immediate project use or as stock seed for cultivated increase. This official Source Identification process can be accomplished by following procedures established by the Association of Official Seed Certifying Agencies (AOSCA) Pre-Variety Germplasm Program (UCIA 2015; Young et al. 2020). Wildland seed collectors should become acquainted with state certification agency procedures, regulations, and deadlines in the states where they collect.

If wildland-collected seed is to be sold for direct use in ecological restoration projects, collectors must apply for Source-Identified certification prior to making collections. Pre-collection applications, site inspections, and species and seed amount verification are handled by the AOSCA member state agency where seed collections will be made (see listings at AOSCA.org).

If wildland seed collected by a grower or private collector is to be used as stock seed for planting cultivated seed fields or for nursery propagation (See Agricultural Seed Certification section), detailed information regarding the collection site and collecting procedures must be provided when applying for certification. Photos and herbarium specimens may be required. Germplasm accessions acquired within established protocols of recognized public agencies, however, are normally eligible to enter the certification process as stock seed without routine certification agency site inspections. For contract grow-outs, however, this collection site information must be provided to the grower to enable certification.

Collection Timing

Wildland seed is generally ready for harvest in the summer months when the inflorescence is dry and seed is hard (Fig. 8) (Skinner 2005; USDI BLM SOS 2017). The Bureau of Land Management's Seeds of Success collection crews recorded the timing and location of 43 nettleleaf giant hyssop collections made over 12 years between 2000 and 2016 (SOS BLM 2017). Four of the 43 harvests were made in July, 26 in August, 12 in September, and 1 in October. The earliest collection date was July 14, 2014, from 6,526 ft (1,989 m) in Lake County, Oregon. The latest collection date was October 4, 2011, from 8,186 ft (2,495 m) in Cache County, Utah. In the single year (2010) with greatest number of collections (17), the earliest harvest date was August 1 from 7,680 ft (2,341 m) in White Pine County, Nevada, and the latest was September 22 from 5,874 ft (1,790 m) in Sierra County, California (USDI BLM SOS 2017).

Collection Methods

Wildland seed can be collected by hand-stripping the seed from the seedheads, or shaking or beating the seedheads into a container (Fig. 10) (Plummer et al. 1968; Skinner 2005; Riley and Fisher 2018).



Figure 9. Harvested nettleleaf giant hyssop seedheads. Photo: K. Herriman, USFS Seed Extractory, Bend, OR.

Several collection guidelines and methods should be followed to maximize the genetic diversity of wildland collections: 1) collect seed from a minimum of 50 randomly selected plants; 2) collect from widely separated individuals throughout a population without favoring the most robust or avoiding small stature plants; and 3) collect from all microsites including habitat edges (Basey et al. 2015). General collecting recommendations and guidelines are provided in online manuals (e.g., ENSCONET 2009; USDI BLM SOS 2021).

It is critical that wildland seed collection does not impact the sustainability of native plant populations. Collectors should take no more than 20% of the viable seed available at the time of harvest (USDI BLM SOS 2021). Additionally, care must be taken to avoid the inadvertent collection of weedy species, particularly those that produce seeds similar in shape and size to those of nettleleaf giant hyssop.

Post-Collection Management

Seed should be moved to a controlled short-term storage environment as soon as possible and until that time should be kept in a dry, shaded place. Short-term storage should be a dry, cool place inaccessible to rodents or other seed predators. If insects are suspected in any collection, seed should be frozen for 48 hours or treated with an appropriate insecticide. The more plant material in the collection, the more ventilation and drying a seed lot may need (Gold n.d.; Hay and Probert 2011).



Figure 10. Seeds, bracts, and other plant material that will need to be separated in the cleaning process from a harvest of nettleleaf giant hyssop seedheads. Photo: K. Herriman, USFS Seed Extractory Bend, OR.

Seed Cleaning

Small seed lots of nettleleaf giant hyssop can be cleaned first by hand or machine screening to separate seeds from plant material, then further cleaned using an air-screening method (Skinner 2005). Small collections were cleaned at the USDA, Natural Resources Conservation Service's Pullman, Plant Materials Center (PMC), by hand screening, then processing through an air column separator (Skinner 2005). Riley and Fisher (2018) cleaned seed by hand rubbing it over a screen and then using an air-screen cleaner with a 1.4 mm top screen, solid bottom screen, and light air (Riley and Fisher 2018). At the Aberdeen, Idaho, PMC, seed was separated from collected plant material using a hammermill or brush machine and then cleaned using an air-screen cleaner with 1.4 mm top screen, solid bottom screen, and light air (Tilley 2016).

The USFS Bend Seed Extractory cleaned a 2.5-lb (1.1-kg) collection of nettleleaf giant hyssop seed (Fig. 11) from Boise County, Idaho, by: 1) processing seed through a Westrup Model LA-H laboratory brush machine (Hoffman Manufacturing, Slagelse, Denmark). The brush machine was fitted with a #14 mantel with pins and run at medium speed; 2) seeds were then air-screened using an office Clipper with 1/16 round top screen, 30 x 30-wire bottom screen, medium speed, and medium air. This cleaning process yielded seed that was 98% pure and 91% viable (tetrazolium [TZ] determined) (Barner 2009).



Figure 11. Individual nettleleaf giant hyssop seeds (1.5–2 mm long, scale in mm). Photo: K. Herriman, USFS Seed Extractory Bend, OR.

Seed Storage

Nettleleaf giant hyssop seed is orthodox (RBG Kew 2019). Seed should be stored cold to cool (-4 to 50 °F [-20–10 °C]) at low humidity (15-30%) (Barner 2009; Tilley 2016; RBG Kew 2019). Viability losses should be low for up to 5 years if seed is stored properly (Plummer et al. 1968).

Nettleleaf giant hyssop seed that was dried, cleaned, and stored in glass jars in a cool, even-temperature store room for 12 years failed to germinate in tests conducted by the Rancho Santa Ana Botanical Garden. No other study details were reported (Everett 1957).

Seed Testing

Viability seed testing procedures and guidance using TZ are provided by the Association of Official Seed Analysts for the *Agastache* genus. Imbibed seed is soaked overnight in a 1% TZ solution at 86 to 95 °F (30–35 °C) and abnormal or non-staining indicates non-viable seed (AOSA 2010).

Germination Biology

Experiments evaluating germination of nettleleaf giant hyssop showed that seed needs no pretreatment and germinates best in light at warm but not hot temperatures. BFI Native Seed in Moses Lake, Washington, considers nettleleaf giant hyssop one of the easiest forbs to germinate in the greenhouse (K. Prickett, BFI Native Seeds, personal communication, Jan 2020). Seeds require pretreatment or afterripening, and germination is rapid and uniform. Emergence generally occurs within 1 to 2 weeks of seeding directly into growth media-filled containers (K. Prickett, BFI Native Seeds, personal communication, Jan 2020). Unpublished data from testing done by the Pullman PMC, showed 75% germination of untreated seed placed on the soil surface in a greenhouse. Another seed lot showed 84% germination when seeded outdoors in November (Skinner 2005).

Laboratory experiments conducted by the Royal Botanic Gardens, Kew (2019), showed better germination (98-100%) with an 8/16 hr light/dark cycle than with a 12/12 hr cycle

(80-95%). Germination with 8/16 hr lighting was 100% after 35 to 42 days at 68 °F (20 °C) and 98% at 77 °F (25 °C) (RBG Kew 2019).

For nettleleaf giant hyssop seed collected from mature aspen stands in Colorado's Routt National Forest, germination was much better in light (32-76%) than dark incubation conditions (4-24%), and seed that was cold stratified for 30 to 60 days had significantly lower germination ($P < 0.05$) than non-stratified seed (Hoffman 1985).

Germination trials conducted at the Corvallis PMC showed the highest germination (90%) for seeds in warm environments (75 °F [24 °C]). Seeds kept at 64 °F (18 °C) germinated at a lower percentage (78%). Germination was reduced for seed that was cool-moist stratified (38 °F [3 °C])

before being placed in the warm environment. After 45 days of stratification, germination was 69% and after 90 days, was 36% (Bartow 2015).

McDonough (1969a) found that germination was increased by imbibing seeds in gibberellic acid (GA3) compared to water imbibition (Table 1). For water-imbibed seeds germination was better at the warm temperatures evaluated (63 °F [17 °C] day/52 °F [11 °C] night) than the very warm temperatures evaluated (90 °F [32 °C] day/72 °F [22 °C] night). Seed used came from subalpine rangelands in Utah and Montana. It was stored for 3 months at room temperature before being cleaned and stored again in vapor-tight bottles at 36 °F (2 °C) until germination testing. Seeds were then incubated for 28 days under controlled alternating day and night temperatures and conditions (Table 1; McDonough 1969a).

Table 1. Germination (% and time) for nettleleaf giant hyssop seed that imbibed water or gibberellic acid (GA3) under very warm to warm day and night time temperatures (McDonough 1969a).

Temperature (day/night in °F)	90/72	72/63	63/52	72/63
Imbibition solution	water	water	water	GA3
Final germination (%)	12	48	68	93
Days to 50% final germination	---	5	7	4

Wildland Seed Yield And Quality

Post-cleaning seed yield and quality of seed lots collected in the Intermountain region are provided in Table 2 (USFS BSE 2017). The results indicate that nettleleaf giant hyssop seed can generally be cleaned to high levels of purity, but the fill and viability of fresh seed is variable. Average seed weights reported elsewhere in the literature (604,686–907,029 seeds/lb [1,333,082–1,999,623/kg] Plummer et al. 1968; RBG Kew 2019) fall within the ranges reported in Table 2.

Table 2. Seed yield and quality of nettleleaf giant hyssop seed lots collected in the Intermountain region, cleaned by the Bend Seed Extractory, and tested by the Oregon State Seed Laboratory or the USFS National Seed Laboratory (USFS BSE 2017).

Seed lot characteristic	Mean	Range	Samples (no.)
Bulk weight (lbs)	3.4	0.1–45	49
Clean weight (lbs)	1.0	0.02–17	49
Clean-out ratio	0.2	0.03–0.6	49
Purity (%)	97	88–99	49
Fill (%) ¹	91	54–99	49
Viability (%) ²	91	60–98	38
Seeds/lb	748,718	182,347–1,054,883	49
Pure live seeds/lb	656,408	107,220–863,316	38

¹ 100 seed X-ray test

² Tetrazolium chloride test

Marketing Standards

Acceptable seed purity, viability, and germination specifications vary with revegetation plans (Fig. 12). Purity needs are highest for precision seeding equipment used in nurseries, while some rangeland seeding equipment can handle less clean seed. Plummer et al. (1968) report an acceptable purity of 75% for nettleleaf giant hyssop seed.

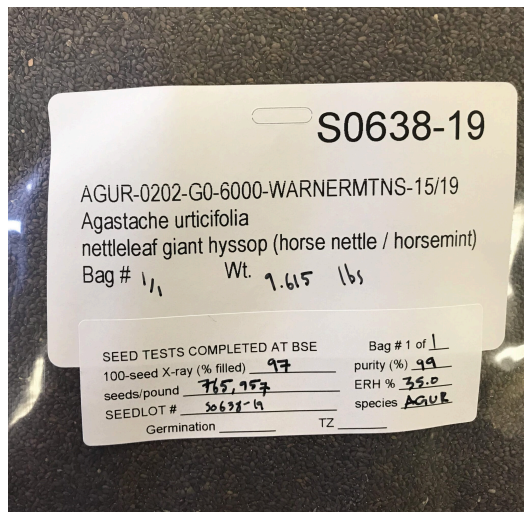


Figure 12. Clean, collection location-identified, but not certified, and packaged nettleleaf giant hyssop seed ready for use. Photo: K. Herriman, USFS Seed Extractory Bend, OR.

Agricultural Seed Production

Growers used container stock to establish seed production stands of nettleleaf giant hyssop in Moses Lake, Washington (K. Prickett, BFI Native Seeds, personal communication, Jan 2020). Greenhouse grown seedlings were also used to establish common gardens in northern Utah (Kratsch et al. 2010), and the Aberdeen PMC grew nettleleaf giant hyssop seedlings for eventual outplanting at Yosemite National Park, California (Tilley and Pickett 2019).

Agricultural Seed Certification

In order to minimize genetic changes in specific accessions of native species when increased in cultivated fields, it is essential to track the geographic source and prevent inadvertent hybridization or selection pressure. This is accomplished by following third party seed certification protocols for Pre-Variety Germplasm (PVG) as established by the Association of Official Seed Certification Agencies (AOSCA). AOSCA members in the U.S., Canada, and other countries administer PVG requirements and standards that track the source and generation of planting stock. Field and cleaning facility inspections then monitor stand establishment, proper isolation distances, control of prohibited weeds, seed harvesting, cleaning, sampling, testing, and labeling for commercial sales (UCIA 2015; Young et al. 2020).

Seed growers apply for certification of their production fields prior to planting and plant only certified stock seed of an allowed generation (usually less than four). The

systematic and sequential tracking through the certification process requires preplanning, knowing state regulations and deadlines, and is most smoothly navigated by working closely with state certification agency personnel. See the Wildland Seed Certification section for more information on stock seed sourcing.

Site Preparation

Seeding will be most successful in firm, weed-free beds. Seeds are attractive to rodents, so newly seeded plots may need protection (Okello 1993).

Seed Pretreatments

Nettleleaf giant hyssop seed does not require pretreatments to germinate. At BFI Native Seeds, nettleleaf giant hyssop seeds are dusted with a fungicide to prevent damping off and root rot prior to seeding in cone-tainers in the greenhouse (K. Prickett, BFI Native Seeds, personal communication, Jan 2020). Unpublished data from testing conducted at the Pullman PMC revealed 84% germination for untreated seed planted outdoors in November (Skinner 2005).

Seeding

The full stand seeding rate for an estimated 50 nettleleaf giant hyssop seeds/ft² is approximately 1-2 lbs/ac (1.1-2.2 kg/ha). Seed should be planted at or just below the soil surface (≤ 0.13 in [0.3 cm]). The Aberdeen PMC recommended broadcasting seeding followed by light harrowing (Tilley and Pickett 2019).

The procedure for establishing seed production stands at BFI Native Seeds is to outplant greenhouse grown seedlings into a 0.1 to 0.25 ac (0.04-0.1 ha) field (K. Prickett, BFI Native Seeds, personal communication, Jan 2020). Seedlings are grown in 4-in³ cone-tainers. Seed is planted 0.125 to 0.25 in (0.3-0.6 cm) depths in a mix of perlite, coconut core, compost, and a slow-release fertilizer, and seedlings emerge within 1 to 2 weeks. This method is used because the initial quantity of wildland seed received is small, and field establishment from seedlings allows for a more uniformly spaced and full stand (K. Prickett, BFI Native Seeds, personal communication, Jan 2020).

Establishment And Growth

In a common garden study conducted at North Logan (4,692 ft [1,430 m]) and Kayesville (4,357 ft [1,328 m]) in northern Utah, first year survival of all nettleleaf giant hyssop accessions exceeded 90%, but second year survival ranged from 0 to 56% (Kratsch et al. 2010). The seedlings were greenhouse grown from seed collections made at elevations ranging from 5,253 to 8,000 feet (1,601–2,438 m) and outplanted in fall 2007. Transplants were irrigated as needed only in the first growing season. Survival was greatest for plants from the two highest elevation collection sites (7,119 ft [2,170 m] and 8,000 ft [2,438 m]). Plants from seed collected at the lowest elevation sites (5,253 ft [1,601 m] and 5,617 ft [1,712 m]) did not survive the summer of 2009 at either common garden location. Plants that survived to summer 2009 ranged from 21 to 28.5 inches (53.2–72.5 cm) tall and 34.5 to 44 inches (87.7–111 cm) wide. Plant size did not differ significantly ($P > 0.05$) by accession or common garden location (Kratsch et al. 2010).

Pollinator Management

Nettleleaf giant hyssop is insect pollinated and important for native bumblebees. At BFI Native Seeds, all farming practices are in line with protecting native pollinators (K. Prickett, BFI Native Seeds, personal communication, Jan 2020). Ground disturbances are kept at a minimum and pesticides are rarely used. If pesticide application becomes necessary, the most chemically safe pesticide is chosen, and it is selectively applied at a time when pollinators are least susceptible. The farm also grows a variety of forb species, which provide season-long blooming for pollinators (K. Prickett, BFI Native Seeds, personal communication, Jan 2020).

Pest Management

Although the damage that may be expected from infection was not reported for agricultural or nursery settings, the following fungi use nettleleaf giant hyssop as a host: *Comoclathris compressa*, *Crocicreas cyathodeum* var. *cacaliae* (collected from dead stems on plant in UT), *C. nigrofuscum* var. *allantosporum*, *Heteropatella alpina* (collected from stems on plant in OR), *H. umbilicata*, *Leptosphaeria brightonensis*, *L. darkeri*, *L. olivacea*, *Mycosphaerella tassiana*, *Phoma herbarum*, *Pleospora compositarum*, *P. helvetica*, *P. herbarum* var. *occidentalis*, *P. richtophensis*, *Podosphaera macularis*, *Ramularia lophanthi*, and *Sphaerotheca humuli* (powdery mildew) (Wehmeyer 1946a; Wehmeyer 1946b; Farr and Rossman 2017).

Seed Harvesting

Because nettleleaf giant hyssop flowering and seed production are very indeterminate, commercial methods of seed harvesting rarely result in high seed yields (K. Prickett, BFI Native Seeds, personal communication, Jan 2020). While multiple hand harvests can be used to maximize seed yields, these are labor intensive and expensive. Hand harvesting methods include clipping the seedheads or swathing seedheads over a collection hopper. At BFI Native Seeds, seed is harvested by swathing. Plants are cut low, near the ground but high enough so that inflorescences are not damaged. Swathing a good portion of the stalks and seedheads allows for another 1 to 2 days of post-harvest seed ripening to occur (K. Prickett, BFI Native Seeds, personal communication, Jan 2020).

Seed Yields And Stand Life

At BFI Native Seeds, some seed is produced the first growing season after plugs are planted in the fields, but the highest seed production occurs in the second and third post-planting seasons. At 4 years, nettleleaf giant hyssop stands lose vigor and plant growth and seed production decline (K. Prickett, BFI Native Seeds, personal communication, Jan 2020).

In locations where moisture levels exceed that of nettleleaf giant hyssop's native range, plants may grow as annuals (Svoboda et al. 1995). Nettleleaf giant hyssop seeds obtained from Chiltern Seeds, Cumbria, UK, were planted in experimental plots in Auchincruive, Scotland, to evaluate the essential oils of this and other giant hyssop species. Seedlings were grown in a greenhouse starting in late April. In mid-June seedlings were transferred to a cold frame until the end of June, when they were outplanted. Plants were spaced 8 in (20 cm) within and 12 in (30 cm) between rows in sandy loam soils with pH 6 to 6.5. Nettleleaf giant hyssop grew slowly, did not flower until early September, and was treated as an annual because the consistently wet, mild fall conditions caused regrowth to rot. Essential oil content of nettleleaf giant hyssop was low compared with other giant hyssop species evaluated in the study (Svoboda et al. 1995).

Nursery Practice

Several growers provide the methods and procedures they used to produce nettleleaf giant hyssop plants. Seedlings started in the greenhouse in winter or early spring are typically ready for outplanting the following fall or winter (Riley and Fisher 2018). Seedlings grown outdoors in the fall are not ready for transplanting the following spring and should be held for outplanting the following fall or spring (Skinner 2005).

Greenhouse experiments indicated that seedling growth did not differ significantly ($P < 0.05$) under various incandescent fluorescent wattage ratios of 0 to 0.47 (McDonough and Brown 1969). Seedlings averaged 1.1 to 1.3 in (2.9–3.4 cm) tall after 8 weeks in growth chambers where conditions were 14 hours of incandescent light at 68 °F (20 °C) and 10 hours of dark at 59 °F (15 °C). Seedlings grown under natural radiation in the greenhouse were just

0.3 in (0.7 cm) tall at 8 weeks. Temperatures in the greenhouse were similar to those of the growth chambers, but light was limited by short winter days and cloudy conditions (McDonough and Brown 1969).

The Pullman PMC produced plugs by sowing seeds in the greenhouse (Skinner 2005). In January, seeds were sown in 10-in³ Ray Leach cone-tainers filled with Sunshine #4 potting mix and covered lightly. A thin layer of pea gravel was applied to the top of each cone-tainer to prevent seeds from floating when watered deeply. Soil was kept moist until seeds germinated (5-14 days, 2-week establishment phase). Cone-tainers were watered deeply every other day and fed once a week using a soluble, complete fertilizer with micro-nutrients. The active growth period was 8 to 10 weeks. Plants were moved to a cold frame in late March or early April and watered every other day during cool weather and every day during hot, dry spells. Seedlings were considered hardened after 2 to 4 weeks (Skinner 2005).

The Aberdeen PMC produced nettleleaf giant hyssop plants with roots that filled 10-in³ cone-tainers (Tilley 2016). Clean dry seeds required no stratification. Between 5 and 25 seeds were placed in cone-tainers filled with Sunshine mix #4. Seed were pressed into the soil for good seed-soil contact and then lightly covered with pea gravel. For the first 30 days in the greenhouse, daytime temperatures were 75 to 85 °F (24–29 °C) day and nights were close to 70 °F (21 °C). Cone-tainers were irrigated by overhead sprinklers for 20 min/day and fertilized weekly (NPK 15:30:15). The seed lot had very high viability, and most cone-tainers required thinning to two to four seedlings. After 4 weeks, seedlings were considered established. Following 30 days of daily irrigation, watering was changed to 40 to 60 minutes every other day to encourage root growth. Plant were trimmed periodically when they grew large enough to affect water distribution. The active growth period was 4 months. Plants were hardened for 1 week with one 60-minute irrigation then a deep watering just prior to shipping. Plants were in a refrigerated truck (50 °F [10 °C]) for 2 days before reaching their destination (Tilley 2016).

The USFS Dorena Genetic Resource Center in Cottage Grove, Oregon soaked dry, clean seed collected from Lane County, Oregon, for 24 hours in GA3 (1000 mg/l), then rinsed and soaked it in water for another 6 hours (Riley and Fisher 2018). Seed was then sown in 16-in³ containers filled with a peat:composted fir bark:perlite:pumice media (40:20:20:20) mixed with a controlled release fertilizer (NPK 18:6:8) and lightly covered with nursery grit. Germination was fairly uniform and complete in 2 to 3 weeks. Seedlings grew rapidly following germination. For 2 weeks following germination, Seedlings were lightly fertilized (NPK 12:2:4 and 6Ca:3Mg at 100 ppm), which was then increased (17-20N: 5-18P: 18-24K, 100–150 ppm). Seedlings flowered when 3 months old. Seedlings remained in the greenhouse for 18 weeks before being moved outdoors to induce dormancy. Plants generally remained at the nursery from mid-March to early October, and outplanting often occurred in fall or early winter. Containers were well irrigated prior to shipping (Riley and Fisher 2018).

Wildland Seeding And Planting

Nettleleaf giant hyssop tolerates early to late-seral conditions (Ellison 1960; Bunting et al. 1999). It is highly valuable to livestock, wildlife, and pollinators (Fig. 13) (USDA FS 1937; Adamson et al. 2018) and an attractive long-lived plant (Eldredge et al. 2013). These traits and values make it a desirable plant in mountain rangeland restoration.

It has been seeded for restoration in mountain rangelands in Utah. Based on studies of restoration on big game range in Utah, Plummer et al. (1968) rated nettleleaf giant hyssop good for: handling, ease of planting, compatibility with other plants, seed production, herbage yield, grazing tolerance, resistance to disease and insects, and early spring and summer palatability. The species was rated fair for: germination, growth rate, final establishment, persistence, natural spread, soil stability, and ease of transplanting. They rated initial establishment and range of adaptation as poor (Plummer et al. 1968).



Figure 13. Nettleleaf giant hyssop being visited by several pollinators at Bloomington Lake on the Caribou-Targhee National Forest. Photo: R. Lehman, USFS.

The seeding rate for nettleleaf giant hyssop is a percentage of the full stand seeding rate (1–2 lbs/acre [1.1–2.2 kg/ha]) that reflects its desired abundance of the overall seed mix of which would likely be minor (Tilley and Pickett 2019). Seed should be planted at or just below the surface of the soil (< 0.13 in [0.3 cm]). Broadcast seeding followed by light harrowing was preferred by the Aberdeen PMC. Newly seeded areas should be protected from grazing for at least 2 years (Tilley and Pickett 2019).

Nettleleaf giant hyssop stands established and were considered good 4 to 7 years after seeding in Davis County, Utah, but very poor after 25 to 32 years (Hull 1973). Nettleleaf giant hyssop was one of many grass and forb species seeded on a denuded and subsequently flooded site. The site was contoured and seeded in fall 1933 and 1934 using wildland seed collected nearby. Seed was broadcast at 30 lbs/ac (34 kg/ha) and raked in to provide cover. Nettleleaf giant hyssop was seeded in four plots, and in assessments made 4 to 7 years later, nettleleaf giant hyssop stands were rated 6.8, where 10 was a full stand and 0.1 when evaluated 32 to 25 years later (Hull 1973).

After being seeded in weedy openings in the spruce-fir zone of the Monte Cristo Range in northeastern Utah, nettleleaf giant hyssop was still present 18 years later. Nettleleaf giant hyssop was seeded as part of a mix into a plowed, firm, weed-free seed bed. It was drill seeded at an average depth of 0.5 in (1.3 cm) and at a rate determined by seed size. Nettleleaf giant hyssop stands were rated as fair 18 years after seeding, and the species was described as a forb with promise for future seeding in mountain rangelands (Hull 1974).

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