New England Plant Conservation Program

Populus heterophylla L.
Swamp cottonwood

Conservation and Research Plan for New England

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SUMMARY

Populus heterophylla L. (Salicaceae), swamp cottonwood, is a deciduous tree of freshwater wetlands that occurs along the Atlantic coastal plain, in the floodplain of the Mississippi River, and in the central lowlands from Illinois to Ohio. Of the 24 states in which it has been found, it is listed as extirpated in one and endangered or threatened in seven others. In southern New England, where it is at or near the northern limit of its range, small extant populations are known from one locality in Massachusetts, one locality in Rhode Island, and five localities in Connecticut. *Populus heterophylla* is ranked S1/E in Connecticut and S1/C in Rhode Island; the rank of S1/E has been recommended for the species in Massachusetts.

Habitat for *Populus heterophylla* in New England varies from river floodplains to swamps to seasonally flooded depressions. It prefers wetlands that are flooded for a few weeks to a few months per year, but saplings and mature trees may tolerate almost constant inundation. Soils range from muck to clay and loam. Three New England populations are located in small perched wetlands on trap rock ridges.

Populus heterophylla is dioecious. Seedling establishment and germination require exposed but moist substrate and ample sunlight. Vegetative reproduction through root and stump suckering is common and is probably the primary mode of reproduction for most small populations.

Four of the extant New England populations of *Populus heterophylla* occur on public lands held in conservation while three are privately owned, one by a private land trust. All populations are in remote areas where direct, negative human impacts are unlikely. Because of their small size, however, all are vulnerable to local disturbance such as drought, wildfire, or storms.

Most of the New England populations of *Populus heterophylla* show evidence of vegetative reproduction, but the extent of seedling recruitment is unknown. In light of small population size and limited regeneration, efforts should be made to protect, stabilize, and manage all populations to maximize the potential for expansion. Recommended management strategies include: detailed inventorying and mapping of sites that have not yet been thoroughly surveyed; regular monitoring, especially in the two sites adjacent to roadways; and ongoing communication with property owners and managers regarding the status and management of each population. Research on the species biology of *Populus heterophylla* is needed, particularly with respect to the effects of competition on regeneration in small populations. Insofar as three of the seven extant populations in New England have been discovered only within the last four years, continued exploration for additional populations in appropriate habitat throughout the region should be encouraged. Finally, although this species is known to be difficult to propagate, efforts at artificial propagation should be continued.

PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Full plans with complete and sensitive information are made available to conservation organizations, government agencies, and individuals with responsibility for rare plant conservation. This excerpt contains general information on the species biology, ecology, and distribution of rare plant species in New England.

The New England Plant Conservation Program (NEPCoP) of the New England Wild Flower Society is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

In 1996, NEPCoP published "*Flora Conservanda*: New England." which listed the plants in need of conservation in the region. NEPCoP regional plant Conservation Plans recommend actions that should lead to the conservation of *Flora Conservanda* species. These recommendations derive from a voluntary collaboration of planning partners, and their implementation is contingent on the commitment of federal, state, local, and private conservation organizations.

NEPCoP Conservation Plans do not necessarily represent the official position or approval of all state task forces or NEPCoP member organizations; they do, however, represent a consensus of NEPCoP's Regional Advisory Council. NEPCoP Conservation Plans are subject to modification as dictated by new findings, changes in species status, and the accomplishment of conservation actions.

Completion of the NEPCoP Conservation and Research Plans was made possible by generous funding from an anonymous source, and data were provided by state Natural Heritage Programs. NEPCoP gratefully acknowledges the permission and cooperation of many private and public landowners who granted access to their land for plant monitoring and data collection.

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I. BACKGROUND

INTRODUCTION

Populus heterophylla L. (Salicaceae), swamp cottonwood, is a deciduous hardwood tree found on the Atlantic coastal plain from Rhode Island to Florida, in the Mississippi River Valley, and in the central lowlands of Illinois, Indiana, and Ohio, and in southern Michigan (Johnson 1990). It reaches the northern limit of its range in New England, where seven populations are currently known. While its global rank is G5 and it has no special status in most of the states in its range (NatureServe Explorer 2001), *Flora Conservanda* (Brumback and Mehrhoff et al. 1996) places it in Division 2, Regionally Rare Taxa.

The seven New England populations are small both in number of stems and in area; the largest documented includes 68 mature trees in 0.35 ha, the smallest includes only one mature tree. While there is evidence of vegetative reproduction in all stands, evidence of seedling recruitment is limited. This low recruitment may be due to flooding regime, to competition for sunlight from other trees within the wetland or in the adjacent upland, or to absence of both male and female trees within a population.

All New England populations are in remote areas that are relatively safe from direct adverse human impacts. Four populations are on publicly-owned lands being managed for conservation. Of the three populations in private ownership, one has recently been placed under a conservation restriction, one is owned and managed by a private land trust, and one is actively managed by a large corporation. The major threat to the survival of the current populations of *Populus heterophylla* in New England is small population size, which places them at risk of extinction due to natural or anthropogenic influences such as hydrologic alterations, competition from other woody species, native and non-native, and herbivory.

Management recommendations include: land acquisition or easements to further protect existing populations; inventorying and regular monitoring of all existing sites; exclusion of deer, beaver, and other potentially harmful herbivores; research relevant to the species biology of *Populus heterophylla* and the reasons for its decline; searches for new populations in southern New England; and continued efforts at *ex-situ* propagation.

The purpose of this conservation and research plan is to assess the status of *Populus heterophylla* in New England, review actual and potential threats to the current populations, and propose actions to protect and expand existing populations throughout the region.

DESCRIPTION

Populus heterophylla is a deciduous tree with alternate leaves. It can grow up to 30 m tall with a diameter as large as 90 cm, although heights of 8 – 15 m and diameters up to 36 cm are commonly reported for mature trees in New England and New York (Brown 1921, McMaster, unpublished data). Bark is brownish, sometimes tinged with red, with fissures and furrows forming as the tree matures. Young branches are whitish and tomentose, becoming glabrous as they mature. In winter and early spring, somewhat pubescent buds are slightly resinous; they are 1 – 1.5 cm long and tomentose toward the base (Fernald 1950, Gleason and Cronquist 1991).

Populus heterophylla is dioecious, with male flowers and female flowers borne on separate trees. Flowers appear before the leaves in April or early May in northeastern North America (Brown 1921), and are arranged in erect or dangling catkins (Fernald 1950, Gleason and Cronquist 1991).

The male or staminate catkin is an open, erect raceme, borne on a short stalk. It is 5 – 7 cm long and about 15 mm thick, but greatly expands as the flowers mature. Each floret has 12 – 20 stamens in a shallow disk; anthers are apiculate. Flower scales are fringed. The catkin is fragile, falling apart almost as soon as it matures (Britton 1887, Fernald 1950, Gleason and Cronquist 1991).

The female or pistillate catkin is also an open raceme that matures at about the same time as the staminate catkin. Each floret is composed of a symmetrical, deeply lobed cup surrounding a globose ovary 2 – 5 mm in length. A long, slender style branches into a 2- or 3-part stigma. Following fertilization, the ovary expands into an ovoid fruit or capsule. The mature fruit has two or three valves and is 7 – 12 mm long on a pedicel 10 – 15 mm long. Seeds are covered with a tuft of fine, cottony hairs (Britton 1887, Fernald 1950, Gleason and Cronquist 1991).

The leaf is broadly ovate, 8 – 25 cm long and 7 – 18 cm wide, with a rounded or acute tip. It is cottony when it first expands, but soon becomes glabrous. The blade is thick and stiff with prominent pinnate venation. The margin is crenate, with 15 or more fine, incurved teeth on each side. The mature leaf is glabrous both above and below except for a small pubescent patch usually persisting at the base of the mid-vein on one or both surfaces. The leaf base is often cordate, the two lobes sometimes slightly overlapping the top of the petiole. The petiole is round in cross section, occasionally somewhat flattened near the summit, and 4 – 15 cm long (Fernald 1950, Gleason and Cronquist 1991). The leaves of *Populus heterophylla* and all congeners are heterophyllic, i.e., with neoformed or "late leaves" initiated throughout the growing season (Eckenwalder 1996). Table 1 provides a key to northeastern species of *Populus*.

Table 1. Key to the genus *Populus* in northeastern U.S. (adapted from Magee and Ahles 1999).

1. Petioles strongly flattened

    2. Blades coarsely dentate, fewer than 15 teeth per side……..*P. grandidentata*

    2. Blades finely dentate, more than 15 teeth per side

        3. Blades triangular, teeth raised, each terminating in an incurved point

            4. Blades longer than wide, base truncate to subcordate……...*P. deltoides*

            4. Blades wider than long, base truncate to cuneate……..…*P. nigra*

        3. Blades ovate, teeth mostly low and rounded…….....……..*P. tremuloides*

1. Petioles somewhat rounded

    5. Blades lobed and/or coarsely toothed, densely tomentose…….*P. alba*

    5. Blades finely and regularly toothed, not lobed

        6. Blades rounded or obtuse to acute at apex, often with a small patch of pubescence near the base of the main vein……..……...*P. heterophylla*

        6. Blades acute to acuminate at apex, glabrous above

            7. Twigs hairy…….....*P. x jackii*

            8. Twigs glabrous, leaves glabrous beneath……*P. balsamifera*

Of the eight other taxa of *Populus* found in New England, three that might be confused with *Populus heterophylla* include Eastern cottonwood (*Populus deltoides* Marshall), Balm of Gilead (*Populus* x *jackii* Sargent), and balsam-poplar (*P. balsamifera* L.). The leaves of Eastern cottonwood are distinctly triangular, the petioles are strongly flattened, and the bark is deeply grooved at maturity. While the leaf bases of Balm of Gilead and balsam poplar are usually truncate or cuneate, they are sometimes slightly cordate, but never overlapping the summit of the petiole. All three taxa may occur on soils that are saturated seasonally, but none

can tolerate prolonged inundation. See the key to the northeastern species of *Populus* (Table 1). *Populus heterophylla* is unique in several respects that distinguish it from similar taxa:

- The female flower has a long, slender style.
- The distinctly cordate leaf base sometimes overlaps the summit of the petiole.
- A small patch of short hairs often persists near the base of a mature leaf (Gleason and Cronquist 1991, Magee and Ahles 1999).
- Young twigs have a distinctive orange-brown pith (Sargent 1891, Rogers 1920, Wagner et al. 1980, Burns and Honkala 1990).

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Contemporary treatments of the angiosperms place the genus *Populus* within the Salicaceae, the Willow Family. Including about 400 species in three genera worldwide, the family consists entirely of woody plants whose most distinctive morphological feature is the inflorescence, an erect or dangling catkin or ament. Chemically, the family is known for the extract salicin from which the active ingredient in aspirin is derived.

Once considered primitive within the dicotyledons, the Salicaceae is today regarded as a relatively advanced family. Cronquist (1988) and Takhtajan (1997) place it in the order Salicales and the subclass Dilleniidae. Chase et al. (1993) place it in the order Malpighiales of the eudicots based on the chloroplast gene rbcL. Due to the structure of the bud scales and ovules and the fact that the flowers are wind-pollinated, *Populus* is generally considered a primitive genus within the Salicaceae (Judd et al. 1999). The species *Populus heterophylla* is the only North American species in section Leucoides (Fernald 1950, Dickmann and Stuart 1983).

Catesby first described swamp cottonwood in his *Natural History of Carolina, Florida, and the Bahama Islands* (1731). Linnaeus applied to it the binomial *Populus heterophylla*; Du Roi and Koch published the same name subsequently. Three synonyms found in the taxonomic literature are *Populus argentea* Michx. f., *Populus heterophylla* var. *argentea* (Michx. f.) Anderssen in DC., and *Aigeiros heterophylla* (L.) Jackson (Gray Herbarium Index 1968). All contemporary treatments of the genus use the original Linnaean name. While hybrids with *P. deltoides* have been reported by Eckenwalder (1996), there are at present no named hybrids of *P. heterophylla*. The most widely used common name in the scientific literature is swamp cottonwood, but other names, some regional, include black cottonwood, bigleaf cottonwood, cotton gum, cotton tree, downy poplar, river cottonwood, and swamp poplar (United States Forest Service Center for Wood Anatomy Research Web Site 2002).

SPECIES BIOLOGY

Male flowers of *Populus heterophylla* appear from March to May; female flowers mature shortly after male flowers and are wind-pollinated. Leaves begin to emerge in mid-May. Fruits ripen and seeds are produced from April through July (Johnson 1990).

Female trees begin to produce seeds at about ten years. The seeds are small and have little or no endosperm; they are tufted with hairs that aid wind and water transport (Braatne 1999). Seed production is heavy, but seeds remain viable for only one to two weeks. Germination occurs most rapidly on bare, moist, un-shaded mineral soils. Seedlings often occur in groups, probably due to washing up of seeds on swamp margins (Johnson 1990). Because of the brief period of viability, there is no seed bank for species of *Populus* (Strauss et al. 1999).

The life cycle of *Populus heterophylla*, like that of most lowland species of *Populus* in North America, is closely linked to the seasonal dynamics of rivers. Pollination and fertilization occur before foliage appears at the height of the spring flooding season. Seeds are dispersed just as floodwaters decline and the ideal habitat for germination is created. Seeds germinate rapidly, their roots reaching into the saturated zone and extending rapidly as the water table drops (Braatne 1999). *Populus heterophylla* does well in sites that are too wet for *P. deltoides*, but wetlands in which the water table does not recede rapidly in late spring may not provide favorable conditions for germination.

Vegetative reproduction is often observed in natural populations of *Populus heterophylla*, where root suckers and stump suckers are frequent (Wagner et al. 1980, McCormac 1993, Searcy and Ascher 2001). Wagner et al. (1980) observed both sexual and asexual reproduction occurring in two of the larger stands of *P. heterophylla* in Michigan, but two smaller populations, each consisting of a single mature tree and numerous root suckers, were entirely male. Vegetative reproduction may help a population to expand, but distant populations probably can be founded only by seed dispersal. Sex ratio may thus be an important factor in evaluating the reproductive potential of isolated populations.

Growth of *Populus heterophylla* is rapid early in life, slows considerably with maturity, and nearly ceases after 40 or 50 years. The species is intolerant of shade, and growth slows once the canopy is closed. The largest tree measured in New York State was 66.2 cm in diameter (Peters 1973). The largest in Massachusetts is 37.0 cm in diameter and 23.5 m tall (McMaster, unpublished data). The largest on record for the species are 165 – 190 cm in diameter and 35 to 40 m tall (Johnson 1990).

While there are no insects or other pathogens known to affect *Populus heterophylla* specifically, it is probably prone to the same species that damage *P. deltoides*. Insect parasites on *P. deltoides* that are common throughout the temperate zone include: cottonwood leaf beetle (*Chrysomela scripta*); cottonwood twig borer (*Gypsonoma haimbachiana*); poplar borer

(*Saperda calcarata*); cottonwood borer (*Plectrodera scalator*); and Melampsora leaf rust (*Melampsora medusae*) (Johnson 1990). Canker diseases also occurring on *Populus deltoides* throughout the region that may affect *P. heterophylla* include *Septoria*, *Cystospora*, and *Fusarium* (Johnson 1990). Gypsy moth may also be a threat to *P. heterophylla* (Gypsy Moth Home Page 2001).

Although no studies have examined genetic diversity in *Populus heterophylla*, other species in the genus exhibit high levels of genetic diversity, probably due to obligate outcrossing required of dioecious species and lack of natural isolation mechanisms. Hybridization between other species of *Populus* has been widely reported, and hybrid zones have been observed that may serve as bridges for the introgression of genes between species (Martinsen et al. 2001). Dickmann and Stuart (1983) and Braatne (1999) report no known hybrids involving *P. heterophylla*; Eckenwalder (1996) reports rare, localized hybrids between *P. heterophylla* and *P. deltoides* in the southeastern United States.

Extensive programs of selective breeding and clonal propagation of species of *Populus* have been undertaken in Europe (Food and Agriculture Organization 1980) and in the United States (Dickmann and Stuart 1983, Braatne 1999) in an effort to produce commercially viable cultivars and hybrids. Some hybrid poplars have been introduced into riverine systems to improve water retention and alter habitat to restore native fisheries; others have been grown in plantations for wood and pulp production. Many hybrid poplars exhibit symptoms of "hybrid breakdown" such as reduced reproductive fitness, lowered seed viability, and increased vulnerability to insects and pathogens (Dickmann and Stuart 1983, Braatne 1999). The commercial value of *P. heterophylla* is limited due to difficulties in growing saplings from cuttings (Johnson 1990).

HABITAT/ECOLOGY

Habitat of *Populus heterophylla* outside of New England has been variously described as swamp (Carter et al. 1994), bottomland hardwood forest and slough (Allen et al. 1997), floodplain forest (Wells 1928, Robertson et al. 1978, White 1983), river swamp (Clark 1971), lake shore (Wunderlin and Wunderlin 1968), swamp forest (Mohlenbrock 1959), cypress swamp (Hunt 1947), wet woods (Zeiner 1946, Peters 1973), and alluvial swamp (Harper 1917). Braun (1950) lists *P. heterophylla* as a common species of the cypress swamp forests and alluvial valleys of the Western Mesophytic Forest Region and of the hardwood bottomland forests of the Southeastern Evergreen Forest Region.

Habitat of the New England populations of *Populus heterophylla* is also variable. Five populations are located in seasonally flooded depressions or vernal pools. Three Connecticut sites are perched on ridges of basalt commonly referred to as trap rock (Rodgers 1985). The Massachusetts site is situated on alluvium underlain by Granby basaltic tuff, a volcanic rock closely related to the trap rock of the adjacent Holyoke Range (Zen et al. 1983).

One Connecticut population is located in a red maple swamp on wetland deposits underlain by schist (Rodgers 1985). One extant site and two historic sites on the Connecticut River in Connecticut (Mehrhoff 1989) and one current site on the Pawcatuck River in Rhode Island are situated on alluvial deposits underlain by gneiss or schist (Rodgers 1985, Hermes et al. 1994). Water levels up to 60 cm have been reported for several of these sites, although exposed substrate has been observed in six of seven localities at various times of year.

The official rank of *Populus heterophylla* in the *National List of Plant Species That Occur in Wetlands* (United States Fish and Wildlife Service 1996) is OBL ("obligate wetland species;" occurring in wetlands > 99 % of the time) both nationally and regionally, although in the northeast it is ranked OBL* suggesting either limited information or conflicting review. In a previous edition of the same list (United States Fish and Wildlife Service 1988) it was assigned the rank of OBL everywhere, except in the northeast where it was assigned the rank FACW+ ("facultative wetland species more frequently found in wetlands than not").

New England populations of *Populus heterophylla* range in elevation from 3 m to 201 m above mean sea level. Populations most often occur on clay and muck swamp soils (Johnson 1990, McCormac 1993). Clay content ranges from 24 to 65 %; soil pH ranges from 4.6 to 5.9 (Johnson 1990). Soils of New England sites range from muck to fine sandy loam to silt loam (Shearin 1962, Reynolds 1979a, 1979b, Rector 1981, Swenson 1981).

Associated woody taxa reported from within the wetland of one or more of the New England populations include *Acer rubrum* L., *Acer saccharinum* L., *Alnus serrulata* (Aiton) Willd., *Alnus* sp., *Amelanchier* sp., *Betula lenta* L., *Betula populifolia* Marshall, *Carpinus caroliniana* Walter, *Cephalanthus occidentalis* L., *Clethra alnifolia* L., *Cornus amomum* Miller, *Decodon verticillatus* (L.) Elliott, *Fraxinus americana* L., *Fraxinus pennsylvanica* Marshall, *Ilex verticillata* (L.) A. Gray, *Lindera benzoin* (L.) A. Blume, *Nyssa sylvatica* Marshall, *Quercus bicolor* Willd., *Quercus palustris* Muenchh., *Quercus* sp., *Rhododendron viscosum* (L.) Torr., *Salix nigra* Marshall, *Tsuga canadensis* (L.) Carriere, and *Vaccinium corymbosum* L. Woody species most frequently reported in association with *Populus heterophylla* in New England include *Acer rubrum* (83 %), *Fraxinus pennsylvanica* (67%), *Ilex verticillata* (67 %), *Cephalanthus occidentalis* (50 %), *Clethra alnifolia* (50 %), *Nyssa sylvatica* (50 %), and *Quercus bicolor* (50 %) (Searcy and Ascher 2001, McMaster, unpublished data).

THREATS TO TAXON

The major threats to the survival of the current populations of *Populus heterophylla* in New England are small population size, competition from other woody species including non-native invasive species, hydrological alteration, and herbivory. Proximity to a roadway is also a concern in two populations.

Population size exerts a strong influence on genetic diversity in native plant populations. As population size declines, rare alleles are lost and gene flow with other populations decreases, causing declines in genetic variability. Inbreeding has been demonstrated to be an important factor in the decline of many species (Brook et al. 2002), although populations that have been isolated for long periods often enjoy the benefit of purging of recessive alleles and may actually benefit from in-breeding. Small populations are particularly vulnerable to stochastic events such as forest fire, hurricane, and invasions of insects or other pathogens. Effective population size, which takes into account factors affecting fecundity such as sex ratio, age structure, and health of reproductive individuals, has been suggested as a more accurate measure of population viability than the total number of individuals. For dioecious species such as *Populus heterophylla*, the number of females in a population must be considered an important limiting factor in population viability.

Estimating minimum viable population size is a topic that has received considerable attention in the scientific literature. Population biologists once considered an effective population size of 500 randomly mating individuals the minimum necessary to maintain genetic variability and thus ensure the long-term viability of a population (Soulé 1980). More recently Lande (1995) has argued that minimum effective population size should be closer to 5000 individuals. For a dioecious species, the higher limit is probably closer to the ideal. The seven extant populations of *Populus heterophylla* in New England have been estimated at between eight and 68 mature individuals, although many "individuals" may be ramets of a single plant. By any measure, all extant occurrences of *P. heterophylla* in New England are exceedingly small and thus at significant risk.

Population viability analysis (PVA) is a quantitative assessment for endangered species that considers the effects on a population of demographic, ecological, and genetic factors (Reed et al. 2002). The ability to run such an analysis repeatedly under a range of assumptions and for multiple generations makes the method especially powerful. Plant populations in which dormancy, periodic recruitment, and clonal growth are important factors present particular challenges for PVA (Menges 2000), but its usefulness has been demonstrated for a few rare tropical tree species (Alvarez-Buylla et al. 1996) where persistence of small, isolated populations is favored by high levels of genetic diversity, especially diversity within populations, predominance of out-crossing, and ample gene flow between populations. Before PVA can be applied to the New England populations of *Populus heterophylla*, much additional empirical information will be needed (see Species Biology Research). Modeling of stochastic events such as hydrologic disturbance, invasion of pathogens, severe windstorms, etc., may be the greatest challenge, since such disturbances may have both harmful and beneficial effects for this taxon. Menges (2000) suggests that a minimum of five years of data be utilized for PVA of plant populations.

Competition for sunlight by other woody species, both within a wetland and in the surrounding upland, may also be a significant threat to the extant populations of *Populus heterophylla* in New England. Seedling recruitment of woody plants within wetlands is

normally limited to species tolerant of fluctuating water tables. When the water table is low for an extended period, however, a wider variety of woody species can invade and eventually shade out sun-loving species. In the past, competition from trees in uplands surrounding wetlands was controlled by land clearing for agriculture. With the decline of agriculture and subsequent reforestation of southern New England in the 20th century, many upland species have achieved dominance and in some instances have shaded out species growing in adjacent wetlands.

Four of the extant New England populations of *Populus heterophylla,* MA .001 (South Hadley), CT .001 (Southbury), CT .002 (Guilford), and CT .013 (Guilford), appear to be suffering from insufficient sunlight. Most of the young plants observed are probably root suckers; in CT .013 (Guilford) no shrub-sized plants or small trees are present. Competition from other tree species both within the wetland and on the wetland/upland margin may suppress seed germination and/or growth at these sites. The most important wetland competitors observed are deciduous trees such as *Acer rubrum, Acer saccharinum, Fraxinus pennsylvanica,* and *Quercus bicolor,* and shrubs such as *Cephalanthus occidentalis, Clethra alnifolia,* and *Ilex verticillata.* Species growing in the surrounding uplands that may also be a threat include *Acer saccharum* Marshall, *Betula lenta, Fagus grandifolia* Ehrh., *Pinus strobus* L., *Quercus palustris, Q. rubra* L., and *Tsuga canadensis*. Although non-native plant species have been observed in only one of the seven New England populations of *Populus heterophylla,* the rapid expansion of invasive species elsewhere in the region argues for particular vigilance in monitoring of these small populations. Thinning efforts should be undertaken only as part of an experimental protocol. Too much sunlight could dry out the moist substrate and increase shading from upland competitors, particularly from non-native species.

Because germination and early growth of *Populus heterophylla* seedlings require exposed but moist substrate, any naturally-occurring or anthropogenic changes in hydrology may limit regeneration or growth of young trees. Water tables lowered by drought or intentional draining of wetlands will likely reduce seed germination. Similarly, extended inundation resulting from heavy rain or spring runoff, beaver activity, obstruction of road culverts, or intentional impoundment of a stream will immerse potential seedbeds and kill newly germinated seedlings. Because of the brief period of seed viability for this species, even temporary hydrological alterations may be harmful. The very small size of the wetlands in CT .001 (Southbury) and CT .013 (Guilford) make them particularly vulnerable to hydrological variation and thus deserving of especially close monitoring.

Concern about the threat of deer browsing has been mentioned in only one of the extant populations of *Populus heterophylla,* CT .012 (Berlin), but high density of white-tailed deer (*Odocoileus virginianus*) throughout the region could be a potential threat to other populations as well. Any increase in activity of beavers (*Castor canadensis*) and porcupines (*Erethizon dorsatum*) in the areas of these small populations should also be noted.

Proximity to a roadway presents a number of potential risks to two of the extant populations, MA .001 (South Hadley) and CT .006 (Haddam). Excavation or filling during road-widening or relocation could result in destruction of trees or alteration of site hydrology. Even minor changes in the frequency, extent, and duration of flooding could be detrimental to the population. Herbicides applied to control weeds along a roadway could affect the population, as could runoff of road salt or petroleum products.

DISTRIBUTION AND STATUS

General Status

Populus heterophylla occurs along the coastal plain from southern New England to Georgia and the Florida Panhandle, in the Mississippi River basin from Louisiana to southeastern Missouri, in the central lowlands from Illinois to Ohio, and in southern Michigan (Johnson 1990). Radford et al. (1968) list it for nearly all counties in the coastal plain of the Carolinas. The only states east of the Mississippi in which it has *not* been recorded are Wisconsin, West Virginia, Maine, New Hampshire, and Vermont. The only states west of the Mississippi in which it *has* been recorded are Arkansas and Missouri.

The northern limit of *Populus heterophylla* is approximately the 42nd parallel. The Massachusetts population is the northernmost, although that site is barely 2 km further north than the populations in Washtenaw County, Michigan described in Wagner et al. (1980) and Pearsall (1990). An historic record for Essex County, New York, approximately 600 km north northwest of the current Massachusetts population, is of doubtful veracity (Troy Weldy, New York Natural Heritage Program, personal communication).

Populus heterophylla has been recorded from 24 states (Table 2). Of the six states in which it is listed as either S1 or S2, five are at or near the northern limit of the range of the species. Its status appears to be secure in 16 states, although detailed data on number of occurrences is not available for many. Its Global Rank is G5 (NatureServe Explorer 2001); it is ranked in Division 2, Regionally Rare Taxa "with fewer than 20 current occurrences (seen since 1970) within New England" in *Flora Conservanda* (Brumback and Mehrhoff et al. 1996.). A list of voucher specimens for *Populus heterophylla* in New England is provided in Appendix 2. All the information provided was obtained from the records of the Connecticut Department of Environmental Protection, except the records from the Gray Herbarium and the herbarium of the New England Botanical Club that were provided by Ray Angelo (personal communication) and the records from the University of Massachusetts – Amherst Herbarium, which were examined by the author.

Of the seven current New England populations of *Populus heterophylla*, three have been discovered only within the last four years. As these all include mature trees, it is clear that

field biologists overlooked them for years, possibly decades. Further explorations for additional populations in southern (and perhaps central) New England might prove fruitful.

A question that may have implications for conservation of this taxon is whether current populations of *Populus heterophylla* in New England are relicts of a wider past distribution or represent recent range extensions. If these small northerly outliers are the only survivors of larger or more numerous populations from a warmer period of the early Holocene, then the continued decline of the taxon in the region might be expected. On the other hand, if they represent a relatively recent range extension, due perhaps to recent climate moderation, that knowledge might give added impetus to efforts to locate new populations around the region. In that regard, a review of palynological studies from the region for evidence of past abundances of *Populus* pollen might be informative, although discriminating among fossil pollens of various species of *Populus* is probably not possible.

Table 2. Occurrence and status of *Populus heterophylla* in the United States based on information from Natural Heritage Programs.*

OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Alabama (S2); 2 extant occurrences (A. Schotz, Alabama Natural Heritage Program, pers. comm.)	Delaware S5 (in 3 counties*)	Arkansas SR (in 19 counties*)	Pennsylvania SX
Connecticut (S1/E); 5 extant and 7-10 historic occurrences (Nancy Murray, Connecticut Dept. of Environmental Protection, pers. comm.)	Georgia S4 (in 2 counties*)	Florida SR (in 5 counties*)	
Massachusetts (S1/E); 1 extant occurrence (Paul Somers, Mass. Natural Heritage Program, pers. comm.)	Illinois S3? (in 21 counties*)	Indiana SR (in 38 counties*)	
Michigan (S1/E); 5 extant occurrences (R. Boehm, Michigan National Features Inventory, pers. comm.)	Kentucky S? (in 16 counties*)	Louisiana SR (in 6 counties*)	
New Jersey (S2); 5 extant and 10 historic occurrences (David Snyder, N. .J. Natural Heritage Program, pers. comm.)	Maryland S? (in 8 counties*)	Missouri SR (in 11 counties*)	
New York (S2/T); 11 extant and10 historic occurrences (Steve Young, N.Y. Natural Heritage Program, pers. comm.)	Mississippi S4S5 (in 4 counties*)	South Carolina SR (in 16 counties*)	
Rhode Island (S1/C); 1 extant occurrence	North Carolina S4 (in 26 counties*)	Tennessee SR (in 11 counties*)	
	Ohio S3 (24 occurrences in 12 counties, McCormac 1993)	Virginia SR (in 25 counties*)	

* County data were derived from range maps of the United States Department of Agriculture Plants Database (USDA Plants Database Web Site).

Figure 1. North American occurrences of *Populus heterophylla.* States shaded in gray have one to five (or an unspecified number of) occurrences of the taxon, while states shaded in black have more than five occurrences. The state with diagonal hatching (Pennsylvania) is ranked "SX," presumed extirpated, where the taxon no longer occurs. See Appendix for explanation of state ranks.

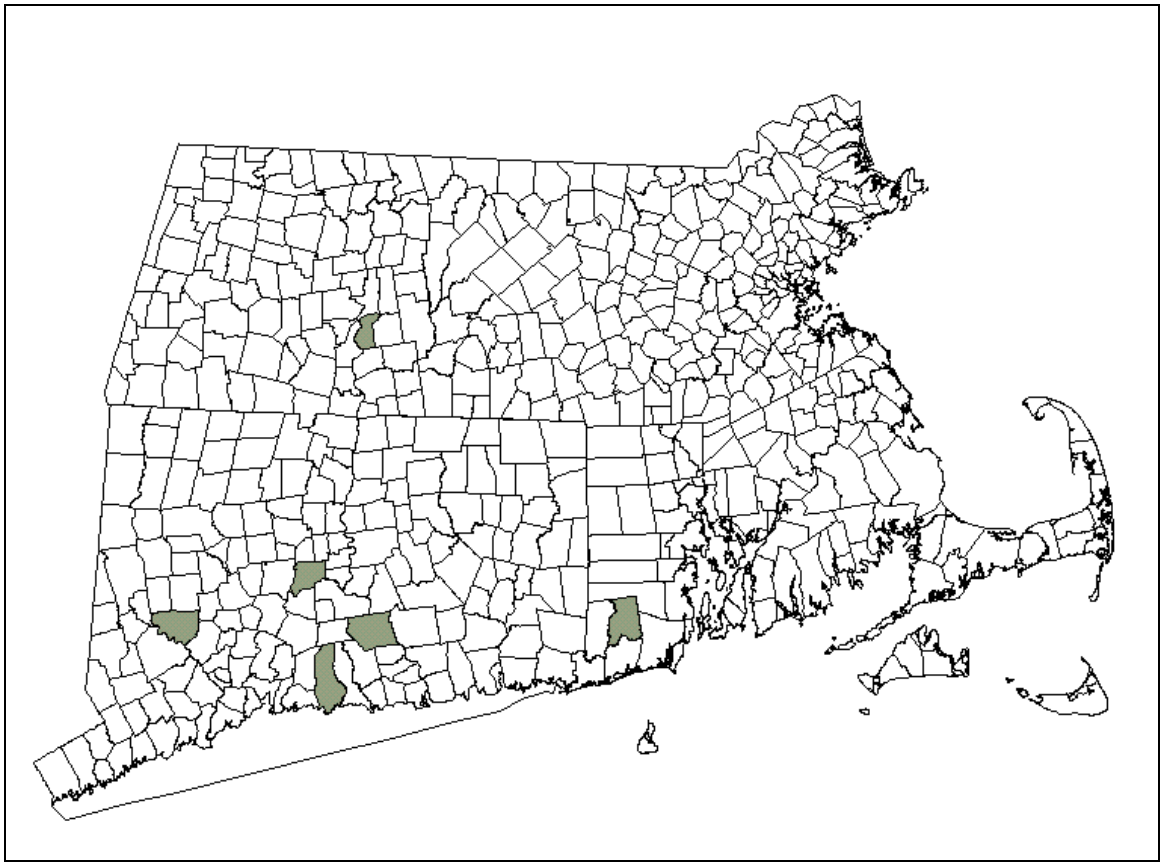

Figure 2. Extant New England occurrences of *Populus heterophylla.* Town boundaries for Connecticut, Rhode Island, and Massachusetts are shown. Towns shaded in gray have one to five confirmed, extant occurrences of the taxon.

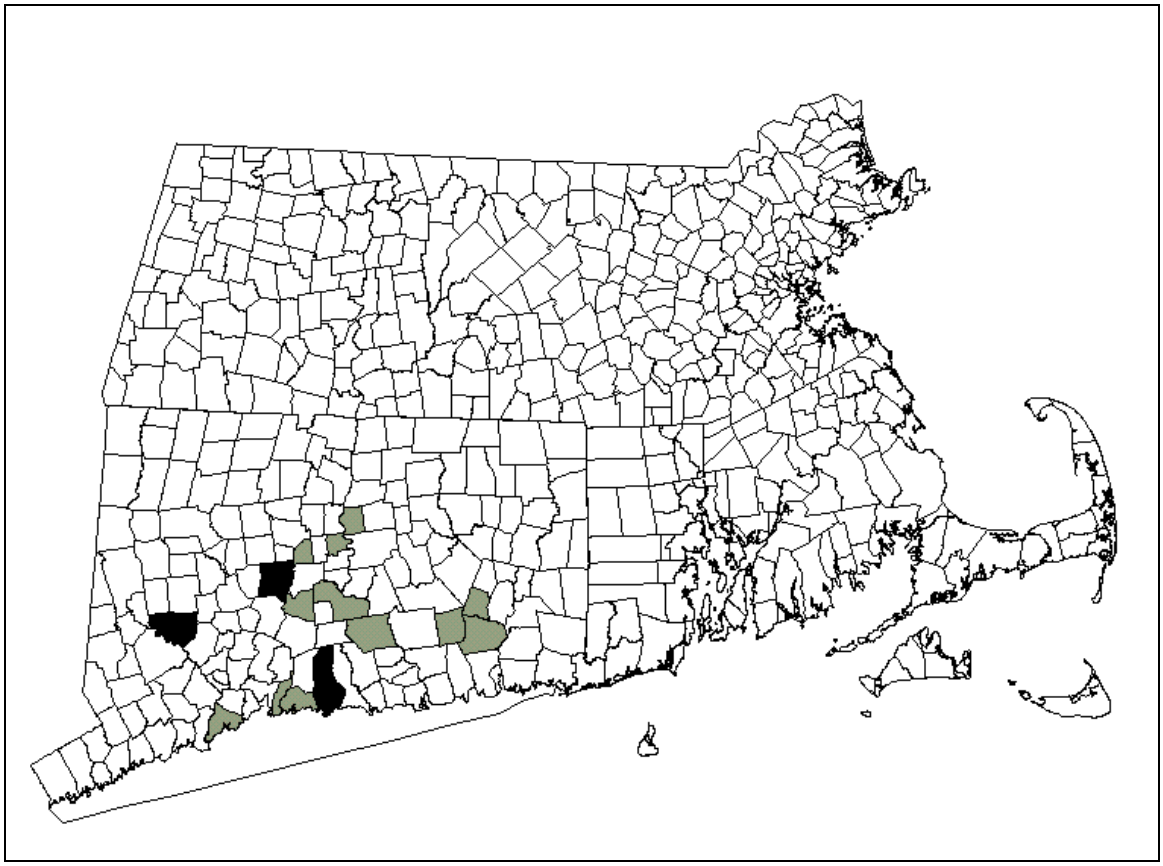

Figure 3. Historical New England occurrences of *Populus heterophylla.* Towns shaded in gray have one to five historical records of the taxon; towns shaded in black have more than five historical records.

Table 3. New England Occurrence Records for *Populus heterophylla*. Shaded occurrences are considered extant.

State	EO #	County	Town
MA	**.001**	**Hampshire**	**South Hadley**
RI	**.001**	**Washington**	**Richmond**
CT	**.001**	**New Haven**	**Southbury**
CT	**.002**	**New Haven**	**Guilford**
CT	.003	New Haven	Branford
CT	.004	Middlesex	Middletown
CT	.005	Middlesex	Middletown
CT	**.006**	**Middlesex**	**Haddam**
CT	.007	New Haven	Meriden
CT	.008	Hartford	Southington
CT	**.012**	**Hartford**	**Berlin**
CT	**.013**	**New Haven**	**Guilford**

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

The goal of establishing one or more populations of *Populus heterophylla* large enough in 20 years to ensure long-term viability is probably unrealistic; the present populations are all far too small to expect that they could be built up to even 500 reproductive individuals in two decades. A more realistic goal for each of these populations would seem to be maintenance of present size while undertaking efforts to establish new populations or to locate other extant populations in the region.

The following specific goals for conservation of *Populus heterophylla* in New England are proposed:

1. To protect each of the existing populations through a combination of land acquisition, conservation easements, and landowner education including annual contact with each owner or property manager;

2. To monitor each population through site visits every year and detailed surveys at least every five years;

3. To stabilize each of the existing populations at current numbers through habitat management;

4. To support research on the biology of *Populus heterophylla* in New England including projects helping to define habitat requirements, to identify actual or potential threats to populations, and to implement and evaluate management measures in each population;

5. To locate additional populations in the region through systematic surveys of appropriate habitat (see specific suggestions below);

6. To encourage continued *ex-situ* propagation efforts.

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IV. APPENDICES

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1. List of New England Voucher Specimens of *Populus heterophylla* from Seven New England Herbaria.

2. An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe

1. List of New England voucher specimens of *Populus heterophylla* from seven New England herbaria. Data from GH and NEBC were provided by Ray Angelo; data from MASS were taken directly from vouchers by the author; all other data are from records of the CT DEP. NCBS=Connecticut Botanical Society, CCNL=Connecticut College, GH=Gray Herbarium, NEBC=New England Botanical Club, CONN=University of Connecticut, MASS=University of Massachusetts, Amherst, YU=Yale University.

Herbarium	Date	Location	Voucher Number	Collector	Habitat
NCBS	1895	Branford CT		C.H. Bissell	Old pasture, pine orchard
NCBS	1903	Middletown CT		R.W. Woodward	
NCBS	1903	Southbury CT		E.B. Harger	Wooded swamp
NCBS	1903	Southbury CT	402	E.B. Harger	Swamp woods
NCBS	1903	Middletown CT		R.W. Woodward	
NCBS	1903	Middletown CT	8671	C.H. Bissell	Border of cove
NCBS	1909	Southbury CT	402	A.E. Blewitt	Wooded pond
CCNL	1890	Haddam CT		C.B. Graves	Connecticut River
CCNL	1899	Montville-Salem CT		C.B. Graves	Lake shore
CCNL	1909	Southbury CT		R.W. Woodward	Rocky ridge
GH	1878	Wethersfield CT			Dry ridge
GH	1883	Guilford CT			
GH	1899	Montville CT			Lake shore
GH	1900	East Hartford CT			
GH	1903	Middletown CT			Wet ground, river shore
GH	?	North Guilford CT			
NEBC	1887	East Haven CT			Swamp
NEBC	1887	East Haven CT			
NEBC	1892	North Guilford CT			Frog pond
NEBC	1902	Southington CT			Swamp
NEBC	1904	Guilford CT			
NEBC	1906	Southbury CT			Pond border, top of ledge
NEBC	1908	Southbury CT			Trap ridge
NEBC	1909	South Britain CT			Pond in trap hills
NEBC	1924	Southington CT		C. A. Weatherby	Swamp
NEBC	1984	Southbury CT			Basalt summit
NY?	1829	Milford CT		Oakes	
CONN	1902	Middletown CT		H.S. Clark	Side of railroad
CONN	1902	Southington CT			
CONN	1902	Southington CT	2573	C.H. Bissell	Wooded swamp
CONN	1904	Guilford CT	5063	G.H. Bartlett	Swamp
CONN	1908	Southbury CT		E.B. Harger	
CONN	1979	Haddam CT	79006	K.J. Metzler	Along slough
MASS	1902	Southington CT		C.H. Bissell	Swamp
MASS	1999	South Hadley MA		K. Searcy	Vernal pool
MASS	2000	South Hadley MA		K. Searcy	Vernal pool
YU	1883	Guilford CT		W.R. Dudley	
YU	1887	East Haven CT		E.B. Harger	Swamp
YU	1909	Southbury CT		R.W. Woodward	Rocky ridge
YU	1924	Southington CT	5292	C.A. Weatherby	Swamp
YU	1928	Bozrah CT		H.C. Beardslee	

2. An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe

The conservation rank of an element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by a G (Global), N (National), or S (Subnational) as appropriate. The numbers have the following meaning:

1 = critically imperiled
2 = imperiled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.

G1, for example, indicates critical imperilment on a range-wide basis -- that is, a great risk of extinction. S1 indicates critical imperilment within a particular state, province, or other subnational jurisdiction -- i.e., a great risk of extirpation of the element from that subnation, regardless of its status elsewhere. Species known in an area only from historical records are ranked as either H (possibly extirpated/possibly extinct) or X (presumed extirpated/presumed extinct). Certain other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate uncertainty.

Elements that are imperiled or vulnerable everywhere they occur will have a global rank of G1, G2, or G3 and equally high or higher national and subnational ranks (the lower the number, the "higher" the rank, and therefore the conservation priority). On the other hand, it is possible for an element to be rarer or more vulnerable in a given nation or subnation than it is range-wide. In that case, it might be ranked N1, N2, or N3, or S1, S2, or S3 even though its global rank is G4 or G5. The three levels of the ranking system give a more complete picture of the conservation status of a species or community than either a range-wide or local rank by itself. They also make it easier to set appropriate conservation priorities in different places and at different geographic levels. In an effort to balance global and local conservation concerns, global as well as national and subnational (provincial or state) ranks are used to select the elements that should receive priority for research and conservation in a jurisdiction.

Use of standard ranking criteria and definitions makes Natural Heritage ranks comparable across element groups; thus, G1 has the same basic meaning whether applied to a salamander, a moss, or a forest community. Standardization also makes ranks comparable across jurisdictions, which in turn allows scientists to use the national and subnational ranks assigned by local data centers to determine and refine or reaffirm global ranks.

Ranking is a qualitative process: it takes into account several factors, including total number, range, and condition of element occurrences, population size, range extent and area of occupancy, short- and long-term trends in the foregoing factors, threats, environmental specificity, and fragility. These factors function as guidelines rather than arithmetic rules, and the relative weight given to the factors may differ among taxa. In some states, the taxon may receive a rank of SR (where the element is reported but has not yet been reviewed locally) or SRF (where a false, erroneous report exists and persists in the literature). A rank of S? denotes an uncertain or inexact numeric rank for the taxon at the state level.

Within states, individual occurrences of a taxon are sometimes assigned element occurrence ranks. Element occurrence (EO) ranks, which are an average of four separate evaluations of quality (size and productivity), condition, viability, and defensibility, are included in site descriptions to provide a general indication of site quality. Ranks range from: A (excellent) to D (poor); a rank of E is provided for element occurrences that are extant, but for which information is inadequate to provide a qualitative score. An EO rank of H is provided for sites for which no observations have made for more than 20 years. An X rank is utilized for sites that are known to be extirpated. Not all EOs have received such ranks in all states, and ranks are not necessarily consistent among states as yet.