Hottonia inflata

Featherfoil

Primulaceae

Hottonia inflata by Doug McGrady, 2015

***Hottonia inflata* Rare Plant Profile**

New Jersey Department of Environmental Protection
State Parks, Forests & Historic Sites
State Forest Fire Service & Forestry
Office of Natural Lands Management
New Jersey Natural Heritage Program

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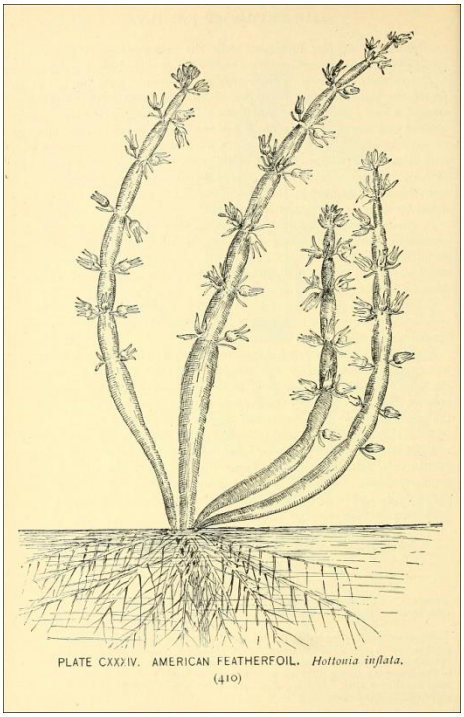
Life History

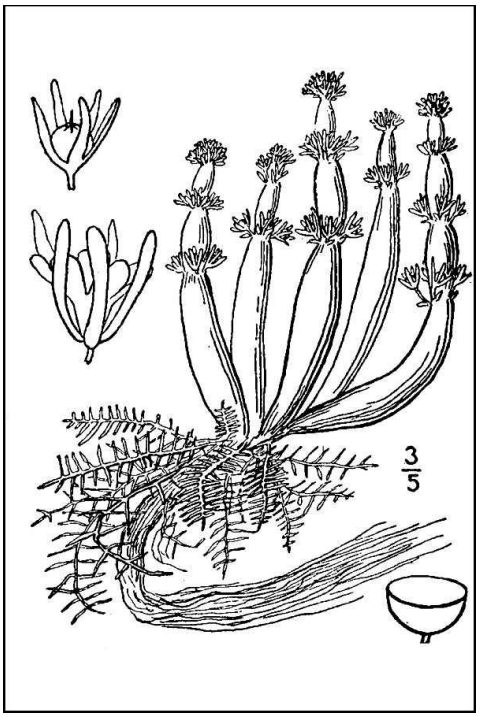
Hottonia inflata (Featherfoil) is a distinctive plant unlikely to be mistaken for any other in New Jersey. The only other species in the genus *Hottonia* is native to Eurasia (POWO 2021). Featherfoil is an aquatic species that derives its common name from the densely whorled leaves, which are pinnate with fine divisions that give them a featherlike appearance (Prankerd 1911, Fernald 1950). The inflorescence is a raceme with an inflated axis along which whorls of small, five-parted white flowers are borne at each constricted joint (Gleason and Cronquist 1991). The swollen internodes are formed by enlargement of the pith cavity (Prankerd 1911), and the inflated stalks help keep the upper portion of the plant afloat (Hill 2007). Water can disrupt the transfer of pollen to stigmas, and a buoyant peduncle allows *H. inflata* to keep its aerial flowers from contact with the water surface (Philbrick and Les 1996). While *Hottonia* plants growing in water may appear to be free-floating they are nearly always firmly anchored to the substrate by a long, slender root (Prankerd 1911), although some individuals occasionally become detached and float (Schaffner 1905, Prankerd 1911, Les 2017).

Hottonia inflata has long been reported as a winter annual (Fernald 1950). Ostile (1990) suggested that the species might actually have a biennial cycle, with seeds remaining dormant for a year or more before germination. Following a study of *Hottonia*'s germination requirements, Baskin et al. (1996) concluded that it is a winter annual because a high proportion of seeds shed in May were initially dormant but germinated by late autumn of the same year. Unlike most winter annuals which need low temperatures for germination, however, *Hottonia* seeds require high summer temperatures in order to break dormancy (Baskin et al. 1996, 2005). Once dormancy has been broken, the seeds may germinate as soon as conditions become favorable.

Conditions conducive to germination success in *Hottonia* are based on temperature thresholds, light availability, and water levels. Baskin et al. (1996) found that darkness inhibits germination, so buried seeds may break dormancy but fail to develop until exposed to light. They reported negligible germination at daily maximum/minimum temperature ranges of 15/6ºC (59/43ºF) but substantial germination at temperatures of 20/10ºC (68/50ºF) and above. Finally, their experiments showed higher germination rates in non-flooded conditions than in flooded ones, and in most cases the differences were significant. Seed viability did not decrease after 39 months of burial under flooded conditions in a non-heated greenhouse (Baskin et al. 1996) and Les (2017) reported that *Hottonia* seeds remain viable for four or more years, germinating when conditions are suitable. Botanists have often observed that the species has disappeared from a site, only to note its reappearance several years later in the same location.

When germination takes place during autumn, *Hottonia* plants develop throughout the months that follow before flowering in the spring. Knowlton (1911) described finding young plants in the icy winter waters of Massachusetts in early December and later the same month removing an inch of ice to gather specimens. Returning the following March, he noted that the plants had grown over the winter. Dense snow cover on the ice can inhibit winter growth by limiting available light (Les 2017). Featherfoil may flower between April and July, and fruit is produced between May and August (Weakley 2015). The leaves are shed post-flowering and the plants rapidly disintegrate (Channell and Wood 1959).





Left: Rowan 1901. Right: Britton and Brown 1913, courtesy USDA NRCS 2022a.

Plant with root, Doug McGrady 2016

Nonflowering plant, Doug McGrady 2016

Closeup of stem, courtesy USDA NRCS 2022b.

Pollinator Dynamics

The pollination requirements of *Hottonia inflata* have often been questioned (Hill 2007, Gracie 2012). Featherfoil's nearest relative, *Hottonia palustris*, has larger flowers and is primarily pollinated by honey bees and bumblebees (Apidae), but it is also visited by hoverflies (Syrphidae) and dance flies (Empididae) (Brys et al. 2007). Although Gracie (2012) observed ants visiting the flowers of *H. inflata* she did not equate that with pollination, suggesting instead that the insects might be collecting nectar without transporting pollen.

Darwin (1896) reported *Hottonia inflata* as a cleistogamous species based on a description by Torrey (1871), who collected some living plants from a site in New Jersey and placed them in a vase in his study to watch them develop. After the scapes expanded and produced flowers, Torrey recounted his observations as follows: "*At a very early age, when the flower-buds are barely formed, fertilization takes place, and the corolla is detached from its base by the enlargement of the ovary, on the summit of which it remains, like a little cap, until the fruit is mature. Fertilization must take place without any aid from without, for the corolla does not open, the stamens and pistil being closely shut in, and the anthers being directly in contact with the stigma*". Prankerd (1911) raised some doubts about cleistogamy in the genus *Hottonia* based on never having seen it take place in the field; however, her first-hand experience was with *H. palustris* while her knowledge of *H. inflata* was restricted to specimens that she had received in the mail. East (1940) pointed out a significant difference in the floral structure of the two *Hottonia* species—*H. palustris* is heterostylous while *H. inflata* is not. A heterostylous species deters self-fertilization by producing multiple flower types with styles of different lengths relative to the stamens. Channell and Wood (1959) found no structural impediments of any kind to self-fertilization in *H. inflata*, and in fact thought that the proximity of anthers and stigma in the species suggested frequent self-pollination. Les (2017) asserted that *Hottonia inflata* is exclusively self-pollinated (although not cleistogamous), and noted that the lack of cross-fertilization has resulted in a dearth of genetic variation between populations.

Seed Dispersal

Hottonia fruits are round capsules that split to the base, releasing 100–200 reddish-brown seeds approximately 0.5 mm long (Cholewa 2020). Many of the seeds float on the water surface for a time before sinking (Ostile 1990, Les 2017), offering them an opportunity to gain some distance from the parent plants. A mucilaginous coating on the seeds allows them to adhere to potential dispersal agents including plant matter, fur, and feathers. The seeds are eaten by waterfowl but they are not viable post-digestion; however, adhesion to duck feathers provides an opportunity for long-distance dispersal (Les 2017).

Although it is not a clonal species, *Hottonia inflata* may also spread vegetatively. Middleton (2003) indicated that vegetative organs were the primary means of dispersal for Featherfoil. Vegetative dispersal is also reported by Gracie (2012), who said that broken fragments of mature plants which are temporarily free-floating may later take root in the wet soil of pond margins. Floating pieces of broken plants also transport *Hottonia* seeds to new locations (Les 2017).

Habitat

Throughout its range, *Hottonia inflata* has been recorded in a variety of aquatic habitats including swamps, bayous, sloughs, millponds, beaver ponds, sag ponds, interdunal pools, oxbows, ditches, lakes, and slow-moving rivers (Weakley 2015, Hill 2007, Brockett 1983, Maine Natural Areas Program 2021). The waters are generally acidic but extend to neutral, with pH values ranging from 5.0–6.5 (–7) (Hill 2007). Les (2017) reported a pH range of 5.7–7.3 in the water and 4.6–5.8 in the sediment. Seedlings or stranded plants may be found growing on wet, muddy soil (Gleason and Cronquist 1991, Ostile 1990, Gracie 2012). *Hottonia* has often been documented at sites with fluctuating water levels, and Les (2017) suggested that exposed sediments were a requirement for germination.

Ostile (1990) emphasized the importance of beaver ponds to *H. inflata* and posited that "*the species apparently requires shallow pools with stable water levels*." Beaver ponds were also reported as critical habitats for the plant species by Hill (2007) and the U. S. Forest Service (undated). In the eastern states, however, Featherfoil plants on the coastal plain have often been associated with intermittent ponds—shallow, seasonally flooded depressions that are typically inundated during winter and spring but draw down in the summer and fall months (NYNHP 2008, McAvoy and Bowman 2002, Ludwig et al. 1987). In New Jersey, coastal plain intermittent ponds are recognized as a significant community type that supports an assortment of rare plants and wildlife (Johnson and Walz 2013), and they are one of the habitats in which *Hottonia* has been documented (NJNHP 2022). A certain amount of hydrological fluctuation is advantageous to a species like *H. inflata*, which germinates better on moist substrate than under submerged conditions (Baskin et al. 1996, Les 2017). Habitats with variable water levels may promote dispersal during the aquatic phase and germination when the water recedes.

Hottonia inflata also occurs in deeper, permanent aquatic habitats. In New Jersey, one long-established population is known from a pond where the water depth exceeds a meter (Schuyler 1990). Other habitats where the species has been found in the state include marshes, swamps, lake margins, and flowing brooks (NJNHP 2022).

Wetland Indicator Status

Hottonia inflata is an obligate wetland species, meaning that it almost always occurs in wetlands (U. S. Army Corps of Engineers 2020).

USDA Plants Code (USDA, NRCS 2022c)

HOIN

Coefficient of Conservatism (Walz et al., 2018)

CoC = 10. Criteria for a value of 9 to 10: Native with a narrow range of ecological tolerances, high fidelity to particular habitat conditions, and sensitive to anthropogenic disturbance (Faber-Langendoen 2018).

Distribution and Range

The global distribution of *Hottonia inflata* is limited to the eastern and central United States POWO 2021). The map in Figure 1 depicts the full range of American Featherfoil. Cholewa (2020) noted that there was an old record from Prince Edward Island in Canada, but believed it to be a casual waif.

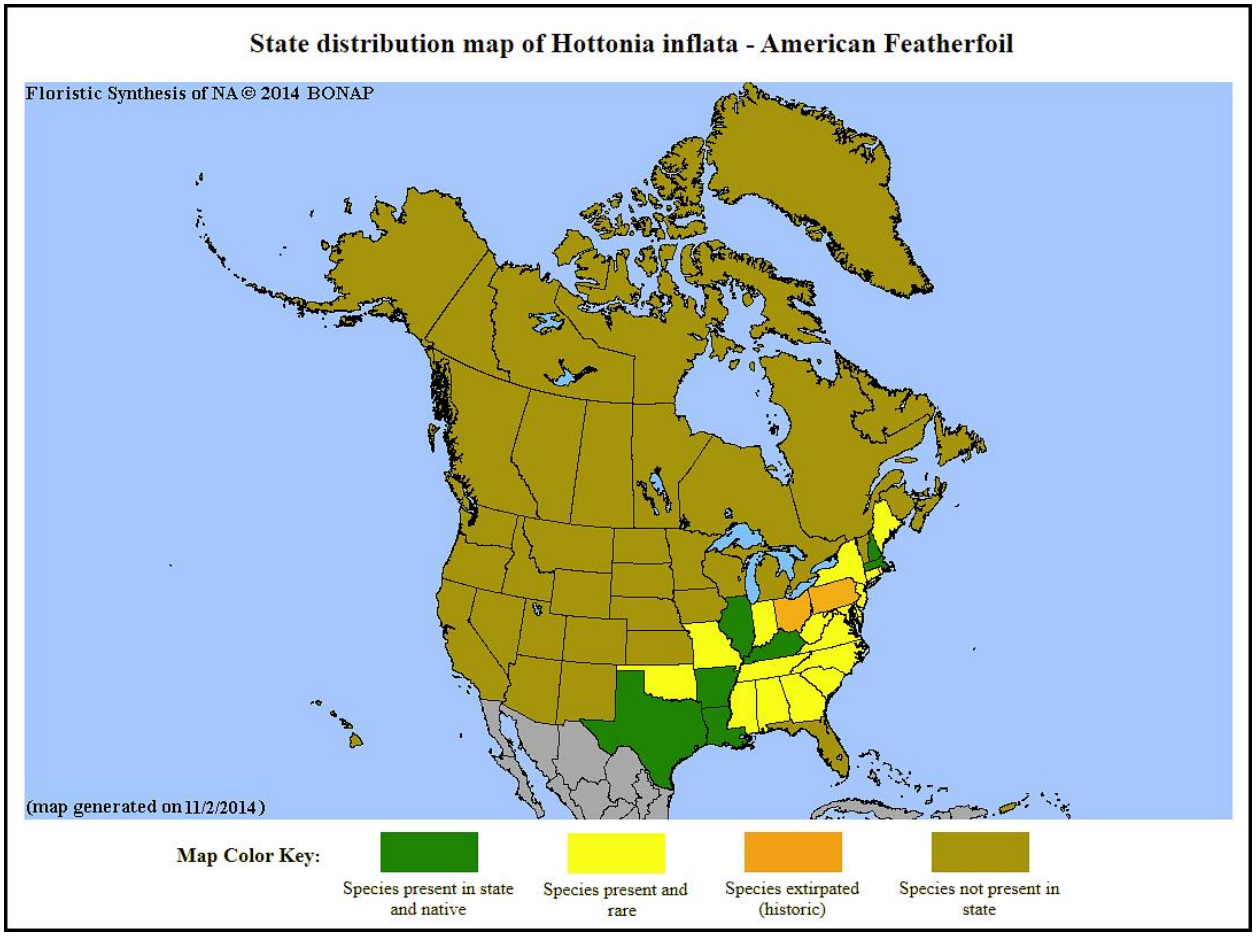


Figure 1. Distribution of H. inflata in North America, adapted from BONAP (Kartesz 2015).

The USDA PLANTS Database (2022c) shows records of Featherfoil in ten New Jersey counties: Bergen, Cape May, Cumberland, Hudson, Mercer, Middlesex, Monmouth, Morris, Ocean, and Salem (Figure 2). The data include historic observations and do not reflect the current distribution of the species. Moore et al. (2016) found no support for the report of *Hottonia* in

Cumberland County. A recent discovery has added Sussex County to the plant's New Jersey range (NJNHP 2022).

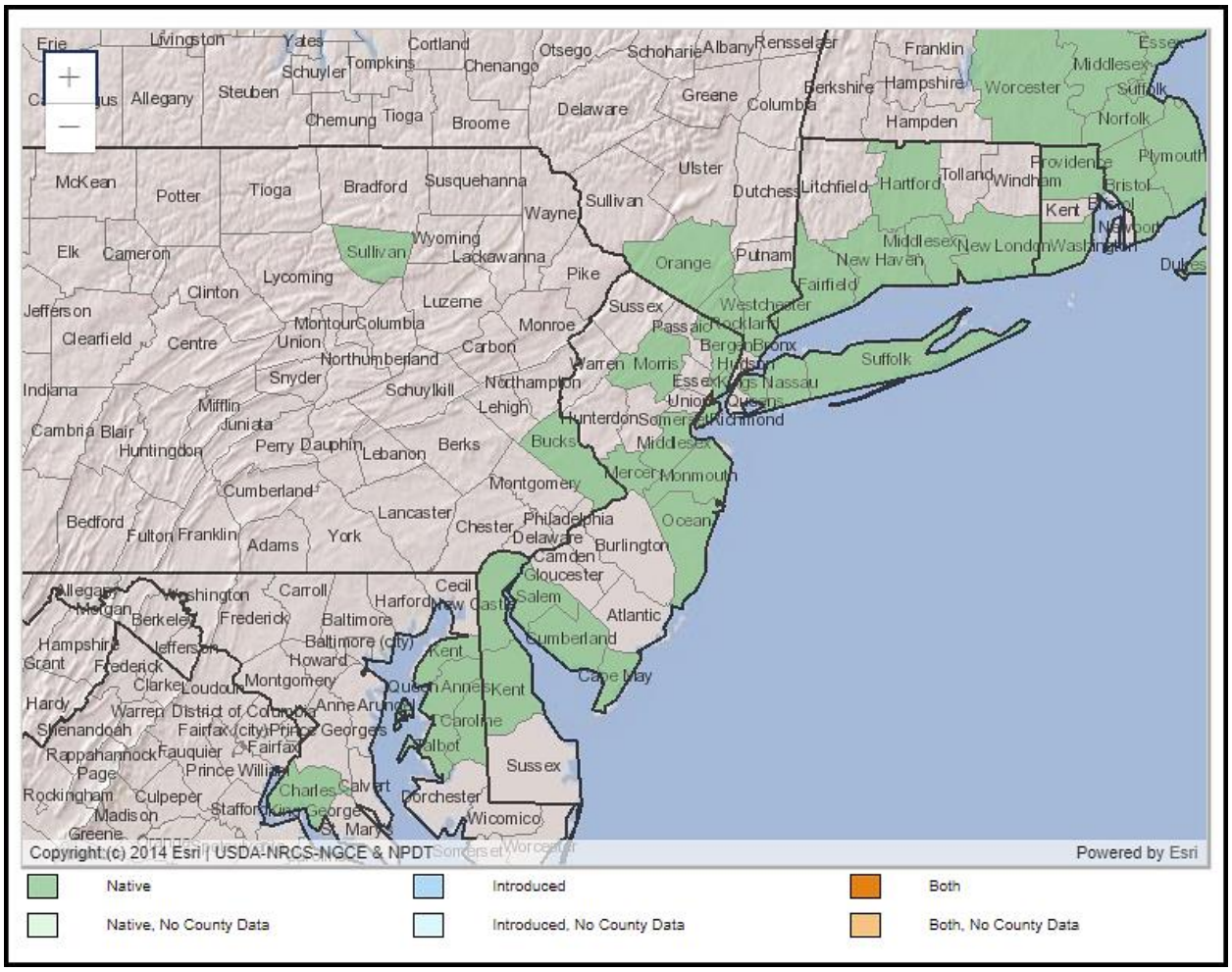


Figure 2. County records of H. inflata in New Jersey and vicinity (USDA NRCS 2022c).

Conservation Status

Hottonia inflata is apparently secure at a global scale. The G4 rank means the species is at fairly low risk of extinction or collapse due to an extensive range and/or many populations or occurrences, although there is some cause for concern as a result of local recent declines, threats, or other factors (NatureServe 2022). The map below (Figure 3) illustrates the conservation status of *H. inflata* throughout its range. Only four states report the plant as secure or apparently so. Featherfoil is listed as critically imperiled (very high risk of extinction) in eleven states, imperiled (high risk of extinction) in eight states, vulnerable (moderate risk of extinction) in four states, and presumed extirpated in Pennsylvania.

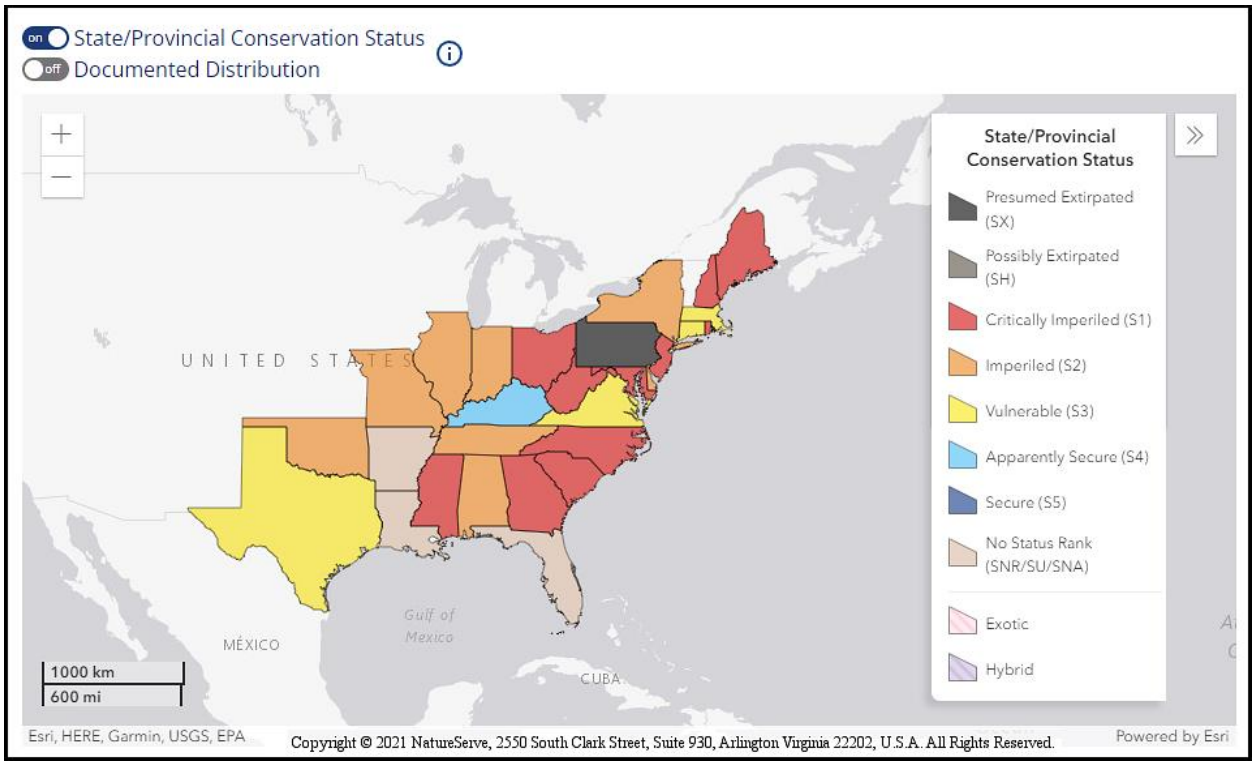


Figure 3. Conservation status of H. inflata in North America (NatureServe 2022).

New Jersey is one of the eleven states where *Hottonia inflata* is critically imperiled (S1) (NJNHP 2022). The rank signifies five or fewer occurrences in the state. A species with an S1 rank is typically either restricted to specialized habitats, geographically limited to a small area of the state, or significantly reduced in number from its previous status. The plant is also listed as an endangered species (E) in New Jersey, meaning that without intervention it has a high likelihood of extinction in the state. Although the presence of endangered flora may restrict development in certain types of wetlands or coastal habitats, being listed does not currently provide broad statewide protection for the plants. Additional regional status codes assigned to *H. inflata* signify that the species is eligible for some safeguards under the jurisdictions of the Highlands Preservation Area (HL) and in the New Jersey Pinelands (LP) (NJNHP 2010).

Records of Featherfoil in New Jersey have always been scattered and sparse. Britton (1881) reported *Hottonia* from Bergen, Hudson and Monmouth Counties. Stone (1911) noted that it was rare, being known at that time only from several localities in Bergen County and one each in Cape May, Monmouth and Salem. Fairbrothers and Hough (1973) remarked on its erratic appearance in the state; at that time it was confirmed present in Bergen, Cape May and Morris counties. Tucker and Dill (1982) mentioned it as a species that might be worthy of federal designation due to its rarity. By 1997 five occurrences were known to be extant: Two in Cape May, two in Morris, and one in Salem (Breden et al. 2006). New Jersey continues to have a small number of extant occurrences with viability ranks ranging from 'Excellent' to 'Fair, and a recently discovered population has not yet been ranked (NJNHP 2022).

Threats

Changes in hydrologic regime

Unfortunately, small isolated ponds have not enjoyed the same legal protections as riparian or lacustrine wetlands (Kirkman et al. 1999). Alterations to hydrologic regime and degraded water quality are the most frequently cited threats to populations of *Hottonia inflata* (e.g. Johnson and Walz 2013, Hill 2007, Ludwig et al. 1987, Ohio DNR 2020, Ostile 1990, U. S. Forest Service undated). While the hydrologic changes cited most often refer to the ditching and draining of wetlands severe flooding can also be a problem, particularly for the top-heavy mature plants which are especially susceptible to uprooting and damage (Ostile 1990). In some states where beaver-created wetlands have been identified as significant habitat for *Hottonia* the elimination of beavers has been reported as a threat (Hill 2007, U. S. Forest Service undated). Conversely, community changes wrought by beaver activity have been identified as a potential threat to some established Featherfoil populations (Johnson and Walz 2013, NJNHP 2022). Siltation of aquatic habitats has also been noted as a concern at multiple locations.

Development of the surrounding landscape

Loss of *Hottonia* populations to development has been reported since the late 1800s (Standley 2003), and a number of former occurrences in New Jersey have been extirpated in that manner (NJNHP 2022). The alteration of natural landscapes for a variety of human uses is obviously the cause of many of the hydrologic changes discussed above, but additional direct and indirect impacts have also been described. Coastal plain ponds in New Jersey have been directly eliminated by sand and gravel mining or by conversion to cranberry bogs (Johnson and Walz 2013), and portions of Baldcypress (*Taxodium distichum*) swamps in Illinois that once supported *Hottonia* have been converted to farmland (Middleton 2003). McCarthy and Modlin (1992) found that natural succession was decreasing the amount of open herb-dominated habitat in some of Maryland's coastal plain pond communities due to urbanization of the surrounding landscape because adjacent development had resulted in the suppression of disturbances that previously maintained open habitats and prevented opportunities for the formation of new openings that could result in favorable conditions for the rare plants. Hill (2007) pointed out that habitat fragmentation often isolates small populations, reducing gene flow and contributing to the decline of rare species.

Invasive species

Establishment of non-native flora may eliminate *Hottonia* and other rare plants from certain sites, particularly invasive species that proliferate and become dominant in particular locations. Two highly invasive plants that have been reported as threats to occurrences of *H. inflata* are *Phragmites australis* ssp. *australis* in New Jersey (Ostile 1990) and *Microstegium vimineum* in New York (NYNHP 2008). *Phragmites* is a clonal perennial that forms monospecific stands to the detriment of many native plants. *Microstegium* is a prolific annual grass that becomes dominant late in the season—a critical period for germination and seedling growth in *Hottonia*.

Climate change

In a review of climate change risk factors for New Jersey species in coastal plain intermittent ponds, *Hottonia inflata* was scored as Presumed Stable, meaning that available evidence did not predict a substantial change in the species' abundance by 2050 (Ring et al. 2013). Shifting

precipitation patterns—already underway in New Jersey—are expected to increase both early season flooding and late season drought (USEPA 2016) so some *H. inflata* occurrences may be subject to altered hydrologic conditions. Lin et al. (2016) pointed out that seeds which can tolerate extended periods of submergence and germinate quickly under favorable circumstances are well-adapted to cope with complex hydrological rhythms. Although *Hottonia* has some tolerance to varying water regimes, Johnson and Walz (2013) warned that meteorologically-induced hydrologic shifts may compound stressors unrelated to climate change. Range wide, low genetic variation is likely to reduce the species' ability to adapt to rapidly changing environmental conditions. As sea levels continue to rise, New Jersey will experience salt water intrusion into some coastal aquifers (USEPA 2016). That could eliminate *Hottonia* populations in low-lying areas near the coast, as the species is intolerant of salinity above 0.05% (Les 2017). The response of individual *Hottonia* populations to climate change will probably vary based on local circumstances.

Management Summary and Recommendations

Due to the precarious status of *Hottonia inflata* throughout most of its range and the limited number of extant occurrences in New Jersey, every effort should be made to protect the remaining populations. Ostile (1990) suggests that protection of vulnerable occurrences should encompass the entire watershed at and above the point where the plants are found. General conservation efforts might include land acquisition, invasive species removal, use of buffers, and/or cooperative efforts with owners of neighboring and upstream parcels in order to prevent impacts from hydrologic changes, erosion, siltation, and the introduction of pollutants that could alter pH or otherwise reduce water quality. Because *H. inflata* is able to utilize a variety of habitat types, site-specific plans should be developed that consider natural community features, local threats, and regional concerns. Extant occurrences should also be regularly monitored to assure that populations are stable and to identify emerging threats. Site visits are best conducted during the spring months when the species is most visible.

Middleton (2006) notes that a possible impact of shifting climactic conditions on *Hottonia inflata* is a diminished presence in the seed bank, which could result from decreased production or from extended intervals between favorable germination conditions leading to decreased viability. Since seed bank density is an important component of community regeneration, a deficiency could impact the species' ability to rebound following an extreme weather event—for example, entire cohorts of the plant have been lost to severe floods at some sites in North Carolina (Ostile 1990). Consequently, research on ex-situ cultivation of *Hottonia inflata* would be valuable. Propagation studies by an experienced horticulturalist using seed from native stock is recommended, along with testing of long-term seed viability.

Synonyms

The accepted botanical name of the species is *Hottonia inflata* Elliott. Orthographic variants, synonyms, and common names are listed below (ITIS 2021, USDA 2022c, Britton and Brown 1913).

Botanical Synonyms	Common Names
-	Featherfoil American Featherfoil Water-feather Water-violet Water-yarrow

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