Dryopteris celsa

Log Fern

Dryopteridaceae

Dryopteris celsa courtesy Alan Cressler, Lady Bird Johnson Wildflower Center

***Dryopteris celsa* 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

Dryopteris celsa (Log Fern) is a perennial pteridophyte in the wood fern family. Like most other ferns, its life cycle includes two independent generations. Spores produced by mature plants initially develop into tiny free-living gametophytes with structures that produce male and female reproductive cells (gametes). Male gametes (sperm) develop in an antheridium and a female gamete (egg) develops in an archegonium. Fertilized female cells develop into the leafy plants (sporophytes) that produce the spores for the next generation, and once the sporophytes are large enough to be self-sufficient the gametophytes disintegrate (Raven et al. 1986).

Gametophytes of plants in the Dryopteridaceae are relatively large when compared to those in many other fern groups, often reaching widths of a centimeter or more. They are thin, flat, and oval in shape with a notch on one side and a median midrib that may be 4–8 cells thick, and they are typically hairy. Most dryopterid gametophytes have a short life span, producing sporophytes in less than eight months (Nayar and Kaur 1971).



Left and Center: Erik Danielsen, 2022. Right: Nate Martineau, 2018.

The sporophytes of *Dryopteris celsa* have short, slender, horizontal rhizomes that remain close to the surface. The fertile and sterile fronds are morphologically similar, ranging from 65–120 cm in length and 15–30 cm in width and having pinnate-pinnatifid divisions. The overall shape of the blades is ovate-lanceolate and they taper gradually to the tips. The primary blade divisions (pinnae) are widest just above the base, and the secondary divisions (pinnules) are scalloped or toothed along the edge. Scales on the stipes (stalks) are dark brown or light brown with a dark central stripe. Sori on the fertile fronds are typically positioned about midway between the midveins and margins of the pinnules (or a bit closer to the midveins) and they have protective covers (indusia) that are smooth and about 1 mm wide. (See Palmer 1899, Fernald 1950, Montgomery and Paulton 1981, Gleason and Cronquist 1991, Montgomery and Fairbrothers 1992, Montgomery and Wagner 2020).

Dryopteris celsa has variously been described as evergreen (Wherry 1957), deciduous (Gleason and Cronquist 1991), or semi-evergreen (Weakley et al. 2018). In Louisiana, the fronds recline

on the ground or lean on nearby vegetation after the growing season ends but their semi-evergreen foliage makes the ferns easy to locate during the winter months. New pale green shoots can be seen unfurling around mid-March (Thomas et al. 1973). Fertile fronds produce spores between June and September (Weakley et al. 2022).

Dryopteris celsa is morphologically similar to a number of other ferns that occur in New Jersey, particularly *D. goldiana*, *D. clintoniana*, and *D. cristata*. Palmer (1899) initially described *D. celsa* as a subspecies of *D. goldiana* because they were so much alike. Walker (1959) observed that *D. celsa* was often used as a catchall label for specimens with features that were intermediate between those of *D. goldiana* and *D. clintoniana*, and Carlson and Wagner (1982) noted that many specimens of *D. celsa* had been misidentified as *D. clintoniana*. The sole record of *Dryopteris celsa* in Texas comes from a single herbarium specimen that was originally co-mounted on a sheet with *Osmundastrum cinnamomeum*, and even after the error was recognized the species was at first mistaken for *D. cristata* (Mink et al. 2011). The lowest pinnae of both *D. clintoniana* and *D. cristata* are widest at the base and their stipe scales are tan, which can help to separate them from *D. celsa* and *D. goldiana* (Montgomery and Fairbrothers 1992). The fronds of *D. goldiana* are broader than those of *D. celsa* and their tips narrow abruptly rather than tapering gradually (Palmer 1899). Spore characteristics can also be useful in distinguishing *Dryopteris* species (Reed 1953) and Montgomery (1975) used differences in mean spore length to confirm the identity of some herbarium specimens of *D. celsa*, but the technique is not handy in the field as the spores are measured in micrometers.

Frequent hybridization between *Dryopteris* species can also complicate their identification. At least five hybrids involving Log Fern have been documented in New Jersey, some of which are more abundant than *D. celsa* and have persisted via rhizomatous growth at sites where the parent species has disappeared (Montgomery 1976). Spores do not fully develop on the sterile hybrids, which generally have characteristics that are intermediate between those of the parent species (Montgomery and Fairbrothers 1992). Most *D. celsa* hybrids have dark-striped scales on their stipes (Montgomery and Wagner 2020).

Dryopteris celsa itself originated via hybridization. The fern's hybrid nature was surmised early on because its morphology appeared to be intermediate between *D. goldiana* and *D. clintoniana* but once it was known to develop viable spores and reproduce independently it was recognized as a species (Bartsch 1938, Crane 1955). Walker (1959, 1962) refuted the idea *that D. clintoniana* was one of the parent species and instead proposed *D. goldiana* and *D. ludoviciana* as the progenitors: His conclusion was subsequently confirmed by biochemical and DNA analyses (Werth 1991, Sessa et al. 2012). Marchant et al. (2016) evaluated the environmental and climactic characteristics of localities where the involved species had been collected and reported that *D. celsa* clearly occupied a niche between the tolerances of *D. goldiana* and *D. ludoviciana*.

Pollinator Dynamics

Because *Dryopteris celsa* is a non-flowering plant, pollination does not take place. Fertilization is dependent on water, which allows the movement of the multiflagellate sperm toward a

receptive egg cell (Raven 1986). Fern gametophytes can be functionally female (producing only archegonia), male (producing only antheridia) or hermaphroditic (producing both types of reproductive cells). Each spore is capable of following multiple developmental paths, and the sex of the gametophyte is not determined until after the spore has germinated (Banks 1999). In the closely related species *Dryopteris ludoviciana*, sexual characteristics usually began to develop within a month of germination (Cousens and Horner 1970). A study of gametophytic sex expression in *D. celsa* found that 50% of the gametophytes were bisexual, 29% were female, and 26% were male (Cousens 1975). Although cross-fertilization was not studied in Log Fern, a high proportion of bisexual gametophytes would create more opportunities for self-fertilization which could allow isolated gametophytes to establish sporophytes (Cousens 1975, Cousens and Horner 1970).

The female gametophytes of many ferns release a hormone (antheridiogen) that induces male development in nearby undifferentiated gametophytes. Antheridiogen can also stimulate the germination of nearby spores beneath the soil surface, which then develop as male or bisexual (Banks 1999). No reports of antheridiogen in *Dryopteris celsa* were found, and other species in the genus differ in their responses to the hormone (Jiménez et al. 2008, Rünk et al. 2012). Some fern gametophytes can also produce allelopathic chemicals which inhibit development in gametophytes of other species—Peterson and Fairbrothers (1980) demonstrated reciprocal allelopathy between *Dryopteris intermedia* and *Osmundastrum cinnamomeum*, but *D. celsa* was not among the species tested.

Seed Dispersal

Dispersal in *Dryopteris celsa* is carried out by spores rather than seeds. A review of Arkansas Log Fern populations indicated that the majority of mature plants produce fertile fronds (Peck and Peck 1988). Mean spore lengths of 50.2–59.0 μm have been reported for *D. celsa* (Whittier and Wagner 1971, Montgomery 1975). All of the sporangia in a sorus do not mature simultaneously, and while some ferns disperse their spores rapidly others extend the process over a long period. Magraw and Musselman (1979) reported that four co-occurring species of *Dryopteris* initiated spore release at slightly different times and *D. celsa* was the last of the group. Another investigation found that *Dryopteris goldiana*, one of *D. celsa*'s parent species, continued to release its spores throughout the winter months (Farrar 1976).

Dust-like fern spores are transported by wind and the majority are likely to be deposited locally but some can end up thousands of kilometers away (Kessler 2010). Larger spores typically travel for shorter distances (Raynor et al. 1976). In forested habitats where air currents are usually mild, spores of *D. celsa* and other *Dryopteris* species generally fall close to the fronds that produced them but a small number drift above the canopy and can then be carried farther (Magraw and Musselman 1979).

Dryopteris celsa is frequently characterized as a species that is easy to propagate (Hoshizaki and Wilson 1999, Leopold 2005, Wade et al. 2009). Under uniform conditions, spores from four Log Fern plants germinated at rates of 90.7, 85.6, 78.1, and 37.3 percent (Whittier and Wagner 1971) and the authors thought the lowest rate was anomalous and likely attributable to an "internal

factor" in the source plant. A developmental study of *D. celsa* progenitor *D. ludoviciana*, which followed typical patterns for the wood fern family, found that the majority of spores on favorable substrates germinated within 6–20 days although some took as long as three months. Shortly after germination one or two rhizoids were produced, followed by filamentous growth, and continued divisions produced a triangular gametophyte of 10–15 cells that became heart-shaped as it developed further (Cousens and Horner 1970). Illustrations of early frond development from fertilized *D. celsa* gametophytes are available in Palmer (1899). Roughly 75% of *Dryopteris* species examined formed mycorrhizal associations (Wang and Qiu 2006), but the fungal relationships of *D. celsa* and its parent species do not appear to have been studied.

Habitat

Dryopteris celsa is typically found in forested wetlands at elevations of 50–800 meters above sea level (Montgomery 1982, Lamont et al. 2011, Montgomery and Wagner 2020). Habitats include swamps, seeps, and floodplains (Montgomery and Paulton 1981, Rhoads and Block 2007, Weakley et al. 2022). Fernald (1938) noted that *D. celsa* was located in wooded sites near spring-heads or in gullies and swamps. The soils may be acidic (Wherry 1927, Peck and Peck 1988, Leopold 2005) or basic (Fernald 1938 and 1942, Wade et al. 2009, Weakley et al. 2022). Palmer (1899) reported that Log Fern occurred in sites that received a fair to abundant amount of light, and Leopold (2005) indicated that the ferns can grow "partial sun to partial shade."

Although it is usually associated with wetlands, *Dryopteris celsa* generally grows on drier microsites such as hummocks, decomposing logs, stumps, or other woody debris (Palmer 1899, Thomas et al. 1973, Carlson and Wagner 1982, Peck and Peck 1988, Wade et al. 2009). Palmer (1899) observed that many *D. celsa* plants were positioned just above the high water mark and Nickrent et al. (1978) indicated that Log Fern was often situated in the well-drained soils along swamp borders. Moisture is essential during the gametophyte phase (Peck and Peck 1988, Leopold 2005, Wade et al. 2009) but it seems that the sporophytes can tolerate drier conditions and may become abundant by reproducing vegetatively in sites where the species would not be able to establish. *D. celsa* has been noted to spread aggressively in well-drained places as road shoulders, dredge spoils, and sites that have been altered by drainage (Fernald 1942, Nickrent et al. 1978).

New Jersey's extant population of *Dryopteris celsa* is located in a seasonally wet area within a hardwood seepage swamp. Characteristic canopy trees include *Betula alleghaniensis*, *Acer rubrum*, *Fraxinus americana*, and *F. nigra* while *Hamamelis virginiana* is common in the understory. Herbaceous associates include *Osmundastrum cinnamomeum*, *Symplocarpus foetidus*, *Veratrum viride*, and *Carex bromoides* (NJNHP 2022). Habitat for a Maryland occurrence was described as an *Acer/Nyssa* swamp (Hirst 1983), and in a Mississippi wetland the dominant canopy species were *Nyssa aquatica* and *Magnolia virginiana* while associated ferns included *O. cinnamomeum*, *Polystichum acrostichoides*, and *Athyrium aspleniodes* (Weakley et al. 2018). In Louisiana Log Fern was found in a *Taxodium distichum* swamp where it co-occurred with ferns such as *Asplenium platyneuron*, *Osmunda regalis*, *Thelypteris palustris*, and *Woodwardia areolata* (Thomas et al. 1973).

Wetland Indicator Status

The U. S. Army Corps of Engineers divided the country into a number of regions for use with the National Wetlands Plant List and portions of New Jersey fall into three different regions (Figure 1). *Dryopteris celsa* has more than one wetland indicator status within the state. In the Atlantic and Gulf Coastal Plain region Log Fern is a facultative species, meaning that it occurs in both wetlands and nonwetlands. In other regions of New Jersey *D. celsa* is an obligate wetland species, meaning that it almost always occurs in wetlands (U. S. Army Corps of Engineers 2020).

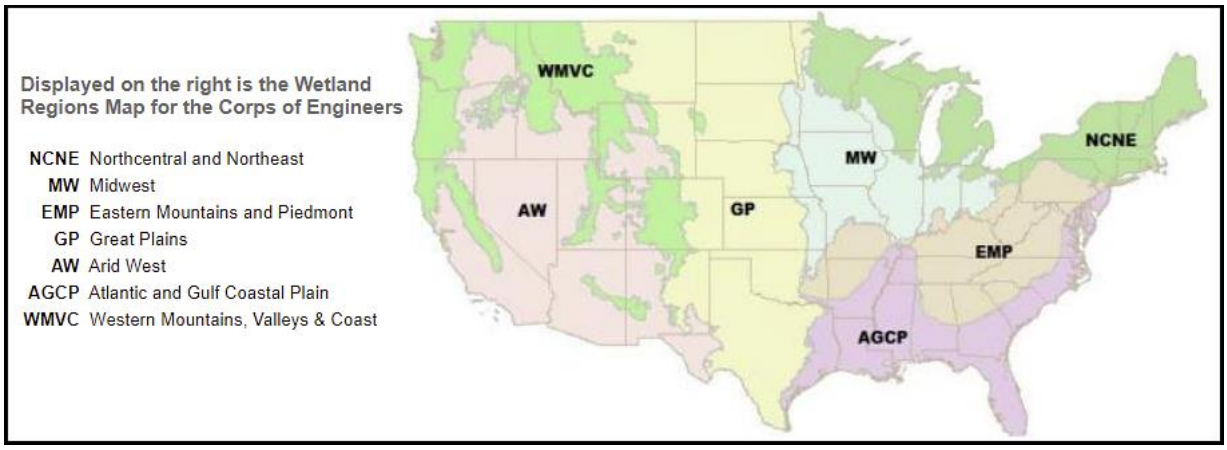

Figure 1. Mainland U. S. wetland regions, adapted from U. S. Army Corps of Engineers (2020).

USDA Plants Code (USDA, NRCS 2023)

DRCE

Coefficient of Conservancy (Walz et al. 2020)

CoC = 9. 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 range of *Dryopteris celsa* is restricted to the eastern and central United States (POWO 2023). The map in Figure 2 depicts the extent of *D. celsa* in North America. The fern was also recently documented in Mississippi (Weakley et al. 2018).

The USDA PLANTS Database (2023) shows records of *Dryopteris celsa* in one New Jersey county: Bergen County (Figure 3). The map reflects the verified distribution of the species in the state. The label of an 1868 specimen in a Berlin herbarium raises the possibility that Log Fern once also occurred in Hudson County (Montgomery and Fairbrothers 1992).

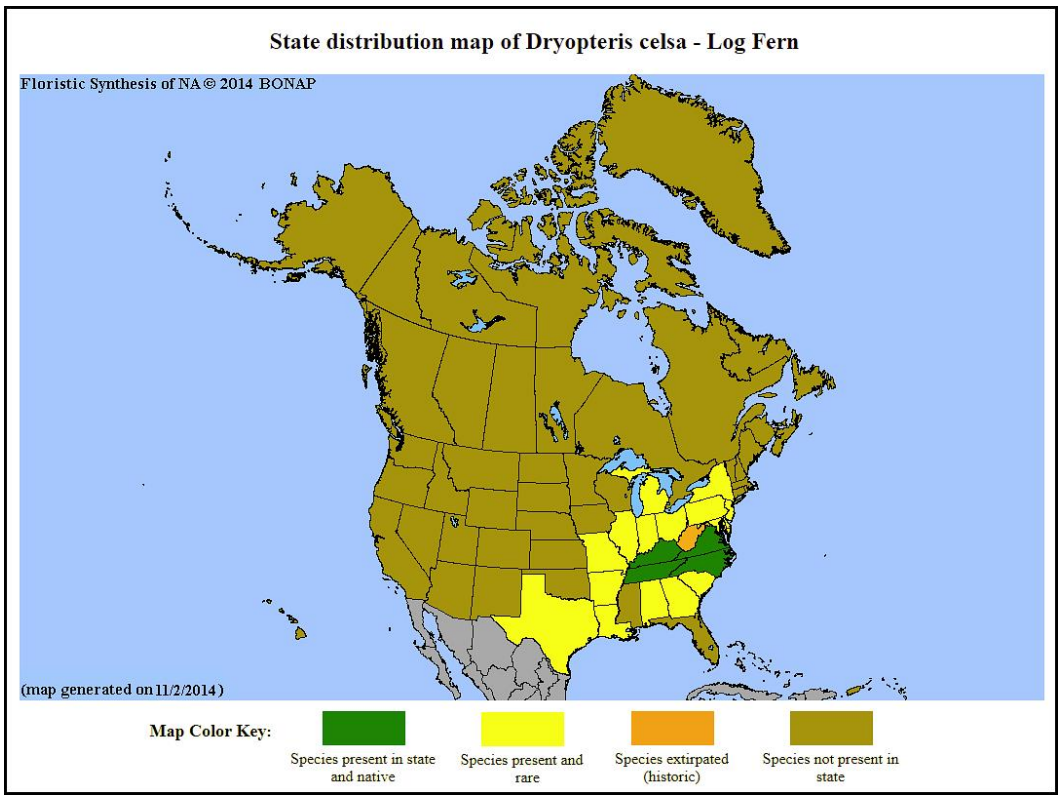

Figure 2. Distribution of D. celsa in North America, adapted from BONAP (Kartesz 2015).

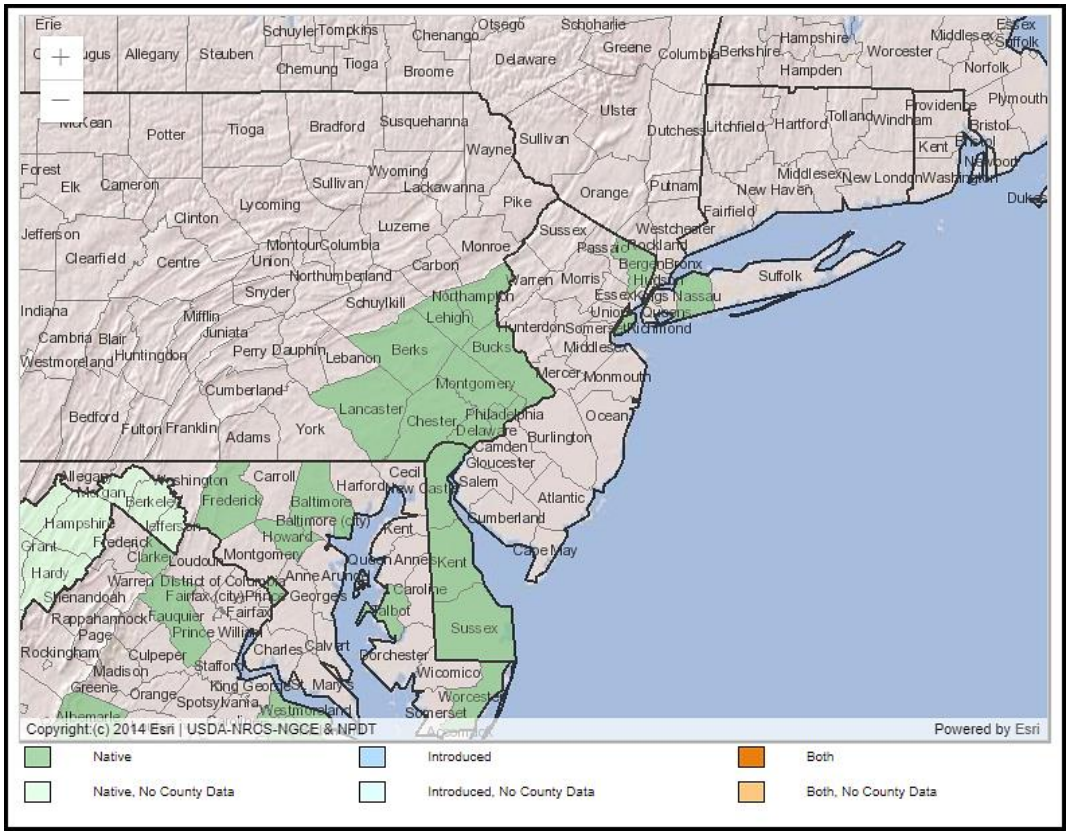

Figure 3. County records of D. celsa in New Jersey and vicinity (USDA NRCS 2023).

Conservation Status

Dryopteris celsa 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 recent local declines, threats, or other factors. However the global status of Log Fern is noted as being in need of a review (NatureServe 2023).

The map below (Figure 4) illustrates the conservation status of *Dryopteris celsa* throughout its range. The fern is vulnerable (moderate risk of extinction) in two states, imperiled (high risk of extinction) in five states, critically imperiled (very high risk of extinction) in ten states, and possibly extirpated in West Virginia. Log Fern is apparently secure in Virginia and it has not been ranked in three other states where it occurs. Although *D. celsa* has spread to locations where neither of its progenitor species occur, Weakley et al. (2018) observed that the fern has a patchy distribution throughout its range and Peck and Peck (1988) noted that Arkansas populations were small and showed little evidence of recruitment. Virginia's Dismal Swamp, where *D. celsa* was first documented by Palmer in 1899, is one of the few places where the species has been reported as common and abundant (Nickrent et al. 1978).

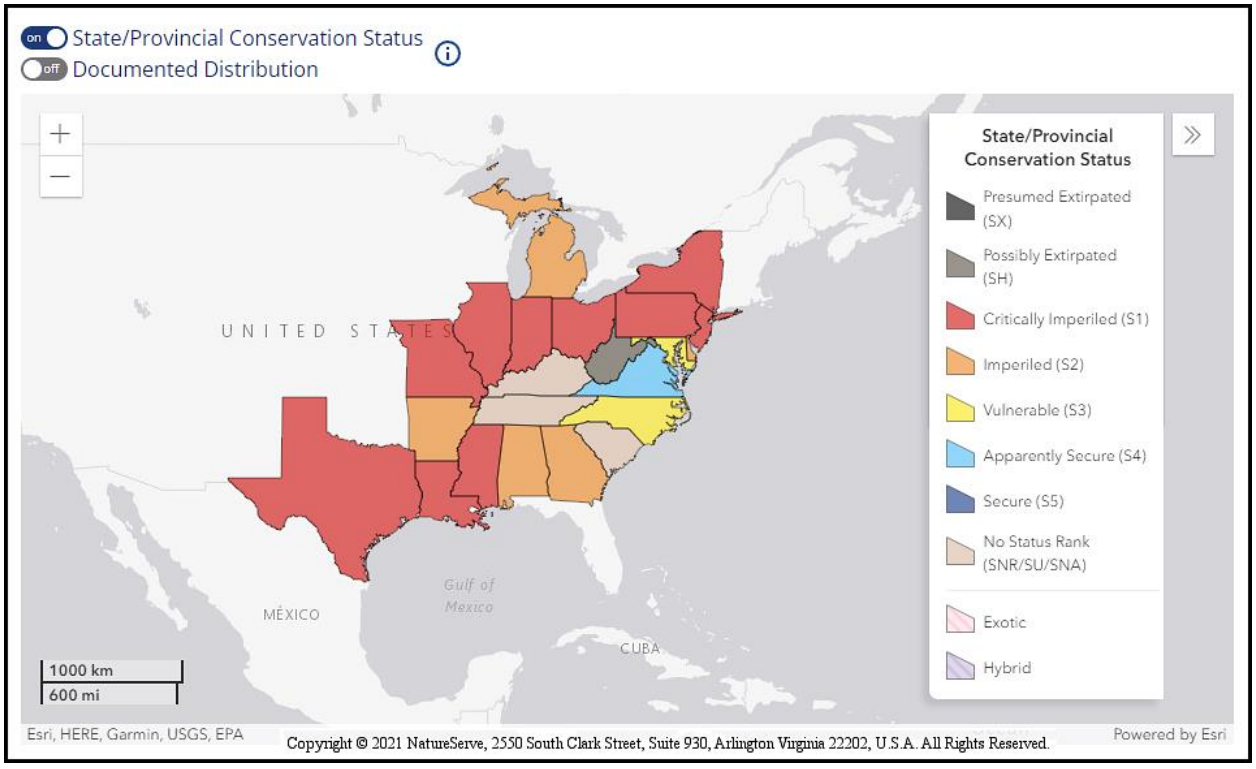

Figure 4. Conservation status of D. celsa in North America (NatureServe 2023).

Dryopteris celsa is critically imperiled (S1) in New Jersey (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. *D. celsa* 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 communities such as wetlands or coastal habitats, being listed does not currently provide broad statewide protection for the plants. Additional regional status codes assigned to *D. celsa* signify that the fern is eligible for protection under the jurisdictions of the Highlands Preservation Area (HL) and the New Jersey Pinelands (LP) (NJNHP 2010).

The earliest known occurrences of *Dryopteris celsa* in New Jersey were initially documented during 1909 and 1910 but the last observation of either population was made in 1922 (NJNHP 2022). Targeted searches for the fern during the mid-1900s were unsuccessful and Montgomery (1975, 1982) concluded that Log Fern was either very rare or no longer present in the state. Some hybrids involving *D. celsa* were collected between 1950 and 1983 from a site that was later destroyed (Montgomery and Fairbrothers 1985, 1992) and at the end of the century the fern was thought to be extirpated in the state (NJNHP 2001). A small population of *Dryopteris celsa* was discovered in a new location by William Standaert in 2005, and that is presently the only known occurrence in New Jersey (NJNHP 2022).

Threats

New Jersey's earliest documented occurrences of *Dryopteris celsa* and its hybrids were lost to urbanization (Montgomery 1975 and 1976, Montgomery and Fairbrothers 1992). The currently extant population is located in a park where it is likely to be protected from development but the presence of nearby trails increases the probability of foot traffic, mainly by dogs that are allowed to run off-leash in the vicinity (NJNHP 2022). An Arkansas population was destroyed after its habitat was converted to pasture (Peck and Peck 1988), although it is not clear whether the ferns were lost to trampling or herbivory. The establishment of invasive flora has also been noted as a concern at the New Jersey site although no particular species was identified as a threat to the *D. celsa* occurrence (NJNHP 2022).

In Illinois, which is also in the northernmost portion of *Dryopteris celsa*'s range, the fern was assessed as being moderately vulnerable to climate change (Molano-Flores et al. 2019). In New Jersey the local effects of climate change include higher temperatures, more frequent and intense precipitation events, and increasing periods of drought (Hill et al. 2020). Hoshizaki and Wilson (1999) indicated that the fern can grow in areas where the average January temperature reaches 4^{o}C. It is possible that *D. celsa* could tolerate or even benefit to some extent from rising temperatures: Conflicting reports as to whether the species is evergreen or deciduous suggest that the fronds might be able to persist longer during warmer winters. Hydrologic changes are likely to pose a greater threat to *D. celsa*. Droughts during the growing season could interfere with establishment or development of the moisture-dependent gametophytes, although the sporophytes may be more tolerant. New Jersey's extant occurrence is vulnerable to drought, particularly since a drainage channel at the site appears to have been enlarged (NJNHP 2022). Nickrent et al. (1978) indicated that *D. celsa* cannot withstand inundation, so populations in low-lying areas could also be threatened by increases in the frequency or duration of floods.

Management Summary and Recommendations

Several areas of potential concern were noted when the New Jersey population of *Dryopteris celsa* was last observed in 2008 (NJNHP 2022). More frequent monitoring is recommended in order to assess the status of the occurrence and evaluate the extent of threats from invasive plants and trampling so that a determination can be made as to whether active management is required.

More than a century elapsed between the documentation of two *Dryopteris celsa* occurrences on Staten Island (Lamont et al. 2011), and a similarly lengthy interval between initial and recent observations of the species New Jersey suggests that additional populations may eventually be found in the state. Log Fern could easily be overlooked because it typically occurs in small colonies and is morphologically similar to a number of other ferns.

Two key subject areas requiring additional research are self-compatibility and mycorrhizae. Knowing whether proliferation of the species is limited by a necessity for cross-fertilization or specific fungal associates might enhance understanding regarding the characteristically small populations and scattered distribution of *Dryopteris celsa*. Information is also needed regarding competition between *D. celsa* and other plant species during both the gametophyte and sporophyte stages.

Synonyms

The accepted botanical name of the species is *Dryopteris celsa* (W. Palmer) Knowlton, Palmer & Pollard ex Small. Orthographic variants, synonyms, and common names are listed below (ITIS 2023, POWO 2023, USDA NRCS 2023). Historic disputes regarding the authority cited for the species name are discussed by Morton (1943).

Botanical Synonyms	**Common Names**
Aspidium goldieanum var. *celsum* B. L. Rob.	Log Fern
Dryopteris atropalustris Small	
Dryopteris clintoniana f. *atropalustris* (Small) Wherry	
Dryopteris clintoniana var. *atropalustris* (Small) C. F. Reed	
Dryopteris clintoniana f. *celsa* (W. Palmer) Wherry	
Dryopteris goldieana ssp. *celsa* W. Palmer	
Dryopteris wherryi Crane	
Filix goldieana var. *celsa* (W. Palmer) Farw.	

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Cressler, Alan. 2017. Cover photo of *Dryopteris celsa*. Courtesy of the Lady Bird Johnson Wildflower Center, https://www.wildflower.org/. Used with permission.

Danielsen, Erik. 2022. Photos of *Dryopteris celsa* from New York. Shared via iNaturalist at https://www.inaturalist.org/observations/132149900, licensed by https://creativecommons.org/licenses/by-nc/4.0/

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