

Rare Plants of the New Jersey Pine Barrens: New Insights into a Unique Botanical Heritage

Wayne R. Ferren Jr., G. Russell Juelg, and William Olson

New Jersey Flora Project

Chrysler Herbarium, Rutgers University, New Brunswick, NJ

Botanical Heritage of the New Jersey Pine Barrens

The Pine Barrens of New Jersey, which occupies most of the outer coastal plain of the southern part of the state, has long been recognized for its low nutrient, acidic soils and waters, and its corresponding unique associations of flora and fauna (Stone 1911; Harshberger 1916; ANSP 1967; Forman 1979; Good 1982). One of the most important aspects of the region is the botanical heritage, including the distinctive and, in some cases, unique vegetation communities, as well as the many rare plants, notably endemic and relict species. Management strategies aimed at preservation and recovery of the region's botanical heritage depend on an understanding of these vegetation communities and the nature of rarity among the many imperiled species. In this paper we examine in detail the classification and causes of rarity among some of its rare plants.

Fortunately, The Pine Barrens is a relatively intact ecosystem, and there is an official plan to protect it. Evidence of the broad recognition of the importance of this ecosystem includes establishment of the Pinelands National Reserve in 1978; The Pinelands Protection Act, passed by the State of New Jersey in 1979, with subsequent implementation of the New Jersey Pinelands Comprehensive Management Plan (CMP); and designation of the region as part of the Atlantic Coastal Plain Biosphere Reserve by UNESCO. Such designations and protection strategies are due, in part, to the recognition that many of the natural communities and plants are imperiled, including state and federally listed threatened and endangered species.

Fifty-four plant species were listed as "threatened and endangered species of the Pinelands" and afforded protection in the CMP. In 2005, at least thirty-eight more species came under protection, due to a revision of the CMP that references the official state list of endangered plant species. Many more plant species of conservation concern in the Pine Barrens are not yet officially protected (Pinelands Preservation Alliance 2007). Another recent development is that the New Jersey Natural Heritage Program has indicated that the majority of the vegetation communities within the Pine Barrens are of conservation concern.

We hope this updated review of the flora of the Pine Barrens will stimulate new interest in the botanical heritage of the Pine Barrens of New Jersey. The findings can be applied to a deeper understanding of the Pine Barrens, and the recommendations have been made with a view toward better conservation of this globally significant ecosystem.

Flora of the Pine Barrens: A Concentration of Botanical Rarities

Within the New Jersey Pine Barrens we have a significant assemblage of rare plant species. Fairbrothers (1980) considered the overall Pine Barrens flora to consist of 580 species, 71 or 12% of which were in jeopardy. This contrasted with 10% of the US flora that was considered to be in jeopardy at the time of his publication. He reported 55% to have southern geographic affinities, 39% to be northern or southern, and 6 % to have northern geographic affinities. Fairbrothers listed the following endemic taxa: *Stylisma pickeringii* var. *caesariensis*, *Juncus caesariensis*, *Liatris graminifolia* ssp. *lasia*, *Leiophyllum buxifolium* var. *buxifolium*, and *Rhynchospora knieskernii*.¹ He suggested rarity in the Pine Barrens is characterized by endemics, relicts, habit-restricted species, peripheral species, and disjunct species.

In a different type of analysis, Ferren et al. (2006) evaluated 379 taxa included in the Pinelands Preservation Alliance (PPA) catalogue of rare plants of South Jersey (Juelg and Gordon 2007). They found that 98% of the taxa are vascular plants, 97% are angiosperms, 91% are herbaceous species, 71% are forbs versus graminoid (grass-like) species, 58% are dicots, and 85% are perennials. Based on this analysis, they concluded that the generalized rare plant of the Pine Barrens is likely to be herbaceous-perennial, dicot species.

Ferren et al. also proposed a system of classification and nomenclature for botanical rarity in the Pine Barrens that includes a series of modifiers:

- (A) The type of known limitation if any (dispersal, reproductive, cytological, etc.) that is attributed to the rare status of the plant;
- (B) The hydrogeomorphic or habitat affinity of the including xerophytic, mesophytic, hydrophytic, aquatic, and seral;
- (C) Geographic affinity including Southeastern, Northeastern, Mid-Atlantic, Mid-Western, and US (United States), or NA (North America, north of Mexico); and
- (D) Endemism or rarity-based types including Endemic, Paleo-endemic, Neo-endemic, among others. (see **Table 1** for examples).

If the distribution of the species is broad or difficult to define, “Endemic” can be replaced by “Rarity,” thereby creating combinations such as “Hydrophytic North American Rarity”. If the current geographic distribution of a plant is greatly reduced because of populations extirpated from various states or provinces, the term “Relict” could be used to reflect its current status. A

¹ The NJ Pine Barrens population of *Stylisma pickeringii* is treated, today, by most authorities, as a disjunct population of *Stylisma pickeringii* var. *pickeringii*. *Juncus caesariensis* is currently recorded in N.S., Del., D.C., Md., N.J., N.C., Pa., and Va. *Liatris graminifolia* ssp. *lasia* = *Liatris pilosa* var. *lasia* is still considered to be endemic to the NJ Pine Barrens (and possibly DE) by some authorities. The NJ Pine Barrens population of *Leiophyllum buxifolium* is now generally considered to be a disjunct population of the typical species, which occurs in several eastern US states. *Rhynchospora knieskernii* has also been documented in DE, but is now presumed extirpated there.

Flora of New Jersey Project

“Xerophytic Mid-Atlantic Relict”, for example, would suggest that the plant once occurred over a broader region but now is limited to Mid-Atlantic States, rather than being endemic to them.

TABLE 1. Examples of Types of Botanical Rarity in southern New Jersey, including the Pine Barrens. Rarity nomenclature from Ferren et al. 2006.

1.a Mid-Atlantic Endemics

Dispersal-limited, Intertidal-Hydrophytic, Mid-Atlantic-US Neo-endemics

Bidens bidentoides

Eleocharis olivacea var. *reductiseta*

Dispersal-limited, Hydrophytic, Mid-Atlantic/Southeastern-US Neo-endemic

Rhynchospora pallida

Dispersal-limited, Reproductively-isolated, Intertidal-Hydrophytic, Mid-Atlantic-US Neo-endemic

Micranthemum micranthemoides (presumed extinct)

Habitat-Restricted, Hydrophytic, Mid-Atlantic Neo-endemic

Rhynchospora knieskernii

1.b Eastern Endemics

Aquatic, Eastern-NA Endemics

Utricularia purpurea

Utricularia resupinata

Aquatic, Eastern-US Endemic

Nymphoides cordata

Dispersal-limited, Hydrophytic, Eastern-US Neo-endemics

Rhynchospora nitens

Rhynchospora scirpoides

Dispersal-limited, Hydrophytic, Eastern/Central-US Neo-endemic

Rhynchospora recognita

Hydrophytic, Eastern-US Endemics

Carex barrattii

Flora of New Jersey Project

*Dichantheium wrightianum**Platanthera cristata**Scleria minor*

Hydrophytic Eastern-Mid-Western US Endemic

Croton wildenowii

Peripheral Species in the Pine Barrens Flora

Perhaps the most important element of botanical rarity in the New Jersey Pine Barrens, and indeed perhaps the most important aspect of this flora in general, is the peripheral nature of many species, i.e., those species at the limits of their geographic occurrence. Because many plant species reach their geographic limits in New Jersey (**Table 2**), which is an important transitional area between northern and southern floras, the word “Peripheral” should be added when appropriate in the above referenced classification and nomenclature of Pine Barrens plants (e.g., Peripheral Southeastern-US Endemic, Peripheral Northeastern-NA Endemic). Peripheral species are a major component of the rare plants in the Pine Barrens. They are generally important biologically because of (1) their likelihood to be populations upon which natural selection acts and evolution occurs (Lesica and Allendorf 1995), and (2) they are genetically isolated from conspecific populations and are likely to be distinct from core populations genetically, morphologically, and ecologically.

Species with disjunct distributions also occur among the list of rare plants in New Jersey. These are generally also peripheral species and therefore the combination “Disjunct-Peripheral” is proposed (Ferren et al. 2006). The most typical examples include “Disjunct-Peripheral Southeastern-US Endemics.” These southeastern species with northern limits in the Pine Barrens or vicinity (e.g. see Table 2b) are very much disjunct from the central portion of the species distribution because of two factors: (1) southern New Jersey is a peninsula disjunct from the southern states, which is separated by the Delaware Bay; and (2) the Pine Barrens can be characterized as an “island” in southern New Jersey, surrounded by other types of geographic provinces and habitats. Disjunct species also can illustrate trends in morphological characteristics that are known among peripheral populations. For example, many “Beaked-rushes” in New Jersey (*Rhynchospora* spp., Cyperaceae) are known to reach their northern limit of distribution in southern New Jersey and also exhibit limited dispersal mechanisms such as reduced, smooth, or lost bristles (Table 3). Such bristles are modified perianth parts, which, in typical species, have retrorse barbs for increased dispersibility.

TABLE 2. Examples of Peripheral Species Characteristic of the Pine Barrens.

Rarity nomenclature from Ferren et al. 2006.

2.a Southeastern Endemics with Peripheral Populations in the New Jersey Pine Barrens

Dispersal-limited, Habitat-restricted, Hydrophytic, Peripheral Southeastern-US Neo-endemics

Rhynchospora filifolia

Rhynchospora globularis

Rhynchospora glomerata

Rhynchospora inundata

Rhynchospora rariflora

Habitat-restricted, Hydrophytic, Peripheral Southeastern-US Neo-endemics

Dichantheium hirstii

Rhynchospora cephalantha

Rhynchospora microcephala

Hydrophytic, Peripheral Southeastern-US Endemics

Gentiana autumnalis

Lobelia canbyi

Prenanthes autumnalis

Solidago stricta

Hydrophytic, Peripheral Southeastern-US Paleo-endemics

Quercus michauxii

Smilax laurifolia

Seral-Xerophytic, Peripheral Southeastern-US Endemic

Stylisma pickeringii var. *pickeringii*

Xerophytic, Peripheral Southeastern-US Endemics

Agalinis fasciculata

Aristida purpurascens var. *virgata*

2.ab Northeastern Endemics with Peripheral Populations in the New Jersey Pine Barrens

Aneuploid/Hypoploid, Habitat-restricted, Hydrophytic, Northeastern-US Neo-endemic

Scirpus longii

Habitat-restricted, Hydrophytic, Northeastern-NA Endemic

Arethusa bulbosa

Hydrophytic, Peripheral Northeastern-NA Endemic

Calamogrostis pickeringii

Hydrophytic, Peripheral, Northeastern-NA Paleo-endemic

Schizaea pusilla

Habitat-restricted, Xerophytic, Peripheral Northeastern-NA Paleo-endemic

Corema conradii

TABLE 3. Beak-Rushes of New Jersey (modified from Ferren et al. 2006). Ten of the 21 species (most of which occur in the Pine Barrens) are peripheral southeastern species, the majority of which can have some form of achene bristles modified for limited dispersal. Twelve of the 13 species with conservation status in New Jersey (**bold-face**) have or can have modified bristles for limited dispersal. The single northeastern peripheral species also has modified achene bristles, whereas the only mid-Atlantic endemic, and also an endangered species (*R. knieskernii*), has retrorse bristles for increased dispersibility.

Rhynchospora alba (L.) Vahl White Beak-rush

Widespread hydrophyte

(retrorsely-barbed bristles; forma *laeviseta* Gale = smooth bristles;

various wet habitats and elevations)

Rhynchospora capillacea Torr. Needle Beak-rush

Hydrophytic Eastern and Central-NA Endemic

(retrorsely-barbed bristles; forma *laeviseta* (E.J. Hill) Fern. = smooth bristles)

Flora of New Jersey Project

Rhynchospora capitellata (Michx.) Vahl Brownish Beak-rush

Hydrophytic Eastern and Central-NA Endemic

(retrorsely-barbed bristles; forma *controversa* (S.F. Blake) Gale = antrorsely-barbed bristles; forma *discutiens* (C.B. Clark) Gale = smooth bristles; various wet habitats and elevations)

Rhynchospora cephalantha Gray Bunched Beak-rush [S3, G5, LP]

Hydrophytic, Peripheral Southeastern-US Endemic

(retrorsely or rarely antrorsely-barbed bristles)

Rhynchospora chalarocephala Fern. & Gale Loose-Head Beak-rush

Hydrophytic, Peripheral Southeastern-US Endemic

(retrorsely-barbed bristles; various wet habitats)

Rhynchospora filifolia Gray Thread-Leaf Beak-rush [S1, G5, E, U]

Dispersal-limited, Hydrophytic, Peripheral Southeastern-US Neo-endemic

(antrorsely-barbed bristles)

Rhynchospora fusca (L.) Ait. f. Brown Beak-rush

Dispersal-limited, Hydrophytic, Peripheral NE and N-Central-NA Neo-endemic

(antrorsely-barbed bristles; various wet habitats)

Rhynchospora globularis (Chapman) Small Grass-like Beak-rush [S1, G5?, E]

Dispersal-Limited, Hydrophytic, Peripheral Southeastern-US Neo-endemic

(antrorsely-barbed bristles)

Rhynchospora glomerata (L.) Vahl Clustered Beak-rush [SH, G5T5?, E]

Dispersal-limited, Hydrophytic, Peripheral Southeastern-US Neo-endemic

(antrorsely-barbed bristles)

Rhynchospora gracilentia Gray Slender Beak-rush

Dispersal-limited, Hydrophytic, Peripheral Southern Neo-endemic

(antrorsely-barbed bristles; various moist to wet habitats)

Rhynchospora inundata (Oakes) Fern. Narrow-Fruit Horned B-r [S2, G3G4, LP]

Dispersal-limited, Hydrophytic, Eastern-US Neo-endemic

(antrorsely-barbed bristles)

Flora of New Jersey Project

Rhynchospora knieskernii Carey Knieskern's Beak-rush [S1, G1, E, LT, LP]

Edaphically-restricted, Hydrophytic, Mid-Atlantic-US Neo-endemic
(retrorsely-barbed bristles; narrow habitat preference)

Rhynchospora macrostachya Torr. Ex Gray Tall Horned Beak-rush

Dispersal-limited, Hydrophytic, Eastern and Central-US Neo-endemic
(antrorsely-barbed bristles; tubercle and bristles longest in the genus;
various wet habitats)

Rhynchospora microcephala (Britt.) Britt. Small-Head Beak-rush [S1, G5T5, E, U]

Hydrophytic, Southeastern-US Endemic
(retrorsely-barbed bristles)

Rhynchospora nitens (Vahl) Gray Short-Beak Beak-rush [S2, G4?]

Dispersal-limited, Hydrophytic, Eastern-US Neo-endemic;
(bristles obsolete)

Rhynchospora oligantha Gray Feather-Bristle Beak-rush [S2, G4, U]

Dispersal-limited, Hydrophytic, Peripheral Southeastern-US Neo-endemic
(antrorsely-barbed plumose bristles)

Rhynchospora pallida M.A. Curtis Pale Beak-rush [S3, G3]

Dispersal-limited, Hydrophytic, Mid-Atlantic/Southeastern-US Neo-endemic
(bristles vestigial and smooth, or obsolete)

Rhynchospora rariflora (Michx.) Ell. Few-Flower Beak-rush [S1, G5, E]

Dispersal-limited, Hydrophytic, Peripheral Southeastern-US Neo-endemic
(bristles reduced, antrorsely barbed)

Rhynchospora recognita (Gale) Kral Coarse Globe Beak-rush [S1, G5?, E]

Dispersal-limited, Hydrophytic, Eastern and Central-US Neo-endemic
(bristles reduced, antrorsely-barbed)

Flora of New Jersey Project

Rhynchospora scirpoides (Torr.) Gray Long-Beak Beak-rush [S2, G4]

Dispersal-limited, Hydrophytic, Eastern-US Neo-endemic; (bristles obsolete)

Rhynchospora torreyana Gray Torrey's Beak-rush

Dispersal-limited, Hydrophytic, Eastern-US Neo-endemic

(bristles reduced, antrorsely-barbed; various habitats)

Why Peripheral Species are Important.

Peripheral populations have conservation value, especially for rare, threatened, and endangered species, but their importance has not generally been recognized (Leppig and White 2006). For example, regulatory policy may not often be utilized to conserve biologically significant peripheral populations of otherwise common species, and scientific studies may not focus on peripheral populations because of a perception that they are not as important as core populations. However, peripheral populations of plants, such as those in the Pine Barrens, are likely to be influenced by selective factors that are different from those that influence central populations (Leppig and White 2006). For example, differing geographic selection regimes may result in morphological or ecological divergence, and the combination of geographic isolation and genetic divergence and directional selection may result in novel evolutionary trajectories (Leppig and White 2006) including the formation of new taxonomic entities restricted to the limits of a peripheral population. Because of the isolation and decrease in size of many peripheral populations, specialized breeding (e.g., self-compatibility) and specialized dispersal systems (e.g., loss of or limited dispersal mechanisms) may be favored in peripheral populations. Thus, peripheral populations tend to have a number of characteristics that make them particularly interesting for research and important for conservation (**Table 4**).

TABLE 4. Characteristics of Peripheral Plant Populations and/or their Habitats Compared to Core Populations (modified from Leppig and White 2006; Fiedler 1995; Ferren & Schuyler 1980; Ferren et al. 2006).²

- Geographic isolation
- Smaller population size
- More-variable population densities

² Some of these aspects can be paradoxical and result in either vulnerability or predisposition for survivability. Although some peripheral populations of the New Jersey Pine Barrens are known to exhibit one or more of these characteristics, little is known about the peripheral populations of most of the species represented by peripheral populations here.

Flora of New Jersey Project

- Ecologically distinctive habitats
 - Occupation of marginal habitats
 - Different natural selection regimes
 - Restricted gene flow
 - Specialized self-compatible breeding systems
 - Greater rates of genetic drift
 - Less genetic variation
 - Increased population-level differentiation
 - Greater morphological similarity within the population
 - Morphologically or physiologically distinct
 - Loss of or limited dispersal mechanisms
 - Decreased fitness
 - Greater risk for extirpation
-

Protected but Threatened

Peripheral populations have a conservation priority based on several important features. The combination of geographic isolation, ecological distinctiveness, and social value has been suggested as a set of principal criteria for evaluating the conservation priority of peripheral species, especially in the absence of genetic data (Lesica and Allendorf 1995; Leppig and White 2006). The New Jersey Pine Barrens provides an excellent opportunity as a case study for evaluating this conservation priority. It is a geographically isolated portion of the outer coastal plain of southern New Jersey, being isolated from the southeastern coastal plain pine forests and the coastal plain of Long Island. It is situated in a peninsula surrounded by other geographic areas, including the inner coastal plain to the west and north, the Delaware River and Bay geographic areas to the west and south, the coastal zone to the east, and the inner coastal plain to the north. The Pine Barrens also is well known for its ecological distinctiveness (Stone 1910; Harshberger 1916; ANSP 1967; Good 1982; Forman 1980), based in part on the underlying Cohansey Sandstone, vegetation, floristic composition, and transition zone between the northeastern and southeastern biogeographic areas. These are the very attributes that highlight its social value to the region, and that have prompted the many layers of formal protection at the national, state, and local levels.

In spite of its conservation importance, however, the flora of the New Jersey Pine Barrens remains at risk for many reasons. Risk factors include, but are not limited to:

- The lack of official national and state level protection for many rare species;

Flora of New Jersey Project

- Ongoing urban and agricultural development, especially in approved growth and agricultural areas;
- Management approaches that favor particular plant communities and ecological processes over others;
- Increasing occurrence of particular invasive exotic plant species;
- Increasing recreational activities including boating and off road vehicular traffic.

Knowledge gaps increase all these risk factors. With respect to peripheral species and possible New Jersey Pine Barrens endemics, data are virtually non-existent concerning local forms, ecotypes, genotypes and perhaps the occurrence of undescribed taxa. Two examples are illustrative:

Carex livida (Wahlenb.) Willd. is known throughout most of the northern portion of North America. The southern limit of its distribution in the eastern US is presumably the New Jersey Pine Barrens. Several facts, though, raise the question of whether the material here might be unique. Geographic location, morphological characters, and habitat make our population an anomaly. "Plants occurring disjunctly in acidic soils of the New Jersey Pine Barrens are unusually broad leaved, occasionally with leaves to 6.5 mm wide. These populations need further research to assess their status" (Ball & Reznicek 2003).

The identity of plants here that have long been called *Tofieldia racemosa* (Walter) Britton, Sterns & Poggenb. has recently come into question. A recent treatment (Packer 2003) moved the plants to the closely related genus *Triantha* (Nutt.) Baker. In this treatment the author speculates that the isolated population of plants occurring in the heart of the Pine Barrens, in Burlington County, is unique, appearing, in some respects, to be intermediate between two species, neither of which occurs here. "I suppose that in the past the two species had overlapping ranges in this northeastern region where they no longer are found, and that some hybridization between *T. glutinosa* and *T. racemosa* has occurred." If Packer's hypothesis is correct, the material here is a population of a fertile hybrid, now isolated from its putative parents, and its occurrence is unique to the Pine Barrens of New Jersey. In any case, the population is on its own unique evolutionary path.

To summarize, the combination of geographic isolation and ecological distinctiveness suggest a potentially high occurrence of unique populations in the Pine Barrens, especially of peripheral species, which increases the conservation value of the region as a whole. The combination of (1) the existing level of protection, (2) ongoing risk factors, and (3) likelihood of unknown, unique and endemic populations of peripheral plant species, however, argue for urgent conservation priority for the botanical heritage of the Pine Barrens.

Research Can Lead to Better Protection

Each new study of the native botanical heritage of the Pine Barrens provides important new information that can contribute to the understanding and preservation of the native flora. For example, a study conducted by Maser Consulting P. A. (2005) for the Medford/Evesham portion of the Pine Barrens produced the following findings:

- With each new study, additional plant species were added to the rare plant list for the sub-regional planning area.
- With each new study, additional localities for plant species known to the sub-regional planning area were added to the list of rare plants.
- New insights have been acquired on the composition of the rare plant flora and the different habitat and biogeographic affiliations the rare plants have within the sub-regional planning area.

Additional site-specific and species-specific intensive studies are likely to provide similar important new results. A study that focuses on the peripheral populations of plant species restricted to the Pine Barrens, for example, is likely to provide vitally important information regarding their richness, distribution, morphological characteristics, ecological affinities, and potentially their uniqueness as Pine Barren endemic forms. This information in turn can be used to make informed management decisions regarding vegetation communities that support those peripheral populations determined to have a conservation priority.

A Proposed Action Plan

To increase our understanding of the peripheral populations of plant species generally restricted in New Jersey to the Pine Barrens, which are a large portion of the rare and endangered plants of the region, we propose the following set of tiered actions:

1. Prepare a complete list of all species represented in the Pine Barrens by peripheral populations. This can be accomplished through a literature review, followed by confirmation with preserved specimens housed in regional herbaria.
2. Classify the types of rarity among the species with peripheral populations using the approach developed by Ferren et al. (2006). Categorize the representative types of rarity identified among the species with peripheral populations. Conduct an initial examination of the groupings for patterns of morphological adaptation, habitat affinity, and/or other trends.
3. Conduct field surveys of identified examples of the peripheral populations at various sites within the Pine Barrens, including at least three populations within each county that have

Flora of New Jersey Project

been determined to support each species of interest. Collect and preserve representative specimens, from multiple seasons as necessary, for voucher material as well as reference material to be examined for unique morphological characters and potentially for comparative DNA studies comparing the peripheral populations with core populations.

4. Select initial representative species for detailed studies including habitat, morphological, cytological, and genetic. If necessary conduct nursery or greenhouse experiments to determine if any identified unique characteristics are maintained under controlled or comparative studies.
5. Continue detailed studies of additional species with peripheral populations in the Pine Barrens. Identify any observed morphological or ecological patterns.
6. Prepare a report or reports on the initial and ongoing findings regarding peripheral populations of plant species restricted to the Pine Barrens. Report discoveries of potentially new unique forms to the appropriate interested parties.
7. Identify conservation priorities among the species with peripheral populations. Make management recommendations regarding the conservation of the important elements of the botanical heritage of the Pine Barrens.
8. Publish important findings in relevant professional journal(s).

Literature Cited and Other References

ANSP. 1967. *A Study of Significance of the Pine Barrens of New Jersey*. Prepared by the Academy of Natural Sciences of Philadelphia. Prepared for the National Park Service, USDI.

Ball, P. W. & A. A. Reznick. 2003. *Carex* Linnaeus. Flora of North America, vol. 23. www.eFloras.org (Accessed April 2011)

Boyd, H. P. 1991. *A Field Guide to the Pine Barrens of New Jersey, Its Flora, Fauna, and Historic Sites*. Plexus Publishing, Inc., Medford, NJ.

Boyd, H. P. 1997. *A Pine Barrens Odyssey. A Naturalist's Year in the Pine Barrens of New Jersey*. Plexus Publishing, Medford, NJ.

Boyd, H. P. 2001. *Wild Flowers Of The Pine Barrens Of New Jersey*. Plexus Publishing, Medford, NJ.

Breden, T. F. et al. 2001. *Classification of Vegetation Communities of New Jersey: Second Iteration*. Office of Natural Lands Management, Division of Parks and Forestry, NJDEP, Trenton, NJ. Digital version available through New Jersey Environmental Digital Library: (<http://njedl.rutgers.edu>). (Accessed September 2008)

Britton, N. L. 1889. *Catalogue of Plants Found in New Jersey*. N. J. Geological Survey, Final Report of the State Geologist.

Flora of New Jersey Project

Collins, B. R. and K. H. Anderson. 1994. *Plant Communities of New Jersey. A Study in Landscape Diversity*. Rutgers University Press, New Brunswick, NJ.

Cromartie, W. J., ed. 1982. *New Jersey's Endangered and Threatened Plants and Animals*. Center for Environmental Research, Stockton State College, Pomona, NJ.

Estill, J. C. and M. B. Cruzan. 2001. *Phytogeography of Rare Plant Species Endemic to the Southeastern United States*. *Castanea* 66:3-33.

Fairbrothers, D. E. 1979. *Endangered, Threatened, and Rare Vascular Plants of the Pine Barrens and Their Biogeography*. In, R. T. T. Forman (ed.), *Pine Barrens: Ecosystem and Landscape*, 395-405. Academic Press, New York.

Fairbrothers, D. E. 1998. *Endangered, Threatened, and Rare Vascular Plants of the Pine Barrens and their Biogeography* in Forman, R.T.T., ed., *Pine Barrens: Ecosystem and Landscape* (rev. ed.). Rutgers University Press, New Brunswick, NJ.

Fairbrothers, D. E. and M. Hough. 1973. *Rare or Endangered Vascular Plants of New Jersey*. Science Notes No. 14. New Jersey State Museum, Trenton, NJ.

Fernald, M. L. 1950. *Gray's Manual of Botany*. Eighth Edition. American Book Company, New York.

Ferren, W. R. Jr. and A. E. Schuyler. 1980. *Intertidal Vascular Plants of River Systems Near Philadelphia*. *Proc. Acad. Nat. Sci. Phila.* 132:86-120.

Fielder, P. L. 2001. *Rarity in Vascular Plants*. California Native Plant Society *Inventory On-Line*. http://www.cnps.org/programs/Rare_Plant/inventory/rarity.htm (Accessed September 2008)

Fielder, P. L. and J. J. Alhouse. 1992. *Hierarchies of Cause: Toward an Understanding of rarity in Vascular Plant Species*. In, P. L. Fielder and S.K. Jain (eds.), *Conservation Biology – The Theory and Practice of Nature Conservation, Preservation, and Management*, pp. 23-47.

Forman, R. T. T. (ed.). 1979. *Pine Barrens: Ecosystem and Landscape*. Academic Press, New York.

Gleason, H. A. 1952. *The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada* (3 volumes). New York Botanical Garden, Bronx.

Gleason, H. A. and A. Cronquist. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. Second Edition. The New York Botanical Garden, Bronx.

Good, R. E. (ed.). 1982. *Ecological Solutions to Environmental Management Issues in the Pinelands National Reserve: Proceedings of a Conference*. Center for Coastal and Environmental Studies, Division of Pinelands Research. Rutgers, The State University of New Jersey.

Gordon, T. 2004. *Rare Plants of the New Jersey Pine Barrens*. A Course Sponsored by the Pinelands Preservation Alliance, April – Oct, 2004.

Flora of New Jersey Project

- Grossman, D. H. et al. 1998. *International classification of ecological communities: terrestrial vegetation of the United States*. Volume I. The National Vegetation Classification System: development, status, and applications. The Nature Conservancy, Arlington, Virginia, USA. Accessed at <http://www.natureserve.org/library/vol1.pdf>.
- Harshberger, J. W. 1916. *The Vegetation of the New Jersey Pine-Barrens*. Christopher Sower Company, Philadelphia. (Dover Edition, 1970)
- Herlihy, C. R. and C. G. Eckert. 2005. *Evolution of Self-Pollination at Geographical Range Margins? A Comparison of Demographic, Floral, and Mating System Variable in Central vs. Peripheral Populations of Aquilegia canadensis (Ranunculaceae)*. American Journal of Botany 92:744-751.
- Hough, M. Y. 1983. *New Jersey Wild Plants*. Harmony Press, Harmony, NJ.
- Juelg, G. R. 2008. *South Jersey Plant Database*. Pinelands Preservation Alliance, Southampton, NJ.
- Juelg, G. R. and T. Gordon. 2007. *South Jersey Rare Plant Workbook* (unpublished early draft). Pinelands Preservation Alliance, Southampton, NJ.
- Leppig, G. and J. W. White. 2006. *Conservation of peripheral plant populations in California*. Madrono 53:264-274.
- Lesica, P. and F. W. Allendorf. 1995. *When Are Peripheral Populations Valuable for Conservation?* Conservation Biology 9:753-760.
- Maser Consulting P. A. 2005. *Field Surveys for rare and Endangered Plant Species of the New Jersey Pinelands: Southern Medford-Evesham Sub-regional Planning Area, Burlington County – Phase II: Spring 2005*. Prepared for the Pinelands Preservation Alliance, Southampton, New Jersey. MC Project No. 05000652 (August 12, 2005).
- McCormick, J. 1970. *The Pine Barrens—A Preliminary Ecological Inventory*. Academy of Natural Sciences of Philadelphia.
- McCormick, J. 1979. The Vegetation of the New Jersey Pine Barrens. In, R. T. T. Forman (ed.), *Pine Barrens: Ecosystem and Landscape*. Academic Press, New York.
- McCormick, J. and R. T. T. Forman. 1979. *Introduction: Location and Boundaries of the New Jersey Pine Barrens*. In, R. T. T. Forman (ed.), *Pine Barrens: Ecosystem and Landscape*. Academic Press, New York.
- Montgomery, J. D. and D. E. Fairbrothers. 1992. *New Jersey Ferns and Fern Allies*. Rutgers University Press, New Brunswick, NJ.
- NatureServe. <http://www.natureserve.org/library/vol1.pdf>
- Nelson, J. K. 2005. *Vascular Plant Species Risk Factors: A Review*. Shasta-Trinity National Forests, Redding, CA. http://www.fs.fed.us/r2/nebraska/gpng/plant_species_risk.html
- New Jersey Pinelands Commission. 1980. *New Jersey Pinelands Comprehensive Management Plan*. New Jersey Pinelands Commission, New Lisbon, NJ.

Flora of New Jersey Project

NJDEP. 2005. *List of Endangered Plant Species and Species of Special Concern*. Natural Heritage Program, Department of Environmental Protection, State of New Jersey.

<http://www.nj.gov/dep/parksandforests/natural/heritage/june2005plantlist.pdf>

Olsson, H. Vegetation of the New Jersey Pine Barrens: A Phytosociological Classification. 1979. *In*, R. T. T. Forman (ed.), *Pine Barrens: Ecosystem and Landscape*. Academic Press, New York.

Packer, J. G. 2003. *Triantha* (Nuttall) Baker. Flora of North America, vol. 26. www.eFloras.org. (Accessed April 2011)

Peterson, A. T. 2001. *Opinion - Endangered Species and Peripheral Populations: Cause for Reflection*. *Endangered Species Update* 18(2):30-31.

Pinelands Preservation Alliance 2007. Petition to Amend the CMP T&E Plant Provision (unpublished draft). <http://www.pinelandsalliance.org/>.

Quinn, J.A. and D.E. Fairbrothers 1971. Habitat ecology and chromosome numbers of natural populations of the *Danthonia sericea* complex. *Amer. Midl. Naturalist* 85:531-536

Rabinowitz, D. 1981. *Seven Forms of Rarity*. *In*, H. Synge (ed.), *The Biological Aspects of Rare Plant Conservation*, pp. 205-217. John Wiley & Sons, Ltd.

Rhodehamel, E. C. 1979. *Geology of the Pine Barrens of New Jersey*. *In*, R. T. T. Forman (ed.), *Pine Barrens: Ecosystem and Landscape*, pp. 39-60. Academic Press, New York.

Snyder, D. and E. Vivian. 1981. *Rare and Endangered Vascular Plant Species in New Jersey*. The Conservation and Environmental Studies Center, Inc.

Stone, W. 1911. *The Plants of Southern New Jersey, with Especial Reference to the Flora of the Pine Barrens and the Geographic Distribution of the Species*. Annual Report of the New Jersey State Museum, 1910, Part II. MacCrellish & Quigley, State Printers, Trenton.

Taylor, N. 1915. *Flora of the Vicinity of New York*. *Memoirs of the New York Botanical Garden*, Vol. V. Press of the New Era Printing Company.