Candidate Conservation Agreement
for Bog Asphodel (*Narthecium americanum*)
in Wharton State Forest, New Jersey

Cooperators:
U.S. Fish and Wildlife Service
New Jersey Department of Environmental Protection - Division of Parks and Forestry

November 2002

United States Department of the Interior

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In Reply Refer to:

ES-02/717

NOV 20 2002

Mr. Richard F. Barker, Acting Director
New Jersey Department of Environmental Protection
Division of Parks and Forestry
P.O. Box 404
Trenton, New Jersey 08625-0404

Dear Mr. Barker:

Pursuant to Cooperative Agreement Number 50181-0-J005 between the New Jersey Department of Environmental Protection, Division of Parks and Forestry (NJDP&F) and the U.S. Fish and Wildlife Service (Service), enclosed are two copies of the final **Candidate Conservation Agreement for Bog Asphodel (*Narthecium americanum*), in Wharton State Forest, New Jersey**. Regarding bog asphodel at Wharton State Forest, this agreement:

- summarizes the state of our knowledge about this plant species;
- describes the conservation efforts undertaken to date by NJDP&F and the Service;
- summarizes recent site observations for all the populations within the forest; and
- identifies research opportunities for this new phase of cooperation between NJDP&F and the Service.

Please sign both copies of the agreement on p. 50 and send one copy back to Carlo Popolizio of my staff for binding. Your comments, and those of your staff, were appreciated and considered while preparing the final agreement. Also, the Service remains available for a meeting with NJDP&F and other interested parties to discuss issues pertaining to Section XIII of this agreement. The meeting purpose should be to focus on and refine specific conservation tasks / research efforts and prepare a time table that will assign responsibilities and target due dates to the parties involved.

We look forward to working with NJDP&F to continue conservation efforts for the benefit of the bog asphodel at Wharton State Forest. If you have any questions regarding this agreement, please contact John Staples, Annette Scherer, or Carlo Popolizio of my staff at (609) 646-9310, extensions 18, 34, and 32, respectively.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

Candidate Conservation Agreement for Bog Asphodel (*Narthecium americanum*) in Wharton State Forest, New Jersey

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November 2002

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Candidate Conservation Agreement for Bog Asphodel (*Narthecium americanum*) in Wharton State Forest, New Jersey

I. INTRODUCTION

This Candidate Conservation Agreement (Agreement) has been developed to implement conservation measures for bog asphodel (*Narthecium americanum* Ker-Gawler, Liliaceae) as a cooperative effort among Wharton State Forest (WSF), New Jersey; the New Jersey Department of Environmental Protection, Division of Parks and Forestry (NJDP&F); and the U.S. Fish and Wildlife Service (Service). Ecological concerns that warrant bog asphodel listing as threatened or endangered under the Endangered Species Act (ESA) of 1973, as amended (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq*.), should be significantly reduced through implementing conservation strategies noted in Sections XII and XIII of this Agreement. The Agreement will provide additional measures to enhance bog asphodel populations, supplementing protection currently afforded to the species by NJDP&F.

With the Service's support, NJDP&F produced a comprehensive series of publications on population surveys for bog asphodel, namely Windisch (1993) for West Branch Wading River and Oswego River corridors; Hill (1993) for Wharton and Lebanon State Forests; Radis (1993) for the Batsto River corridor, WSF; and Gordon (1996) for Atlantic and Burlington Counties. Schuyler (1995) surveyed historical and known bog asphodel populations on private lands. In these publications, populations are estimated as number of vegetative and flowering plants (individuals are virtually impossible to count for plant species that are rhizomatous but, for the purpose of this agreement, discrete, above-ground portions of the bog asphodel will be called individuals). Moreover, NJDP&F produced the confidential *Handbook of* Narthecium americanum *Populations on State Owned and Managed Lands*, summarizing site-specific survey results, potential threats, and preliminary management recommendations (Cartica, 1995).

Also with the Service's support, NJDP&F published the results of an investigation on hydrology and succession at ten sites populated with bog asphodel (Dodds, 1996) and revised the boundary of Batsto Natural Area within WSF, incorporating 35 percent of bog asphodel's global occurrences into the new boundary and providing bog asphodel with the most protective designation available for State-owned conservation lands (Cartica, 1996). A year later, proposals for active management of bog asphodel, as well as conservation plans and enhancement measures for populations, began to emerge in confidential reports by Dodds (1997a, b), Dodds and Cartica (1997), and Dodds and Goodwin (1997). More recently, *de novo* surveys were launched, implementing GIS technology to locate potential habitat for bog asphodel that had not been surveyed in the past (Breden *et al*., 1998). The surveys resulted in the discovery of a new bog asphodel population comprising a few thousand individuals.

Most recently, the Environmental Protection Agency funded a series of NJDP&F research projects within the Pinelands' savannas on community classification (Walz *et al*., 2000), palynology and fire history (Russell, 2000), and geomorphology (Stanford, 2000). Significant results and findings were:

- the classification of six savanna plant associations;
- the documented presence of a savanna community at a site for over 8,000 years by pollen counts and identification, demonstrating that savannas are not uniquely early successional stages of Atlantic white-cedar (*Chamaecyparis thyoides*) swamps;
- the successional conversions of Atlantic white-cedar swamps into savanna types by logging;
- the historical abundance of savanna community types and their decrease resulting from conversions to cranberry bog operations;
- the important role of fire in savanna ecology;
- the origins of Pinelands' rivers, almost exclusively sustained by groundwater of artesian origin;
- the Pinelands' geomorphology; and
- the historical uses of savannas (turf cutting, surface mining, and peat extraction).

II. STATUS OF BOG ASPHODEL

Bog asphodel is listed by the State of New Jersey as an endangered species (N.J.A.C. 7:5C-1.1 *et seq*.). The New Jersey Natural Heritage Program (State of New Jersey, 1998) ranked bog asphodel as imperiled both globally and State-wide (G2, S2). The New Jersey Natural Heritage Database (State of New Jersey, 2002a) contains records for 66 occurrences (45 extant, 11 historical, and 10 extirpated) of bog asphodel. Within WSF, there are records of 33 occurrences (28 extant, 2 historic, and 3 confirmed or presumed extirpated) (State of New Jersey, 2002b). With the exception of one population in Greenwood Forest Wildlife Management Area administered by the New Jersey Division of Fish and Wildlife, all populations of bog asphodel on State lands are managed by the NJDP&F.

Bog asphodel was listed by the U.S. Fish and Wildlife Service as a Category 2 taxon from 1980 until 1990 (U.S. Fish and Wildlife Service 1980; 1985). In 1990, the status of bog asphodel was re-evaluated. The taxon was elevated to Category 1 status (U.S. Fish and Wildlife Service, 1990) and was retained following review (U.S. Fish and Wildlife Service, 1993). In 1996, category listings were eliminated and bog asphodel became listed as a candidate species (U.S. Fish and Wildlife Service, 1996). This determination has not changed to date (U.S. Fish and Wildlife Service, 1997; 1999). While the Service has gathered sufficient information on biological vulnerability and threats to support a

proposal to list bog asphodel as endangered or threatened, implementation of conservation activities may lessen or prevent the need for such listing.

III. GOALS

The goals of this conservation agreement are to ensure the conservation, protection, and survival of bog asphodel within WSF and to assist in developing cooperative conservation efforts between NJDP&F and the Service.

IV. OBJECTIVES

The following five objectives will be required to attain the goals of this agreement:

Objective 1: Eliminate or significantly reduce threats to bog asphodel and its habitat to the extent necessary to prevent extirpation of populations throughout all or a portion of the species' current range in Wharton State Forest, or the likelihood that these populations will become endangered within the foreseeable future throughout all or a portion of Wharton State Forest.

Objective 2: Restore and maintain a sufficient number of populations of bog asphodel and habitat to support these populations and ensure the continued existence of the species throughout its current range in Wharton State Forest.

Objective 3: Establish monitoring protocols, a communication network, and an information database to better evaluate the periodic status of bog asphodel populations and assess the success of conservation and management efforts.

Objective 4: Fill data gaps pertaining to the ecology and life history of bog asphodel.

Objective 5: Conduct searches for unknown populations of bog asphodel based on historical information, GIS layering, and/or intuitive reconnaissance.

These objectives will be reached through implementation of the specific measures set forth in Sections XII and XIII of this Agreement. The parties to this Agreement understand that failure to implement the Agreement or failure of such measures to remove threats to the species' continued existence will be considered by the Service in making its determination on whether listing of bog asphodel as a threatened or endangered species is required under the ESA.

V. SPECIES DESCRIPTION

Bog asphodel is a perennial herb that grows 25-40 centimeters (cm) high and has basal leaves 10-20

cm long that extend from slender underground rhizomes. The basal leaves are narrow [1-2 millimeters (mm) (Gleason and Cronquist, 1991); 1.5-3.0 mm (Radford *et al*., 1968); 2-5 mm (personal observation)], con-duplicate (enfolded lengthwise), stiff, and with parallel veins (7-9 nerves). Culm leaves are few and greatly reduced in length. A dense raceme (2-5 cm long) of small, showy, bright-yellow flowers tops the simple, erect flowering culm from late June through July. Each flower is made up of six tepals that persist around the fruit (capsule), six stamens with filaments half as long as the tepals, and a superior ovary with a minutely three-lobed stigma. The perianth, raceme, and flowering culm are long-persisting. Capsules are long-pointed, reddish-brown (up to 14 mm long). Seeds are pale yellow, fusiform and long-pointed (Fernald, 1950; Radford *et al*., 1968; Schuyler, 1990; Gleason and Cronquist, 1991).

VI. NOMENCLATURE

Bog asphodel was historically and scientifically known by the synonyms *Abama montana* Small, *Abama americana* (Ker-Gawler) Morong, and *Narthecium ossifragum* (L.) Huds. variety *americanum* (Ker-Gawler) Gray (Stone, 1911; Fernald, 1950; Radford *et al*., 1968; Gleason and Cronquist, 1991; Natural Resources Conservation Service, 1999). *Narthecium californicum* Baker is the only other species within this genus in the United States (Natural Resources Conservation Service, 1999). The generic name comes from the Greek *narthecion*, meaning a chest or box to store ointments (Fernald, 1950), likely referring to the capsule's shape. A common name synonym is yellow asphodel (Fernald, 1950; Natural Resources Conservation Service, 1999).

VII. HABITAT

Bog asphodel habitat occurs in Pinelands' mesic to wet savanna areas, usually with water moving through the substrate, as well as sandy bogs along streams and rivers (Stone, 1911; Fernald, 1950; Radford *et al*., 1968; Schuyler, 1990; Gleason and Cronquist, 1991). In the New Jersey Pinelands, savannas occur adjacent to rivers and creeks, often separated by a wooded levee and bordered by an Atlantic white-cedar swamp. Listed micro-habitats include open bogs surrounded by Atlantic white-cedar, lowlands near sharp river bends and oxbow meanders, *Sphagnum* bogs, iron ore streamlet seeps, small mat hummocks, quaking bogs, mud flats, sunny borders with Atlantic white-cedar swamps, and transitional areas (ecotones) (Radis, 1993; Dodds, 1996; Dodds and Goodwin, 1997). Walz *et al*. (2000) described six plant associations within the New Jersey Pinelands:

- *Orontium aquaticum -Juncus pelocarpus - Drosera intermedia*
  (semi-permanently flooded herbaceous vegetation) (G3G4 S3);

- *Cladium mariscoides - Panicum longifolium*
  (semi-permanently flooded herbaceous vegetation) (G3 S2S3);

- *Rhynchospora* (*alba, cephalantha*) - *Muhlenbergia uniflora* - *Lophiola aurea* (saturated herbaceous vegetation) (G2 S2);

- *Muhlenbergia torreyana* - *Lobelia canbyi* - *Rhynchospora alba* (saturated herbaceous vegetation) (G2 S2);

- *Narthecium americanum* - *Sarracenia purpurea* - *Drosera filiformis / Sphagnum pulchrum* (saturated herbaceous vegetation) (G2 S2); and

- *Chamaecyparis thyoides* - *Gaylussacia dumosa / Andropogon glomeratus* (saturated shrub-herbaceous vegetation) (G2G3 S2).

The growth of woody vegetation in savanna communities is most likely suppressed by substrates of iron ore deposits, by continual ground water seepage, and by intermittent flooding from adjacent rivers and creeks (Cartica, 1999; Walz *et al*., 2000). The end of one of these flooding events, which occurred after several days of heavy rain, was witnessed in March 2000 by Service personnel. Two feet of moving water had temporarily flooded the savanna at the Below Big Doughnut site along the Mullica River, with no noticeable negative effect on the bog asphodel population at the site. Russell (2000) documented the presence of a savanna community at the Above Buck Run site for over 8,000 years by pollen counts and identification, and found bog asphodel pollen in the peat from 1,200 years ago. Russell (2000) and Walz *et al*. (2000) underlined the important role of fire in savanna ecology by obtaining evidence of periodic, historical fires that consumed peat strata as thick as 48 cm.

VIII. OTHER FEDERALLY LISTED AND STATE ENDANGERED PLANT SPECIES / SPECIES OF CONCERN

The primary focus of this Agreement is the conservation and enhancement of bog asphodel and the ecosystems upon which it depends; however, other rare species occurring within or adjacent to bog asphodel habitat should also benefit. Some of the rare species documented by Cartica (1995), Dodds (1996), Dodds and Cartica (1997), Dodds and Goodwin (1997), Gordon (1996), Hill (1993), Radis (1993), Schuyler (1990, 1995), the State of New Jersey (1980, 1998), and Windisch (1993) are presented in Table 1. Using an ecosystem approach, accomplishment of actions identified in the Agreement should significantly reduce or eliminate threats to these species and the need for federal protection pursuant to the ESA.

Table 1. Federally and State-listed plant species, and species of concern associated with bog asphodel.

Scientific Name	Common Name	Global	State	Federal	State	Pinelands
Arethusa bulbosa	dragon mouth	G4	S2			
Asclepias rubra	red milkweed	G4/G5	S2			LP
Calamagrostis pickeringii	Pickering's reedgrass	G4	S1		E	
Calamovilfa brevipilis	pine barren reedgrass					LP
Carex barrattii	Barratt's sedge					LP
Eriophorum tenellum	rough cottongrass	G5	S1		E	
Eupatorium resinosum	pine barren boneset	G3	S2		E	LP
Gentiana autumnalis	pine barren gentian	G3	S3			LP
Juncus caesariensis	New Jersey rush	G2	S2		E	LP
Lobelia canbyi	Canby's lobelia					LP
Muhlenbergia torreyana	pine barren smoke grass	G3	S3			LP
Nymphoides cordata	floating heart	G5	S3			LP
Panicum scabriusculum	sheathed panic grass	G4	S2			
Platanthera ciliaris	yellow-fringed orchid	G5	S2			LP
Platanthera cristata	crested yellow orchid	G5	S3			LP
Platanthera integra	yellow fringeless orchid	G3/G4	S1		E	LP
Potamogeton confervoides	algae-like pondweed	G3/G4	S2			
Prenanthes autumnalis	pine barrens rattlesnake root	G4/G5	S2			LP
Rhynchospora	large-headed beaked rush	G5	S3			LP
Rhynchospora inundata	horned beaked rush	G3/G4	S2			LP
Rhynchospora knieskernii	Knieskern's beaked-rush	G1	S1	LT	E	LP
Rhynchospora oligantha	few-flowered beaked-rush	G4	S2			
Rhynchospora pallida	pale beaked rush	G3	S3			
Schizaea pusilla	curly grass fern	G3	S3			LP
Scirpus longii	Long's bulrush	G2	S2		E	LP
Scleria minor	slender nut rush					LP
Scleria reticularis	reticulated nut rush					LP
Sclerolepis uniflora	bog buttons	G4	S2			LP
Solidago stricta	wand-like goldenrod	G5	S3			LP
Sphagnum cyclophyllum	sphagnum	G3	S2			
Sphagnum portoricense	sphagnum	G5	S2			
Spiranthes laciniata	lace-lip ladies'-tresses	G4/G5	S1		E	
Tofieldia racemosa	false asphodel	G5	S1		E	LP
Utricularia purpurea	purple bladderwort	G5	S3			LP
Utricularia resupinata	reversed bladderwort	G4	S1		E	LP
Xyris fimbriata	fringed yellow-eyed grass	G5	S1		E	

IX. ECOLOGY AND LIFE HISTORY

Very little research has been conducted to date on the ecology and life history of bog asphodel. Scientific experimental designs, testing of hypotheses, and monitoring studies pertaining to life history are warranted, although caution should be taken not to damage the population under study by excessive trampling in bog asphodel habitats. In New Jersey, bog asphodel grows scattered on hummocks and in mucky soil. Large populations form dense green mats of leaves in late spring and throughout the summer months, although they may remain relatively inconspicuous without inflorescences. Bog asphodel may reproduce sexually by producing flowers and seeds and vegetatively by growing and spreading rhizomes. However, pollinators and specialized sexual reproductive strategies are unknown. Bog asphodel flowers in late June through July (Gleason and Cronquist, 1991). The reproducing plants are easily distinguished by their showy raceme of yellow flowers or reddish capsules. Racemes may persist for one year, becoming straw-colored, or for two or more, turning gray in color. However, not all individual plants (defined here as the above-ground portions originating from a rhizome) reproduce sexually every year, depending perhaps on the amount of shading from woody encroachment (Dodds, 1996), excessively wet conditions, substrate types, and nutrient deficiencies (observations by Service personnel).

X. DISTRIBUTION

The historic range of bog asphodel was New Jersey, Delaware, North Carolina, and South Carolina (U.S. Fish and Wildlife Service, 1999). Bog asphodel is currently listed as extirpated (SX) in Delaware and North Carolina (Delaware Natural Heritage Program, 2000; North Carolina Natural Heritage Program, 2000). According to Frost and Boyer (pers. comms., 2000), bog asphodel has not been seen for many years in its historical range in Henderson County, North Carolina; its former habitat currently being a Superfund site. The North Carolina Department of Agriculture and Consumer Services has recently purchased a bog in Henderson County, representing a portion of *Narthecium* historic habitat, and would like to re-introduce the species there (Frost, pers. comm., 2000). In South Carolina, bog asphodel is assumed to be historical (SH), although it remains a conservation priority in the State (South Carolina Heritage Program, 2000). Schuyler (1990) determined that bog asphodel is currently limited to the Pinelands region of New Jersey. According to the Natural Heritage Database, 45 extant populations of bog asphodel are located in a very limited geographical area within Atlantic, Burlington, and Ocean Counties of New Jersey and are found in watersheds of the Batsto, Forked, Mullica, Oswego, and West Branch Wading Rivers; Cold Run, Oyster and Nescochague Creeks; and Morses Mill Stream (Cartica, 1999; State of New Jersey, 2002a).

XI. SUMMARY OF CONSERVATION AND MANAGEMENT ACTIVITIES 1985-2000

The success of any conservation or recovery program depends on eliminating or reducing the impact of activities that threaten the species existence. The following list highlights and summarizes conservation and recovery activities that were conducted since 1985 to address the threats facing bog asphodel. The list is also a compilation of problems and threats as perceived by researchers and managers of bog

asphodel populations, which signatories to this agreement will address with management actions. Major threats to the persistence of bog asphodel populations within WSF have been highlighted by State resource managers and field personnel (Hill, 1993; Radis, 1993; Windisch, 1993; Cartica, 1995; Schuyler, 1995; Cartica,1996; Dodds, 1996; Gordon, 1996; Dodds and Cartica, 1997; Dodds and Goodwin, 1997; Breden, *et al.*, 1998; Cartica, 1999), as well as Service personnel. More recently, the Service signed a cooperative agreement with NJDP&F to support implementation of conservation activities beneficial to bog asphodel. Pursuant to the cooperative agreement, the Service obligated funding to NJDP&F in the amount of $24,500 for these purposes (U.S. Fish and Wildlife Service, 2000).

A. THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF ITS HABITAT OR RANGE

No research data are available on hydrological requirements pertaining to bog asphodel, although it appears that soil saturation and shallow inundation are essential conditions for maintaining healthy populations. Therefore, there is an obvious reluctance to modify water levels for bog asphodel conservation based on observation only.

At two sites within WSF (Below the Locks and Twin Savanna), several dozen cedar trees were felled to reduce shading on dwindling bog asphodel populations (Dodds and Cartica, 1997). The cut was conducted in November 1997 and, so far, there is no indication that it benefitted the populations. The bog asphodel populations at the Below the Locks and Twin Savanna sites were visited in March, July, and September 2000 by Service personnel and appeared to be as described in 1993. From growing season 1997 to 2000, the populations actually decreased in the number of individuals by two-fold and nine-fold at the two sites, respectively. Flowering did not increase at Below the Locks; 22 individuals flowered at Twin Savanna. Pre- and post-treatment quantitative data were never collected from permanent plots. Other sites were proposed for Atlantic white-cedar cuts as well, but permits were disallowed by the WSF because of Atlantic white-cedar conservation issues and potential public disapproval. The State may attempt shade reduction projects in the near future, but only on a very limited basis (Cartica, pers. comm., 2000). Some savannas have remained at their successional stage for centuries while others were the result of logging Atlantic white-cedar stands (Russell, 2000; Walz *et al.*, 2000). The Service recommends obtaining further research data on the effects of hydrology, nutrients, substrate, and shade on bog asphodel's ability to reproduce sexually and vegetatively prior to conducting Atlantic white-cedar cuts.

The use of fire as a management tool has been advocated. An instance at the Pump House Bog has been documented where a natural fire slowed successional processes, benefitting a bog asphodel population. Fire regimes have been altered in the Pinelands. Fire must be relatively hot to provide for successful habitat modifications in wetland areas, but there is a reluctance to propose prescribed burns for bog asphodel because research data are lacking. Excessive accumulations of litter and smothering of bog asphodel individuals and populations by vigorous

growth of graminoids have been documented on limited occasions. This encroachment is likely the result of decreases in hydrological levels and/or fire suppression.

Very little is known about bog asphodel's ecology. Demography, genetic variations, hydrological requirements, types of substrates, nutrient requirements, responses to succession and fire, life history, reproductive and pollination biology, dispersal, and parasitism are presumably unknown. Population management is hampered by lack of these research data.

B. DISEASE OR PREDATION

Deer and geese are known to crop some of the flowering culms occasionally (Windisch, 1993; Dodds and Goodwin, 1997). These instances cannot be considered major threats to bog asphodel, although they have been reported from time to time. Deer use bog asphodel habitat quite extensively. Trampling by deer was observed frequently, but without noticeable detrimental impacts to bog asphodel populations overall. At the Twin Savanna site, a deer trail ran across the center of a small bog asphodel population, damaging one of the fruiting culms.

Seed predation by long-horned grasshoppers has been documented (Doods and Goodwin, 1997), although little is known about the frequency and intensity of this predation on bog asphodel capsules. No other diseases or predators are known to adversely affect bog asphodel populations.

C. OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

Some of these activities have been documented, particularly collecting wildflower bouquets and trampling of habitats. The rivers within WSF are also major attractions to canoeists and campers. There may be a few opportunities to prevent canoe landing nearby bog asphodel sites by creating natural barriers. During Service field inspections, trash was observed only infrequently. A few road pullouts could be closed and restored to discourage site visits and foot traffic in nearby bog asphodel populations. However, these restoration methods need to be closely monitored and enforced or they will fail. As an example, restoration activities at the Martha Pond population (closing of eroding road, application of preventive erosional methods,
and re-seeding in 1994) failed completely when recreationists reclaimed the obliterated road with their off-road vehicles. Restricting areas with signs was proposed by the Office of Natural Lands Management (ONLM) and rejected by WSF. The rational was that signs attract people to a site.

D. THE INADEQUACY OF EXISTING REGULATORY MECHANISMS

With the Service's support, NJDP&F revised the boundary of Batsto Natural Area within WSF, incorporating 35 percent of bog asphodel's global occurrences into the new boundary and providing bog asphodel with the most protective designation available for State-owned

conservation lands (Cartica, 1996). Most of the occurrences in Batsto Natural Area are demonstrably secure.

Cranberry operations have been notoriously detrimental to bog asphodel because of water management strategies (flooding) associated with cultivation and water diversion from rivers and creeks (Stone, 1911). Cranberry operations are also responsible for direct conversion and destruction of savannas, particularly in the upper watersheds (Walz *et al.*, 2000; State of New Jersey, 2001). Expansion of cranberry bog operations allowed under new State regulations may pose a threat to bog asphodel.

Non-point sources of pollution and changes in pH are potential threats that were not mentioned, observed, or quantified, but should be included and addressed. There is a lack of regulatory controls over factors such as human demands for water outside WSF that are affecting the hydrology of WSF wetlands. Droughts can compound the adverse effects on bog asphodel.

Finally, lack of enforcement regarding off-road vehicles use within WSF resulted in trail and road damage near Fawn Bog, Three Bogs, and Ice House sites; trespassing into a posted wilderness area near Cold Spring Bog site; and destruction of a restoration project preventing road erosion into a bog asphodel sub-population at Martha Pond site. More recent incidents, including a savanna along the Nescochague Creek at WSF and severe damage to a bog asphodel population and its habitat in the Forked River drainage, suggest that periodic catastrophic incidents such as these may constitute the single greatest threat to the security of populations. Further, we should anticipate that illegal off-road vehicle use will continue to adversely affect bog asphodel in the future and prepare strategies to avoid further occurrences.

E. OTHER NATURAL OR MANMADE FACTORS AFFECTING ITS CONTINUED EXISTENCE

Beaver activities have been detrimental at the Above the Locks site on the Batsto River, where the bog asphodel population was completely flooded. Conversely, beaver have been providing hydrological support for bog asphodel habitat at the Pump House Bog site on the Oswego River.

XII. SITE INFORMATION SUMMARIES, SURVEY YEAR 2000 OBSERVATIONS, AND PROPOSED CONSERVATION ACTIONS

The site-specific monitoring and management actions outlined below have been recommended by the Service to meet the objectives set forth in this Agreement. The site recommendations are preliminary, pending development of more detailed monitoring procedures by the NJDP&F and the Service. Further, management actions are likely to be modified as more information is gathered on existing populations and on the species' life history. Consideration was given to the problems existing at locations where bog asphodel populations currently exist. Management actions are intended to alleviate threats to bog asphodel populations, the habitats that support them, and other rare plant associates in the savanna communities. General locations of the following sites are presented in Appendix A. The

rationale for ranking element occurrences is listed in Appendix B. Five of the occurrences described under this section (Ore Spong, Above Buck Run, Pebbel Spong, Hidden Savanna, and Whispering Savanna) are newer occurrences based on sources other than the Natural Heritage Database. Walz (pers. comm., 2002) is the source for the former four populations and Service personnel located Whispering Savanna, which is being treated as a sub-population of the Unexpected Site.

A. BATSTO RIVER

1. Batsto Bog (occurrence number 044)

a. Past site observations

The site was described by Radis (1993) as a large, wet complex of habitats such as Atlantic white-cedar swamp, savanna, quaking *Sphagnum* bog, and muck. Batsto Bog is located on the east bank of the Batsto River, approximately 2.0 miles north of Batsto Village. Over 10,000 individuals and thousands of culms with maturing capsules were estimated. Rare taxa included the State- and Pinelands-listed species bog buttons and yellow fringed orchid, and the species of concern, sheathed panic grass.

The site was described by Dodds and Goodwin (1997) as a 20-acre bog surrounded by Atlantic white-cedar on three sides and partially separated from the Batsto River by a levee. Bog asphodel was seen growing in open bog, in large savannas, and in transitional areas. Tens of thousands of individuals were estimated with thousands of flowering culms. Pale beaked-rush and curly grass fern (species of concern), and New Jersey rush (State-listed as endangered) were documented during the survey.

b. Recent observations

The site was visited by Service personnel on September 19, 2000. The site is best accessed by taking the road/trail downslope to the Batsto River from the intersection of unnamed creek and the sand road connecting Batsto Village and Quaker Bridge on the east side of Batsto River. The population at Batsto Bog is spectacular. The population has been ranked “A” since 1985. Most individuals were growing in slow-moving water within open canopy, among shrubs tentatively identified as dwarf huckleberry (*Gaylussacia dumosa*) and surrounded by Atlantic white-cedar with interspersed lowland pitch pine (*Pinus rigida*). Associates were also pipewort (*Eriocaulon decangulare*), beaked rush (*Rhynchospora* spp.), bog aster (*Aster nemoralis*), gold crest (*Lophiola americana*), clubmoss (*Lycopodium* sp.), and lowland broom-sedge (*Andropogon glomeratus*). Others occurred in sphagnum moss habitat near Atlantic white-cedar trees. Tens of thousands of individuals were present. Bog asphodel was displaying a profusion of fruiting culms, up to 20 within a clump and several hundred throughout the area. The population was thoroughly described by Dodds and Goodwin (1997); therefore, no further efforts at characterizing the site were attempted to avoid trampling dense bog asphodel cover.

c. Site recommendations

Radis (1993) recommended posting signs at the site and limiting access to special permit only. These precautionary measures are likely to attract visitors to the site; therefore, WSF has so far rejected these proposals. Dodds and Goodwin (1997) proposed to monitor this population every 3-4 years, and to establish permanent photo points at the site to gather ecological trend evidence. The Service recommends avoiding Batsto Bog as a research site, except for periodic monitoring and photographic trend recording. Hydrology supporting the bog asphodel population in the proximity to the Batsto River is sustained by an unnamed creek, which extends to the east for approximately 2.0 miles. According to United States Geological Survey topographic maps, the unnamed creek originates approximately 0.6 mile south of Penn Swamp. Protection of this unnamed creek is critical to survival of the bog asphodel's population at Batsto Bog.

2. Batsto Oxbow (occurrence number 002)

a. Past site observations

The site was described by Radis (1993) as a small savanna at a sharp bend on the west bank of the Batsto River, approximately 1.5 miles north of Batsto Village. Apparently, most of the habitat was overgrown by Atlantic white-cedar and red maple (*Acer rubrum*) and only a small area received direct sunlight. Bog asphodel was not found at the site.

Gordon (1996) found the population along a back cove on the east bank of the Batsto River. Bog asphodel had been first sighted here in the 1800s and again in 1930. Apparently, the population was stable for 66 years. There were four or five major pockets of bog asphodel over 0.5 acre, totaling 1,300 fruiting culms and over 500 vegetative individuals. Documented State-listed species were false asphodel and New Jersey Rush; Pinelands-listed species were curly grass fern, pine barren reed grass, Canby's lobelia, and reticulated nut rush. Gordon (1996) extended the search 1,000 yards north through dense Atlantic white-cedar and found 6 and 8 fruiting culms of bog asphodel in two small areas.

b. Recent observations

The site was visited by Service personnel on October 2, 2000. A large Atlantic white-cedar swamp buffers the bog asphodel population from the lowland trail to the east. To the south, following a narrow foot trail, there is a band of red maple and mixed shrubs growing along a small, unnamed stream. Access to the bog asphodel population is easier by cutting directly across the Atlantic white-cedar swamp to the north as a result of wet, relatively arduous and treacherous conditions encountered near the ecotone between the maple swamp and the Atlantic white-cedar swamp. Caution is recommended when re-visiting this site because of wet, sinking ground. It was hard to obtain an accurate number of bog asphodel individuals because of flooded conditions. Some fruiting culms were submerged in 5 inches of water and the back

cove described by Gordon was completely flooded to the Atlantic white-cedar swamp's margin. Flooded conditions were likely the result of rain events preceding the site visit.

c. Site recommendations

Gordon (1996) listed succession by Atlantic white-cedar as a potential threat, although limited by flooding events. The Service recommends establishing permanent monitoring methods, including permanent points to be photographed during yearly monitoring visits. Also, the hydrological conditions should be thoroughly evaluated to understand if flooding observed in October 2000 represented a temporary or permanent change over time, adversely affecting the bog asphodel population at the site, and whether these conditions represent the wet extreme of the hydrological range suitable to bog asphodel.

3. Beaver Trail Savanna (occurrence number 066)

a. Past site observations

Beaver Trail Savanna, a *de novo* population of bog asphodel, is located on the east bank of the Batsto River, approximately 1.0 mile south of Quaker Bridge. Dodds and Goodwin (1997) found approximately 250 individuals in one patch and 100 vegetative individuals in a second patch. Approximately 25 flowering culms were sighted within the population. Rare taxa documented at the site were New Jersey rush (State-listed); pine barren reed grass, Canby's lobelia, pine barren smoke grass, and curly grass fern (Pinelands-listed); and sheathed panic grass and pale beaked rush (species of concern).

b. Recent observations

The site was visited by Service personnel on July 20 and September 20, 2000. Perhaps two dozen bog asphodel individuals were observed in the southernmost portion of the site. Twenty-three flowering culms were observed in July, but none were there in September. Signs of recruitment by vegetative propagation were obvious. This area was muddy and mostly flooded with 2-4 inches of slow-moving water. The main sub-population to the north was composed of approximately 200 vegetative individuals and 15 fruiting culms. Hummocks where bog asphodel grew were surrounded by 1-2 inches of water. The savanna was protected by a large Atlantic white-cedar swamp to the east. Common associates were Canada rush (*Juncus canadensis*), lowland broom-sedge, beaked rush, and pipewort.

c. Site recommendations

Dodds and Goodwin (1997) documented the presence of beaver at this site, as indicated by several trails and cut trees. There was no historical information on the impacts of beaver on bog asphodel, as

Beaver Trail Savanna represented a *de novo* site. Therefore, it was unclear if beaver activities provided bog asphodel with hydrological support or not. The beaver landing site was still present in September 2000, but no signs of disturbance to the entire population were obvious. Dodds and Goodwin (1997) also recommended documenting trends by photograph at the site from fixed points. The authors expressed concern over building up of organic matter, dry conditions, successional advancement, and human use of the site (Atlantic white-cedar logs were harvested and removed). In September 2000, Service personnel observed wet conditions and no immediate threats to the bog asphodel population, except for flower cropping. The Service recommends including Beaver Trail Savanna site in a study targeted for determining flowering success in bog asphodel populations.

4. Fawn Bog (occurrence number 042)

a. Past site observations

The site was described by Hill (1993) as open *Sphagnum* bog, with a levee covered by Atlantic white-cedar, located in an oxbow on the east bank of the Batsto River. The site was rich with iron ore streamlets seeping through the area and appeared in pristine condition. A vigorous population of bog asphodel was sighted.

The site was described by Dodds and Goodwin (1997) as a bog subdivided in open water to the north and savanna in the remainder, approximately 0.75 acre in size, and surrounded by Atlantic white-cedar as well as a band of shrubs in between. Thousands of bog asphodel plants were found, including approximately 200 that were flowering.

b. Recent observations

The site was visited by Service personnel on October 23, 2000. A small creek descending toward the Batsto River from the northeastern uplands sustains an Atlantic white-cedar swamp and an open iron-ore bog and quaking bog / savanna, with plentiful bog asphodel dominating sizeable portions of these open areas. Bog asphodel was also observed along the stream within Atlantic white-cedar tree cover. The population was well over 10,000 individuals with several hundred fruiting culms.

c. Site recommendations

Hill (1993) sighted trash (including cans) in the swamp upstream from the site. No other apparent disturbances were reported. Dodds and Goodwin (1997) recommended considering tree removal to provide more direct sunlight to the population. The population was ranked “A” in 1985 and 1993, but was downgraded to “B” because of a low percentage of flowering culms. The Service has concluded that neither tree cutting nor downgrading the population are warranted. The population flowered profusely in 2000 and appeared very healthy. The site is remote and undisturbed. There was evidence of deer browsing on low shrubs under Atlantic white-cedar canopy, but none on bog asphodel. Permanent monitoring methods should be selected and applied to this site. Also, permanent points

should be established and photographed during monitoring visits. An upland foot trail is frequented by motor-cross

enthusiasts with resulting erosional damage to the trail, although this activity is not adversely affecting the bog asphodel population in a direct way. Canoeists were not a threat at the site.

5. Ice House (occurrence number 034)

a. Past site observations

The site was described by Radis (1993) as a small *Sphagnum* bog rich with sedges on a slight slope above a bend in the Batsto River and surrounded on three sides by Atlantic white-cedar stands. The bog asphodel population was estimated at 60 clumps. The Pinelands-listed curly grass fern was also present.

Approximately 100 individuals were documented by Dodds (1996) during the 1995 growing season, but there was no evidence of flowering during 1994 and 1995. The site was rated as very wet, considering the drought that occurred in 1995. Bog asphodel plants grew in the sunny portion of the bog.

Approximately 150 individuals were counted by Dodds and Goodwin (1997). No flowering occurred in 1997. The population was ranked "B" in 1985, "D" in 1993, and "D" in 1997. The habitat was considered very limited.

b. Recent observations

The site was visited by Service personnel on October 13, 2000. Approximately 200 individuals with one fruiting culm were growing in a small opening of an Atlantic white-cedar swamp just north of a camping ground. The Atlantic white-cedar swamp had a seepage area leading to the river; about 20 feet from the river, there was a small, open *Sphagnum* bog encircled by Atlantic white-cedar trees and low shrubs. The site was remote and did not appear disturbed. Hay Road was accessible from the abandoned railroad tracks to the north. The road was used by motor cross enthusiasts, with consequent damage to it.

c. Site recommendations

Radis (1993) reported that the bog asphodel population was relatively undisturbed by a nearby foot trail and did not express any immediate concerns. Dodds (1996) mentioned that little could be done to save this population without intensive removal of Atlantic white-cedar trees. An aggressive tree-cutting initiative was later proposed by Dodds (1997a) who also theorized that shaded conditions were responsible for such limited sexual reproduction. The proposal was rejected by the New Jersey State

Park Service. The population has barely flowered since 1992 but appears to have increased by vegetative reproduction. Permanent monitoring methods should be selected and applied to this site. Also, permanent points should be established and photographed during monitoring visits. The Service recommends including the Ice House site in a study to determine flowering success in bog asphodel populations.

6. Long Savanna (occurrence number 043)

a. Past site observations

The site was described by Radis (1993) as the largest Pinelands savanna in New Jersey, measuring 0.5 mile in length on the west bank of the Batsto River. Areas with *Sphagnum* and muck were present and the site was surrounded by Atlantic white-cedar stands, including a levee. The population was estimated to be of intermediate size, with ten percent of it in flower. Approximately 1,500 individuals were counted (Cartica, 1995). Pine barren boneset and lace-lip ladies' tresses (State-listed – endangered), and Canby's lobelia and red milkweed (Pinelands-listed) were documented during the survey.

Several thousand individuals were located by Dodds and Goodwin (1997). There were limited fruiting culms persisting from the previous year and only three flowering culms in 1997. The population has been ranked "B" since 1985. The following rare taxa were documented: New Jersey rush and fringed yellow-eyed grass (State-listed – endangered); pine barren reed grass, Canby's lobelia, pine barren smoke grass, and curly-grass fern (Pinelands-listed); and sheathed panic grass, and pale beaked-rush (species of concern). Long savanna is recovering from bog iron mining activities.

b. Recent observations

Service personnel visited the site on July 19, 2000, when approximately 800 fruiting culms were counted, and on September 14, 2000. In September, the southern sub-population was composed of thousands of vegetative individuals. Approximately 95 flowering culms were counted. The northern sub-population was associated with scattered lowland pine and Atlantic white-cedar trees. This sub-population was smaller, but approximately 250 fruiting culms were counted. The population appears to be stable and the ranking "B" assigned in 1993 should be retained in 2000.

c. Site recommendations

Radis (1993) reported that all documented disturbances were human-caused (canoe landing, trailing, trampling, wildflower collecting). Some of the State-listed taxa, including bog asphodel, had been collected by wildflower enthusiasts. A large canoe pullout was observed in the northeastern section of the savanna. Dodds and Goodwin (1997) observed human trails across the savanna; some human footprints were sighted in 2000, a much wetter year. In 2000, the site was partially inundated, with over 1 inch of standing water in places, discouraging human encroachment. A proposal to post the site

as off limits to the public by Dodds and Cartica (1997) was rejected by the New Jersey State Park Service. It is the Service's recommendation to make the site more inconspicuous by closing the pull-out area to vehicular traffic on the sandy road parallel to the western bank of the Batsto River and re-vegetating the pull-out area naturally or by planting trees and shrubs. Deer and racoon prints were observed on-site as well but were not common. Dodds and Goodwin (1997) deemed flowering negligible during the 1996 growing season, but Service personnel observed a sharp increase in flowering in 2000, although most appeared to have been cropped by unidentified organisms from July to September. The Long Savanna site could be included in a study that targets flowering success in bog asphodel populations. Permanent monitoring methods should be selected and applied at this site. Also, permanent points should be established and photographed during monitoring visits. Areas within the site where bog asphodel is not growing could be burned to see whether this practice results in a population spread. However, the site might be too wet (State of New Jersey, 2001).

7. Lower Forge (occurrence number 033)

a. Past site observations

The site was described by Radis (1993) as a wetland complex that included Atlantic white-cedar swamps, *Sphagnum* hummocks, mucky bogs, and mesic savannas. Over 1,500 individuals were counted, but few were flowering.

The site was described by Dodds and Goodwin (1997) as a 4- to 5-acre wetland complex with six large savannas separated by narrow bands of Atlantic white-cedar, and with a pitch pine island present along the lower savanna. The area between the savannas and the Batsto River was described as an upland island. Bog asphodel was found occurring in five of the six savannas; the southernmost savanna supported over 10,000 individuals, with hundreds in flower. A second harbored thousands of individuals, with hundreds in flower. Two others sheltered over 700 individuals, with several dozen in flower. The northern-most savanna had 25 individuals and was partially shaded by Atlantic white-cedar and scattered shrubs. The site has been ranked "A" since 1985. Documented rare plant taxa included the State-listed Pickering's reed grass, pine barren boneset, and New Jersey rush; the Pinelands-listed pine barren reed grass and curly-grass fern; and the species of concern, pale beaked-rush. Previous surveys documented the presence of lace-lip ladies' tresses (State-listed – endangered) and crested yellow orchid (Pinelands-listed).

b. Recent observations

The site was visited by Service personnel on July 20 and again on October 23, 2000. Bog asphodel in the southernmost savanna was estimated at well over 10,000, with several hundred fruiting culms. This savanna was shallowly inundated and was encircled by a narrow band of Atlantic white-cedar trees, with a levee and high sand bank on the Batsto River. There was no evidence of Atlantic white-cedar encroachment, except for a narrow band of young, 1- to 2-feet tall cedars at the savanna's edge. The population appeared very healthy, with no obvious signs of disturbance, except for a foot/deer trail at

the savanna's boundary with Atlantic white-cedars. The savanna just to the north had more *Sphagnum* cover and was inundated only in small areas. There were approximately 2,000 bog asphodel individuals, but very few had flowered in 2000. Old flowering culms from 1999 were more numerous, although still relatively few. Bog asphodel was growing in the central and the south-facing portion of this savanna surrounded by Atlantic white-cedar trees. The next small savanna to the north harbored approximately 100 bog asphodel individuals along a narrow, shallow rivulet. None flowered in 2000. The savanna had many hummocks with dense herbaceous vegetation and small Atlantic white-cedar islands. No bog asphodel individuals were sighted in the northernmost savanna. Encroachment was mainly by dense, herbaceous vegetation.

c. Site recommendations

Radis (1993) reported that the Lower Forge site had been a study area for botanists and ecologists. Collecting and trampling were disturbances associated with this site. Radis (1993) proposed to restrict the site by posting, allowing entrance by permit only. Dodds and Goodwin (1997) observed some footprints and pathways, but disturbance was limited to savanna borders. Some woody encroachment was noted in the smaller savannas. Periodic monitoring and trend photography with wide angle lenses from fixed points were recommended. Dodds and Goodwin (1997) also documented extensive damage to bog asphodel capsules by feeding grasshoppers. Service personnel in 2000 observed a decrease of bog asphodel numbers in the two northernmost savannas, apparently resulting from increased density of herbaceous vegetation and litter accumulation. Therefore, the Service recommends selecting and applying permanent monitoring methods. A prescribed / controlled burn to reduce litter accumulation and release nutrients back into the substrate would likely benefit this population; however, the effects of fire should be quantified and hydrological information obtained prior to recommending specific habitat manipulations.

8. Odd Spot (occurrence number 047)

a. Past site observations

The site was described by Radis (1993) as a large wetland complex on the western bank of the Batsto River, with *Sphagnum* bog, muck, Atlantic white-cedar swamp, pitch pine lowland, and savanna. A very large population of bog asphodel was dispersed throughout most of the wetland complex, with few flowering ramets present.

Two sub-populations of bog asphodel at the site were described by Dodds and Goodwin (1997): a larger southernmost colony represented by 800-1,000 individuals, but with very few flowering culms, in a narrow, open bog bordered by streamlets draining in the river; and a northernmost colony of 500-600 individuals, with 125-150 flowering culms, associated with inkberry (*Ilex glabra*) and lowland broom-sedge. The following rare plant taxa were documented during surveys between 1985 and1997: New Jersey rush, yellow fringeless orchid, lace-lip ladies' tresses, and fringed yellow-eyed grass (State-listed – endangered); pine barren reed grass, pine barren gentian, Canby's lobelia, pine barren smoke grass,

curly-grass fern, and bog buttons (Pinelands-listed); and sheathed panic grass and pale beaked-rush (species of concern).

b. Recent observations

The site was visited by the Service on July 19 and again on September 18, 2000. The population of bog asphodel was estimated at over 1,500 and ranked "A" in 1995 and "B" in 1996 (Cartica, 1995; Dodds and Goodwin, 1997). In 2000, only approximately 200 individuals were counted in the southernmost sub-population and only three fruiting culms were observed. Three yellow fringed orchids (Pinelands-listed) and two white fringed orchids (*Platanthera blephariglottis*) were associated with the bog asphodel sub-population. Overall, this site was wet, with shallowly standing or slow-moving water. The northernmost site was drier and overgrown with mixed woody vegetation. This sub-population described by Dodds and Goodwin (1997) was not located by the Service. Relatively open areas at the site were smothered by cypress panic grass (*Panicum ensifolium*).

c. Site recommendations

Radis (1993) reported that the site appeared undisturbed, although access by foot or canoe was potentially easy. Dodds and Goodwin (1997) associated flowering success of the southernmost sub-population with relatively dry conditions. According to Service estimates, this sub-population decreased both in numbers and flowering culms since 1996. The hummocks found within the narrow, open bog bordered by ground water seepage channels draining into the Batsto River appeared choked by heavy grass and sedge litter. A localized prescribed burn or manual removal of the dense grass/sedge litter accumulation would likely benefit the bog asphodel sub-population, which may not persist at the site without active management. Research methods should be selected and applied for the purpose of obtaining data to support these habitat manipulations. Also, permanent points should be established and photographed during monitoring visits. According to Service estimates, the northernmost sub-population of bog asphodel at the site was likely extirpated. Future attempts should be made to locate this sub-population. Dodds and Goodwin (1997) reported succession by woody species (mixed trees and mixed shrubs) and recommended annual monitoring and experimental management of the sub-population of this area.

9. Quaker Bridge (occurrence number 001)

a. Past site observations

Quaker Bridge is the type locality for bog asphodel (Radis, 1993). Two sub-populations on opposite sides of the Batsto River consisted of 100 plants, with few flowering culms.

The population was ranked "D" by Dodds and Goodwin (1997). No individuals were sighted on the

east side of the Batsto River. Two small areas on the west side, one herbaceous and one herbaceous with some shrubs, harbored 35 and over 100 individuals, respectively. Rare plant species were New Jersey rush and yellow fringeless orchid (State-listed – endangered); Canby's lobelia, pine barren smoke grass, and curly grass fern (Pinelands-listed); and dragon mouth (species of concern).

b. Recent observations

The savanna west of the Batsto River was visited by the Service on July 19, 2000. The sub-population occurred within a swale and was estimated at 32 small individuals, one of which was flowering. Searches were unsuccessful by Service personnel on July 19 and October 2, 2000, for the open bog east of the Batsto River and cedar swamp at Quaker Bridge that sustained the second sub-population described by Radis (1993). The habitat was under very dense encroachment of young Atlantic white-cedar trees and no savanna types were sighted. The habitat for bog asphodel was very marginal, at best. The ranking of "D" is retained for the Quaker Bridge site at large.

c. Site recommendations

Quaker Bridge was deemed by Radis (1993) to be the most heavily impacted bog asphodel population in the entire WSF but very worthy of protection, as it represents bog asphodel's type locality. Frequent visits by naturalists and plant collectors resulted in noticeable footpaths and trampling. A canoe and raft landing area was adjacent to the site, resulting in campfires and trash. A portion of the population adjacent to a gravel bar was severely trampled by canoeists. Erecting signs posting the area was rejected by WSF. Nonetheless, the Service recommends restricting access by canoeists to one small area adjacent to the bridge, as proposed by Radis (1993). The swale supporting the western sub-population appeared overgrown with blueberry (*Vaccinium corymbosum*) and other woody shrubs. The Service supports reducing encroachment by shrubs. The eastern sub-population has not been sighted since 1992. The habitat was undergoing successional advancement by young Atlantic white-cedar trees and no savanna types were observed. The high density of young trees and shrubs, along with bog asphodel being likely absent, is precluding the opportunity for management practices and conservation actions in the eastern portion of the site. Permanent monitoring methods should be selected and applied at this site. Also, permanent points should be established and photographed throughout the site at large. The site should be monitored yearly because of its type locality designation and susceptibility to disturbance. Further surveys should be undertaken to confirm extirpation of the sub-population on the eastern bank of the Batsto River.

10. Savanna Verde (occurrence number 065)

a. Past site observations

A *de novo* population was found by Dodds and Goodwin (1997) in a bog dissected in part by a ground water seepage channel. The population was located between a mature Atlantic white-cedar swamp on the upland side and a levee with Atlantic white-cedar and shrubs on the east bank of the

Batsto River. Tens of thousands of individuals were documented, with over 1,000 flowering culms. The population was ranked "A" with no concerns listed. The following rare plant taxa were sighted: New Jersey rush (State-listed – endangered); Canby's lobelia and curly-grass fern (Pinelands-listed); and sheathed panic grass pale beaked-rush (species of concern).

b. Recent observations

The site was visited by Service personnel on October 2, 2000. The site and the bog asphodel population were as described by Dodds and Goodwin (1997). Savanna Verde and the large Atlantic white-cedar swamp to the east were fed by an intermittent stream flowing from the eastern uplands, making the field survey relatively arduous and treacherous. Therefore, caution is recommended when re-visiting this site. In the confidential site survey summary, Dodds and Goodwin drew a map of the site showing Batona Trail extending to the south of the site, parallel to the Batsto River, when instead it curves to the eastern upland toward Goodwater Road. This correction would help locate Savanna Verde with greater precision. According to Stanford (2000), this is one of only three savannas that appear to have had no impacts from bog iron mining or logging. The basal peat is just over 1 meter deep and has been dated 6,000 radio-carbon years (BP). The surface peat is dated at 1,000 BP, suggesting either oxidation of peat resulting from drying in a higher position in the landscape or scarping (unlikely).

c. Site recommendations

Dodds and Goodwin (1997) recommended conducting research on the hydrological regime at the site to understand the dynamics that keep savannas free from encroaching Atlantic white-cedar seedlings and trees. The site is protected by large bands of mature Atlantic white-cedar from the trail to the east and river to the west. Dodds and Goodwin (1997) reported that some Atlantic white-cedar trees were cut down and removed. A hunting blind was observed both by Dodds and Goodwin (1997) and Service personnel on a tree within the Atlantic white-cedar swamp. Dodds and Goodwin (1997) and the Service recommend establishing permanent points to be photographed for visual trend during monitoring visits. Permanent monitoring methods should be selected and applied, as well.

11. Skit Branch Bog (occurrence number 010)

a. Past site observations

Two sub-populations of bog asphodel were described by Hill (1993). The first was composed of approximately 200 individuals, with 60 flowering culms, in a quaking bog within a cedar swamp, 0.25 miles east of Carranza Road on the north side of the stream. The Pinelands-listed curly grass fern was present. Twenty individuals comprised the second, approximately 10 meters east of Carranza Road, on the south side of the stream.

A population increase in the first area was witnessed by Dodds (1996) with numbers in the hundreds,

but with few flowering culms. Some flowering culms were present from the previous year (1994). Atlantic white-cedar trees taller than 10 feet were dead. The second sub-population was the largest in 1993, but became the smallest by 1995. Fewer than 60 individuals were seen in an opening within an Atlantic white-cedar stand. The site appeared different from how it was described by Hill (1993). Large areas of mud flats and open water bog were visible in 1995. Two adjacent areas were surveyed for additional bog asphodel, but none were found.

b. Recent observations

The site was visited by Service personnel on September 22, 2000. The sub-population of bog asphodel to the north, approximately 0.25 mile from Carranza Road, was located in a small opening into Atlantic white-cedar, with a levee near Skit Branch. The open area was visible from the sandy road that parallels Skit Branch on the north side. This sub-population was roughly estimated at 2,000 individuals, with approximately 400 fruiting culms. Bog asphodel was quite dominant, although the available habitat was relatively small. No disturbance was observed, although there appeared to be a faint trail from the sandy road through Atlantic white-cedar to the bog asphodel sub-population.

c. Site recommendations

Hill (1993) reported that the area on the southern edge of Skit Branch adjacent to Carranza Road was slowly filling with Atlantic white-cedar saplings. Overall, changes in hydrology at the site were signified by dead standing Atlantic white-cedar trees in some areas and dense stands of saplings elsewhere. Service personnel witnessed a remarkable increase in the bog asphodel's sub-population on the northern side of Skit Branch (200 individuals in 1993, 60 in 1995, over 2,000 in 2000). Permanent monitoring methods should be selected and applied to this sub-population. Also, permanent points should be photographed during monitoring visits. The Service was unable to locate the small sub-population of bog asphodel adjacent to Carranza Road on the south side of Skit Branch. The habitat was extremely marginal for bog asphodel in this area, with heavy Atlantic white-cedar encroachment. The Service recommends resuming searches for bog asphodel in this area during monitoring field trips to the Skit Branch site.

12. Three Bogs (occurrence number 040)

a. Past site observations

The site was described by Radis (1993) as an undisturbed series of small savannas and bogs surrounded by Atlantic white-cedar swamp on an old meander on the east side of the Batsto River. The hard-to-find site sustained a medium-sized population of over 500 individuals. Approximately 25 individuals were flowering.

The habitat was described by Dodds (1996) as three open bogs, with mixed graminoids and Atlantic white-cedar seedlings, connected by shrubby corridors. Bog asphodel was scattered throughout.

The central and southern *Sphagnum* bogs comprised most of the population, estimated at approximately 2,000 scattered individuals by Dodds and Goodwin (1997). Two *de novo* small sub-populations of 200 individuals each were located in small openings approximately 200 feet south of the southern-most bog. The population was ranked "B" in 1985 and "C" in 1993 and 1997. Rare plant taxa at the site were pine barren reed grass and large-headed beaked rush

(Pinelands-listed), and New Jersey rush (State-listed – endangered). Additional listed species previously documented were few-flowered beaked rush and dragon mouth (species of concern).

b. Recent observations

Three small bogs at the site were visited by Service personnel on October 13, 2000. The southernmost of the three was directly west from the old pond on the eastern side of Hay Road. The sub-population was composed of approximately 1,500 individuals. Fifteen fruiting culms were counted. This bog was inundated in part, but mostly saturated and covered with *Sphagnum* moss. The small bog was in large part shaded by Atlantic white-cedar trees. Most bog asphodel individuals displayed long leaves (approximately 7 inches), likely an adaptation to shade. Some individuals were growing in the Atlantic white-cedar forest. A levee separated the bog from the Batsto River. Cypress panic grass was dominant in portions of the bog. A second sub-population of just a few clumps was found in a small opening to the north. A third opening to the north harbored approximately 1,000 individuals, with only three fruiting culms. All of the fruiting ramets were in the shade. A fourth opening to the north did not support bog asphodel.

c. Site recommendations

Radis (1993) listed recreational trails and canoeing as potential threats to bog asphodel at the site, but did not recommend any management initiatives. Radis (1993) also reported that no vehicles were allowed on Hay Road, south of the abandoned railroad tracks. However, Service personnel observed heavy recent road damage by motor-cross enthusiasts. Hay Road was open to four-wheel-drive vehicles as well. According to Dodds (1996), approximately half of the habitat suitable to bog asphodel was lost (from 4 to less than 2 acres) and the majority of the original 2,500 individuals documented in 1985 no longer occurred at the site. Individual numbers did not change between 1993 and 1995. According to Dodds and Goodwin (1997), numbers grew to 2,000 but very few individuals were seen in flower. Cypress panic grass was steadily increasing as ground cover and was considered a possible threat to bog asphodel. The population was reported to be under heavy shade. Recording population trends from permanently-marked photographic points, controlling shrub encroachment, and bi-annual monitoring were recommended. Evaluating removal of Atlantic white-cedar trees was suggested, if found to be a good conservation strategy for bog asphodel. Service personnel observed no disturbances to the population, except for encroachment by cypress panic grass. The Service recommends against control of woody vegetation except, perhaps, in areas dominated by cypress panic grass. Research methods should be selected and applied for the purpose of obtaining data to support

habitat manipulations.

13. Unexpected Site (occurrence number 037)

a. Past site observations

The site was described by Radis (1993) as a shrub/grass savanna on an old meander bend on the east bank of the Batsto River, approximately 1.0 mile south of Quaker Bridge. The population was estimated to be of medium size, with over 500 individuals and about 16 flowering culms, compared to over 500 individuals and approximately 200 flowering culms sighted in 1985. The site supported the State-listed (endangered) New Jersey rush and Pinelands-listed pine barren reed grass and curly grass fern.

The 1995 population was estimated at over 500 and with 95 flowering culms by Dodds (1996). The site was bordered by an Atlantic white-cedar levee, with the western third of the open area supporting dense shrubs.

The 1997 population was estimated by Dodds and Goodwin (1997) at a few thousand, but only a few flowering culms were noted. The population of bog asphodel was ranked "A" in 1985, "C" in 1993, and "C" in 1997. Rare State plant species documented between 1985 and 1997 included New Jersey rush and yellow fringeless orchid (State-listed – endangered); red milkweed, pine barren reed grass, Canby's lobelia, pine barren smoke grass, and curly-grass fern (Pinelands-listed); and sheathed panic grass and pale beaked-rush (species of concern).

b. Recent observations

The site was visited by the Service on July 20 and October 2, 2000. The population was estimated at over 2000, with only 97 flowering culms. The savanna habitat was circumscribed and not extensive. The population was ranked "B."

c. Site recommendations

Radis (1993) observed that the bog asphodel population was relatively undisturbed, although in close proximity to a very busy foot trail, a popular canoe landing site, and a campground. Evidence of a burn was noted. Dodds (1996) described the site as stable, with no encroachment by woody species except for Atlantic white-cedar seedlings growing on hummocks. Some level of herbivory was noted.

Dodds and Goodwin (1997) described the site as limited, nestled between the uplands to the east and a levee on the river's side and, perhaps, losing hydrological support. Continued monitoring and photographic documentation of trends from permanent points were recommended. Low numbers of flowering / fruiting culms and damage to fruiting capsules were noted, the latter perhaps resulting from grasshopper consumption. The population looked healthy to Service personnel, but there had been a decrease in flowering since 1985 (from 200 to 95). The presence of Atlantic white-cedar trees, young or mature, did not appear to be of concern to the survival of bog asphodel at this site. The Service recommends an evaluation of the hydrological condition of the site, particularly in relationship to seasonal fluctuations.

14. Hampton Gate Bog (occurrence number 028)

a. Past site observations

Located in the headwaters of the Batsto River north of Carranza Road, the site was not considered suitable habitat for bog asphodel by Hill (1993). The site was described as having a closed canopy and dense shrub layer, as well as portions of channelized stream associated with active cranberry bog operations. No bog asphodel plants were found.

Gordon (1996) documented 39 flowering culms and 30 vegetative individuals in a bog opening concealed by regenerating Atlantic white-cedar, approximately 0.55 mile southeast of the junction of Batsto River and Carranza Road. A second site approximately 300 yards to the west was described as good habitat, but with no bog asphodel present. The State-listed New Jersey rush and the Pinelands-listed curly grass fern and pine barren reed grass were present.

b. Recent observations

The bog asphodel site was visited by Service personnel on September 22, 2000. The population was located in a small opening surrounded by Atlantic white-cedar, in 1-2 inches of stagnant water. Population numbers were limited to approximately 150 individuals and six fruiting culms, one of which was partially cropped by unidentified organisms. Associates were pitcher plants, *Sphagnum* moss, gold crest, beaked rushes, cotton grass (*Eriophorum* sp.), young cedars, and a few lowland pitch pines.

c. Site recommendations

The population was partially shaded and could benefit from shade reduction, if this practice is found to be beneficial to populations of bog asphodel that are dwindling. The Service recommends establishing permanent points to be photographed during yearly monitoring visits. The site is too small for applying other permanent monitoring methods.

15. Whispering Savanna (*de novo* sub-population)

a. Recent observations

A "*de novo*" bog asphodel sub-population was located approximately 200 yards south of Unexpected Site by Service personnel on October 2, 2000. This occurrence is considered a sub-population of bog asphodel found at Unexpected Site in the Biological Conservation Database, although the two are separated by an Atlantic white-cedar swamp and occur in somewhat different savanna habitats. The "*de novo*" sub-population can be accessed from Unexpected Site by following the nearby sandy trail in a southern direction to its end. An opening into the savanna is visible in a southwestern direction. Several vegetative individuals were located in a small opening directly accessible from the sand trail. Approximately 300 individuals and only one fruiting culm were sighted in a larger savanna nearby. The general habitat was grassy, with very few hummocks, and was mostly inundated with 1 to 2 inches of water. Associates were lowland broom-sedge, pipewort, beaked rushes, autumn bent (*Agrostis perennans* var. *elata*), rushes (*Juncus* spp.), and spike rushes (*Eleocharis* spp.), slowly inter-grading in areas dominated by cypress panic grass, leather leaf (*Chamaedaphne calyculata*), and/or young Atlantic white-cedars mixed with lowland pitch pines. A levee of mixed Atlantic white-cedar, lowland pitch pine, and red maple trees was also present.

16. Ore Spong (*de novo* population)

a. Past site observations

Ore Spong is on the west side of the Batsto River, directly west-northwest of Batsto Bog. The site was discovered by ONLM staff on September 9, 1998 and re-visited with Ted Gordon on September 10, 1998. The site has been described (Walz *et al.*, 2002) as a wetland mosaic that includes Atlantic white-cedar swamp, shrub savanna, tussocky sedge savanna, and aquatic vegetation on iron-rich muck. Tens of thousands of bog asphodel individuals were observed in 1998, many in flower. The Pinelands-listed curly grass fern was so abundant in the Atlantic white-cedar swamp that one could not avoid stepping on it.

The survey documented New Jersey rush and yellow fringeless orchid (State-listed – endangered); pine barren reedgrass, Canby's lobelia, pine barren smoke grass, large-headed beaked rush, and curly grass fern (Pinelands-listed); and sheathed panic grass, few-flowered beaked-rush, and sphagnum (*i.e.*, *Sphagnum cyclophyllum*) (species of concern).

The site was historically mined for bog iron, with evidence of scarring on aerial photographs taken in the 1930s. New Jersey Geological Survey (NJGS) surficial geologist Scott Stanford conducted a survey of the geomorphology at this site in 1999 and surmised that the site had been heavily mined based on trough and ridge base topography and significant holes in the sand and iron muck. The site is recovering nicely with typical savanna vegetation. Atlantic white-cedar is encroaching in the northernmost lobe of the savanna, but it is possible that this area was originally Atlantic white-cedar swamp before bog iron mining activities opened it up.

b. Site recommendations

This site is particularly difficult to find and access either from road or by canoe. No evidence of trampling was noted in 1998, other than the tracks from the ecologists conducting reconnaissance surveys of the savanna vegetation at the time of site discovery. Research opportunities at Ore Spong remain to be evaluated.

B. MULLICA RIVER

1. Atsion Bog (occurrence number 038)

a. Past site observations

The site is on the west bank of the Mullica River with dense Atlantic white-cedar nearby. Frequent fires have ravaged Atsion Bog over time (State of New Jersey, 2001). Approximately 250 individuals were counted by Stasz in 1985 and only 50 by Hill (1993) in 1992. No other State-listed plant species were documented on site.

Dodds (1996) reported one large patch of bog asphodel at the site. The population was estimated at 250 for growing season 1995. There were 15 fruiting ramets, but 10 had been cropped by unidentified organisms. A second area with favorable habitat had no plants.

The population was estimated by Dodds and Goodwin (1997) at fewer than 200 mostly stunted individuals. New Jersey rush was present at the site. The population of bog asphodel was ranked "A" in 1985, "C" in 1993, and "D" in 1997.

b. Recent observations

The site was visited by Service personnel on July 17 and September 27, 2000. Approximately 63 ramets flowered in 2000 and 23 seed heads from the 1999 growing season were counted. The population was estimated at slightly over 200 individuals. Associates were lowland broom-sedge, gold crest, beaked rush, white fringed orchid, and dwarf huckleberry.

c. Site recommendations

According to Hill (1993), the bog was developing a dense shrub layer with inkberry, swamp azalea

(*Rhododendron viscosum*), sweet pepper bush (*Clethra alnifolia*), red maple, and Atlantic white-cedar. Hill (1993) reported that this encroachment may have resulted from a 1983 fire and may threaten the bog asphodel population. Dodds (1996) reported herbivory on flowering culms, resulting in loss of reproductive capability. Dodds and Goodwin (1997) suggested that the site was drying overall and there was no evidence of periodic flooding to prevent shrub encroachment. The site was recommended for experimental habitat restoration. According to Cartica (pers. comm., 2001), the savanna at Atsion Bog was opened by fire. Hydrology in this upper watershed is not as voluminous as downstream because of its position on the landscape relative to the Great Swamp of WSF.

According to Service personnel, bog asphodel was located in areas with slow-moving water, creating more open micro-habitat. Plentiful shrubs and small Atlantic white-cedar trees 5-12 feet high were encroaching at the site, which was described as a meadow. Apparently, water flow through the site is not adequate enough to prevent woody encroachment. In September 2000, the site was visited following two days of steady rain; nonetheless, the site did not display flooded conditions typically observed at other bog asphodel sites. The population remains small but apparently stable, and the ranking "D" is retained. Bog asphodel plants at the site did not look stunted in 2000 as they were described back in 1997. The site may represent an example of a dwindling population in marginal hydrological conditions that should be documented. If experimental restoration is conducted by enhancing water flow, the likely bog asphodel spread should be carefully studied. Alternatively, the site could be seeded, following hydrological enhancement. The Service recommends that research methods be selected and applied for the purpose of obtaining data to support potential habitat manipulations for Atsion Bog. Photographs should be taken from permanent points during monitoring visits.

2. Below Big Doughnut (occurrence number 048)

a. Past site observations

The site was described by Hill (1993) as a savanna with an open bog. Over 1,000 vegetative individuals were counted. New Jersey rush (State-listed –endangered), pine barren gentian, and curly grass fern (Pinelands-listed) were observed on site. The site remained stable since 1985 when 750 individuals and 25 flowering racemes were counted. Below Big Doughnut was severely impacted by bog iron mining down to the mineral soil (State of New Jersey, 2001).

The site was described by Dodds and Goodwin (1997) as an oval savanna of approximately 2 acres, occurring inside a bend in the Mullica River approximately 1.2 miles north of Constable Bridge. Thousands of vegetative individuals and approximately 500 flowering culms were sighted. The healthiest plants were found on large, well-developed hummocks, while those found on small hummocks and mud flats were smaller than average. The population has been ranked "B" since 1985. The plants did not appear to be disturbed, although footprints were detected.

b. Recent observations

Service personnel visited the site on March 15, 2000. The site is near a 60-year-old water gaging station. Approximately 60 seed heads from the 1999 growing season were counted. The small site is an iron bog savanna mostly surrounded by Atlantic white-cedar trees. Shallow water moved through the site. There appeared to be no serious encroachment by Atlantic white-cedar, likely the result of bog iron mining and the substrate's high iron content (State of New Jersey, 2001). Plant associates at the site were lowland broom-sedge, leather leaf, autumn bent, spike rushes, pitcher plants, long leaf panicum (*Panicum longifolium*), cranberry (*Vaccinium macrocarpum*), *Sphagnum* mosses, and the Pinelands-listed pine barren smoke grass.

The site was visited again by the Service on September 14, 2000. The best way to access this site is to drive approximately 1.1 miles north of Constable Bridge, turn right on the side sand road, and park near the water gaging station. The population appeared healthier in September 2000 than in March 2000 for growing season 1999. Over 1,000 plants and 200 fruiting culms were observed in September 2000. For the most part, the plants that flowered and fruited were growing in full sunlight. The site was very mucky and with hummocks. The slow moving water through the site contributed to preventing Atlantic white-cedar encroachment.

c. Site recommendations

No management activities were recommended by Hill (1993) and by Dodds and Goodwin (1997). Monitoring was not deemed necessary more than once every 3-4 years. No threats were evident at the site to Service personnel. Permanent points should be established and photographed during monitoring visits. The site should be incorporated in the research effort as a comparative example, given the supportive hydrological conditions and successful flowering of the bog asphodel population.

3. Below the Locks (occurrence number 035)

a. Past site observations

The site was described by Hill (1993) as mostly open savanna divided by Atlantic white-cedar at various locations and with a levee covered by red maple, blueberry, and sweet pepper bush. The habitat looked undisturbed and harbored approximately 100 individuals. No changes were discerned by Dodds (1996) during the 1995 growing season, except for the site being dry because of a drought that year. Historically, this site was mined for bog iron (State of New Jersey, 2001).

The site was described by Dodds (1997b) as composed by three main bog areas with typical savanna vegetation. A fourth small open area to the north appeared to be a good habitat for bog asphodel, but none were found there. About 800-900 vegetative individuals and just a few flowering ramets were estimated by Dodds and Goodwin (1997). Most were located in the largest savanna. A few individuals were observed in the northernmost bog as well. The site sustained the State-listed New Jersey rush; the Pinelands-listed red milkweed, pine barren reed grass, Canby's lobelia, pine barren smoke grass, and curly-grass fern; and the species of concern, sheathed panic grass and pale beaked-

rush.

b. Recent observations

The site was visited by Service personnel on July 17 and September 27, 2000. The site was wet and boggy throughout the year. Small, clumped sub-populations of bog asphodel occurred within the three bogs. The entire population was estimated at fewer than 200 individuals. Four flowering/fruiting culms were observed in the southernmost bog, two in the central bog, and four in the northernmost bog. Only a one-year-old fruiting culm was found.

c. Site recommendations

This site was deemed stable, except for tree encroachment (Dodds, 1996). In November 1997, approximately 90 Atlantic white-cedar trees were cut and left on the ground to prevent encroachment and shading onto the bog asphodel population (Dodds and Cartica, 1997; Dodds and Goodwin, 1997). The felled Atlantic white-cedar trees were sighted by Service personnel at the bog's margins. It appeared that cutting mature Atlantic white-cedar trees did not induce a flowering response in bog asphodel at the site during years 1999 and 2000. Heavy water-logged conditions may have an inhibiting effect on flowering in bog asphodel populations. The Service recommends discontinuing Atlantic white-cedar removal until research data are collected to help explain inhibition of flowering in bog asphodel populations. The site was heavily trampled by humans in July 2000, but few signs of disturbance were present in September. Deer bedding areas were observed near the northernmost sub-population. Deer trails were also visible between the forested uplands and the bogs. A series of yellow pin flags and piezometers were placed by Matt Palmer, graduate student at Rutgers University, to take hydrological measurements in the southernmost bog. The Service requests to be informed of all studies directly or indirectly related to bog asphodel on State-owned lands in New Jersey for inclusion in project files. The Service also recommends taking photographs from permanent points during yearly monitoring visits.

4. Cold Spring Bog (occurrence number 051)

a. Past site observations

The bog asphodel's habitat was characterized by Hill (1993) as mucky bog containing much iron ore and in good condition. The population was estimated at 3,000 individuals. Historically, this site was mined for bog iron (State of New Jersey, 2001).

The site was described by Dodds and Goodwin (1997) as a long, narrow savanna with large mud flats

in the bank of the Mullica River, approximately 0.5 acre in size. The population was composed of thousands of individuals, with several hundred flowering culms, and was ranked "B" since 1985. Rare plant taxa included the State-listed New Jersey rush; the Pinelands-listed pine barren reed grass, pine barren gentian, Canby's lobelia, pine barren smoke grass, and curly grass fern; and the species of concern, sheathed panic grass.

b. Recent observations

This large bog iron savanna was visited by Service personnel on March 15, 2000. Bog asphodel grows on hummocks in shallowly flooded substrate and at the edges of tall Atlantic white-cedar trees. Approximately 300 seed heads from the 1999 growing season were counted and thousands of small individuals were likely represented. No changes were detected since the thousands of vigorous individuals observed in 1985 (Cartica, 1995). Lowland broom-sedge, autumn bent, New Jersey muhly, long leaf panicum, spike rushes, Canada rush, cranberry, leather leaf, pitcher plant, bog aster, *Sphagnum* mosses, gerardia (*Agalinis* spp.), hairy seed reed grass (*Calamagrostis cinnoides*), pipewort (*Eriocaulon compressum*), white beak rush (*Rhynchospora alba*), bog yellow eyed grass (*Xyris difformis*), and twisted yellow eye grass *(X. torta*), as well as the State-listed New Jersey rush and the Pinelands-listed pine barren gentian and pine barren smoke grass were identified as standing dead material from the previous year.

The site was re-visited by Service personnel on September 19, 2000, to document current year's conditions. The bog asphodel's performance during growing season 2000 was more vigorous than what was inferred during March 2000 for growing season 1999. Flowering/fruiting was profuse, likely a three-fold increase from 1999.

c. Site recommendations

No concerns were raised by Dodds and Goodwin (1997), but tree removal was suggested. The Service recommends against cutting and removal of Atlantic white-cedar trees at the site. No disturbances were witnessed by Service personnel except for a set of footprints crossing the iron bog in the direction of the Atlantic white-cedar levee, with no apparent damage to the bog asphodel population. Research methods should be selected and applied for monitoring purposes. Permanent points should be established and photographed during monitoring visits. Historically, a side road led recreationists' vehicles to the iron bog's margins, but upland vegetation is slowly regenerating, thanks to the wilderness designation and posted requirements disallowing motor vehicles on the sand road east of the Mullica River, perhaps within one mile north of Constable Bridge. The designation has provided for added protection to the bog asphodel population at Cold Spring Bog, although recreationists continue to drive their private vehicles within wilderness designated areas.

5. Mystery Savanna (occurrence number 067)

a. Past site observations

A *de novo* population was found by Dodds and Goodwin (1997) 0.85 miles north of the Constable Bridge near the east bank of the Mullica River. Approximately 1,000 individuals, with 70-100 in flower, were sighted among young Atlantic white-cedar. The population was ranked "C" and was associated with other Pinelands-listed taxa such as curly grass fern and large-headed beaked rush.

b. Recent observations

The site was visited by Service personnel on July 24 and September 14, 2000. The site was saturated to the surface, with about 1 inch of standing water in spots. Rain was plentiful in 2000, re-establishing savanna-bog habitat at the site. Bog asphodel was scattered throughout the savanna, with large, vigorous, healthy, fruiting clumps in the open areas. Other small clumps appeared young. Fifty-four fruiting culms were counted in July and 40 in September, occurring away from the boundary with Atlantic white-cedar trees. A few, vigorous, vegetative

clumps were observed near the trees. Common associates were drum heads (*Polygala cruciata*), pitcher plant, Canada rush, gold crest, clubmoss, and lowland broom-sedge.

c. Site recommendations

Shading was not of immediate concern to Dodds and Goodwin (1997), but the site appeared dry and there was some encroachment by woody species. Monitoring the site periodically and establishing population trends from a permanently marked photographic point was recommended. Service personnel sighted heavy deer trailing in open areas near the Mullica River, but trampling was light throughout the bog asphodel site. There was also a favorable canoe landing area, but no signs of human trampling were observed. Cropping of fruiting culms occurred between July and September 2000. Young Atlantic white-cedars were encroaching in the savanna's southern portion. The Service discourages removal of Atlantic white-cedar trees until research results pertaining to flowering success and survivorship of bog asphodel become available from comparative studies of hydrological conditions, nutrient availability, and shading.

6. Twin Savannas (occurrence number 036)

a. Past site observations

Twin savannas were completely destroyed by bog iron mining (State of New Jersey, 2001). The site was described by Hill (1993) as an open bog on the east bank of the Mullica River, approximately 1.5 miles north of Constable Bridge. The population of bog asphodel decreased from 70 individuals in 1985 to 20 in 1993. The decrease was attributed to woody encroachment. The population was ranked "B" in 1985 and "D" in 1993.

The population persisted and few individuals flowered in 1996 (Dodds, 1997b). The savanna habitat

was estimated at less than 0.25 acre. Rare plant species documented at the site were New Jersey rush (State-listed); pine barren reed grass, Canby's lobelia, curly-grass fern, and pine barren smoke grass (Pinelands-listed); and sheathed panic grass and pale beaked-rush (species of concern).

b. Recent observations

The site was visited by Service personnel on March 24, 2000, two days after heavy rain and consequent flooding. One and one-third feet of flood water covered the substrate. Felled Atlantic white-cedar trees were layered on the ground at the site. The population of bog asphodel from the 1999 growing season was estimated at fewer than 50, with 6 fruiting culms, and the "D" ranking of the population was retained.

The site was visited again by Service personnel on September 14, 2000. Bog asphodel's sub-population in the northern portion of the savanna was composed of a few, non-flowering individuals. The area was extensively utilized by deer, resulting in trampling of a few bog asphodel plants. The Pinelands-listed pine barren smoke grass was plentiful in this area. The sub-population in the southern portion of the savanna was composed of approximately 50 individuals, 22 of which had fruiting culms. Overall, this sub-population was small, but it has retained stability since 1985.

c. Site recommendations

Hill (1993) reported a decrease in bog asphodel numbers from 70 individuals in 1985 to 20 in 1993. The decrease was attributed to woody encroachment. According to Dodds (1997b), the site did not have a levee, and an island of Atlantic white-cedar was shading the bog asphodel's population. A prescribed cut of a few dozen Atlantic white-cedar trees was proposed and conducted in November 1997 to reduce shading of this bog asphodel population (Dodds, 1997b; Dodds and Cartica, 1997; Dodds and Goodwin, 1997). According to Service personnel, the population did not appear to rebound as a result of this management action. The Service recommends discontinuing Atlantic white-cedar removal until research data are collected that may help explain inhibition of flowering in bog asphodel populations. A heavily utilized deer trail ran through this sub-population. One fruiting culm was broken. A natural barrier could be placed in the trail's pathway though a band of Atlantic white-cedar leading to this sub-population. However, it remains to be understood whether deer trampling is preventing competing vegetation from smothering the bog asphodel plants. The Service also recommends taking photographs from permanent points during yearly monitoring visits. The population is too small to recommend selection and application of research monitoring methods.

C. OSWEGO RIVER

1. Harrisville Bow (occurrence number 045)

a. Past site observations

Three sub-populations, mostly growing on *Sphagnum* hummocks, were described by Windisch (1993) at this site, each in a separate cove on the east side of Harrisville Pond: (045A) a small sub-population of scattered, vegetative individuals found upstream; (045b) the middle sub-population with plentiful numbers and many flowering culms; and (045) a large population, but with few flowering culms, found downstream. The population numbers were documented by Cartica (1995) at over 10,000. The population was ranked "A."

b. Recent observations

The site was visited by Service personnel on October 10, 2000. Bog asphodel sub-population numbers were not different from those estimated by Windisch (1993). The noticeable difference was the virtual absence of flowering/fruiting culms among individuals. Sub-population 045b was shaded, particularly in the morning and evening hours by surrounding mixed forest; however, sub-population 045 was in full sun. Therefore, absence of flowering may not be a response to shading only. The substrates at these sub-population sites were inundated; it is possible that prolonged periods of flooding may depress flowering in bog asphodel.

c. Site recommendations

Windisch (1993) did not report disturbances except for trash accumulating at this site from the river and grazing by geese. No disturbances were observed by Service personnel except for deer trails to water. No grazing by geese was observed. Research methods should be selected and applied at this site. Permanent points should be established within each sub-population and photographed during monitoring visits.

2. Martha Pond (occurrence number 024)

a. Past site observations

Three sub-populations of bog asphodel were described by Windisch (1993): 024A was a large bog at the bottom of a steep slope located on the southeastern bank of Martha Pond, where many individuals were seen in flower; 024B was a small area fed by ground water seepage harboring approximately 300 individuals, 13 of which were in flower; 024 was a large sub-population, with most individuals in flower, located on the east bank of the Oswego River, upstream from 024A. Cartica (1995) reported that the whole population of bog asphodel at Martha Pond was ranked "A" and was represented by tens of thousand of individuals.

b. Recent observations

The site was visited by Service personnel on October 10, 2000. Sub-population 024A was composed of over 10,000 healthy individuals, growing along *Sphagnum* mats. However, no fruiting culms were observed. The site was not shaded except during morning hours, but it appeared to be very wet, with a

rivulet running through the open *Sphagnum* bog. Sub-population 024 was growing in flooded muck along *Sphagnum* hummocks, with very young Atlantic white-cedar trees and plentiful pitcher plants. This sub-population was estimated at over 10,000, with some of the most robust clumps observed throughout WSF, with leaves as long as 6 inches. Conversely, other individuals appeared stunted. Fewer than 10 fruiting culms were sighted from the 2000 and 1999 growing seasons. Substrates supporting bog asphodel were saturated to inundated with 3-4 inches of running water. Sub-population 024B looked the way it was described by Windisch (1993). The habitat was limited to a seep area in a small opening within Atlantic white-cedar, approximately 3 feet above the river bank. Only one flowering culm was observed. The individuals were growing in slime among large *Sphagnum* clumps. There was another seep between sub-populations 024 and 024B that supported approximately 20 individuals growing among dense *Sphagnum* moss. A few of these individuals were trampled as well.

c. Site recommendations

Windisch (1993) reported several disturbances at population 024A, including off-road vehicle tracks in the mud, road erosion leading down the ridge, trampling by wildflower enthusiasts, deer trails, and nibbling of bog asphodel leaves by geese. Windisch (1993) did not report disturbances at 024B and 024, although the sites were near a footpath or deer trail. Service personnel reported that this foot trail intersected bog asphodel clumps on 11 occasions, with obvious damage to the species' aerial portion. The trail was also extensively used by deer. In two instances, the trail ran through bog asphodel extensively. The path leading downhill to populations 024 and 024B from an upland road that splits from the Old Martha Road could be obliterated and restored to natural conditions.

Windisch (1993) also reported erosion resulting from a road near sub-population 024A. In November 1994, NJDP&F followed up on Windisch's recommendation and filled the eroding portion of road, seeded the surface with native grasses and sedges, and stabilized the area with a layer of coconut fiber blanketing. The road at the top of the bluff was blocked with logs and posted with signs requesting non-entry by vehicles for the purpose of erosion control. However, Service personnel reported that the eroding road is now open to traffic again. The netting placed over the road was ripped apart and all re-seeding failed as a result of continued use by recreationists with off-road vehicles. Current conditions are similar to those described by Windisch (1993) prior to road closure and restoration. The Service recommends closing and restoring this road again; however, the effort would be of little avail, if physical barriers are not erected and trees are not planted on the road to prevent vehicle access, and the injunction is not enforced.

Fewer than 10 fruiting culms were observed by Service personnel. The site at large was shaded only in the morning, but substrates were saturated or inundated with 1 to 4 inches of water. The Service recommends including the Martha Pond site in a study that would target flowering success in bog asphodel populations. Permanent points should be established and photographed during monitoring

visits.

3. Pump House Bog (occurrence number 041)

a. Past site observations

Four sub-populations of bog asphodel were described by Windisch (1993). Site 041A was immediately adjacent and upstream from the old pump house. Thousands of individuals were located in a quaking bog with wet swales separated from the river by an Atlantic white-cedar levee. No disturbances were detected. Site 041B was located just upstream in a very large *Sphagnum* bog and sustained vast numbers of flowering individuals. No disturbances were detected. Site 041C was located further upstream on an island in the middle of the Oswego River. Several flowering individuals were sighted on the downstream side of the island. A beaver dam was visible in the oxbow area. Site 041D was located even further upstream, just past a dirt road ending in a trashed campground. Thousands of bog asphodel individuals were sighted, apparently undisturbed. Cartica (1995) reported that the population was ranked "A" and was composed of tens of thousands of individuals.

According to Dodds (1996), the four sub-populations encompassed 5-6 acres. Most individuals were sighted in open areas, but also on hummocks with young Atlantic white-cedar trees, in elevated areas with shrubs, and also on micro-sites that were dry and densely vegetated. The site was deemed ideal to characterize bog asphodel's micro-site preferences. Colonization of new habitat by bog asphodel was occurring on mud flats on sites 041A and 041C. The beaver dam was abandoned and water was running freely through it. Bog asphodel became established on both sides of the river at site 041C.

b. Recent observations

Sub-population 041A was visited by Service personnel on October 10, 2000. Bog asphodel was co-dominant, with numbers estimated at well over 10,000. Only a few individuals flowered in 1999 (as demonstrated by the presence of old fruiting culms) and 2000. The sub-population was surrounded by Atlantic white-cedar, with a back cove. Bog asphodel was growing mainly in muck and *Sphagnum*. Water was stagnant, 1 to 3 inches deep.

Sub-population 041B was visited by Service personnel on October 12, 2000. Bog asphodel was co-dominant, with over 10,000 individuals present, but only a few fruiting culms. It appeared that flowering was more plentiful in 1999, as evidenced by widely scattered old fruiting culms. The sub-population was supported by a large, open savanna within a bog, with stagnant to slowly moving water. The substrate was saturated to shallowly inundated. A portion of this bog was shaded in the morning, but mostly sunny otherwise. The opening was large, with isolated Atlantic white-cedar islands. The sub-population looked healthy and well-established under current hydrological conditions. Apparently, succession was creating no threats. The site was not disturbed, with the exception of a deer trail.

Sub-population 041C was visited by Service personnel on October 12, 2000. Bog asphodel was

located on an island created by an old oxbow on the eastern side of the Oswego River's current main channel. The oxbow was filled with 2 to 3 feet of running water, making the island habitat inaccessible to Service personnel. The presence of bog asphodel was obvious from a distance. Some individuals appeared to be in fruit. Succession would be slow at best under current hydrological conditions. Bog asphodel would likely colonize portions of the old oxbow, if water level drops in the future. No signs of disturbance were obvious. Beaver activity was not observed.

Sub-population 041D was visited by Service personnel on October 12, 2000. Bog asphodel at site 041D occurred in a savanna on the northern side of the old oxbow, with young Atlantic white-cedars and many dead mature trees. The bog asphodel sub-population was comprised of a few thousand individuals. Hydrology at the site was provided by the Oswego River, by the old oxbow, and by an unnamed creek from the eastern uplands. This creek sustained an Atlantic white-cedar swamp throughout a large portion of the upland.

c. Site recommendations

Windisch (1993) did not observe disturbances and recommended not to post the area with signs blocking access to the sub-populations. The recommendation was followed by the Office of Natural Lands Management. The site is, apparently, very popular with recreationists. According to Dodds (1996), bog asphodel was disappearing under increased shade. Service personnel reported that some of the 2000 flowers had been cropped by unidentified organisms at site 041A. Some trash was present and the general area was very disturbed because of visitors attracted to the nearby old pump house. The bog where the sub-population occurred was too wet for people walking there, but a foot trail was present at the margins of the surrounding Atlantic white-cedar swamp. This human activity resulted in the trampling of a few bog asphodel clumps as well. Threat-abatement and monitoring methods should be identified and applied to site 041A to minimize disturbances from recreational activities and to investigate the reason why so many flowering culms were cropped. Permanent points should be established and photographed during monitoring visits. No other recommendations are proposed at this time.

4. Above Buck Run (*de novo* population)

a. Past site observations

Above Buck Run is located on the east side of the Oswego River north of Buck Run, immediately north of Pump House Bog. The site was discovered by ONLM staff on September 24, 1998 and revisited with on September 9, 1999 to conduct quantitative vegetation sampling and establish permanent monitoring plots. The site has been described (Walz *et al.*, 2002) as a pristine wetland mosaic that includes Atlantic white-cedar swamp, shrub savanna, tussocky sedge savanna, and aquatic vegetation on deep peat crossed by numerous ground water seepage channels. Thousands of bog asphodel individuals were observed in 1998 and 1999, most in fruit. During the summer of 1999, Scott Stanford (NJGS) conducted research on the geomorphology of the site and determined that it is pristine (no

human impact from mining, turf cutting, logging). On November 1, 1999 a peat core was extracted for pollen and charcoal analysis. The basal peat at this site has a radiocarbon date of 8050 ± 40 years before present. The presence of savanna species in the pollen record is evidence that savanna vegetation has persisted at this site for millenia. Vegetation monitoring plots were established in 1999, and ground water hydrology monitoring (peizometers placed in the adjacent uplands, edge of cedar swamp, and in the savanna) began in 2000 and has continued through 2001. Rare plant taxa included the State-listed New Jersey rush and false asphodel; the Pinelands-listed pine barren reedgrass, Canby's lobelia, large-headed beaked rush, and curly grass fern; and the species of concern, few-flowered beaked-rush and sphagnum spp. (namely *Sphagnum cyclophyllum* and *S. portoricense*).

b. Site recommendations

This site is in pristine condition and is only one of three savanna sites known to be completely undisturbed. Monitoring of vegetation in established plots and measuring ground water hydrology in wells should continue.

D. WEST BRANCH WADING RIVER

1. Below Frank's Ford (occurrence number 046)

a. Past site observations

The site was described by Windisch (1993) as boggy meadows with standing water in the center and as having two extant and three extirpated sub-populations of bog asphodel. Sub-population 046A was a small patch, with few flowering culms; 046E was larger, with few, scattered flowering culms.

Dodds (1996) stated that, during the 1995 growing season, sub-population 046A was comprised of 100-500 vegetative individuals, with three flowering culms. Sub-population 046E was larger, with over 1,000 individuals and over 100 flowering culms. The substrate was described as solid ground, with no muck or standing water. The population expanded by seed toward the river on a new stretch of sandy soil. A few seedlings were counted there. Apparently, the vegetative plants noted growing near mature Atlantic white-cedar trees during previous field surveys had disappeared by the 1995 growing season.

b. Recent observations

The site was visited by Service personnel on October 20, 2000. Sub-population 046A was composed of approximately 750 individuals growing among juvenile Atlantic white-cedar trees (8-15 feet tall) in the back area of a river bend. Mud flats and slowly moving water were present at this site. Bog

asphodel did not flower in 2000, nor was there evidence of flowering from 1999. Although not flowering, bog asphodel may be increasing vegetatively. Succession at the site is progressing slowly. The developing mud flats may provide new areas for bog asphodel expansion. Sub-population 046E was located in a savanna encircled by a narrow band of young Atlantic white-cedar trees, white tall cedars on the river side and to the north. Bog asphodel was plentiful (probably over 3,000 individuals), but none had flowered in 2000.

c. Site recommendations

Windisch (1993) reported that there was no evidence of disturbance at the site, nor did the site provide for a canoe landing area. Apparently, the site was drying out, with Atlantic white-cedar and red maple encroachment. Dodds (1996) did not suggest management practices at this site. Service personnel did not observe threats to the sub-populations, although the site was close to recreational activities. Current hydrological conditions appeared critical to bog asphodel's survival; if the site were to become drier, Atlantic white-cedar would encroach readily. There were noticeable deer trails throughout the savanna. The Service recommends including the Below Frank's Ford site in a study to target flowering success in bog asphodel populations. Permanent points should be established and photographed during monitoring visits.

2. Hawkins' Bridge (occurrence number 003)

a. Past site observations

Three sub-populations, mostly growing in small-sized but relatively un-impacted areas, were described by Windisch (1993) at this site: 003A was located on a pond's edge on the north side of Tulpehocken Creek, near Maxwell-Friendship Road; 003B was composed of scattered, vegetative individuals along small, lateral streamlets in a very wet area downstream from the former, on the northern side of the creek; and 003C was located downstream from the latter in a small, wet meadow, with scattered, vegetative individuals growing on the south side of the creek.

b. Recent observations

The site was visited by Service personnel on October 12, 2000. Sub-population 003A was composed of approximately 800 individuals, mostly growing in a small opening among Atlantic white-cedar trees. Only 20 fruiting culms were observed. The surrounding area was very dense with young Atlantic white-cedar trees and tall shrubs. Field conditions were too wet to visit sub-population 003B. The site for sub-population 003C was located, but no bog asphodel plants were observed there. The habitat was rated as very marginal for bog asphodel. The site can be accessed by a foot trail originating at the confluence of Tulpehocken Creek with the Wading River. Aluminum cans and other trash littered the trail.

c. Site recommendations

Windisch (1993) reported that a canoe-landing site resulted in heavy foot traffic just upstream from 003C. However, no direct detrimental effects were accrued by bog asphodel because of the poor footing provided by the wet meadow. Overall, the site was considered relatively undisturbed. Service personnel visited sub-population 003A near Hawkins' Bridge, a popular spot for recreationists, and found trash near bog asphodel, but concurred with Windisch (1993) that overall wet conditions dissuaded visitors from venturing into the bog. Nonetheless, a few individuals showed signs of having been trampled. The Service recommends establishing permanent points for trend photography and developing research methods for quantitative monitoring.

3. Sacred River (occurrence number 052)

a. Past site observations

A population of bog asphodel was located by Windisch (1993) along a streamlet which enters Tulpahocken Creek. The population extended from a sand road crossing the streamlet downstream to Tulpahocken Creek. Three sub-populations were described by Windisch (1993): 052A, 052B, and 052C. Most individuals were counted in the proximity of the sandy road. The large boggy meadow at the midpoint (052B) sustained bog asphodel on both sides of the streamlet. A larger bog near the confluence with Tulpahocken Creek (052A) harbored plentiful individuals and an island of Atlantic white-cedar. This site was mined for bog iron in the past (State of New Jersey, 2001).

Cartica (1995) reported the population at near 10,000 individuals between 1985 and 1993, with 30-60 percent observed in flower. Numbers were still high in 1995, but fewer individuals were flowering, reportedly as a result of shade increase (Dodds, 1996). Atlantic white-cedar encroachment had split the population in three. One of the sub-populations was expanding.

b. Recent observations

The site was visited by Service personnel on October 12, 2000. Sub-population 052A was observed in a large iron bog savanna. Well over 10,000 individuals were estimated, with several hundred fruiting racemes, both in the open and under Atlantic white-cedar trees bordering with the savanna. Some bog asphodel clumps had fruiting culms in profusion. The substrate characteristic of iron bog savannas appeared to retard or prevent encroachment by Atlantic white-cedar. Sub-population 052B was very similar to 052A. Bog asphodel had flowered profusely. Some individuals with healthy fruiting culms were growing under young Atlantic white-cedar trees 3-7 feet tall. Sub-population 052C was observed as a small, but highly dense patch of over 1,000 individuals growing within an Atlantic white-cedar stand in complete shade. The substrate was saturated, right on the northern bank of an unnamed

creek flowing eastward. Approximately 150 inflorescences were counted, but around 50 had been cropped. A deer trail ran through this sub-population.

c. Site recommendations

Windisch (1993) described the population as large and undisturbed. The easy access into bog asphodel habitat provided to an off-road vehicle by the sandy road crossing was listed as a possible threat. No management strategies were recommended for this site. The Service is in agreement with Windisch's concerns. Because the profusion of flowering in shaded and wooded conditions at Sacred River contradicts claims that shading depresses flowering in bog asphodel, the Service recommends including this site in a study to compare flowering success among bog asphodel populations. Service personnel reported that sites rich in iron ore appear to have healthy populations of bog asphodel, flowering in profusion regardless of shaded conditions. Permanent points should be established and photographed during monitoring visits.

4. Pebble Spong (*de novo* population)

a. Past site observations

Pebble Spong is on the west side of West Branch Wading River, approximately ¾ mile north-northeast of Hawkins Bridge. The site was discovered by NJDEP ONLM staff on September 22, 1998 and revisited with on October 18, 1999 to conduct quantitative vegetation sampling and establish permanent monitoring plots. The site has been described (Walz *et al.*, 2002) as a wetland mosaic that includes Atlantic white-cedar swamp, red maple - hardwood swamp, shrub savanna, tussocky sedge savanna, and aquatic vegetation on muck and sand with quartzite pebbles. Bog asphodel was discovered and documented in 1999, with approximately 12 clusters of vegetative plants and 3-4 plants in fruit. Rare plant taxa included the Pinelands-listed Canby's lobelia, pine barren smoke grass, large-headed beaked rush, and curly grass fern, and the species of concern, sheathed panic grass, and sphagnum (namely, *Sphagnum cyclophyllum* and *S. portoricense*). The site was historically mined for bog iron, with evidence of scarring on aerial photographs taken in the 1930s and exposed muck/sand present today in the deepest excavations in the southern lobe. The site is recovering nicely with typical savanna vegetation.

b. Site recommendations

The bog asphodel population should be re-visited and monitored. The vegetation community analysis in established plots should continue.

E. NESCOCHAGUE CREEK

1. High Beach Bog (occurrence number 006)

a. Past site observations

The site sustains a *de novo* population discovered by Gordon (1996). The occurrence was discovered in a wetland corridor along the northeastern bank of Nascochague Creek, southeast of Mill Road and, more precisely, off Route 542, 1.15 miles northwest of Pleasant Mills church and cemetery, in the northeastern section of an open ore-stained savanna bordering with shrubs and Atlantic white-cedar saplings. Twenty-one flowering culms were observed in a small area. The Pinelands-listed curly grass fern was encountered at the site. Historically, High Beach Bog was mined for bog iron. Half of the site is dominated by smooth sawgrass (*Cladium mariscoides*), an indicator of former mining (State of New Jersey, 2001).

b. Recent observations

The site was visited by Service personnel on November 3, 2000. According to Service estimates, the site was 1.25-1.3 miles northwest of Pleasant Mills church and cemetery, which are near the junction of Roads 542 and 623. Bog asphodel plants were sighted near the edge of rejuvenating Atlantic white-cedar trees growing close to the sandy road. The population was estimated at over 500 individuals, with approximately 100 fruiting culms from 2000 and approximately 60 fruiting culms from 1999, all originating from the same clumps. The bog was saturated to shallowly inundated in parts, with no moving water. Common associates were lowland broom-sedge, gold crest, beaked rushes, Canada rush, pitcher plants, and autumn bent. The Pinelands-listed pine barren smoke grass appeared to occur at the site.

c. Site recommendations

According to Gordon (1996) sufficient favorable habitat exists for a spread by bog asphodel at this site. No disturbances were listed by Gordon (1996) or by Service personnel, except for occasional deer tracks. The Service also visited another bog adjacent to the sandy road, approximately 0.8 mile northwest of Pleasant Mill Church and cemetery. No bog asphodel was encountered there. The Service recommends taking photographs from permanent points during site visits and developing research methods for quantitative monitoring.

2. Nescochague Bog (occurrence number 058)

a. Past site observations

The site sustains a *de novo* population discovered by Gordon (1996). The occurrence was discovered approximately 0.6 mile northwest of High Beach Bog, in an open savanna swale with hummocks, surrounded by a pitch pine lowland to the east, a sand road to the north, and a shrub - Atlantic white-cedar / hardwood swamp to the south and west. Approximately 1,000 fruiting culms were located in two small areas within the northern third of the site. The species richness of the site was emphasized. Deer and/or waterfowl browsing was evident. Pinelands-listed plant taxa included pine barren reed

grass, Canby's lobelia, pine barren smoke grass, curly-grass fern, and reticulated nut rush. The site burned in 1997. All the peat was consumed. Hydrology is almost completely fed by ground water seepage (State of New Jersey, 2001).

b. Recent observations

The site was visited by Service personnel on November 6, 2000. According to Service estimates, the site was approximately 1.9 miles northwest of Pleasant Mills church and cemetery, which are near the junction of Roads 542 and 623. Bog asphodel plants were sighted in low areas near the eastern edge and in the central portion of an oval-shaped depression that was visible from the sandy road. The population was estimated at over 2,000 individuals, with approximately 250 fruiting culms from 2000 and approximately 100 fruiting culms from 1999. Bog asphodel was tightly mixed with plentiful graminoids. A few clumps appeared to be smothered by graminoids, with inflorescences protruding through the herbaceous cover. Growth of some of the bog asphodel plants appeared stunted. Most plants appeared to have gone dormant well before those of more typical populations growing in wetter conditions. The site was mostly atypical, surrounded by lowland pitch pine, mixed in places with scattered red

maple trees and very few Atlantic white-cedar trees. There was also an inner ring of shrubs, mostly huckleberries. There was no evidence of inundation, but the substrate was saturated.

c. Site recommendations

Gordon (1996) proposed prescribed burning and / or turf removal as management alternatives to peripheral invasion by shrubs and saplings, as well as graminoid succession on interior hummocks. According to Service personnel, bog asphodel numbers appeared to have decreased since 1996 estimates. Hydrology at the site should be closely monitored. Nescochague Bog would represent a good comparative site for research on both hydrology and fire. This site is probably one of the driest encountered, which could represent the "dry" extreme of bog asphodel's hydrological range. There was evidence of a past fire sweeping through the area and likely contributing control of woody encroachment. The population should be visited yearly to understand trends. The Service recommends taking photographs from permanent points during yearly monitoring visits. Research methods should be selected and applied for the purpose of obtaining data to support potential habitat manipulations.

3. Hidden Savanna (*de novo* population)

a. Past site observations

Hidden Savanna is located on the eastern side of Nescochague Creek, approximately ¼ mile southeast of High Beach Bog and ¾ mile north of Pleasant Mills church and cemetery. The site was discovered

by ONLM staff on September 2, 1999 when quantitative reconnaissance vegetation sampling was completed. The site has been described (Walz *et al.*, 2002) as a wetland mosaic that includes Atlantic-white cedar swamp, shrub savanna, tussocky sedge savanna, and aquatic vegetation on shallow muck over sand. Three clusters of bog asphodel were scattered in the sedge savannas and around the periphery of the savanna complex. One cluster contained 8 vegetative plants, and two clusters each had only 2 vegetative plants. Pinelands-listed plant taxa included Canby's lobelia and curly grass fern; species of concern present were sheathed panic grass and sphagnum (namely *Sphagnum cyclophyllum*). The site appears on recent aerial photos to be in an old oxbow of the creek. Land use history has not been determined, but the site is a beautiful savanna.

b. Site recommendations

The site should be revisited to monitor the bog asphodel population. The site's history should be determined.

Table 2. Rank Specifications for *Narthecium americanum* populations, Wharton State Forest (*de novo* populations with missing rank specifications are not included).

SITE	1985	1993	1995	1996	1997	2000
Atsion Bog (038)	A	C	D	D	D	D
Batsto Bog (044)	A	A	A	-	A	A
Batsto Oxbow (002)	-	-	-	-	-	C
Beaver Trail Savanna (066)	-	-	-	-	D	C
Below Big Doughnut (048)	B	B	B	B	B	B
Below Frank's Ford (046)	-	-	B	B	-	B
Below the Locks (035)	-	-	D	D	D	D
Cold Spring Bog (051)	B	B	A	-	B	B
Fawn Bog (042)	-	-	A	-	B	A
Hampton Gate Bog (042)	-	-	-	-	-	C
Harrisville Bow (045)	-	-	A	-	-	A
Hawkins' Bridge (003)	-	-	B+	-	-	B-
High Beach Bog (006)	-	-	-	-	-	C
Ice House (034)	B	D	B	B	D	C
Long Savanna (043)	B	B	B	-	B	B
Lower Forge (033)	A	A	A	-	A	A
Martha Pond (024)	-	-	A	-	-	A-
Mystery Savanna (067)	-	-	-	-	C	C
Nescochague Bog (058)	-	-	-	-	-	B
Odd Spot (047)	-	-	A	-	B	C-
Pump House Bog (041)	-	-	A	A	-	A
Quaker Bridge (001)	-	-	B	-	D	D
Sacred River (052)	-	-	A	A	-	A
Savanna Verde (065)	-	-	-	-	A	A
Skit Branch Bog (010)	-	-	C	C	-	C
Three Bogs (040)	B	C	B	B	C	B
Twin Savannas (036)	B	D	D	-	D	D
Unexpected Site (037)	A	C	A	A	C	B
Whispering Savanna (no#)	-	-	-	-	-	C

XIII. RESEARCH OPPORTUNITIES

Management of bog asphodel populations is hampered by a lack of data regarding the species' hydrological requirements, soil types, nutrient requirements, responses to light, fire adaptations, life history, flowering success, and reproductive biology. Through this conservation agreement, the Service and the NJDP&F will work cooperatively to alleviate some of these information gaps. For the populations within WSF, the Service has identified the following opportunities to understand bog asphodel's life history and habitat requirements better.

A. LITERATURE SEARCH

A literature search, covering *Narthecium* spp. from 1963 to present, was provided by ONLM to the Service. Searches for studies done on other associated or closely related wetland plants, particularly State-listed plant species of the Pinelands' savannas, would be useful in identifying more clearly the state of our knowledge and research opportunities for bog asphodel.

B. HYDROLOGIC REQUIREMENTS

Bog asphodel populations are essentially supported by continual ground water seepage and by intermittent flooding from adjacent rivers and creeks (Cartica 1999; Walz *et al.*, 2000). The threats posed by meeting the water needs of proposed new developments in southern New Jersey, coupled with the prolonged recent drought, has the potential to spell disaster for bog asphodel populations as well as for other State- and Pinelands-listed plant species. Further, the New Jersey Department of Environmental Protection approved a new general permit that allows growers to impact up to 5 acres of Pinelands wetlands for cranberry production. These impacts have been mitigated so far by a sluggish cranberry market.

Overall, woody encroachment appears inevitable once hydrological resources decrease at a site. It is therefore essential to quantify baseline hydrological requirements for bog asphodel to document and demonstrate adverse effects in the future. Dr. Zampella at the Pinelands Commission has recently received a grant to model fluctuations to the Kirkwood-Cohansey aquifer that underlines the Pinelands Reserve. Although bog asphodel has not so far been selected as an indicator plant species, a valid model would provide much-needed information on sustainable water use under different scenarios.

C. THE ABILITY OF *NARTHECIUM AMERICANUM* TO FLOWER

Dodds and Goodwin (1997) related lack of flowering by bog asphodel to shaded conditions and woody encroachment. Service personnel have visited sites where this relation appeared valid, but have also observed bog asphodel flowering profusely both in the shade and within Atlantic white-cedar swamp habitat, as well as bog asphodel not flowering in full sunlight. Therefore, research should focus not only on light availability, but on characterizing hydrological requirements, soil types, soil pH, nutrient availability, and possibly genetics as well. Flower and fruit production by plants are

expensive energetically. Water-logged conditions may be limiting nutrient availability to bog asphodel. Iron-ore bogs should be included as sites representing profuse flowering success. The Service views vegetative reproduction as a survival strategy rather than a problem indicator. Nonetheless, data need to be collected to understand the relative contributions of fruiting and vegetative clumps in developing appropriate management strategies. Potentially favorable study sites are listed in Table 3.

Table 3. Favorable sites for studies of factors affecting flowering success.

SITE	HYDROLOGY	ASPECT	FLOWERING
Below Frank's Ford	Inundated	Sunny	No
Martha Pond	Inundated	Sunny	No
Beaver Trail Savanna	Inundated	Sunny	No
Long Savanna	Inundated/Saturated	Sunny	Partially
Below Big Doughnut	Inundated/Saturated	Sunny	Yes
Savanna Verde	Inundated/Saturated	Sunny	Yes
Nescochague Bog	Decreasing	Sunny	Yes
Unexpected Site	Fluctuating	Sunny	Decreasing
Sacred River	Inundated/Saturated	Shaded	Yes
Batsto Oxbow	Flooded	Partially shaded	Yes
Atsion Bog	Decreasing	Increasingly shaded	Yes
Ice House	Saturated	Shaded	No

D. THE LIFE HISTORY OF *NARTHECIUM AMERICANUM*

The life history of bog asphodel is unknown. Monitoring studies can range from simple to complicated, depending on the level of information required. One characteristic typical of these studies is that they require monitoring of permanent plots over several years, resulting in information on demography and population flux, seedling survival, flowering schedule, pollination and reproductive performance, seed set, flower / fruit consumption, and parasitism. Other variables such as percent foliar cover and species composition are estimated from permanent plots. Sites should be selected and plots should be placed in ways that minimize trampling by researchers and technicians.

There are various scientific papers highlighting the process of mapping individual plants within permanent plots. Sarukhán and Harper (1973) used a pantograph attached to a portable aluminum frame to map individuals of the genus *Ranunculus* within 2 mm of precise locality. Bishop *et al*. (1978)

mapped rosettes of *Hieracium pilosella* in England by the use of calipers and by giving each plant a four-digit coordinate, which allowed the center of a rosette to be located within ± 1 mm. Kelly (1989) located individuals of *Euphrasia pseudokerneri*, *Gentianella amarella*, *Rhinanthus minor*, and *Linum catharticum* in England by tying a label with polyester thread to each seedling. Kearns and Inouye (1993) mentioned that terrestrial wildlife, birds, and vandals are attracted to tags and unusual features in the field. This may result in tag removal and damage by trampling to bog asphodel occurrences. A combination of tagging and mapping would be very laborious.

E. THE FIRE ECOLOGY OF *NARTHECIUM AMERICANUM*

Staff at ONLM does not currently recommend prescribed burning in *Narthecium americanum* populations of stream-side savanna habitats, until at least better observations and data become available on fire effects to this and associated rare plant species, as well as the natural communities that make up their habitat. The following research on fire ecology is recommended for further discussion (State of New Jersey, 2001):

- Observe and sample sites known to have been recently burned by wildfire, such as Nescochague Bog (1997) and Middle Branch Forked River (1992) to understand the short-term impacts and benefits of fire in the system. If available, use pre-fire data to help evaluate post-fire changes.

- Evaluate fire history of all known stream-side savannas and *Narthecium americanum* sites. Fire records and historical aerial photography may be of limited usefulness, since wet sites such as these may not always burn when their surrounding firesheds do. On-site and near-site searches for fire scars may be more productive in establishing years since last fire and fire intervals within stream-side savannas. No information is available to determine whether a "fire return interval" can be associated with savannas or if fire is a rare and random event. Evaluation of data is advised prior to applying prescribed fire as a management tool for bog asphodel.

- Develop fire life history attribute tables for all plant species in these natural communities, including *Narthecium americanum* and other rare plant species, from available scientific knowledge. This may help predict how plant species and natural communities would respond to different intensities, types, and seasons of fire, as well as the possible outcome of fires, both desired and undesired. Useful attributes include seed banking, seed dispersal, vegetative propagation, soil depth of vegetative organs, and
fire / heat tolerance.

- Work with the New Jersey Forest Fire Service (NJFFS) to evaluate feasible methods of burning surface organic layers in wet habitats, which often have organic soils. Burning during the typical January-March prescribed fire season may be difficult or impossible to accomplish, when seasonal high water tables are at the surface. Although not currently practiced by

NJFFS, fall or growing season burns may need to be considered. The standard procedure of installing plow lines through prescribed burning sites is not appropriate within these sensitive wetland sites; therefore, less impacting means of fire control and containment would need to be developed. Burn units would likely need to include adjacent uplands. Smoke management becomes an issue when burning surface organic materials; burn windows may be further constrained.

The main purpose of burning would be to alleviate heavy deposits of litter, recycle nutrients, and set succession back. Permanent plots should be placed for the purpose of gathering pre-and post-treatment data over several years, and would be useful in identifying more clearly the state of our knowledge in regard to bog asphodel.

F. THE RE-ESTABLISHMENT OF *NARTHECIUM AMERICANUM* POPULATIONS

The Plant Conservation Program of the North Carolina Department of Agriculture and Consumer Services (NCDACS) recently purchased a bog in *Narthecium americanum*'s historic range in Henderson County, North Carolina and would like to reintroduce the species there (Frost, pers. comm., 2000). Although preference would be given to genetic material from the southern part of the taxon's range, a cooperative effort between NCDACS and ONLM is critical in attempting to re-introduce bog asphodel to its former range in North Carolina. According to Schuyler (1990), bog asphodel is currently limited to the Pinelands region of New Jersey.

XIV. INVOLVED PARTIES

New Jersey Department of Environmental Protection
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Office of Natural Lands Management
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Trenton, New Jersey 08625-0404

New Jersey Department of Environmental Protection
Division of Parks and Forestry
Wharton State Forest
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United States Department of the Interior
Fish and Wildlife Service
New Jersey Field Office
927 North Main Street, Bldg. D

Pleasantville, New Jersey 08232

XV. AUTHORITY

- The signatory parties hereto enter into this Conservation Agreement under federal and State law, as applicable.

- All parties to this Agreement recognize that they each have specific statutory responsibilities that cannot be delegated, particularly with respect to the management and conservation of floral and faunal resources, the management of habitats, and the development and allocation of water resources. Nothing in this Agreement is intended to abrogate any of the parties' respective responsibilities.

- This Agreement is subject to and is intended to be consistent with all applicable federal and State laws.

XVI. CONSERVATION SCHEDULE AND ASSESSMENT

An annual assessment of conservation activities and accomplishments will be made by the NJDP&F and the Service. This assessment will determine the effectiveness of this agreement and whether revisions are warranted. It will be provided to all signatories of this document.

XVII. DURATION OF AGREEMENT

The initial term of this Agreement shall be 5 years. Prior to the end of each 5-year period, a thorough analysis of actions implemented for the species will be conducted by the Service. This Agreement shall be extended for an additional five (5) years, if all signatories agree that sufficient progress has been made towards the conservation and recovery of bog asphodel. Any party may withdraw from this Agreement on sixty (60) days written notice to the other party.

XVIII. SIGNATORIES

New Jersey Department of Environmental Protection
Division of Parks and Forestry
P.O. Box 404
Trenton, New Jersey 8625-0404

_____

Richard F. Barker Date
Acting Director

United States Department of the Interior
Fish and Wildlife Service
New Jersey Field Office
927 North Main Street, Buildling D
Pleasantville, New Jersey 08232

_____

Clifford G. Day Date
Supervisor

XIX. REFERENCES

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B. PERSONAL COMMUNICATIONS

Boyer, M. 2000. Botanist and Ginseng Coordinator. North Carolina Department of Agriculture and Consumer Services, Plant Industry Division, Plant Protection Section, Plant Conservation Program.

Cartica, R.J. 2000. Supervisor. Natural Areas Program, New Jersey Department of Environmental Protection, Division of Parks and Forestry, Office of Natural Lands Management, P.O. Box 404, Trenton, New Jersey 08625-0404.

Frost, C. 2000. Plant Ecologist. North Carolina Department of Agriculture and Consumer Services, Plant Industry Division, Plant Protection Section, Plant Conservation Program.

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APPENDIX A

Map of *Narthecium americanum* populations within Wharton State Forest
(does not include *de novo* populations)

Hampton Gate Bog
Skit Branch Bog
Fawn Bog
Three Bogs
Ice House
Above the Locks
Lower Forge
Below the Locks
Sacred River
Hawkins Bridge
Quaker Bridge
Odd Spot
Beaver Trail Savanna
Below Franks Ford
Pump House Bog
Unexpected Site
Martha Pond
Savanna Verde
Twin Savannas
Below Big Doughnut
Long Savanna
Cold Spring Bog
Mystery Savanna
Batsto Bog
Harrisville Bow
Batsto Oxbow
WESCHOCHAGUE BOG
HIGH BEACH BOG
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APPENDIX B

Rank Specifications for *Narthecium americanum* (State of New Jersey, 1995)

Rank Specifications for *Narthecium americanum*

A. Habitat: Pristine or near pristine wetland complexes with no or minimal hydrological impacts. No dams or obstructions that would either increase flooding of habitat beyond seasonal norms or lower water table and subject soil to prolonged periods of drying. Habitat occupied by *Narthecium americanum* open and free from succession by woody or rank herbaceous species. Habitat free from extensive or excessive trampling. Aggressive exotic plant species none or easily controlled. Surrounding land in sufficient wooded or other compatible buffer to assure long term viability.

Population Size and Vigor: 5,000 or more clumps occupying (either scattered or essentially throughout) one or more acres of contiguous habitat.

Exemplary Occurrence: 10,000 or more clumps in three or more acres.

II. Habitat: In excellent conditions with only minor impacts or disturbances, none of which are directly impacting or degrading habitat. Site may have trails or be bisected by road. May be near agricultural or cleared lands or low density development, but no direct or significant long-term impacts are observable. Some habitat succession, but much open, unoccupied potential habitat available. Exotic plant species may be present but not significantly impacting habitat. All impacts can be mitigated with minimal effort and expense. Reasonable amount of wooded or other buffer present to insure long term viability.

Population Size and Vigor: 1,000 or more clumps occupying less than two acres.

III. Habitat: Significantly disturbed and fragmented, often with declining conditions, but reversible with management. Portions of habitat ditched, dammed, cleared, in rapid succession, etc. Remaining buffer less than optimal. Occurrence recoverable with significant effort or expense.

Population Size and Vigor: Any population of 100 or more clumps.

IV. Habitat: Heavily and possibly irreversibly disturbed or altered. Impacts significant and directly impacting population. Little or no remaining buffer. Population with little or no potential for recovery, at least not without an extraordinary expenditure of time and money.

Population Size and Vigor: Any population regardless of size or numbers in above described habitat, or less than 100 clumps in an A, B or C ranked habitat.