

American Hart's-tongue Fern
(*Asplenium scolopendrium* var. *americanum*)

**5-Year Review:
Summary and Evaluation**



October 2012

**U.S. Fish and Wildlife Service
Ecological Services Field Office
Cookeville, Tennessee**

5-YEAR REVIEW
American hart's-tongue fern (*Asplenium scolopendrium* var. *americanum*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional or Headquarters Office:

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Other Reviewers:

David Lincicome, Tennessee Natural Heritage Program

Donald Leopold, State University of New York (SUNY)

Danilo Fernando, SUNY

Steve Young, New York Natural Heritage Program

Mike Penskar, Michigan Natural Features Inventory

Sara Davis, Hiawatha National Forest, U.S. Forest Service, Michigan

1.2 Methodology used to complete the review:

This five-year review of the conservation status of American hart's-tongue fern was conducted by the U. S. Fish and Wildlife Service's (Service) Asheville, North Carolina and Cookeville, Tennessee Field Offices. The review process was initiated on July 28, 2006, when a formal notice of review was published in the Federal Register (71 FR 42871), opening a 60-day public comment period. Copies of the notice and written requests for information were sent to 56 organizations, individuals, and State and Federal agencies. Recipients of these requests were those individuals and entities that have management responsibility for the species, had demonstrated interest in the conservation of the species in the past or were thought to have current information on the status of the species. We received three responses to this request for information. The information provided in these responses as well as other information in our files, including peer-reviewed scientific publications, unpublished reports, field observations and personal communications, formed the basis of this review of the status of American hart's-tongue

fern. This review was also sent to 7 peer reviewers. Comments and corrections received from these reviewers were incorporated into the 5-year review (see Appendix).

1.3 Background:

1.3.1 FR Notice announcing initiation of this review: 71 FR 42871 (July 28, 2006)

1.3.2 Species status (2011 Recovery Data Call): Unknown – The Service did not have current data on status of populations during 2011 at the time the Recovery Data Call was completed.

1.3.3 Recovery achieved: According to data in the Recovery Action Online Reporting database, 2 out of 16 recovery tasks are considered completed. Therefore, recovery achieved would be classified as 1 (i.e., 0 – 25 %) on the scale of 1 to 4 used for 5-year review purposes.

1.3.4 Listing history

Original Listing

FR Notice: 54 FR 29726-29730

Date listed: August 14, 1989

Entity listed: *Asplenium (Phyllitis) scolopendrium* var. *americanum* (= *Phyllitis japonica* ssp. *americana*) - subspecies

Classification: Threatened

Revised Listing

Not applicable

1.3.5 Associated rulemakings: Not applicable

1.3.6 Review History: Prior to the initiation of this formal review the status and progress towards recovery of American hart's-tongue fern was informally evaluated periodically by the Asheville Field Office. The results of these reviews were included in the Service's periodic Reports to Congress on implementation of the Federal Endangered Species Recovery Program. The Service also reviews the status of American hart's-tongue fern during the annual Recovery Data Call. These reviews consisted of telephone or email contacts with state and federal agency personnel and others familiar with the species or responsible for its conservation and management.

1.3.7 Species' Recovery Priority Number at start of 5-year review: 9 (this subspecies has a moderate degree of threat and high recovery potential)

1.3.8 Recovery Plan

Name of plan: American Hart's-tongue Recovery Plan

Date issued: September 15, 1993

Dates of previous revisions: N/A

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy: N/A

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

No. New information on the biology of American hart's-tongue fern is presented in this review.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

Yes

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information

The recovery plan for the species lists two criteria that should be met prior to considering the species for removal from the Federal List of Endangered and Threatened Plants. These are:

1. It has been documented that at least 15 U.S. occurrences (2 in Alabama, 2 in Tennessee, 4 in Michigan, and 7 in New York) are self-sustaining and occur on sufficiently large tracts to ensure their perpetuation with a minimal amount of active management.

This recovery criterion has not been met. There currently is only one extant occurrence in Alabama, which decreased from 97 plants in 1981 to 33 plants in

1995 (Evans 1981, Garton 1995). There currently is only one occurrence known from Tennessee (Lincicome 2005), which had been reduced to only two mature plants as of 2011. W. E. Moritz (in litt. 2006) reports that the Michigan Department of Natural Resources (MDNR) currently has records of American hart's-tongue fern from 11 sites in Michigan. Kelsall et al. (2004) reported that there are 16 extant occurrences of American hart's-tongue fern in New York. While some populations in Michigan and New York are likely self-sustaining, those in Alabama and Tennessee are vulnerable to localized extinction due to small population sizes.

2. All of the above occurrences and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the occurrences.

This criterion has not been met. The extant occurrences in Alabama and Tennessee are on privately owned lands, and no formal agreements have been established with the owners of those properties to ensure the protection of American hart's-tongue fern or its habitat. Small population size and long-term declining trends in these southern populations have left them vulnerable to localized extinction with little chance for recolonizing sites where they occur, absent human intervention. Seven of the occurrences in Michigan occur on U.S. Forest Service (USFS) lands, and six of these are protected by old-growth designation of the stands in which they are located. The seventh occurrence on USFS land in Michigan is located in a site that was proposed for a timber harvest, but this site was removed from the proposal when the American hart's-tongue fern was found there (Davis 2007). Ten of the occurrences in New York are distributed among three protected sites: Clark Reservation State Park (6), Chittenango Falls State Park (3), and Split Rock Unique Area (1), the last of which is owned by New York State Department of Environmental Conservation.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Several persons have attempted to propagate American hart's-tongue fern for the purpose of augmenting existing populations or to establish new ones (Garton 1995, Cressler 1996, Pence 2005, Leopold pers. comm. 2012). The Tennessee Department of Environment and Conservation (TDEC) used section 6 Cooperative Endangered Species Recovery funds to initiate a project to locate a suitable site for introduction on protected lands and to augment the Marion County, Tennessee, population with cultured plants. This project was successful in producing gametophytes from spores sown onto sterile culture; however, no spores germinated when sown onto native soils gathered at the sites where spores were

collected. Spores collected at the Morgan County, Alabama, site produced higher germination rates and more vigorous gametophytes than those collected from the depauperate population in Jackson County. No sporophytes were produced from gametophytes, regardless of source population.

Data loggers installed at the Alabama sites recorded stable summer temperatures of 14-15° C (58-60° F) and incident solar radiation of 14-18 watts/m² (Garton 1995). A suitable candidate site for introducing a population onto protected lands was found at Oak Ridge National Laboratory, in Tennessee (Cressler 1996), but an introduction was never attempted at this site.

Leopold (SUNY, pers. comm. 2012) reported that Holly Emmons, SUNY Catskill, produced over 1500 American hart's-tongue fern from a single frond, many of which were large enough to produce spores, for introduction into a site near the population at Split Rock Unique Area. However, none of the introduced plants are known to have survived, presumably due to lack of watering during dry spells that occurred during the first growing season.

TDEC used section 6 funding to initiate a study in 2004 with Cincinnati Zoo and Botanical Garden to accomplish the following objectives: (1) obtain germplasm from three populations in Alabama and Tennessee, (2) dry and bank spores, (3) test the viability of the spores, (4) evaluate tissue culture propagation via *in vitro* collecting, and (5) evaluate tissue culture propagation via aseptic spore germination. Because of a lack of material, spores and tissues were only collected at the Morgan County, Alabama, site, and all the spores were used to produce gametophytes. Germination was attempted using two methods: (1) germination *in vitro* on various semi-solid media, and (2) germination on sterile soil-less potting mixes. Germination *in vitro* only occurred on media lacking hormones, and spores readily germinated on potting mix; but, no sporophytes were produced during 2005 using either technique (Pence 2005). However by 2009, approximately 50 sporophytes had been produced (V. Pence, Cincinnati Zoo and Botanical Garden, pers. comm. 2009). None of these plants have been reintroduced to the Tennessee site as of 2012.

J.E. Watkins (Colgate University, pers. comm. 2012) has produced a single gametophyte from spores collected from Tennessee, but it remains to be seen whether production of sporophytes from this material will be possible. In 2011, W. Barger (pers. comm. 2012) acquired samples of sporangia from material collected circa 1986 at the Morgan County, Alabama, site. These materials were sterilized and plated on agar in February 2011, and produced gametophytes approximately one year later.

By late April 2012, sporophytes were growing from two plants and several others appeared to be initiating sporophyte development.

Testo and Watkins (2011) completed a study on the comparative development and gametophyte morphology of the hart's-tongue fern, in order to describe the gametophyte of North American *A. scolopendrium* var. *americanum* and improve understanding of how this stage compares to European *A. scolopendrium* var. *scolopendrium*. They found significant differences in gametophyte development, morphology, and propensity for sexual and asexual reproduction, which they concluded support the separation of these taxa at the varietal level. Gametophytes of *A. scolopendrium* var. *americanum* germinated earlier, but grew slower and produced sporophytes much later (166 days vs. 119 days), than those of the European variety. Another marked difference was that the North American variety produced numerous gametophytic outgrowths that could develop into functional, independent thalli, while the European variety did not. Testo and Watkins (2011) reasoned that this ability to asexually produce propagules that could produce new thalli, which often produced sporophytes in lab culture, may produce more robust gametophytes capable of resisting periods of physiological stress.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Alabama. There are two known occurrences of American hart's-tongue fern in Alabama. Both were discovered by cavers associated with the Huntsville Grotto of the National Speleological Society (NSS) (Batchelder 1979, Evans 1982). One site is in a Jackson County sinkhole on lands managed by Wheeler National Wildlife Refuge and is considered protected. Short (1979) observed 20 plants present when he first visited this site. Evans (1981) found that the occurrence had dwindled to nine plants by July 1981. Evans further stated that this occurrence appears, for undetermined reasons, to be in static or declining condition. In 1990, members of the Huntsville Grotto surveyed the site and found only four plants (Huntsville Grotto 1990). In 1994, Garton (1995) reported that three plants bearing fronds with sporangia were present at this site. At the present time the fern is thought to have been extirpated from the site. No plants have been observed there for several years (W. Gates, Wheeler National Wildlife Refuge, pers. comm. 2010).

The second Alabama location is in Morgan County in the privately owned pit entrance to a limestone cave. This occurrence is located about 25 miles southwest of the Jackson County site (Short 1980). Evans (1981) reported that this site contained a vigorous, healthy, reproducing occurrence, which

in 1981 supported 97 plants. Members of the Huntsville Grotto resurveyed the site in 1990 and reported that the occurrence had declined to 39 plants (Huntsville Grotto 1990). Garton (1995) counted 33 plants at this site in 1994, 18 of which bore sporangia. Although there has not been a recent formal survey of this site, Barger (pers. comm. 2012) visited this site in 2011 and found the population there to be stable, compared to 1995 numbers, but did not provide a count.

Tennessee. There are at least three records of American hart's-tongue fern in Tennessee. The first of these was discovered in the entrance to a Roane County cave by Gattinger in 1849. Despite repeated searches for the plant at this site since the early 1900s, it has not been seen again and is considered to be extirpated from the area (Maxon 1900, Shaver 1954, Evans 1981).

The second possible location for the species in Tennessee is mentioned by Lincicome (2005). A site, near Crossville, Tennessee, was reported in 1928 to support a population of American hart's-tongue fern. Lincicome (2005) states that soon after this report, efforts to locate and confirm the existence of this population were not successful and that the population at this site may have been destroyed by wildfires in 1928.

The only extant Tennessee occurrence is in Marion County and was discovered by Cheatham in 1879 (Williamson 1879, Evans 1981). Originally supporting about 200 plants, this occurrence contained only about 17 plants in the 1970s (Evans 1981). Early concern about the decline of this occurrence led Graves in 1929 to scatter American hart's-tongue fern spores at the site. The spores were obtained from a plant collected in Ontario, Canada (McGilliard 1936). There appear to be no morphological characters that distinguish Tennessee from Canadian representatives of this taxon; therefore, without electrophoretic or other genetic analysis it is impossible to know the origin of the few plants that survive. Lincicome (in litt. 2006) states that the site currently supports only a few depauperate individual plants. A private landowner purchased this site and one acre surrounding the sinkhole, knowing that American hart's-tongue fern was present, and prohibits recreational caving in order to protect habitat. Two plants were present at the site in 2011.

Michigan. In 1986, the Michigan Natural Features Inventory (MNFI) recognized four extant occurrences of American hart's-tongue fern in Michigan (S. Crispin, MNFI, pers. comm. 1986). All of these sites were in Mackinac County. W. E. Moritz (in litt. 2006) reports that the Michigan Department of Natural Resources (MDNR) currently has records of American hart's-tongue fern from 11 sites in Michigan. One additional site on USFS land was discovered during September 2007, but is not included in the MNFI records discussed above (Davis 2007). Ten of

the American hart's-tongue fern observations recorded by MNFI are from Mackinac County and one from Chippewa County.

Six of the ten Mackinac County sites tracked in the MNFI database occur on USFS lands, along with the site discovered in 2007 (Table 1). The USFS monitored these populations during 1999-2004 (Marr 2006) and again in 2007 (Davis 2007) (Table 1). Marr (2006) found that there were about 2,000 American hart's-tongue fern plants present (including sporelings, which are not counted in Table 1) during the three years in which a census of plants was conducted and documented several trends at most sites during the five-year monitoring study: increased numbers of sporelings and immatures, decreased numbers of mature plants (primarily due to reduced sori (clusters of sporangia) production), decreased frond length, and reduced numbers of fronds per plant. In a less intensive survey of these sites, Davis (2007) counted 1,379 plants, with 15 plants at the site discovered in 2007, and concluded that the occurrences appeared healthy and were stable. Populations at sites 1, 3, 4, 5, and 7 were found to be in good condition during 2008 and 2009, with few apparent threats observed (USFS 2008 and 2009).

The remaining three Mackinac County sites occur on private lands and contain the largest populations of American hart's-tongue fern in Michigan. These three sites are considered to have excellent viability (C. Mensing, pers. comm. 2012). The lone Chippewa County occurrence was vandalized in 1983. One individual plant was present in 1992; however, the current status of this population is unknown.

Table 1. Census data of immature (fronds > 2.5 cm but lacking sori) and mature (fronds > 2.5 cm and at least one containing sori) American hart's-tongue fern plants, Hiawatha National Forest, Mackinac Co., Michigan (note: blank cells indicate no data collected during that year).

Occurrence (Site #)	Site Name	1999	2000	2001	2002	2004	2007	% change 2000-2002	% change 2002-2004
1	Pipeline Site	67	61 [†]	56	63	47	65		
2	NW of East Lake		141		136	111	91	-3.5	-18.4
3	SE of East Lake		409		464	441	438	13.4	-5.0
4	East Lake		129		142	140	42	10.1	-1.4
5	SW of East Lake		158		269	280	194	70.3	4.1
6	Taylor Creek		384		468	445	549	21.9	-4.9
7	Grykes						15		
Totals (excluding site 7)		67	1282	56	1542	1464	1379	20.3	-5.1

[†]Value for site 1 during 2000 is average of 1999 and 2001, because data were not collected during 2000 (Marr 2006).

1999-2004 data from Marr (2006)

2007 data from Davis (2007) - survey done differently than Marr (2006) with no separation of life history states, so sporelings also were counted; however, based on report, it is likely that some plants were missed due to lower intensity of survey effort. For these reasons, percent change is not reported for the period 2004-2007.

New York. The status of American hart's-tongue fern in New York has been carefully documented since the early 1900s (Hunter 1922, Faust 1960, Cinquemani et al. 1989, Cinquemani Kuehn and Leopold 1992, Kelsall et al. 2004). The fern is known from a limited area within Madison and Onondaga Counties. The delineation of the species distribution in New York used here is based on Kelsall et al. (2004), who listed 16 occurrences as extant in 2002. These occurrences are divided among seven sites for American hart's-tongue (Table 2). Four sites totaling 10 occurrences are located in Onondaga County, and three sites totaling six occurrences are located in Madison County. Ten of these extant occurrences are located on protected lands: six at Clark Reservation State Park, three at Chittenango Falls State Park, and one at Department of Environmental Conservation's Split Rock Unique Area.

At the time American hart's-tongue fern was listed only nine of the 16 extant occurrences were known to support the species, and it had been extirpated from four locations. Three of these were destroyed by quarrying operations between 1924 and 1935 and one by undetermined means soon after 1959. Since the species was listed it appears to have been extirpated from one additional Onondaga County site (Kelsall et al. 2004).

Since the first census of American hart's-tongue fern was undertaken at the Clark Reservation sites in 1916 (Hunter 1922), various parties have monitored American hart's-tongue fern occurrences in New York (Table 2) (Faust 1960, Cinquemani et al. 1988, Cinquemani Kuehn and Leopold 1992, Tango 1999 cited in Kelsall et al. 2004, Kelsall et al. 2004). Since 1936, a census has been conducted at the Clark Reservation sites approximately every five years (Cinquemani et al. 1988). While these censuses have included counts of sporelings, immature, and mature plants, data reported here do not include sporeling counts because of the high potential for observers to overlook this inconspicuous size-class (Cinquemani et al. 1988).

In reporting on the censuses conducted at the Clark Reservation sites between 1956 and 1986, Cinquemani et al. (1988) noted the high variability observed between some years and concluded this was most likely attributable to climatic variability. For example, the authors concluded that a regional drought likely was responsible for steep reductions seen at some sites during the mid-1950s and mid-1960s. Localized site conditions appeared to influence susceptibility to climate driven fluctuations, as occurrences that are located in drier and more exposed sites (i.e., sites 1, 4, and 6) suffered greater percentage decreases than those in moister sites (i.e., sites 3 and 5). The drier, exposed sites also harbor smaller populations (Table 2) of American hart's-tongue fern,

and individual plants at these sites tend to be smaller and possess fewer fronds per plant, as compared to the moister sites.

Cinquemani Kuehn and Leopold (1992) analyzed long-term demography of all American hart's-tongue fern populations in New York in relation to climatic data, focusing on data obtained between 1945 and 1989. They concluded that (1) distribution and size of the New York populations were strongly related to climatic and topographic factors such as snow cover, aspect, slope position, percent slope, and presence of wind barriers and (2) variation in census numbers among years at a given site were most likely attributable to climatic variations and past anthropogenic disturbances (Cinquemani Kuehn and Leopold 1992).

Variability among years is evident in more recent censuses conducted in New York (Table 2). Kelsall et al. (2004) report that overall the New York population declined between 1995 and 2002. However, the overall population increased by nearly 100 percent by the time a census was conducted in 2008/9, only to decrease again by about 11 percent in 2011 (Table 2). For the period 1988-2011, American hart's-tongue fern populations in New York increased by approximately 35 percent overall (Table 2), with only one occurrence suffering a negligible decline. While interannual variability has been observed to a great extent in these populations, with some steep declines since monitoring began in 1916, they appear to be stable over longer time periods.

Table 2. Census data of immature (fronds > 2.5 cm but lacking sori) and mature (fronds > 2.5 cm and at least one containing sori) American hart's-tongue fern plants in New York (note: blank cells indicate no data collected during that year).

Occurrence	County	1988	1993-1995	1999	2000	2002	2008/9	2011	% change 1995-1999	% change 1999-2000	% change 2000-2002	% change 2002-2008/9	% change 2008/9-2011	% change 2000-2011	% change 1988-2011
Clark Reservation 1	Onondaga	257	378	213	228	173	461	385	-43.7	7.0	-24.1	166.5	-16.5	68.9	49.8
Clark Reservation 2	Onondaga	250	279	188	165	145	266	254	-32.6	-12.2	-12.1	83.4	-4.5	53.9	1.6
Clark Reservation 3	Onondaga	968		688	772	468	997	965	-46.8	12.2	-39.4	113.0	-3.2	25.0	-0.3
Clark Reservation 4	Onondaga	87	120	71	68	46	107	110	-40.8	-4.2	-32.4	132.6	2.8	61.8	26.4
Clark Reservation 5	Onondaga	460	1023	594	669	549	1089	851	-41.9	12.6	-17.9	98.4	-21.9	27.2	85.0
Clark Reservation 6	Onondaga	5	35	39	40	19	25	23	11.4	2.6	-52.5	31.6	-8.0	-42.5	360.0
Ram's Gulch	Onondaga	2	10	11	11	14	18	5	10.0	0.0	27.3	28.6	-72.2	-54.5	150.0
Split Rock	Onondaga	80	248	295	291	45	210	134	19.0	-1.4	-84.5	366.7	-36.2	-54.0	67.5
Evergreen Lake 1	Onondaga	13	18	14	17	18	15	13	-22.2	21.4	5.9	-16.7	-13.3	-23.5	0.0
Evergreen Lake 2	Onondaga	9	14	8	7	3	26		-42.9	-12.5	-57.1	766.7			
Chittenango Falls 1	Madison	40	90	40	39	36	51	91	-55.6	-2.5	-7.7	41.7	78.4	133.3	127.5
Chittenango Falls 2	Madison	79	240	58	138	102	103	134	-75.8	137.9	-26.1	1.0	30.1	-2.9	69.6
Chittenango Falls 3	Madison		10	66	34	36	60	54	560.0	-48.5	5.9	66.7	-10.0	58.8	
Munnsville 1	Madison	3	5	6	9	8		8	20.0	50.0	-11.1			-11.1	166.7
Munnsville 2	Madison	21	29	21	29	31	37	43	-27.6	38.1	6.9	19.4	16.2	48.3	104.8
Perryville Falls	Madison	14	16	12	8	47	6	15	-25.0	-33.3	487.5	-87.2	150.0	87.5	7.1
Clark Reservation Total		2027	3128	1793	1942	1400	2945	2588	-42.7	8.3	-27.9	110.4	-12.1	33.3	27.7
Chittenango Falls Total		119	340	164	211	174	214	279	-51.8	28.7	-17.5	23.0	30.4	32.2	134.5
Total (note some small sites omitted 1988, 2008/9, 2011)		2288	3808	2324	2525	1740	3471	3085	-39.0	8.6	-31.1	99.5	-11.1	22.2	34.8

1988 data from Cinquemani Kuehn and Leopold (1992)

1993-1995 data from Tango (1999) cited in Kelsall et al. (2004)

2000 and 2002 data from Kelsall et al. (2004)

2008/9 data from Gawronski-Salerno and Leopold (unpublished)

2011 data from Brumbelow and Leopold (unpublished)

Canada. American hart's-tongue fern is listed as a special concern species in Canada and in Ontario, where all Canadian populations are found (http://www.rom.on.ca/ontario/risk.php?doc_type=fact&id=155&lang=en, accessed April 24, 2012). There are 74 occurrences of American hart's-tongue fern that are believed to be extant in Ontario, constituting approximately 73 percent of the species' global distribution; 35 (47%) of these occurrences are on publicly owned land where some degree of protection is provided. However, many of these have not been visited for 20 or more years (Austen 2000). Population sizes in Canada range from a single plant to estimates of between 10,000 and 100,000 plants. Extant occurrences are largest and most numerous in Bruce and Grey Counties, with smaller occurrences found in Simcoe, Dufferin, Peel, and Halton Counties. Five occurrences are thought to have been extirpated from sites in Bruce and Grey Counties (Austen 2000).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.): The New York Natural Heritage Program provided funding to support optimization of a protocol to estimate the level of genetic diversity in American hart's-tongue fern. Using Inter-Simple Sequence Repeats (ISSR) as molecular markers, 60 individuals were examined from the five-subpopulations in Clark Reservation State Park in New York. Three of the 11 PCR primers used showed differences in banding patterns; however, individuals from just one sub-population showed differences in banding patterns, while all individuals from the other four sub-populations had the same banding patterns and might be genetically similar. The number of PCR primers used in this study was very low, and it is premature to draw conclusions about levels of genetic diversity in American hart's-tongue fern in Clark Reservation State Park. Nevertheless, this short-term project showed the feasibility of the ISSR technique in revealing genetic differences between individuals and populations (Fernando and Leopold, unpublished results). A grant from USFWS-Great Lakes Restoration Initiative will support continued study of population genetic structure using a greater number of PCR primers and examining more individuals and populations, including individuals from Michigan (D. Fernando, SUNY, pers. comm. 2012).

2.3.1.4 Taxonomic classification or changes in nomenclature: Mickel and Smith (2004) state that the hart's-tongue fern in Mexico (*Asplenium scolopendrium* var. *lindenii*) should be included within the concept of American hart's-tongue and that the differences previously cited to distinguish it from the plants in the United States and Canada were in error or are within the normal range of variation for the taxon. This interpretation of the taxonomy of *A. scolopendrium* outside Europe needs further evaluation.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

No new information is available.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

No new information is available.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range: American hart's-tongue fern is threatened throughout most of its range by competition or shading from invasive plants, trampling and habitat alteration or destruction caused by timber removal, quarrying or residential development. The invasive plant swallow-wort (*Vincetoxicum rossicum*) is the most serious threat to some populations of the species in New York and may eventually threaten all populations (S. Young, New York Natural Heritage Program, pers. comm. 2007). Other invasive species affecting New York populations of American Hart's-tongue ferns include exotic honeysuckles (*Lonicera* spp.) and European buckthorn (*Rhamnus cathartica*) (Leopold, pers. comm. 2012). Leopold (unpublished data) noted the presence of invasive species at 8 out of 14 New York sites that were monitored during 2008. The southern populations remain vulnerable to extirpation by inadvertent trampling because of their small size and the steep precarious nature of their habitat. Quarrying operations destroyed three of New York's populations and could pose a threat to at least one of the remaining New York sites and two of the southern sites (Clemants in litt., Evans 1981). Timber removal at most of the sites would be expected to raise light levels and lower humidity levels to the detriment of the species. Alterations associated with residential or other development would, in most cases, either directly destroy the plants present or result in environmental changes that would make the sites unsuitable for American hart's-tongue fern. The Michigan sites that are on USFS lands should receive protection from habitat destruction. Timber harvest, quarrying, or other types of development are considered to be the most significant threats to the Ontario populations of the species.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: At the time the species was listed there was limited commercial trade in *A. scolopendrium* var. *americanum*. This material was believed to be of cultivated origin and not obtained from wild

populations. The original source of this material was one of the New York populations destroyed in the early 1900s by quarry operations (S. Clemants, New York Natural Heritage Program, pers. comm. 1988). At the present time there does not appear to be a commercial source for American hart's-tongue plants. Most of the populations in New York, Michigan, Alabama, and Tennessee are too small to support any collecting for scientific purposes, for fern enthusiasts, or for other reasons. Inappropriate collecting remains a threat to these populations (Nepstad 1981). The larger Ontario populations have withstood, apparently without ill effects, low levels of collecting for some time (Pryer in litt.).

2.3.2.3 Disease or predation: While reports of herbivory affecting American hart's-tongue fern populations are not common, Marr (2006) observed fronds on some plants with holes or eroded margins. Slugs, snails, molds, and insects were suggested as possible causes; though, none were directly observed damaging frond tissues.

2.3.2.4 Inadequacy of existing regulatory mechanisms: American hart's-tongue fern is listed as endangered under Michigan's Endangered Species Protection Law (Act 451 of 1994, Part 365) and Tennessee's Rare Plant Protection and Conservation Act. In Michigan, taking is prohibited on all public and private lands. In Tennessee, taking is only restricted when the permission of the landowner or manager has not been obtained. In New York the species is protected under the Protected Native Plants Law that prohibits collection on State lands and states that removal of the fern from private lands without the landowner's permission is a violation of the law and subjects the violator to a \$25 fine. Alabama does not directly protect endangered and threatened plants. However, American hart's-tongue fern is protected as a form of cave life by the Alabama Cave Conservation Act of 1988. The species' current status on the Federal List of Endangered and Threatened Plants provides additional protection from taking on Federal lands. Protection from inappropriate commercial trade (utilizing plants of wild origin rather than cultivated material) is also provided.

2.3.2.5 Other natural or manmade factors affecting its continued existence: Presumably due to climatic changes that have occurred over geologic timescales, the southern populations of the species are restricted to extremely rare sites with physical environments that duplicate the conditions under which the northern populations grow. During the glacial period, the species may have been more widespread in southern limestone areas, but as the climate has warmed, it has become restricted to a few sites in or near caves (Evans 1982).

Crispin (pers. comm. 1986) reports that in 1985 an infestation of leaf miners destroyed the leaves on the trees above one of the Michigan sites.

The loss of shade that resulted from this alteration of the canopy desiccated many of the ferns growing on the forest floor. Insect infestations that temporarily remove the leaves of the canopy or result in long-term damage or death to the trees found there remain a threat to the species, especially emerald ash borer (*Agrilus planipennis*) to American ash (*Fraxinus* spp.) and Asian longhorn beetle (*Anoplophora glabripennis*) to sugar maples (*Acer saccharum*) (S. Young, pers. comm. 2007).

Marr (2006) noted that mats of bryophytes were sometimes seen to slough off of boulders where American hart's-tongue ferns were found in Michigan, and in at least one case a mature fern was dislodged along with the moss mat in which it was positioned. While the cause or extent of bryophytes sloughing off boulders is not known, the loss of this substrate type could reduce availability of suitable sites for gametophyte development if it occurred throughout sites harboring occurrences of American hart's-tongue fern. Cinquemani Kuehn and Leopold (1993) observed that almost 80 percent of sporelings were found on bryophyte covered substrates at sites in New York.

2.4 Synthesis:

When listed, American hart's-tongue fern was threatened throughout most of its range by trampling, alteration, or destruction of its habitat caused by timber removal, quarrying, and residential or other development (Evans 1981, Nepstad 1981). While these potential threats remain at many sites, Leopold (pers. comm. 2012) reports that invasive species pose the greatest threat to this species in New York. Britton (in litt.) states that the most significant threats to the Canadian populations are lumbering or development of the escarpment lands (e.g., quarries, ski slopes, country estates, etc.) on which it occurs. In the southern portion of its range American hart's-tongue has declined significantly, but the causes of this decline are not readily apparent. The two remaining southern populations are vulnerable to localized extinction resulting from demographic stochasticity, given the high variability that has been observed in census numbers in northern populations (Tables 1 and 2) and the low numbers that have been observed for several decades at these sites. Despite this, the populations in Tennessee and Morgan County, Alabama, have persisted, albeit in low numbers, since the recovery plan for the species was published in 1993.

Although the two sites in Alabama are protected (one is on a National Wildlife Refuge and the other is owned by private individuals that are committed to protecting the plant and its habitat on their lands), only one of the two sites has a stable population of the species and the species is believed to be extirpated from the other site. The criteria for considering delisting the species require two

protected and self-sustaining populations in Alabama; this requirement has not been met.

The Tennessee site is not protected and the only plants remaining there are depauperate and non-reproductive. The criteria for considering delisting the species require two protected and self-sustaining populations in Tennessee; this requirement has not been met.

The criteria for considering delisting the species require four protected and self-sustaining occurrences in Michigan. A sufficient number of Michigan locations are on federally managed lands to meet the protection requirements and monitoring data suggest that they likely are self-sustaining (Marr 2006, Davis 2007).

The criteria for considering delisting the species require seven protected and self-sustaining populations in New York. Ten of the New York populations are on State managed lands and are protected and long-term monitoring data suggest they are self-sustaining. However, numbers of mature and immature plants combined have consistently been less than 100 at three of these protected sites. Further, the genetic distinctiveness of these occurrences is not known. In addition, the threat posed by the invasive plant swallow-wort further reduces the long-term security of American hart's-tongue in New York.

Overall, the species is known from fewer extant populations than existed when it was listed as threatened. While the number of protected sites in New York and Michigan meet the criteria for delisting, neither the Tennessee nor Morgan County, Alabama, populations are protected. Despite the fact that the Jackson County, Alabama, site is located on lands managed by the Service, this population appears to now be extinct. Long-term monitoring data demonstrate that at least seven of the protected occurrences in New York are self-sustaining, and monitoring data from Michigan suggest that six of the seven protected occurrences there also are likely self-sustaining. However, continued monitoring of the Michigan populations will be necessary to verify this. The two extant southern populations do not appear to be self-sustaining, given the long-term declining trends observed at these sites and the low numbers of plants present at these sites.

While the delisting criteria appear to have been partially met in the northern portion of this taxon's range in the U.S., the delisting criteria have not been met for the southern populations. In addition, threats to this species still remain. Therefore, American hart's-tongue fern continues to meet the definition of a threatened species under the ESA.

3.0 RESULTS

3.1 Recommended Classification:

 X No change is needed

3.2 New Recovery Priority Number: No change

Brief Rationale: American hart's-tongue fern is a variety of a full species that is under a moderate degree of threat and has a medium to high recovery potential; therefore the appropriate recovery number is 9.

3.3 Listing and Reclassification Priority Number: Not applicable

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS:

- Develop and implement a program to control swallow-wort at sites harboring American hart's-tongue populations in New York and to provide for early detection and removal from sites in Michigan. This task is urgent given the prevalence of this threat to populations in New York and the rapid expansion of swallow-wort that has been seen in sites where American hart's-tongue fern occurs.
- Fund and coordinate range-wide surveys of all populations at two to five-year intervals.
- Conduct long-term monitoring of microenvironmental characteristics of sites in Tennessee and Alabama to document ranges of variability in factors such as humidity, soil moisture, solar insolation, abundance of bryophytes and herbaceous vascular plants, and canopy cover. These data will be necessary to evaluate whether regional changes in climate patterns affect site suitability at the localized scale.
- Provide protection for the remaining occupied sites in Tennessee and Alabama
- Conduct detailed genetic studies of the species throughout North America to assess population genetic structure and to guide potential reintroduction/augmentation projects in Tennessee and Alabama.
- Continue developing propagation techniques for the southern populations of American hart's-tongue and evaluate potential for augmenting or reestablishing populations at these sites using sporophyte material produced from collections made at southern sites.
- Develop and implement a program to ensure that damage to or destruction of overstory trees by insect pests at occupied sites does not permanently alter site microclimate to the extent that the sites are no longer suitable for American Hart's-tongue fern.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of American Hart's-tongue fern

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
 Uplist to Endangered
 Delist
 No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review Conducted By: Geoff Call, Tennessee Field Office, Cookeville, Tennessee

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve *Reginald Smith* Date 5/30/12

REGIONAL OFFICE APPROVAL:

for Lead Regional Director, Fish and Wildlife Service

Approve *Jeanette Mijni* Date 6/19/12

for Cooperating Regional Director, Northeast Region, Fish and Wildlife Service

Concur Do Not Concur

Signature *Paul R. Hy* Date 10/31/12

Assistant
Cooperating Regional Director, Midwest Region, Fish and Wildlife Service

Concur Do Not Concur

Signature *Gymn Lewis* Date 8/21/12

APPENDIX: Summary of peer review for the 5-year review of American hart's-tongue fern (*Asplenium scolopendrium* var. *americanum*)

A. Peer Review Method: A draft of this review was sent to the following individuals to solicit peer review:

David Lincicome, Tennessee Natural Heritage Program
Donald Leopold, State University of New York (SUNY)
Danilo Fernando, SUNY
Steve Young, New York Natural Heritage Program
Mike Penskar, Michigan Natural Features Inventory
Robyn Niver, US Fish and Wildlife Service, New York
Chris Mensing, US Fish and Wildlife Service, Michigan

B. Peer Review Charge: The Service's lead recovery biologist sent an email to the individuals listed above, requesting that they review the draft document and provide comment on the information it contained and to request any relevant information that had been omitted.

C. Summary of Peer Review Comments/Report: We received comments from the reviewers that were, in many cases, supportive of the draft review. However, we also received comments informing us of new data that were available, yet unpublished, about the current status of some populations – especially in New York.

D. Response to Peer Review: We have incorporated the most current data available to us, provided by peer reviewers, into this revised 5-year review.