U.S. Fish & Wildlife Service

Post-Delisting Monitoring Plan

for

Tennessee Purple Coneflower
(*Echinacea tennesseensis*)

Prepared by:

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I. Summary of the Roles of all Cooperators in the Post-Delisting Monitoring Planning Effort

Post-delisting monitoring is a requirement of the Endangered Species Act of 1973, as amended (Act; 16 U.S.C. 1531 *et seq*.). Section 4(g)(1) requires the Service to:

> *implement a system in cooperation with the States to monitor effectively, for not less than five years, the status of all species which have recovered to the point at which the measures provided pursuant to this Act are not longer necessary.*

The purpose of this post-delisting monitoring is to verify that *Echinacea tennesseensis* (Tennessee purple coneflower) remains secure from the risk of extinction after it has been removed from the protections of the Act. The U.S. Fish and Wildlife Service (Service) prepared this post-delisting monitoring (PDM) plan (Plan), in coordination with the Tennessee Department of Environment and Conservation (TDEC), based largely on the monitoring methods used in 2004 (TDEC 2005, pp. 3-7). This Plan is designed to detect substantial declines in *E. tennesseensis* populations with reasonable certainty and precision. It meets the minimum requirement set forth by the Act by effectively monitoring the status of *E. tennesseensis* using a minimum of five annual sampling events.

Most of the secure, self-sustaining *Echinacea tennesseensis* colonies are located on lands either owned or cooperatively managed by TDEC, which has also been the principal party monitoring the recovery of this species. Working under a contract between TDEC and the University of Tennessee, Drew and Clebsch (1995, pp. 62-67) conducted the first monitoring of *E. tennesseensis* during the summers of 1987 through 1989. Their work produced estimates of density and total numbers of *E. tennesseensis*. It also produced estimates of the area the species occupied in the primary colony of each of the five populations that were included in the recovery plan (U.S. Fish and Wildlife Service 1989, pp. 3-7), as well as information on the demographic structure of these populations. TDEC monitored each of these same *E. tennesseensis* colonies one or more times in the years 1998, 2000, and 2001, and again in 2004 with some modifications to the protocol used in the previous three years (TDEC 2005, pp. 3-5).

II. Summary of Species Status at Time of Delisting

A. Demographic Parameters

Echinacea tennesseensis bears showy purple flower heads on one-to-many hairy branches, with bolting beginning during May. Seeds are shed from plants during fall and winter and begin germinating in early March of the following year, producing numerous seedlings by late March. Most of the seedling growth occurs during the first six or seven weeks of the first year, during which plants will grow to a height of 2–3 cm (0.8–1.2 in) or less. Plants remain in a rosette stage and root length increases rapidly during these weeks. Plants can reach sexual maturity by the middle of their second growing season and only small losses

in seed viability have been observed after a period of five years in dry storage (Hemmerly 1976, p. 17). However, Baskin and Baskin (1989, p. 66) suggest that *Echinacea tennesseensis* might not form persistent seed banks, based on results of field germination trials. Individuals of *E. tennesseensis* can live up to at least six years, but the maximum lifespan is unknown (Baskauf 1993, p. 37).

B. Discussion of Populations

Echinacea tennesseensis is restricted to limestone barrens and cedar glades of the Central Basin, Interior Low Plateau Physiographic Province, in Davidson, Rutherford, and Wilson Counties in Tennessee (TDEC 2006, p. 2). The species' recovery plan defined a population as a group of colonies in which the probability of gene exchange through cross pollination is high, and a colony was defined as all *Echinacea tennesseensis* plants found at a single site that are separated from other plants within the population by unsuitable habitat (Service 1989, p. 1). Despite analyses that revealed low levels of genetic differentiation among *E. tennesseensis* populations, as delimited in the recovery plan (Baskauf *et al.* 1994, p. 186), recovery efforts have been implemented and tracked with respect to these geographically defined populations. The geographic distribution of these populations and the colonies they are comprised of was updated in a status survey of *E. tennesseensis* by TDEC (1996, Appendix I) to include all known colonies at that time, including those from a sixth population introduced into glades at the Stones River National Battlefield. For the purposes of this Plan, we have followed these population delineations and have assigned most colonies that have been discovered since the status survey was completed to the geographically closest population.

There are six *Echinacea tennesseensis* populations which occur within an approximately 400 square kilometers (km^2) (154 square miles (mi^2)) area and include between 2 and 11 colonies each. Surveys conducted by TDEC and the Service in 2005 confirmed the presence of *Echinacea tennesseensis* at 36 colonies, and the number of flowering stems in each was counted (Table 1)(TDEC 2006, pp. 4-5). Fifteen of the colonies occur naturally, and 21 colonies have been established through introductions for the purpose of recovering *E. tennesseensis* (TDEC 1991, pp. 3-7; TDEC 1996, Appendix I; Lincicome 2008, pers. com.). Three of the introduced colonies constitute the sixth population that was established at a Designated State Natural Area (DSNA) in the Stones River National Battlefield in Rutherford County, Tennessee (TDEC 1996, Appendix I). We do not include two of the 21 introduced colonies in our discussion of *E. tennesseensis* populations. One of these excluded colonies was introduced into a privately owned glade well outside of the known range of the species in Marshall County, Tennessee; consists of only a few vegetative stems, and is of doubtful viability. The other introduced colony that we excluded is located in Rutherford County, approximately seven miles from the nearest *E. tennesseensis* population, and is believed to contain hybrids with *E. simulata*. An additional introduced colony that was not monitored during 2005, but for which TDEC maintains an element occurrence record, brings the number of introduced colonies we consider here to 20 and the total number of colonies included in Table 1 to 35.

Table 1. Summary of Tennessee purple coneflower populations and colonies. Includes data on origin, whether colonies are secure or self-sustaining, and flowering stem counts from 2005 surveys. * = Colonies selected for post-delisting monitoring.

Population	Population Name	Colony Number	EO Number	Ownership	Origin	Year First Observed	Secure Y/N	Self-Sustaining Y/N	Flowering Stems
1	**Mount View**	1.1*	001	TDEC–DNA[a]	Natural	1963	Y	Y	5,430
		1.2	022	COE[b]	Introduced	1990	Y	Y	252
		1.4	031	COE	Introduced	1989	Y	Y	596
								TOTALS	**6,278**
2	**Vesta**	2.1	011	Private	Natural	1970	N	Y	2,820
		2.1*	006	TDEC–DNA	Natural	1988	Y	Y	4,970
		2.2	002	TDEC–DNA	Natural	1980	Y	Y	4,274
		2.3	038	TDF[c] (DSNA[d])	Introduced	1983	Y	Y	139
		2.4	039	TDF (DSNA)	Introduced	1983	N	N	1
		2.6*	040	TDEC–SP	Introduced	1982	N	Y	252
		2.7	048	TDF (DSNA)	Introduced	2003	N	N	6
		2.8	050	TDEC–DNA	Natural	2003	Y	Y	2,143
		2.9 +	053	Private	Introduced	2006	N	Y	n/a
								TOTALS	**14,605**
3	**Vine**	3.1*	005	TDEC–DNA	Natural	1979	Y	Y	7,555
		3.2*	016	TDEC–DNA	Natural	1989	Y	Y	12,457
		3.2	015	Private	Natural	1989	N	Y	432
		3.2	012	Private	Natural	1989	N	Y	610
		3.2*	017	TDEC–DNA	Natural	1989	Y	Y	12,457
		3.3	014	Private	Natural	1989	N	N	11
		3.4*	021	Private (DSNA)	Natural	1990	Y	Y	12,979
		3.5	013	Private	Natural	1989	N	Y	2,529
		3.6	018	Private	Natural	1989	N	Y	157
		3.7	007	Private	Introduced	1979	N	Y	1,705
		3.8*	030	TDF	Introduced	1990	N	Y	1,863
		3.9	036	TDF	Introduced	1989	Y	Y	2,744
		3.10	033	Private	Natural	1999	N	Y	5,374
		3.11	041	Private	Natural	1998	N	Y	1,935
								TOTALS	**62,808**

Table 1. (cont.) Summary of Tennessee purple coneflower populations and colonies. Includes data on origin, whether colonies are secure or self-sustaining, and flowering stem counts from 2005 surveys. * = Colonies selected for post-delisting monitoring.

Population	Population Name	Colony Number	EO Number	Ownership	Origin	Year First Observed	Secure Y/N	Self-Sustaining Y/N	Flowering Stems
4	**Allvan**	4.2*	027	COE (DSNA)	Introduced	1989	Y	Y	6,183
		4.3*	047	COE	Introduced	1989	N	Y	385
								TOTALS	**6,568**
5	**Couchville**	5.1*	010	TDEC–DNA	Natural	1984	Y	Y	7,353
		5.2	020	Private	Natural	1990	N	Y	392
		5.3	024	TDEC–SP	Introduced	1985	N	Y	1,607
		5.4	035	TDEC–SP	Introduced	1991	Y	Y	863
		5.4	026	TDEC–SP	Introduced	1989	Y	Y	987
		5.5*	025	TDEC–SP	Introduced	1987	N	Y	1,300
		5.6	032	TDEC–SP	Introduced	1989	Y	Y	846
		5.7	008	TDEC–SP	Natural	1981	N	N	17
		5.8	049	COE (DSNA)	Introduced	2000	Y	Y	101
								TOTALS	**13,466**
6	**Stones River National Battlefield**	6.1*	009	NPS[e] (DSNA)	Introduced	1970	Y	Y	2,535
		6.2	028	NPS (DSNA)	Introduced	1995	Y	Y	237
		6.3	029	NPS (DSNA)	Introduced	1991	Y	Y	852
								TOTALS	**3,624**
								GRAND TOTALS	**107,349**

[a]Tennessee Department of Environment and Conservation – Division of Natural Areas Designated State Natural Areas (DSNA), [b]U.S. Army Corps of Engineers, [c]Tennessee Division of Forestry, [d]DSNA that are not owned by TDEC–DNA, [e]National Park Service.

[+] Colony 2.9 was not monitored during 2005, because it was not reported to TDEC–DNA until 2006, at which time there were thousands of plants (Lincicome 2006, pers. com).

Natural colonies, or those not known to have been established through introductions, included 83,895 flowering stems in 2005 (TDEC 2006, p. 6). Introduced colonies, excluding the 2 mentioned above, accounted for 23,454 flowering stems (TDEC 2006, p. 6). Natural colonies constituted approximately 78 percent of the total flowering stems and introduced colonies approximately 22 percent. In this Plan, we use the colony numbers reported by TDEC (1996, Appendix I) and have sequentially assigned additional colony numbers to those which have been discovered since that report was issued. In some instances, there are gaps evident in the sequence of colony numbers discussed, representing colonies that have been documented in the past but were either extirpated or of unknown status at the time of delisting.

While data on numbers of juvenile plants have not been collected from all colonies, monitoring data that have been collected for this demographic attribute (Table 2) have typically exceeded the value used in defining self-sustaining in the recovery plan–i.e., that there be two juvenile plants for every flowering adult in a colony. The mean ratio of juvenile to adult plants in natural colonies, for a given year of monitoring, has ranged from 1.08 to 10.93, based on data collected at two to six sites per year in 1998, 2000, 2001, 2004, and 2008 (Table 2). The mean of this ratio for each of these natural colonies across all years exceeds the ratio of two juveniles per adult. Ratios of juvenile to flowering adult plants in introduced colonies were first estimated during 2006, when the mean was found to be 6.44 juveniles per adult from a single year of data collected at six introduced colonies and the ratio for each of these colonies was greater than 4 juveniles per adult (Table 2).

Various sampling designs have been used to estimate density per square meter in one or more colonies of each *E. tennesseensis* population, providing long-term monitoring data to use in judging their stability (Drew and Clebsch 1995, p. 62, TDEC unpublished data). The confidence intervals are substantial for many of the density estimates (Table 3) produced from the monitoring data for 1998 through 2008. Drew and Clebsch (1995, p. 62) did not provide a measure of precision for the estimated densities they reported from 1987 for some colonies. However, these are the best scientific data available for judging the stability of these populations since initial monitoring data were collected in 1987. The available quantitative data demonstrate that while *E. tennesseensis* densities fluctuate over time, the species' density has remained comparable to reference values provided by Drew and Clebsch (1995, p. 62). The notable exception to this trend is colony 4.1, which was located in a heavily disturbed site and was destroyed sometime after monitoring was conducted during 2004 and before flowering stems were counted at each colony in 2005. A brief discussion of each population and its constituent colonies follows:

<u>Population 1 – Mount View</u>: This population consists of three secure colonies, all of which are located in a 2.5 km^2 (1 mi^2) area in Davidson County: colony 1.1 at the Mount View Glade DSNA and colonies 1.2 and 1.4 on Army Corps of Engineer (COE) lands at the J. Percy Priest Reservoir. The mean ratio of juveniles to adults colony 1.1 over five years of monitoring is 3.45 (Table 2) and density estimates (Table 3) have remained comparable to or have exceeded the initial estimate provided by Drew and Clebsch (1995,

Table 2. Ratio of juveniles to adult determined from stage-specific count data acquired during sampling by Drew (1991, p. 54) for 1987, Clebsch (1993, p. 11) for 1992, and TDEC (unpublished data).

Origin	Colony Number	EO Number(s)	1987	1992	1998	2000	2001	2004	2006	2008	Colony Mean
Natural	**1.1**	**1**	1.58		1.78		2.47	10.37		1.06	**3.45**
	1.2	**22**		2.76							n/a
	2.1	**6**	3.45		0.94	2.60	1.67	9.43		1.16	**3.21**
	3.1	**5**	2.49		2.01		2.78	14.52		0.91	**4.54**
	3.2	**12, 15-17**		1.94							n/a
	3.4	**21**		2.00				10.96		1.38	**4.78**
	3.5	**13**		1.88							n/a
	4.1	**3**	2.21		1.82		2.03	12.03			**4.52**
	5.1	**10**	4.77		5.19	2.64	1.42	8.27		0.92	**3.87**
Introduced	**3.8**	**30**							6.17		n/a
	4.2	**27**							4.78		n/a
	4.3	**47**							11.95		n/a
	5.5	**25**							4.12		n/a
	6.1	**9**							5.18		n/a
		Annual mean	**2.90**	**2.15**	**2.35**	**2.62**	**2.07**	**10.93**	**6.44**	**1.08**	

Table 3. Estimated mean density per square meter of Echinacea tennesseensis and 95% confidence interval. Data sources include Drew and Clebsch (1995, p. 62) for 1987 and TDEC (unpublished data).

			1987	1998		2000		2001		2004		2006		2008	
Origin	Colony Number	EO Number	mean	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI
Natural	**1.1**	**1**	12.90	41.63	42.25			25.56	20.57	44.03	37.33			9.71	8.02
	2.1	**6**	13.10	30.59	12.01	21.33	8.95	16.38	6.70	48.45	16.59			13.83	3.40
	3.1	**5**	20.70	58.20	23.84			51.77	29.82	92.45	30.73			18.79	7.27
	3.4	**21**								65.33	41.07			20.93	12.47
	4.1	**3**	6.20	25.50	63.35			14.13	21.98	15.36	24.37				
	5.1	**10**	6.20	27.75	11.84	7.82	3.78	8.56	3.10	15.03	6.16			4.76	1.79
Introduced	**3.8**	**30**										3.15	6.24		
	4.2	**27**										11.60	12.98		
	4.3	**47**										19.50	34.91		
	5.5	**25**										12.03	8.96		
	6.1	**9**										41.37	47.09		

p. 62) for 1987. The total number of flowering stems counted in the Mount View population in 2005 was 6,278.

Population 2 – Vesta: This population consists of eight colonies primarily located within an area of approximately 3 km^2 (1.5 mi^2) in Wilson County, four of which we consider secure. Five of these colonies (2.3, 2.4, 2.6, 2.7, and 2.9) were introduced. Colonies 2.2 and 2.8 are entirely within the Vesta Cedar Glade DSNA at the Cedars of Lebanon State Forest, and colony 2.1 lies primarily within this DSNA but extends onto private lands. Colonies 2.3, 2.4, and 2.7 are located in the 422 hectare (ha) (1,043 acre (ac)) portion of the state forest that is designated as the Cedars of Lebanon State Forest DSNA. Colony 2.6 is located in a conspicuous location on the north and south sides of a road through Cedars of Lebanon State Park. Colony 2.9 is located in a powerline right-of-way on private lands, adjacent to the state forest boundary.

The mean ratio of juveniles to adults in colony 2.1 over six years of monitoring is 3.21 (Table 2), and density estimates (Table 3) have remained comparable to the initial estimate provided by Drew and Clebsch for 1987 (1995, p. 62). The total number of flowering stems counted in the four secured and self-sustaining colonies of the Vesta population was estimated to be 14,346 in 2005. Colonies that we do not consider secure accounted for 259 flowering stems in 2005.

Population 3 – Vine: This population consists of 11 colonies located within an area of approximately 17 km^2 (7 mi^2) in Wilson and Rutherford Counties. Three of these colonies (3.7, 3.8, and 3.9) were introduced. Colony 3.1 is located primarily within the Vine Cedar Glade DSNA. Most of colony 3.2 is located in a site recently acquired by TDEC using funding from a Recovery Land Acquisition Grant from the Service and matching state funds. The portions of the colony that lie entirely or mostly within the recently protected lands contained 24,914 flowering stems when counted in 2005. Colonies 3.3, 3.5, 3.6, 3.7, 3.10, and 3.11 are located on private lands and not considered secure. Colony 3.4 is located in the Gattinger Glade and Barrens DSNA, which is owned by the developers of the Nashville Super Speedway who donated a conservation easement to the State of Tennessee. Colonies 3.8 and 3.9 are located within the Cedars of Lebanon State Forest; of these, colony 3.9 is considered secure.

The mean ratio of juveniles to adults for colony3.1 over five years of monitoring is 4.54 (Table 2) and density estimates (Table 3) have remained comparable to the initial estimate provided by Drew and Clebsch for 1987 (1995, p. 62). The ratio of juveniles to adults in 1992 was 1.94 at colony 3.2 and 1.88 at colony 3.5 (Clebsch 1993, p. 16). The mean ratio of juveniles to adults for colony 3.4 over three years of monitoring is 4.78 (Table 2). Clebsch (1993, pp. 9-11) did not provide density estimates for this colony in 1992; however, density estimates produced from monitoring conducted by TDEC in 2004 and 2008 are comparable to those generated for other long-term monitoring sites (Table 3). The total number of flowering stems in secured and self-sustaining colonies of the Vine population was 48,192 in 2005. Colonies that we do not consider secure accounted for 14,616 flowering stems in 2005.

Population 4 – Allvan: This population consists of only two introduced colonies (4.2 and 4.3) on public lands because colony 4.1, a natural colony on privately owned land, was destroyed. Colony 4.2 is located in the Elsie Quarterman Cedar Glade DSNA on COE lands at J. Percy Priest Reservoir and is secure. Colony 4.3 is located near the COE Hurricane Public Access Area and is one of four colonies at which impacts from illegal outdoor recreational vehicle (ORV) use have been observed.

The mean ratio of juveniles to adults for colony 4.1 over four years of monitoring was 4.52 (Table 2) and density estimates (Table 3) were comparable to or exceeded the initial estimate provided by Drew and Clebsch for 1987 (1995, p. 62), until the colony was destroyed sometime after monitoring was conducted during 2004 and before flowering stems were counted at each colony in 2005. TDEC first conducted quantitative monitoring at colonies 4.2 and 4.3 in 2006, when the ratios of juveniles to adults they sampled were 4.78 and 11.95, respectively (Table 2). The estimated mean densities at colonies 4.2 and 4.3 were 11.60 and 19.50 *E. tennesseensis* per square meter, respectively (Table 3). The confidence intervals for the density estimates at both sites are substantial, reflecting a high degree of variability among the transects that were sampled at each colony. There were 6,183 flowering stems at colony 4.2 and 385 flowering stems at colony 4.3 in 2005.

Population 5 – Couchville: This population consists of three natural and five introduced colonies, all located within an approximately 2.8 km^2 (1.1 mi^2) area of Davidson and Rutherford counties on lands owned by the State of Tennessee (except for colony 5.2, which is on private land). Four of these colonies are secure. Colony 5.1 is located in the Couchville Cedar Glade DSNA, which was designated in 1995 and is protected by fencing. The only colony within the Couchville population that is located on privately owned property is colony 5.2. Colonies 5.3 through 5.7 are all located within Long Hunter State Park and two of these are secure; three are near walking trails or other frequently trafficked areas, where they are visible and vulnerable to poaching that has been observed in the past. Colony 5.8 is located in the Fate Sanders DSNA on COE lands at J. Percy Priest Reservoir.

The mean ratio of juveniles to adults for colony 5.1 over six years of monitoring is 3.87 (Table 2) and density estimates (Table 3) have remained comparable to the initial estimate provided by Drew and Clebsch for 1987 (1995, p. 62). TDEC (unpublished data) first conducted quantitative monitoring at colony 5.5 in 2006, when the ratio of juveniles to adults they sampled was 4.12 (Table 2) and the estimated density was 12.03 *Echinacea tennesseensis* per square meter (Table 3). The total number of flowering stems from the Couchville population in secured and self-sustaining colonies was 10,150 in 2005. Colonies that we do not consider secure accounted for an estimated 3,316 flowering stems in 2005.

Population 6 – Stones River National Battlefield: The introduced population at the Stones River National Battlefield DSNA consists of three secured and self-sustaining colonies requiring no protective management, as access is controlled by the National Park Service (NPS). TDEC (unpublished data) first conducted quantitative monitoring at colony 6.1 in 2006, when the ratio of juveniles to adults they sampled was 5.18 (Table 2). The

estimated mean density was 41.37 *Echinacea tennesseensis* per square meter (Table 3), but the confidence interval at this site was large reflecting a high degree of variability among the sampled transects, some of which contained no plants. The total number of flowering stems in the Stones River National Battlefield population in 2005 was 3,624 (TDEC 2006, 4).

C. Residual Threats

Losses of cedar glade habitat and colonies of *Echinacea tennesseensis* to development have posed a significant threat to *E. tennesseensis*. However, protection of natural colonies on publicly owned conservation lands and establishment of additional colonies through introductions have effectively diminished this threat to the survival of *E. tennesseensis*.

Illegal ORV use remains a threat to *Echinacea tennesseensis* at three colonies on public lands which we have not counted among the 19 secure colonies. Damage from ORV activity was noted by TDEC (1996, Appendix I) at only one of the 9 colonies located exclusively on private lands that are not under recovery protection agreements. While disturbance from ORV use has been observed in the past and remains unaddressed at four colonies on publicly and privately owned lands harboring *E. tennesseensis*, most of the largest colonies are located in DSNAs and are protected from this threat by fences or other barriers that TDEC has constructed and maintained. Therefore, we anticipate that the status of *E. tennesseensis* will remain secure after delisting under the Act because recovery efforts have secured habitat for 19 colonies that are self-sustaining and distributed among six geographically defined populations (Table 1).

D. Legal and/or Management Commitments for Post-delisting Conservation

There are now 27 colonies, distributed among the six populations of *Echinacea tennesseensis*, which occur entirely or primarily on conservation lands in either state or Federal ownership. The lone exception to public ownership of these conservation lands is the Gattinger Glade DSNA, which is managed by TDEC but privately owned and protected under a conservation easement. We consider 19 of these colonies to be secure and self-sustaining. Sixteen colonies, all but two of which are secure, are located in DSNAs that were designated at various times between 1974 and 2009.

Given the statutory nature of the DSNA designation and TDEC's demonstrated commitment to protecting lands through this mechanism and to maintaining the quality of habitats in the DSNAs, the colonies located in DSNAs will receive long-term protection and necessary management to control vegetation succession. Two exceptions to this expectation are colonies 2.4 and 2.7, which are located in the largely unmanaged Cedars of Lebanon State Forest DSNA. We expect that the delisting of *E. tennesseensis* will not lessen TDEC's commitment to the conservation of these DSNAs, several of which harbor one or more federally listed plant species other than *E. tennesseensis*. We have identified 5 colonies on public lands outside of DSNAs that we consider secure (Table 1).

Numerous partners are involved in managing *Echinacea tennesseensis* populations on their lands. TDEC compared management options at the Vesta Cedar Glade DSNA, including mowing, discing, burning, and application of selective herbicides for removal of grasses (Clebsch 1993, pp. 2-8). TDEC and The Nature Conservancy have used grazing of goats, mechanical removal, and herbicide applications to control woody species encroachment on the margins of cedar glade openings at Mount View Glade DSNA (TDEC 2003, pp. 4-9). TDEC applies prescribed fire or mechanical removal, as needed and within constraints imposed by locations within the urban interface, to control woody species, including the invasive exotic privet (*Ligustrum* sp.), at many DSNAs where *E. tennesseensis* occurs; these include Mount View Glade, Vesta Cedar Glade, Vine Cedar Glade, Cedars of Lebanon State Forest Natural Area, Gattinger's Cedar Glade and Barrens, Elsie Quarterman Cedar Glade, Fate Sanders Barrens, and Couchville Cedar Glade and Barrens. TDEC works with the Tennessee Division of Forestry (TDF) to ensure that colonies in the Cedars of Lebanon State Forest, which includes three DSNAs, receive necessary management and collaborates with TDF to implement all prescribed burns that are conducted on DSNAs. TDEC also has cooperated with COE on construction of fences or earthen berms around sites at J. Percy Priest Reservoir that have been threatened by urban encroachment and illegal ORV use. The NPS monitors the introduced population at the Stones River National Battlefield and controls woody plant encroachment and vegetation succession in the glade openings where the colonies occur, as necessary.

III. Monitoring Methods and Locations

The PDM methods used for *Echinacea tennesseensis* are those that TDEC (2005, pp. 3-7) used during 2004, which were adapted from methods that TDEC used during 1998, 2000, and 2001.

A. Definitions of Terms

Adult – a plant with one or more stems bearing a flower or seed head.

Baseline – a line roughly bisecting a macroplot, along which transects are positioned according to a randomized sampling design and from which transects originate and extend perpendicularly to one edge of the macroplot.

Macroplot – a relatively large area into which sampling units, such as quadrats or transects, are randomly located (Elzinga *et al*. 1998, p. 100), in this case defined as the entire glade opening containing *Echinacea tennesseensis* that is sampled.

Juvenile – a plant with leaves greater than 2 centimeters (cm) in length but not bearing a flower or seed head.

Quadrat – a sampling frame often used for estimating density, frequency, or biomass. In this case we use a 1 meter (m) by 1 m square PVC frame to subdivide the larger sampling unit (i.e., the transect) into discrete, easily sampled subunits.

Restricted random sampling – a sampling method that involves dividing the sampled population into *n* equal-sized segments and then randomly positioning a single sampling unit within each segment. The data are then analyzed as a simple random sample (Elzinga et al. 1998, p. 126).

Transect – a 1-m wide swath that originates at the baseline and along which quadrats are placed for the purpose of systematically sampling all or a portion of the discrete subunits located within the transect. For the purposes of analyzing data collected with the methods described in this plan, transects are considered independent sampling units.

Seedlings – plants with leaves less than 2 cm in length.

B. Procedures for Selecting and Locating Samples

Two monitoring approaches will be used during the PDM period:

(1) plot-based sampling of multiple life-history stages at selected sites (Table 2) to track changes in estimated density per m^2 of *E. tennesseensis* and changes in ratios of juveniles to adults within permanently established, fixed areas

(2) flowering stem counts of all colonies during the fifth year of post-delisting monitoring

[Note: Landowner permission will be obtained prior to surveying colonies located on privately owned lands.]

The 12 colonies selected for plot-based sampling of multiple life history stages primarily are those that TDEC (unpublished data) has previously monitored, including both natural and introduced colonies. The only colony that TDEC monitored in the past but which will not be included in PDM is colony 4.1, which was located in the Allvan population but has been destroyed. This colony has been replaced with colony 4.2, located in a nearby DSNA on COE property. Other new colonies to be included in PDM are numbers 2.6 and 3.2. These colonies are all considered self-sustaining, but not all are considered secure. Including some colonies that were deemed not secure at the time of delisting assures that the threats present at the time of delisting will be monitored. Within each site, one or more macroplots (represented in Table 2 by numbers of baselines) are established and sampled, depending on the colony size, configuration, and heterogeneity. The distribution of PDM sites and numbers of baselines and transects among colonies appears in Table 2.

In each of the cedar glades where PDM will occur, baseline locations either have been or will be permanently marked along a central axis that bisects the macroplot in either an east-west or north-south orientation (Figure 1a). Permanent transect locations along the baselines were selected using a restricted random sampling approach, with at least one transect per 10 m of baseline length. These transects perpendicularly extend from the baseline to the glade edge, alternating orientation (i.e., north-south or east-west) with each new transect. Because each transect extends to the glade edge, their length varies

according to the distance from their location along the baseline to the edge of the glade opening.

Table 4. Distribution of PDM sites, baselines, and transects among colonies of *Echinacea tennesseensis*.

Colony	EO Number(s)[#]	Origin	Number of Baselines	Baseline	Number of Transects
1.1	001	Natural	2	1	7
				2	2
2.1	006	Natural	3	1	7
				2	5
				3	5
2.6	040	Introduced	TBD	TBD	TBD
3.1	005	Natural	1	1	5
3.2	016, 017	Natural	2	1	TBD
				2	TBD
3.4	021	Natural	1	1	7
3.8	030	Introduced	1	1	6
4.2	027	Introduced	1	1	8
4.3	047	Introduced	1	1	5
5.1	010	Natural	2	1	10
				2	6
5.5	025	Introduced	2	1	6
				2	4
6.1	009	Introduced	1	1	8

[#] EO Number = Element Occurrence Number assigned and tracked by Tennessee Natural Heritage Program

C. Sampling and Data Recording Procedures

Plot-based sampling of multiple life-history stages: Beginning at the origin of each transect, consecutive 1 m^2 quadrats are used to collect data along the entire transect length and are positioned such that the transect line bisects the sampling frame (Figure 1b). Thus, a 20 m long transect would contain 20, 1 m^2 quadrats. The following variables are recorded in each quadrat: number of adult plants, stems per adult plant, and reproductive structures (i.e., flower or seed heads). The numbers of juveniles and seedlings are recorded in every other quadrat. The initial quadrat in which juveniles and seedlings are counted is determined by coin toss (i.e., “heads” = 0-1 m, “tails” = 1-2 m) for each transect. These data are recorded on a standard data sheet. To avoid potential for double-counting some plants, observers must take special care to position the sampling frame for

each subsample so that plants located at the edge of the previous quadrat are excluded from the subsequent subsample.

Figure 1. a) baseline bisecting a glade, b) 1 m² square quadrat positioned along a transect for collecting subsample data.

Flowering stem counts: The first step in these counts is to determine the spatial extent of the colony. The counts are conducted by systematically walking through the colony, using colored wire flags to mark areas that have been sampled and prevent double-counting. This is especially important in large colonies, where multiple observers might be working simultaneously in different portions of the colony. Tally counters are used to aid in counting flowering stems, which include those with buds, flowering inflorescences, seed heads, or stems that have been browsed. It is important that observers count only the number of flowering stems, not the number of heads, as some stems may bear more than one.

D. Practices to Assure Consistency of Data Collection

The following practices will be followed in order to minimize variability that could be introduced by inconsistent sampling practices:

- TDEC-DNA will be the primary entity conducting the PDM and employs multiple staff members that have conducted recovery monitoring and are familiar with macroplot and baseline locations and sampling procedures.
- Baseline end points will be permanently marked at each monitored colony. Markers will be reinforced or reestablished as needed during each monitoring event. Transects will be established at identical locations along the baselines in each monitoring event.

- A 1 m^2, PVC sampling frame with index marks painted on it will be used to ensure consistent placement of quadrats along transects.
- Plot-based sampling of multiple life history states must be accomplished during the period, July 15–August 31.
- Flowering stem counts must be accomplished during the period, July 15–October 30.
- Because a single stem may bear more than one flower or seed head, it is important that the number of flowering stems, not heads, be recorded during flowering stem counts.

E. Frequency and Duration of Monitoring

The PDM period will be initiated during the first growing season following the publication of the final rule to delist *Echinacea tennesseensis* and will extend, at a minimum, through the fifth growing season following delisting. The plot-based sampling will be conducted at half of the sites listed in Table 2 during each of the first four years of monitoring, with each site being monitored twice – once every other year. Flowering stem counts will be conducted during the fifth PDM year. These counts will be conducted by TDEC with assistance from the Service.

IV. Definition of Response Triggers for Potential Monitoring Outcomes

Effective PDM requires timely evaluation of data and responsiveness to observed trends. In order to assure timely response to observed trends, it is necessary to identify possible outcomes from monitoring that could be anticipated and general approaches for responding to these scenarios. In order to identify thresholds that would trigger alternative responses in the case of *Echinacea tennesseensis*, it will be necessary to analyze data from the recovery monitoring period to identify the range of variability that has been observed with respect to each of the variables that will be monitored during the PDM period. From this analysis, it will be possible to categorize observations into one of the following three possible PDM outcomes.

A. Category I

<u>*Echinacea tennesseensis* remains secure without ESA protections</u>. This would be true if:

(1) at no more than one colony does the estimated mean density per m^2 for all stage classes combined decrease more than 50 percent in a given year from baseline values established from initial sampling, and

(2) at no more than one colony does the mean ratio of juveniles to adults, across all years of monitoring, drop below the recovery plan ratio of 2:1 used to characterize self-sustaining populations, and

(2) no new or increasing threats to the species are observed.

In this case, PDM would be concluded at the end of the timeframe specified in this Plan.

B. Category II

Echinacea tennesseensis may be less demographically stable than anticipated at the time of delisting, but information does not indicate that the species meets the definition of threatened or endangered. This would be true if:

(1) at two or more colonies, the estimated mean density per m^2 for all stage classes combined decreases in a given year more than 50 percent from baseline values established from initial sampling, or

(2) at two or more colonies, the mean ratio of juveniles to adults, across all years of monitoring, drops below the recovery plan ratio of 2:1 used to characterize self-sustaining populations, and

(3) there are no new or increasing threats that are considered to be of a magnitude and imminence that may threaten the continued existence of *Echinacea tennesseensis* within the foreseeable future.

In this case, the PDM period should be extended for an additional five years from the year such decreases are observed, and if necessary, sampling intensity could be increased to provide greater precision in detecting trends at existing monitoring sites. Also, stage-specific counts or sampling would be conducted at an additional site in each population in which declines are observed. Existing data will be analyzed to determine if any management interventions are available that would be expected to reverse declines and stabilize or improve trends.

C. Category III

PDM yields substantial information indicating that threats are causing a decline in the status of *Echinacea tennesseensis* since the time of delisting, such that listing the species as threatened or endangered may be warranted. This would be true if:

(1) at two or more colonies, the estimated mean density per m^2 for all stage classes combined decreases in two consecutive monitoring periods more than 50 percent from baseline values established from initial sampling, and

(2) at two or more colonies the mean ratio of juveniles to adults, across all years of monitoring, drops for two consecutive monitoring periods below the recovery plan ratio of 2:1 used to characterize self-sustaining populations, and

(3) there are new or increasing threats that are considered to be of a magnitude and imminence that they could threaten the continued existence of *Echinacea tennesseensis* within the foreseeable future.

If only the first two of these conditions are true or the third condition is true by itself, then the Service should initiate a status review to assess changes in threats to the species, its abundance, population structure, and distribution to determine whether a proposal for relisting is appropriate. If all of these conditions are true, then the Service should promptly propose that *Echinacea tennesseensis* be relisted under the Act in accordance with procedures in section 4.

V. Data Compilation and Reporting Procedures

Microsoft Excel spreadsheets containing all data collected will be submitted to the Tennessee Ecological Services Field Office of the Service, in a format collaboratively designed with TDEC biologists. These spreadsheets should be submitted by the end of each calendar year to ensure that adequate data are being collected and analyzed, to allow evaluation of the efficacy of the monitoring program, and to provide a periodic assessment of the status of *Echinacea tennesseensis*. The Service will review these data annually within the context of the response triggers outlined above to determine whether additional action is necessary. After five years of data are available, the field collection data will be reviewed to determine overall population change and status with respect to threats. We will prepare a final monitoring report that will be made available to the public, which will include a description of the geographic areas surveyed, the survey protocol, and updated population metrics for each colony surveyed.

If the response triggers in Section IV above are met or exceeded, then the Service will consult with TDEC and other partners to determine whether to conclude the PDM process or to pursue alternative actions as described in Section IV. Our determination will also include, if necessary, an evaluation of the threats to *E. tennesseensis* using the five factors required under the Act to list a species on the Federal List of Threatened and Endangered Species.

VI. Estimated Funding Requirements and Sources

Post-delisting monitoring is a cooperative effort among the Service; state, tribal, and foreign governments; other Federal agencies; and other non-governmental partners under the Act. Although the Act authorizes expenditures of both recovery funds and section 6 grants to the states to plan and implement PDM, Congress has not allocated nor earmarked any special funds for this purpose. To the extent feasible, the Service intends to provide funding for PDM efforts from annual Endangered Species general appropriations. Nonetheless, nothing in this Plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act (31 U.S.C. ' 1341) or any other law or regulation.

The primary entity conducting the PDM and preparing reports will be TDEC, who has accomplished or funded all of the recovery monitoring for *Echinacea tennesseensis*. Based on TDEC costs associated with recovery monitoring efforts, annual PDM expenditures for TDEC should not exceed $15,000. The Service will provide assistance as needed and as resources permit, especially during the flowering stem counts of all colonies that is planned for the fifth growing season after delisting. Annual costs to the Service should not exceed $5,000 in each of the first four years and should not exceed $15,000 during year five.

VII. PDM Implementation Schedule

Table 5. Post delisting monitoring schedule for E. tennesseensis, 2012 – 2016.

Origin	Colony	2012	2013	2014	2015	2016
Natural	1.1		X		X	Flowering Stem Counts All Colonies
	2.1		X		X	
	3.1	X				
	3.2	X		X		
	3.4	X		X		
	5.1		X		X	
Introduced	2.6	X		X		
	3.8	X		X		
	4.2		X		X	
	4.3		X		X	
	5.5		X		X	
	6.1	X		X		

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