Leafy prairie-clover
(Dalea foliosa)

5-Year Review:
Summary and Evaluation

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

5-YEAR REVIEW
Leafy prairie-clover/*Dalea foliosa*

I. GENERAL INFORMATION

A. Methodology used to complete the review - In conducting this 5-year review, we relied on the best available information pertaining to historic and current distributions, life history, and habitat of this species. Our sources include the final rule listing this species under the Endangered Species Act; the recovery plan; unpublished field observations by Service, U.S. Forest Service (USFS), State and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts. We published an announcement of this review in the *Federal Register* and requested information on this species on July 29, 2008 (73 FR 43947), and a 60-day comment period was opened. Comments received and suggestions from peer reviewers were evaluated and incorporated as appropriate (see Appendix A). No part of this review was contracted to an outside party. This review was completed by the Service's lead Recovery biologist in the Cookeville Field Office, Tennessee.

B. Reviewers

Lead Field Office: Cookeville Field Office – Geoff Call, 931-528-6481, ext. 213
Lead Region: Southeast Region – Kelly Bibb, 404-679-7132

Cooperating Field Office: Chicago Field Office – Kristopher Lah, 847-381-2253, ext. 15
Cooperating Region: Great Lakes – Big Rivers Region – Carlita Payne, 612-713-5339

C. Background

1. FR Notice citation announcing initiation of this review: July 29, 2008, 73 FR 43947

2. Species status: Stable in Illinois and Tennessee – monitoring data from these states display substantial interannual variability in total numbers of plants as well as for multiple life history stages. However, many of these populations are characterized by low levels of abundance and threats are present across much of the species range. The species has declined in Alabama, where only two extant populations are known to exist. That status of four other populations in Alabama is uncertain.

3. Recovery achieved: 3 (50 – 75% recovery objectives achieved)

4. Listing history

Original Listing
FR notice: 56 FR 19953
Date listed: May 1, 1991
Entity listed: Species
Classification: Endangered

5. Review History: Recovery Data Call: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, and 2008
1996 Recovery Plan

6. Species' Recovery Priority Number at start of review (48 FR 43098):
5 (high degree of threat, low recovery potential).

7. Recovery Plan

Name of plan: Recovery Plan for the Leafy Prairie-clover (*Dalea foliosa*)
Date issued: September 30, 1996

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy – *Dalea foliosa* is a plant; therefore, the DPS policy does not apply. The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review is a plant and the DPS policy is not applicable, the application of the DPS policy to the species listing is not addressed further in this review.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2. Adequacy of recovery criteria.

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

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? Yes

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.

Dalea foliosa will be considered for reclassification from endangered to threatened when the first three of the following criteria have been met for a minimum of 5 years. Delisting the species will be considered when all four criteria have been met for 10 years. These recovery criteria are based on a derived Population Viability Index (PVI, explained below).

1. A minimum of three populations ranked as high viability are protected and managed in Alabama.

This criterion has not been met. There are two extant populations and four of uncertain status in Alabama (Schotz 2011), but their viability has not been ranked using the PVI. The Lawrence County population is located in a Tennessee Valley Authority (TVA) transmission right-of-way and should receive protection from potentially harmful maintenance practices (e.g., poorly timed mowing or herbicide application); though, TVA has not consulted with the Service regarding right-of-way maintenance. All other known occurrences are located on private land.

2. A minimum of three populations ranked as high viability are protected and managed in Illinois.

This criterion has not been met. There currently are 14 extant populations in Illinois, of which 12 are protected, and another is included in lands covered by a proposed Habitat Conservation Plan for the Hine's emerald dragonfly [Appendix B (Illinois Department of Natural Resources 2008, C. Pollack pers. comm. 2015)]. Using a modified version of the PVI model presented in the recovery plan, Bowles et al. (1999) calculated PVI values for four of these populations: the population at Keepataw Forest Preserve was ranked as low viability; populations at Romeoville Prairie and Midewin National Tallgrass Prairie (NTP) were ranked as moderate viability; and the Lockport Prairie Nature Preserve population was ranked as high viability. The viability of the remaining eight protected populations is not known; therefore, based on the best available data this criterion has not been met.

3. A minimum of twelve populations ranked as high viability are protected and managed in Tennessee. More populations ranked as high viability are recommended for protection in Tennessee because of the significance of the Central Basin as the species' distribution center and reservoir of genetic diversity. In short, by conserving the diverse Tennessee gene pool, the species' evolutionary potential is more likely to be conserved.

This criterion has not been met. Based on information from surveys undertaken during 2001 through 2003, there were no occurrences ranked as high viability out of 55 extant occurrences assessed in Tennessee [Tennessee Department of Environment and Conservation (TDEC) 2004]. There has been no assessment of the number of populations that these occurrences constitute. There were 17 occurrences ranked as moderate viability, all of which are protected, and 48 ranked low, of which 10 are considered either historical or extirpated. In addition

to the 55 sites reported by TDEC (2004a), two additional occurrences have been found TVA transmission rights-of-way, where they should receive protection from potentially harmful maintenance practices (e.g., poorly timed mowing or herbicide application). However, both sites are on private lands and are not protected from other possible threats.

Since TDEC's (2004) assessment was completed, the agency has, in a few cases, grouped patches of plants that were formerly tracked as separate occurrences into a single occurrence due to their close proximity to one another. As of 2015, there were 49 extant occurrences in Tennessee, 5 that have been extirpated, and 6 that are known from historical records (Appendix C). We consider 31 extant occurrences in Tennessee to be protected, based on the discussion of various protection options in the recovery plan [Service 1996; see Appendix C (TDEC 2015) for more information). Of these 31 protected sites, 23 are located in designated state natural areas (DSNAs), some of which were purchased, in part, with funds from Recovery Land Acquisition grants from the Service. Eight of these occurrences in DSNAs are located on lands owned by the Tennessee Wildlife Resources Agency (TWRA), seven on lands owned by the Tennessee Division of Forestry (TDF), and eight are owned by TDEC (Appendix C). Those DSNA on TWRA and TDF lands are managed cooperatively with TDEC.

In addition to occurrences in DSNAs, seven additional extant occurrences are on protected lands owned by either Tennessee State Parks or TDF, but no specific management agreements are in place to secure them. And, one extant occurrence is on Army Corps of Engineers land and should receive protection from Federal actions through section 7 consultation (Appendix C).

4. Restored populations persist at high or moderate viability for a minimum of 10 consecutive years.

This criterion has not been met; though, several efforts have been initiated in Illinois to reintroduce or augment *D. foliosa* populations. Of the 13 extant populations in Illinois, six are the product of reintroductions, either from seed or using cultivated plants (Appendix B). In 1991, seeds and 6 plants were planted to reintroduce a population at the Waterfall Glen Forest Preserve in Dupage County, Illinois. Introductions of plants and seeds have continued through present at two sites in this preserve, and one of these appears to have been effective (Scott Kobal pers. comm. 2005, Illinois Department of Natural Resources 2008, C. Pollack pers. comm. 2015). Experimental plantings were attempted at a historic site northeast of Romeoville in 1992 and 1993; and, in 1993, the Forest Preserve District of Will County broadcasted seed to augment the population at Romeoville Prairie Nature Preserve (Illinois Department of Natural Resources 2008).

In 2006, the Service's Chicago ES Field Office, U.S. Forest Service, Illinois Department of Natural Resources, and the Forest Preserve Districts of Kane and Will counties initiated a project to introduce populations into two sites and augment populations at six sites (Redmer and Lah 2008). Based on the limited success reported from previous attempts to establish or augment populations by

sowing seed, these partners chose to plant one-year old seedlings in an attempt to increase survival and recruitment. Plants were grown in greenhouses at the Midewin NTP from seeds collected in 2006 and 2007. In July 2008, over 2,500 seedlings were planted into selected sites within the species' historic range, containing suitable dolomite prairie habitat. Over 1,100 of these seedlings were planted into a state-owned conservation area with extensive habitat, but that lacked a known population. The species was also returned to a preserve in Kane County that is thought to be the type locality, but where *D. foliosa* has not been seen since the late 1800s. Seedlings are being grown to continue this introduction/augmentation in 2009. A monitoring program is in place to measure effectiveness of these efforts over time (Redmer and Lah 2008).

Population Viability Index – a basic assumption in developing these recovery criteria was that populations would likely survive because the chances of extinction would be lowered to acceptable levels by the recommended recovery actions. Because estimating minimum viable population sizes requires data that typically are unavailable for rare species, the Recovery Plan [U.S. Fish and Wildlife Service (i.e., Service) 1996] employed a model to derive a PVI for each population:

$$PVI = (A_i + B_i + C_i + D_i + E_i + F_i)/19$$

where,

A = population size (range 0 to 4)
B = habitat size and suitability (range 0 to 3 for variables B through F)
C = degree of disturbance
D = management needs
E = offsite threats
F = protection status

Bowles et al. (1999) modified this PVI model for the purpose of ranking viability of Illinois populations by (1) scoring population size on an equal scale to other variables and adjusting the denominator to 18, (2) incorporating a population growth trend variable, and (3) removing the offsite threats variable. This model is only applicable to populations for which demographic monitoring data are available to estimate population growth rates.

Using either version of the PVI model, viability of each population with respect to the recovery criteria is interpreted using this scale:

Viability Rank	PVI Range
High	>0.75 – 1.0
Medium	>0.5 – <0.75
Low	<0.5

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range:

Alabama

There currently are two known extant populations in Alabama, one each in Franklin and Lawrence counties (Schotz 2011). There are four occurrences of uncertain status, located in Franklin, Jefferson, and Morgan counties. No other occurrences are known to have been extirpated from Alabama besides those reported in the recovery plan (Service 1996).

Illinois

There currently are 14 known extant populations in Illinois (Appendix B), ranging in size from a few hundred to several thousand individuals (Redmond and Lah 2008, J. Armstrong pers. comm. 2012, C. Pollack pers. comm. 2015). One population is located in Cook County, four in DuPage County, and the others are in Will County. The population at Midewin NTP was discovered in 1997 (Molano-Flores 2004). The Cook County population was first observed in 2002 (Illinois Department of Natural Resources 2008). Contrary to the statement in the recovery plan that the population at Lockport Prairie East was extirpated, we have concluded based on information in our records that this population is represented by the Will County population that was discovered in 2001 at Dellwood Park West (Barbers and Wilhelm 2005) (Appendix B). No other occurrences are known to have been extirpated from Illinois besides those reported in the recovery plan (Service 1996).

Tennessee

There currently are 55 known extant occurrences in Tennessee in the following counties: Bedford (1), Davidson (7), Marshall (2), Maury (14), Rutherford (15), Williamson (1), and Wilson (15). Ten of these occurrences were found in surveys conducted during 2001 through 2003, mostly on public lands or private conservation lands (TDEC 2004a). In addition to the 55 sites reported by TDEC (2004a), two occurrences have been found in TVA transmission rights-of-way (TDEC 2015). There are 11 occurrences that are considered either historic or extirpated, distributed among the following counties: Davidson (2), Maury (1), Rutherford (5), Sumner (1), Williamson (1), and Wilson (1) (TDEC 2004a). No occurrences are known to have been extirpated from Tennessee besides those reported in the recovery plan (Service 1996).

b. Abundance, population trends (e.g. increasing, decreasing, stable), demographic features, or demographic trends:

Alabama

Biologists from TVA observed 21 plants at the Lawrence County population in 2008 (Adam Dattilo pers. comm. 2008), which was estimated to consist of 30 to 40 plants in 1987 (TVA 2014). There were 61 plants at this site and 72 at the Franklin County site as of 2011 (Schotz 2011).

Illinois

Monitoring data for the population at Lockwood Prairie Nature Preserve display considerable interannual variability with respect to abundance in each of three stages: seedling/juvenile, non-flowering adult, and flowering adult. Between 1990 and 2004, 11 *D. foliosa* censuses were conducted at this site. Total number of plants ranged from a high of 5,636 in 1990, to a low of 1,056 in 2000 (Figure 1). The total number rebounded to 5,022 in 2004 (Key 2004). This population increased to a total of 13,345 total individuals in 2006 (J. Armstrong pers. comm. 2012). Beginning in 2008, the Forest Preserve District of Will County reduced the monitoring effort to a subsample of the entire population using permanent plots; we will include these plot-based data in future reviews of this species' status.

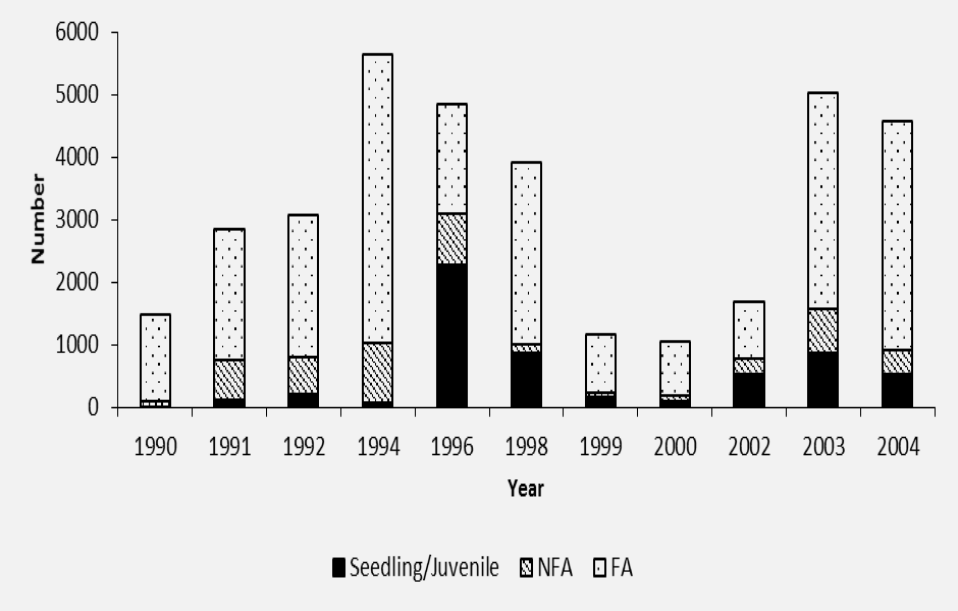

Figure 1. Monitoring data for leafy prairie clover (*D. foliosa*) at Lockwood Prairie Nature Preserve, Illinois, 1990 - 2004 (adapted from Key 2004). NFA = non-flowering adult; FA = flowering adult.

Monitoring was conducted in 2002 and 2004 at the Dellwood Park West site in Lockport, where a population was discovered in 2001. The total number of plants increased over this period from 154 to 1289, apparently in response to removal of invasive woody plants and subsequent fire management (Barbers and Wilhelm

2005). In 2014, there were 1,410 plants at this site, 1,002 of which were flowering or fruiting (C. Pollack pers. comm. 2015).

The total number of plants at Romeoville Prairie Nature Preserve, inclusive of all life history stages, peaked at 2006, the last year during which a population census was conducted (Figure 2). Beginning in 2008, the Forest Preserve District of Will County reduced the monitoring effort at this site to a subsample of the entire population using permanent plots; we will include these plot-based data in future reviews of this species' status.

Considerable variability has also been observed in a population at the Midewin NTP from 2002 through 2014, during which time the total number of plants ranged from a low of 92 in 2002, to a high of 839 in 2014, 375 of which were flowering or fruiting (Figure 3) (USDA Forest Service no date, C. Pollack pers. comm. 2015).

The Illinois Natural History Survey began monitoring a population at Keepataw Forest Preserve in 2005, under contract with the Illinois Toll Highway Authority (Taft et al. 2010). There are five colonies at this site, from which census data are collected for four life history stages: seedlings, juveniles, non-flowering adults, and flowering adults. The data from 2005-2006 display an increase, followed by a decrease in total numbers of plants from 2006-2010 (Figure 3). Despite the fact that the total number of plants recorded was lowest in 2010, both the number of flowering adults (Figure 4) and inflorescence spikes per adult reached their recorded peak, yielding the greatest potential reproductive output in 2010 compared to the five prior years (Taft et al. 2010).

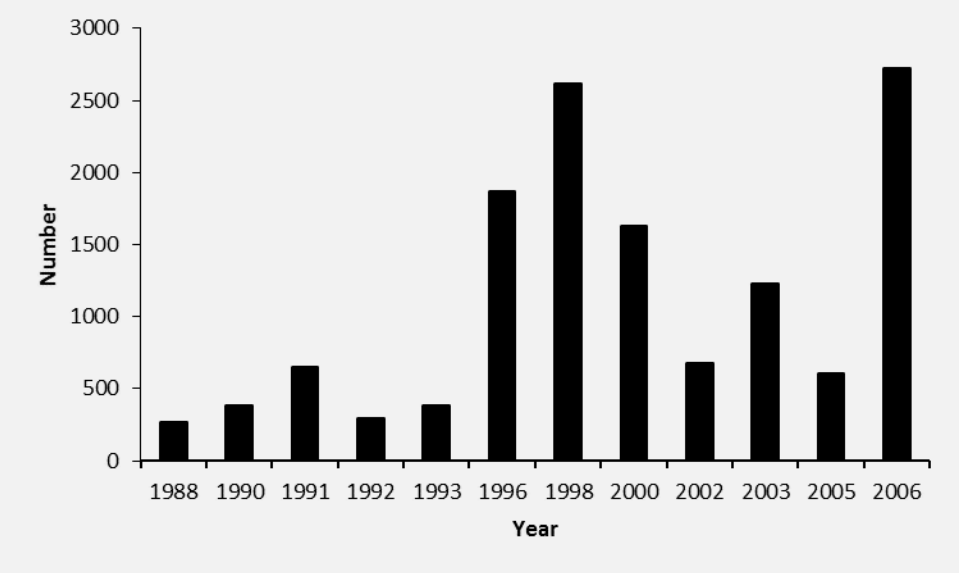

Figure 2. Monitoring data for total number of leafy prairie clover, inclusive of all life-history stages, at Romeoville Prairie Nature Preserve, Illinois, 1988 – 2006 (J. Armstrong pers. comm. 2012).

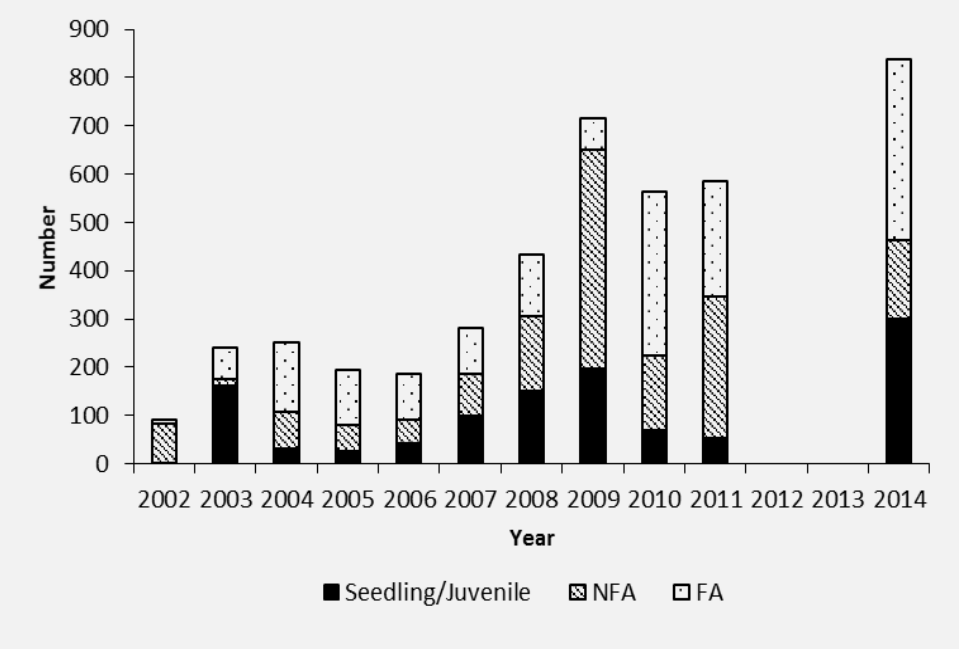

Figure 3. Monitoring data from Midewin NTP, Illinois, 2002 - 2014 (USDA Forest Service no date, C. Pollack pers. comm. 2015). NFA = non-flowering adult; FA = flowering adult.

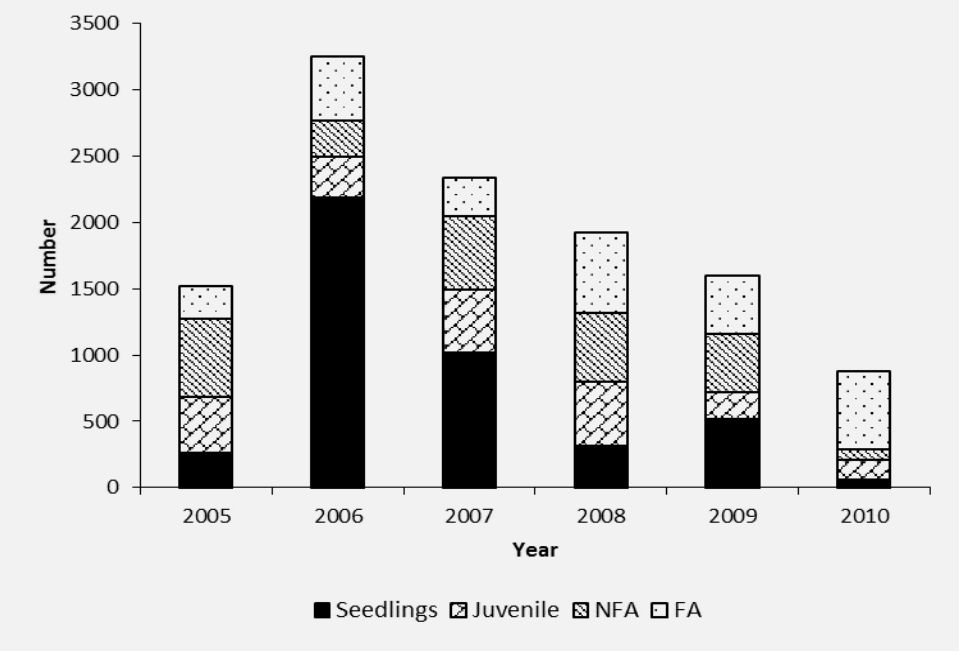

Figure 4. Monitoring data from Keepataw Forest Preserve, Will County, Illinois, 2005 - 2010 (Taft et al. 2010). NFA = non-flowering adult; FA = flowering adult.

Tennessee

From 1996 through 2001, TVA monitored six *Dalea foliosa* occurrences that are located within the lands that were acquired for the proposed Columbia Dam project (see section II.C.2.a below), but are now protected as the Yanahli Wildlife Management Area (WMA) and Duck River Complex DSNA. The TVA monitored no more than two of these occurrences per year, and TDEC assumed responsibility for monitoring these occurrences in 2003 (TDEC 2004b). Because of the inconsistencies among occurrences with respect to the years that monitoring occurred and sampling design used, we only discuss here the general trends reported by TDEC (2004b). Site names and element occurrence numbers, in parentheses, for the monitored occurrences include:

- Blue Springs (049)
- Columbia Glade (005)
- Columbia Glade East (054)
- Sowell Mill North Glade (028)
- Sowell Mill North Glade A.T.&T. right of way (068)
- Nancy Branch (047)

TDEC (2004b) reported a general decline during the period 1996 through 2003 in numbers of plants, stems, flowering stems, and flowering heads at all of these occurrences besides 005 and 068. Increases were observed in numbers of flowering stems and flowering heads at 005, despite a decrease in total number of plants, and in all *Dalea foliosa* metrics at 068. The most notable decline was observed at 047, where total number of plants declined from 1,589 plants in 2000 to 32 plants in 2003. Given the considerable interannual fluctuation that has been observed at locations that have been monitored more consistently in Illinois, inferring trends from the data for these six occurrences is difficult due to inconsistency among monitoring years and methods. Monitoring data in figures 1 and 2 demonstrate the importance of monitoring populations at a sufficient frequency, ideally annually, for detecting trends and cyclical variation in *D. foliosa* populations.

TDEC conducted general surveys of 18 *D. foliosa* occurrences during 2004, to provide current data on numbers of plants (Table 1) (TDEC 2005a).

Table 1. Results from general surveys of 18 *D. foliosa* occurrences conducted in Tennessee in 2004; "- -" indicates data not collected (TDEC 2005a).

Site Name	EO Number	Non-flowering	Flowering	Total Plants
Flat Rock/Adams #3 Glade	011	--	544	544+
Couchville South	014	23	6	29
Cedars of Lebanon – S. of Cedar Forest Road	018	3	6	9
Cedars of Lebanon – Richmond Shop Barren	024	0	5	5
Long Hunter State Park – Wet Barren	031	--	--	37
Hall Farms Glades	032	--	559	559+
Cedars of Lebanon – Rowland Barren	033	--	187	187+

Site Name	EO Number	Non-flowering	Flowering	Total Plants
Jones Mill Glade / Campbell Road	037	--	--	70
Hamilton Creek Glade	040	--	--	442
Cedars of Lebanon State Forest – Quarry Creek	044	--	14	14
Cedars of Lebanon – Cedars Natural Area, Moccasin Road	052	0	0	0
Rocky Hill Glade	057	--	28	28
Cedars of Lebanon – Cedar Forest Road West 8	059	--	244	244
Long Hunter State Park	060	--	--	51
Cedars of Lebanon State Forest	064	--	80	80+
Flat Rock / Adams #2 Glades, Roadside, Trailside	065	0	0	0
Couchville North	066	0	1	1
Hall Farm Glades	067	--	824	824+
TOTALS		**26+**	**2934+**	**3118+**

Beginning in 2009, TDEC began annual monitoring using permanent plots at 16 protected sites in Tennessee (TDEC 2014). The number of 1 x 2 meter plots ranges from one to six at each site, depending on the population sizes and area occupied by *Dalea foliosa*. This monitoring approach does not allow for tracking changes within entire populations present at each protected site, but does provide a means for examining variability in density over the full range of monitored sites. Data are recorded for the following variables in each plot: flowering plants, flowering stems, non-flowering plants (excluding seedlings), non-flowering stems, seedlings, and browsed stems. Because of variability in plot numbers among sites, and the fact that some sites were sampled using 1 x 1 monitoring plots in 2009 and 2010, we have standardized data to numbers per square meter (m^2) for analysis purposes (Figure 5).

As is the case for monitoring data collected from Illinois, preliminary analysis of these monitoring data (Figure 5), conducted for this status review, demonstrate considerable variability both among sites (as depicted by 95% confidence intervals around mean values per square meter) and among years for all sites combined. The mean number of plants per m^2 for all stages combined decreased from 2009 through 2012, but peaked at 23.9 during 2014. The number of flowering plants/m^2 peaked at 13.17 in 2010, but was less than 4 in all other years. Non-flowering plants, excluding seedlings, were most abundant in 2009 (16.27/m^2), decreased through 2012, but increased during 2013 and 2014. The mean number of seedlings/m^2 has remained low throughout all years, with a high in 2013 of 2.27. Based on these preliminary analyses, these 16 protected *Dalea foliosa* populations have fluctuated considerably, and mean numbers of flowering and non-flowering plants per m^2 suggest some decline since 2009. However, assessment of the species' overall status require additional years of data and more careful analysis before reaching firm conclusions.

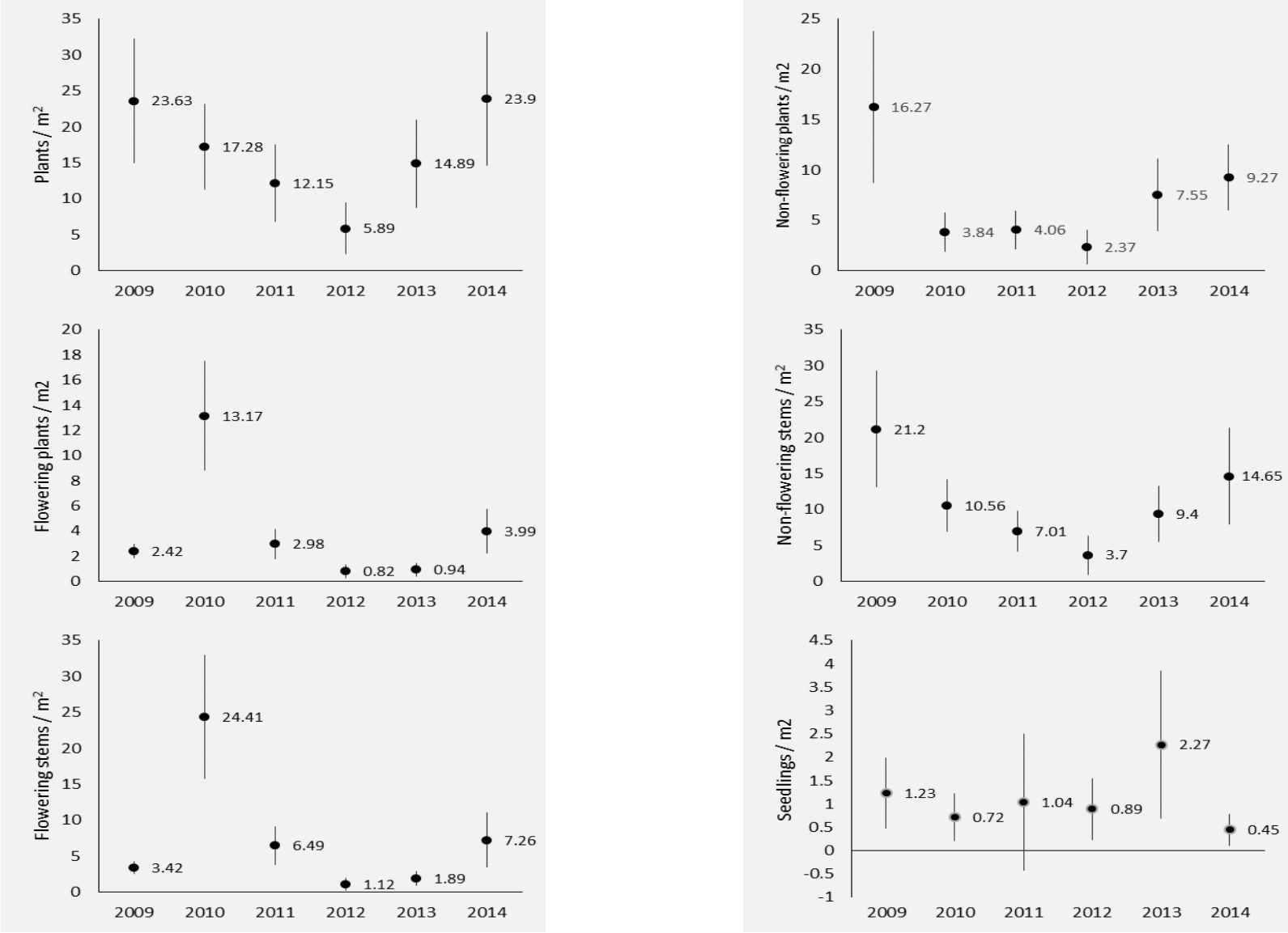

Figure 5. Mean (± 95% confidence interval) number of *Dalea foliosa* per square meter (total number of plants and individual stages) from 16 protected sites in Tennessee, 2009 – 2014 (TDEC unpublished data).

As noted above, analyzing data for trends across all 16 monitored populations does not effectively examine trends within individual sites or groups of sites. In the future, these data will be analyzed to provide insight into trends at individual sites. This will be necessary due to the variability in *Dalea foliosa* abundance among the sites and differences in threats affecting them, as well as varying levels of management to address those threats. During 2015, TDEC will again collect data to calculate the PVI for protected occurrences, to provide data to compare to results from 2004.

c. Life history, ecology, reproductive biology.

Baskin and Baskin (1998) conducted studies on the ecological life cycle of *D. foliosa*, examining aspects including seed dormancy and mechanisms for breaking dormancy; phenology of seed germination, growth, and flowering; presence of seed bank; and effects of vernalization and photoperiod on flowering. This study revealed that seed dormancy in *D. foliosa* is due to a water impermeable ("hard") seed coat and that germination rates, for both fresh seed and seed that had been stored up to 25 years, were much higher when mechanically scarified compared to untreated seeds. Based on these findings and observations of seeds that germinated over a four-year period from soil samples that were collected from the Sneed Road site and monitored for seedling emergence in a greenhouse, Baskin and Baskin (1998) concluded that *D. foliosa* is capable of forming a persistent seed bank.

The species' recovery plan (Service 1996) and others (Bowles et al. 1999; Barber and Wilhelm 2005; Tennessee Division of Natural Heritage 2005) cite the role of fire as a management tool in maintaining the habitats where *D. foliosa* occurs. Though most embryos were killed during treatments that Baskin and Baskin (2008) experimentally applied to investigate the role of fire in breaking seed dormancy, the authors reasoned that fire in a natural setting should be effective in breaking down seed coats without killing seeds. They based this conclusion on observations from another component of their study, in which high percentages of seeds that had been dry-heated at 100^{o}C and 90^{o}C germinated, compared to less than five percent in non-heated controls. They suggested that the lack of germination of buried seeds in their burn treatments might have occurred for one of two reasons: (1) insufficient heat penetration to the depth of 1 cm to be effective at breaking seed dormancy, or (2) temperatures at this depth might have been too high and killed the seeds (Baskin and Baskin 1998).

Through their photoperiod and vernalization studies, Baskin and Baskin (1998) determined that *D. foliosa* is an obligate long-day perennial plant that does not require exposure to winter vernalizing temperatures for budbreak/shoot growth or for flowering.

In a study of reproductive success conducted from 1998 through 2000 at Midewin NTP, Molano-Flores (2004) found a relatively high percentage of fruits on *D. foliosa* infructescences to be filled. During two of the three years, the mean

percentage of filled fruits (i.e., containing plump, well rounded seeds) was greater than 79 percent. Despite declines in the plants that were monitored during the three-year study (Molano-Flores 2004), data in Figure 3 (USDA Forest Service no date, C. Pollack pers. comm. 2015) suggest an increase in the number of flowering adults and, presumably, an increase in the overall number of inflorescences occurred from 2002 to 2014 in this population. The results from these two efforts illustrate the interannual demographic variability that has been observed during monitoring across the species' range.

In a subsequent seed germination study of *Dalea foliosa*, Molano-Flores (2005) observed greater percent germination rates in seeds from filled versus small, dented seeds from unfilled fruits. This was also true for the more widespread and common congeners *D. purpurea* and *D. candida*. However, overall germination rates in the two congeners exceeded 89 percent compared to only 8.5 percent in *D. foliosa* (Molano-Flores 2005). Two possible explanations offered for this difference were seed inviability and seed dormancy. Seed inviability was ruled out by tetrazolium tests, in which all plump, ungerminated seeds of *D. foliosa* tested positive. Because this study examined germination over a period of 30 days, it is possible that insufficient time was provided for *D. foliosa* to break dormancy. An alternative explanation is that low germination rates in apparently viable *D. foliosa* seeds from the Midewin population could be an expression of inbreeding depression (Molano-Flores 2005), given the low levels of genetic variation documented in this species by Edwards et al. (2004, see section II.C.1.d).

Molano-Flores (2005) determined that *Dalea foliosa* is self-compatible and that self-pollination (i.e., autogamy) can occur in this species, despite that fact that it is protandrous [i.e., on a given individual, anthers (part of the male reproductive structure) develop and release pollen prior to the stigma (part of the female reproductive structure) becoming receptive]. However, based on phenological observations she concluded that this process probably did not play a major role in the reproduction of the species.

In a study examining microhabitat requirements of *Dalea foliosa* compared to its cedar glade congener *D. gattingeri*, Thompson et al. (2006) found soil depth in *D. foliosa* microhabitats was significantly greater than in *D. gattingeri* microhabitats. Percent cover of associated herbaceous vegetation was the only variable that was significantly correlated (negatively) with percent cover of *D. foliosa* (Thompson et al. 2006). Based on their observations, the authors (2006) recommended that attempts to establish new populations be undertaken in sites that are relatively free of competition from other herbaceous species and where soil depths exceed 4 cm. Quarterman (1986) noted that soil depths greater than 20 cm in the vicinity of cedar glades tend to support plant communities dominated by eastern red cedar (*Juniperus virginiana*) and other woody species. The results of the microhabitat study underscore the importance of disturbance processes, such as fire, in maintaining suitable *D. foliosa* by mediating competition within habitats located

in the transition zone between open cedar glades and adjacent barrens and woodlands that replace them as soil depth increases.

As monitoring results have shown at least periodic declines in populations of *Dalea foliosa*, it is critical to maintain seeds in *ex situ* conservation facilities to use if needed for recovery purposes. During 2006, TDEC biologists collected seed heads from 17 sites in four Tennessee counties and provided individual packets of seed from each site to the Missouri Botanical Garden for long-term storage (TDEC 2008).

d. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

The species' recovery plan recommended that the highest number of viable sites be protected in Tennessee because of the significance of the Central Basin as the species' distribution center and reservoir of genetic diversity, citing a personal communication from B. Wiltshire (at the time a graduate student at Southern Illinois University) that, because the only detectable genetic variation was conserved between populations in Tennessee it was critical to protect as many populations in the Central Basin as is feasible. The rationale for this recommendation was that by conserving the diverse Tennessee gene pool, the species' evolutionary potential was more likely to be conserved.

Using isozyme analysis, Edwards et al. (2004) confirmed the pattern reported in the recovery plan and also found that populations of *Dalea foliosa* "…were quite genetically depauperate." Measures of both polymorphism and expected heterozygosity were lower than reported averages for other endemic plant species (Hamrick and Godt 1989 in Edwards et al. 2004). With respect to the distribution of genetic variation within the species, the isolated populations known from Alabama and Illinois each contained only a subset of the variation present in the populations from central Tennessee (Edwards et al. 2004). Despite this fact, the authors cautioned against exchanging genetic material among geographical regions during any attempts to establish, reintroduce, or augment populations, unless inbreeding depression were first shown to threaten viability of a given population (Edwards et al. 2004). The importance of protecting numerous viable populations in Tennessee is borne out, in part, by the fact that within this center of the species' geographical distribution, individual populations are genetically distinct from one another, which, combined with demographic and environmental variability affecting *D. foliosa* populations, makes the protection of numerous populations necessary in order to reduce the risk of extinction (Edwards et al. 2004).

e. Taxonomic classification or changes in nomenclature:

There have been no changes in the taxonomic classification or nomenclature for *Dalea foliosa*.

f. Habitat or ecosystem conditions:

The species' recovery plan stated that extant populations in Illinois occur exclusively in mesic to wet-mesic dolomite prairie. According to Redmond and Lah (2008), dolomite prairie is characterized by a suite of specific plants (some of them rare) growing in areas where dolomite bedrock forms exposed or "paved" areas and as little as 600 acres of high quality dolomite prairie remain in Illinois. We have no information on the current extent of cedar glade habitats in middle Tennessee or Alabama. However, efforts are underway in Tennessee to increase management of limestone outcrop communities, including cedar glades and barrens, on DSNA in Tennessee. This will include an increase in prescribed burning to restore and maintain desirable conditions by reducing woody plant encroachment, which should benefit *Dalea foliosa* populations.

2. Five-Factor Analysis

a. Present or threatened destruction, modification or curtailment of its habitat or range:

We are not aware of any populations having been extirpated other than those reported in the recovery plan (Service 1996). The threat of outright habitat destruction has been greatly diminished since the release of the recovery plan due to the protection of many previously threatened sites through mechanisms like Recovery Land Acquisition grants from the Service, designation as DSNAs in Tennessee, and management by county forest preserve districts in Illinois. There currently are 44 occurrences on protected lands throughout the species' range (Appendices 1 and 2). Nonetheless, several of the threats to *Dalea foliosa* habitat identified in the recovery plan still have the potential to affect this species even in protected sites, namely, degradation due to invasive exotic or native species encroachment, illegal outdoor recreational vehicle (ORV) use, and incompatible management of utility rights-of-way.

The main threat to protected sites comes from the potential for either exotic or native, invasive plant species to displace *Dalea foliosa* from otherwise suitable habitat. The need for exotic species control in managed sites has been noted in both Illinois (Barbers and Wilhelm 2005; Redmer and Lah 2008; Taft et al. 2010) and Tennessee (TDEC 2005b). Management plans prepared for each of the Tennessee DSNA where *D. foliosa* occurs recommend control of invasive exotic species due to their presence in or near those sites [e.g., sericea lespedeza (*Lespedeza cuneata*), Queen Anne's lace (*Daucus carota*), privet (*Ligustrum* spp.), Asian clover species (*Kummerowia* spp.), tree-of-heaven (*Alianthus altiissima*), and tall fescue (*Lolium arundianceum*)].

Through the process of vegetation succession in the absence of disturbance (e.g., fire), native herbaceous and woody species also can pose a threat. Prescribed fire is used to manage most of the sites where Illinois populations occur on public lands. Efforts to develop a fire management program for lands managed by TDEC have met limited success, owing to insufficient funding, staff turnover, and challenges associated with burning in the urban interface. The latter constraint

limits opportunities to burn populations located in Davidson and Rutherford counties, where the cities of Nashville and Murfeesboro, respectively are located. Nonetheless, working cooperatively with the Tennessee Division of Forestry, TDEC has conducted a few prescribed burns in DSNA where *Dalea foliosa* occurs: Couchville Cedar Glade, Flat Rock, and Cedars of Lebanon. As an alternative to prescribed fire, TDEC (2005b) has used mechanical or manual removal of competing vegetation to manage *D. foliosa* habitat at localized scales.

Tennessee Valley Authority's proposed construction of a dam near the town of Columbia in Maury County no longer poses the threat to several occurrences in the Duck River Basin that was reported in the species' recovery plan. In 1995, TVA concluded that the Columbia Dam project could not be completed and instead began considering alternative uses of the lands that were acquired for the purposes of the dam project. TVA's preferred alternative was to work with the Tennessee Wildlife Resources Agency (TWRA) and TDEC to permanently protect those lands. The former TVA-owned lands where the *Dalea foliosa* occurrences are located are now under state ownership in the Yanahli Wildlife Management Area (WMA), which is managed by TWRA. The specific areas in which *D. foliosa* is located are now designated as the Duck River Complex DSNA.

Despite its protected status a relatively large population was essentially lost to habitat destruction at the Sneed Road Cedar Glade DSNA site in Tennessee, which at the time was a Registered Natural Area owned by The Nature Conservancy. This site was severely impacted in 2001, apparently by activities associated with development of adjacent property that resulted in placement of fill material on areas where *Dalea foliosa* occurred. This population contained an estimated 300 or more plants in 1980, but had declined to 53 plants in 2000, despite removal of the fill material, and only 6 plants were observed there in 2003 (TDEC 2005a).

Barbers and Wilhelm (2005) noted that the population at the Dellwood Park West site is periodically inundated by floodwater from the adjacent Illinois and Michigan Canal, which poses a threat to this population and to habitat restoration efforts at this site. We know of no other populations that are affected by this threat.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

Both the final rule listing *Dalea foliosa* as an endangered species and the species' recovery plan cited over-collection as a potential threat to this species. However, only the recovery plan provided a specific example of this threat, citing Hill's (1879) report of the the loss of a historic population to overcollecting. We have no current information to suggest that *D. foliosa* is threatened by over-collection for any purpose.

c. Disease or predation:

The recovery plan (Service 1996) identified intense livestock grazing and selective browsing by eastern cotton-tail rabbits (*Sylvilagus floridanus*) and white-tailed deer (*Odoicoileus virginianus*) as threats to *D. foliosa*. Molano-Flores (2004) observed herbivory at the Midewin NTP in 2002, with little evidence of recovery of affected plants during that growing season. McNicoll and Sivicek (2005) recorded evidence of damage caused by browsing animals in approximately 21 percent of the adult plants they counted at Keepataw Forest Preserve in 2005, and 483 of the 607 plants at Romeoville Prairie Nature Preserve in 2005 were impacted by herbivory (Key 2005). Taft et al. (2010) reported herbivory affecting 31.3 percent of adult plants at Keepataw Forest Preserve in 2010, which had increased from 12.5 percent in 2009. Because of the threat of browsing to seedlings, cages were used to protect at least a portion of the seedlings at each site where plantings occurred in 2008 as part of a project to reintroduce or augment populations (Redmer and Lah 2008).

d. Inadequacy of existing regulatory mechanisms:

We have no new information on this threat. *Dalea foliosa* remains listed as endangered by the States of Illinois (Illinois Endangered Species Protection Board 2009) and Tennessee (Tennessee Department of Environment and Conservation 2008), but is not protected by the State of Alabama. Occurrences in Tennessee DSNAs receive additional protection under The State of Tennessee's Natural Area Preservation Act of 1971 (T.C.A. 11–1701), which protects DSNAs from vandalism and forbids removal of threatened and endangered species from these areas. TDEC monitors these sites and protects them as needed through construction of fences or placement of limestone boulders to prevent illegal ORV access. Most of the occurrences in Illinois are located on lands protected by either state agencies or local governments, all of which would be required under the Illinois Endangered Species Act to consult with the Illinois Department of Natural Resources before authorizing, funding, or undertaking actions that disturb land, air, or water resources. The occurrence at the Midewin NTP is on lands administered by the U.S. Forest Service and is subject to federal protection under the Endangered Species Act.

e. Other natural or manmade factors affecting its continued existence:

Edwards et al. (2004) found populations of *Dalea foliosa* "…were quite genetically depauperate" and that the isolated populations in Alabama and Illinois contained only a subset of the variation found in Tennessee populations. Measures of both polymorphism and expected heterozygosity were lower than reported averages for other endemic plant species (Hamrick and Godt 1989 in Edwards et al. 2004). Population sizes tend to be small throughout the range of *D. foliosa*, which combined with spatial isolation could result in genetic drift exerting a dominant influence on population genetic structure. Increased incidence of inbreeding also is a risk associated with small populations, which can lead to a loss of fitness (i.e., inbreeding depression). These factors combined

place many *D. foliosa* populations at a potentially heightened risk of localized extinction (Barrett and Kohn 1991).

The ability of populations to adapt to environmental change is dependent upon genetic variation, a property of populations that derives from its members possessing different forms (i.e., alleles) of the same gene (Primack 1998). Small populations occurring in isolation on the landscape can lose genetic variation due to the potentially strong influence of genetic drift, i.e., the random change in allele frequency from generation to generation (Barrett and Kohn 1991). Smaller populations experience greater changes in allele frequency due to drift than do larger populations (Allendorf and Luikart 2007). Loss of genetic variation due to genetic drift heightens susceptibility of small populations to adverse genetic effects, including inbreeding depression and loss of evolutionary flexibility (Primack 1998).

Both the final rule listing *Dalea foliosa* as endangered (Service 1991) and the recovery plan (Service 1996) identify drought as a threat to populations of this species. The recovery plan points out that the species possesses some life history traits (e.g., formation of persistent banks, dormancy response to drought) that enhance its resilience to this threat. However, threats associated with small population sizes and diminished genetic variation could combine with increased drought severity to diminish the species' resilience to this threat over time, leading to substantial declines through the cumulative loss of small, isolated populations. In the face of accelerated climate change, it is imperative that effective monitoring programs are instituted throughout the range of the species in order to track trends in the face of potentially more severe (i.e., frequent, intense, or prolonged) drought conditions.

In a study using count data of seedlings/juveniles, non-flowering adults, and flowering adults from Midewin NTP, all stages and total annual census were positively correlated with snowfall. Flowering plants negatively correlated with fall days below 0 ^{o}C, seedlings negatively correlated with mean February temperature, and non-flowering adults positively correlated with September precipitation (Molano-Flores and Bell 2012). Their count-based population viability analysis (PVA) projected a low risk of extinction (i.e., 0.2 percent) by both 2050 and 2080, but the upper 95 percent confidence limits for these projections were 89 and 95 percent, respectively, indicating that extinction within these timeframes is a possibility (Molano-Flores and Bell 2012). However, the count-based PVA assumes that current conditions, including climate, will remain the same. When the authors incorporated predicted effects of climate change, using projections for mean February temperature and September precipitation in September, into regression models, the majority of the climate models predicted that population size would decrease from the mean population size of 188 plants from 1997-2008 (Molano-Flores and Bell 2012). This provides further evidence to suggest that climate change presents an increased risk of extinction for *Dalea foliosa*, especially for smaller populations and those with reduced genetic variation, which could limit potential for adapting to changing conditions.

D. Synthesis

The recovery plan for *Dalea foliosa* was released in 1996, and since that time there has been considerable information developed about the life history, ecology, and reproductive biology of this species. Also, additional information is available to us concerning factors (e.g., threats, conservation measures) that either limit or promote the recovery of this species. We believe that the recovery plan adequately accommodates this new information within existing recovery criteria, owing to its use of a PVI in measuring the contribution of a given population to the species' recovery. The PVI integrates information on population size, habitat, threats, management, and protection status. New information can be incorporated, as appropriate, in the framework for evaluating these variables and calculating the PVI.

While the threat of habitat destruction has been greatly diminished due to the protection of many occurrences in Tennessee and the discovery of several new occurrences on protected lands, threats associated with habitat degradation remain across much of the species' range. The final listing rule for *Dalea foliosa* (Service 1991) stated that all known populations were threatened by encroachment of more competitive herbaceous vegetation and/or woody plants, and this remains largely true today. While prescribed fire is used to manage most protected populations in Illinois, most sites on protected land in Tennessee have either burned very infrequently or not at all. Instead, habitat manipulations to reduce competing vegetation at Tennessee sites have typically implemented, by hand, on a small scale to improve conditions in the immediate vicinity of known occurrences. Efforts are underway to increase the scale of habitat management using prescribed fire in Tennessee, but time is needed to evaluate whether this will be feasbile and whether the management achieves desired results. Invasive exotic plant species also remain a threat throughout much of the species' range if left unmanaged. Lesser threats to habitat include ORV use in some sites on private and public lands in Tennessee and flooding at a single site in Illinois.

In addition to the threat of habitat degradation, the combined threats of small population size, low genetic variability, and accelerated climate change could increase the risk of localized extinction facing many *Dalea foliosa* populations (Barrett and Kohn 1991, Molano-Flores and Bell 2012). This underscores the importance of managing habitats at larger scales to control growth of more aggressive vegetation, decrease fragmentation of suitable habitat patches, and increase availability of suitable microhabitats across the landscape for *D. foliosa* populations to persist and, hopefully, grow demographically and spatially.

The fact that most *Dalea foliosa* occurrences are ranked as either low or moderate viability using the PVI from the recovery plan illustrates the fact that many threats are still acting upon this species across its range. Active management of *Dalea foliosa* will be necessary for these viability ratings to increase over time. Neither the criteria for

reclassification nor delisting have been met, and many populations are threatened with the risk of localized extinction by encroachment from exotic and native plant species, herbivory by rabbits or deer, and inadequate management to prevent habitat declines. For these reasons, *D. foliosa* still meets the definition of endangered. We also do not recommend a change from the existing recovery priority number of 5, because threats associated with small population sizes and the need for management to maintain habitat remain throughout most of the species' range. Also, the need for intensive management to conserve most populations makes potential for recovery low given the scarcity of resources available for this purpose.

III. RESULTS

A. Recommended Classification:

X **No change is needed**

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

A. The Service should coordinate with Drs. Brenda Molano-Flores (pers. comm. 2008) and Tim Bell on their efforts to develop a population viability analysis for *D. foliosa* across its entire range. If this effort were successful across the species range, it could be used in conjunction with the existing PVI to provide a better estimation of the extinction risk faced by individual populations and the species as a whole.

B. Increase frequency of monitoring in Tennessee and Alabama populations, and standardize methods throughout the species' range, as feasible. Feasibility is a constraint in Tennessee, owing to the large number of populations and the fact that TDEC is the only agency currently monitoring this species at most sites in the state. The Service should work with TDEC to increase capacity by participating in monitoring activities.

C. Increase use of prescribed fire, or other techniques, for maintaining open conditions with limited competing vegetation in areas with sufficient soil depth to support *D. foliosa*.

D. Determine the number of populations that are represented by element occurrences throughout the range of *D. foliosa*. This is of highest priority in Tennessee, where multiple occurrences within a single protected area are often tracked as distinct entities. This is especially relevant when calculating PVI values for populations, as aggregating multiple occurrences into what are believed to be biological populations could have the effect of increasing the population size, and in turn the calculated PVI for those populations. It appears that the only circumstance in Illinois where such a determination might be warranted is the case of the two

"populations" at the Waterfall Glen Preserve in DuPage County (Appendix B), which might be more appropriately treated as a single population for recovery purposes. Most of the Alabama occurrences appear to be separated by sufficient distance to warrant treatment as separate populations.

E. Continue efforts to reintroduce/augment Illinois populations.

F. Collect data to calculate a current PVI for each protected population, in order to evaluate the species' status with respect to recovery criteria.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Dalea foliosa*

Current Classification ____Endangered_____
Recommendation resulting from the 5-Year Review

__X__ **No change is needed**

Review Conducted By Geoff Call, Cookeville, Tennessee

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Mary E Jennings Date 3-20-15

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

for **Lead Regional Director, Fish and Wildlife Service**

Approve Aaron L Valt Date 5-4-15

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. If a change in classification is recommended, written concurrence from other regions is required.

Cooperating Regional Director, Fish and Wildlife Service

__X__ Concur _____ Do Not Concur

Signature Lynn M. Lewis Date 6/4/15

APPENDIX A: Summary of peer review for the 5-year review of *Dalea foliosa* (leafy prairie-clover)

A. Peer Review Method:
The Service made formal requests for peer review from Alabama Natural Heritage Program, Tennessee Natural Heritage Program, Illinois Natural History Survey, and llinois DNR – Natural Heritage Database. Peer review of the scientific information used in our analysis of the status of this plant and the validity of the data will be requested, but peer reviewers will not be asked to provide recommendations on the legal status of the species.

B. Peer Review Charge:
Request sent (email – dated 05/27/2010) to potential reviewers requesting comments on the 5-year review. Request was sent to Andrea Bishop (Tennessee Natural Heritage Program), Dr. Brenda Molano-Flores (Illinois Natural History Survey), Tara Kieninger (Illinois DNR – Natural Heritage Database), and Al Schotz (Alabama Natural Heritage Program).

C. Summary of Peer Review Comments/Report – We received replies from Andrea Bishop, Tara Kieninger, and Al Schotz. Tara Kieninger and Al Schotz concurred with information presented in this review concerning *Dalea foliosa* in Illinois and Alabama, respectively. Andrea Bishop provided constructive comments and more current data concerning the species' status in Tennessee, which we have incorporated into this document.

D. Response to Peer Review – See Section C of this Appendix.