Recovery Plan For The Leafy Prairie-clover *(Dalea foliosa)*

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

RECOVERY PLAN

for

***Dalea foliosa* (Leafy Prairie-clover) (Gray) Barneby**

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Atlanta, Georgia

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The cover illustration was provided by the Will County Forest Preserve District in Illinois.

EXECUTIVE SUMMARY

Current Status: The federally endangered *Dalea foliosa* (leafy prairie-clover) has declined by over 45 percent from historic occurrences. (Occurrences, as used here, include all verified reports of the species regardless of size.) There are 29 known populations in three States--Alabama (2), Illinois (3) and Tennessee (24), but many of these populations are not likely to persist under their current habitat conditions. Thirteen populations are considered to have high to moderate viability with potential for recovery and persistence. Of these, ten populations are protected to some degree.

Habitat Requirements and Limiting Factors: *Dalea foliosa* requires full sun and low competition for optimum growth and reproduction. The species occurs in thin-soiled (less than 45 centimeters [cm] [18 inches] deep) mesic and wet-mesic dolomite prairie, limestone cedar glades, and limestone barrens. It can persist in successional plant communities following disturbance or woody succession, but will decline in advanced stages of woody succession. The natural communities supporting leafy prairie-clover must be maintained by periodic burning. Because the species is short-lived and does not spread vegetatively, population maintenance is dependent upon seed production and may be buffered from extinction-causing phenomena by a persistent seed bank.

Recovery Objective: Delisting.

Recovery Criteria: Recovery criteria are based on an artificially derived population viability index (high, moderate, and low) that is based on population, habitat, protection status, management needs, and threats. Currently there are 2 high-viability populations, 11 moderate-viability populations, and 16 low-viability populations. *Dalea foliosa* can be considered recovered and eligible for delisting when at least 3 high-viability populations each in Illinois and Alabama and 12 high-viability populations in Tennessee are protected and managed. If there are less than the recommended high-viability populations in each geographic region, populations can be managed and restored to high viability, or three protected and managed populations of moderate viability can be substituted for one high-viability population. New populations can also be established at suitable recovery sites to meet the recovery criteria and must persist at a moderate or high viability for at least 10 years.

Actions Needed:

1. Identify and prioritize protection, management, and restoration needs.
2. Develop preserve designs and implement protection plans.
3. Develop and implement management plans, enhance existing populations and establish new populations.
4. Develop and implement population monitoring studies.
5. Conduct demographic and life history studies and conduct public education efforts.

Cost ($000s):

YEAR	NEED 1	NEED 2	NEED 3	NEED 4	NEED 5	TOTAL
1996	9.0		25.0	25.0	37.0	96.0
1997	15.0		25.0	25.0	40.0	105.0
1998		506.0	33.0	25.0	15.0	579.0
1999		500.0	35.0	25.0	15.0	575.0
2000		250.0	10.0	25.0	15.0	300.0
2001			10.0	25.0	15.0	50.0
2002			10.0	25.0	15.0	50.0
2003			10.0	25.0	15.0	50.0
2004			10.0	25.0	15.0	50.0
2005			10.0	25.0	15.0	50.0
TOTAL	24.0	1,256.0	178.0	250.0	197.0	1,905.0

Date of Recovery: The year 2006, provided that recovery actions are funded and recovery criteria are met.

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INTRODUCTION

Dalea foliosa (Gray) Barneby, leafy prairie-clover, is a rare legume that is narrowly restricted to cedar glades, barrens, and dolomite prairies in Tennessee, Alabama, and Illinois. Since it was first observed nearly 138 years ago, known leafy prairie-clover occurrences have declined by 45 percent due to habitat destruction, overgrazing, and habitat loss from encroachment by woody species. (Unless explicitly stated otherwise, occurrences, as used here and throughout the text, include all verified reports of the species regardless of size.) As a result, leafy prairie-clover was proposed for listing as endangered by the U.S. Fish and Wildlife Service (Service) on March 27, 1990 (Service 1990), and it received final listing approval effective May 31, 1991 (Service 1991). The species is listed as endangered in Tennessee (Somers *et al.* 1989) and Illinois (Illinois Endangered Species Protection Board 1990).

A. Description

Dalea foliosa, a member of the legume family or Fabaceae, was first described as *Petalostemon foliosus* by Asa Gray in 1868 (Gray 1868). The holotype specimen was collected by Burgess Truesdell in 1867 along the banks of the Fox River in Kane County, Illinois; a paratype was collected in 1854 near Nashville, Tennessee. According to Wemple (1970), both of these specimens are mounted on one sheet in the Gray Herbarium, with a similar mixed sheet at the Missouri Botanical Garden and a sheet of the Truesdell collection at the New York Botanical Garden. The generic name *Petalostemum* A. Michaux, first published in 1803, has been conserved over the earlier *Kuhnistera* Lamarck of 1789, with the spelling of *Petalostemon* also conserved over the original *Petalostemum* (Greuter *et al.* 1988, Farr *et al.* 1979). Because the gender of *Petalostemon* is neuter, the correct name of leafy prairie-clover under this genus is *Petalostemon foliosum* A. Gray.

Past taxonomic treatments of related genera in the tribe Amorpheae have focused on petal attachment, separation point of the filaments, and the number of functional stamens. Barneby (1977) considered ovule number and chromosome number as more fundamental attributes for generic delimitation. Consequently, he included all species of *Petalostemon* in the genus *Dalea*, as both genera have two ovules in the ovary and a base chromosome number of $n = 7$. Thus, the currently accepted name for the leafy prairie-clover is *Dalea foliosa* (A. Gray) Barneby. In Barneby's classification of the genus *Dalea*, *D. foliosa* belongs to the subgenus *Dalea*, section *Kuhnistera*, series *Candidae*. There are no obvious closely related species to *D. foliosa*, although there are some morphological similarities with *D. sabinale* (S. Wats.) Barneby, an endemic of Sabinal Canyon in western Texas (Wemple 1970, Barneby 1977).

Leafy prairie-clover is easily distinguished from most other species of the genus east of the Mississippi River on the basis of the leaflet number, which ranges from 9 (Barneby 1977) to 31 (Gleason and Cronquist 1963) but typically is between 20 and 27 (Fernald 1950). Leafy prairie-clover is a glabrous, stout perennial herb, with one to several stems 2 to

8 decimeters (dm) (8 to 31 inches [in.]) long arising from a hardened root crown. The alternate, oddly pinnately compound leaflets are sparsely glandular-punctate beneath; flat, oblong, or oblanceolate to elliptic in shape; and 5 to 13 millimeters (mm) (0.2 to 0.5 in.) long. The axillary leaf clusters are reduced in the upper portions of the stem. The dense conic to cylindric flowering heads are between 0.4 and 8.9 centimeters (cm) (0.15 to 3.5 in.) long and 0.6 to 1.0 cm (0.24 to 0.4 in.) wide (DeMauro and Riddle, unpublished data) on short peduncles, 0 to 2 mm (0 to 0.08 in.) long, with lance-ovate, long acuminate bracts which surpass the small (up to 5 mm [0.2 in.] long) lavender-purple calyx that has five petals and five strongly exerted anthers with orange pollen (Fernald 1950, Gleason and Cronquist 1963, Wemple 1970, Barneby 1977).

B. Distribution and Status

The genus *Dalea* comprises approximately 160 species of generally xerophytic legumes of grasslands, deserts, and pampas ranging from 50° north to 33° south latitudes, with the center of distribution in California and Mexico (Barneby 1977). The section *Kuhnistera*, a highly modified and specialized group, which includes all the prairie clovers (formerly *Petalostemon*), is distributed throughout the Central and Southeastern United States (Barneby 1977).

The distributional center for *Dalea foliosa* is the limestone cedar glades of central Tennessee and northern Alabama, where the species is considered nearly endemic (Baskin and Baskin 1973). It is disjunct in Illinois, where it is now restricted to dolomite prairies on river terraces in the northeastern part of the State (Kurz and Bowles 1981). It occurs with the glade endemic *D. gattingeri* in Tennessee and Alabama and with *D. purpurea* in Illinois (Mahler 1970, Swink and Wilhelm 1979) (see Figure 1).

Among 29 taxa endemic or nearly endemic to the limestone cedar glades of the Southeastern United States, only two, *D. foliosa* and *Astragalus tennesseensis* (Tennessee milkvetch), occur north of the glacial boundary (Baskin and Baskin 1986). This bicentric distribution may have resulted from western taxa or their ancestors first migrating from the Southwest or Ozark Plateau to the Southeast. Then, during the dry Hypsithermal (=Xerothermic) Interval of the mid-Holocene, these species could have migrated from the unglaciated Central Basin of Tennessee to the glaciated Midwest, possibly via gravel exposures or limestone outcrops in western Kentucky, southern Illinois, or along the Mississippi and Illinois Rivers (Baskin and Baskin 1986, Delcourt *et al.* 1986).

1. Alabama

There are four county records for *Dalea foliosa* in Alabama of which two are extant (see Table 1). The species was discovered in Franklin and Morgan Counties in 1966 (Baskin and Caudle 1967). Additional populations were discovered along a road and creek bed

Figure 1. Distribution and Status of *Dalea foliosa*

● = Extant population(s)
■ = Historic record with voucher specimen
▲ = Referenced as historic without voucher specimen

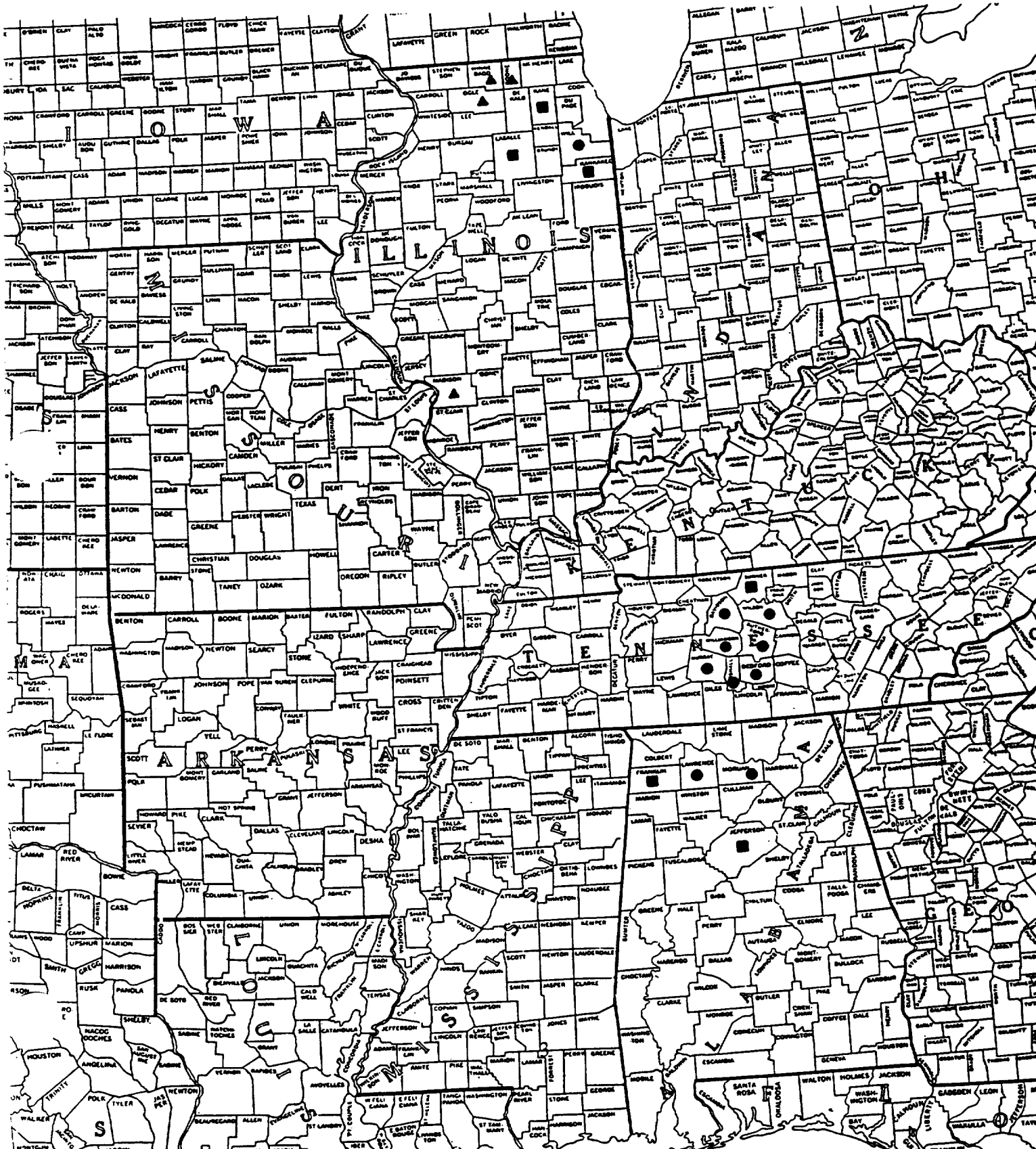


Table 1. *Dalea foliosa* population status summary[a].

STATE/COUNTY SITE NAME/EOR	FIRST OBSD.	LAST OBSD.	POP. SIZE, COMMENTS, AND/OR MGMT. THREATS	OWNERSHIP
ALABAMA				
Franklin County	1966	1971	Extirpated by road work	Road ROW
Jefferson County	1984	1984	Extirpated by road work	No information
Lawrence County	1990	1992	339; line maintenance threats	Private (TVA ROW)
Morgan County	1966	1992	33; extirpated by road work or grazing	Road ROW
ILLINOIS				
Boone County	?	?	No voucher specimen	No information
Kane County	1867	1891	Extirpated, likely by development	Location unknown
Kankakee County	1872	1873	Extirpated by overcollecting	Public (IDC)
LaSalle County	1881	1885	Extirpated, likely by development	Private
Madison County	?	?	No voucher specimen	No information
Ogle County	?	?	No voucher specimen	No information
Will County				
Keepataw Forest Preserve	1979	1992	75; persistence from seed bank, ORVs, cool-season grasses	Public (FPDWC)
Lockport Prairie East	1979	1981	Extirpated; habitat scraped	Private
Lockport Prairie Nature Preserve	1974	1992	>5,000; best example in Illinois	Public
Romeoville Prairie	1907	1992	295; decline from drought, ORVs, and line maintenance threats	Private (CEC)
Winnebago County	?	?	No voucher specimen	No information

Table 1 (continued)

STATE/COUNTY SITE NAME/EOR	FIRST OBSD.	LAST OBSD.	POP. SIZE, COMMENTS, AND/OR MGMT. THREATS	OWNERSHIP
TENNESSEE				
Bedford County				
Burnt Hill Road (16)	1990	1993	>1,500; best example in Tennessee	Private
Davidson County				
Woodmont Boulevard (6)	1980	1992	11; extirpation is certain from development; plants moved to Cheekwood Botanical Garden in 1993	Private
Mt. View School (8)	1931	1992	13; extirpation is likely from woody succession or development	Public
Lake Trail Wet Barren (31)	1993	1994	6; threatened by woody succession; needs to be control-burned	Private
Hamilton Creek (13)	1985	1985	0; habitat highly degraded; seed bank unlikely	Public (TDEC)
Couchville Glade (14)	1985	1993	7; habitat intact, possible seed bank; is being managed by TNC; will be transferred to State	Private (TNC)
Sumner County	1975	1975	Extirpated by development	Private
Marshall County				
Rt. 99 Glade (4)	1970	1992	23; extirpation likely from woody succession and mowing in road ROW	Private
South Berlin Glade (17)	1983	1993	80; TVA manages power line through site	Private
Maury County				
Columbia Glade (5)	1980	1992	1,130; threatened by dam project and woody succession	Public (TVA)
Baskin Site (12)	1966	1971	Extirpated by residential development	Private
Sowell Mill Road (20)	1989	1993	142; threatened by woody succession	Private, Public (TVA)

Table 1 (continued)

STATE/COUNTY SITE NAME/EOR	FIRST OBSD.	LAST OBSD.	POP. SIZE, COMMENTS, AND/OR MGMT. THREATS	OWNERSHIP
Tennessee, Maury County (continued):				
TVA Sowell Mill North (28)	1993	1993	55; needs to be cleared or control-burned to control woody plants	Public (TVA)
Sowell Creek (35)	1994	1994	325; need to contact landowner	Private
Rutherford County				
Sharp's Barren (1)	1958	?	Extirpated by industrial development	Private
Walterhill Site (7)	1958	1968	Extirpated by dumping and woody succession	Private
Lascassas Site (9)	1962	1962	Extirpated by grazing	Private
Fosterville (10)	1980	1980	Extirpated by road work and woody succession	Road ROW
Jones Mill Road (21)	1985	1994	194; EOR location incorrect, not on public land	Private
Factory Road (22)	1984	1984	0; woody succession, but site regularly bush-hogged; seed bank unlikely	Private
Manus Road #4 (23)	1990	1994	100+; site protection design completed by TNC in 1994	Private
Hall Farm (32)	1994	1994	400; stable, with many seedlings; need to contact landowner	Private
Adams #3 (11)	1993	1994	135; site protection design completed by TNC in 1994.	Private
Overbridge (34)	1993	1994	2; new State natural area	Public (TDEC)
Williamson County				
Sneed Road Cedar Glade (2)	1987	1994	800-1,500; threatened by woody succession	TNC; private (Woodmont Golf Club)
Sneed Road (15)	1987	1987	Extirpated by dumping and woody succession	Private
Wilson County				
Cedars of Lebanon SF (3)	?	1979	Extirpated by woody succession	Public (TDF)
Cedars of Lebanon SF (18)	1990	1992	17; threatened by ORVs	Public (TDF)
Cedars of Lebanon SP (19)	1989	1992	11; threatened by woody succession	Public (TDF)

Table 1 (continued)

STATE/COUNTY SITE NAME/EOR	FIRST OBSD.	LAST OBSD.	POP. SIZE, COMMENTS, AND/OR MGMT. THREATS	OWNERSHIP
Tennessee, Wilson County (continued):				
Cedars of Lebanon SF (24)	1989	1992	16; in heavy little bluestem matrix; TNC doing experimental burn	Public (TDF)
Cedars of Lebanon SP (25)	1990	1992	14; in roadside ditch, heavy woody succession; extirpation likely	Public (TDF)
Cedars of Lebanon SF (30)	1989	1993	100; appears stable; need to exclude ORVs	Public (TDF)
Cedars of Lebanon SF (33)	1993	1994	130; need to use control-burns	Public (TDF)
Lane Farm (26)	1992	1993	About 25	Private

[a]Occurrence/status information based on Baskin and Caudle 1967, Baskin and Baskin 1973, Smith and Wofford 1980, Kurz and Bowles 1981, Baskin and Wofford 1990, Bowles and Jones 1992, TDEC Natural Heritage data base files, and 1992 site surveys by the lead author.

KEY TO ACRONYMS:

CEC - Commonwealth Edison Company (Utility)
EOR - Element Occurrence Record
FPDWC - Forest Preserve District of Will County, Illinois
IDC - Illinois Department of Conservation
TDEC - Tennessee Department of Environment and Conservation
TDF - Tennessee Division of Forestry
TNC - The Nature Conservancy
TVA - Tennessee Valley Authority
ORVs - Off-road-vehicles
ROW - Right-of-way

near the town of Ketona in Jefferson County in 1984 and under power transmission lines in a Tennessee Valley Authority (TVA) right-of-way in Lawrence County in 1990 (Service 1990). Surveys over the last 8 years have failed to relocate *Dalea foliosa* in Franklin County (D. Webb, TVA, personal communication, 1992) and Jefferson County (Currie 1990; D. Whetstone, Jacksonville State University, personal communication, 1992). Road maintenance eliminated the Franklin County population, and no information is available for the Jefferson County occurrence.

The Morgan County population has declined drastically since 1966 (see Table 2). This is undoubtedly due to road maintenance, because the plants occur within 2 meters (m) (6.6 feet) of the road's edge. The Lawrence County population is in successional habitat, probably produced by right-of-way maintenance. The number of plants in this moderately sized population appears to be increasing from previous censuses.

2. *Illinois*

Only five historic *Dalea foliosa* sites are known from four Illinois counties (Kane, Kankakee, La Salle, and Will), which are represented by collections from 1867 to 1907 (Kurz and Bowles 1981, Bowles and Jones 1992) in habitats described as dry or gravelly riverbanks, rocky hills, or stony flats. (Unless explicitly stated otherwise, historic, as used here and in the remainder of the text, includes all recent records as well as records from much older dates.) Unconfirmed or other sites are recorded from four additional counties; these records are discussed below and are summarized in Table 1. The species was mapped from Boone and Ogle Counties by Jones and Fuller (1955); however, there are no references or voucher specimens in Illinois herbaria for these counties (Bowles and Jones 1992). Isley (1962) mapped leafy prairie-clover from Winnebago and Madison Counties. The former occurrence is based on a Bebb collection labeled "county unknown" but specifies "Fountaindale," which was the collector's home in Winnebago County. There is no known voucher specimen in Illinois herbaria for the Madison County occurrence (Bowles and Jones 1992).

Hill (1879) suggested that the Fox, Illinois, and Kankakee Rivers formed the nucleus of the species' geographic range in Illinois. Recent discoveries in the Des Plaines River valley fit within this range, but the historic records from Boone, Ogle, and Winnebago Counties, if accurate, suggest the Rock River valley may be a distributional outlier in Illinois. If the Madison County collection is accurate, then it would be an intermediate location between populations in Illinois and middle Tennessee and would suggest a possible migration route from the Southeast to Illinois (Bowles and Jones 1992).

The three extant Illinois leafy prairie-clover populations occur in the Des Plaines River valley in Will County. The species was thought to be extirpated from Illinois until a large population was discovered west of the Des Plaines River in 1974 (Swink and Wilhelm 1979) in what is now Lockport Prairie Nature Preserve. A second population, discovered

Table 2. Population censuses at extant *Dalea foliosa* sites[a].

STATE/COUNTY SITE NAME (EOR)	TYPE COUNT[b]	1992 POPULATION COUNTS[c] SDLG.	NFP	FP	TOTAL	HISTORICAL OBS. OF POPULATION SIZE[d]
ALABAMA/Lawrence						
TVA ROW	TPC	152	123	64	339	50-100 in 1990 and 1991
ALABAMA/Morgan						
Cedar Plains Road	TPC	19	17	8	44	100s in 1966, 50 mature plants in 1980
ILLINOIS/Will						
Keepataw Forest Preserve	TPC	21	54	0	75	<25 in 1988 and 1989 but died back by August of each year; 200 juveniles in 1990; 0 in 1991
Lockport Prairie Nature Preserve	TFP	*	*	2,308	---	1,389 FP in 1990; 2,342 FP in 1991
Romeoville Prairie Nature Preserve	TPC	10	129	156	295	372 FP in 1990; 335 FP in 1991
TENNESSEE/Bedford						
Burnt Hill Road (16)	PPC	448	335	103	886[e]	248 in 1990; ca. one-half population censused in 1991
TENNESSEE/Davidson						
Woodmont Boulevard (6)	TPC	---	4	7	11	12 FP in 1980; seedlings only from 1986 to 1989; 19 in 1990; all plants moved to Cheekwood Botanical Garden in 1993
Mt. View School (8)	TPC	2	10	1	13	24 in 1977; 20 in 1978; present but not counted in 1980 and 1985
Hamilton Creek (13)	S	---	---	---	0	4 in 1985
Couchville Glade (14)	TPC	---	2	5	7	Few plants in 1994

Table 2 (continued)

STATE/COUNTY SITE NAME (EOR)	TYPE COUNT[b]	1992 POPULATION COUNTS[c] SDLG.	NFP	FP	TOTAL	HISTORICAL OBS. OF POPULATION SIZE[d]
Tennessee (continued):						
TENNESSEE/Marshall						
Rt. 99 Glade (4)	TPC	2	20	1	23[f]	9 in ROW in 1980; 21 juveniles in 1990, 2 of these in ROW
South Berlin Glade (17)	TPC	---	16	64	80	Counted in 1993
TENNESSEE/Maury						
Columbia Glade (5)	TPC	377	441	312	1,130	630 in 1990, 40% of which were mature
Sowell Mill Road (20)	TPC	35	52	56	143	52 in 1990
TVA Sowell Mill North (28)	TFP	---	---	55	55	Counted in 1993
Sowell Creek (35)	TFP	---	---	375	375	Counted in 1994
TENNESSEE/Rutherford						
Jones Mill Road (21)	TPC	102	67	25	194	25-30 in 1985
Factory Road (22)	S	---	---	---	0	2 FP in 1984
Manus Road #4 (23)	PPC	---	---	100+	100+	2 in 1990
Hall Farm (32)	PPC	---	---	---	---	Estimated 400 in 1994
Adams #3 (11)	FPC	---	---	135	135	Counted in 1994
Overbridge (34)	TPC	---	1	1	2	Counted in 1994
TENNESSEE/Williamson						
Sneed Road Cedar Glade (2)	TFP	*	*	470[g]	800-1,500	Several dozen in 1973; 300-500 in 1990; 800-1,500 in 1993
TENNESSEE/Wilson						
Cedars of Lebanon State Forest:						
(3)	S	---	---	---	0	<12 in 1979
(18)	TPC	7	10	0	17	28 and seedlings in 1990
(24)	TPC	1	11	4	16	35 in 1990
(30)	TPC	---	75	29	100+	Counted in 1993
(33)	FPC	---	---	130	130	Counted in 1994

Table 2 (continued)

STATE/COUNTY SITE NAME (EOR)	TYPE COUNT[b]	1992 POPULATION COUNTS[c] SDLG.	NFP	FP	TOTAL	HISTORICAL OBS. OF POPULATION SIZE[d]
Tennessee (continued):						
Cedars of Lebanon State Park:						
(19)	TPC	---	5	6	11	16 in 1990
(25)	TPC	5	9	0	14	1 in 1990
Lane Farm (26)	---	?	?	10	25[h]	

[a]Results of a 1992 survey of all but three extant *D. foliosa* populations by the author with assistance from M. Bowles, Mr. and Mrs. Jones, M. Pyne, T. Radke, J. Raveill, R. Reeves, G. Roach, D. Webb, and B. Wiltshire.

[b]Type Count: TPC = total population census, PPC = partial population census, TFP = census of all flowering plants, S = site searched, NS = site not searched.

[c]Population Count: SDLG. = seedling (single ramet $\leq$ 10 cm in height), NFP = nonflowering plants, FP = flowering plants, * = many observed.

[d]Past census data based on DeMauro (unpublished data) for Illinois sites; D. Webb (personal communication, 1992) for Lawrence County, Alabama; and Baskin and Caudle (1966, 1973), Smith and Wofford (1980), and the Natural Heritage data base (TDEC, Division of Ecological Services) for the remaining Alabama and Tennessee sites.

[e]This population consists of four large and several smaller noncontiguous patches, roughly half the number of the patches that were censused in 1992. The 1990 observations likely included all the small patches and one large patch.

[f]Three of the NFP were observed in the mowed road ROW; all stems were cut.

[g]Flowering plants represented approximately one-third and two-thirds of the total population north and south of Sneed Road, respectively.

[h]Discovered in 1992 by J. Raveill; approximately 25 plants were observed.

in 1978 west of the river in Romeoville, is probably the original 1907 collection site (White 1978). A third population was discovered in 1979 east of the river and directly across from the Lockport Prairie population (Kurz and Bowles 1981), but it was destroyed when the prairie was scraped to supply fill for the construction of a nearby sewage treatment plant. A fourth location was discovered north of the river near Lemont about 1979 (K. Klick, Planning Resources, personal communication, 1992) and was rediscovered in 1986 during an inventory for impacts of a Federal assistance highway project in the area (Taft 1989). The site is now the Keepataw Forest Preserve.

The populations at Lockport Prairie Nature Preserve and Keepataw Forest Preserve are in public ownership. Lockport Prairie supports the largest population known for the species. The small population at Keepataw has had only nonflowering plants since its discovery. If plants are not persisting, the population is expending its seed bank and may be near extirpation. The population at Romeoville occurs in disturbed marginal habitat under a privately owned power transmission line adjacent to the publicly owned Romeoville Prairie Nature Preserve. This population appears to be in decline, primarily as a result of the severe mid-summer droughts that have occurred in 3 of the last 6 years.

3. *Tennessee*

Tennessee likely had the most extensive and widespread presettlement *Dalea foliosa* populations. There are historic collections from Davidson, Rutherford, and Sumner Counties in middle Tennessee and from Knox County in eastern Tennessee, but the latter record was discounted as a transplant that did not survive (Baskin and Baskin 1973). A report that the species occurred in Franklin County is believed to be in error. Milo Pyne (Tennessee Department of Environment and Conservation [TDEC], personal communication, 1993) believes this record should be considered to be from Franklin, in Williamson County, rather than from Franklin County.

There are 33 element occurrence records (EORs) for *Dalea foliosa* across seven counties in the Central Basin of Tennessee: Bedford (1), Davidson (5), Marshall (2), Maury (5), Rutherford (10), Williamson (2) and Wilson (8). Twenty-seven of these records represent extant sites for the species. The EORs are based on historic collection records; recent surveys by Baskin and Baskin (1973), Smith and Wofford (1980), and Baskin and Wofford (1990); and the results of an intensive search from 1990 to 1994 for rare plants on over 200 cedar glades by the TDEC's Division of Ecological Services. Many of these EORs were surveyed by M. DeMauro in 1992.

Nine of the EORs are historic records known or presumed to be extirpated. Of the 24 extant populations, 14 (53.8 percent) have 25 or fewer plants (see Table 2). These populations are highly vulnerable to extirpation by development, road maintenance, woody succession, grazing, or as a consequence of their small population sizes. Only three large *Dalea foliosa* populations of more than 1,000 plants remain in Tennessee. The

largest population, in Maury County, is owned by the TVA and is within the Columbia Dam project impact area (Baskin and Wofford 1990). The second largest population, Burnt Hill Road (Bedford County), occurs on a privately owned high-quality habitat. The third largest population, Sneed Road Cedar Glade (Williamson County), is owned and managed by The Nature Conservancy (TNC). The remaining populations contain between 55 and 400 plants (typically more than half the plants at each site are immature); most of these are privately owned and are threatened by woody succession.

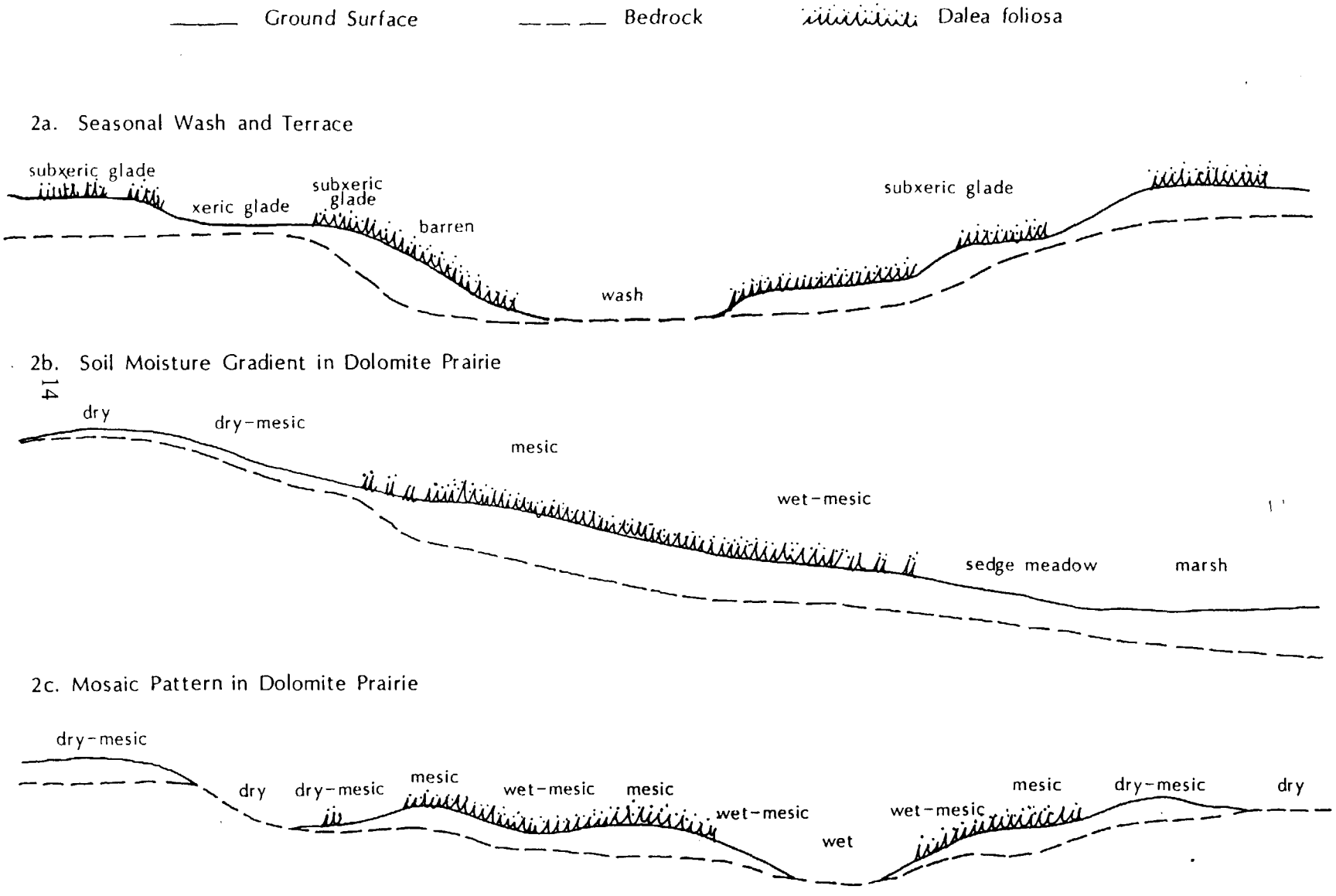
C. Habitat

Leafy prairie-clover is found only in open limestone cedar glades, limestone barrens, and dolomite prairies which have shallow, silt to silty clay loam soils over flat and often highly fractured, horizontally bedded limestone or dolomite with frequent expanses of exposed bedrock at surface elevations typically between 168 and 213 m (550 and 700 feet). These habitats experience high surface and soil temperatures, generally have low soil moisture but are wet in the spring and fall and become droughty in summer, and have a seasonal aspect to the flora (Quarterman 1989, DeMauro 1986, White 1978). The distribution of glade, barren, and dry to wet dolomite prairie at any particular site is determined by subtle, local variations in soil and bedrock depths and topographic position, which create a random and intergrading mosaic of these different habitats and their associated plant communities (see Figure 2).

Although *D. foliosa* plants can persist in partial shade, the species' preferred habitat is open sun with a soil depth from 4 to 45 cm (1.6 to 17.7 in.) (DeMauro, unpublished data; Baskin and Baskin 1973) but is most abundant in 10 to 30 cm (3.9 to 11.8 in.) of soil. Along a topographic gradient, the deeper, moister soils are typically at the lower portions of a slope while the more shallow, drier soils are typically near the top of a slope. Leafy prairie-clover occurs in the relatively mesic and wet-mesic portions (=subxeric glades and submesic barrens) of the soil moisture gradient, typically in association with dry washes. The wet-mesic component is probably critical to population persistence, particularly in drought years. Leafy prairie-clover roots may also penetrate the upper fractured bedrock layers, which likely provide some moisture.

Important factors that may limit the distribution of leafy prairie-clover include shallow soils, low soil moisture, low pH, poor competitive ability, and possibly allelopathy. As soil depth increases (greater than 20 cm [7.9 in.]), the vegetation cover increases and is more favorable to invasion by woody species (Quarterman 1989). Leafy prairie-clover may be reduced or excluded from these areas, presumably by increased competition, particularly from perennial grasses and by shading effects, respectively. Under heavy woody invasion, leafy prairie-clover is eliminated (Smith and Wofford 1980).

FIGURE 2. DISTRIBUTION OF DALEA FOLIOSA IN RELATIONSHIP TO TOPOGRAPHIC POSITION, BEDROCK ELEVATION AND SOIL DEPTH



1. Alabama and Tennessee

The limestone cedar glades of middle Tennessee and northern Alabama occur in the Interior Low Plateau Province, an unglaciated, dissected limestone plateau formed by cycles of uplift, erosion, subsidence, inland sea advance, and deposition of lime sediments (Fenneman 1938). Glades in middle Tennessee occupy the Central Basin in which erosion of the Nashville Dome exposed Ordovician deposits (Miller 1974). Leafy prairie-clover occurs almost exclusively on middle Ordovician limestones of the Stones River Group (Ridley, Lebanon, and occasionally Carter), but there are some occurrences on the younger Catheys and Leiper Ordovician formations. The species is found in neutral to alkaline, rocky and silty clay loam soils formed in residuum over limestone and include Rockland, Gladeville-Rock outcrop-Talbott association, Bradyville-Rock complex, and Talbott silt clay loam (True *et al.* 1977, Harmon *et al.* 1959, U.S. Department of Agriculture 1992a and 1992b). Leafy prairie-clover also occurs in Mimosa-Urban complex, Bradyville silt loam, and Talbott silt loam soils that are reddish brown to dark brown and are generally acidic, except where limestone is near the surface (North 1981). Within well-developed washes, leafy prairie-clover is found in Egam silt to silty clay loam, an alluvial soil derived from limestone (True *et al.* 1964).

The Central Basin is surrounded by the Highland Rim, a rolling upland plateau comprising sharply incised valleys on younger Mississippian rocks and extending to the Tennessee River in northern Alabama (Fenneman 1938). This feature is known as the Moulton Valley in the Tennessee Valley Region (Harper 1943). All leafy prairie-clover stations in the northern part of the State occur on Bangor limestone, a Mississippian deposit that contains interbeds of dusky red and olive green mudstones (Raymond *et al.* 1988). The Jefferson County station is in the Appalachian Plateau Province near the transition to the Ridge and Valley Province (Fenneman 1938). Here, late Cambrian (Ketona dolomite) to early Ordovician (Chepultepec and Copper Ridge dolomite) rocks were exposed as a result of eroding sandstone-capped anticlines (Raymond *et al.* 1988).

The limestone cedar glade is a distinct natural community dominated by low-growing herbaceous plants, and it supports a highly endemic flora (Quarterman 1950a and 1950b, Baskin *et al.* 1968, Baskin and Baskin 1986, Delcourt *et al.* 1986, Bridges and Orzell 1986, Somers *et al.* 1986, Baskin and Baskin 1989, Quarterman 1989). Vertical fissures and rock crevices provide niches for the establishment by woody plants, particularly red cedar (*Juniperus virginiana*). There are two distinct microhabitats within the glade complex, limestone barrens and limestone cedar glades. Limestone barrens are submesic, have deeper soils (more than 20 cm [7.9 in.]), have less exposed bedrock, and resemble tall-grass prairies because of their higher perennial prairie grass cover (more than 50 percent). Limestone cedar glades have less than 50 percent perennial grass cover and are classified as xeric, with soil depth of 0 to 5 cm (0 to 2 in.), or submesic, with soil depth 5 to 20 cm (2 to 7.9 in.) or more (Quarterman 1989).

In Tennessee, leafy prairie-clover occurs in limestone barrens and subxeric limestone cedar glades, consistently along the edges or directly upslope of dry washes with *Andropogon scoparius*, *A. virginicus*, *Bromus commutatus*, *Sporobolus clandestinus*, *S. vaginiflorus*, *Eleocharis compressa*, *Carex* spp. (including *C. meadii*) *Juncus* spp., *Scirpus pendulus*, *Allium cernuum*, *Ambrosia artemisiifolia*, *Desmanthus illinoensis*, *Dodecatheon meadia*, *Erigeron strigosus*, *Hypericum sphaerocarpum*, *Isanthus brachiatus*, *Lobelia* spp., *Ruellia humilis*, *Rudbeckia triloba*, *Satureja* sp., *Sisyrinchium albidum*, *Senecio anonymus*, and *Solidago nemoralis*. In more degraded glades and barrens, the species is found with *Cynodon dactylon*, *Festuca* sp., *Poa* spp., *Setaria* spp., *Sorghum halepense*, *Achillea millefolium*, *Croton capitatus*, *Daucus carota*, *Melilotus alba*, and *Lespedeza cuneata*.

In northern Alabama, *Dalea foliosa* occurs in limestone barrens in pockets of lower or higher relief relative to the adjacent drier or wetter flat areas, respectively (see Figure 2). Associates include *Andropogon scoparius*, *Bouteloua curtipendula*, *Sorghastrum nutans*, *Apocynum cannabinum*, *Asclepias verticillata*, *Blephilia ciliata*, *Cassia marilandica*, *Ceanothus americanus*, *Euphorbia corollata*, *Hypericum sphaerocarpum*, *Liatris aspera*, *Lithospermum canescens*, *Lobelia spicata*, *Sisyrinchium albidum*, and *Solidago nemoralis*.

Fire likely played an important historical role in the maintenance of limestone cedar glades and barrens. Presettlement fires, ignited primarily by native Americans, were prevalent across nearly every landscape in North America (Pyne 1982, Ladd 1991). The floristic similarities of the glades and barrens to the fire-maintained tall-grass prairies, including dominance by the same grass species, suggest some influence of fire in community structure and maintenance. In one Missouri limestone cedar glade, presettlement (1630 to 1870) fire frequency was estimated at approximately once every 3.2 years from historic fire scar data, and this was enough to prevent red cedars from becoming established (Guyette and McGinnes 1982). After 1870, active fire suppression by settlers, reduced fuel loads, soil erosion from heavy grazing, and fragmentation by roads decreased fire frequency to approximately once every 22 years and resulted in red cedar invasion of open glades (Guyette and McGinnes 1982). Many of the limestone barrens and subxeric limestone cedar glades occupied by *Dalea foliosa* are also succeeding to forested cedar glades (*sensu* Baskin and Baskin 1973), undoubtedly due to post-settlement fire suppression. With two exceptions, none of the leafy prairie-clover sites in Tennessee and Alabama are being managed for the control of woody plant succession.

2. *Illinois*

Former and extant *Dalea foliosa* sites in Kane and Will Counties occur in the Morainal Section of the Northeastern Morainal Division (Schwegman 1973). This section is characterized by prominent glacial features such as kettles, kames, eskers, lake plain

deposits, outwash plains, and moraines. Historic sites in LaSalle and Kankakee Counties occur in the Grand Prairie Division, a relatively flat and poorly drained glacial till plain in which the black prairie soils developed. Glacial features in each natural division belong to the Woodfordian Substage (which occurred between 12,500 to 22,000 years ago) of the Wisconsin Stage, the most recent glaciation (Willman 1971). In both natural divisions, *Dalea foliosa* was restricted to river valley floors, in which Silurian dolomite was exposed by glacial meltwaters, or to sand and gravel river terraces (Mackinaw member of the Henry Formation) that were formed by the repeated deposition and erosion episodes of glacial rivers or outlets of glacial lakes (Willman 1971). The species occurs in neutral to alkaline silt loam soils formed in loamy alluvium or drift, including Romeo silt loam and soils of the Faxon-Ripon complex (Wascher *et al.* 1962, U.S. Department of Agriculture 1979).

Extant leafy prairie-clover populations occur exclusively in dolomite prairie. These prairies have less than 1.5 m (4.9 feet) of soil but typically are less than 0.3 m (1 foot) deep, have a high pH, and range from dry to wet (White 1978). Natural plant communities are recognized by their dominant and indicator plant species along the soil moisture gradient (see Figure 2). *Dalea foliosa* is found in mesic to wet-mesic dolomite prairie with *Andropogon gerardii, A. scoparius, Sorghastrum nutans, Sporobolus heterolepis, Carex crawei, C. meadii, Eleocharis compressa, Juncus dudleyi, Allium cernuum, Apocynum* spp., *Hypericum sphaerocarpum, Phlox glaberrima* ssp. *interior, Pycnanthemum virginianum, Rudbeckia hirta, Satureja arkansana, Senecio pauperculus, Sisyrinchium albidum,* and *Solidago riddellii* (DeMauro 1986). In more degraded areas, the species is also found with *Achillea millefolium, Asclepias verticillata, Aster ericoides, Daucus carota, Helianthus grosseserratus, Melilotus alba, Pastinaca sativa, Poa compressa,* and *Solidago altissima* (DeMauro 1986).

D. Life History and Ecology

Dalea foliosa is a short-lived herbaceous perennial that has no capacity for vegetative spread (Baskin and Baskin 1973; Schwegman and Glass, unpublished data). In March, new ramets (stems) begin to grow from buds on the root crown just below the soil surface. By July, these ramets are 40 to 65 cm (15.7 to 25.6 in.) tall (Baskin and Baskin 1973). Nonflowering plants have from 1 to 4 ramets, and flowering plants have from 1 to 20 ramets. A single ramet will develop one or more inflorescence buds in late June.

Flowering begins in late July, peaks in mid-August, and can continue until late August. First-year plants in greenhouse cultivation may flower, but plants may take up to 3 years to flower under field conditions (Baskin and Baskin 1989). Mature plants may have from 1 to 10 (or more) flowering ramets. In 1992, the average number of flowering ramets per plant varied between 0.58 to nearly 3 in extant *Dalea foliosa* populations throughout the species' range, and Illinois populations had the lowest mean values. The number of flowers per

inflorescence varies from 40 to 495 (mean of 158.95 $\pm$ 97.04 sd) (DeMauro and Riddle, unpublished data).

Flowers are hermaphroditic and protandrous (Wemple 1970). Bumblebees, small bees, and syrphid flies have been observed visiting flowers (Schwegman and Glass, unpublished data; Baskin and Baskin 1973). Although the species' breeding system is unknown, insect pollination, probably by *Bombus* spp. (bumblebee species), is required for successful seed set in other species in the genus (Wemple 1970). Wemple (1970) also observed male sterile plants and parthenogenic seed formation induced by sterile "foreign" pollen. During one normal growing season (1990), the percent seed set in Illinois populations was greater than 70 percent. The number of viable seeds per head ranged between 5 and 429, averaged 141.81 $\pm$ 88.08 sd, and was highly correlated (r=0.986, n=76) to inflorescence length (DeMauro and Riddle, unpublished data).

Dalea foliosa seeds ripen by early October and disperse from the erect dead ramets from late fall to early spring (Baskin and Baskin 1973). Potential dispersal vectors include wind, gravity, birds, and small mammals. Dormant seeds are capable of forming a persistent seed bank. Under natural conditions, several years are required to soften the hard seed coat, although mechanical scarification yields high germination rates in fresh seeds (Baskin and Baskin 1973, 1989). Seeds from Illinois populations, however, readily germinate without scarification (R. Betz, Northeastern Illinois University, personal communication, 1992). Germination occurs in April and by late May the seedlings have several leaves (Baskin and Baskin 1973). Adequate soil moisture is critical for seedling establishment. Bacterial nodules form on the roots (Baskin and Baskin 1989).

Seedlings are killed by summer drought and frost heave and very few survive to maturity (Baskin and Baskin 1973; Schwegman and Glass, unpublished data). In one demographic plot at the Romeoville site, 174 plants were monitored from their appearance as seedlings to their death between 1986 and 1992. Most of these died within their first year, and only 4.6 percent survived for 5 years (see Table 3). The oldest living plants monitored to date have reached 8 years (n=2) and 7 years (n=2) of age (Schwegman and Glass, unpublished data). Dormancy has been observed in six mature plants, two of which were apparently dormant for 2 consecutive years. Mature plants may not flower every year and may show decreased vegetative growth following a year of exceptionally vigorous growth.

The direct effects of prescribed burning on *Dalea foliosa* have not been documented experimentally. There are, however, general observations based on monitoring projects that are being conducted on actively burned sites in Illinois. Fire benefits *Dalea foliosa* habitat by maintaining open patches for the establishment of new plants and by controlling woody plant succession. Spring fires appear to stimulate germination and establishment, possibly by the removal of accumulated duff and subsequent creation of more openings in which buried seeds can germinate and survive. Fall fires may increase frost heaving and indirectly affect mortality. At Lockport Prairie, overall population size has increased under both spring and

Table 3. Longevity of *Dalea foliosa* plants monitored between 1986 and 1992 at Romeoville, Will County, Illinois[a].

Number of Plants Monitored	Number of Years Alive
113	1
32	2
10	3
11	4
8	5

[a]Schwegman and Glass, Illinois Department of Conservation, unpublished data.

fall prescribed burning regimes. A study is currently underway by Roach *et al.* (1991) that examines the role of fire in limestone cedar glades and barrens and its effects on endemic taxa at six sites in Tennessee and Kentucky.

E. Population Structure and Dynamics

Dalea foliosa occurs in small to large isolated populations that range across a disturbed and patchy habitat. The population characteristics can be analyzed spatially and temporally with respect to: (1) differences in structure within and among populations and (2) demographic variability within and among populations over a period of time. Interrelationships between these different population characteristics and how different population sizes affect structure, dynamics, and persistence over time were determined.

1. Population Structure

Dalea foliosa populations were censused throughout the species' range in 1992 to characterize and compare population structure (see Table 2). Plants were classified by arbitrary reproductive class/growth stages: Flowering plants, nonflowering plants (plants greater than 10 cm [3.9 in.] tall), and seedlings (defined as single ramet plants less than 10 cm [3.9 in.] tall). Mature plant sizes were quantified by the number of ramets per plant in each class. Population sizes were arbitrarily partitioned into the following categories: Small (less than 100 plants), moderate (greater than 100 but less than 500 plants), and large (more than 500 plants).

The large *Dalea foliosa* population at Lockport Prairie comprises subpopulations that occupy numerous and discrete habitat patches within a mosaic of unsuitable habitat. The size of and distance between habitat patches vary, and increasingly greater distances probably impose a greater impediment to seed dispersal than to pollen transfer. To assess small-scale differences between subpopulations at Lockport Prairie, plants were monitored at the individual patch level (DeMauro, Bowles, and Flakne, unpublished data). Population frequency, density, and structure were monitored within three patch size classes. These class sizes were determined by the number of flowering plants--small (less than or equal to 25), medium (greater than 25 but less than, or equal to, 100), and large (greater than 100).

2. Structural Differences between Populations

In moderate and large populations, flowering plants ranged from 11.6 to nearly 53 percent of all plants, nonflowering plants ranged from 34.5 to 43.7 percent, and seedlings ranged from 3.4 to nearly 53 percent (see Table 2). Small populations are more variable in structure, have fewer seedlings, and are represented either by a few persistent mature or nonflowering plants or entirely by immature plants. Plant size was compared for a range of population sizes in Tennessee and Alabama (see Table 2). The largest population had a

greater number of smaller plants (see Figure 3), whereas smaller populations had more homogeneous distributions across size classes and were generally truncated at five ramets or less.

3. *Structural Differences within Populations*

Large- and moderate-sized subpopulations (patches) at Lockport Prairie Nature Preserve appeared to have greater proportions of seedlings and higher plant densities (see Table 4). The large variation around mean densities reflects the aggregated distribution of plants. Although the number of flowering plants within patches has remained consistent over time, the proportions of plants in different reproductive stages have varied due to high seedling mortality and recruitment. Seedling recruitment is lowest in the small patch, and the appearance of nonflowering plants in 1992 may represent dormant individuals. For example, in 1991 (a drought year) the density and number of nonflowering plants and seedlings declined in moderate- and small-sized patches and then rebounded in 1992 (see Table 4). No predrought data are available for the large patch, which are compared to earlier (1983) census data.

Plant size distributions at Lockport Prairie (see Figure 4) are similar to those for isolated populations at a larger geographic scale (see Figure 3). In general, larger populations across the species' range and larger subpopulations at Lockport Prairie had similarly greater proportions of plants in the smaller size classes due to higher recruitment. At Lockport, small- and moderate-sized patches had less recruitment. These differences may relate to more optimal habitat conditions and larger seed banks in larger populations.

4. *Within Population Dynamics and Subpopulation Fluctuations*

Differences in subpopulations were compared over a period of time at Lockport Prairie, Romeoville, and Keepataw Forest Preserve. Initially, all subpopulations (patches) were located and mapped in 1983 (1979 at Keepataw). Since 1990, surveys have been conducted at each preserve to relocate patches, search all suitable but previously unoccupied habitat patches, and census all flowering plants within patches (DeMauro, Mauger, and Riddle, unpublished data). Subpopulation patches were defined as follows: (1) new, if they represented new discoveries or colonizations; (2) lost, if plants could not be relocated; and (3) a reappearance, if formerly lost patches were relocated in the same habitat patch. New patches were distinguished from reappearances on the assumption that if a seed bank were present, seedlings or previously dormant individuals would likely be found, especially in a moderate growing season. As patches are monitored over longer periods of time, these two processes will be easier to distinguish.

Patch number has declined at the Romeoville site but has remained the same at Keepataw (see Table 5). At Lockport, the total number of patches has increased slightly, but only 69 to 78 percent of all patches have persisted from year to year. The other patches result

Figure 3. 1992 Plant Size Distribution
from Different D. foliosa Populations

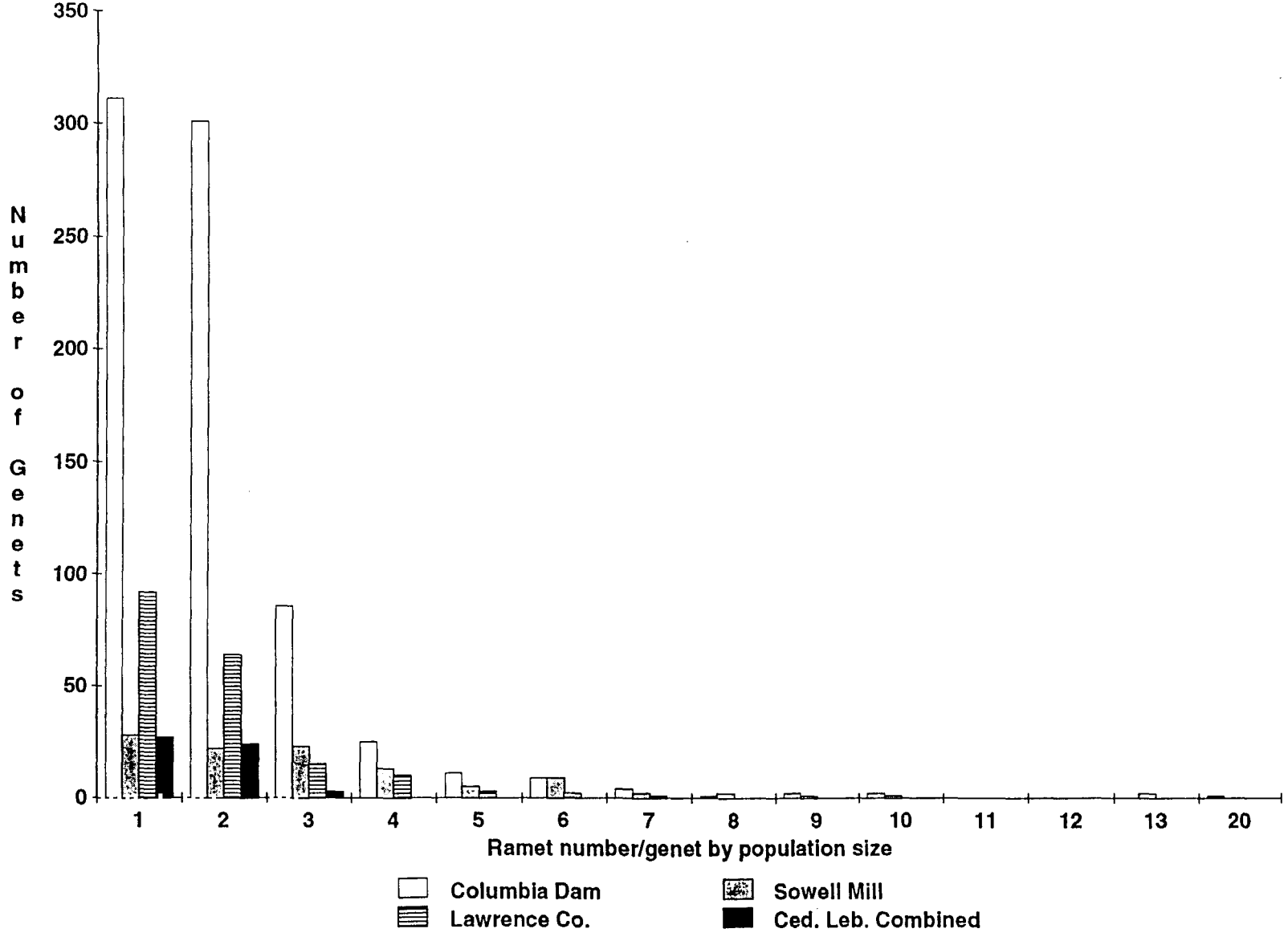


Table 4. Population structure, distribution, and density in different size patches of *Dalea foliosa* at Lockport Prairie Nature Preserve.

Year	Occurrence by No. of Plots[a]	No. and (%) of Plants by Growth Stage[b] Adult	NF Plant	Sdlg.	Total	Density[c]
Quadrat #2 - Large Patch						
1983	20	115 (74%)	40 (26%)	?	155+?	19.42±20.00
1991	38	151 (47%)	146 (45%)	25 (8%)	322	8.47±10.25
1992	39	140 (18%)	219 (29%)	40 (53%)	760	19.46±21.00
Quadrat #8 - Moderate Patch						
1990	26	33 (11%)	182 (61%)	85 (28%)	300	11.54±14.15
1991	14	38 (65%)	19 (33%)	1 (2%)	58	4.14±3.394
1992	25	42 (5%)	484 (64%)	233 (31%)	759	30.36±42.33
Quadrat #4 - Small Patch						
1990	13	12 (17%)	50 (70%)	9 (13%)	71	5.46±5.724
1991	5	15 (58%)	9 (34%)	2 (8%)	26	5.20±4.439
1992	9	11 (21%)	38 (72%)	4 (7%)	53	6.00±6.500

[a]The number of 1 m^2 quadrats in which plants occurred.
[b]Adult = flowering plant, NF = nonflowering plant, Sdlg. = seedling.
[c]Mean number of plants ± sd per 1 m^2.

Figure 4. 1992 Plant Size Distribution
of D. foliosa at Lockport Prairie N.P.

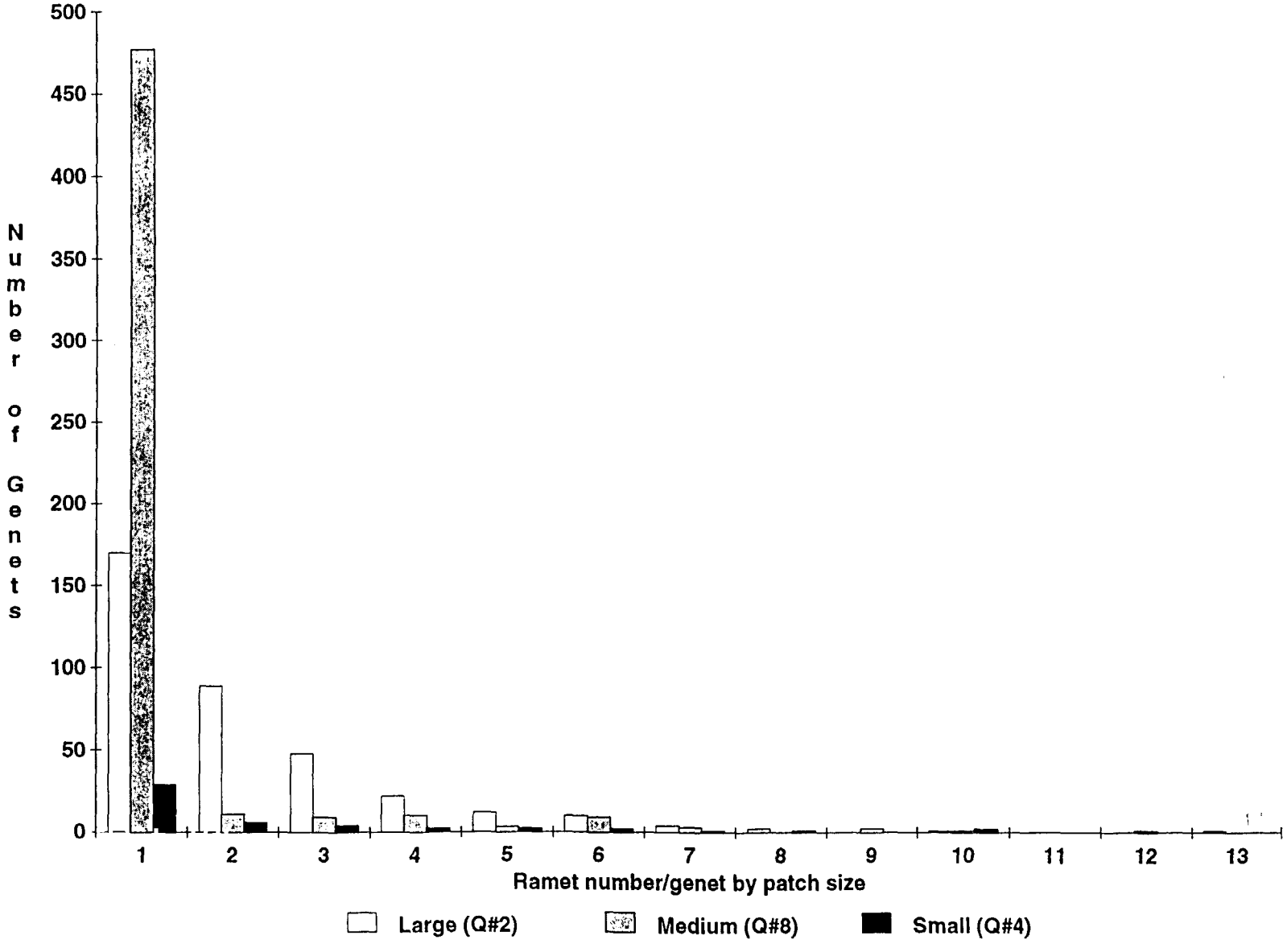


Table 5. Patch dynamics in Will County populations of *Dalea foliosa*[a].

SITE/DESCRIPTION	YEAR				
	1979	1983	1990	1991	1992
Lockport Prairie Nature Preserve:					
New Patches	---	---	8	13	6
Lost Patches	---	---	7	4	12
Reappeared	---	---	0	1	5
TOTAL PATCHES	**---**	**28**	**29**	**39**	**38**
Romeoville Prairie:					
New Patches	---	---	1	0	0
Lost Patches	---	---	0	0	2
Reappeared	---	---	0	0	0
TOTAL PATCHES	**---**	**6**	**7**	**7**	**5**
Keepataw Forest Preserve:					
New Patches	---	---	0	0	0
Lost Patches	---	---	0	1	0
Reappeared	---	---	0	0	1
TOTAL PATCHES	**1**	**1**	**1**	**0**	**1**

[a]See text for descriptions.

from the balance of patch extinctions, colonizations, or reappearances in any given year. New or lost patches are generally very small (25 plants or less).

5. *Summary of Demographic Considerations*

In general, factors affecting the persistence of *Dalea foliosa* must be examined at two scales. On a landscape basis, populations occur very locally in areas of optimum habitat. Within populations, plants are distributed in optimum microhabitats within a mosaic of unsuitable habitat. Subpopulation distribution, density, and structure vary spatially in relation to microhabitat conditions. Population or subpopulation numbers fluctuate over time, depending on their size, isolation, environmental conditions, and buffering by seed banks. Populations in small or suboptimal patches have fewer seedlings and reproductive plants, and may have smaller seed banks. In these habitats, extinction probabilities are likely high due to the plant's short life span and dependence on seed production for population persistence, limited recruitment, and exhaustion of seed banks.

Optimum conditions for population persistence may occur when numerous subpopulations are present within a habitat mosaic such as at Lockport Prairie. Under a metapopulation model (*sensu* Hanski and Gilpin 1992), if these subpopulations are interconnected but persist independently of landscape disturbance processes, then total population extinction will be low at any given time. Interconnection of subpopulations can occur by pollen flow, seed banks, and seed dispersal, and when these events exceed extinction rates, metapopulation viability is maintained.

F. Genetic Considerations

During 1992, leaf samples of leafy prairie-clover were collected throughout the species' range in order to estimate the levels of genetic variation within and among populations (B. Wiltshire and D. Nickrent, in progress). Preliminary electrophoretic data (number of alleles per locus) indicate that genetic diversity in the species is relatively low. Nearly all of the observed genetic variation (polymorphism) occurs among the Tennessee populations, whereas populations in Alabama and Illinois are monomorphic at virtually the same loci (B. Wiltshire, Southern Illinois University, personal communication, 1992).

G. Reasons for Listing

Since it was first observed nearly 138 years ago, known leafy prairie-clover occurrences have declined by 45 percent due to habitat destruction, overgrazing, and habitat loss from encroachment by woody species (see Table 6). Of the 29 extant populations, many are very small, containing less than 25 primarily immature and nonflowering plants. Given the intensity of searches in all States, there is little likelihood that significant additional populations will be discovered. Only two sites, Lockport Prairie and Burnt Hill Road, are relatively free of threats. Most of the recently known *Dalea foliosa* populations have been

Table 6. Status of historic and extant *Dalea foliosa* populations.

STATE	NO. OF EXTANT VS. HISTORIC COUNTY RECORDS	NO. OF EXTANT VS. HISTORIC POPULATIONS	NO. OF EXTANT AND VIABLE POPULATIONS[b]	NO. OF SITES MANAGED AND PROTECTED
Alabama	2/4	2/4	1/2	0
Illinois	1/4[a]	3/8	2/3	1
Tennessee	7/8	24/34	10/24	2
TOTAL	**10/16**	**29/46**	**13/29**	**3**

[a]Only included counties with specimens.
[b]Includes all moderate and high-viability populations, see Part II, Recovery.

lost to or are currently threatened by road work, right-of-way management, site development, off-road-vehicle (ORV) damage, and competition from woody species invasion (see Table 1).

1. Collecting

Small populations of rare plants may be impacted by inappropriate collecting (Pavlovic *et al.* 1992). Most leafy prairie-clover populations are small and would be threatened by collecting. One historic population at Altorf Island, Illinois, was eliminated by overcollecting (Hill 1879). If a voucher specimen is needed, a photograph should be taken or only the above-ground portion of the plant should be removed.

In Illinois there is a horticultural interest in the species because it is rare and is easily propagated from seed. At least one nursery is known to sell leafy prairie-clover from a cultivated source. Natural populations could be threatened by illegal (unpermitted) or inappropriate seed-collecting if natural seed production is low due to small population size, high rates of herbivory, or drought conditions.

2. Destruction or Alteration of Habitat

At least one population (Morgan County, Alabama) is likely to be extirpated by road maintenance and the installation of new storm sewers. Several additional populations are at some risk due to their proximity to existing roads (Route 99 Glade, Sneed Road Cedar Glade, Jones Mill Road, and Cedars of Lebanon State Forest/Park, Tennessee). Although reportedly bulldozed (Service 1991), there are still plants at the Woodmont Boulevard site in Nashville. Unless these plants are salvaged, the population will undoubtedly be lost to development. The current alignment of the Federal assistance highway project (FAP 340) through Keepataw Forest Preserve is not likely to directly impact the population (Taft 1989). Two populations (Romeoville, Illinois, and Lawrence County, Alabama) occur under active power transmission lines. The habitats are kept open by right-of-way management, but the populations are at risk from cleared brush being piled on the plants, the nonselective use of herbicides during the growing season, and damage caused by large trucks.

Approximately 30 percent of the *Dalea foliosa* plants in Maury, Marshall, and Bedford Counties, Tennessee, will be lost if the Duck River is impounded to the originally proposed 630-foot full-pool elevation (Baskin and Wofford 1990). The actual number of plants adversely affected will be much higher than originally thought, based on the 1992 census counts (see Table 2). Most of the information about direct impacts to the species is known only for the Columbia Dam site in Maury County, Tennessee. Field surveys established this population as occurring between 189.4 and 191.3 m (621 and 627 feet) (Currie 1990), which would completely submerge the population, but Baskin and Wofford (1990) estimated that 50 percent of the plants would be eliminated at the 192.2-m (630-foot) pool level. Based on the 1992 population census, leafy prairie-clover was

found between 187.6 and 193.7 m (615 and 635 feet). The full-pool elevation would eliminate more plants and only marginal leafy prairie-clover habitat would remain because the optimal growth zone of moister, deeper soils would be submerged. The optimal growth zone is critical to long-term persistence because it is a refugium that buffers the population during drought years. Additional indirect effects to the populations may occur, such as alteration of site hydrology by flooding, which could allow aggressive native grasses, herbaceous plants, and woody plants to invade and outcompete leafy prairie-clover.

ORVs cause extensive habitat damage and threaten any population that has available access points. Three sites, Romeoville Prairie and Keepataw Forest Preserve in Illinois and Cedars of Lebanon State Forest/Park in Tennessee, have ongoing ORV problems. No actions have been taken to secure the populations from this threat except for the posting of signs in the State forest.

3. Drought

Severe drought conditions may drastically reduce or entirely eliminate populations without seed banks. Populations that are large (more than 500 plants), have extensive seed banks, and occur in sites with moist (wet-mesic) microhabitats are buffered from extirpation and rebound more rapidly in the year following a drought (see Tables 2, 3, and 4). J. Schwegman (Illinois Department of Conservation [IDC], personal communication, 1993) reports that their research indicates that some plants respond to drought by dormancy. This strategy, in addition to seed banks, may permit the species to survive droughts.

4. Grazing and Herbivores

Leafy prairie-clover does not persist where there is intense grazing (Smith and Wofford 1980), which has eliminated at least one historic occurrence (see Table 1). One population (Lane Farm, Tennessee) appeared after grazing was stopped; however, the plants would again be threatened if grazing were to resume. The eastern cotton-tail rabbit (*Sylvilagus floridanus*) and, to a lesser extent, the white-tailed deer (*Odocoileus virginianus*) selectively feed on flowering ramets and can significantly reduce reproductive success. Over a 3-year monitoring period of three leafy prairie-clover patches at Lockport Prairie, Illinois, the rate of herbivory varied from 17 to 73 percent of all ramets produced by flowering plants (see Figure 5). The rates were consistently higher in flowering ramets (DeMauro and Bowles, unpublished data). Few of the grazed ramets resprout axillary flowering branches. High rates of herbivory were also observed at the Romeoville, Illinois, site, where the proportion of grazed stems and plants has increased over time (see Table 7) (Schwegman and Glass, unpublished data). These impacts may be insignificant at the population level if seedling establishment is density-dependent or if

Figure 5. Fate of Dalea foliosa ramets
at Lockport Prairie N.P. (1990-1992)

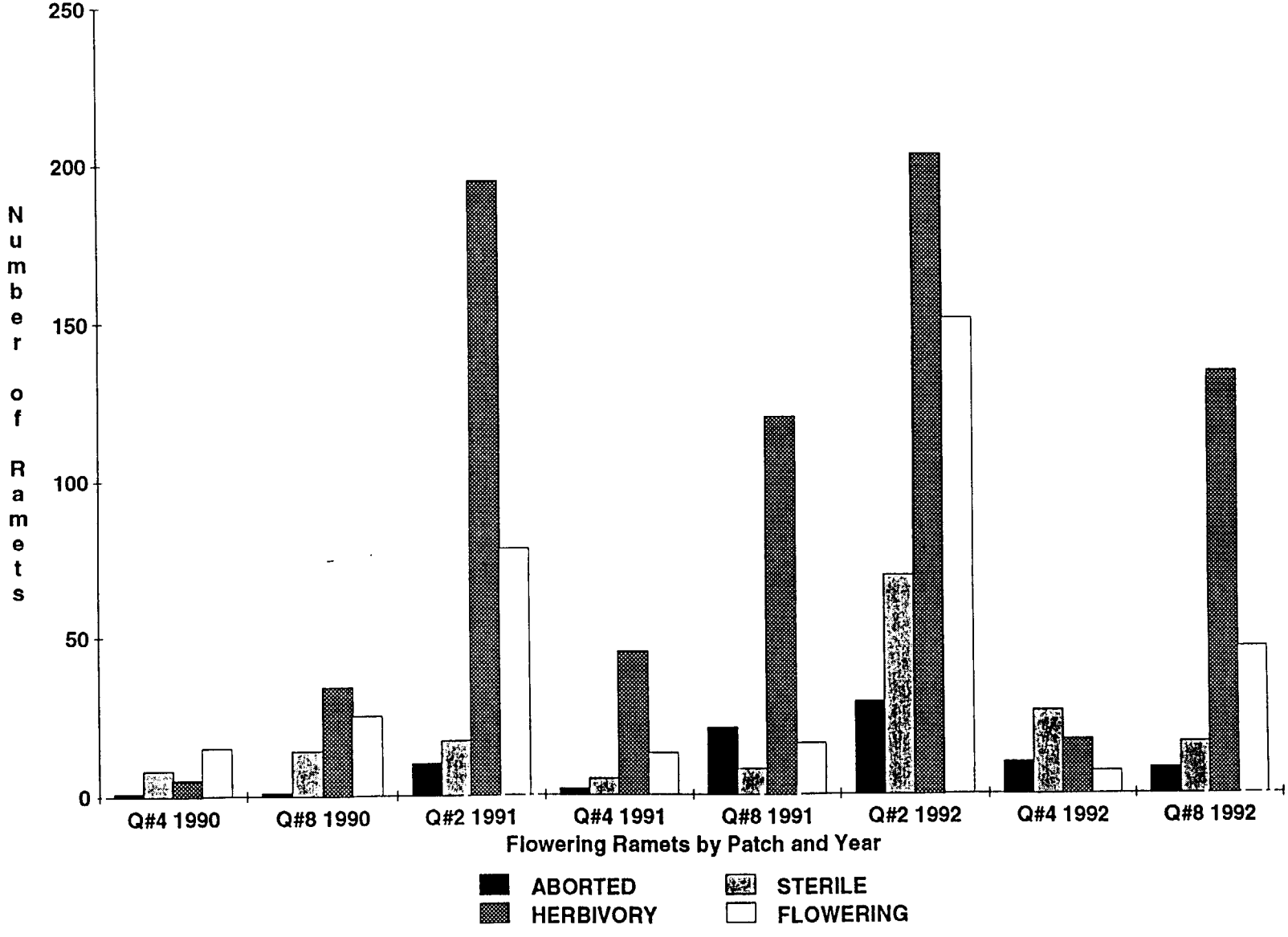


Table 7. Herbivore damage to *Dalea foliosa* ramets and plants at the Romeoville Site, Will County, Illinois[a].

Year	No. Of Plants Monitored	% of Plants Damages	No. Of Ramets Monitored	% of Ramets Damaged
1986	---	0		
1987	25	20	32	56
1988	26	65	193	34
1989	33	81	250	41
1990	28	79	116	50
1991	21	100	143	84
1992	10	100	66	80

[a]Schwegman and Glass, Illinois Department of Conservation, unpublished data.

there is a persistent seed bank. Intense and persistent grazing, however, will reduce annual seed production and seed bank contributions.

5. *Woody and Exotic Plant Species*

The invasion of woody species poses a very serious threat to leafy prairie-clover. The species is intolerant of shade but may persist as a seed bank, although the factors controlling the development and longevity of the seed bank are unknown. For example, new patches of leafy prairie-clover seedlings appeared after brush removal at Lockport Prairie in Illinois and Sneed Road Cedar Glade in Tennessee, two sites containing large extant populations.

In the limestone cedar glades and limestone barrens, the primary invader is eastern red cedar (*Juniperus virginiana*), but other woody invaders include hackberry (*Celtis laevigata*), redbud (*Cercis canadensis*), glade privet (*Forestiera ligustrina*), white ash (*Fraxinus americana*), honey locust (*Gleditsia triacanthos*), tartarian honeysuckle (*Lonicera tatarica*), chinquipin oak (*Quercus muehlenbergii*), aromatic sumac (*Rhus aromatica*), and winged elm (*Ulmus alata*). In dolomite prairie, the primary invader is the aggressive exotic European buckthorn (*Rhamnus cathartica*). Depending on the extent and density of woody growth, these species can be controlled by a combination of cutting, herbicide spraying, and prescribed burning. Aggressive nonwoody species that may threaten leafy prairie-clover are the blue grasses (*Poa compressa* and *P. pratensis*), Bermuda grass, (*Cynodon dactylon*), Johnson grass (*Sorghum halepense*), white sweet clover (*Melilotus alba*), thistles (*Cirsium* spp.), and sericea lespedeza (*Lespedeza cuneata*). Depending on the extent of the infestation, these species can be controlled by successive spring burns, hand-pulling, and herbicide application.

H. Existing Regulatory Mechanisms and Conservation Measures

Leafy prairie-clover is listed as endangered in Tennessee and Illinois. Statutes in each State protect listed plants on public lands; plants on private lands are prohibited from being taken without the permission of the landowner. In Illinois, written permission of the landowner is required. Also in Illinois, selling or offering to sell listed plants or plant parts is prohibited without a permit, and government-funded developments that threaten any listed species require nonbinding consultation with the Illinois Department of Conservation (IDC) in order to minimize negative impacts. Populations in State nature preserves receive protection under the Illinois Nature Preserves Act. The species is not afforded any State protection in Alabama. The Federal Endangered Species Act (Act) provides protection to populations on Federal land and to other populations when the taking is in violation of any State law, including trespass laws. The Act also provides protection from inappropriate interstate commercial trade. Populations in wet-mesic dolomite prairie may receive protection through Section 404 of the Clean Water Act, which requires a permit from the U.S. Army Corps of Engineers for filling or discharging into jurisdictional wetlands.

Of the 21 extant leafy prairie-clover populations, 8 occur on public land (see Table 1). Five of these populations are small and are not currently managed (four in the Cedars of Lebanon State Forest/Park, Tennessee, and one in Keepataw Forest Preserve, Illinois). Two of these populations are on TVA land, where the primary land management objectives may not necessarily benefit listed species or natural areas. Only one of the publicly owned sites, Lockport Prairie, has full legal protection (State nature preserve status) and is managed to maintain natural communities and rare species. Two additional populations, Sneed Road Cedar Glade in Tennessee and Romeoville in Illinois, are privately owned and managed, but the latter has only informal protection (verbal agreement). All other extant populations are privately owned and are not managed.

1. Illinois Restoration Efforts

Several attempts by the IDC to reintroduce leafy prairie-clover to Altorf Island have failed due in part to severe summer drought conditions (Schwegman, IDC, personal communication, 1992) and the reduction of historic "gravelly bank" habitat described by Hill (1879), the result of heavy canary reed grass (*Phalaris arundinacea*) infestation (DeMauro, personal observation). No seedlings have been observed from two seeding attempts, and none of the 105 plants transplanted in 1990 survived. Only one of the five large plants transplanted in October 1991 was observed in August 1992 (Schwegman, personal communication, 1992).

Leafy prairie-clover has been introduced into three prairie restorations. Five seedlings originally planted into wet-mesic prairie in 1985 at the College of DuPage (DuPage County) have survived and reproduced; there are now approximately 20 plants in this area (R. Kirt, College of DuPage, personal communication, 1992). Eight additional transplants (three planted in 1988 and five in 1991) still persist. While this introduced population has educational value, it does not contribute to the species' recovery because plants are not in natural or historically appropriate habitats within the species' geographic range in Illinois. Over time, this population can be expected to decline once the restoration succeeds to a denser grass matrix.

Twelve leafy prairie-clover seedlings were transplanted into degraded and overgrazed mesic to dry-mesic gravel prairie at the Waterfall Glen Forest Preserve (DuPage County), located in the Des Plaines River valley approximately 4.4 kilometers (km) (2.75 miles) upstream from the population at Keepataw Preserve. By September 1992 only two plants remained. Although within the species' range, this site may be too degraded, dry, and small to support a viable population.

In 1990, fifty juvenile leafy prairie-clovers grown from seeds collected from the Lockport Prairie population were planted into re-created gravel and dolomite prairie at the Morton Arboretum in Lisle, Illinois. This prairie creation features endangered and threatened plants in simulated natural habitats and functions both as source material for *in situ*

restorations as well as an educational exhibit. These leafy prairie-clover plants flowered and produced seeds in 1991 and 1992. Seeds collected from these plants will be used in Illinois recovery efforts (see Part II, Recovery).

Approximately 2,500 seeds were collected from Will County populations and were provided to the Holden Arboretum in Mentor, Ohio, for long-term storage as part of the Center for Plant Conservation's cooperative program.

J. Tennessee Restoration Efforts

Seeds and plants have been collected from the Woodmont Boulevard (Nashville, Tennessee) population. The status of plants transplanted into one private garden is unknown, and none of the plants transplanted to Longhunter State Park, Tennessee, survived (Service 1990).

PART II

RECOVERY

A. Recovery Objective and Criteria

The recovery strategy for *Dalea foliosa* includes the enhancement and maintenance of population viability through habitat protection, management, and population restoration. The end goal of this strategy is to recover and ultimately delist the species when (1) population occurrences are increased to levels that approximate the species' former distribution and abundance in each geographic region (to the extent that it is feasible or can be determined with existing information) and (2) the long-term survival of a minimum number of viable populations in each geographic region is reasonably ensured. Key objectives of the strategy are as follows: (1) to prioritize recovery efforts by defining and identifying viable populations and recovery sites, (2) to provide the highest available legal protection for the most critical populations, (3) to enhance existing populations by managing and restoring stability to natural plant communities through prescribed burning and control of exotic and woody species, and (4) to establish new populations into suitable protected habitat within the species' historic range.

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 (described below).

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

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

3. **A minimum of twelve populations ranked as high viability are protected and managed in Tennessee.**

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

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. Because the only detectable genetic variation is conserved between populations in Tennessee (Wiltshire, personal communication, 1992), it is critical to protect as many populations in the Central Basin as is feasible. In short, by conserving the

diverse Tennessee gene pool, the species' evolutionary potential is more likely to be conserved.

The persistence of restored populations for at least 10 consecutive years at high or moderate viability is recommended. This should allow enough time to achieve a stable population size, density, and structure that is within the range of values observed for the same demographic variables in naturally occurring, high-viability populations.

Critical sites are those required to meet the recovery criteria. The remaining populations not covered by the recovery criteria should be prioritized for protection and management based on the current viability ranking and the potential for recovery from a low- to a moderate- or high-viability ranking. The recovery-related criteria for any site, reclassification criteria, and delisting criteria may be revised on the basis of new information, including research specified as recovery tasks. The earliest estimated recovery date is 2005.

Population Viability Index (PVI) - The basic assumption in achieving the recovery criteria is that populations will likely survive because the chances of extinction are lowered to acceptable levels by the recommended recovery actions. A minimum viable population analysis examines genetic, demographic, life history, ecological, and environmental factors to derive a minimum population size that exceeds the probability of extinction over a defined time interval (Menges 1991). The generalization is that small populations are much more likely to become extinct than large ones because they are more vulnerable to stochastic extinction-causing phenomena (Shaffer 1981). This analysis, however, requires data that are unavailable for most rare species, including leafy prairie-clover. As an alternative, this plan uses criteria related to population, habitat, management, and site protection status to derive a PVI based on a model developed by Bowles (in preparation).

For each extant or presumed extant population, the index was calculated by $PVI = (A_i + B_i + C_i + D_i + E_i + F_i)/19$, where A through F represents population size, habitat size and suitability, degree of disturbance, management needs, off-site threats, and protection status, respectively (see Tables 8 and 9). The PVI values range from 0 to 3 and 0 to 4 for criteria B through F and A, respectively. Dividing by 19 gives the relative values between 0 and 1.0. Populations of low, moderate, and high viability have PVI values of ≤ 0.5, >0.5 to ≤ 0.75, and >0.75 to 1.0, respectively. PVI values can be increased by implementing recovery actions that will, depending on the site and population, affect one or more of the PVI criteria thus providing a way that is as objective as possible to achieve and assess the recovery criteria. The PVI criteria are described below.

Population Size - Leafy prairie-clover population sizes are from the most recent census data (see Table 2). Populations were given a PVI value of 0 if plants were not located, but a seed bank or dormant plants may still persist because suitable habitat was intact. Populations with 100 or less total plants or without flowering plants were assigned a value of 1. Moderate (>100 to ≤ 500 plants) and large (>500 to $\leq 1,000$ plants) populations were assigned values

Table 8. Population viability index (PVI) values for all extant *Dalea foliosa* populations.

ST/CO/SITE	POP. SIZE	HAB. SIZE	DIST. LEVEL	MGMT. NEEDS	ADJACENT THREATS	PROT. STATUS	TOT.	PVI
ALABAMA								
Lawrence County	2	1	2	2	3	2	12	.63
Morgan County	1	0	0	1	0	0	2	.11
ILLINOIS								
Will County:								
Keepataw Forest Preserve	1	0	2	2	1	3	9	.47
Lockport Prairie Nature Preserve	4	3	3	2	3	3	18	.95
Romeoville Prairie	2	2*	2	2	2	1	11	.58
TENNESSEE								
Bedford County:								
Burnt Hill Road	4	3	3	2	3	0	15	.79
Davidson County:								
Woodmont Boulevard	1	0	0	0	0	0	1	.05
Mt. View School	1	0	1	1	2	2	7	.37
Couchville Glade**	1	1	2	2	2	2	10	.52
Lake Trail Wet Barren	1	0	1	1	2	0	5	.26
Marshall County:								
Rt. 99 Glade	1	1	1	2	1	0	6	.32
South Berlin Glade	1	1	2	2	1	0	7	.37
Maury County:								
Columbia Glade	4	2	2	2	2	2	14	.74
Sowell Mill Glade	2	2*	2	1	2	0	9	.47
TVA Sowell Mill North	1	1	2	1	2	2	9	.47
Sowell Creek	2	2	2	2	1	0	9	.47
Rutherford County:								
Jones Mill Road	2	3	2	2	2	0	11	.58
Manus Road #4	2	1	1	1	1	1	7	.37
Hall Farm	2	2	2	1	1	0	8	.42
Adams #3	2	1	3	3	1	0	10	.53
Overbridge	1	1	1	0	3	3	9	.47

Table 8 (continued)

ST/CO/SITE	POP. SIZE	HAB. SIZE	DIST. LEVEL	MGMT. NEEDS	ADJACENT THREATS	PROT. STATUS	TOT.	PVI
Tennessee (continued)								
Williamson County:								
Sneed Road Cedar Glade	3	2	1	1	2	2	1	.58
Wilson County (EOR #):								
Cedars of Lebanon SF (18)	1	0	2	2	2	2	9	.47
Cedars of Lebanon SF (24)	1	2	2	2	3	2	12	.63
Cedars of Lebanon SF (30)	1	2	3	3	2	2	13	.68
Cedars of Lebanon SF (33)	2	1	2	1	3	3	12	.63
Cedars of Lebanon SP (19)	1	2	2	2	2	2	11	.58
Cedars of Lebanon SP (25)	1	0	1	0	1	2	5	.26
Lane Farm	1	2	1	1	1	1	7	.37

*Site may be lacking wet-mesic component of habitat.
**Included because habitat is still intact.

Summary of Population Viability Indices by State

POPULATION VIABILITY INDEX	STATE			TOTAL
	AL	IL	TN	
High: ≥0.75 to 1.0	0	1	1	2
Moderate: <0.75 to ≥0.50	1	1	9	11
Low: <0.50	1	1	14	16
TOTAL	**2**	**3**	**24**	**29**

Table 9. Description of the population viability index (PVI) criteria and numerical values[a].

CRITERIA DESCRIPTION	PVI VALUES				
	0	1	2	3	4
A. Population Size	Seed bank or dormant plants only	Small (≤100 plants or no flowering plants)	Moderate (>100 to ≤500 plants)	Large (>500 to ≤1,000 plants)	Very large (>1,000 plants)
B. Habitat Size	Very small (≤ ha)	Small (>1 ha to ≤5 ha)	Moderate (>5 ha to ≤20 ha)	Large (>20 ha)	
C. Degree of Disturbance and Succession	Very high (heavy/early succession)	High (high/early succession)	Moderate (moderate/ midsuccession	Low (low/ stable and late succession	
D. Management Needs	High	Moderate	Low	Community maintenance	
E. Off-site Threats	High	Moderate	Low	None	
F. Protection Status	Private; none	Private, with informal agreement	Public; not-for-profit or private conservation easement or landmark	Public or private; State nature preserve	

[a]For each extant population, PVI = $(A_i + B_i + C_i + D_i + E_i + F_i)/19$, where "A" through "F" are the PVI criteria and "i" is the assigned value. Values range from 0 to 4 for A and from 0 to 3 for B through F.

of 2 and 3, respectively, while very large populations (>1,000 plants) were given the highest value of 4. These population size classes are based on the observed extinctions (i.e., the minimum patch size) at Lockport Prairie as well as the recommended ranges for minimum viable population sizes that are likely buffered from stochastic extinction-causing events and processes (Menges 1991, Lande and Barrowclough 1987, Shaffer 1981).

Habitat Size - Sites were evaluated by the presence and approximate amount of suitable habitat patches (as previously described), not on site size, although a large site typically has more suitable habitat than a small site. Included in the evaluation was the occurrence of specific microhabitat components (see Figure 2) and unless otherwise indicated, are assumed to be present. Although the size classes are somewhat arbitrary, the assumption is that as habitat size increases, the population viability also increases because the site can support more *Dalea foliosa* plants and include a wider range of microhabitats (especially the wet-mesic soil moisture component). This assumption is supported by the observed site, habitat, and population sizes; the smallest leafy prairie-clover populations typically occur in sites that are less than 1 hectare (2.2 acres).

Degree of Disturbance - The degree of disturbance was assessed by the successional stage and natural quality of the plant community (*sensu* White 1978). The underlying assumption is that stable native plant communities have characteristic dominant and indicator, or conservative, plant species. Under different disturbances of varying intensities, community structure is altered, indicator species are lost, and disturbance-tolerant native and exotic species increase. Vegetative changes can also occur in relatively undisturbed sites in which the ecological processes that historically maintained the natural community are lost; e.g., woody succession due to fire suppression or exotic plant species that become established.

The PVI values for disturbance range from severe (=0, the near or complete loss of the natural community) to low (=3, a stable, diverse natural community). The largest leafy prairie-clover populations are found in the least disturbed sites, but plants can survive in disturbed early- to midsuccessional sites, such as along roadsides and power lines or in partial shade. Populations on the latter sites have a lower viability because the threats from disturbance and woody succession still persist and the early- to midsuccessional stages are transitory.

Management Needs - The degree of human disturbance and the successional stage of a plant community are usually related to the site's management needs. Specific community management problems may include woody succession, exotic species invasion, hydrologic changes, grazing impacts, and long-term fire suppression. Specific population management needs may include enhancing population size, monitoring existing populations, and assessing new habitat patches for population recovery. Leafy prairie-clover populations on late successional, relatively undisturbed sites that require only routine maintenance or some control of woody or exotic species are assigned a higher PVI values (3 and 2, respectively). The level of management increases as the extent and severity of the threats increase, with a concomitant decline in the PVI value.

Off-site Threats - Leafy prairie-clover populations are also threatened by activities originating off the site, such as ORV use, grazing, dumping, road or power line maintenance, development, and drainage alterations. Sites that are highly threatened by adjacent land uses or are vulnerable because of a historical use (e.g., illegal dumping or ORVs) have a low PVI value (=0). As the buffer between

the site and the threat increases and the severity and likelihood of occurrence decreases, the PVI value increases.

Protection Status - Protection status was determined by evaluating the ownership and the degree of legally binding deed restrictions. Public or private lands dedicated under a State nature preserve act have the highest legal protection at the State level and are given the highest PVI value (=3). Although land in public ownership is formally protected, the responsible agency may have primary management goals that do not include preservation (PVI=2). Private land may have formal protection under a legal conservation easement (PVI=2) or informal protection through a volunteer registry program or a renewable lease/management agreement in which the long-term land use remains at the owner's discretion (PVI=1).

B. Narrative Outline

1. **Identify and prioritize protection, management, and restoration needs for all high- and moderate-viability populations (and low-viability populations with recovery potential) for each geographic region in order to achieve the recovery criteria.** Of the 21 known or presumed extant leafy prairie-clover populations only 2 (10 percent) rank as high viability, 7 (33 percent) rank as moderate viability, and 12 (57 percent) rank as low viability (see Table 9). To meet the recovery criteria established in this plan, recovery activities need to be implemented for at least 18 (86 percent) populations. This includes all nine populations of high and moderate viability, at least five populations of low viability with recovery potential, and an estimated four new populations. One or more recovery actions can increase a population from a low or moderate viability to a high viability. Key management needs or threats are identified for all critical sites by geographic region below and are summarized in Table 10. More detailed site recommendations are also provided.

   1.1 **Identify and prioritize protection, management, and restoration needs for the Tennessee populations.** Of the 24 extant populations, 12 (50 percent) must be protected and managed to meet the recovery criteria. Most critical are all nine populations of high viability and moderate viability. The balance of sites needed to satisfy the recovery criteria include the recovery of low-viability populations to either high or moderate viability and the establishment of new populations.

   Only the Burnt Hill Road site (Bedford County) ranks as high viability due to its large population and habitat size and lack of disturbance. A preserve design that identifies key tracts and adequate buffer and provides the highest legal protection has been developed by The Nature Conservancy in Tennessee. A management plan must be developed that includes brush control and prescribed burning. This population may be affected by the Columbia Dam project at the proposed full-pool elevation (Baskin and Wofford 1990); thus, any potential impacts should be evaluated (see below).

   The Columbia Dam site (Maury County) is of high priority for protection. The site harbors the second largest leafy prairie-clover population in the State and ranks as moderate viability due to the degree of past disturbance and woody encroachment and the pending threat of the Columbia Dam project. Half of the population would be lost if the full-pool elevation of Columbia Dam is implemented (Baskin and Wofford 1990). Lower alternative pool levels are being evaluated by TVA to avoid adverse impacts to federally endangered mussels in the project impact area (Service 1991) and should also be considered to avoid or reduce adverse impacts to leafy prairie-clover. The area occupied by leafy prairie-clover must be accurately surveyed to determine the exact elevations of the species. Accurate soil depths should be determined to ascertain the full extent of any remaining unoccupied but suitable leafy prairie-clover habitat. A site management plan must be developed to increase this population to high viability. Management should include brush control, prescribed burning, restoration of glade and barrens communities, and population enhancement in unoccupied habitat, including the glade complex to the east of old Highway 50.

   Sneed Road Cedar Glade (Williamson County) is the third largest population in the State and ranks as moderate viability due to the habitat's early- to midsuccessional stages, woody and

Table 10. Potential recovery sites for *Dalea foliosa* in Illinois[a].

COUNTY	WATERSHED	SITE NAME	SIZE[b]	COMMENTS
DuPage	Des Plaines River	Waterfall Glen Forest Preserve	20	Degraded dolomite prairie; under management. Previous restoration in marginal habitat. HIGH PRIORITY.
Kane	Upper Fox River	Fabyan Forest Preserve	<2	Small but extensive management is underway. MODERATE PRIORITY.
	Upper Fox River	River Bend Forest Preserve	8	Site has no natural communities and requires extensive management; need survey of soil conditions. LOW PRIORITY.
Kankakee	Kankakee River	Kankakee River State Park	?	Altorf (=Langham) Island. Several restoration attempts have failed. Gravel bars that once supported *D. foliosa* now support *Phalaris arundinacea*. Extensive management required. LOW PRIORITY.
	Kankakee River	Kankakee River State Park	<2	Very small dolomite prairie remnant downstream of Altorf Island, destroyed by flooding from a beaver dam. Community restoration is required. SITE CURRENTLY NOT SUITABLE.
LaSalle	Lower Fox River	Naplate Prairie	12	Habitat very degraded. Under development threat. LOW PRIORITY.
	Lower Fox River	Covel Creek Prairie	2	Highly disturbed by past grazing; would need protection and extensive management. LOW PRIORITY.
Will	Des Plaines River	Lockport Prairie Nature Preserve	10	High-quality natural area. Requires protection and some management. HIGH PRIORITY.
	Kankakee River	Des Plaines River Conservation Area	2	High-quality natural area but small; may not have enough wet-mesic habitat. MODERATE PRIORITY.
	Des Plaines River	Des Plaines River Conservation Area	10	Degraded habitat patches in a matrix of dry-mesic dolomite prairie. Requires management; removal of crown vetch. MODERATE PRIORITY.

[a]From Bowles and Jones (1992) and DeMauro (unpublished data). All sites are in public ownership except the LaSalle County tracts; title conveyance for Lockport Prairie East is pending.
[b]Estimate (in hectares) of suitable habitat, not site size.

exotic species encroachment, and site size. The population core occurs in highly disturbed habitat adjacent to the road right-of-way. There is an informal protection agreement between the highway department and the owner (TNC), but this should be formalized by a conservation easement. If there is adjacent suitable habitat, consideration should be given to increasing the size of the preserve. TNC has initiated brush control and a monitoring program to assess changes in the community (Carter 1983). The brush control needs to be continued and expanded westward to the intermittent drainage and should include herbicide applications to prevent stump sprouting in deciduous hardwood species. Management should also include removal of exotic plants in the population core, community restoration, and prescribed burning.

The Jones Mill Road population (Rutherford County) was ranked as moderate viability due primarily to protection status but also due to population size, management needs and adjacent threats. This population has a high recovery potential because of a large amount of prime habitat (seasonal washes) north and south of Jones Mill Road between Longhunter State Park and Weakly Road. A preserve design is needed that identifies key tracts and adequate buffer, links to the State park, and provides the highest level of legal protection. A management plan should be developed that would include cleanup and control of illegal dumping, brush control near the existing population, prescribed burning, and population enhancement.

The Hall Farm site was known as a significant limestone glade, but the leafy prairie-clover was just discovered there in 1994 as part of the survey for new populations. It is ranked as low, principally due to the lack of any management agreement or landowner contact. The population has potential to be elevated to moderate or high viability if pasture grasses can be suppressed and habitat management can be consistently applied. It will become a high-priority site for regional conservation attention by the Tennessee Natural Heritage Program and TNC.

The Cedars of Lebanon State Forest/Park (Wilson County) harbors six extant populations. Four are ranked as moderate viability (EORs 19, 24, 30, and 33) and two as low viability (EORs 18 and 25) due to very small population sizes, occurrence in midsuccessional habitats that are threatened with loss from brush encroachment, and potential damage from ORVs. The EORs with the greatest recovery potential to high viability are 18, 19, 24, 30, and 33; EORs 18 and 19 require immediate brush control. A management plan which gives the highest priority to increasing population size through management and population restoration must be developed. The plan should include brush control, prescribed burning, a survey of other areas in the Cedars of Lebanon State Forest/Park to identify additional leafy prairie-clover habitat for population restoration, and control of all illegal ORV access points. Prescribed burning has been initiated at EOR 24 by TNC (Roach, personal communication, 1992). EOR 25 should be located and any remaining plants should be salvaged for

propagation (seeds) or transplanted into one of the other EOR locations. EOR 30 is apparently stable and secure if ORV traffic is excluded. EOR 33 is the subject of a monitoring study with controlled burning initiated in 1994.

Sowell Mill Road (Maury County) has the potential to be restored to high viability. A preserve design is needed that identifies key tracts and adequate buffer and provides the highest level of legal protection. A management plan should be developed that includes brush control and prescribed burning. Sowell Mill Road has a small, unprotected population in disturbed habitat that is threatened by woody succession. A preserve design has been completed by TNC, and the TDEC is considering measures for legal protection. A management plan is needed and should include brush control, prescribed burning, and natural community restoration to facilitate the enhancement of the leafy prairie-clover population. TVA Sowell Mill North is on public land; measures are needed to retard woody succession (i.e., controlled burning), and a preserve design is needed (in consultation with TVA). Plants have also been discovered on private land on the west side of the interstate highway from TVA Sowell Mill North; this is called "Sowell Creek." This site is ranked as low viability (0.47) but if landowner contact is successful this could be elevated to moderate viability. Its fate depends, in part, on whether the Columbia Dam is completed. A complete preserve design would include all three Sowell Mill vicinity sites.

Two low-viability populations, Mount View School (Davidson County) and Route 99 Glade (Marshall County), have limited recovery potential. Both highly disturbed sites have very small populations and a limited amount of habitat and are threatened by woody succession. Efforts should be made to protect and manage the sites through landowner contacts and conservation easements or to salvage the plants if development is imminent. The plants remaining at the Woodmont Boulevard site (Davidson County) were salvaged during 1993 and relocated to Cheekwood Botanical Garden.

1.2 **Evaluate potential Tennessee recovery sites.** New leafy prairie-clover populations may need to be established to meet the recovery criteria, and at least one former site is suitable for population restoration. Couchville Glade is relatively large, harbors enough suitable habitat and is being managed with prescribed burning by TNC (Roach, personal communication, 1992). Extensive surveys of Central Basin glades/barrens have been completed (Shea, personal communication, 1992). These sites should be reviewed, evaluated, resurveyed if necessary, and prioritized for suitability as leafy prairie-clover recovery sites (see 2.4.2 below).

1.3 **Identify and prioritize protection, management, and restoration needs for the Alabama populations.** Of the two extant leafy prairie-clover populations, only the TVA site (Lawrence County) has recovery potential; thus, in order to work toward recovery of *Dalea foliosa* in Alabama, it is critical to protect and manage this site.

The site has a moderate-viability index due to the limited amount of habitat within the right-of-way under transmission towers, degree of disturbance, woody succession, and threats from power line maintenance. Areas within and adjacent to the right-of-way should be searched for additional populations and potential habitat. A preserve design is needed that includes the following: (1) protection from inadvertent damage from right-of-way maintenance; (2) any additional habitat with recovery potential; (3) an adequate buffer area; and, (4) a mechanism to achieve formal protection for the site. A management plan must be developed that reconciles the right-of-way management needs and community and population management needs. The plan should include brush control, prescribed burning, and population enhancement.

The Cedar Plains Road site (Morgan County) has a low-viability index because it is an unprotected small population with limited habitat, has a high degree of disturbance, and is in close proximity to the road. This population may have already been eliminated by the installation of new storm sewers. The site should be searched and any remaining plants should be salvaged for propagation (seeds) and restoration purposes.

1.4 **Evaluate potential Alabama recovery sites.** To meet the recovery criteria, two new populations must be established within the species' geographic range. Surveys and evaluations for suitable recovery sites should be conducted, ideally near present and former leafy prairie-clover locations (see 2.4.2 below). The best and largest examples of glade and barrens communities still exist near the former leafy prairie-clover location in eastern Franklin County (Webb, personal communication, 1992) and would be of high priority for protection and restoration.

1.5 **Identify and prioritize protection, management, and restoration needs for the Illinois populations.** The Lockport Prairie population ranks as a high-viability population and a model for the species. This publicly owned site has the highest form of legal protection available (State nature preserve), harbors a very large population with enough suitable habitat, and is actively managed by prescribed burning and brush control. Population enhancement should be considered in recently cleared areas. No additional recovery actions are required at this time.

The Romeoville Prairie population ranks as moderate viability because it occurs in disturbed, midsuccessional dolomite prairie that is within a privately owned power line right-of-way. This population is also threatened by ORV activity entering from industrial property to the west and from the power line maintenance road to the north. The population has been in decline in recent years, partly because of the lack of a refugium (wet-mesic dolomite prairie) during severe droughts in 3 of the past 6 years. The site is actively managed (prescribed burning, brush control, etc.) through an informal verbal agreement with the landowner; however, the population must be

legally protected and secured from ORV intrusions and inadvertent damage from power line maintenance. A primary recovery goal is to increase population size in optimal microhabitats in the adjacent nature preserve.

The Keepataw Forest Preserve population is approximately 4.0 km (2.5 miles) upstream from the Romeoville population and just north of the same power line right-of-way. The Keepataw population ranks as low viability due to its small population size, absence of flowering plants, small habitat size, woody succession, and threats from ORVs. The site is formally protected but not managed and is under consideration for dedication as a State nature preserve. A management plan must be developed that incorporates brush control, prescribed burning, and population size and increase with seeds from Lockport Prairie. The population has limited recovery potential because of the limited amount of suitable habitat.

1.6 **Evaluate potential Illinois recovery sites.** Bowles and Jones (1992) and DeMauro (unpublished data) conducted field surveys to locate suitable Illinois restoration sites based on certain habitat criteria (e.g., soils, geology, presence of natural community, and key plant associates, *sensu* DeMauro 1988). Ten sites were found, but not all are suitable for leafy prairie-clover recovery at this time because of differences in habitat size, protection status, and the intensity of past disturbances (see Table 10). Although not surveyed, mesic and wet-mesic dolomite prairie also exists at the Joliet Army Ammunition Plant (JAAP). These habitats should be evaluated to determine the recovery potential for leafy prairie-clover. JAAP is scheduled for closure and is currently under review to locate contaminated areas. Parcels not requiring cleanup will be disposed.

Sites with the highest potential for leafy prairie-clover recovery are Lockport Prairie East and Waterfall Glen Forest Preserve. Lockport Prairie East, a former leafy prairie-clover location, contains high-quality mesic and wet-mesic dolomite prairie that requires some management in the upland portions of the tract. Acquisition is pending, and when title is conveyed to the Forest Preserve District of Will County, site management and population recovery plans should be developed and implemented. Waterfall Glen Forest Preserve is owned and managed by the DuPage County Forest Preserve District. The site contains 20 hectares (50 acres) of degraded mesic and wet-mesic dolomite prairie along the Des Plaines River. Population recovery should be incorporated into the management plan for this site as well.

Sites with some recovery potential for leafy prairie-clover are Fabyan Forest Preserve (the type locality, which no longer has any known plants) and the Des Plaines River Conservation Area. Existing conditions in each area are marginal and require management and/or community restoration. Sites should be evaluated in more detail prior to developing a recovery plan. At this time, any population restoration actions

should be considered experimental. If restorations are attempted, experimental data should be collected, analyzed, and reported.

Sites that have a low recovery potential or that are not suitable for recovery at this time include Naplate Prairie, River Bend Forest Preserve, Kankakee River State Park, and Covel Creek Prairie (locations in Bowles and Jones 1992). These sites are either too small, too highly degraded, lack the ecological conditions that can support leafy prairie-clover, or are under imminent development threat. If the landowners are interested in intensive management to restore the natural communities, these sites should be reevaluated for their recovery potential.

2. **Initiate and complete preserve design and implement the protection and management required to meet recovery criteria.**

2.1 **Develop preserve designs.** Because leafy prairie-clover occurs in rare community types with other rare species throughout its range, preserve design should be at a scale that conserves the local complex of natural communities as well as the physical habitat features. With the exception of four publicly owned preserves, State parks, or forests in Illinois and Tennessee, most of the leafy prairie-clover populations are identified as EORs on private tracts that may not include all the attributes for species conservation or preserve viability within a landscape context. Preserve designs should incorporate both considerations (Saunders *et al.* 1991, Noss 1987) and should be completed for all populations that are not protected within an existing preserve and that are either ranked as high and moderate viability or as low viability with potential for recovery.

Specific considerations for leafy prairie-clover (and other rare species that would be protected within the preserve) include the amount of suitable habitat, presence of the full microhabitat gradient, and the patchiness of habitats. At a minimum, other design considerations should include watershed integrity (erosion, siltation, water quality, etc.) and defendable boundaries (roads, streams, etc.). The latter takes into account how well the preserve is buffered from illegal access, off-site threats, and adjacent land uses as well as permanent perimeter firebreaks for prescribed burns.

2.2 **Implement protection.** There are two primary land protection strategies that secure a legally binding interest to a property. Gaining clear title and gaining a permanent conservation easement with rights of access, monitoring, and management. These strategies can be accomplished through full fee simple acquisition, donation, or eminent domain proceedings for critical sites that cannot be protected by other means. The highest form of preservation is a State nature preserves act that provides legal protection from condemnation by government agencies, tollway authorities, or certain utilities for public works projects (except in extreme circumstances). In Tennessee and Illinois this protection is afforded to public or private tracts dedicated as State

natural areas or State nature preserves. Because Alabama does not have a State nature preserves act, public or not-for-profit (e.g., TNC) ownership by title or conservation easement would provide the best means of legal protection. Public lands not owned and managed by a State or Federal conservation agency should have conservation easements or other appropriate designations placed on critical sites. These easements should be granted to the appropriate agency.

Other legally binding forms of land protection include easements and contracts, such as lease or management agreements, that provide rights of access, monitoring, and management. The disadvantages are that these agreements may not have explicitly stated conservation goals and typically are not in effect for perpetuity. Nonbinding protection includes informal agreements with private landowners or volunteer registry programs secured through landowner contact.

All leafy prairie-clover populations of high and moderate viability or of low viability with recovery potential should be provided the highest form of legal protection available in each State. If a site is to be protected through a conservation easement, a secondary grantee with greater regulatory powers (e.g., the Service) should be named on the easement.

2.3 **Develop management plans.** Management plans are working guidelines that provide a framework within which to achieve identified site and/or population recovery and management goals and objectives within an established time frame (Nuzzo and Howell 1991, Forest Preserve District of Will County 1992). The plan should include the following: (1) an assessment of the ecological conditions supporting leafy prairie-clover and its associated plant communities, (2) an identification of all elements to be managed and of specific management problems (see 2.3.2 below), (3) an analysis of any past or present land use within or adjacent to the site that adversely impacts any element to be managed, (4) an evaluation of the site and population recovery potentials, (5) recommendations for specific recovery and management actions that resolve identified problems for leafy prairie-clover populations and the associated plant communities (differentiate between and address the short-term [specific] and long-term [routine] recovery and management actions as well as cost and time estimates), and (6) recommendations for population and community monitoring programs that evaluate the results of recovery and management actions. Site and population management actions are addressed in 2.4 and 2.5, respectively. A preliminary assessment of the critical threats and management concerns for most sites supporting leafy prairie-clover populations are provided. More detailed surveys are needed to develop management plans for all critical sites.

2.4 **Implement management plans.** Management plans should be implemented on all critical sites. The following issues are essential to the maintenance of leafy

prairie-clover populations and plant communities and should be addressed in the management plans.

Prescribed Burning - Fire was a historic ecological process that maintained the open grassland communities inhabited by leafy prairie-clover (Woodruff 1874). Fire benefits leafy prairie-clover habitat by burning accumulated duff, which keeps patches open for the establishment of new plants and by controlling woody plant succession. Prescribed burning is the most natural and effective management tool for population and community maintenance and should be used routinely. Fire frequency, however, will vary in each geographic region due, in part, to differences in fuel types, how fuel loads develop, how fuel loads are distributed, and climatic variables. The historic data support longer intervals between fires in the limestone cedar glades and barrens (Guyette and McGinnes 1982) as compared to the tall-grass prairies in northern Illinois. If other management treatments replace prescribed burning, the reasons should be justified.

Woody Plant Succession - Because of decades of grazing and fire suppression, woody plant succession (encroachment) now threatens all plant communities occupied by leafy prairie-clover, and, unless open conditions are maintained, the species will decline and may be lost. Routine prescribed burns control woody growth in high-quality communities that have relatively little woody encroachment and enough of a fuel (grass) matrix to sustain a moderate to hot fire. With more advanced woody succession, prescribed burning is a less effective control method because of the reduced fuel loads, and it should be augmented by cutting and applying the appropriate herbicide to the cut stems/trunks. The application of herbicides is critical to the prevention of resprouting in deciduous woody species and should only be conducted by licensed applicators and operators under appropriate conditions. The cuttings should either be removed from the site or they should be placed in piles on appropriate areas (degraded or buffer) and burned on the site. Prior to the application of any herbicides into habitat supporting leafy prairie-clover, a thorough analysis of the potential adverse effects of herbicide use must be conducted, and a carefully designed application plan must be developed and followed. Once areas are cleared of brush and a grass matrix is established, fire will maintain the open conditions.

Exotic Species Control - Several exotic plant species invade and threaten the communities supporting leafy prairie-clover populations. The woody exotic European buckthorn (*Rhamnus cathartica*) is the most serious threat in Illinois; once established, it can exclude native prairie species. The species can be controlled as stated above. In degraded natural communities, exotic perennial grasses compete with and threaten leafy prairie-clover populations. This includes Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*P. compressa*) in Illinois and Bermuda grass (*Cynodon dactylon*) and Johnson grass (*Sorghum halepense*) in Tennessee and Alabama. The perennial *Lespedeza cuneata* and the biennials white sweet clover

(*Melilotus alba*), Queen Anne's lace (*Daucus carota*), wild parsnip (*Pastinaca sativa*), cut-leaved teasel (*Dipsacus lacinatus*), common mullein (*Verbascum thapsus*), and thistle (*Cirsium* spp.) can persist. Successive spring prescribed burns may control these graminoid and herbaceous exotics, but if there is a heavy infestation or seed bank, burning should be supplemented by foliar herbicide applications (grasses and the first-year rosettes), hand-pulling (second-year flowering plants), and removal from the site.

Protection from Overuse and Illicit Activities - Some leafy prairie-clover populations are adversely affected by ORVs, dumping, and trampling from off-trail use. These problems can be remedied by posting signs, erecting fences, limiting public access, patrolling and enforcing applicable regulations, and when appropriate, using educational programs to inform the public of the value and need for the protection and management of leafy prairie-clover. In addition, all Federal, State, and local laws that protect leafy prairie-clover and its habitats should be enforced, including State regulations that require a nonbinding endangered species consultation process.

Herbivore Damage - Intense herbivory will lower seed production because it is concentrated on the flowering stems. This loss may be an important concern in small populations. To reduce these impacts, herbivores can be excluded during flowering and fruiting (July through August) by exclosures, commercial sprays (e.g., Ropel), or scent-marking with predator urine/feces.

2.5 **Conduct population recovery and restoration efforts.** To meet the recovery criteria for species recovery, increasing the size of existing populations (assuming unoccupied habitat is available) and establishing new populations to former or other suitable sites will be required. Although the species is easily propagated and has high seed production in natural and artificial settings, past transplant efforts have not been very successful. Choosing the appropriate microhabitat conditions for seeding or transplanting is likely critical for successful recovery/restoration. Isozyme analysis will soon be completed (Wiltshire, personal communication, 1992), and these results will help in the development of recovery protocols based on geographic differences in genetic variation.

2.5.1 **Enhance existing populations.** Population sizes should be increased at sites harboring small or moderate numbers of leafy prairie-clovers (see Table 9) and at suitable unoccupied clover habitat. The recovery of existing populations by enhancement will increase the population's viability ranking. Seeds should be collected on the site (this assumes no pollinator limitation and adequate seed production) and should be broadcast by hand and raked into open patches of low swales/pockets, lower slope positions, or along dry washes (see Figure 2) without adversely impacting the native vegetation. These conditions can be

found in either high-quality or moderately disturbed/midsuccessional natural communities. Avoid putting seeds near the edges of dense vegetation to reduce allelopathy and other competitive affects. Although bacterial nodules develop on the roots (Baskin and Baskin 1989), seeds readily germinate and successfully grow without inoculation. If establishment is successful, plants should flower in 2 or 3 years.

2.5.2 Establish new populations. To meet the recovery criteria, leafy prairie-clover must be restored at former sites or established at new sites. The intent is to augment population occurrences within a geographic region, not to justify the destruction of natural populations. Recovery sites should be assessed by site size and the presence and amount of all suitable microhabitats and should closely match known locations with respect to geology, soils, aspect, and plant associates (*sensu* DeMauro, in press; Huenneke 1991). Recovery sites should be protected and managed within the species' historic range. Using seeds for restoration (as described in 2.4.1) is the most efficient method. Using transplants for restoration is more labor intensive but, if successful, will achieve the desired results more quickly. Some transplant considerations include origin (field- versus greenhouse-grown), size (maintain high root/shoot ratio), initial number, planting density, monitoring methods, and post-transplant watering (DeMauro, in press).

There are conflicting opinions as to the use of propagules from different geographic sources in population recovery and restoration. While higher genetic variation is generally considered an advantage in responding to changes in novel environments, it may not necessarily confer greater adaptive value (Huenneke 1991) or it may result in outbreeding depression in hybrids (Fenster and Dudash, in press). Thus, there are no general guidelines. Protocols should be species-specific, based on the available information.

An electrophoretic study of the genetic diversity in leafy prairie-clover is underway (B. Wiltshire and D. Nikrent, in progress), and the results should be used to develop these genetic protocols. In the interim, any propagules used in population recovery and restoration should come from the same geographic region. At least one moderate- or large-source population exists within each geographic region where the species occurs. Rescue efforts should be implemented as soon as possible for any population under immediate threat of extinction, including the Woodmont Boulevard site in Tennessee (Davidson County) and the Morgan County site in Alabama. Plants should be maintained in a greenhouse or garden setting in order to harvest seeds for recovery and restoration efforts.

3. **Develop and implement population monitoring programs.** A monitoring program should be designed to gauge the status of naturally occurring populations over a period of time and to evaluate the status of population recovery and restoration actions. By relating the data to changing environmental or management conditions, the monitoring program will help determine if and what management or recovery actions are needed for population maintenance. Populations can be monitored by tracking the total census count and by using sampling or demographic data and should at least include accurate mapping of locations (patches). Demographic monitoring is most important in the initial stages of population restoration. Tracking of individual survivorship, reproductive status, and recruitment will help determine if and how these variables are related to changes in successional stage, management actions, or environmental stochasticity (*sensu* Shaffer 1981); e.g., drought. At a minimum, monitoring data for all populations should include growth stage (seedling, juvenile, mature, or dormant), flowering frequency, rate of herbivory, number of flowering and/or fruiting ramets per plant, and observations of general vigor. Reproductive potential and seed output can also be estimated.

4. **Conduct research needed to enhance recovery efforts.**

   4.1 **Determine the species' breeding system.** Because the breeding system affects population dynamics, maintenance of genetic diversity, effective population size, and extinction probabilities (Menges 1991, Karron 1991), it is an important consideration in any management and recovery strategy. Specific research questions should address the species' breeding system and relate the results to population recovery and restoration. Under artificial conditions, a determination should be made as to whether leafy prairie-clover is an obligate outcrosser and whether inbreeding depression is a potential problem. In natural populations, pollinators should be identified and their movement patterns within the population should be documented. These data can be compared to the levels of genetic variation and heterozygosity observed in natural populations (B. Wiltshire and D. Nikrent, in progress).

   4.2 **Study the role of dormant life stages in the survival of the species.** Population persistence is enhanced by dormant life stages that are unaffected by environmental stochastic events. Research is needed to accomplish the following: (1) characterize seed dispersal in natural populations, (2) determine the prevalence of seed banks and the frequency of plant dormancy in natural populations, (3) determine if and how dormant life stages are related to environmental fluctuations, and (4) assess the contribution of dormancy to population dynamics. Successional and high-quality habitats should be compared to determine if these contributions vary with respect to disturbance levels.

   4.3 **Conduct long-term demographic studies.** Long-term monitoring of key demographic variables is needed in high-viability populations in order to characterize

population dynamics. These data would provide objective criteria to help determine if and when a restored or recovered population is successful.

5. **Develop materials to inform the public about the status of the species and the recovery plan objectives.** Public support for the conservation of leafy prairie-clover could greatly encourage landowner assistance in conservation efforts. However, informational material should not identify the plant's precise locations in order to discourage vandalism to, or collection of, wild populations.

   Informational materials should stress pragmatic reasons for species conservation as well as intellectual, aesthetic, or moral considerations. Background information about the pharmacological, agricultural, or economic properties of the species, its congeners, or other plant family relatives will help address the questions frequently posed by laypersons. Additional information should be provided about known or suspected bio-indicator properties of the species.

   5.1 **Prepare and distribute news releases and informational brochures.** Informational materials should be prepared about the status, significance, and recovery of the species. News releases should be distributed to major newspapers in the species' range and to smaller newspapers in the vicinity of the species' habitat. Interpretive displays and brochures should be developed for use on public land or in public schools. These materials should stress the fragility of this rare plant's habitat.

   5.2 **Prepare articles for popular and scientific publications.** Published articles are necessary to inform local citizens and public officials about the need to protect leafy prairie-clover in its native habitat and to encourage their enthusiastic cooperation in conservation efforts. Scientific publications should identify the most pressing needs for further studies and seek the assistance of college and university researchers who have studied this or closely related species.

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PART III

IMPLEMENTATION SCHEDULE

Priorities in column one of the following Implementation Schedule are assigned as follows:

1. Priority 1 - An action that **must** be taken to prevent extinction or to prevent the species from declining irreversibly in the **foreseeable** future.

2. Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

ADC - Alabama Department of Conservation
CPC - Center for Plant Conservation
TE - Endangered Species Division of the U.S. Fish and Wildlife Service
FPDDC - Forest Preserve District of DuPage County, Illinois
FPDKC - Forest Preserve District of Kane County, Illinois
FPDWC - Forest Preserve District of Will County, Illinois
FWS - U.S. Fish and Wildlife Service
IDC - Illinois Department of Conservation
R3 - Region 3 (North Central Region), U.S. Fish and Wildlife Service
R4 - Region 4 (Southeast Region), U.S. Fish and Wildlife Service
TDEC - Tennessee Department of Environment and Conservation
TNC - The Nature Conservancy
TVA - Tennessee Valley Authority
UNIV - University

LEAFY PRAIRIE-CLOVER IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates ($000s)			Comments
				FWS	Other	FY1	FY2	FY3	
2	1.1	Identify and prioritize protection, management, and restoration needs for Tennessee's populations.	2 years	R4/TE	TDEC, TNC, TVA	6.0	6.0		Initiated in FY 1993.
2	1.2	Evaluate potential Tennessee recovery sites.	1 year	R4/TE	TDEC, TNC, TVA		4.0		
2	1.3	Identify and prioritize protection, management, and restoration needs for the Alabama populations.	2 years	R4/TE	ADC, TNC, TVA	3.0	3.0		
2	1.4	Evaluate potential Alabama recovery sites.	1 year	R4/TE	ADC, TNC, TVA		2.0		
2	1.5	Identify and prioritize protection, management, and restoration needs for the Illinois populations.		R3/TE	IDC				Completed.
2	1.6	Evaluate potential Illinois recovery sites.		R3/TE	IDC				Completed.
2	2.1	Develop preserve designs.	1 year	R3 and R4/TE	IDC, TDEC, TNC, ADC			6.0	Initiated in Tennessee in FY 1993.
2	2.2	Implement protection.	3 years	R3 and R4/TE	TDEC, FPDWC, FPDDC, IDC, ADC, TNC, TVA			500.0	Second year cost - $500K; third year cost - $250K.
2	2.3	Develop management plans.	1 year	R3 and R4/TE	IDC, ADC, TNC, TDEC, TVA, FPDWC, FPDDC, FPDKC			8.0	

LEAFY PRAIRIE-CLOVER IMPLEMENTATION SCHEDULE (continued)

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates ($000s)			Comments
				FWS	Other	FY1	FY2	FY3	
2	2.4	Implement management plans.	7 years	R3 and R4/TE	IDC, ADC, TNC, TDEC, FPDWC, FPDDC, TVA, FPDKC				Initiated upon completion of Task 2.3; cost estimated to be $10K per year.
2	2.5.1	Enhance existing populations.	4 years	R3 and R4/TE	CPC, IDC, ADC, TDEC, FPDWC, TNC, TVA	15.0	15.0	15.0	
2	2.5.2	Establish new populations.	4 years	R3 and R4/TE	CPC, IDC, ADC, TDEC, FPDWC, FPDDC, TNC, FPDKC, TVA	10.0	10.0	10.0	
3	3	Develop and implement population monitoring programs.	Ongoing	R3 and R4/TE	IDC, TNC, ADC, TDEC, FPDWC, FPDDC, TVA, FPDKC	25.0	25.0	25.0	A monitoring program is in place in Illinois.
3	4.1	Determine the species' breeding system.	2	R3 and R4/TE	UNIV	10.0	10.0		
3	4.2	Study the role of dormant life stages in the survival of the species.	2	R3 and R4/TE	UNIV	10.0	10.0		
3	4.3	Conduct long-term demographic studies.	Ongoing	R3 and R4/TE	UNIV, IDC, ADC, TDEC, FPDWC, TVA	15.0	15.0	15.0	
3	5.1	Prepare news releases and brochures.	Ongoing	R3 and R4/TE	ADC, CPC, IDC, TDEC, TNC	2.0	5.0		
3	5.2	Prepare articles for popular and scientific publications.	Ongoing	R3 and R4/TE	UNIV, ADC, CPC, IDC, TDEC, TNC				

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