# Conservation Status and Genetic Variation of the Diana Fritillary

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## Preface

This report details the magnitude and breadth of what is a continuing work in progress. As such, numerous components of the broader study that the current funding initiated are not fully completed. The report is designed to justify the expenditure of funds and to demonstrate that there is a great deal more management insight forthcoming. Four scientific publications (tentative titles given below) are likely to result from the current research and an educational poster is also being developed. With the first phase of genetic assessment nearly completed, the stage has been set for examining gene flow among various metapopulations, which if funded (see below), will provide critical insight for management and conservation.

COMPARATIVE ECOLOGY AND Behavior OF WESTERN POPULATIONS OF DIANA (*SPEYERIA DIANA*) AND GREAT SPANGLED (*SPEYERIA CYBELE*) FRITILLARIES

GENETIC VARIATION AMONG SYMPATRIC CONGENERS: DIANA FRITILLARY (*SPEYERIA DIANA*) AND GREAT SPANGLED FRITILLARY (*SPEYERIA CYBELE*)

REARING DIANA FRITILLARIES (*SPEYERIA DIANA*) TO FACILITATE MANAGEMENT AND CONSERVATION OBJECTIVES

CONSERVATION AND MANAGEMENT OF WILDLIFE HABITAT FOR DIANA FRITILLARIES (*SPEYERIA DIANA*): A RECIPE FOR FORESTS AND PRAIRIE HABITATS AND HIGHWAY, POWER, AND PIPELINE CORRIDORS

DIANA FRITILLARY LIFE CYCLE POSTER (*artwork nearly completed and photographs of all aspects in hand*)

GENE FLOW AMONG METAPOPULATIONS: MICROSATELLITE ANALYSIS OF DIANA (*SPEYERIA DIANA*) AND GREAT SPANGLED (*SPEYERIA CYBELE*) FRITILLARY POPULATIONS (*basis for upcoming grant proposal*)

## Background

The objectives of this study from an ecological perspective are to enhance the understanding of the distribution, abundance, and habitats occupied by the Diana Fritillary (*Speyeria diana*) in

Arkansas. The data base upon which current decisions are being made in regard to the management of this species is incomplete and often anecdotal. Results of this study will aid conservation and help to resolve the status of the species in the state, serve as baseline data for subsequent monitoring, and guide future management efforts.

In addition to ecological concerns, the fact that there are two Diana Fritillary populations (eastern - Appalachian Mountains vs. western - Ouachita/Ozark Mountains) is of interest with respect to genetic variability. Investigations by Baltosser and Bush (Co-PI) are assessing genetic variability in western populations by examining mitochondrial DNA (mtDNA). Portions of samples procured during the present study will ultimately be used to examine gene flow among various metapopulations via DNA fingerprinting based on microsatellite data (not a component of the current investigation).

Areas of historic occurrence (e.g., see Carlton and Nobles 1996) have been visited to assess suitability and the persistence of the species. Additional habitats have been surveyed and the relative abundance of individuals at occupied sites assessed. Limited numbers of voucher specimens have been collected for genetic analysis. Collections are generally separated by a minimum 5-10 mile radius, depending upon habitat and landform. Localities have been mapped for the Diana Fritillary and the Great Spangled Fritillary (*S. cybele*); the latter is under simultaneous investigation to better understand the biology of the Diana.

## Effort

Baltosser was physically in the field 71 days during the 2006 field season and during this period drove 13,985 miles (Table 1). Efforts during the 2007 field season were similar in that 72 days were spent in the field and during this period 13,399 miles were driven (Table 1). This

exhaustive effort was aimed at visiting, verifying, and searching (1) historic sites of occurrence, (2) verifying that the species was still present, and (3) searching and finding new sites of occurrence; all three endeavors were successful.

Table 1. Days in field and mileage for 2006 and 2007.

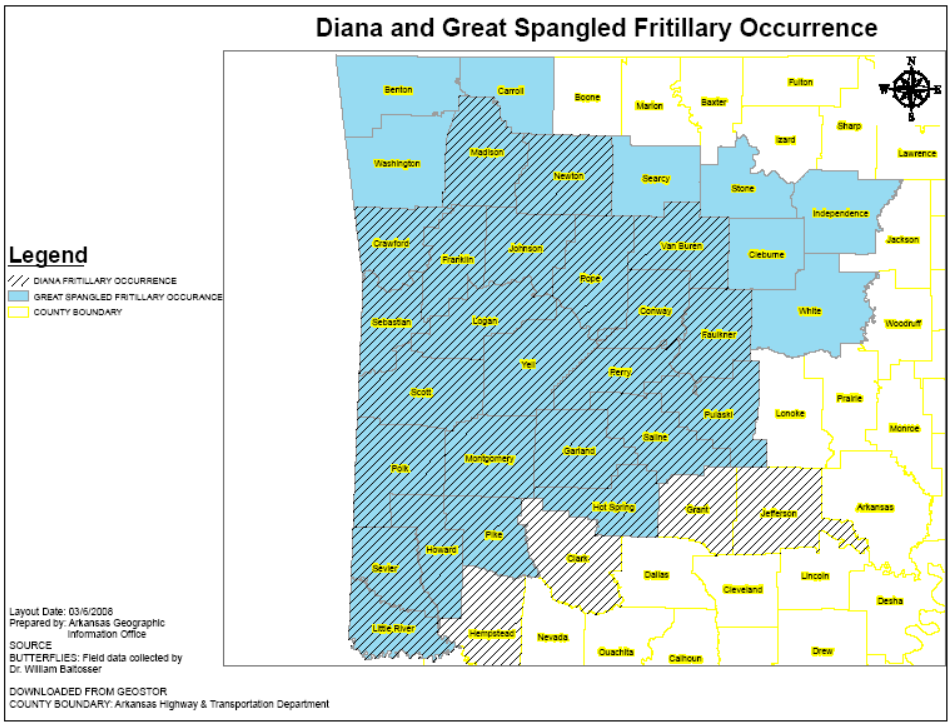
| Month | 2006 Days In Field | Total Miles | Month | 2007 Days In Field | Total Miles |
|---|---|---|---|---|---|
| January | 1 | 287 | January | 1 | 74 |
| March | -- | ---- | March | 2 | 132 |
| April | 1 | 206 | April | 3 | 439 |
| May | 1 | 296 | May | 6 | 1,184 |
| June | 17 | 3,488 | June | 19 | 3,846 |
| July | 14 | 3,010 | July | 18 | 3,236 |
| August | 16 | 2,907 | August | 9 | 2,050 |
| September | 15 | 2,867 | September | 11 | 1,951 |
| October | 6 | 924 | October | 3 | 487 |
| Totals | 71 | 13,985 | Totals | 72 | 13,399 * |

* Includes 16 days and 1,572 miles by student intern (Jeffrey A. Teague).

## Geographic Scope and Ecoregions

One or both species were found in 36 counties throughout the western half of Arkansas (Figure 1). The Great Spangled occurred in 8 counties where the Diana was not and the Diana was found in 4 counties where the Great Spangled was not present. Both species were found together (literally) in 24 counties and in many of the same ecoregions (Table 2; Figures 2, 3). Limited searches in four additional counties (Cleveland, Dallas, Nevada, Ouachita) failed to note either

species. Separate localities of occurrence within each county are depicted in Figure 4 (Diana) and Figure 5 (Great Spangled).




## Habitat

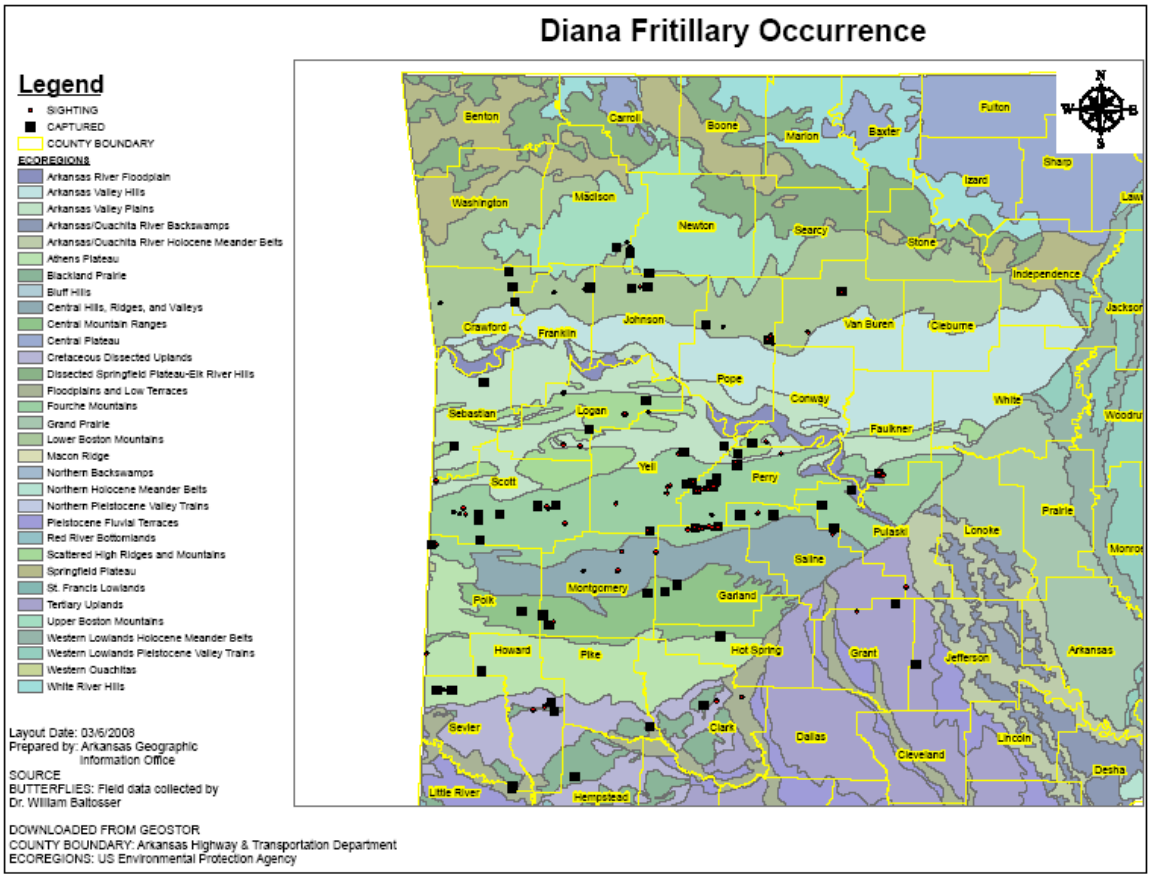
Habitats occupied by Diana Fritillaries have been documented photographically and characterized in various ways. However, with respect to this report, discussions are confined primarily to the evidence that can be gleaned from photographs. Figures 6-12 are examples of habitats, each in a different portion of the western half of Arkansas, that support good numbers of Diana Fritillaries. A common attribute of each is that the habitat, whether wooded or prairie intermingled with woodland, has been subjected to management that periodically reduces brush cover. Management that retards the encroachment of brush and simultaneously fosters the germination and establishment of important nectar producing plant species is an essential

Table 2. Fritillary occurrence (present study) in the various ecoregions of Arkansas.

| Ecoregion[1] / Subregions | Fritillary: Diana | Fritillary: Great Spangled |
|---|---|---|
| South Central Plains (#35) | | |
| Tertiary Uplands (#35a) | X | -- |
| Floodplains and Low Terraces (#35b) | X | X |
| Blackland Prairie (#35h) | X | X |
| Ouachita Mountains (#36) | | |
| Athens Plateau (#36a) | X | X |
| Central Mountain Ranges (#36b) | X | X |
| Central Hills, Ridges, and Valleys (#36c) | -- | X |
| Fourche Mountains (#36d) | X | X |
| Western Ouachitas (#36e) | X | X |
| Arkansas Valley (#37) | | |
| Scattered High Ridges and Mountains (#37a) | X | X |
| Arkansas Valley Hills (#37c) | -- | X |
| Arkansas Valley Plains (#37d) | X | X |
| Boston Mountains (#38) | | |
| Upper Boston Mountains (#38a) | -- | X |
| Lower Boston Mountains (#38b) | X | X |
| Ozark Highlands (#39) | | |
| Springfield Plateau (#39a) | -- | X |
| Dissected Springfield Plateau (#39b) | -- | X |

[1] Woods, A. J., T. L. Foti, S. S. Chapman, J. M. Omernik, J. A. Wise, E. O. Murray, W. L. Prior, J. B. Pagan, J. A. Comstock, and M. Radford. 2004. Ecoregions of Arkansas (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,000,000).

## Diana Fritillary Occurrence

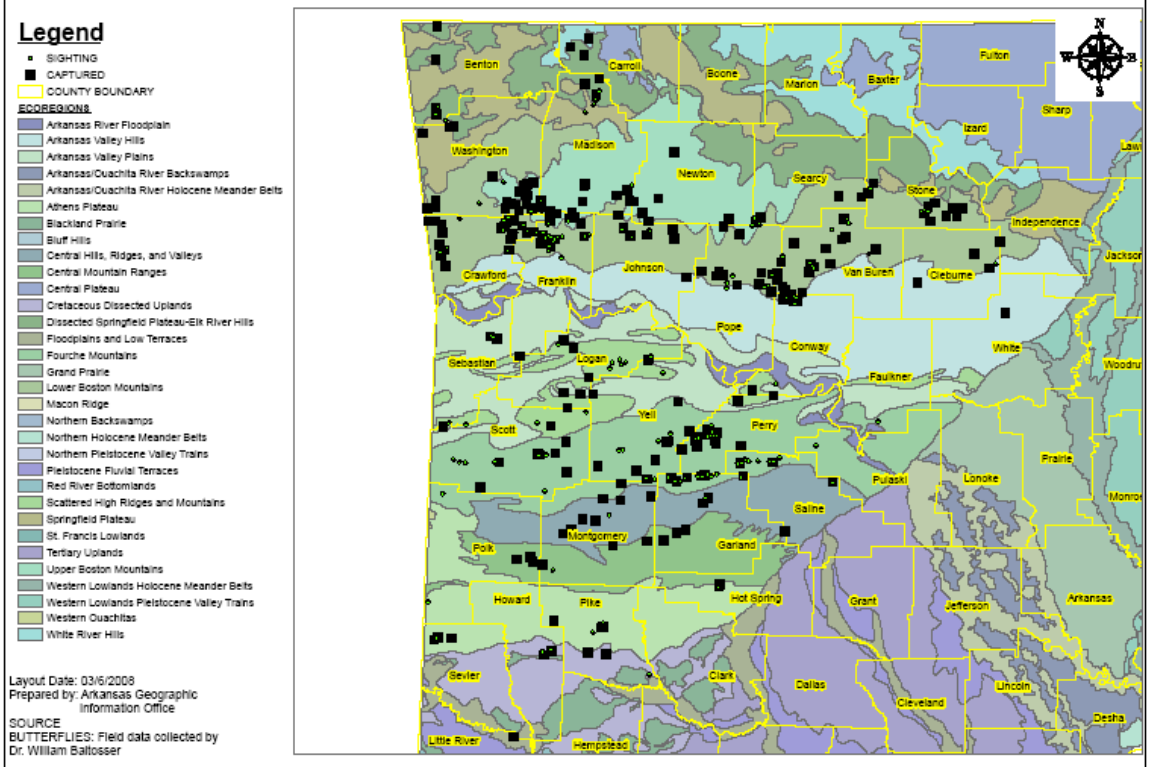



Layout Date: 03/6/2008
Prepared by: Arkansas Geographic Information Office

SOURCE
BUTTERFLIES: Field data collected by Dr. William Baltosser

DOWNLOADED FROM GEOSTOR
COUNTY BOUNDARY: Arkansas Highway & Transportation Department
ECOREGIONS: US Environmental Protection Agency

## Great Spangled Fritillary Occurrence

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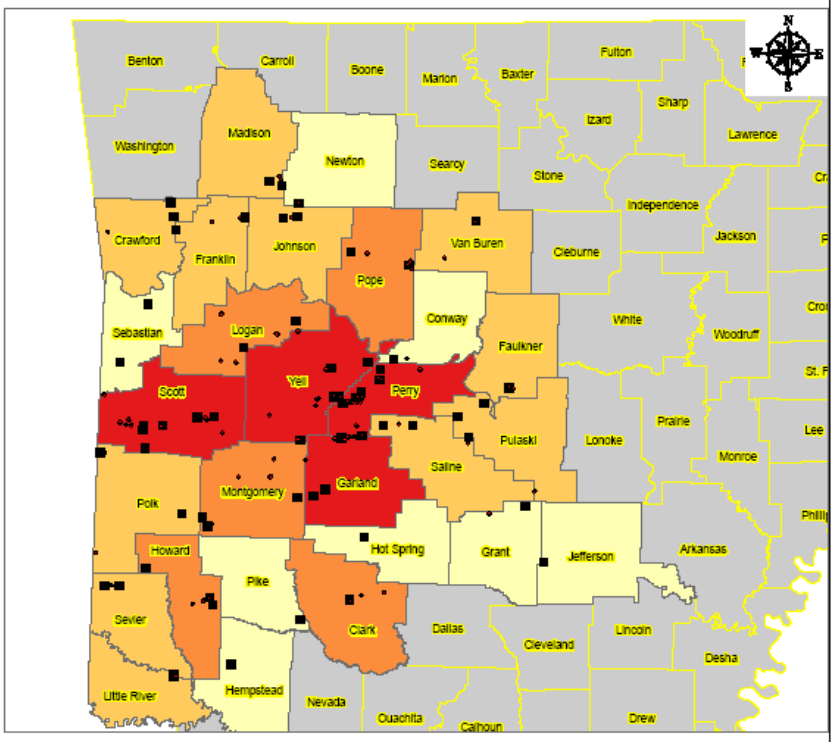
## Separate Localities - Diana Fritillary




**Legend**

- SIGHTING
- CAPTURED

SEPARATE LOCALITIES by COUNTY

- 1 - 2
- 3 - 5
- 6 - 9
- 10 - 23
- COUNTY BOUNDARY

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BUTTERFLIES: Field data collected by Dr. William Baltosser

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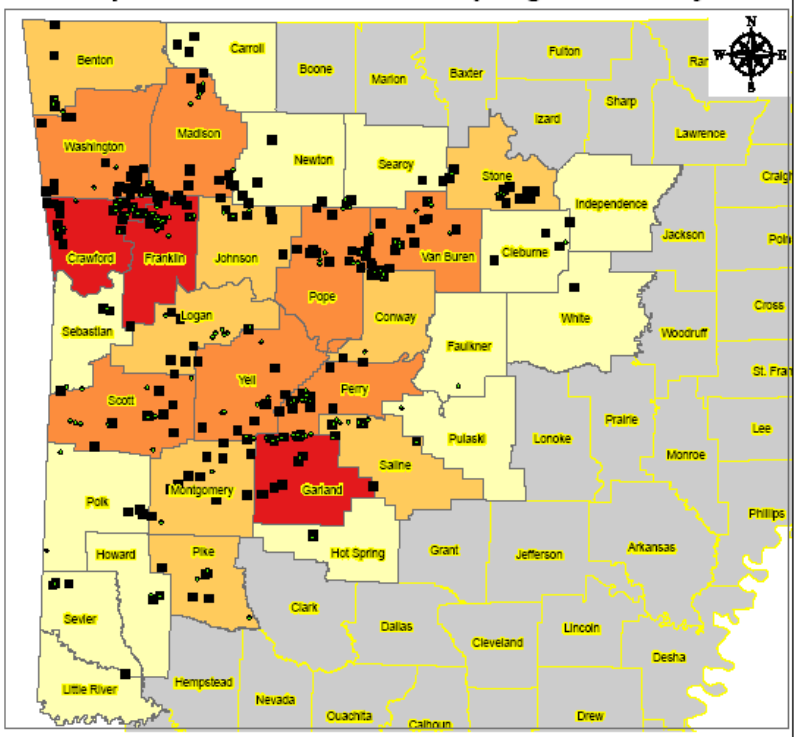
COUNTY BOUNDARY: Arkansas Highway & Transportation Department

## Separate Localities - Great Spangled Fritillary




**Legend**

- SIGHTING
- CAPTURED

SEPARATE LOCALITIES by COUNTY

- 1 - 7
- 8 - 15
- 16 - 24
- 25 - 39
- COUNTY BOUNDARY

Layout Date: 03/06/2008
Prepared by: Arkansas Geographic Information Office

SOURCE
BUTTERFLIES: Field data collected by Dr. William Baltosser

DOWNLOADED FROM GEOSTOR
COUNTY BOUNDARY: Arkansas Highway & Transportation Department

MONTGOMERY  COUNTY

FAULKNER  COUNTY

GARLAND COUNTY

SCOTT COUNTY

HOWARD COUNTY

HEMPSTEAD COUNTY

MADISON COUNTY

prerequisite for the maintenance of Diana Fritillary populations. Habitats supporting the greatest numbers of Diana Fritillaries have invariably been those having this gestalt (i.e., open woodland or prairie with interspersed open woodland), coupled with seasonal continuity in nectar producing plants.

## Important Nectar Plants

Moran and Baldridge (2002) identified seven plant species as being utilized for nectar sources by the Diana Fritillary. Their data set did not reference utilization by the Great Spangled Fritillary but a reasonable assumption is that this species utilized the same nectar sources as the Diana. Rudolph et al. (2006) noted utilization by both fritillary species and partitioned their data set with

respect to plant species of primary importance vs. those of secondary importance; 12 species were noted of primary importance. The data sets that follow are based on the present study and the aforementioned publications, which surprisingly had only 3 species in common (*Echinacea purpurea*, *Echinacea pallida*, and *Pycnanthemum albescens*), though Rudolph et al. (2006) listed *Cephalanthus occidentalis* as being of secondary importance in the habitats they surveyed. The three tables that follow represent a synthesis of all data and provide a "state-wide" perspective of importance rather than a more "local" perspective.

Table 3. Nectar producing plant species of primary importance to the Diana Fritillary (D) and the Great Spangled Fritillary (G) in Arkansas based on extensive feeding as documented in the published literature and the present study (2006, 2007).

| Plant Species | | Source[1] | D | G | B[2] |
|---|---|---|---|---|---|
| *Asclepias tuberosa* | Butterfly Weed | RB | * | * | b |
| *Cephalanthus occidentalis* | Buttonbush / Globe Flower | MRB | * | | b |
| *Cirsium carolinianum* | Purple Thistle | RB | * | * | b |
| *Cirsium discolor* | Field Thistle | RB | * | * | b |
| *Echinacea purpurea* | Purple Coneflower | MRB | * | * | b |
| *Monarda fistulosa* | Beebalm / Wild Bergamot | RB | * | * | b |
| *Pycnanthemum tenuifolium* | Slender Mountain Mint | RB | * | * | b |
| *Monarda russeliana* | Horsemint | B | | | b |

[1]Source: M = Moran and Baldridge 2002, R = Rudolph et al. 2006, and B = Baltosser (2006 and 2007 field seasons)

[2]B: Baltosser 2006 and 2007 data sets, b = utilization by both species of fritillary vs. utilization by only one of the two species (i.e., d or g).

Table 4. Nectar producing plant species of secondary importance to the Diana Fritillary (D) and the Great Spangled Fritillary (G) in Arkansas based on documented feeding on multiple occasions as documented in the published literature and the present study (2006, 2007).

| Plant Species | | Source[1] | D | G | B[2] |
|---|---|---|---|---|---|
| *Aralia spinosa* | Devil's Walkingstick | RB | | * | g |
| *Asclepias purpurascens* | Purple Milkweed | B | | | g |
| *Asclepias syriaca* | Common Milkweed | B | | | b |
| *Carduus nutans* | Musk Thistle / Nodding Thistle | RB | | * | b |
| *Echinacea pallida* | Pale-purple Coneflower | MRB | * | * | b |
| *Eupatorium fistulosum* | Joe-Pie Weed | RB | * | | g |
| *Liatris aspera* | Rough Blazing Star | B | | | g |
| *Liatris elegans* | Blazing Star / Gayfeather | RB | * | * | b |
| *Liatris pycnostachya* | Prairie Gayfeather | B | | | d |
| *Liatris squarrosa* | Scaly Blazing Star | RB | | * | g |
| *Porteranthus stipulatus* | Cinquefoil / Five-Finger | R | * | * | |
| *Pycnanthemum albescens* | Mountain Mint | MRB | * | * | b |
| *Verbesina virginica* | White-Crowned-Beard / Frostweed | B | | | b |
| *Vernonia gigantea* | Tall / Giant Ironweed | RB | * | * | b |
| *Vernonia baldwinii* | Baldwin's / Interior Ironweed | RB | * | * | g |

[1]Source: M = Moran and Baldridge 2002, R = Rudolph et al. 2006, and B = Baltosser (2006 and 2007 field seasons)

[2]B: Baltosser 2006 and 2007 data sets, b = utilization by both species of fritillary vs. utilization by only one of the two species (i.e., d or g).

Table 5. Nectar producing plant species of tertiary importance to the Diana Fritillary (D) and the Great Spangled Fritillary (G) in Arkansas based on documented feeding on at least one or two occasions as documented in the published literature and the present study (2006, 2007).

| Plant Species | | Source[1] | D | G | B[2] |
|---|---|---|---|---|---|
| *Achillea millefolium* | Common Milfoil / Yarrow | RB | | * | g |
| *Allium canadense* | Wild Garlic / Wild Onion | R | | * | |
| *Asclepias variegata* | White Milkweed | B | | | g |
| *Aster ericoides* | White Heath Aster | R | | * | |
| *Bidens aristosa* | Tickseed Sunflower | R | * | | |
| *Ceanothus americanus* | New Jersey Tea | B | | | g |
| *Clematis virginiana* | Virgin's Bower | B | | | g |
| *Coreopsis grandiflora* | Large-flowered Tickseed | RB | | * | g |
| *Coreopsis palmata* | Stiff Tickseed | R | | * | |
| *Coreopsis tripteris* | Tall Tickseed | R | | * | |
| *Cornus drummondii* | Roughleaf Dogwood | R | | * | |
| *Daucus carota* | Wild Carrot / Queen Anne's Lace | RB | | * | g |
| *Erigeron strigosus* | Lesser Daisy Fleabane | RB | * | * | g |
| *Eryngium yuccifolium* | Rattlesnake Master | B | | | g |
| *Eupatorium perfoliatum* | Clasping-leaf Boneset | B | | | d |
| *Eupatorium serotinum* | Late Boneset | B | | | g |
| *Helianthus divaricatus* | Woodland Sunflower | RB | * | * | g |
| *Helianthus hirsutus* | Stiff-haired Sunflower | B | | | g |
| *Heliopsis helianthoides* | Oxeye/False Sunflower | B | | | g |
| *Hydrangea arborescens* | Wild Hydrangea | B | | | g |

Table 5. *Continued*.

| Plant Species | | Source[1] | D | G | B[2] |
|---|---|---|---|---|---|
| *Ligustrum vulgare* | European Privet | R | | * | |
| *Lobelia spicata* | Pale-spiked Lobelia | B | | | g |
| *Lonicera japonica* | Japanese Honeysuckle | R | | * | |
| *Mimosa quadrivalvis* | Sensitive Brier | B | | | g |
| *Parthenium integrifolium* | Wild Quinine | RB | | * | g |
| *Phlox glaberrima* | Smooth Phlox | RB | | * | g |
| *Prunella vulgaris* | Self-Heal / Heal-All | R | | * | |
| *Rhexia* sp. | Meadow Beauty | R | * | | |
| *Rhus glabra* | Smooth Sumac | B | | | g |
| *Rosa setigera* | Prairie Rose | B | | | g |
| *Rubus* sp. | Dewberry / Blackberries etc. | M | * | | |
| *Rudbeckia hirta* | Black-eyed Susan | R | | * | |
| *Ruéllia* sp. | Petunia | R | | * | |
| *Satureja arkansana* | Calamint | M | * | | |
| *Scutellaria ovata* | Heart-leaved Skullcap | R | * | * | |
| *Silphium asteriscus* | Starry/Southern Rosinweed | B | | | g |
| *Silphium integrifolium* | "Compass Plant" | RB | | * | g |
| *Silphium laciniatum* | Compass Plant | MB | * | | g |
| *Solidago rugosa* | Goldenrod | RB | * | | g |
| *Strophostyles leiosperma* | Slickseed Fuzzybean | R | | * | |
| *Trifolium pratense* | Red Clover | RB | | * | g |

Table 5. *Continued*.

| Plant Species | | Source[1] | D | G | B[2] |
|---|---|---|---|---|---|
| *Trifolium vesiculosum* | Arrowleaf Clover | B | | | g |
| *Verbesina helianthoides* | Wingstem | R | | * | |
| *Vicia dasycarpa* | Smooth Vetch | B | | | g |

[1]Source: M = Moran and Baldridge 2002, R = Rudolph et al. 2006, and B = Baltosser (2006 and 2007 field seasons)

[2]B: Baltosser 2006 and 2007 data sets, b = utilization by both species of fritillary vs. utilization by only one of the two species (i.e., d or g).

## Development and Captive Propagation

Among the various stages in the life cycle of a butterfly, the adult stage is generally the most conspicuous and thus the best known. However, the adult stage is not the only important and certainly not the most vulnerable with respect to survival. Fritillaries in the genus *Speyeria* have exceptionally high fecundity in that each female can lay as many as 2,000 eggs (various sources, including the present study). Despite this high potential, most eggs and caterpillars do not survive to become adults.

Given high incidence of mortality prior to the adult stage, a few late-season females of both species were removed from the field and brought into the lab to obtain eggs for developmental studies. Total numbers of eggs obtained from individual females of both species varied, but obtaining gravid females was timed so that many if not most eggs would have already been deposited in the field. This strategy worked in most instances, but occasionally over a thousand