

**West Virginia Diana Fritillary**

**2023 Pilot Survey Summary**



**United States Fish & Wildlife Service**

**Science Applications – At-Risk Species Program**

## Table of Contents

Introduction.....	3
Status .....	3
Survey Objectives .....	4
Summary of Survey Effort.....	5
West Virginia State Parks & Wildlife Management Areas.....	6
NAFO Timber Company Lands.....	7
Preliminary Analysis.....	7
Survey Methodology .....	7
Habitat Variables.....	7
Model set 1 .....	8
Model set 2 .....	8
Model set 3 .....	9
Recommended Changes for 2024 .....	9
Literature Cited .....	10

## **Introduction**

The Diana fritillary (*Argynnis diana*) is a large forest-dependent butterfly that relies on robust concentrations of violets (*Viola spp.*), their only known larval host plants (Vaughan and Shepherd 2005). Their range in the Appalachians extends from West Virginia south to northern Georgia and Alabama and into the Ozark mountains (Vaughan and Shepherd 2005). Recently, the Diana fritillary has undergone range contractions and is shifting to higher elevations, possibly in response to climate change (Wells and Tonkyn 2014).

Other potential threats to the species include historic and current spraying for forest pests, and overbrowsing of suitable host and nectar plants by deer (Schweitzer et al. 2018). The state of West Virginia additionally considers the species threatened by mountaintop coal mining and associated valley fills (West Virginia Division of Natural Resources 2015). Some early authors suggested that declines in the species was the result of forest management and the loss of larval host plants (e.g., Hammond and McCorkle 1983). More recent research has suggested that management may actually benefit the species, as disturbances such as timber harvest or fire promote the growth of preferred nectar resources (Moran and Baldrige 2002, Thill et al. 2004, Rudolph et al. 2006, Campbell et al. 2007, Rossell 2009).

In West Virginia, observations of the Diana fritillary are largely from the southern half of the state. Many historic and recent observations occur on state-owned properties, such as Wildlife Management Areas (WMAs) and State Parks, or on large timber management areas owned by companies that are members of the National Alliance of Forest Owners (NAFO). The US Fish and Wildlife Service, West Virginia Division of Natural Resources (WVDNR), and NAFO participants share an interest in understanding the status and distribution of the species on NAFO member lands. They are also interested in better understanding the impact of timber management practices on declining species such as the Diana fritillary.

In partnership with NAFO, WVDNR, and the National Council for Air and Stream Improvement, Inc. (NCASI), the Science Applications program initiated field investigations of the Diana fritillary butterfly in West Virginia. In the summer of 2023, Science Application's Rapid Response Team conducted a pilot study to test methods for field investigations and recommend a more comprehensive approach to compare Diana fritillary occupancy under various sustainable forest management practices. The results from this pilot effort are summarized below.

## **Status**

The Midwest and Northeast Association of Fish and Wildlife Agencies have identified the Diana fritillary as a Regional Species of Greatest Conservation Need of high concern (Terwilliger et al. 2021, Terwilliger Consulting Inc. and Northeast Fish and Wildlife Diversity Technical Committee 2023). In the Northeast Region, both West Virginia and Virginia consider the Diana fritillary a Species of Greatest Conservation Need (SGCN) in their state (Virginia Department of

Game and Inland Fisheries 2015, West Virginia Division of Natural Resources 2015). NatureServe classifies the Diana fritillary as G2 (globally imperiled). At the state level, NatureServe ranks the species as S2 (imperiled) in Alabama, Arkansas, Kentucky, Oklahoma, and West Virginia; S3 (vulnerable) in Georgia, North Carolina, South Carolina, Tennessee, and Virginia; and SX (presumed extirpated) in Indiana and Ohio. (Figure 1; NatureServe 2024).

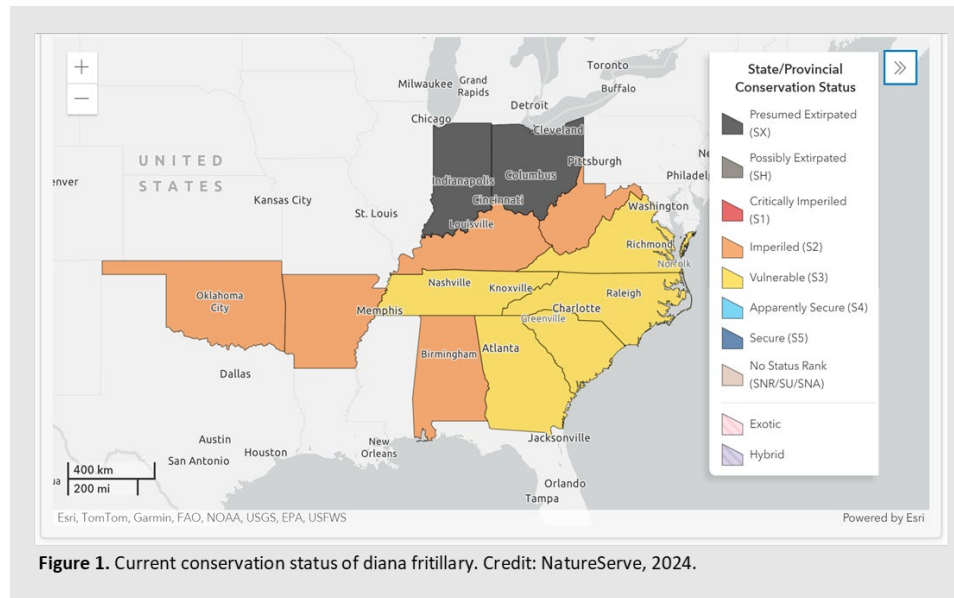


Figure 1. Current conservation status of diana fritillary. Credit: NatureServe, 2024.

## Survey Objectives

The United States Fish & Wildlife Service Northeast Science Applications Rapid Response Team (RRT) worked with West Virginia Department of Natural Resources, NAFO member companies, and the National Council for Air and Stream Improvement (NCASI) to identify the following objectives:

- 1) Evaluate survey methods designed to detect Diana fritillary on selected state lands and partnering timber landowner holdings.
- 2) Describe habitat conditions at locations where Diana fritillary are detected and compare to randomly selected locations within the same grid cell.
- 3) Determine the effect sustainable forestry management practices used on partner lands have on Diana fritillary presence.
- 4) Develop recommendations for future habitat management.

For the pilot study in 2023, we focused on evaluating two butterfly survey methodologies, wandering transects and timed point counts, to determine which would better enable us to address the goals for the larger study. Full descriptions of both methodologies are available on request. We used our results from the first year to compare the two butterfly survey methods and to evaluate potential habitat variables for their relevance to the species.

## Summary of Survey Effort

Between June 1, 2023, and August 22, 2023, the RRT conducted surveys for the at-risk Diana fritillary *in* a portion of their historic range in southern West Virginia. Five different property owners were consulted for permission to access and conduct surveys on both public and private lands: Twin Falls State Park, Babcock State Park, Beury Mountain Wildlife Management Area, Weyerhaeuser Timberlands, and Lyme Mountaineer Timberlands (Figure 2). Each property was stratified into 25-hectare (ha) (61.8 acres (ac)) grid cells where the RRT conducted both adult surveys and habitat assessments, with the primary focus of detecting the target species, gathering information on habitat variables, and confirming host plant presence.

A total of 127 surveys were completed on 71 grid cells across the five properties, which included 316 habitat assessments in 4-5 plots per grid cell. Together, 1,775 ha of habitat were surveyed in southern West Virginia. Diana fritillaries were detected on 86 occasions including 15 observations during 7-minute point counts, 36 observations during wandering transect counts, and 35 additional opportunistic detections while traveling between surveyed grid cells. We detected 64 males and 22 females during the survey. Most detections occurred while the individuals were either flying or nectaring, primarily on milkweed (*Asclepias spp.*) and ironweed (*Vernonia ssp.*). The first detection occurred July 5, 2023, and the last on August 21, 2023. While the number of detections vary widely by site, the RRT was able to detect the species at all five properties surveyed consistently throughout July and August, with peaks in late July (Figure 3). Males were active from early July to early August, peaking the week of July 31, while females appeared and persisted later in the season (Figure 3). Importantly, the Diana fritillary's larval host plants were also observed in high densities at each of the five properties and often near detections of Diana fritillary, along roads, and within forested areas.

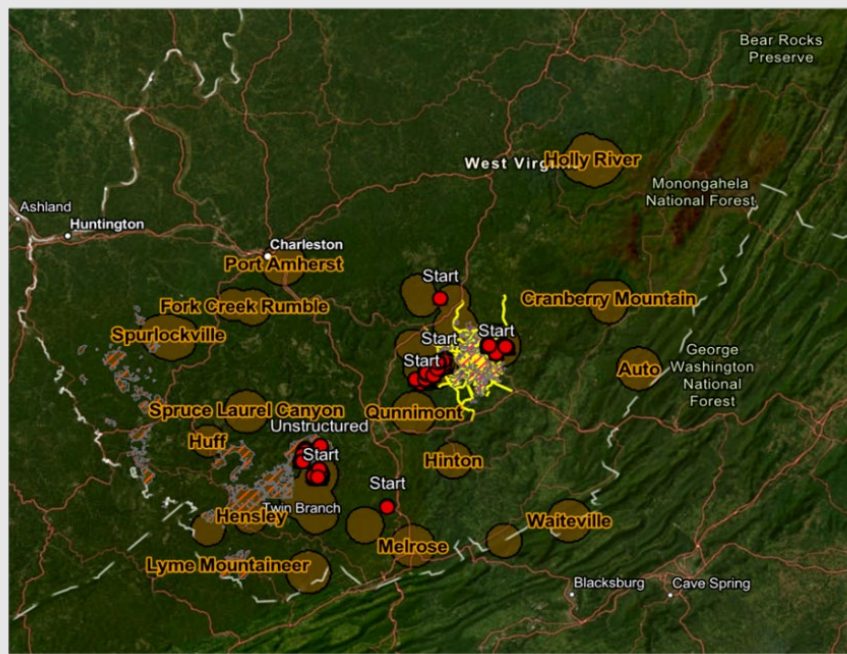
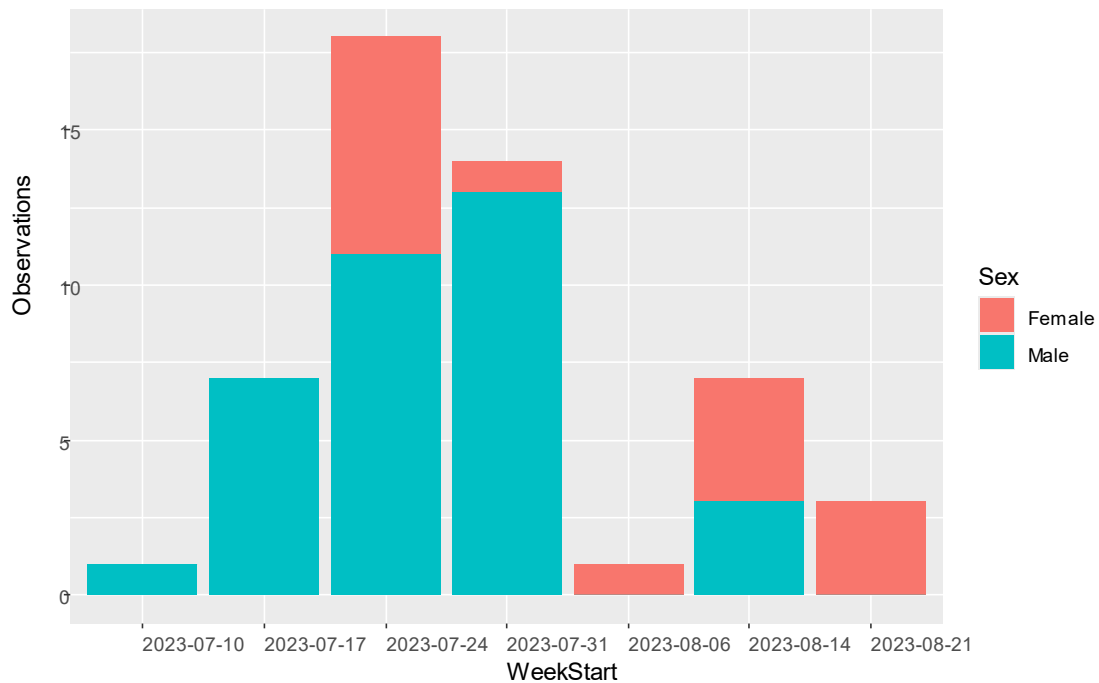


Figure 2. Map of Diana fritillary survey areas in West Virginia.



**Figure 3.** Male and female Diana fritillary detections throughout the July and August sampling period. Observations were summed by sex and week to detect trends over the sampling period. The species was detected throughout the sampling period, with numbers peaking in late July.

### **West Virginia State Parks & Wildlife Management Areas**

The RRT surveyed Twin Falls State Park, Babcock State Park, and Beury Mountain Wildlife Management Area from June 1-August 22, 2023. The RRT completed surveys in 42 grid cells for a total of 1,050 ha surveyed. We also completed 228 habitat assessments within predetermined plots in the grid cells. We detected a total of 69 Diana fritillaries on state-owned lands within 39 grid cells. A total of 11 butterflies were detected during the timed point count surveys, 27 during the wandering transect, and an additional 31 butterflies were observed opportunistically while traveling to survey points. A total of 53 males and 16 females were observed. The first Diana fritillary was detected on July 5, 2023, and the last on August 21, 2023. Violets were abundant on all state lands and were present at 153 of the 228 vegetation plots (67% of all plots surveyed).

Diana fritillary detections were greatest at Beury Mountain Wildlife Management Area, which accounted for 60% of total detections on state-owned lands. Notably, most detections occurred during unstructured surveys along roadsides where common milkweed was abundant.

## **NAFO Timber Company Lands**

The RRT surveyed parcels of Lyme Mountaineer and Weyerhaeuser property from July 12th—August 21, 2023. We completed surveys in 17 grid cells, totaling 425 ha and 86 habitat assessments in predetermined plots within the grid cells. We detected a total of 17 Diana fritillaries on NAFO Timber Company lands within 8 grid cells. A total of 4 butterflies were detected during the timed counts, 9 during the wandering transects, and an additional 4 butterflies were observed opportunistically while traveling to survey points. The first Diana fritillary was detected on July 21, 2023, and the last on August 17, 2023. In total, 11 males and 6 females were observed. Violets were abundant on both properties and were present at 52 of the 88 habitat plots (59% of all plots surveyed).

Diana fritillary detections were higher on Weyerhaeuser lands, accounting for 72% of total detections on timber land. However, the RRT only surveyed 200 ha (494.21 ac) of Lyme-Mountaineer property, compared to 400 ha of Weyerhaeuser property, which could account for the discrepancy.

## **Preliminary Analysis**

### **Survey Methodology**

At a surficial level, the wandering transect surveys are more effective at observing Diana fritillaries in terms of numbers of individuals seen, with 36 butterflies observed during wandering transects and 15 during point counts. However, the spatial and temporal scale of the two methods is unequal. The point count surveys are only 7 minutes in length and cover an area only 25-m in diameter; when multiplied across the 5 point counts taken within a grid cell, the effort is 35 minutes across ~0.2 ha. In contrast, a wandering transect survey takes up to an hour and covers a much larger portion of the 25-ha grid cell. Anecdotally, at the 20 grid cells where butterflies were detected, there is only one grid cell where butterflies were detected *only* during point count surveys, 10 grids where butterflies were detected *only* during wandering transect surveys, and 9 grids where butterflies were detected during *both* surveys. This further suggests that the wandering transects are more effective at determining presence at the scale of the 25-ha grid.

We ran a U-test on the pilot survey data to determine if there was a difference between the point count and wandering transect surveys. Wandering transect surveys have a slightly higher detection rate, but the difference is only borderline significant ( $p = 0.0558$ ). Based on these results, wandering transect surveys are marginally better at detecting Diana fritillary.

### **Habitat Variables**

We collected more than 40 habitat variables during the pilot effort. This is excessive but was intended to help us identify the variables that are potentially meaningful and inform and address our research objectives. We had limited ability to conduct these analyses as only the results from the point count surveys could be matched to specific habitat data. This left us with only 15

observations to inform our analyses, resulting in limited power for any analyses conducted with this data. To assess the impact of habitat characteristics on Diana fritillary presence, we used an information-theoretic approach and considered all possible combinations of our habitat variables.

We considered 3 sets of models. The first set included just variables that described environmental conditions, while the second included just the variables that described management activities; both were at the scale of the individual habitat assessment point (0.2 ha circles). For the third set, we summarized data at the scale of the grid cell (25 ha), generating proportional measures of each habitat description class. All models were run with a binary detection/nondetection variable as the response. To reduce model run time and avoid overfitting, we restricted models to no more than 3 variables per model. Models were compared using AIC values; we focused on all models with  $< 2 \Delta AIC$ .

We removed any variables where 95%+ of values were identical or more than 50% of the values were NA; these variables do not have sufficient information to be informative. This left us with only 25 variables. None of these variables were correlated with one another, so all were retained. For data summarized to the scale of the 25-ha grid cells, we kept all but one of the proportional cover type variables; Forest and Herbaceous cover were highly correlated (-0.76), so we elected to eliminate the Herbaceous variable from the models.

#### *Model set 1*

Environmental variables, ~0.2 ha – 697 total model combinations

Four variables appear in multiple of the top models, suggesting they have greater support than the other variables: amount of boulders/rock, amount of lichen, high canopy closure, and distance to canopy gap. That both boulders/rock and lichen ended up scoring so high was surprising, as we are not aware of any biological reason these two variables would be particularly important to Diana fritillary. Moreover, these two variables were both heavily skewed, with nearly all values falling within the lowest two categories, “None” or “<5%.” We suspect that the lichen and rock variables are not necessarily crucial to Diana fritillary ecology, but rather are correlated with another variable that they are responding to more directly. One variable to consider would be soil type; lichen and rocks may be associated with sites with poorer soil qualities that thus produce fewer nectar plants.

Another pattern to note in this model set is the relationship between the high canopy layer and distance to canopy gap. Diana fritillary observations were associated with areas where the upper canopy was closed, but the distance to a canopy gap was small, suggesting that the species is most frequently found at or near forest edges, rather than in the middle of large openings or deeper in the forest.

#### *Model set 2*

Management variables, ~0.2 ha – 299 total model combinations

This model set is overwhelmed by the Forestry variable. If we remove this variable and re-run the model, none of the other variables explain large portions of the variability within the



collected data. There's also a positive relationship with forestry, indicating that the Diana fritillary is more commonly observed in areas with forestry. More detailed forest management variables, such as basal area and treatment type, would allow us to dig deeper into Diana fritillary's responses.

### *Model set 3*

Environmental variables, 25 ha – 128 total model combinations

For the grid scale models, Diana fritillary appear to be positively associated with greater amounts of Forest and High Shrub, and negatively associated with Lawns. As Forest and Herbaceous were negatively correlated, Diana fritillary are also less common in cells with greater amounts of herbaceous cover. The other cover types do not appear to have much influence in our models. Overall, these results are not surprising, but must be interpreted carefully as it assumes the 5 habitat points assessed accurately represent the entire grid. It would be better to collect data at the same scale as the intended analysis.

## **Recommended Changes for 2024**

Based on the results from the preliminary analysis, we recommend making the following changes to the survey methodology:

- Focus on just the wandering transect methods, as they appear to maximize Diana fritillary detections
- Ensure all grid cells are visited at least 3x each; this will allow us to estimate species detectability and occupancy across the study area
- In addition to the habitat assessment points, collect habitat variables at all Diana fritillary observation points
- Change the habitat variables being collected:
  - Eliminate variables that these preliminary analyses do not indicate are important
  - Add forestry-relevant variables (e.g., basal area and treatment type) to better understand and describe the impacts of management
- Consider remotely sensed data (e.g., habitat classifications and soils) for conducting analyses at larger scales

These changes will focus the efforts of the RRT, ensuring we are collecting sufficient high-quality data to address our stated research objectives. They will also ensure the collected data are robust enough to support the intended analyses, which will support the development of meaningful management guidelines for this species on state and NAFO member company lands.

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