

Frosted Elfin Habitat and Butterfly Survey Protocol

U.S. Fish and Wildlife Service, December 2020

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Frosted elfin butterfly (*Callophyrus irus*) (Credit: Ryan Bell, USFWS)

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Introduction

The U.S. Fish and Wildlife Service (USFWS) completed an [interim species status assessment \(SSA\) for the frosted elfin \(*Callophyrus irus*\)](#) in April 2018, which provides a summary of the species' biological information and needs, the factors influencing species viability, and its current condition. The interim SSA revealed that 86% (n = 381) of populations of frosted elfin exhibit an "unknown"¹ status (USFWS 2018). The overarching goals of this survey protocol are to help standardize data collection and reduce the uncertainty around these unknown populations.

Specific survey objectives include:

- 1) Estimate the amount, extent and quality of frosted elfin habitat;
- 2) Document the presence or probable absence of the species and obtain data to estimate the probability of detection for future studies;
- 3) Derive an index of relative abundance of volant² frosted elfin in habitat patches; and
- 4) Describe the correlation, if one exists, between habitat condition and relative abundance of volant butterflies.

Field Method Overview

Establishment of sampling units

Populations

Frosted elfin populations occupy patchy networks of habitat defined by the presence of their host plants. Our current definition of a frosted elfin population suggests they can be distinguished from one another by greater than 2 kilometers (km) of unsuitable habitat between native lupine species or wild indigo patches or by 10 km segments of suitable habitat (e.g., rights-of-way) (USFWS 2018). Therefore, all host plant patches within 2 km of each other will eventually be considered as part of one population. In most cases, GIS will be used to check the distance among patches of habitat and aggregate neighboring patches into one population of frosted elfin butterflies. Delineating populations is not necessary to conduct surveys. When complete, the survey data will help delineate populations by establishing patch locations.

Sites

For the purpose of the surveys, the term site refers to a group of habitat patches that will be accessed for surveys from a common access location, without applying any of the criteria used

¹ **Unknown** - At least one survey has indicated presence of frosted elfin AND currently: habitat appears suitable for frosted elfin, but no butterfly surveys have been conducted in recent (10) years; or habitat appears suitable, no butterflies have been observed during recent (10) years, but survey effort is considered insufficient to suggest "presumed extirpated"; or there is no information to indicate habitat condition or number of frosted elfin butterflies observed during last count.

² Adults capable of flight

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for delineating populations. In practice, such patches are associated only for the convenience of surveys or land ownership logistics--how they are aggregated into populations will be addressed using GIS. It is possible that a network of habitat patches is so extensive that it cannot all be accessed from one location and may be divided into two sites. Survey Sites will be evaluated under SOP1. You can conduct counts for individual patches and note if they are part of the same site.

Patches

Formally, the sampling unit for our survey is the habitat patch containing the host plants. The observer will walk through the area occupied by the plants, moving between fixed beginning and end points, attempting to observe most of the plants within the area. We recommend that the beginning and endpoints be marked and recorded with GPS to ensure the area covered by the observers is consistent. During the habitat condition scoring, the observer will use one of several methods to record a line around the host plants and record the area within. Patch boundaries will only need to be modified when considerable habitat changes occur that modify the habitat. Although survey sites may not change from year to year, patch boundaries should be verified every year, especially at locations engaged in substantial habitat manipulation.

Pre-survey coordination logistics and preparation

Coordinate with the State agencies holding jurisdiction for the frosted elfin, wild indigo, or wild blue lupine to identify:

- 1) Laws protecting frosted elfin, wild indigo, or wild blue lupine;
- 2) Permits, if any, required for surveying butterflies, such as scientific collection permits from State natural resource agencies;
- 3) Procedures for validating State records--it is important to affirm that new or changed records are valid because they will form the basis of a future listing decision;
- 4) Priority locations to survey; and
- 5) Contacts for initial survey data submission and quality control--many States have identified biologists to review new data before submitting it to the USFWS.

Please coordinate with the USFWS in advance of the survey season and before beginning data entry:

- In order to provide quality control and ensure users receive proper guidance on the submission process, the USFWS is requesting that participants register as described under ***Data submission procedures*** before beginning the surveys.

Planning for field work should begin well in advance of the flight initiation. For example:

- Known patches of host plants can be scouted, verified and delineated prior to initiation of habitat evaluation; and
- Equipment needed for surveys should be ordered and contact should be made with landowners regarding survey plans or other logistics.

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Equipment List:

- Handheld mechanical counter
- Handheld thermometer or weather station
- Pencils
- Data sheets A, B, C, D
- Clipboard
- Plastic cover for data sheet
- Wire stake flags and/or flagging (biodegradable preferred)
- GPS unit (or phone or tablet if using for GPS coordinates)
- Phone or tablet if using Survey123
- Binoculars
- UV light (see SOP 4)
- Insect sweep net (recommended)
- Glass jar
- Optional: laptop or portable computer to enter data into spreadsheet

Field data collection procedures

The SOPs describe four phases of a comprehensive survey:

- Conduct a preliminary site evaluation (SOP 1)
- Delineate host plant patches and conduct butterfly counts (SOP 2)
- Score habitat condition within patches (SOP 3)
- Surveying for frosted elfin larvae with Ultraviolet light (SOP 4)

We recommend that both Survey123 and paper datasheets be used to record data in the field. This provides data security through the electronic submission of data as soon as it is recorded, as well as the creation of a hardcopy backup that can be used for quality assurance/quality control.

Registration and data submission procedures

The USFWS has developed data management support tools that are available to assist with data submission and to ensure your data contribute to the frosted elfin status assessment. Frosted elfin data may be submitted to the USFWS: (1) in an excel spreadsheet data form, or (2) online through ArcGIS Survey123.

In order to provide quality control and ensure users receive proper guidance on the submission process, the USFWS is requesting that participants register. Please visit <https://www.fws.gov/northeast/frosted-elfin/survey.html> for more information on registration.

Recognizing State authority for frosted elfin, before accepting the new data, the USFWS will take measures to ensure they receive appropriate review by States:

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Data Submission Approach: State review of the data occurs after individuals conducting surveys have submitted it to the USFWS. In this approach, individuals will e-mail spreadsheets to renee_farnsworth@fws.gov, or enter it in Survey123. The USFWS will compile all of the data for each state and make it available for review before it is integrated in future status assessment updates. Please include “frosted elfin data” in your email subject line.

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SOP 1: Preliminary Site Evaluation

For the purposes of these protocols, a site is a group of habitat patches that can be accessed from one entry point or are contained within one property. Preliminary site evaluations are needed to identify or reconfirm potential frosted elfin habitat. Important outcomes of this evaluation are:

- 1) Generation of a list of survey sites; and
- 2) Documentation of sites where former habitat has been degraded, converted, or mischaracterized.

Site evaluations may involve conducting a general field inspection of previously known patches that have not been visited in recent years, as well as potential new habitat patches. It also involves observing features, including ecological communities, improved areas, infrastructure, and access. The evaluation should indicate any areas to exclude from future surveys, as well as those to include. Sites that are well-known from recent surveys, analysis of remote sensed data, and/or local knowledge may not require a field visit. On-site approaches to detect host plants are described below.

Objective 1.1: Complete the Site Assessment Information Section of Data Sheet A: Frosted Elfin Preliminary Site Assessment

On Data Sheet A, complete the fields under the SITE ASSESSMENT INFORMATION section of the data form as follows:

Evaluator Name: First and last name of the person who is evaluating the site.

Evaluator Email: Email address of the person who is evaluating the site.

Evaluator Affiliation: Organization of the person who is evaluating the site.

Evaluator Phone: Phone number of the person who is evaluating the site.

Evaluation Date: Date you are evaluating the site. Use this format YYYY-MM-DD.

State: Postal abbreviation of the state in which the site is located.

Town: Name of the town where the site is located.

Site Name: Name of the site (or property) commonly used by the organization responsible for the survey (if applicable). If a site name does not exist, assign one based on a nearby landmark, such as the street name. **The same name should be used for the same site on data sheets A, B, C, and D.**

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Objective 1.2: Obtain and document access information

1.2.1 Gain permissions

Obtain necessary permissions to inspect each site and be prepared to provide documentation on demand while in the field. For future surveys, if landowner permission is required, describe the procedure for obtaining permission including contact information. If the landowner grants permission but desires anonymity, omit any sensitive information.

1.2.2 Complete the ACCESS INFORMATION section of Data Sheet A

Here you will document information about the property location and how to gain permission. Use a GPS unit to record the general location of the site. There can be many patches of habitat on a site, each requiring a separate count (see SOP 2). For ease of access, we recommend recording a GPS point at the access point for the site. For the sake of consistency, we recommend using the WGS84 coordinate system and recording the coordinates in decimal degrees. Always double check the coordinate system on your device to ensure it is set to WGS84.

On Data Sheet A, complete the fields under the ACCESS INFORMATION section of the data form as follows:

Site Owner(s): Enter the name of the agency/organization that owns the property. For sites comprised of separate ownerships, list each. For private lands, enter “private”.

Access Address: Enter the address or nearest intersection of the primary property through which access to the survey site is necessary or granted.

Will Access be Available Consistently for This Year’s Surveys?: Enter “Yes” if access is anticipated throughout the current survey season. Enter “No” if access is not anticipated throughout the season.

Access Description: Describe permission and access confirmation procedures. Describe the best location for parking. From the parking site, provide directions to reach the host plant population, including compass direction, landmarks, paths, roads, or trails.

Access Latitude: Enter the latitude coordinates for the parking location to access the site in WGS84 decimal degrees (to the sixth digit) in the following format: 00.000000.

Access Longitude: Enter the longitude coordinates for the parking location to access the site in WGS84 decimal degrees (to the sixth digit) in the following format: -00.000000.

Objective 1.3: Confirm the habitat is suitable for surveys

1.3.1 Review the survey history and remote sensed information about the site

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If the site is not one that you or your colleagues are familiar with, there are multiple sources of information to help determine where previously documented or potential sites may occur. For example, you can consult historical records, State Natural Heritage Programs and natural resource agency staff, subject-area experts, and online digital resources. Most counties in every state contain soil surveys with descriptions and maps. Many of these documents have been digitized and are available on the internet, or they can be accessed through local Natural Resources Conservation Service offices. Consult satellite images, aerial photos, or GIS land cover layers to locate areas with sandy soils.

On Data Sheet A, complete the SURVEY HISTORY section of the data form as follows:

FE Recorded Before?: Circle “Yes” if a FE have ever been reported on the site, “No” if the species has not been confirmed by a prior survey, and “Unknown” if there is no information about prior surveys;

HP Recorded Before?: Circle “Yes” if the host plants (wild blue lupine or wild indigo) have ever been reported on the site; “No” if they have never been reported; and “Unknown” if there is no information about prior surveys.

1.3.2 Complete the fields under the CONFIRM HABITAT section of Data Sheet A

A site evaluation should only occur when host plants are likely to be observed. The detection of these species may be highest when they are in flower, but earlier detection will allow time to prepare for butterfly counts. There should be no snow cover in the search area and the timing should coincide with the host plants emergence early in the growing season. Wild blue lupine and wild indigo are among the first herbaceous plants to begin their development in the spring, therefore their early green leaves will appear in contrast to the surrounding leaf litter and brown vegetation, as early as late January in the southernmost states to late April in northern states. Look for places where plants will green-up first (sunny areas or southern facing edges of canopy cover).

For seasoned field biologists, observation may be possible by finding stems, leaf litter, and seed pods from the preceding season. To find signs from the preceding season, it is essential that you know the precise location of the last observations, are able to identify any persistent parts of the plant, are familiar with growth form and preferred site conditions, and have a familiarity with typical co-occurring plants such as little bluestem grass. If you know where to look, a basal cluster of broken stems may often persist after the full-length stems have broken off. Dried stems and leaf litter persist longer in a recognizable form when they are upright, entangled, or resting on neighboring vegetation. Former flowering stems with persistent erupted seed pods are the most detectable and easily identifiable part of plants that have senesced.

If host plants are present, butterfly surveys should begin (SOP 2) soon after the host plants emerge in the spring and the habitat assessment should be completed during the flowering

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period (SOP 3). **If it will only be possible to visit a site one time, complete SOPs 1-3 at that time, even if host plant or frosted elfin phenology are less than ideal.**

On Data Sheet A, complete the CONFIRM HABITAT section of the data form as follows:

Habitat Indicators: Circle “Yes” if soil, natural community, or indicator plants can be confirmed through remote sensed information or by direct observation on site. Specific indicators include sandy soil and xeric natural community plants like pines, shrub oaks, and little bluestem grass. Circle “No” if habitat indicators are not present;

Host Plant Confirmed: Circle “Yes” if the host plant has been confirmed on the site within the past year, and “No” if the host plant has not been found within the past year;

Factors Contributing to the Exclusion of All or Part of Site: Circle each of the factors that disqualify a part or all of the site:

- ***Agriculture:*** exclude only active row-cropped agricultural lands and fallow fields [Note that other open agricultural areas may support host plants and may be included];
- ***Active Management:*** exclude areas with ongoing land management, forestry, or construction operations that will temporarily impede surveys, access, or habitat phenology;
- ***Mowed/Lawn/Hay:*** exclude areas regularly mowed during the growing season including lawns and some hay fields [Note that warm season grasses, such as little bluestem grass, are typically not harvested until after host plants have senesced and flight period is complete and may be included];
- ***Paved/Developed:*** exclude paved and non-vegetated developed areas such as parking lots, buildings, and roads;
- ***Closed Canopy:*** exclude areas with >50% canopy cover (only if there are no openings, trails, or paths through such areas); such areas will have shade for most or all of the day;
- ***Wet Soil:*** exclude areas with non-sandy or poorly drained soils;
- ***Thick Vegetation:*** exclude areas with complete shrub or herbaceous cover other than the host plant;
- ***Imminent Conversion:*** exclude areas where conversion/development of the habitat is immediately imminent.

Recommend Site for Frosted Elfin Surveys? Circle “Yes” if you recommend surveying the site for frosted elfin **because the host plant is known to be present** and the combination of historical information, remote sensing, habitat indicators, and/or prior surveys confirm potential habitat suitability for frosted elfin. Circle “No” if the host plant is NOT known to be present and the evidence indicates the habitat DOES NOT merit survey effort. If “No,” the survey for the site is complete (SOP 2 and SOP 3 are not used), but it is very important that information from Data Sheet A be recorded and submitted in order to document the current status of the site.

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Description of Host Plant Patch Location(s) within Site: Note the approximate location of separate host plant patches within the property; include a bearing from the access point. Precise locations will be documented during the habitat assessment (SOP 3).

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SOP 2: Marking the Host Plant Patch and Conducting Butterfly Counts

After completing the preliminary site evaluation and affirming that the site satisfies the criteria for frosted elfin counts (SOP 1), the next step is to mark the host plant patch(es) within the site as early as possible. Keep in mind that this is a preliminary delineation of the host plant patch(es), which helps decide where to locate butterfly count transects. Although it is advisable to mark the host plant patch location(s) as soon as possible after completing SOP 1, it is **essential to wait for the immature plants to be clearly visible first**. The final delineation of the patch(es) should be conducted when the host plants are in **peak flowering, 4-8 weeks after new growth emerges in the spring (SOP 3)**. If it is only possible to visit a site one time, complete Data Sheets A, B, and C at that time, even if host plant or frosted elfin phenology are less than ideal.

Objective 2.1: Complete the COUNTING EVENT INFORMATION section of Data Sheet B: Frosted Elfin Patch Count

On Data Sheet B, complete the COUNTING EVENT INFORMATION section of the data form as follows:

Observer Name: First and last name of the person who is making the observations.

Observer Email: Email address of the person who is making the observations.

Observer Phone: Phone number of the person who is making the observations.

Observer Affiliation: Organization of the person conducting the observations.

Others Present: First and last name of the person(s) recording the data or helping the observer.

Survey Date: Date you are conducting the count. Use this format YYYY-MM-DD.

State: Postal abbreviation of the state (e.g., MA) in which the site is located.

Town: Name of the town where the site is located.

Site Name: Name of the site (or property) commonly used by the organization responsible for the survey (if applicable). **Use the same name used for the same site as recorded on Data Sheet A. The same Site Name must be used every time a site is visited.**

Patch ID: Name of the patch using the following convention [SiteName-XX] where XX is a number assigned to the patch by the surveyors. For each site, begin the patch numbering with 01 and continue in sequence [02, 03, 04...]. Do not use spaces and do not abbreviate the Site Name. **The same Patch ID must be used every time the patch is visited within the year.**

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Objective 2.2: Describe the location of the host plant patch to determine the start and end points for butterfly surveys

2.2.1 Mark the location of the patch

If permissible and necessary, use flagging tied to vegetation to mark the path to the host plant patch(es) so that each patch can be easily located on return visits. Record any helpful tips on locating the patch(es) on data sheet.

2.2.2 Delineate the patch and set up start and end points for butterfly survey

The purpose of delineating the host plant patch is to:

- 1) Know where you will later survey for butterflies; and
- 2) Generate an estimate of the area occupied by *most* of the host plants.

The host plant patch will vary in extent from year to year--new plants will grow and some plants will die. Therefore, the patch delineation should be conducted each year. As the growing season advances, your understanding of the patch dimensions may change. Initially, we recommend visually delineating the patch early in the season. Later, when the plants are in flower and it is time to conduct a habitat assessment, it will be necessary to use mapping tools to delineate the perimeter of the patch. SOP 3 describes several methods for *recording* a line around the patch--these methods will be used to allow you to estimate the area of the patch for the habitat assessment.

To get started early in the season, before you begin walk-through butterfly counts you need to do your best to approximate the dimensions of the patch so you can set up starting and ending points of your walk-through count, which **MUST** remain fixed throughout the season.

2.2.3 Record start and end coordinates associated with each walk-through count

Each patch in which a walk-through count is made should have well-defined start and end locations. While the exact path of the walk-through might vary from count-to-count due to variable flowering phenology of individual host and nectar plants, the start and end points should remain fixed.

The start and end points should be determined before the first count is conducted. It is not necessary to wait for butterflies to be observed before marking the count transect--they may not be present in the host plant patch. However, it is acceptable to mark the transect after the butterfly flight period has already started.

Please record the coordinates of the start and end points (using the WGS84 coordinate system in decimal degrees) and mark them on site using flagging, stake flags, etc.

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Please take a photograph from the start location looking across the patch toward the end location. This step is for your records and is not a part of the data submission process.

On Data Sheet B, complete the PATCH LOCATION INFORMATION section of the data form as follows:

Start Latitude: Enter the latitude coordinates for the starting point of the butterfly count transect in WGS84 decimal degrees (to the sixth digit) in the following format: 00.000000.

Start Longitude: Enter the longitude coordinates for the starting point of the butterfly count transect in WGS84 decimal degrees (to the sixth digit) in the following format: -00.000000.

End Latitude: Enter the latitude coordinates for endpoint of the butterfly count transect in WGS84 decimal degrees (to the sixth digit) in the following format: 00.000000.

End Longitude: Enter the longitude coordinates for the endpoint of the butterfly count transect in WGS84 decimal degrees (to the sixth digit) in the following format: -00.000000.

Description of Count Path Location: Enter a description that others can use to find the count path location. Please use landmarks, landforms, compass direction, distance, a map screenshot, etc.

2.2.4 Re-evaluate walk-through navigation on each count occasion to ensure maximum encounters with flowering host and nectar plants

Host and nectar plants within a patch develop, mature and bloom at different rates. As early blooming plants senesce, younger plants that are more vigorous become attractive to butterflies. Consequently, the exact path between start and end locations will require some adjustment to maintain high encounters with plants in the proper phenological stage of development. Typically, subtle shifts in the direction and distance of the path will be sufficient to accommodate changing plant phenology.

Objective 2.3 Complete the walk-through count of frosted elfin butterflies

The primary purpose of counting butterflies is to establish, with as much confidence as possible, the presence or absence of frosted elfin at each site. Butterflies will be detected (or not) through a series of three walk-through counts in each designated habitat patch. The counts are not intended to estimate absolute population size. Rather, they are meant to provide an index (potentially related to the relative quality of the habitat patch). Consequently, emphasis is placed on repeatability and replication. Repeatability is important because it increases the quality of the data by reducing variability due to factors other than real changes in the number of butterflies present. Repeatability is attained through standardization of the count methodology, which includes the environmental criteria and proper timing. Replication is critical because it informs us about the probability of detection. Replication is achieved by visiting the patch and making counts on multiple occasions throughout the flight duration. If zero adults are observed after all

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replications of walk-through counts are complete, then UV light surveys for larvae are implemented (see SOP 4).

Adult frosted elfin have one flight period per year. Depending on site latitude, flight initiation can occur from mid-February to late-May. However, the timing of the flight periods can vary by as much as 2 to 3 weeks from year-to-year due to weather and microclimatic influences. The flight duration lasts from 2 to 6 weeks, though it too can vary substantially from year-to-year. Because the flight period and duration cannot be reliably predicted, several visits may be needed prior to confirmation of flight initiation. Communication with partners and USFWS/State coordinators will also help to refine the counting window for any particular year.

Counts should be conducted by an individual knowledgeable in butterfly identification. Identification photographs of butterflies are available in Appendix A. **Please note that scientific collector permits may be required by State natural resource agencies for butterfly surveys. Allow for adequate processing time to ensure that permits are in place prior to the flight period.** Photographs should be taken by netting a butterfly and placing it in a glass jar. Before using this method, obtain a permit or confirm that a permit is not required to handle frosted elfin in your state.

At first, it will seem almost impossible to confidently differentiate frosted elfin from other elfins. It will be somewhat uncommon but entirely possible to see frosted elfin alongside look-alike elfins, such as the hoary, brown, pine or Henry's elfin. Several identification tricks will help with identification from a distance (also see [Appendix A](#)):

- Frosted elfin activity will be most **focused within host plant patches and open sunlight**, while their look-alikes tend to be more concentrated in pines and around blueberries, bearberry, holly, and buckthorn;
- Both sexes of frosted elfin will be seen **landing on the host plants** to perch or search, with females flying in and around the plants seeking sites to lay eggs, males patrolling above the plants to chase away other males, and both males and females **swirling upward in courtship flights**; each butterfly species has a distinctive flight rhythm and pattern that is adapted to different behaviors, study these early and you will quickly recognize species by their flight;
- The **body and wings are lighter** in color on the Frosted elfin than the look-alikes, with less contrast in tones across the underside of the wings, and **frosting only on the hindwing**;
- **The look-alikes are darker and smaller.**

2.3.1 Record environmental conditions present during the count

Conduct counts only during optimal weather conditions as listed below:

- When temperatures are 65-95°F;
 - If temperatures are between 65-70°F, counts should only be conducted under mostly sunny skies with calm to light wind;

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- If temperatures are above 70°F, there are no restrictions on cloud cover
- When winds 5-6 ft above ground are less than 20 mph;
- When it is not raining, except that counts can continue through very light rain if the sun is shining and the temperature is at or above 75°F. Please Note: not more than 1 patch visit per flight period should occur under these conditions.

Delay counting after heavy rain until the vegetation and the butterflies have had a chance to dry.

Local temperature can be read from the nearest meteorological station accessed on your smartphone (record the station name on the datasheet) OR if possible, record site temperature from a handheld thermometer, or digital temperature recording device (e.g., Kestrel). Record this information on the data sheet for each walk-through count.

On Data Sheet B, complete the ENVIRONMENTAL DATA section as follows:

Site Air Temp (F): Record the air temperature at the count starting point in degrees Fahrenheit using a handheld thermometer or weather-station at the site.

Local Air Temp (F): This data should only be collected if you **cannot** measure the site temperature in person (above). Record the temperature during the count from the nearest meteorological station in degrees Fahrenheit.

Cloud Cover: Record cloud cover by circling one of the following choices:

- **Clear:** the blue sky is completely visible most of the time;
- **Partial:** the blue sky is only partially visible most of the time;
- **Overcast:** most of the time the blue sky is not visible.

Wind: Record the wind level by selecting from the following simplified Beaufort scale:

- **Calm:** calm, smoke would rise vertically if present;
- **Light:** light breeze, leaves rustle, wind felt on face;
- **Moderate:** moderate breeze, small branches are moving; (*note: butterfly counts should not be conducted under these conditions*).
- **Strong:** strong breeze, large branches and small trees are in motion (*note: butterfly counts should not be conducted under these conditions*).

Precipitation: Record the precipitation by selecting a level from the following scale:

- **Dry:** although it might be humid, there is no mist, fog, or rain;
- **Light:** a light mist, fog, or drizzle can be felt on face but does not soak clothing;
- **Moderate:** a steady rain is falling and clothes will eventually soak through (*note: butterfly counts should not be conducted under these conditions*);
- **Strong:** a heavy rain is falling and clothes with soak through quickly (*note: butterfly counts should not be conducted under these conditions*).

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Conservation Security: If you have this information, record the level of conservation security by selecting a level from the following scale:

- **None:** no protections are in place to protect the patch or butterflies;
- **Partial:** some potentially harmful forms of access (such as motorized vehicles), land use (such as regular mowing), or activity (such as trampling) are restricted, but others are allowed;
- **Full Protection:** the habitat is fully protected from development and potentially harmful forms of access, land use, and activities are prohibited.

Impact Level: Record the current threat level by selecting from the following scale:

- **None:** On-site threats are negligible;
- **Low:** On-site threats have resulted in impacts to part of the patch;
- **Moderate:** On-site threats have resulted in impacts to most of the patch;
- **High:** On-site threats have resulted in loss of the patch.

Threats Present: Circle each of the threats that are present in the patch or near enough on the site to warrant concern:

- **Vehicular:** vehicular activity is not contained to roads or tracks and is impacting the habitat patch;
- **Human:** human activity is not constrained to trails, campsites, or other designated areas and is impacting the habitat patch;
- **Chemical:** chemicals, including herbicides and/or pesticides, are evident nearby;
- **Succession:** vegetation is encroaching on host plants and/or shading the patch;
- **Invasive Species:** invasive species are present on the site and the patch is susceptible to colonization;
- **Development:** roads, parking lots, buildings or other development is impacting the patch;
- **Browse:** deer and/or other herbivores are targeting host plants in the patch;
- **Mowing:** the patch has been mowed during the flight period of the frosted elfin or during the growing season of the host plant;
- **Forestry:** forestry equipment, logs, and or slash are present in the patch during the flight period of the frosted elfin or during the growing season of the host plant;
- **Burning:** fire has been present in the patch during the flight period of the frosted elfin or during the growing season of the host plant;
- **Grazing:** cattle or other grazers are impacting the patch by trampling or incidentally eating the host plant;
- **List Other Threats Below:** use the space to enter other threats.

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2.3.2 Conduct the walk-through count

Standing at the start location, with the patch boundary in mind, visualize a path that maximizes view of host and nectar plants from beginning to end without stepping on host plants.

Follow a path that will allow you to view the entire patch, without doubling back onto ground already traversed. Your path should pass nearer to areas most densely populated with the host plants, recognizing you may need to observe lower density areas from further away.

Record the start time and begin walking. Because the exact path selected for each walk-through may vary from count to count, it is important that start and end times be recorded on the data sheet every time a count is conducted³. We suggest recording both times using the hh:mm format. Do not round-off minutes as this will bias the count duration calculation. If using a stopwatch to record the duration of the count, record the exact start time (i.e., hh:mm), then add the duration to obtain the end time.

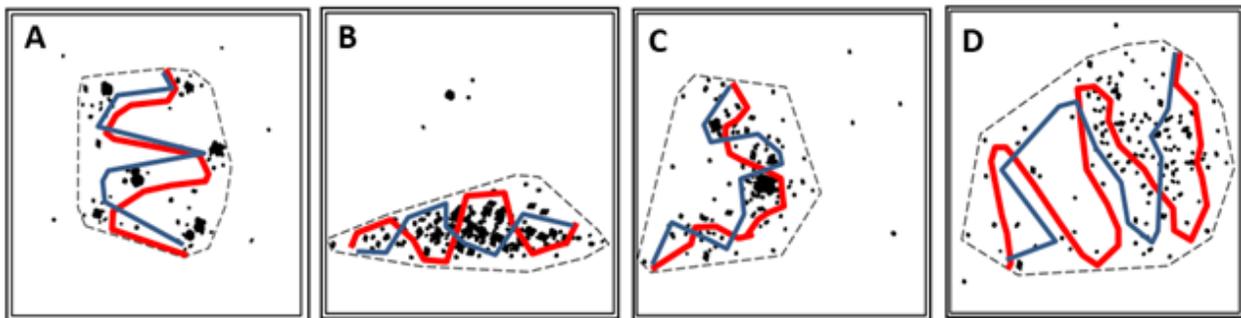


Figure 1. Walk-through count paths. Colored lines represent possible paths. Observers will mark a fixed beginning and end point, but the path may vary somewhat each count. The path should weave through the patch allowing the observer to view the areas most densely populated by host plants, but without doubling back. Observers may need to step over plants to avoid trampling. Try to walk near most of the plants and observe closely--it will be easiest to visually confirm butterflies at rest on the plants. Do not attempt to net butterflies until the count is complete and only with necessary permits

Walk slowly but at a steady pace. Keep eyes forward a short distance ahead but regularly glance toward your feet and about 10 feet ahead and on either side. This will help you to maintain a straight course and avoid trampling plants.

We suggest tallying the number of butterflies encountered with a handheld, mechanical counter.

Avoid the tendency to slow down as you encounter many butterflies and speed up when there is not much to see. [Note: in advance of conducting a butterfly count, you can practice maintaining

³ The elapsed time (i.e., difference between the start and end times) will be used as a yardstick with which to scale the number of butterflies counted.

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a slow and steady pace while simultaneously tallying randomly strewn objects (e.g., white-colored bottle caps or other small objects) across the ground.]

Record the end time, butterfly tally, and end coordinate when completed.

On Data Sheet B, complete the FROSTED ELFIN COUNT DATA section as follows:

Start Time: at the transect starting point, enter the time in the hh:mm format and immediately begin walking;

Adult Count: as you walk, click the counter or count out loud for each frosted elfin butterfly you see, then enter your final tally;

End Time: stop walking at the transect end point and enter the time in the hh:mm format;

Adult ID Method: circle the method(s) you used to attempt to confirm adult ID. Always attempt to take a photograph of the underside of the wings if you are uncertain of your identification:

- **Sight:** adult(s) diagnostic features were observed by sight without handling during or after the count;
- **Net:** adult(s) diagnostic features were observed on captured individuals before or after the count (*NOTE: follow any state permitting requirements regarding use of nets or capture*);
- **Photo:** diagnostic features were observed by photograph before or after the count--please be sure to record the email of the person who can provide this photo upon request in "Photo email" section below;

Adult ID Confidence: Circle "confident" or "uncertain" to indicate your confidence in the identification you made.

- **Confident:** the method(s) used provided a confident identification;
- **Uncertain:** none of the above methods provided a confident identification.

Count Notes: Record relevant information about the count that may indicate why a count was higher or lower than expected, if a count was limited by any circumstances, etc.

2.2.3 Repeat walk-through counts for the flight duration

Each patch should be visited and a walk-through count completed at least weekly throughout the flight duration. **Minimally, each patch should have no fewer than 3 counts made, each separated by 4 to 7 days.** If all walk-through counts produce **zero adult observations**, then **larval UV light surveys** are implemented (see SOP 4).

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Objective 2.3 Verify patch occupancy using non-adult life stages (optional)

Because butterflies eclose at different rates, encounters with volant adults will be variable from one count to the next. In fact, it is plausible that no flying butterflies are counted, despite evidence of larval activity. In situations where butterflies were not detected during the three walk-through counts (or when the ID of adults was uncertain), we recommend recording any evidence of eggs or larval activity on host plants. Document any eggs, larvae, or larval feeding damage with photographs for experts to confirm field identifications. Eggs are typically laid in the apical shoot of wild indigo or in the young flower stalks and buds of lupine. They usually hatch into larvae about two weeks after oviposition. Larvae feed for approximately 5 to 6 weeks and leave visible damage to host plant flowers, seedpods, leaves, and stems.

On Data Sheet B, complete the VERIFICATION DATA section (if adults have not been confirmed at the site) as follows:

Egg Present: circle “Yes” if possible frosted elfin eggs were found and “No” if they were not;

Larvae Present: circle “Yes” if possible frosted elfin larvae were found and “No” if they were not;

Feeding Present: circle “Yes” if signs of possible larval feeding found and “No” if they were not;

Photo(s) Taken: circle “Yes” if clear photos were taken of the observed stages or feeding and “No” if photos were not taken;

Photo Stage(s): circle each of the stages or signs that were photographed for verification of any stage: egg, larvae, or feeding damage;

Photo Email: enter the email of the person who can provide photos upon request; photos will not be submitted unless they are requested.

Photo Notes: Record the file name of the photo or other identifying information so that you know which patch the photo was taken at. This may include information about pictures of adults recorded during the same survey.

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SOP 3: Frosted Elfin Habitat Rapid Assessment

The purpose of this component of the frosted elfin survey is to provide a rapid assessment of the quality and abundance of habitat available to the species. SOP 3 should be completed when the host plants are in **peak flowering, 4-8 weeks after new growth emerges in the spring**. If it is only possible to visit a site one time, complete the habitat rapid assessment and other protocols at that time (Data Sheets A, B, and C), even if host plant or frosted elfin phenology are less than ideal.

Objective 3.1 Document the basic survey information for the patch

3.1.1 Complete the survey information section of the data form

On Data Sheet C, complete the HABITAT ASSESSMENT INFORMATION section of the data form as follows:

Observer Name: First and last name of the person who is making the observations.

Observer Email: Email address of the person who is making the observations.

Observer Phone: Phone number of the person who is making the observations.

Observer Affiliation: Organization of the person who is making the observations is affiliated with (if applicable).

Others Present: First and last name of the person(s) recording the data or helping the observer.

Assessment Date: Date you are conducting the habitat assessment. Use this format YYYY-MM-DD.

State: Postal abbreviation of the state where the site is located.

Town: Name of the town where the site is located.

Site Name: Name of the site (or property) commonly used by the organization responsible for the survey (if applicable). **Use the same name used for the site on Data Sheet A and B.**

Patch ID: Name of the patch using the following convention [SiteName-XX] where XX is a number assigned to the patch by the surveyors. For each site, begin the patch numbering with 01 and continue in sequence [02, 03, 04...]. Do not use spaces and do not abbreviate the Site Name. **Use the same Patch ID used for this patch on Data Sheet B.**

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Objective 3.2 Estimate the area of the host plant patch

There are three methods provided for estimating and recording the area of host plants described in Appendix B. We do not require any shapefiles of host plant patches; however, we are happy to receive that information.

3.2.1 Determining where to draw the polygon

First, walk around the host plant patch and try to include any obvious host plants. If you see a single plant that is much further afield than the others, and if you would have to go out of your way to include it, exclude it. The goal is to end up with a somewhat rounded or elliptical polygon that contains most of the plants and some empty space. The shape may be somewhat irregular, but it must be convex. Avoid a jagged or star-shaped line that attempts to include every plant and eliminate open space. Review **Figure 2** for guidance on how to draw the line around the patch. Some patches will be small with dense host plants, some large and sparsely populated, and others will have heterogeneous host plants.

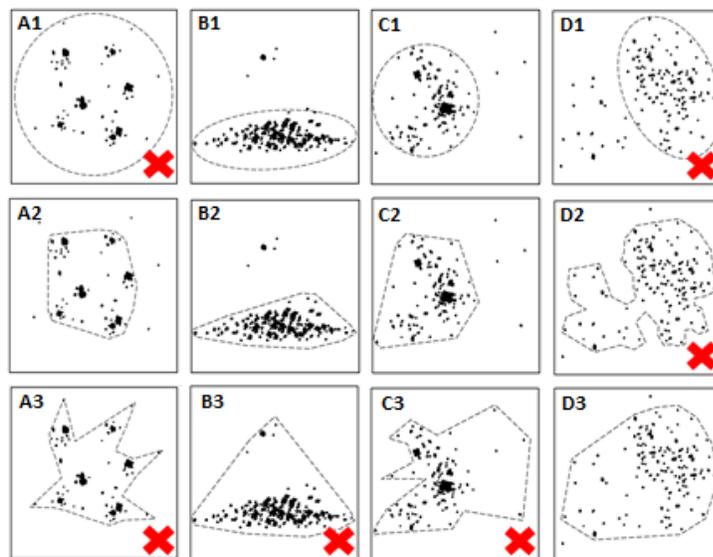


Figure 2. Examples of drawing a line to delineate the host plant patch. The red X indicates an improper delineation. A1 has included outliers inflating the area. A2 is correct because it is a close-fitting convex polygon. A3 is not convex. B1 and B2 efficiently include most of the plants and exclude outliers. B3 includes outlier plants that should be excluded. C1 and C2 properly exclude outliers. C3 includes unnecessary outliers and is not convex. D1 has erroneously excluded plants that are contiguous but lower density. D2 is not convex. D3 is convex and includes the lower density part of the patch while excluding outliers.

Now draw the line and estimate the patch area using one of the methods in [Appendix B](#).

3.2.2 Record the patch delineation data

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On Data Sheet C, complete the HABITAT AREA section as follows:

Habitat Area: Estimated area of the habitat patch using *hectares*, up to two decimal places. It is advisable to file a map or image of the patch with other survey information for your records, but this does not need to be submitted as part of the data entry process.

Centroid Latitude: Enter the latitude coordinates for the centroid point of the habitat patch. Use WGS84 decimal degrees (to the sixth digit) in the following format: 00.000000.

Centroid Longitude: Enter the longitude coordinates for the centroid point of the habitat patch. Use WGS84 decimal degrees (to the sixth digit) in the following format: -00.000000.

Objective 3.3 Estimate Vegetation Cover

The purpose of estimating and recording vegetation structure is to provide information that can be used to understand whether invasive species or natural succession are a threat to the viability of the host plant population, and thereby prioritize sites for land management.

3.3.1 Estimate the cover of structural layers of vegetation

The growth of vegetation surrounding the host plant populations influences their microclimate and limits light, water, and nutrient availability. Without appropriate conditions, the host plants cannot spread and their seeds may be unable to germinate and become established as new plants. Estimating the cover classes for the structural layers provides insight into the viability of the host plant population.

On Data Sheet C, complete the COVER DATA section as follows:

Canopy Cover: The purpose of this field is to estimate how much the host plant is shaded by selecting an approximate cover class. Circle one of the following choices on the data sheet:

0 - 10%: Nearly all host plants are in full sun for the whole day.

11 - 30%: Many host plants have some shade part of the day.

31 - 60%: Most host plants have some shade during the day.

61 - 100%: Most host plants have shade for most of the day

Grass/Herb Cover: The purpose of this field is to estimate how much the host plant is being encroached upon by herbaceous plants of other species by selecting an approximate cover class. Circle one of the following choices on the data sheet:

0 - 10%: Few host plants have herbaceous plants near them.

11 - 30%: Some host plants have herbaceous plants encroaching on them.

31 - 60%: Many host plants have herbaceous plants encroaching on them.

61 - 100%: Host plants are mostly surrounded by herbaceous plants.

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Shrub Cover: The purpose of this field is to estimate how much the host plant is shaded by selecting an approximate cover class. Circle one of the following choices on the data sheet:

- 0 - 10%: Nearly all host plants are in full sun for the whole day.
- 11 - 30%: Many host plants have some shade part of the day.
- 31 - 60%: Most host plants have some shade during the day.
- 61 - 100%: Most host plants have shade for most of the day

Bare Ground Cover: The purpose of this field is to estimate how much bare soil is available for seeds to germinate on by selecting an approximate cover class. Circle one of the following choices on the data sheet:

- 0 - 10%: Host plants have negligible bare soil around them.
- 11 - 30%: Host plants have mostly vegetation with some bare soil nearby.
- 31 - 60%: Host plants have bare soil, litter and some vegetation nearby.
- 61 - 100%: Host plants are mostly surrounded by plant litter and bare soil.

Objective 3.4 Identify the host plants

The purpose of this section is to identify the species of host plant(s)⁴ in use by the frosted elfin butterfly.

3.4.1 Document host plant species and identify the dominant host plant species

On Data Sheet C, complete the HOST PLANT SPECIES DATA section as follows:

HP Present: Circle each of the host plant species that are present. If you cannot make a reliable identification of *Baptisia* species on site, take photos or collect samples and seek guidance later. If you cannot resolve the identity of questionable plants, enter the genus under "Other".

HP Dominant: Circle the most common (dominant) host plant species present in the habitat patch.

Objective 3.5 Visually estimate the abundance of the host plants

The purpose of this component of the survey is to provide a rough estimate of how much forage is available to frosted elfin larvae. Combined with the aerial coverage supplied by the patch delineation, an estimate of density leads to a better understanding of total host plant availability.

⁴ If you are uncertain about the identification of host plants, please contact the Natural Heritage Program in your state.

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We provide two approaches to visually estimate density. As a final check, we provide a scaled counting method to estimate the number of plants. Combined with the estimated area of the patch, these three alternative measures will provide a coarse estimate of host plant availability.

3.5.1 Estimate the host plant density within the habitat patch

We recommend using two estimation techniques to estimate host plant density.

On Data Sheet C, enter the plant density information on the data sheet as follows:

Visual Density Estimate: Refer to Figure 3. Write the letter corresponding to the **ROW** of pictures that best represents the density of the host plant throughout the patch area you delineated earlier. Imagine that each box represents a 3 meter square plot (roughly 10' x 10'). Select the box that best represents the typical density across the whole patch, not just the least or most dense portion of the patch.

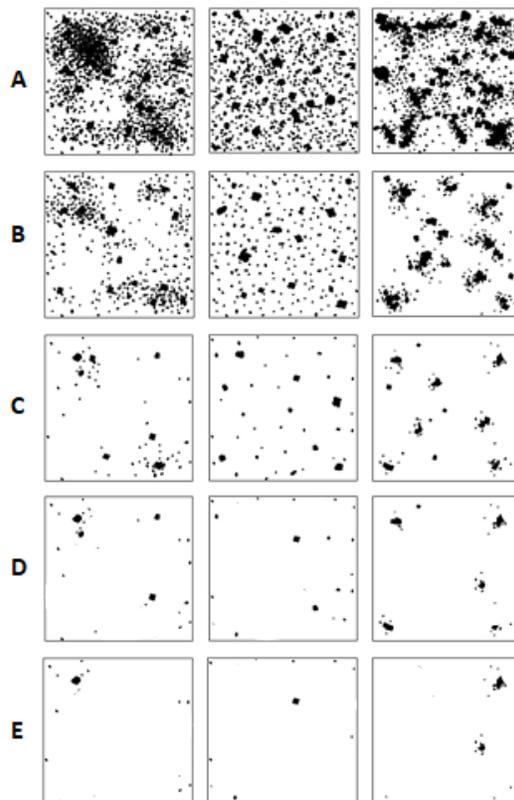


Figure 3. Density plots with different potential patterns of dispersion that you could encounter while in the field. Select the row that contains the image that best corresponds to the average density of the host plant in your habitat patch.

Walking Density Estimate: Review descriptions A through E below. Enter the letter (only one) of the description that best fits your experience walking through the habitat patch.

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- A. Plants are growing thickly throughout much of the area. Even with focused effort it is very difficult or impossible to avoid stepping on them.
- B. The plants are very common throughout the area. I can find a path through without stepping on any. I often need to tiptoe in between or step over the plants.
- C. The plants are common but it is not difficult to avoid them. Most of the time as I weave through, my feet are less than a yard from the nearest plant and rarely more than two yards away.
- D. The plants are widely spaced. It is easy to avoid the plants. Most of the time as I meander through, my feet are more than 1 or 2 yards from the nearest plant.
- E. The plants are very sparse. Walking in an almost straight line, my feet are often at least a few yards from the nearest plant.

3.5.2 Count the number of host plants

Counts apply to individual host plants that have at least one flowering (or budding) stem OR are larger than a one gallon milk jug in any dimension--**exclude all other plants**. For low-density patches, move through the habitat patch you delineated to measure area and click a hand-held counter once for each countable host plant. For areas of high-density or continuous cover, estimate the number of non-overlapping milk jugs it would take to cover all the plants. A direct measurement is not necessary; the goal is to exclude small plants and those that have not reached flowering maturity and find the approximate number of host plants in the patch.

HP Count for Lupine: Circle the range (0-100; 101-500; 501-1,000; 1,001-5,000; 5,001-10,000; 10,001-25,000; >25,000) that includes the number of plants you counted or estimated.

Depending on site conditions, you will count: individual plants; 1 x 1 m plots; and/or 3 x 3 m plots, then apply a multiplier as follows: **1 (for individual plants), 20 (for 1 x 1 m plots), or 200 (for 3x3 m plots)**. For sites with large areas of continuous cover, we recommend that you count 1 x 1 m and/or 3 x 3 m plots (a tally system is available on the back of Datasheet C to assist with this). After counting individual plants and/or plots, and multiplying them by the appropriate multiplier, sum the values to obtain the final count.

HP Count for Baptisia: Circle the range (0-100; 101-500; 501-1,000; 1,001-5,000; 5,001-10,000; 10,001-25,000; >25,000) that includes the number of plants you counted or estimated.

Depending on site conditions, you will count: individual plants; 1 x 1 m plots; and/or 3 x 3 m plots, then apply a multiplier as follows: **1 (for individual plants), 10 (for 1 x 1 m plots), or 100 (for 3x3 m plots)**. For sites with large areas of continuous cover, we recommend that you count 1 x 1 m and/or 3 x 3 m plots (a tally system is available on the back of Datasheet C to assist with this). After counting individual plants and/or plots, and multiplying them by the appropriate multiplier, sum the values to obtain the final count.

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SOP 4: Surveying for Frosted Elfin Larvae with Ultraviolet Light

Ultraviolet (UV) light surveys for frosted elfin larvae are a supplemental method for assessing frosted elfin presence at sites with confirmed host plants (SOP 1). This method should be used after conducting adult butterfly counts (SOP 2) that resulted in 0 adult detections (this may be particularly helpful during poor spring weather years when it is more challenging to find adults). Failure to detect frosted elfin adults during the flight period does not necessarily indicate the absence of the species as multiple factors influence detectability. Many caterpillars, including frosted elfin, fluoresce or at least stand out brightly against the background when exposed to UV light (Moskowitz 2017, 2018) as the molecules in their pigments react to UV light exposure. This makes them relatively easy to detect compared to the cryptic coloration and behavior of adult frosted elfin.

Objective 4.1: Complete the COUNTING EVENT INFORMATION section of Data Sheet D: Frosted Elfin Ultraviolet Light Larval Count *

*When entering UV light survey data into Survey123, use the Frosted Elfin Patch Count survey.

Observer Name: First and last name of the person who is making the observations.

Observer Email: Email address of the person who is making the observations.

Observer Phone: Phone number of the person who is making the observations.

Observer Affiliation: Organization of the person conducting the observations.

Others Present: First and last name of the person(s) recording the data or helping the observer.

Survey Date: Date you are conducting the count. Use this format YYYY-MM-DD.

State: Postal abbreviation of the state (e.g., MA) in which the site is located.

Town: Name of the town where the site is located.

Site Name: Name of the site (or property) commonly used by the organization responsible for the survey (if applicable). **Use the same name used for the same site as recorded on Data Sheet A. The same Site Name must be used every time a site is visited.**

Patch ID: Name of the patch using the following convention [SiteName-XX] where XX is a number assigned to the patch by the surveyors. For each site, begin the patch numbering with 01 and continue in sequence [02, 03, 04...]. Do not use spaces and do not abbreviate the Site Name. **The same Patch ID must be used every time the patch is visited within the year.**

Objective 4.2 Complete the walk-through UV light count of frosted elfin larvae

The primary purpose of counting larvae is to establish the presence or absence of frosted elfin larvae at each patch. The patch being used for UV light surveys is the same patch delineated in SOP 2, with the same start and end points used in the adult butterfly count. Similar to the adult

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butterfly counts, larvae will be detected (or not) through a series of three walk-through counts in each designated habitat patch. The counts are not intended to estimate absolute population size, but to complement (not replace) data collected during the adult flight period (Swengel 2012).

Depending on site latitude, larval activity can occur for up to 12 weeks from mid-April to mid-July. However, the timing of the larval period in a specific region or state can vary by as much as 2 to 3 weeks between years due to weather and microclimatic influences. The duration of the egg and larval stages varies with temperature, but eggs generally hatch into larvae within 2 weeks of spring adult emergence (Schweitzer et al. 2011). Frosted elfin eggs typically hatch within a week of oviposition (Moskowitz 2020; Albanese et al 2008) and their larvae remain active for 5-6 weeks (33 days on average), passing through four larval instars (Albanese et al. 2007). Several visits during the flight period may be needed prior to conducting larval surveys to determine the flight peak and to more accurately predict the peak of the larval period for timing the UV surveys. Larval surveys should begin 10 days after peak flight is established, to increase the probability of detection. Information about the peak flight period should be obtained from a state or federal biologist in your specific region.

After marking the host plant patch and conducting adult butterfly counts (SOPs 1 and 2), surveyors may implement UV larval surveys using a handheld long wave UV flashlight (e.g. uvBeast with UV InGan LED Lights, 385-395nm). The starting and ending points of your walk-through UV light larval count MUST remain fixed throughout the season.

Surveys should begin at least ten minutes after last light, in order to maximize the effectiveness of the flashlights (www.sunrise-sunset.org). Surveyors should be sure to change batteries at the outset of each survey for consistent light strength. Beginning with a full charge, the uvBeast should only be run for a total of two hours, in order to remove the bias of dimming LED's.

Larval counts should be conducted by an individual knowledgeable larvae identification. Identification photographs of larvae are available in Appendix C. Similar to SOP 2, scientific collector permits may be required by State natural resource agencies for larval surveys. Photographs should be taken by holding the UV light over the plant at an angle that causes the larvae to fluoresce. If possible, photographic vouchers with white light may also be useful for verifying identification.

It will be possible to detect the larvae of other species including wild indigo weevils (*Apion rostrum*), wild indigo duskywing (*Erynnis baptisiae*), gray hairstreak (*Strymon melinus*), and the moth (*Agonopterix lecontella*). In most cases, their shape is distinctly different from that of frosted elfin larvae (Moskowitz 2020) with the exception of the gray hairstreak, which can have similar shape and color and is known to cohabit on the same host plants (see Appendix C for photographs). This is by no means an exhaustive list, as studies using UV light to detect larval activity are numerically and geographically limited. It is entirely possible for other look-a-like species to be present in your region. However, several identification tricks will help to distinguish frosted elfin larvae from other species.

- Frosted elfin larval activity will be limited to the leaves and stems of host plants and the leaf litter below individual plants.
- Newly hatched and early instar frosted elfin larvae are pale green and unmarked while later instars are light green with faint chevrons and a light dorsolateral line. These colors are similar to the leaves and stems of the host plant (Moskowitz 2020).

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- Wild indigo duskywing larvae may be found and fluoresced on the same plants, but their shape is distinctly different. Wild indigo duskywing larvae have a clearly visible head and classic caterpillar shape whereas frosted elfin larvae are more oblong with a somewhat hidden head.
- Wild indigo weevils may be common on the leaf tips and can be mistaken for early instar frosted elfin larvae without closer examination (Moskowitz 2020).
- Gray hairstreaks cohabitate the same host plants as frosted elfin. Their larvae tend to have a hint of red coloration, shorter body length (<1/3 inch or < 8.467 mm), and longer hair length than frosted elfins (McElveen 2018).
- If you are unable to identify the species of larvae under UV light, use the flash on your camera or light from a headlamp to take a photograph of the larva (after the survey) and submit with results. Do not include unknown species in the count for frosted elfin larvae but make note of the possibility on your data sheet. If the image can be confirmed as frosted elfin larvae, survey data may be updated accordingly.

4.2.1 Record environmental conditions present during the count

Conduct counts only on rain-free nights. Local temperature can be read from the nearest meteorological station accessed on your smartphone (record the station name on the datasheet) OR if possible, record site temperature from a handheld thermometer, or digital temperature recording device (e.g., Kestrel). Record this information (including source) on the data sheet for each walk-through count.

On Data Sheet D, complete the ENVIRONMENTAL DATA section as follows:

Site Air Temp (F): Record the air temperature at the count starting point in degrees Fahrenheit using a handheld thermometer or weather-station at the site.

Local Air Temp (F): This data should only be collected if you cannot measure the site temperature in person (above). Record the temperature during the count from the nearest meteorological station in degrees Fahrenheit.

Local Daytime Temp (F): Using a smartphone or computer, record the local temperature for 12:00 noon on the day of the UV light survey from the nearest meteorological station in degrees Fahrenheit.

Cloud Cover: Record cloud cover by circling one of the following choices:

- Clear: the night sky and stars are completely visible most of the time;
- Partial: the night sky and stars are only partially visible most of the time;
- Overcast: most of the time the night sky and stars are not visible.

Precipitation: Record the precipitation by selecting a level from the following scale:

- Dry: although it might be humid, there is no mist, fog, or rain;
- Light: a light mist, fog, or drizzle can be felt on face but does not soak clothing;
- Moderate: a steady rain is falling and clothes will eventually soak through (*note: larvae counts should not be conducted under these conditions*);

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- Strong: a heavy rain is falling and clothes will soak through quickly (*note: larvae counts should not be conducted under these conditions*).

4.2.2 Conduct the walk-through count

Follow the approximate path previously used for the adult count survey. As a reminder, this path should maximize the view of host and nectar plants, passing nearer to areas that are more densely populated. Record the start time and begin walking. Because the exact path selected for each walk-through may vary from count to count, it is important that start and end times be recorded on the data sheet every time a count is conducted. We suggest recording both times using the hh:mm format. Do not round-off minutes as this will bias the count duration calculation. Do not stop to capture or photograph larvae during the survey, as this will skew how we use survey time as a measure of effort.

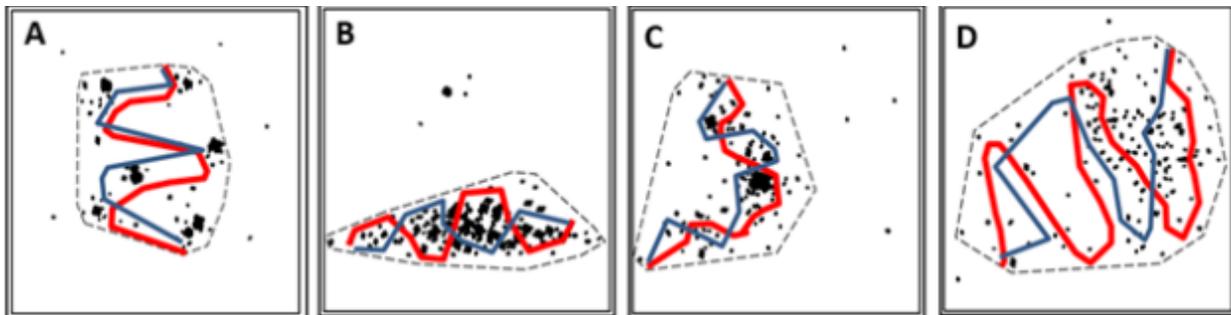


Figure 4. Walk-through count path examples from SOP 2-Adult butterfly count. Colored lines represent possible paths.

Walk at a steady pace, but slowly enough to scan the host plant from top to bottom with the UV light, counting individual larvae, and recording their position on the plant and larval stage. Angle the UV light up and down the plant, checking from base of stem to tops of leaves – you do NOT need to physically handle the plant as the UV light illuminates hidden areas of bushy host plants to provide a clear view of any larvae. Do not attempt to capture or photograph larvae until the count is complete and asked to do so by a supervisor.

Give yourself enough time to properly identify the species and tally your observations but spend no more than a few seconds at each plant. Larvae are typically visible from 2 to 3 feet away, depending on the vegetation structure. We suggest using a paper data sheet to tally position and instar stage (Table 1). Avoid the tendency to slow down as you encounter many larvae and speed up when there is not much to see. Record the end time, larvae position tally, instar tally, and total larvae tally. Do not pause to capture or photograph any larvae during the count – you may return to the plants after the survey is done.

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Table 1. Data sheet example for tallying larval stage and position on host plant.

Position	Early Instar (< 8mm)	Late Instar (> 8mm)
Leaves/Canopy	IIII	
Stem/Branches	II	II
Plant Base	IIII	III
Ground/litter	II	

On Data Sheet D, complete the FROSTED ELFIN LARVAE COUNT DATA section as follows:

Start Time: At the transect starting point, enter the time in the hh:mm format and immediately begin walking;

Larvae position: There are 4 position categories: Ground/Litter, Plant Base, Stem/Branches, and Leaves/Canopy. Tally the number of larvae at each position and include the sum in the corresponding box on the data sheet.

Larvae instar: As you walk, tally the instar of each larvae. Early instar will be measured at 8mm or less and late instar larvae as anything larger than 8mm. Please note that exact measurements are not necessary. Please use your best judgement from a visual perspective only.

Larvae Count: The larvae count will be the sum of tallies used for larvae position and stage. Simply add the total number of tallies to find the total count. You can also use a mechanical counter as a backup.

End Time: Stop walking at the transect end point and enter the time in the hh:mm format;

Larvae ID Confidence: Circle “confident” or “uncertain” to indicate your confidence in the identification you made.

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Count Notes: Record relevant information about the count that may indicate why a count was higher or lower than expected, if a count was limited by any circumstances, etc.

4.2.3 Repeat walk-through counts for the larval period

Each patch should be visited and a walk-through count completed at least weekly throughout the larval period. Minimally, each patch should have no fewer than 3 larval counts made, each separated by 4 to 7 days based on the expected larval period peak.

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Appendix A. Similar looking species

The following is excerpted from the SSA (USFWS 2018).

Two similar looking species overlap in range with the frosted elfin. Henry's elfin (*Callophrys henrici*) and hoary elfin (*Callophrys polios*) also have dusting of pale scales on the hindwing margin. Henry's elfin usually does not have the distinctive dark spot near the tail and has more contrast between outer and inner halves of the hindwing (Schweitzer et al. 2011, p. 160) (Figure A1). The hoary elfin lacks a tail, is smaller (Schweitzer et al. 2011, p. 160), and has pale scales on the forewing margin (Allen 1997, p. 93) (Figure A2).

A1



A2



Figure A. Henry's Elfin photo (a) by Greg Dysart, Massachusetts Butterfly Club <http://www.naba.org/chapters/nabambc/construct-species-page.asp?sp=Callophrys-henrici>. and Hoary Elfin photo (b) by Bruce de Graaf, Massachusetts Butterfly Club <http://www.naba.org/chapters/nabambc/construct-species-page.asp?sp=hoary-elfin>.

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Appendix B. Methods for delineating host plant patches

Smartphone method

In advance, download Google Earth on to your smartphone and familiarize yourself with the “My Location” and “Distance” functions. Familiarize yourself with taking a screenshot on your smartphone. Tutorials are available online and training may be available. Different versions of the application may have slightly different user interfaces, but all current versions have the needed functions.

First, from the starting screen showing the globe, use the icon with three parallel lines in the upper left to select the “Map Style.” From there, Select the “Exploration” view. Generally, from the starting screen showing the globe, the needed controls appear in the upper right of the smartphone screen. The icon showing three dots leads the user to a menu that should contain “My Location.” Selecting “My Location” causes the map to zoom in to your location. Use your fingers to expand the screen and zoom in as far as you need to locate the host plant patch. While the trees displayed aerial photo may be out of season, you should be able to recognize key features of the terrain and vegetation.

Once you have oriented yourself to the view shown in relation to the host plant patch, you are ready to draw the line. Select the ruler icon in the upper right of the screen. In the lower right you will see the “Add Point” button. You will add points to mark the perimeter of the host plant patch. Find the crosshairs symbol in the approximate center of the screen and use your finger to move the crosshairs to the first point on the perimeter, then press “Add Point.” The color of the crosshair will change. Use your finger to move to the next point on the perimeter; press “Add Point.” You may undo a point by pressing the arrow in the upper right of the screen (the blue full circle icon allows you to start over). Continue until you can close the shape by moving the crosshairs over your first point, which will be indicated by a halo around the first point. Press “Close Shape.” Now, the measured “Perimeter” and “Area” will be displayed. The default “Area” unit is ft² but scroll through the list to find the area in hectares. Record the area on area in hectares on your data sheet and take a screenshot of the area you have drawn. You will later transcribe the area to the habitat assessment data sheet. When the host plant is in full flower, if your understanding of the patch dimensions has changed, delineate a new line and area estimate, even if it no longer corresponds precisely to your walk-through transect.

On-site GPS method

If you want to draw a polygon representing the host plant patch using a handheld GPS device, please collaborate with a GIS technician in advance to ensure that you are properly prepared. Please ensure that you know how to set the device to the correct coordinate system and how to check it in the field. For the sake of consistency, we recommend using the WGS84 projection and recording the coordinates in decimal degrees format to 6 digits. Please seek assistance if you are uncertain how to do this. Always check the units before you record a line. When you have drawn the line, use the GPS device to estimate the area in hectares. If the device does not

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perform this function, you will need to bring the device to a technician to calculate the area of the patch you have delineated. Once the area is calculated, confirm that it has been calculated in hectares and enter the number on the data sheet. When the host plant is in full flower, if your understanding of the patch dimensions has changed, delineate a new line and area estimate, even if it no longer corresponds precisely to your walk-through transect.

Hand drawn map

If you want to draw the line representing the host plant patch by hand on a map, please coordinate with a GIS technician in advance to ensure that you are properly prepared. This approach will require you to bring a printed map or aerial photograph to the site and draw the line on the paper. Detailed instructions on drawing a map using an aerial photograph or topographic map is beyond the scope of this document. Once you are prepared with the help of a GIS technician, you may use the guidelines provided above for deciding where the line should be drawn. When you have completed the survey, you will need to bring the hand drawn paper map to the GIS technician, who then translate the paper map into a polygon and provide the estimate of area in hectares.

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Appendix C. Frosted Elfin Larvae Look-A-Likes



Wild Indigo Duskywing



Henry's Elfin



Brown Elfin



Agonopterix lecontella (moth)



Wild Indigo Weevil



Frosted Elfin



Gray Hairstreak (*Strymon melinus*)



Frosted Elfin under UV light

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Appendix D. Getting Survey Coordinates Using Garmin GPS

Last Updated April 18, 2019

These instructions were written for the 66st, but may apply to other units.

1. Go outside preferably with a view of the Southern sky
2. Turn on the unit using power button on top next to antenna
3. The first time it is turned on it will take some time to acquire the satellites and download the GPS almanac – allow 15 minutes for this to happen
4. The GPS will either prompt you to continue searching or show you a map



5. Press the **Menu** button and go to the **Setup** page. Click on **Setup**.



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6. On Setup page, find **Position Format** setting



7. On Position Format page, make sure **Map Datum** and **Map Spheroid** are set to **WGS 84**. If not, set them to this value. Make sure **Position Format** is set to **hddd.ddddd**. If not, set it to this value.



8. You are now ready to get coordinates for your position. Simply press the arrow up or down keys and your position will appear in a window at the top of the screen. Copy down these values on your field data sheet.

There are more things you can do with GPS units, but this is the basic information needed to complete the data sheets.

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Appendix E. Getting Survey Site GPS Coordinates using Google Maps

Last Updated February 28, 2019

In a web browser

If GPS units or other field equipment are unavailable for recording the location of a survey, the coordinates for a survey site can be determined using the Google Maps website (Figure E1). The interface of Google Maps is intuitive and allows users to navigate to a survey site by entering a street address, location name, or GPS coordinates into the search bar on the left and by scrolling and zooming the map to a specific location.

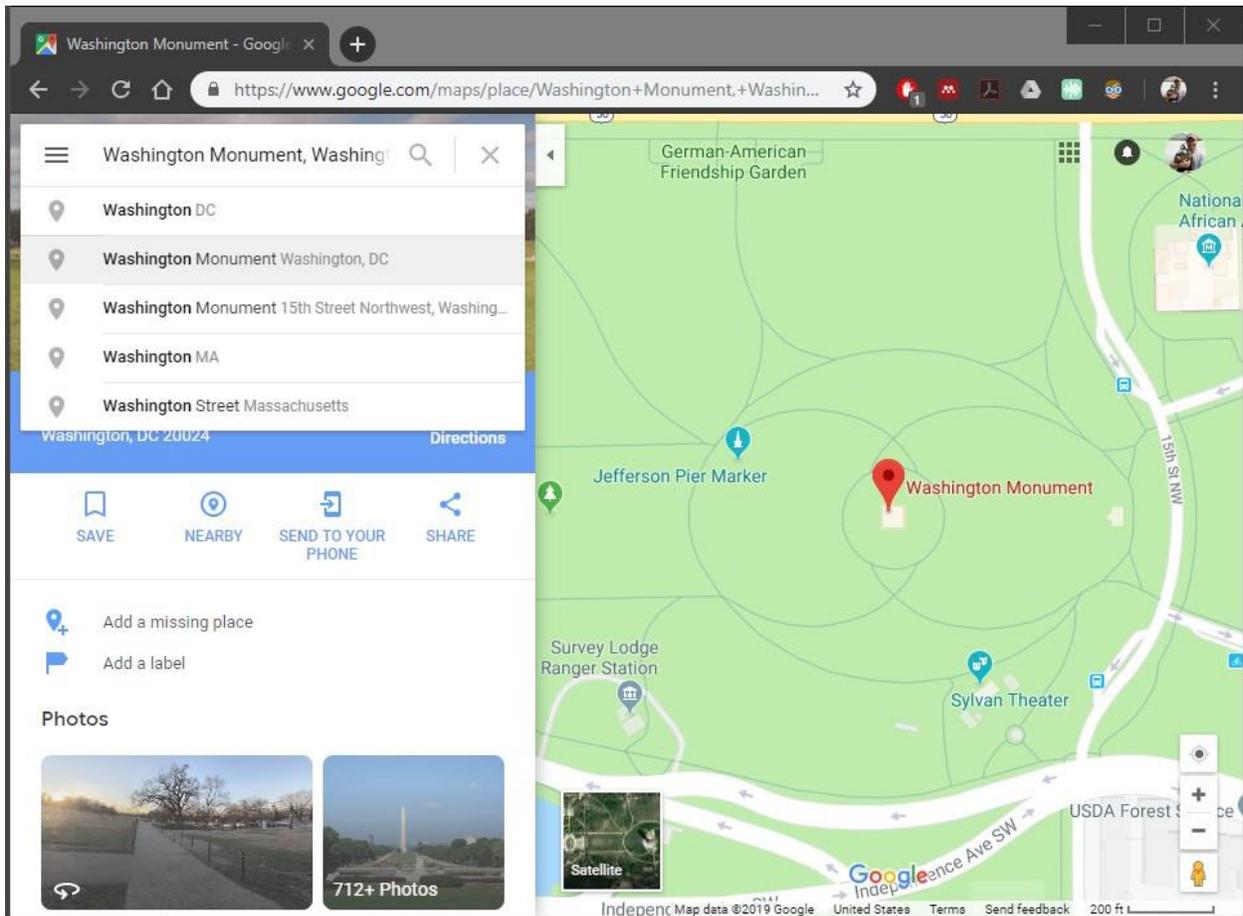


Figure E1. Google Maps website zoomed in on the Washington Monument in Washington, D.C.

To determine a point's exact GPS coordinates, users may switch between the "map" and "satellite" mode (selected in the bottom left of the map) to help find landmarks – often the satellite view will have imagery that allows a user to locate hiking trails or paths, openings or powerline clearings, and vegetation patches. A user may then drop a 'pin' by clicking on the exact point of interest, and the information associated with that pin will show up in a small popup window at the bottom of the map (Figure E2). The given coordinates are by default in WGS84 decimal degrees, the coordinate reference system and units that we request you use to submit your location data. The first number is the latitude (north/south position) and the second number is the longitude (east/west position) in decimal degrees. For Frosted Elfin surveys the latitude

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values should be between 25 and 48, and longitude values should be between -67 and -108. For reference, the Washington Monument's southwest corner is located at approximately 33.889397, -77.035345 (latitude, longitude).

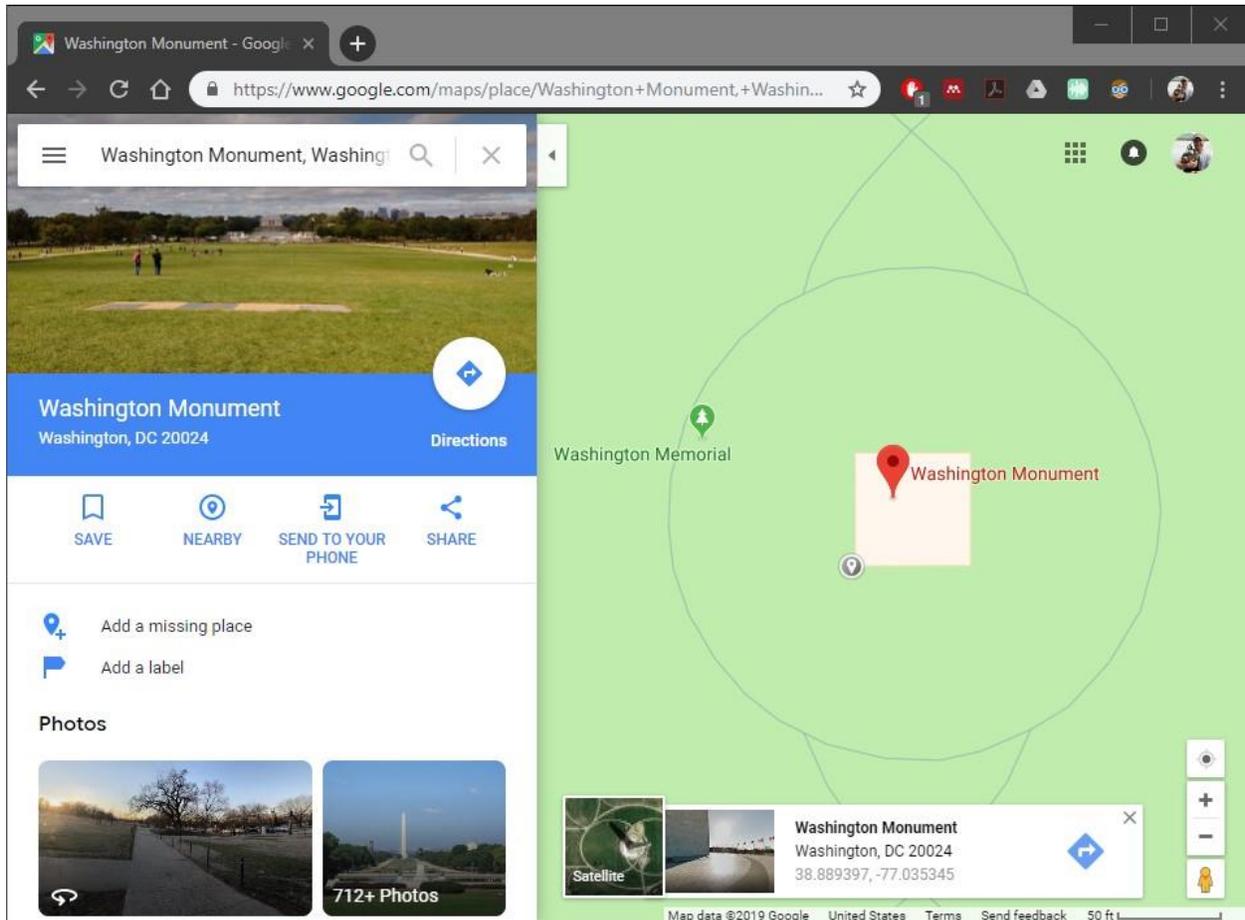


Figure E2. Google Maps with a 'pin' dropped in the southwest corner of the Washington Monument, D.C. showing the pop-up window at the bottom with the GPS coordinates in WGS84 decimal degrees.

On a phone

Google Maps is also available as a free app for the both iOS and Android phone and can be used to determine locations in a very similar way to the online website (Figure E3). In this case, the user will open the Google Maps app, navigate to the point of interest and then drop a pin by tapping the screen in the desired location. The information associated with the pin, including the coordinates, can be accessed by dragging up the window at the bottom of the screen after the pin is dropped.

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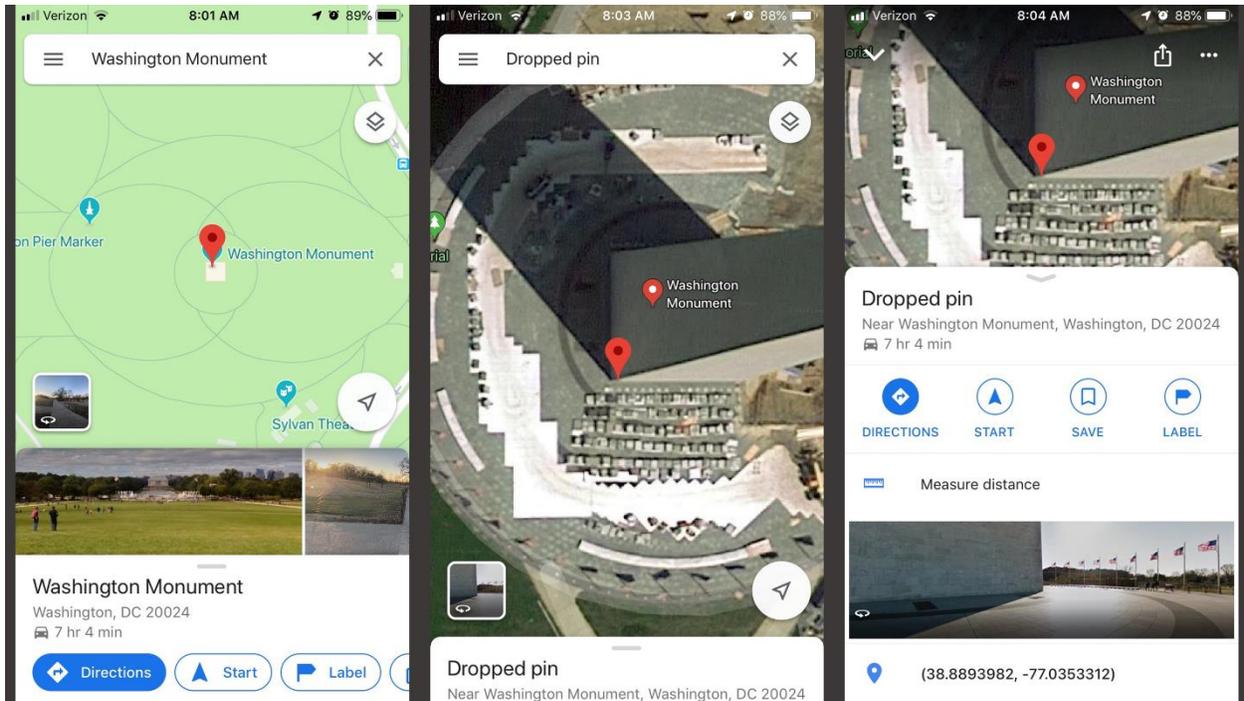


Figure E3. Google Maps on a phone showing the interface and how to get GPS coordinates for a location. The left panel shows the map zoomed in the Washington Monument in Washington D.C. in the default "map" mode. The center panel shows a closer view in "satellite" mode with a 'pin' dropped on the monument's southwest corner. The right panel shows information about the dropped pin, including the coordinates in parentheses at the bottom of the screen.

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Appendix F. Data Sheets for Frosted Elfin Surveys

DATASHEET A: FROSTED ELFIN PRELIMINARY SITE ASSESSMENT

SITE ASSESSMENT INFORMATION: Complete this form once per site in advance of survey season. Local knowledge may be used in lieu of a site visit.

Evaluator Name			
Evaluator Email		Evaluator Phone	
Evaluator Affiliation			
Assessment Date (YYYY-MM-DD)		State	Town
Site Name			

ACCESS INFORMATION: Only enter property owner if they have given consent, otherwise enter "Anonymous". For sites comprised of separate ownerships, list each separated by semi-colon. Enter address of property providing primary access. Describe best location for parking and give directions to host plant population. Enter coordinates of access point. Coordinates must be in **WGS84 decimal degrees**, up to six decimal places. Longitude should be negative.

Site Owner(s)			
Access Address Actual or nearest intersection		Will access be consistently available for this year's surveys?	Yes / No
Describe Access Permission and access procedures, including parking			
Access Latitude (00.000000)		Access Longitude (-00.000000)	

SURVEY HISTORY: Record if frosted elfin (FE) was confirmed on this site in the past. Also, record if any host plant (HP) was documented on the site in the past. Enter "Unknown" if there is no information about prior surveys.

FE Recorded Before?	Yes / No / Unknown	HP Recorded Before?	Yes / No / Unknown
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CONFIRM HABITAT: Confirm the general habitat type is potentially appropriate for the host plants and/or frosted elfin using soil type (sandy) and xeric site natural community indicator species (pines, shrub oaks, and little bluestem grass). Confirm the host plant has been observed on the site within the last year. Document factors that may disqualify part or all of the site from receiving surveys, make a recommendation for current year surveys, and note the approximate location of host plants.

Habitat Indicators?	Yes / No	HP Confirmed?	Yes / No
Circle factors contributing to exclusion of all or part of site	Agriculture Closed Canopy	Active Management Wet Soil	Mowed/Lawn Thick Vegetation Paved/Developed Imminent Conversion

Do you recommend this site for frosted elfin surveys? Choose "No" if the host plant is <u>not</u> known to be present and the habitat does <u>not</u> merit survey effort.	Yes / No
--	----------

Description of host plant patch location(s) within site	
--	--

DATASHEET B: FROSTED ELFIN PATCH COUNT

COUNTING EVENT INFORMATION: Complete this section for every count conducted, at least 3 per habitat patch. For **Patch ID**, use format *SiteName-XX* where SiteName has no spaces, and XX = two digit number (begin with 01 and continue in sequence).

Observer Name					
Observer Email			Observer Phone		
Observer Affiliation					
Others Present <small>(names)</small>					
Survey Date <small>(YYYY-MM-DD)</small>		State		Town	
Site Name					
Patch ID <small>(SiteName-XX)</small>					

Before FIRST Patch Count of the season: Please complete the PATCH LOCATION INFORMATION section at the bottom of the page.

ENVIRONMENTAL DATA: Complete this section for every walk-through count (at least 3 per habitat patch).

Site Air Temp (°F)		Wind	Calm / Light / Moderate / Strong		
Local Air Temp (°F) <small>(only if Site Air Temp is not available)</small>		Precipitation	None / Light / Moderate / Strong		
Cloud Cover	Clear / Partial / Overcast		STOP SURVEY if either Precipitation or Wind are Moderate or Strong!		
Conservation Security	None / Partial / Full Protection		Impact Level	None / Low / Moderate / High	
Threats Present	Vehicular Human Chemical Succession Invasive Species Development Browse Mowing Forestry Burning Grazing <i>List Other Threats:</i>				

FROSTED ELFIN COUNT DATA: Complete this section for every walk-through count (at least 3 per patch).

Start Time <small>(HH:MM)</small>		Adult ID Method <small>Circle all that apply</small>	Sight / Net / Photo		Adult ID Confidence	Confident / Uncertain
End Time <small>(HH:MM)</small>		Count Notes <small>Any useful info about the count results, if needed.</small>				
Adult Count						

VERIFICATION DATA: Attempt to complete this section if ID of adults is uncertain for any count.

Eggs Present	Yes / No		Larvae Present	Yes / No		Feeding Damage Present	Yes / No	
Photo(s) Taken	Yes / No	Photo Stage(s)	Egg / Larvae / Feeding Damage		Photo Email <small>If photo taken</small>			
Photo Notes <small>(File name, description, etc. to help identify file and/or patch)</small>								

PATCH LOCATION INFORMATION: Complete this section only for the first count of the season. Enter coordinates for the start and end of the path used for butterfly counts. Start/end points must remain fixed for the season. Coordinates must be in **WGS84 decimal degrees**, up to six decimal places. Longitude should be negative.

Start Latitude <small>(00.000000)</small>		Start Longitude <small>(-00.000000)</small>	
End Latitude <small>(00.000000)</small>		End Longitude <small>(-00.000000)</small>	
Description of count path location			

DATASHEET C: FROSTED ELFIN HABITAT RAPID ASSESSMENT

HABITAT ASSESSMENT INFORMATION: Complete one habitat assessment during peak flowering of the host plant. Use same Site Name as Datasheet A & B. Use same Patch ID as Datasheet B (formatted as *SiteName-XX*, see Datasheet B for details).

Observer Name				
Observer Email			Observer Phone	
Observer Affiliation				
Others Present (names)				
Observation Date (YYYY-MM-DD)		State	Town	
Site Name				
Patch ID (SiteName-XX)				

HABITAT AREA: Habitat area is rough estimate of the area covered by host plants and does not need to include every outlying plant. We recommend using Google Earth to print a map of aerial imagery in advance, then delineating the patch by hand and bringing it into the field, so you can be familiar with the site prior to the survey. **Coordinates** should be the centroid of the habitat patch and must be in **WGS84 decimal degrees**, up to six decimal places. **Habitat Area** must be in hectares, use up to 2 decimal places.

Centroid Latitude (00.000000)		Centroid Longitude (-00.000000)		Habitat Area (hectares)	
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COVER DATA: Estimate the cover class for each layer of vegetation. "Canopy Cover" is overhead tree cover blocking view of sky (>3 m); "Shrub Cover" is woody plants <3 meters high, "Grass/Herb Cover" is non-woody cover, typically, but not necessarily <1 meter, and "Bare Ground Cover" is partially or fully exposed (bare) soil, with few or no vascular plants.

Canopy Cover	0-10%	11-30%	31-60%	61-100%	Shrub Cover	0-10%	11-30%	31-60%	61-100%
Grass/Herb Cover	0-10%	11-30%	31-60%	61-100%	Bare Ground Cover	0-10%	11-30%	31-60%	61-100%

HOST PLANT SPECIES DATA: Document the host plant species. Next to "HP Present" circle all host plant species present, and next to "HP Dominant", circle the most common host plant species. If you cannot resolve ID of questionable plants, enter genus in "Other".

HP Present	L. perennis	B. tinctoria	B. nuttallii	B. australis	B. sphaerocarpa	Other:
HP Dominant	L. perennis	B. tinctoria	B. nuttallii	B. australis	B. sphaerocarpa	Other:

HOST PLANT SPECIES DENSITY AND ABUNDANCE: The goal is to determine approximate density and number of host plants present.

Visual Density: Refer to SOP 3 (Fig. 3) to determine a visual density estimate.

Circle the letter corresponding to the row of pictures that best represents the density of host plants throughout the patch area. Imagine each box represents a 3 meter square plot (roughly 10' x 10'). Select which box best represents the typical density across the whole patch, not just the least or most dense portion of the patch. You may need to observe multiple "plots" before choosing an image that represents the average density.

Visual Density →	A	B	C	D	E
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Walking Density: Select a letter that corresponds to the best description of walking through the plot area.

- A) Plants are growing thickly throughout much of the area. Even with focused effort it is very difficult or impossible to avoid stepping on them.
- B) Plants are very common throughout area. I can find a path through without stepping on any. I often need to tiptoe in between or step over them.
- C) Plants are common, but it is not difficult to avoid them. Most of the time as I weave through them, my feet are generally <1 yard from nearest plant, rarely >2 yards away.
- D) Plants are widely spaced. It is easy to avoid the plants. Most of the time as I meander through, my feet are often more than 1 or 2 yards from the nearest plant.
- E) The plants are very sparse. Walking in an almost straight-line, my feet are often at least a few yards from the nearest plant.

Walking Density →	A	B	C	D	E
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Host Plant Count: Circle the range that includes the number of plants counted using a **counter and/or the tally sheet** (provided on the **backside**). Counts apply to individual host plants that have at least one flowering (or budding) stem or are larger than a one gallon milk jug in any dimension - **exclude all other plants**. For sites with large areas of continuous cover, you may need to use the counter/tallies to count one square yard/meter plots or 3x3 m plots, then apply the **appropriate multiplier** based on the host plant species: **Lupine or Baptisia** (see backside of this data sheet). The **sum of all totals combined = HP Count** (circle appropriate range below).

HP Count →	0-100	101-500	501-1,000	1,001-5,000	5,001-10,000	10,001-25,000	>25,000
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DATASHEET C: FROSTED ELFIN HABITAT RAPID ASSESSMENT - HOST PLANT TALLY SHEET

Sum of Totals = HP Count (Add all totals together to find the HP Count range provided on the front side of this data sheet)

<p><i>Lupine</i> Individual Plants</p>	<p><i>Lupine</i> 1m x 1m Plots</p>	<p><i>Lupine</i> 3m x 3m Plots</p>
<p>Total = # of tally marks (e.g., 10 tally marks = 10 individual plants total)</p> <p>Total: <input data-bbox="159 1016 480 1087" type="text"/></p>	<p>Total = (# of tally marks) multiplied by 20 (e.g., 10 tally marks = 200 individual plants total)</p> <p>Total: <input data-bbox="617 1016 938 1087" type="text"/></p>	<p>Total = (# of tally marks) multiplied by 200 (e.g., 10 tally marks = 2000 individual plants total)</p> <p>Total: <input data-bbox="1143 1016 1464 1087" type="text"/></p>
<p><i>Baptisia</i> Individual Plants</p>	<p><i>Baptisia</i> 1m x 1m Plots</p>	<p><i>Baptisia</i> 3m x 3m Plots</p>
<p>Total = # of tally marks (e.g., 10 tally marks = 10 individual plants total)</p> <p>Total: <input data-bbox="159 1898 480 1969" type="text"/></p>	<p>Total = (# of tally marks) multiplied by 10 (e.g., 10 tally marks = 100 individual plants total)</p> <p>Total: <input data-bbox="617 1898 938 1969" type="text"/></p>	<p>Total = (# of tally marks) multiplied by 100 (e.g., 10 tally marks = 1000 individual plants total)</p> <p>Total: <input data-bbox="1143 1898 1464 1969" type="text"/></p>

DATASHEET D: FROSTED ELFIN ULTRAVIOLET SURVEY

COUNTING EVENT INFORMATION: Complete this section for every UV survey conducted. For **Patch ID**, use format *SiteName-XX* where SiteName has no spaces, and XX = two-digit number (begin with 01 and continue in sequence).

Observer Name				
Observer Email		Observer Phone		
Observer Affiliation				
Others Present <small>(names)</small>				
Survey Date <small>(YYYY-MM-DD)</small>		State		Town
Site Name				
Patch ID <small>(SiteName-XX)</small>				

ENVIRONMENTAL DATA: Complete this section for every ultraviolet survey count.

Site Air Temp (°F)		Wind	Calm / Light / Moderate / Strong
Local Air Temp (°F) <small>(only if Site Air Temp is not available)</small>		Precipitation	None / Light / Moderate / Strong
Local Daytime Temp (°F)		Cloud Cover	Clear / Partial / Overcast

STOP SURVEY if either Precipitation or Wind are Moderate or Strong!

FROSTED ELFIN COUNT DATA: Use this section to tally the larval stage and position during the UV blacklight count.

	Position	Early Instar ($\leq 8\text{mm}$)	Late Instar ($> 8\text{mm}$)	
	Leaves/Canopy			
	Stem/Branches			
	Plant Base			
	Ground/Litter			
Start Time <small>(HH:MM)</small>			Count Notes Record relevant information about the count that may indicate why a count was higher or lower than expected, if a count was limited by any circumstances, etc.	
End Time <small>(HH:MM)</small>				
Larvae Count				
Larvae ID Confidence	Confident / Uncertain			