

MONARCH HABITAT QUANTIFICATION TOOL

USER'S GUIDE v1.0

SOUTH CENTRAL REGION

APRIL 2017





Acknowledgements

The Monarch Habitat Quantification Tool was developed to support the Monarch Butterfly Habitat Exchange. It is the product of Environmental Defense Fund, Environmental Incentives, and the Monarch Lab at the University of Minnesota. The expert insight and guidance provided by the Monarch Lab has been essential to the development of this document and the HQT in general.

Authors and contributors of this document include:

- Monarch Lab: Karen Oberhauser, Ph.D., Carl Stenoien, and Kelly Nail, Ph.D.
- Monarch Joint Venture: Wendy Caldwell
- Environmental Incentives: Eoin Doherty, Erik Anderson, Chris Sonnier and Lauren Morrell
- Environmental Defense Fund: David Wolfe and Audrey Archer

Members of the Monarch Lab who have participated in field testing the HQT are also appreciated:

- Monarch Lab: Kyle Kasten and Laura Lukens

Table of Contents

CONTEXT	4
The Monarch Butterfly Habitat Exchange.....	5
GETTING STARTED.....	6
What does the Monarch HQT do?.....	6
Who conducts the Monarch HQT assessment?	7
Where does the South Central version of the Monarch HQT apply?	7
Which sites are eligible?.....	7
When is the assessment conducted?.....	9
How should monarch habitat be managed?	10
INSTRUCTIONS	12
Recommended Supplies & Equipment.....	12
STEP 1: DEVELOP PROJECT BASE MAP.....	12
STEP 2: VISIT THE SITE	16
STEP 3: COMPLETE DESKTOP ANALYSIS.....	18
STEP 4: INPUT DATA INTO CALCULATOR	21
STEP 5: REVIEW RESULTS & FINALIZE PROJECT BASE MAP	24
APPENDIX A: BEST MANAGEMENT PRACTICES	26
APPENDIX B: DEFINITIONS	32
APPENDIX C: REFERENCES.....	34
APPENDIX D: SAMPLE FRAME CONSTRUCTION.....	36
APPENDIX E: FIELD DATA COLLECTION METHODS	37
APPENDIX F: FIELD DATASHEETS	58

CONTEXT

Monarch butterflies are an iconic North American species; their remarkable migration and presence across the continent make them an exceptional example of our natural heritage. Over multiple generations, Eastern monarchs migrate from overwintering grounds in central Mexico to as far north as southern Canada and back every year. Western monarchs undergo a shorter migration, with the majority overwintering along the California coast. However, this extraordinary phenomenon is in peril. Monarch numbers have declined significantly, by over 80% in both the Eastern and Western populations in the past 20 years. If this trend is not reversed, monarch populations could reach a level at which they would no longer be able to sustain the migration, and the North American population will be in danger.

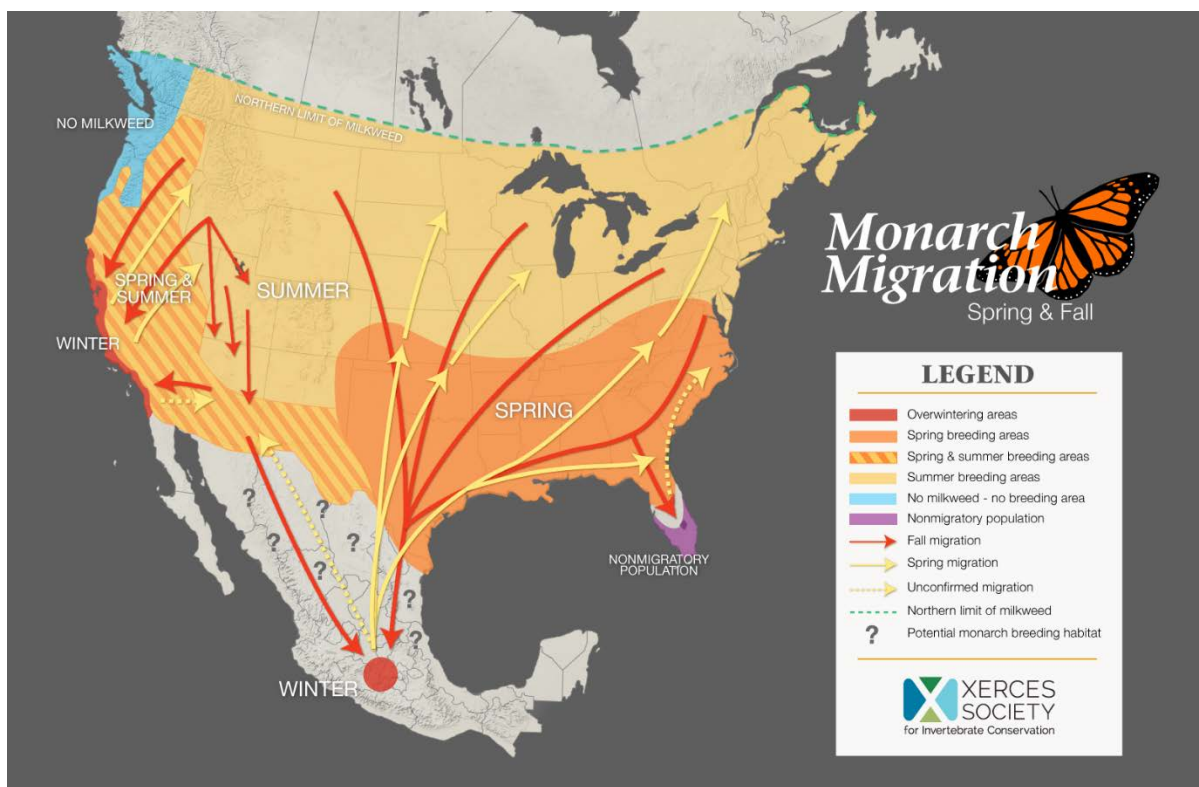


Figure 1. Migration routes, breeding areas and overwintering areas of monarchs in North America. Reprinted from the Xerces Society, 2016. Copyright by Xerces Society. Reprinted with permission.

The biggest factor contributing to the dramatic decline in monarch population numbers is the loss of habitat, which includes milkweed and nectar plants. In order to complete their migration, monarchs must find specific plants to lay eggs and feed upon. Female monarchs lay eggs only on milkweed plants, which provide food for their larvae. Adult monarchs consume nectar from a variety of different flowering plants. The adoption of herbicide-tolerant crops and changing land uses have diminished the abundance of milkweed and nectar plants on the landscape. Furthermore, pesticides used to control plant pests can have unintended consequences on monarch survival. Thus, it is imperative to not only reduce the loss of existing monarch habitat, but to also create new monarch habitat by, for example, actively managing fallow fields, marginal farmlands and roadsides for monarch use.

The Monarch Butterfly Habitat Exchange

In order to support a healthy monarch population, milkweed and nectar plant species must be restored and protected where they currently exist. Scientists, policymakers and other stakeholders have set a goal to increase the monarch population to approximately 225 million butterflies (or enough to cover 6 hectares of land in the Mexican overwintering sites) by 2020. Achieving this goal will require returning more than 1.6 billion milkweed stems to the landscape in the U.S., in areas where nectar resources are also available (Pleasants 2016). High quality monarch habitat will also benefit pollinators and other wildlife. The



Photo courtesy of Wendy Caldwell

The Monarch Habitat Exchange creates new opportunities for landowners to produce high-quality monarch habitat and contribute to meeting this goal for monarch recovery.

The Monarch Butterfly Habitat Exchange (MBHE; “The Monarch Exchange”) provides landowners with incentives to conserve monarch habitat. Participants in the Monarch Exchange generate “credits” based on the estimated contribution to monarch recovery goals that their enrolled habitat creates, as calculated by the Monarch Habitat Quantification Tool (Monarch HQT). Conservation organizations, federal and state government agencies, philanthropists, corporations or anyone interested in monarch conservation can purchase credits to fund monarch conservation and mitigate risk to the species’ existence.

The Monarch Habitat Quantification Tool (Monarch HQT) is a habitat assessment method, based on best-available science and expert opinion, for assessing the quality of monarch habitat on a piece of land. Understanding the quality of the habitat, not just the number of acres, is useful for decision-makers to evaluate multiple sites and/or multiple management options for a specific site. In addition, the acts of measuring, tracking, and reporting improvements in habitat quality are critical to ensure progress toward the overall conservation goal of 1.6 billion milkweed stems for monarchs. The results of each HQT assessment will be tracked in a registry which will contribute towards national monitoring of monarch conservation.

GETTING STARTED

This section provides a brief introduction to the Monarch HQT. If you have additional questions after reviewing the Monarch HQT, contact the Monarch Exchange Administrator in your region.

What does the Monarch HQT do?

The Monarch HQT assesses the quality of monarch breeding and foraging habitat. Habitat quality refers to the ability of a site to sustain monarchs and support monarch population growth. The Monarch HQT was specifically designed to assess monarch habitat enrolled in the Monarch Exchange. The Monarch Exchange Administrator will use the results of the assessment to prioritize projects for funding, verify project objectives are met, and report contributions towards national conservation goals.

For landowners and managers, the Monarch HQT can help:

- Evaluate the current habitat quality on the site and estimate future habitat quality resulting from management actions;
- Inform the selection of management actions to maintain and improve habitat quality;
- Monitor changes in habitat quality on the site over time;
- Adaptively manage the site based on the results of repeated assessments.

During the HQT assessment, data is collected on milkweed abundance and diversity, blooming forb abundance and diversity, threats (e.g., the risk of pesticide exposure), and the priority of the site for conservation of monarchs. These data are scored and weighted by a spreadsheet-based model of monarch habitat quality to produce an overall score for habitat quality (Figure 2). This model is provided in the *Monarch HQT South Central Region Credit Project Calculator*, available for download at www.edf.org/monarch. The size of the site in acres and the habitat quality are multiplied to calculate **functional acres**, the basic currency of the Monarch Exchange.

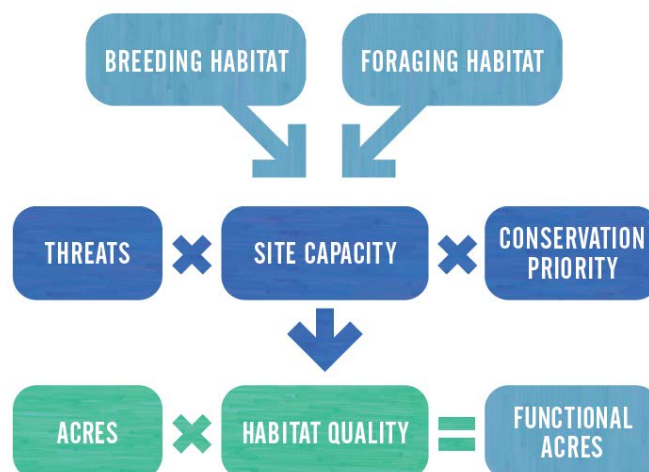


Figure 2. Diagram of the monarch habitat quality model utilized by the Monarch HQT.

Each functional acre is estimated to contribute an average of 70 monarchs per year to the overwintering monarch population¹. The total number of monarchs contributed per site is described as the **monarch yield** of the site. Habitat quality, functional acres, and monarch yield are the primary outputs of the Monarch HQT.

Who conducts the Monarch HQT assessment?

Assessing monarch habitat using the Monarch HQT requires knowledge of milkweed and other nectar plant species, which make up monarch's primary habitat. Typically, the help of a technical service provider or other trained field biologist will be required to use the Monarch HQT and may be mandatory for credit verification in your local Monarch Exchange. To obtain a list of qualified technical service providers, please contact your local Monarch Exchange Administrator.

Where does the South Central version of the Monarch HQT apply?

This version of the Monarch HQT is intended for use in the South Central region of the United States (Figure 3). An alternative version of the Monarch HQT is available for the North Central region. A version for each region of the U.S. will be developed as Monarch Exchanges are developed in those regions.

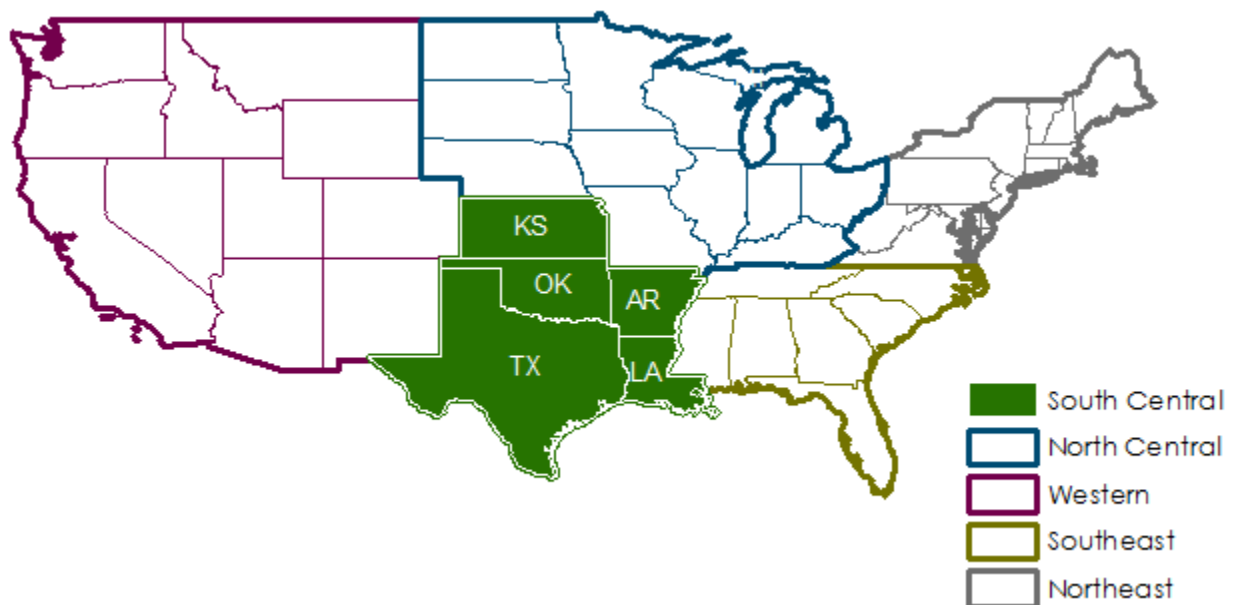


Figure 3. This version of the Monarch HQT applies only to the South Central region.

Which sites are eligible?

Any site that supports monarchs can be assessed using the Monarch HQT and may be eligible to participate in the Monarch Exchange. In order to achieve the national conservation goals established for monarchs, broad participation from farmers, ranchers, and roadside and rights-

¹ The value of 70 is calculated by multiplying the number of monarchs likely to migrate to overwintering grounds per milkweed plant (approximately 0.035, Nail et al 2015) by the number of milkweeds in one functional acre as calculated by the Monarch HQT (2,000 milkweeds per functional acre).

of-way managers is critical. However, some areas are unsuitable for monarchs and should not be assessed.

Examples of suitable areas include:

- Fallow fields and set-asides
- Marginally-productive crop lands
- Grazing lands
- Areas between fields
- Field borders
- Roadsides
- Riparian buffers
- Golf course edges
- Areas intended for creation or restoration of monarch habitat

Unsuitable areas may include:

- Bodies of water
- Forested areas
- Mowed areas*
- Hayed fields*
- Areas where pesticides are applied*

* These areas may be eligible if mowing, haying and pesticide application does not occur during the time monarchs are present in the region. Consult your Monarch Exchange Administrator for specifics.

While the Monarch HQT can be used on any area of monarch habitat, to be eligible to participate in the Monarch Exchange the landowner or manager must commit to proactively managing the habitat for monarchs during the time monarchs are present in the region. See below *How should monarch habitat be managed?* for more information.

Project Area

To begin the Monarch HQT assessment, the technical service provider will work with the landowner or manager to define the Project Area. The Project Area refers to the entire area of the site that will be assessed using the Monarch HQT. This should include any existing monarch habitat and any areas where monarch habitat will be created or restored. For example, a single farm may have multiple patches of monarch habitat across the property; all of these areas should be included in the Project Area. The Project Area does not need to be contiguous. The landowner or manager may choose not to include any areas at his or her discretion.

Assessment Areas

The Project Area will be subdivided into Assessment Areas. Assessment Areas are areas within the Project Area that share similar characteristics such as landscape position, vegetation, soils, and management. For example, a roadside may be considered a single Assessment Area. Each Assessment Area will receive a unique score for habitat quality. Understanding the habitat quality of each Assessment Area can help the landowner or manager prioritize areas for management as monarch habitat. Guidance for delineating map units are provided in Step 1 of the Instructions.

Each Assessment Area will also receive a functional acre score and a monarch yield estimate. These values will be aggregated across all Assessment Areas in the Project Area. The functional acre score and monarch yield estimate for the Project Area will be evaluated by the Monarch Exchange Administrator for decision making.

Project Base Map

Project Area and Assessment Area boundaries will be delineated on a Project Base Map. The Project Base Map will also be used to assess threats to monarch habitat (e.g., proximity to conventional agriculture). The Project Base Map, along with the Monarch HQT Credit Project Calculator, will be used by the landowner or manager to help develop a management plan for monarch habitat on their property, and must be submitted when enrolling in the Monarch Exchange. For an example of a project base map, see Figure 14 on page 25.

Field Data Collection

Assessment Areas are evaluated in the field by collecting data from 100 plots placed along transects. Transects are distributed either randomly or systematically across the Assessment Area, depending on the size of the Assessment Area. The field data collection methods are described in detail in Appendix E: Field Data Collection Methods.

When is the assessment conducted?

Monarch HQT assessments typically start with a meeting between the landowner and the technical service provider to identify existing monarch habitat or areas where monarch habitat may be created or restored. The Monarch HQT assessment can be completed the same day or scheduled for an appropriate time in the future.

What time of year?

Ideally, the assessment should occur when monarchs are present in the region and when the abundance and diversity of blooming forbs, including milkweed, is highest. However, the assessment may be conducted anytime within the sampling windows provided in Table 1 below. For sites in the extreme northern and southern latitudes of the South Central region, the earliest and latest dates in these ranges may not be appropriate. Consider local conditions before scheduling the assessment. For more information on when monarchs are present near the area of interest, refer to Journey North's citizen-science observational data available at <https://www.learner.org/jnorth>.

Table 1. Sampling Windows for the South Central Region

REGION	SAMPLING WINDOWS
South Central	<ul style="list-style-type: none"> ▪ March 15 – May 15 (Early Season) ▪ August 15 – October 15 (Late Season)

How often?

A site should be assessed at least twice per year, once during each sampling window. If possible, the site can be assessed more than twice per year. Multiple assessments per year will provide more information about the availability of nectar plants since various nectar plants bloom at different times throughout the year. The Monarch Exchange Administrator will consider the highest score achieved for the site if multiple assessments are conducted in a single sampling

window. In subsequent years, the site may be assessed during the time period when the highest score was achieved provided it also coincides with monarch presence in the region.

The first year's assessment of a site will provide the current condition, which can be interpreted as a baseline. Subsequent assessments should be compared to this baseline to quantify enhancement or degradation of habitat quality and to inform adaptive management of the site. Subsequent assessments should use the same transect locations as the initial assessment.

How long does it take?

A full Monarch HQT assessment could take between a half day and up to multiple days, depending on the size of the site, the number of areas to be assessed, and the diversity of plant species present. A small farm with one to three Assessment Areas of a few acres each may take only a half day. A large ranch with hundreds of acres of habitat and more than ten Assessment Areas could require a week. Each assessment requires, on average, an hour in the office to develop the Project Base Map and two to three hours of field data collection. Assessment Areas of 50 acres or more should allow more time to travel between transect locations.

How should monarch habitat be managed?

To be eligible for participation in the Monarch Exchange, the landowner or manager must commit to proactively managing the habitat as monarch habitat during the time monarchs are present in the region. A management plan will be drafted that specifies management actions and excludes specific uses of the habitat. The results of a Monarch HQT assessment are valid for one year; incompatible management of habitat during the time monarchs are present will result in invalidation of the assessment. The Monarch HQT can be used to help landowners or managers understand the current and potential value of a site for monarchs and determine whether to manage the site for monarchs or to manage the site for other objectives.

To enroll in the Monarch Exchange, the landowner or manager will complete a management plan for any monarch habitats to be enrolled. Management plans include two elements: a description of selected management actions and a process for adaptive management.

Management Actions

Management actions can affect milkweed and nectar plant diversity, abundance, and distribution. With the help of a technical service provider, a management plan should be created and assessed periodically to track results and to analyze habitat performance to determine actions for adaptive management. For a list of applicable management actions, see Appendix A: Best Management Practices. For additional information, contact your local NRCS office.

Note that specific management recommendations may not produce identical results at each site, and professional judgment, in combination with results from adaptive management, can help ensure that management actions continue to be relevant and effective. Additionally, management actions may have different impacts for different wildlife species. Consider the effects to other wildlife species before implementing any conservation practice.

Adaptive Management

Adaptive management maximizes the potential to achieve desired outcomes by monitoring a site's continued habitat quality over time and adjusting management actions using feedback from the results of monitoring. Specific protocols regarding adaptive management will be defined for each individual Monarch Exchange. Please contact your local Monarch Exchange Administrator for more information on adaptive management protocols that apply to your site.



Photo courtesy of John Rae

INSTRUCTIONS

This section provides step-by-step instructions for completing the Monarch HQT assessment. It is intended for the technical service provider or trained field biologist who will complete the assessment.

Recommended Supplies & Equipment

- Aerial image of the site
- *Monarch HQT South Central Region Credit Project Calculator (Calculator)*, available for download at www.edf.org/monarch
- 100-meter transect tape (optional but recommended)
- Pin flags (optional but recommended)
- 2 transect stakes (optional but recommended)
- Subplot frame (0.5 x 1.0-meter frame with nested subplots). The subplot frame can be constructed prior to the assessment, see Appendix D for guidance.
- Data sheets (Assessment Area datasheets & Transect datasheets)
- Clipboard & pencil/pen
- Plant list and identification guides for local area
- Clicker counter
- Thermometer
- Duct tape (optional, but recommended in case subplot frame breaks)
- Calculator (optional)
- Watch
- Camera
- Compass
- Handheld GPS unit

STEP 1: DEVELOP PROJECT BASE MAP

Before starting the habitat assessment, coordinate with the landowner or manager to identify (1) known or potential areas of monarch habitat and (2) areas where the landowner or manager is interested in developing monarch habitat. While any existing monarch habitat may be assessed using the Monarch HQT, the results will be invalidated if the habitat is subject to incompatible management, such as mowing or haying during the time monarchs are present (except as to promote establishment of the habitat). If the landowner or manager has not decided which areas to manage for monarch habitat, the results of the Monarch HQT assessment may help landowners or managers identify which areas have the most potential.

This coordination may take place over the phone before the assessment, or at the site before the site assessment begins. Prior to collecting field data, you will need an aerial image of the site. Ensure that all potential monarch habitats in the project area are included on the aerial image if

using a printed version, or you may utilize a computer or handheld device with software such as Google Earth Pro (free software available at <https://www.google.com/earth>).

The aerial image of the site will be developed into the Project Base Map, which will be delivered to the landowner or manager at the conclusion of the assessment. See Figure 4 and Figure 5 for an example of the base map. Developing the base map is a three-stage process. Before beginning the assessment, all known or potential monarch habitats will be identified on the base map. These locations will guide the field crew during field data collection. During data collection, the crew will update the base map with new habitat patches and revised Assessment Area boundaries. After data collection, the updated base map will be used to evaluate additional indicators of monarch habitat quality and finalized for delivery to the landowner or manager.

1.1 Locate an aerial image of the site: hard-copy aerial images that may be marked on are acceptable, but a software program such as [ArcGIS](#), [QGIS](#), or [Google Earth Pro](#) is preferable. Review the software documentation for help with this step, if necessary. Coordinate with the landowner or manager to complete the Project Base Map.

1.2 Delineate the Project Area: Using the aerial photograph of the site, delineate the boundaries of any areas to be included in the assessment. Include any areas that may contain milkweed or nectar plants on the property, as well as areas being considered for restoration. Only areas which the landowner or manager choose to include should be included.

1.3 Exclude areas that will not be assessed during the site visit: identify and delineate the boundaries of any areas included in the project area but that will not be evaluated for milkweed and nectar plant abundance. Areas that should be excluded from the assessment include:

- Non-Habitat: forested areas, open water, cultivated croplands, monotypic grasslands, and other areas that do not support milkweed or nectar plants should not be assessed. Do not exclude any areas for which you are unsure, or which will be restored to monarch habitat.
- Areas managed for incompatible objectives: areas that are managed for alternative objectives may include cropland or hay fields where management is incompatible with monarch habitat. Areas where management regimes will impact milkweed or blooming forb availability, or where pesticides are directly applied, except when specifically intended to create or restore monarch habitat, are not eligible to be enrolled in the Monarch Exchange. However, an assessment may be conducted anywhere to provide baseline information, which may help the landowner or manager decide where to prioritize monarch habitat on the site.
- Hedgerows within 125 feet (38 meters) of conventional agriculture: hedgerows that may intercept pesticide drift are encouraged and will benefit the habitat quality of the site; however, monarch habitats should not be developed within those hedgerows because

of the likelihood of exposing monarchs to pesticide drift. Do not assess monarch habitat within hedgerows near conventional agriculture.

1.4 Define Assessment Areas: Identify known locations of milkweed and nectar plants within the project area in consultation with the landowner or manager. Also identify areas where monarch habitat will be created or restored. For individual patches (typically of 500 milkweed stems or fewer) indicate on the map where the patch is likely to be found. For larger areas, delineate boundaries around the area to be assessed. These boundaries should contain consistent ecological sites, vegetation, soils, and management. Each patch or area will be assessed separately, and is referred to as an Assessment Area. Provide a name for each Assessment Area (we recommend alphabetical notation such as A, B and C). Assessment Areas that share similar site characteristics but are not spatially continuous may be grouped and should share the same name. Assessment Areas may also be defined during field data collection if unclear from the aerial photograph.

Large Assessment Areas (typically greater than 5 acres in size) must have random transect locations generated within the Assessment Area prior to the field visit. Proceed to step 1.5 if large Assessment Areas are present in the project area.



Figure 4. Example Project Area Base Map for a farming operation. The Project Area includes a small field (Assessment Area A), a turf area that will be restored to monarch habitat (Assessment Area B), a roadside (Assessment Area C), and a strip within the farm field (Assessment Area D). Within Assessment Area A, a hedgerow and a small ponding area were excluded. Within Assessment Area B, a strip used as access to the farm field was excluded due to the

likelihood that monarch habitat would be disturbed by heavy machinery. Each Assessment Area was assigned a name using alphabetical notation. Note that Assessment Area B is not contiguous, but is similar in vegetation and proposed management and so both areas are considered a single Assessment Area. Map shown in 1:5,000 scale.

1.5 Generate 10 random transect locations (if needed): For Assessment Areas greater than 100 meters in width (typically greater than 5 acres in size), random transect locations must be generated prior to the field visit. First, define the Assessment Area boundaries as well as possible on the Project Base Map. Next, generate 10 random transect locations, separated by a minimum distance of 100 meters, within the Assessment Area. Every Assessment Area should have 10 transects, there is no limit to the size of the Assessment Area provided it is of similar vegetation, soils, and management. To generate random transect locations, use a GIS or create a coordinate system across the Assessment Area and use a random number generator to select coordinates for each transect. Upload transect locations to a GPS unit.

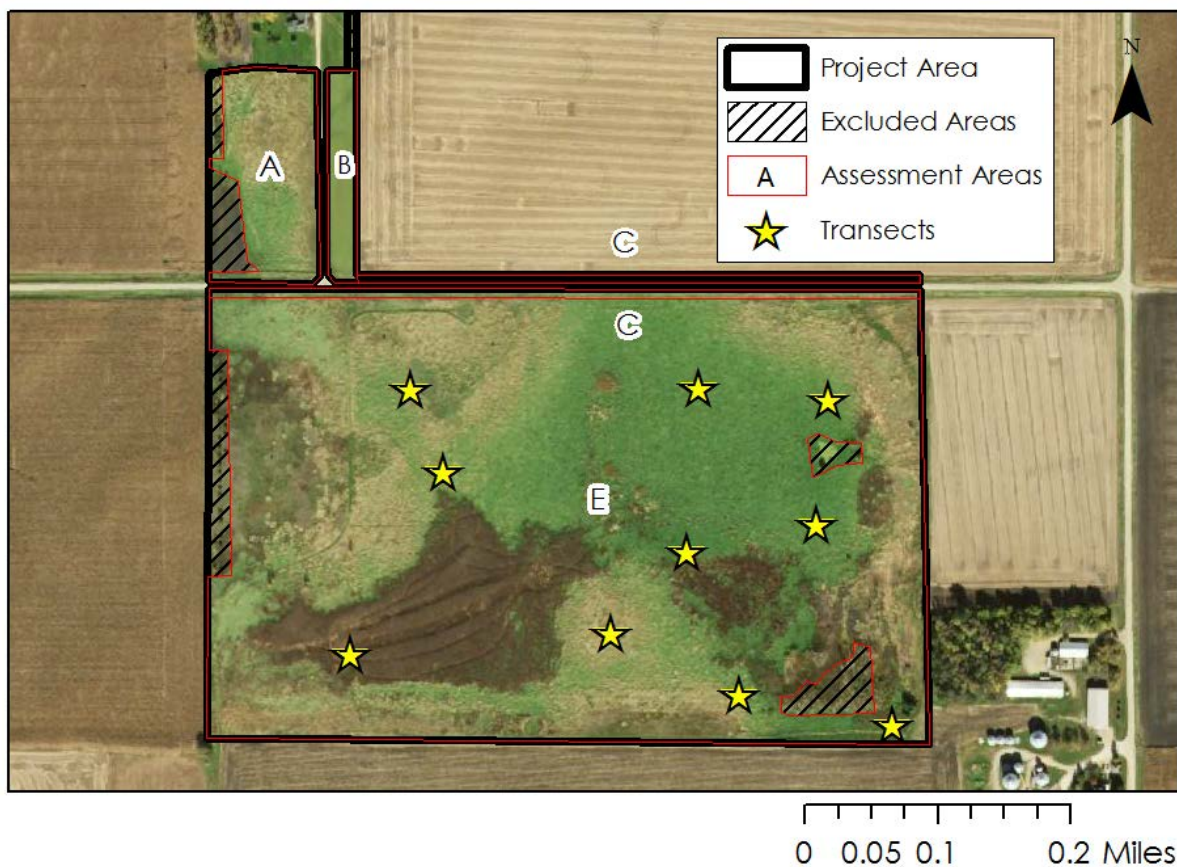


Figure 5. Example Project Area Base Map for a farming operation with a large Assessment Area. Assessment Area E is a proposed prairie restoration project approximately 50 acres in size, and so 10 transect origins were randomly generated within the Assessment Area. These transects will be used during the Site Visit (see step 2). Within Assessment Area E, a hedgerow on the west side was excluded. A small stock pond and a patch of forested area were excluded on the east side. The area between the fence and the road is delineated as a separate Assessment Area and grouped with Assessment Area C from the previous example (Figure 4). Map shown in 1:9000 scale.

STEP 2: VISIT THE SITE

Using the Project Base Map as a guide, visit each Assessment Area, select the most appropriate field data collection method, and collect field data. Field data collection methods can be found in Appendix E. See Figure 7 for help selecting a field method for any given site. The technical service provider and any other members of the field crew should familiarize themselves with all field data collection options. Importantly, for large Assessment Areas (typically for sites greater than 5 acres), random transect locations must be generated prior to arriving at the site, or the crew must have the means to generate random transect locations on site. See step 1.5 for more information.

Data is collected on the site within 1-m² plots. Within each plot, data is collected on the following vegetation characteristics:

- Milkweed Density & Diversity
- Blooming Forb Frequency (an index of density) and Diversity

Data will be collected from approximately 100 plots for each Assessment Area. Plots may be placed along transects using a transect tape or by pacing a set distance from each transect start location. When learning the field data collection methods, we recommend using a transect tape to ensure accurate spacing and placement of plots. As field crew members gain experience, pacing may be a more efficient means of collecting data across the site. It is critical that plots placement is not biased by the presence of milkweeds or blooming forbs within the site.

Field crews will also note nearby threats, specifically conventional agricultural fields within 125 feet, and describe the current and expected management regime of the site if possible.

Field crews are expected to have expertise identifying to species level milkweed and blooming forbs. However, identification to species level is not required to calculate a score for a site. If blooming forbs cannot be identified to species level, a score can be calculated based only on the density of both milkweeds and blooming forbs. However, the score will not reflect the maximum score possible for the site. In the future, a list of monarch-friendly forbs will be developed to help field crews identify important plants for monarch butterflies. Similar lists are available from the NRCS for the South Central region (USDA NRCS 2016).



Figure 6. Field data being collected along a roadside Assessment Area using field data collection method “II: Roadside & Rights-of-Way”.

- 2.1 Collect required materials:** collect all required materials before travelling to the first Assessment Area. See the list of required materials in *Recommended Supplies & Equipment*. Each field data collection method requires similar materials. Multiple field methods may be required for Project Areas with multiple Assessment Areas. It is best to be prepared for all potential situations.
- 2.2 Travel to the first Assessment Area:** the field crew should travel to the first Assessment Area with the required materials. Ensure the landowner or manager provides permission for the proposed route and means of transportation.
- 2.3 Revise Assessment Area boundaries (if necessary):** if the Assessment Area boundaries have not been defined on the Project Base Map, or were defined inaccurately, revise the boundaries. Assessment Area boundaries must be defined for all sites except individual patches (typically 500 milkweed stems or less) when there are many such patches. However, Assessment Area boundaries should be defined for individual patches if reasonable. Ensure the revised Assessment Area boundaries are reflected on the final Project Base Map.
- 2.4 Select the appropriate field data collection method:** upon arrival at the Assessment Area, the field crew should investigate the site and select the appropriate field data collection method. Use the decision tree in Figure 7 to help decide which field data collection method to use. The goal is to collect data within around 100 1-m² plots dispersed across the Assessment Area, where every point in the Area has an equal probability of being selected.

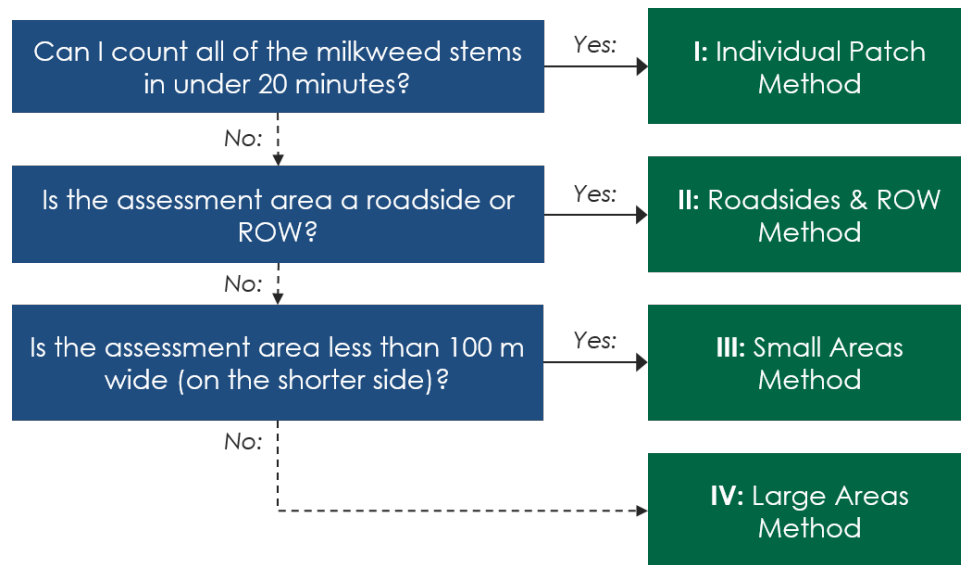


Figure 7. Decision tree for selecting a field data collection method. Beginning at the top left (blue) box, evaluate the Assessment Area for an answer to the question. If yes, follow the solid arrow to the right and select the corresponding field data collection method. If no, follow the dotted arrow down to the next question. Familiarize yourself with all field data collection methods and use proper judgement when selecting the best method for the Assessment Area.

2.5 Collect field data: Follow the steps in the appropriate field data collection methods (Appendix E) to collect field data for each site.

2.6 Repeat for each Assessment Area: after assessing the first Assessment Area, travel to the next Assessment Area and repeat steps 2.3 - 2.5. Continue until all Assessment Areas have been assessed.

STEP 3: COMPLETE DESKTOP ANALYSIS

In this step, you will calculate the area of each assessment area and assess threats to monarch habitat. The primary threat to monarch habitat is nearby conventional agriculture that may contribute to pesticide exposure for monarchs or monarch habitat. Pesticides can harm monarchs by reducing the availability and nutritional value of milkweed and nectar plants (herbicides) and by killing or harming monarchs (insecticides). Insecticide use is prohibited within habitat enrolled in the Monarch Exchange. Herbicide use in and adjacent to monarch habitat should be avoided, or closely controlled to achieve full productivity. Herbicides can be effectively used during the restoration process or to control weedy species that may compete with milkweed and nectar species.

For the purposes of the HQT, the score of any site areas within 125 feet (38 meters) of conventional agriculture will be reduced by 70%, because there is good evidence that pesticides can be transmitted through the soil or air at least this far. Mitigating techniques such as hedgerows can limit the impact of aerial pesticide drift. If hedgerows are present, the site's value will only be reduced by 40% within the 125-foot buffer area. Where it can be demonstrated that

pesticides will not be applied, such as for an organic agricultural operation, no reduction should be applied.

Using the Project Base Map, identify sources of threat (e.g., areas of conventional agriculture) and delineate the acreage that is at-risk from nearby threats. Figure 8 and Figure 9 provide a graphical illustration of the process steps listed below. These data will be input into the Calculator in Step 4.

3.1 Calculate the area in acres of each Assessment Area: using software such as [ArcGIS](#), [QGIS](#), or [Google Earth Pro](#) calculate the area of each Assessment Area in acres. If software is not available, use a scale map of the Project Area to estimate Assessment Area acreage. Accurate estimates of Assessment Area acreage are important for accurately estimating functional acres for each Assessment Area and the Project Area. If Assessment Area boundaries were modified during the Site Visit, ensure those changes are reflected on the Project Base Map.

3.2 Locate nearby threats to monarchs: using the Project Base Map, identify any areas of conventional agriculture within 125 feet (38 meters) of an Assessment Area boundary. Any agricultural fields where it can be assured that pesticides will not be applied during the time monarchs are present may be excluded. These include fields where organic practices are used or fields under the control of the landowner or manager where they have committed to monarch-friendly pesticide practices. Contact the Exchange Administrator for more information on these exclusions.

3.3 Calculate area of habitat-at-risk: calculate the area of each Assessment Area that is within 125 feet (38 meters) of conventional agriculture.

3.4 Calculate the area of habitat-at-risk protected by hedgerows or other mitigating techniques: at this time, only hedgerows will be quantified as mitigating techniques. To qualify as a mitigating technique, the hedgerow should have multiple rows of small-needle evergreen trees and/or shrubs achieving 50 – 60% density (40 – 50% porosity) at a height of at least 1.5 times taller than the spray height release. Spacing between rows should be between 12 – 20 ft. For specifics, see Appendix B of *Preventing or Mitigating Potential Negative Impacts of Pesticides on Pollinators Using Integrated Pest Management and Other Conservation Practices* (USDA 2014).



Figure 8. Conventional agricultural fields are located on both the east and west sides of the Project Base Map, and affect Assessment Areas A, B, and C. To assess threats to monarch habitat, first 125 feet was measured from each conventional agricultural field within each Assessment Area (indicated with turquoise lines). Next, the area within each Assessment Area that is within 125 feet of conventional agriculture was delineated and the area in acres calculated.



Figure 9. In Assessment Area A, a double-row hedgerow (which was excluded in Step 1), is protecting much of the habitat from pesticide drift. The area protected by the hedgerow was delineated (indicated in the yellow cross hatched area) and the area in acres calculated.

STEP 4: INPUT DATA INTO CALCULATOR

Now that field data has been collected during the Site Visit and the Desktop Analysis, input this data into the Monarch HQT Credit Project Calculator, following the steps below.

4.1 Download the Monarch HQT Credit Project Calculator: Obtain the *Monarch HQT South Central Region Credit Project Calculator*, available for download at www.edf.org/monarch.

4.2 Input field data into the Calculator: input data from the field data sheets for each Assessment Area into the Calculator, worksheets numbered 1 through 6. See the 'Instructions' tab of the Calculator. See Figure 11 and Figure 12 for guidance on where to input data from the field datasheets into the Calculator. See Step 2 for more information on the Site Visit.

4.3 Input Desktop Analysis results into the Calculator: input data from the Desktop Analysis into the Calculator, worksheet number 7. See Step 3 for more information on the Desktop Analysis process. Figure 10 illustrates the worksheet in the Calculator where this data is entered.

4.3.1 Enter Assessment Area name: enter the name of the Assessment Area under Assessment Area (name).

4.3.2 Enter Assessment Area Acreage: enter the area in acres of each Assessment Area under Assessment Area Acreage (acres) as calculated in Step 3.1.

4.3.3 Enter the Habitat-At-Risk Acreage: enter the area in acres of each habitat-at-risk area under Habitat-At-Risk Acreage (acres) as calculated in Step 3.2.

4.3.4 Enter the Protected Habitat-At-Risk Acreage: enter the area in acres of any areas of habitat-at-risk protected by a mitigating factor such as a hedgerow as calculated in Step 3.3.

4.3.5 Identify the Mitigating Factor Employed: select the mitigating factor employed to protect the habitat-at-risk within each Assessment Area. Currently, only hedgerows are quantifiable as mitigating factors by the Monarch HQT.

Assessment Area (name)	Assessment Area Acreage (acres)	Habitat-At-Risk Acreage (acres)	Protected Habitat- At-Risk Acreage (acres)	Mitigating Factor Employed (factor)
A	3.52	0.95	0.30	Hedgerow
B	2.83	2.39	0.00	None
C	2.01	1.76	0.00	None
D	0.18	0.18	0.00	None
E	57.95	8.29	0.43	Hedgerow

Figure 10. Screenshot of the Desktop Analysis worksheet within the Monarch HQT Credit Project Calculator with example data. Input data from the Desktop Analysis as described in Step 4.3.

Assessment Area Datasheet

The diagram shows two pages of the 'Assessment Area Datasheet' with blue callout boxes indicating data input locations:

- 1. Assessment Area Data:** Points to the top section of the front page (Site Name, Recorder, Observers, Date, Start/Stop Time, Temp, Field Data Collection Method, Baseline Length/Bearing).
- 2. Blooming Forb Species:** Points to the table listing various plant species with columns for Scientific Name, Abbreviation, Common Name (optional), and Notes.
- 1. Assessment Area Data (only if using Field Method I: Individual Patch Method):** Points to a specific note at the bottom of the front page: 'If Using Field Data Collection Method I, record the number of milkweed stems counted: n/a stems'.
- 3. Management Data:** Points to the back page, which includes sections for 'Provide a brief narrative description of the Assessment Area', 'Describe any potential threats to monarch habitat nearby, especially conventional agricultural fields', 'Describe the current management regime of the Assessment Area and note any disturbances (mowing, haying, pesticide spraying, haying, etc.)', 'Note any observations of monarch butterflies, larvae, pupae, or eggs', and 'Additional Notes'.

Figure 11. This figure illustrates where to input data from the Assessment Area field datasheet into the Monarch HQT Credit Project Calculator. Both the front and back of the datasheet should be input into the Calculator. The Calculator consists of a series of numbered worksheets with required data entry fields. Data should be input from the Assessment Area datasheet into worksheets numbered 1 – 3. The blue boxes in this figure describe which numbered worksheet each area of the datasheet corresponds to.

Transect Datasheet

Monarch Habitat Quantification Tool – Transect Datasheet Revised 09.22.2016

Site Name Green Acres Assessment Area Homestead #1 Recorder JJ Observers RJ, PJ

Transect ID 1 UTM E 496073.1 UTM N 4,825,906.3 Transect Length (m) 50 m Transect Bearing 135

BLOOMING FORB AVAILABILITY											MILKWEED DENSITY & DIVERSITY			
For each 2 m x 0.5 m plot along the transect, record the smallest subplot within which each species occurs (i.e., 1, 2, or 3). Record only plants in flower, including milkweeds. If more than 10 plots are sampled for a transect, use a second datasheet.											Record the number of milkweed plants and stems by species found in each 2 m x 0.5 m plot. Record the plot number in which the milkweed is found. Record all milkweeds encountered, including those on which you do not observe monarchs.			
2 m x 0.5 m plots														
Plot Location (m):	2	6	10	14	18	22	26	30	34	38	Milkweed Species Abbreviation	Plot #	# of Plants	# of Stems
Blooming Forb Species Abbreviation	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10				
LIAPYC	0	3	1	2	0	0	0	3	3	1	ASCTUB	1	2	4
ASCTUB	0	0	3	2	2	0	0	0	0	3	ASCSYR	3	2	2
LOTGOR	1	0	0	0	0	3	2	1	3	0	ASCSYR	4	1	1
ERIANN	1	0	1	2	0	0	0	3	0	0	ASCTUB	7	1	4
HELHEL	1	0	2	0	0	0	1	1	0	0	ASCSYR	10	3	4
CHAFAS	0	0	3	0	0	0	0	0	0	3				
SOLRIG	0	3	2	0	0	0	0	0	0	3				
VERFAS	3	3	0	0	0	2	3	2	0	3				
DESPAN	1	0	3	3	3	0	2	2	2	2				
HELACT	1	0	0	0	0	0	1	1	0	2				
ALLSTE	1	3	0	0	2	0	2	0	0	0				
All Blooming Forb Species ¹ :	1	3	1	3	2	3	1	1	2	1				

¹Record the minimum value for each column. This represents the smallest subplot in which any blooming forb species was found.

Notes:

4. Transect Data

All Forb Data (Optional)

(collecting data for each species is optional; this section of the datasheet may be blank.)

5. Forb Availability

6. Milkweed Availability

Figure 12. This figure illustrates where to input data from the Transect field datasheet into the Monarch HQT Credit Project Calculator. The Calculator consists of a series of numbered worksheets with required data entry fields. Data should be input from the Transect datasheet into worksheets numbered 4 – 6. The blue boxes in this figure describe which numbered worksheet each area of the datasheet corresponds to. Each transect may include more than one datasheet. Check the back of the datasheet for data. Blooming forb availability data per species may not be collected during the site visit, however if data is present, record it in the All Forb Data (Optional) worksheet in the Calculator. This data does not affect the score for the project.

STEP 5: REVIEW RESULTS & FINALIZE PROJECT BASE MAP

You are now ready to review results and finalize the Project Base Map. Within the Monarch HQT Credit Project Calculator, the 'Summary' worksheet presents the combined results for all Assessment Areas in the project (Figure 13). This worksheet also serves as one part of an application for the Monarch Exchange. Complete the project information fields and print to submit to your local Monarch Exchange Administrator along with the finalized Project Base Map (Figure 14).

5.1 Review 'Summary' worksheet in the Calculator: The results of the HQT Assessment are summarized in the worksheet titled 'Summary' in the Calculator. The overall results are displayed in the first row 'HQT Assessment Results'. A breakdown of results is provided below for the following factors:

- **Site Capacity:** Site Capacity describes the potential of the project to support monarchs based on milkweed and nectar plant availability, ignoring threats and conservation priority. The Site Capacity scores can be improved by improving the abundance and diversity of native milkweed and nectar plants.
- **Threats:** Threats refer to the impact of pesticide drift on the project. Higher scores are better. The threats score can be improved by reducing acreage of habitat-at-risk or increasing the proportion of habitat-at-risk protected using mitigating factors like hedgerows.
- **Conservation Priority:** Conservation Priority refers to the relative importance of the project's geographic location along the migration route for monarchs. The Conservation Priority of a project is determined based on the region in which the project is located.

For detailed information for each Assessment Area, see the 'Assessment Area Results' worksheet.

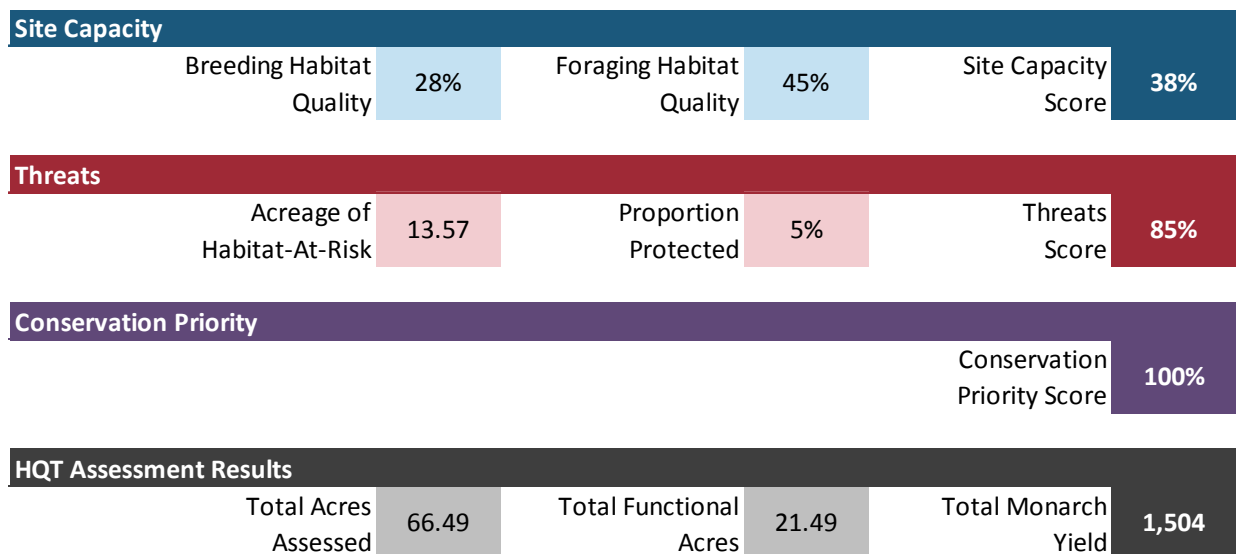


Figure 13. Screenshot of a portion of the Summary worksheet in the Monarch HQT Credit Project Calculator. This captures the final result of the HQT assessment for the entire Project Area.

5.2 Finalize Project Base Map: The final Project Base Map should include the boundaries of the Project Area, any excluded areas, the boundaries and names of each Assessment Area, locations of any transects (if generated for large Assessment Areas), areas of habitat-at-risk, and areas of habitat-at-risk protected by mitigating factors such as hedgerows. See Figure 14 for an example.



Figure 14. Example Finalize Project Base Map. The final Project Base Map should include the boundaries of the Project Area, any excluded areas, the boundaries and names of each Assessment Area, locations of any transects (if generated for large Assessment Areas), areas of habitat-at-risk, and areas of habitat-at-risk protected by mitigating factors such as hedgerows.

APPENDIX A: BEST MANAGEMENT PRACTICES

Management actions can affect milkweed and nectar diversity, abundance, and distribution for each season (breeding or migrating). Milkweed and nectar sources should provide adequate habitat for continued presence of all monarch life stages. Management actions can limit woody and invasive plant species, improving longevity of habitat viability for monarchs. In addition to improving habitat, management actions can reduce threats to monarchs and monarch habitat. For example, installing hedgerows can reduce the risk of pesticide exposure from drift.

Some species of milkweed are disturbance adapted, which makes them respond more favorably to disturbance. Since some milkweed species need disturbance in order to thrive, the milkweed species composition at a site should be considered when making management decisions.

Potential management actions include mowing or haying, grazing, burning, targeted use of herbicides, control of invasives, planting additional milkweeds or nectar sources, and installing hedgerows. All enrolled habitats should have a management plan in place, which should be assessed periodically, particularly if habitat quality does not respond to management actions as expected. In this section, management actions and considerations for monarchs and monarch habitats are provided based on the best available science. However, there is no one-size-fits-all prescription; these guidelines should be used in conjunction with best professional judgement and adaptive management.

Please note that all management practices will affect different wildlife species differently. We focus here on effects on monarchs and monarch habitat, but there is a large literature on mowing and other management actions to minimize effects on many species. Management actions like mowing or burning should be avoided whenever monarchs are present, particularly when they are abundant

Mowing/Haying

Mowing is often used to control woody and weedy species and keep other undesirable species from setting seed, and can lead to higher native plant diversity, which will benefit monarchs and other pollinators. However, mowing established habitat too often or when monarchs are present may result in higher mortality for monarchs and other wildlife, including important pollinators (MJV 2016c). Mowing may be conducted to prevent undesirable plants from creating a closed canopy during the first few years of habitat establishment, which will impact prairie plants by reducing germination, growth and survival of those plants (Williams et al. 2007). In areas where milkweed is present year-round, mowing or cutting the aboveground milkweed foliage during times when monarchs should not be historically present (e.g., winter in Texas) may help mitigate spread of disease in monarchs by removing plants that harbor higher numbers of OE parasite spores (Satterfield et al. 2015). Mowing should be restricted between May 1 and July 15 to avoid impacting grassland bird nesting season; practice rotational mowing as appropriate (USDA -NRCS 1999).

Mowing studies that relate specifically to milkweed or monarchs are limited in geographic scope or species observed, and thus are not necessarily applicable for all species and landscapes. Fischer et al. (2015) looked at *Asclepias syriaca* in New York, and concluded that timely mid-summer mowing could provide new milkweed growth which was preferred for monarch reproduction. Baum and Mueller (2015) studied *A. viridis* in the Southern Great Plains and determined that summer disturbance (fire or mowing) could result in increased milkweed availability during the early fall monarch pre-migration. Milkweed response to mowing (regrowth) is affected by precipitation and available moisture (Chip Taylor, personal communication and observations of UMN Monarch Lab). Since there is limited information on species- and region-specific milkweed responses to mowing, adaptive management will play a key role.

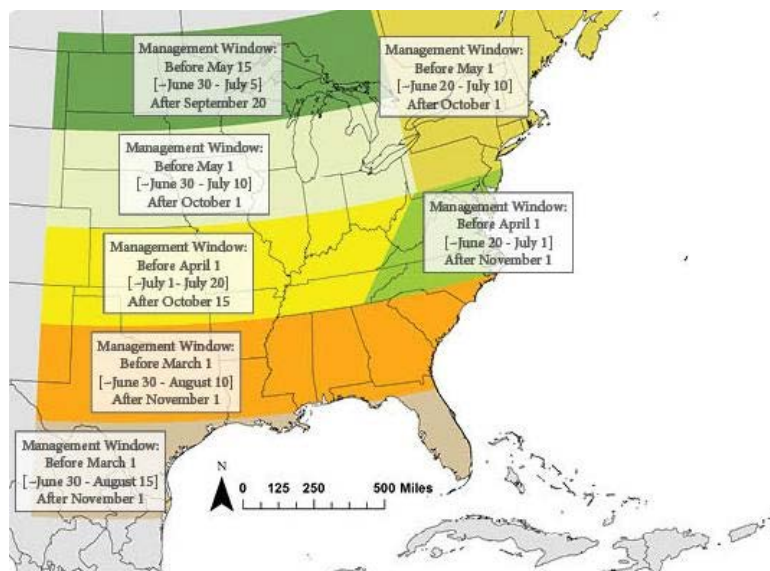


Figure 15. Appropriate Management Timing for Monarchs. The management windows represented in each region of the map offer different windows in spring, summer and fall when mowing or other management may be safer for monarchs. Recommendations are based on long term monarch trends and some variation may occur from year to year; recommendations for other priority species should be considered in addition to these monarch-specific recommendations. When possible, avoid mowing during growing season or bloom period for milkweed and nectar plants or before they have dispersed seed. Figure courtesy of the Monarch Joint Venture.

We recommend the following basic mowing BMPs for monarchs:

1. Avoid mowing the entire habitat to leave refuge areas for wildlife using the site at the time of mowing. Marking known areas may prevent accidental mowing. Maintenance should be done on less than 1/3 of the acreage during any given year, except during the first year post-planting (USDA - NRCS 2015a).
2. Timing of mowing is critical (Figure 15, MJV 2016c). Avoid mowing during times of high monarch reproduction or migration. (MJV 2016c)

3. When possible, avoid mowing during growing season or bloom period for milkweed and nectar plants or before they have dispersed seed (USDA and DOI 2015, USDA- NRCS 2015a).
4. Limit mowing to no more than twice per year, and less frequently if possible. Mowing too frequently disrupts plant growth and the ability of forbs to compete with grass species. However, during the first year of prairie restoration, more frequent mowing may be needed for weed control. (MJV 2016c)
5. Use a minimum cutting height of 8-12 inches (shorter heights may be needed for early establishment mowing) to effectively remove seed producing parts of most invasive plants and minimize impacts on native plants. (MJV 2016c)
6. If the entire hay field must be harvested within a short time period, harvest from one end of the field to another, rather than harvesting the perimeter and inward, to allow insects— and other wildlife—a route to escape the field (USDA and DOI 2015).
7. As a general rule, do not let weeds and other vegetation get taller than knee high in the first growing season. For tall biennial weeds, mow or pull just prior to flowering to curtail the plants' ability to go to seed (Sheley et al. 2001). By the third growing season, most of the vegetative growth throughout the site should be prairie plants and mowing should not be needed. (Tallgrass Prairie Center 2015)

Grazing

Conservation grazing can be an effective management tool that has economic incentives and could potentially decrease the amount of land in row-crop production. While economic importance of grazing varies by region, and thus the size and abundance of grazing lands will also vary, this practice could result in additional, higher quality habitat for monarchs and other pollinators across the U.S.

While extensive scientific research on the risks of milkweed toxicity in grazing lands is not available, we conclude that properly managed grazing lands containing milkweed should pose little risk to livestock. Milkweed species, although often avoided by grazing animals in the presence of other forage (Fleming 1920, Fulton 1972, Marsh 1924, Pfister et al. 2002), may have different levels of toxicity to livestock if consumed. Additionally, depending on the species consumed and the livestock species, an animal may become ill from eating milkweed, but consumption of a lethal dose is very rare. However, dried milkweed can retain its toxicity and may become more palatable, so milkweeds should be avoided in lands that will be hayed for later consumption by livestock.

We recommend the following basic grazing BMPs for monarchs:

1. Consider limiting grazing to outside of the monarch growing season, when immature monarchs are present.
2. Minimize livestock concentrations in one area by rotating livestock grazing timing and location to help maintain open, herbaceous plant communities (USDA and DOI 2015). Do not overgraze an area.

3. Protect the current season's growth in grazed areas by retaining at least 50% of the annual vegetative growth on all plants (USDA and DOI 2015).
4. Enhance the growth of forbs to ensure their ability to reproduce and to provide floral resources throughout the growing season by setting grazing levels to allow forbs to flower and set seed (USDA and DOI 2015).
5. Prevent grazing during periods when flowers are scarce (USDA and DOI 2015).

Burning

Prescribed burning in portions of monarch habitat can help reduce woody and weedy species, much like other management methods. It can also provide the disturbance needed by some species of milkweed to thrive. However, caution must be used with fire in monarch habitat, as fire can directly kill monarchs, particularly the less mobile immature stages.

Monitoring of *A. viridis* in control sites and sites post-disturbance in Oklahoma (either fire or mowing) indicated that the species was present in late summer in previously burned sites, but nearly absent in unburned sites. This may allow for late-season breeding of pre-migratory monarchs (Baum and Mueller 2015).

We recommend the following basic burning BMPs for monarchs:

1. Burning should be conducted outside of the growing season or bloom period, and ideally on less than 1/3 of the acreage during any given year, except during the first year post-planting (USDA - NRCS 2015a, USDA and DOI 2015).
2. The second year (after installation), evaluate the stand to determine if weed control is necessary (and implement control if deemed necessary). If there is enough material for a prescribed burn, this may be an effective weed control method (USDA - NRCS 2015b).
3. If possible, leave small unburned patches within the burned areas (USDA and DOI 2015, Gilgert and Vaughan 2011, Black et al. 2007).
4. Burn a prairie planting as soon as the site can carry a continuous fire. Proper use of prescribed fire will accelerate growth of most prairie plants and deter cool-season weeds and small woody plants. Typically, there is not enough fuel to carry a fire in a one or two-year-old planted prairie due to frequent mowing. By the end of third growing season however, there should be enough grass growth to carry a fire (Tallgrass Prairie Center 2015).

Herbicides and Insecticides

Herbicides are often used to eliminate unwanted and invasive plant species at a site, help with site preparation, prevent invasive plant encroachment, and promote native plant growth. Caution must be taken in timing of application and type of herbicide used, so as not to eliminate milkweed or important nectar sources for monarchs and other pollinators. Conventional agricultural systems where herbicides are used to eradicate weeds from row crops or grazing lands pose a higher risk to milkweed/monarch habitat due to pesticide drift or unintended effects on non-target species. Application of insecticides may result in direct monarch mortality and

should not be used in or near monarch or pollinator habitat. Whenever pesticides are used, it is important to minimize risks of unintended consequences to non-target species.

If herbicide is required for successful management, we recommend the following practices:

1. Herbicides can be used during site preparation (prior to planting) to eliminate competing weeds from a planting area. In fact, after most of the residue is removed by fire or mowing, use of a broad-spectrum herbicide will kill remaining vegetation (especially aggressive perennial weeds). For organic farms, the use of smother crops or solarization with plastic can provide acceptable results (USDA - NRCS 2015b).
2. Spot spray using backpack sprayers or other feasible application methods to reduce overspray and drift (USDA and DOI 2015, Tallgrass Prairie Center 2015).
3. Minimize or eliminate broadcast herbicide applications when flowers in the habitat are in bloom (USDA and DOI 2015).
4. Choose less toxic compounds, apply using coarse sprays or ground application when possible, and avoid spraying milkweed plants (Black et al. 2007).
5. Apply the herbicide at the proper stage of plant development and at the rate specified by the label. The herbicide application rate will vary according to the weed species and severity of infestation (Tallgrass Prairie Center 2015).
6. After planting, herbicides may be spot-sprayed to remove broadleaf weeds, or grass-selective herbicides may be applied to larger areas to eliminate persistent weedy grasses (USDA - NRCS 2015a). Spray only the persistent perennial weeds and woody plants. Over time prairie plants will exclude most other weeds from the planting. If possible, spray when the natives are dormant (Tallgrass Prairie Center 2015).
7. Minimize or avoid herbicide applications when dew is present or forecasted to be present on vegetation (USDA and DOI 2015).
8. If possible, use herbicides that are species specific. Some herbicides work better than others on individual weed and woody species (Tallgrass Prairie Center 2015).

If you have control of pesticide application practices on lands adjacent to the site, we recommend following these general BMPs:

1. Adopt Integrated Pest Management principles to limit the need for pesticides (USDA and DOI 2015).
2. Avoid aerial spraying whenever possible. Limit spray applications to times when wind speed is low (i.e., less than 10 miles per hour) (USDA and DOI 2015).
3. Reduce the risk of drift by operating standard boom sprayers at the lowest effective pressure and with nozzles set as low as possible and/or by using nozzles that are capable of operating at low pressures (15–30 pounds per square inch). Operate spray equipment with nozzles set just above plant height (USDA and DOI 2015).
4. Use GPS systems to prevent overlapping application to reduce the total amount of active ingredient applied. Additionally, use electrostatic or image-responsive sprayers to improve application efficiency and reduce off-target application. Using hooded sprayers or spray curtains to better contain the spray area (USDA 2014).

5. Minimize or avoid pesticide applications when dew is present or forecasted to be present on vegetation (USDA and DOI 2015).

Control of Invasives

Invasive plant species can alter the structure of the plant community; ongoing invasive management is often needed to maintain good habitat. Additionally, a species of invasive swallow-wort (*Cynanchum rossicum*) may present a direct risk to monarchs by creating an ecological sink: monarchs lay eggs on the plant, but larvae are unable to use it as a food source (Casagrande and Dacey 2007, DiTommaso and Losey 2003).

We recommend the following basic BMPs for invasive species control:

1. Inspect the habitat regularly for invasive plants or other plants that may compromise the quality of the habitat for monarchs. Undesirable species should be controlled using the least damaging method (USDA - NRCS 2015a)
2. Use adaptive management approaches to try various techniques on small plots to determine what works best for a given species and area. Management of invasive species may include felling by hand or machine, machine mulching, applying spot treatments of herbicide to bark, cut stumps, or leaves, controlled burning, mowing, or combinations of the approaches. Follow-up treatments may be necessary to prevent growth of new seedlings or plants that survived the initial treatment (USDA and DOI 2015).
3. Clean all equipment before moving to new sites to ensure that invasive species are not transported to new areas (USDA and DOI 2015).
4. Use BMPs from above recommended management actions sections to control invasive plants as needed.

Planting Additional Milkweed and Nectar Sources

Native milkweed and nectar sources are necessary for monarch survival. Increasing the number of beneficial species in a plot will promote a diversity of resources for monarchs.

We recommend the following considerations for adding milkweed and nectar plants to a habitat:

1. Ensure that early, mid, and late flowering nectar plants are available.
2. Increase diversity of native milkweed species at a site to provide additional benefits during different times of the growing season, or provide more options for ovipositing females.
3. Consult with local restoration ecologists, land management agencies, or technical service providers for appropriate recommendations for site preparation, planting, species selection, and timing for your location.
4. Whenever possible, use locally sourced wildflower and milkweed seeds.

Hedgerows

Hedgerows, or similar structures, may serve as buffer zones around agricultural areas (Felsot et al. 2010). Hedgerows may absorb a percentage of pesticide deposits from neighboring areas, potentially reducing monarch mortality and negative effects on milkweeds and nectar sources.

APPENDIX B: DEFINITIONS

Adaptive Management – a structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring.

Assessment Area – an area of similar landscape attributes, soils, vegetation, and management actions which is assessed as a single unit using the Monarch HQT.

Breeding Habitat – habitat required by monarchs for reproduction. Breeding habitat is assessed in the Monarch HQT based on the availability of milkweed plants.

Conservation Priority – The relative importance of your site's geographic location along the migration route for monarchs.

Foraging Habitat – habitat required by adult monarchs for obtaining food. Foraging habitat is assessed in the Monarch HQT based on the availability of blooming forbs, including milkweeds.

Functional Acres – describe both the quantity and quality of habitat. Calculated by multiplying habitat quality (as a percentage) by the number of acres of habitat.

Habitat-At-Risk – monarch habitat within 125 feet (38 meters) of conventional agriculture where impacts from pesticide drift are possible.

Habitat Quality – the ability of a site to sustain monarchs and support monarch population growth.

Landowner or manager – the individual who owns or makes decisions for the monarch habitat being assessed by the Monarch HQT.

Monarch Butterfly Habitat Exchange – provides farmers and ranchers with incentive-based opportunities to restore and conserve monarch habitat. Participants in the MBHE generate "credits" based on the estimated contribution to monarch recovery goals that results from their project, as calculated by the Monarch HQT.

Monarch Habitat Quantification Tool – a habitat assessment method, based on best-available science and expert opinion, for assessing existing quality, as well as changes in quality over time, of monarch habitat on a piece of land; it is the basis for determining the number of "credits" that can be generated from a project enrolled in the Monarch Butterfly Habitat Exchange.

Monarch Yield – an estimate of the total number of monarchs contributed per site to the overwintering population.

Protected Habitat-At-Risk – monarch habitat within 125 feet (38 meters) of conventional agriculture that is protected by a mitigating factor, such as a hedgerow.

Project Area – includes all areas within the site to be assessed using the Monarch HQT.

Site Capacity – The availability of abundant and diverse milkweed and nectar plants, which monarchs need for feeding and reproduction.

Technical Service Provider – a trained field biologist capable of assessing monarch habitat using the Monarch HQT and communicating results to landowners or managers.

Threats – The risk of pesticide drift on areas within 125 feet of conventional agriculture, which can lead directly to monarch mortality or severely impact milkweed and nectar plant availability and quality. This threat takes into consideration the potential for mitigation by management practices that limit pesticide drift, such as hedgerows.

APPENDIX C: REFERENCES

- Baum, K. A., and E. Mueller. 2015. Grassland and roadside management practices affect milkweed abundance and opportunities for monarch recruitment, pp. 197–202. In K. S. Oberhauser, K. R. Nail, and S. M. Altizer, (eds.), *Monarchs in a changing world: Biology and conservation of an iconic butterfly*. Cornell University Press, Ithaca, New York.
- Black, S. H., N. Hodges, M. Vaughan, and M. Shepherd. 2007. *Pollinators in Natural Areas: A Primer on Habitat Management*. Xerces Society for Invertebrate Conservation.
- Casagrande, R.A. and J.E. Dacey. 2007. Monarch Oviposition on Swallowworts (*Vincetoxicum* spp.). *Environ. Entomol.* 36(3):631-636.
- DiTommaso, A. and J.E. Losey. 2003. Oviposition Preference and Larval Performance of Monarch Butterflies (*Danaus plexippus*) on two invasive swallowwort species. *The Netherlands Entomological Society Entomol. Exp. Appl.* 108: 205-209.
- Felsot, A.S., J.B. Unsworth, J.B.H.J. Linders, G. Roberts, D. Rautman, C. Harris, and E. Carazo. 2010. Agrochemical spray drift; assessment and mitigation—A review. *Journal of Environmental Science and Health, Part B*, 46: 1-23.
- Fischer, S. J., E. H. Williams, L. P. Brower, and P. A. Palmiotto. 2015. Enhancing monarch butterfly reproduction by mowing fields of common milkweed. *Am. Midl. Nat.* 173: 229–240.
- Fleming, C. E. 1920. *The Narrow-leaved Milkweed (Asclepias mexicana) and the Broad Leaved or Showy Milkweed (Asclepias speciosa): Plants Poisonous to Livestock in Nevada*. (Agricultural Experiment Station Bulletin No. 99). 32 pp. Reno: University of Nevada.
- Fulton, D. H. (ed). *Poisonous Plant Groups*. 1972. Technical Note—Range No. 1. 23 pp. Boise, ID: USDA—Soil Conservation Service.
- Gilgert, W. and M. Vaughan. 2011. The Value of Pollinators and Pollinator Habitat to Rangelands: Connections among Pollinators, Insects, Plant Communities, Fish and Wildlife. *Rangelands*. 33(3): 14-19.
- Marsh, C. D. *Stock-Poisoning Plants of the Range*. 1924. (Department Bulletin 1245) 36 pp. Revised 1929. Washington, D.C.: United States Department of Agriculture.
- Monarch Joint Venture. *Mowing: Best Practices for Monarchs*. 2016c. <<http://monarchjointventure.org/images/uploads/documents/MowingForMonarchs.pdf>> (Date of access: 2/26/2016).
- Nail, K.N., C.M. Stenoien, and K.S. Oberhauser. 2015. Immature monarch survival: Effects of site characteristics, density, and time. *Annals of the Entomological Society of America*. 108: 680-90.
- Pfister, J. A., F. D. Provenza, K. E. Panter, B. L. Stegelmeier, and K. L. Launchbaugh. 2002. Risk Management to Reduce Livestock Losses from Toxic Plants. *Journal of Range Management* 55(3):291–300.

Pleasants, J. 2016. Milkweed restoration in the Midwest for monarch butterfly recovery: estimates of milkweeds lost, milkweeds remaining and milkweeds that must be added to increase the monarch population. *Insect Conservation and Diversity* (2016).

Satterfield, D.A., J.C. Maerz, and S. Altizer. 2015. Loss of migratory behaviour increases infection risk for a butterfly host. *Proc. R. Soc. B.* DOI: 10.1098/rspb.2014.1734.

Sheley R, Goodwin K. and Rinella M. Mowing to manage noxious weeds. 2001. Agricultural Extension Publication. Weeds A-16 (Range and Pasture). Montana State University. Bozeman, Montana.

Tallgrass Prairie Center. Prairie Restoration Series. 2015. Technical Guides (Vols. 1-10). <www.tallgrassprairiecenter.org/publications> (Date of access 2/26/2016).

[USDA and DOI] US Department of Agriculture and US Department of Interior. 2015. Draft pollinator-friendly best management practices for federal lands. <www.fs.fed.us/wildflowers/pollinators/BMPs/> (Date of access: 2/26/2016).

[USDA - NRCS] US Department of Agriculture Natural Resources Conservation Service. 2016a. Monarch Butterfly Wildlife Habitat Evaluation Guide and Decision Support Tool: S. Great Plains. <http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/plantsanimals/pollinate/?cid=nrcseprd402207> (Date of access: 6/164/2016).

[USDA - NRCS] US Department of Agriculture Natural Resources Conservation Service. 1999. Grassland Birds, Fish & Wildlife Habitat Management Leaflet Number 8. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_009930.pdf (Date of access: 4/1/2017).

US Department of Agriculture Natural Resources Conservation Service. 2015a Plant Enhancement Activity – PLT15 – Establish pollinator and/or beneficial insect habitat. <www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/csp/?cid=stelprdb1265825> (Date of access: 2/26/16).

US Department of Agriculture Natural Resources Conservation Service, Minnesota. 2015b. Native Habitat Development for Pollinators CP42 Job Sheet. <www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/programs/?cid=nrcs142p2_023677> (Date of access: 2/26/2016).

[USDA] US Department of Agriculture. 2014. Agronomy Technical Note No 9. Preventing or Mitigating Potential Negative Impacts of Pesticides on Pollinators Using Integrated Pest Management and Other Conservation Practices <<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=34828.wba>> (Date of access: 2/26/2016).

Williams D, Jackson L, Smith D. 2007. Effects of frequent mowing on survival and persistence of forbs seeded into a species-poor grassland. *Restoration Ecology* 15: 24-33.

APPENDIX D: SAMPLE FRAME CONSTRUCTION

Follow these instructions to construct the subplot frame that will be used to collect field data for the Monarch HQT. The subplot frame is a 0.5 x 1.0-meter frame, divided into 2 subplots; the final (3rd) subplot results from flipping the sample frame over. These instructions result in a subplot frame that can easily be broken down for transportation; however, after repeated use the connections may weaken. Be prepared to glue or tape together the frame after many uses. A single frame should cost approximately \$5.

MATERIALS REQUIRED

- 3 meters (10 feet) $\frac{3}{4}$ or $\frac{1}{2}$ PVC pipe (to be cut into $\frac{1}{2}$ meter sections)
- 4 PVC 90° elbow joints
- 2 PVC straight couplings
- Electrical tape or marker to visually divide the sample frame into plots

INSTRUCTIONS

1. Cut the PVC pipe into 6 sections of $\frac{1}{2}$ meter each.
2. Connect the PVC sections using the 90° elbow joints and straight couplings to create a 0.5 x 1.0-meter frame. Ensure all couplings are very tight and the sample frame lays flat.
3. Mark the straight couplings on either side of the frame to visually divide the frame into 2 subplots.



Figure 16. Subplot frame used to collect field data for the Monarch HQT. The subplot frame is a 0.5 x 1.0-meter frame, divided into 2 subplots; the final (3rd) subplot results from flipping the subplot frame over

APPENDIX E: FIELD DATA COLLECTION METHODS

Monarch Butterfly Habitat Quantification Tool

FIELD DATA COLLECTION METHOD

I: Individual Patches

1/30/2017

This field data collection method is typically used for small patches of milkweed of less than 500 plants.

MATERIALS NEEDED

- Clicker counter
- Data sheets (Assessment Area datasheets; Transect datasheets)
- Clipboard & pencil/pen
- Plant list and identification guides for local area
- Watch or clock
- Camera
- Handheld GPS unit (optional)
- Thermometer

INSTRUCTIONS

Follow these instructions in each Assessment Area. Each Assessment Area should be assessed separately. Assessment Areas will be defined in *Step 1: Develop Project Base Map* of the User's Guide. If an Assessment Area has not been defined, you will define the Assessment Area in Step 1 below.

REPEAT FOR EACH ASSESSMENT AREA:

1. Confirm or Define Assessment Area Boundaries

Upon arrival at the site, field crews should walk together to define the boundaries of the Assessment Area. The Assessment Area should include the patch of milkweed and any associated blooming forb species. Assessment Area boundaries may be man-made (e.g., fence line) or natural (e.g., forest edge). Exclude any areas of open water or forest. If there are two milkweed patches nearby, but a significant gap exists between them, consider those patches as two separate Assessment Areas. If a single milkweed patch will be subject to differing management regimes, it should be divided based on the expected management actions. If part of the milkweed patch will be subject to management actions that are inconsistent with monarch habitat, as defined in Appendix A: Best Management Practices, exclude that part of the patch from the Assessment Area. For example, the mowed edge of a roadside should be excluded from the

Assessment Area unless mowing of the road edge can be prevented during sensitive times for monarchs in the region.

Mark the location of the Assessment Area on the Project Base Map. If a handheld GPS unit is available, record the coordinates of the center of the Assessment Area and capture the boundaries of the Assessment Area by walking the boundary of the Assessment Area with the GPS unit, logging your track.

2. Conduct Timed Species Diversity Assessment

While defining the assessment area, field crews should familiarize themselves with the species of milkweed and blooming forbs present in the Assessment Area. Use local plant identification guides and the relevant NRCS plant list for monarch butterflies² for assistance in species identification. For each blooming forb species encountered, agree on a consistent abbreviation (first three letters of genus and first three letters of species) based on the [Integrated Taxonomic Information System](#) (ITIS). Note that in some cases, more than one species will have the same code (e.g., *Asc vir* could be either *Asclepias viridis* or *A. viridiflora*), so be particularly careful with such a species.

Record the name of all blooming forb species encountered in the Assessment Area based on the Integrated Taxonomic Information System (ITIS) on the *Blooming Forb Species* section of the Assessment Area datasheet. Stop searching for new blooming forb species if more than 2 minutes passes before encountering a new blooming forb species; however, add any blooming forb species encountered within the assessment area during the assessment.

Record only blooming forb species; non-blooming species should not be recorded. A forb species is considered blooming if it has any active flower parts. The status of a forb as a 'nectar' plant is not relevant for this assessment. An accurate count of the number of unique blooming forb species is more important than the accurate identification of each species. For any species that cannot be identified, capture a robust description, photograph, and/or sample of the species for later identification.

3. Count Milkweed Stems

Record the number of stems of each milkweed species on the bottom of the Assessment Area datasheet.

A milkweed plant is defined as all above-ground stems of milkweed originating from a visually-identifiable, common central point in the ground. A single milkweed plant may be composed of one or multiple stems depending on the species. For example, *A. viridis* (green antelopehorn milkweed) plants may grow multiple stems per plant, similar to *A. syriaca* (common milkweed) shown in Figure 24. Other frequently encountered species of milkweed that often grow multiple stems per plant are *A. tuberosa* (butterfly weed) and *A. incarnata* (swamp milkweed). If you encounter these plants, count each cluster of stems originating from the same central point as a

² Important Plants of the Monarch Butterfly – Midwest; Important Plants of the Monarch Butterfly – Southern Great Plains.

single plant. Record data about both number of plants and number of stems per plant in the appropriate columns of *Milkweed Density & Diversity* section of the Transect datasheet. Stems of some species of milkweed may branch aboveground, but branches originating from a single stalk should be counted as one stem.

A single *A. syriaca* plant (common milkweed) may grow many ramets (above-ground as stalks) that are separated by small or large distances, but without excavating roots, it is impossible to tell if ramets are from the same or different plants (Figure 17). Record each individual stalk of *A. syriaca* as a plant.

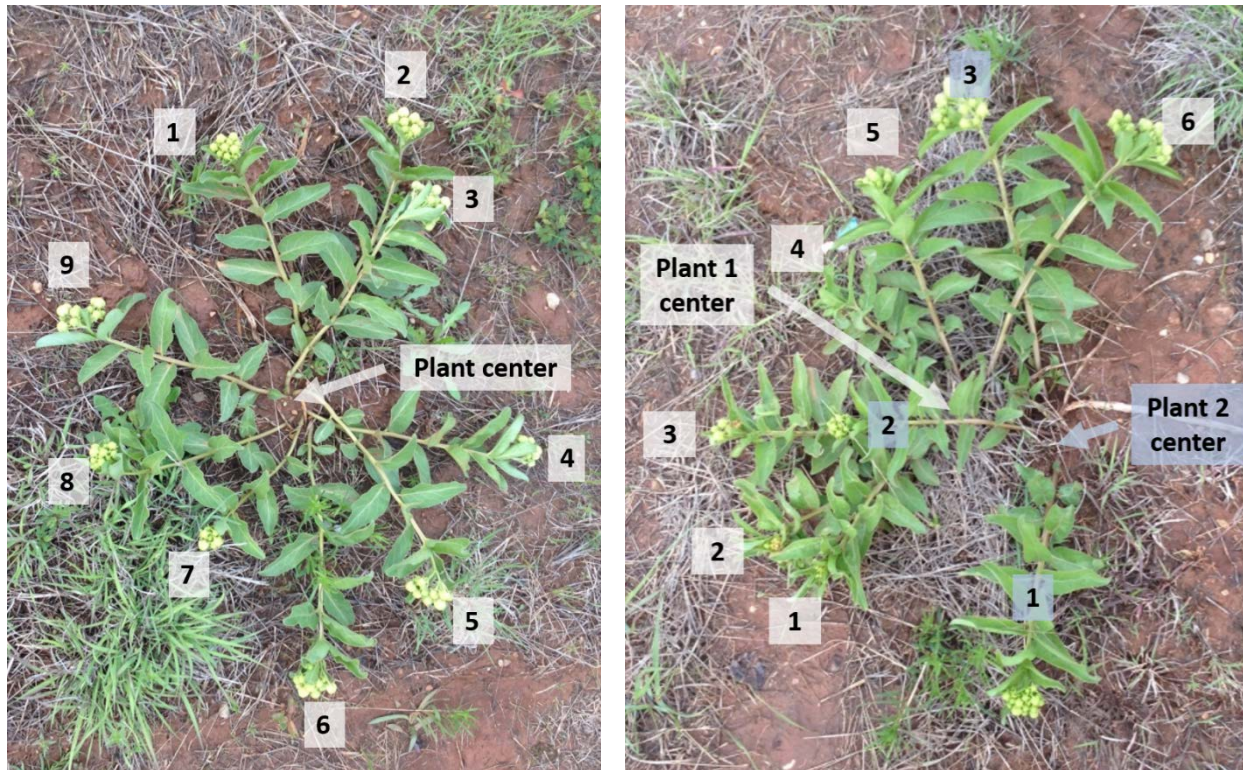


Figure 17. *A. syriaca* (common milkweed) plants. Each above-ground stalk (ramet) could be from different or the same plant. Count each stalk as an individual plant. (Photo courtesy of Kristen Baum).

4. Review Datasheets

Using a field temperature gauge, measure the temperature in the shade. **Record the temperature in the shade and the stop time on the Assessment Areas datasheet.**

Check datasheets for legibility and mistakes (exchanging sheets with someone that didn't record the data is a good technique) soon after you finish collecting data (e.g., during a lunch break or end of day).

ACKNOWLEDGEMENTS

This field method is based on the MCSP Monarch Monitoring Trial Protocol (2016).

Monarch Butterfly Habitat Quantification Tool

FIELD DATA COLLECTION METHOD

II: Roadsides & Rights-of-Way

1/30/2017

This field data collection method is typically used for roadsides & rights-of-way.

MATERIALS NEEDED

- 100-meter transect tape (optional)
- Pin flags (optional)
- 2 transect stakes (optional)
- Subplot frame (0.5 x 1.0-meter frame with nested subplots). The subplot frame can be constructed prior to the assessment, see *Appendix D* for guidance.
- Data sheets (Assessment Area datasheets; Transect datasheets)
- Clipboard & pencil/pen
- Plant list and identification guides for local area
- Watch or clock
- Camera
- Compass
- Handheld GPS Unit (optional)
- Thermometer
- Duct Tape (optional but recommended in case subplot frame breaks)
- Calculator (optional)

INSTRUCTIONS

Follow these instructions in each Assessment Area. Each Assessment Area should be assessed separately. Assessment Areas will be defined in *Step 1: Develop Project Base Map* of the User's Guide. If an Assessment Area has not been defined, you will define the Assessment Area in Step 1 below.

REPEAT FOR EACH ASSESSMENT AREA:

1. Confirm or Define Assessment Area Boundaries

Upon arrival at the site, field crews should walk together to define the boundaries of the Assessment Area. The Assessment Area should include the patch of milkweed and any associated blooming forb species. Assessment Area boundaries may be man-made (e.g., fence line) or natural (e.g., forest edge). Exclude any areas of open water or forest. If there are two milkweed patches nearby, but a significant gap exists between them, consider those patches as two

separate Assessment Areas. If a single milkweed patch will be subject to differing management regimes, it should be divided based on the expected management actions. If part of the milkweed patch will be subject to management actions that are inconsistent with monarch habitat, as defined in Appendix A: Best Management Practices, exclude that part of the patch from the Assessment Area. For example, the mowed edge of a roadside should be excluded from the Assessment Area unless mowing of the road edge can be prevented during sensitive times for monarchs in the region.

Mark or check the boundaries of the Assessment Area on the Project Base Map. Record the Site Name, Assessment Area, Recorder, Observers, Date, Start Time, and Field Data Collection Method used (II for the Roadsides & Rights-of-Way method) on the Assessment Area datasheet.

2. Conduct Timed Species Diversity Assessment

While defining the Assessment Area, field crews should familiarize themselves with the species of milkweed and blooming forbs present in the Assessment Area. Use local plant identification guides and the relevant NRCS plant list for monarch butterflies³ for assistance in species identification. For each blooming forb species encountered, agree on a consistent abbreviation (first three letters of genus and first three letters of species) based on the [Integrated Taxonomic Information System](#) (ITIS). Note that in some cases, more than one species will have the same code (e.g., *Asc vir* could be either *Asclepias viridis* or *A. viridiflora*), so be particularly careful with such a species.

Record the name of all blooming forb species encountered in the Assessment Area based on the Integrated Taxonomic Information System (ITIS) on the *Blooming Forb Species* section of the Assessment Area datasheet. Stop searching for new blooming forb species if more than 2 minutes passes before encountering a new blooming forb species; however, add any blooming forb species encountered within the assessment area during the assessment.

Record only blooming forb species; non-blooming species should not be recorded. A forb species is considered blooming if it has any active flower parts. The status of a forb as a 'nectar' plant is not relevant for this assessment. An accurate count of the number of unique blooming forb species is more important than the accurate identification of each species. For any species that cannot be identified, capture a robust description, photograph, and/or sample of the species for later identification.

If additional blooming forb species are encountered during the remainder of the assessment, record the species name and an appropriate abbreviation on the Assessment Area datasheet. Confer with all members of the field crew in the Assessment Area for any new species encountered, as the other members of the field crew may have encountered the same species but identified it differently.

³ Important Plants of the Monarch Butterfly – Midwest; Important Plants of the Monarch Butterfly – Southern Great Plains.

3. Establish Baseline

Establish a baseline along the mowed edge of the roadside or long edge of the right-of-way (see Figure 18). Using the 100-meter tape or by pacing, measure the length of the baseline, if the baseline is longer than 100 meters, estimate the length by pacing. **Record the length and bearing of the baseline on the Assessment Area datasheet.** Be sure to adjust the compass for declination.

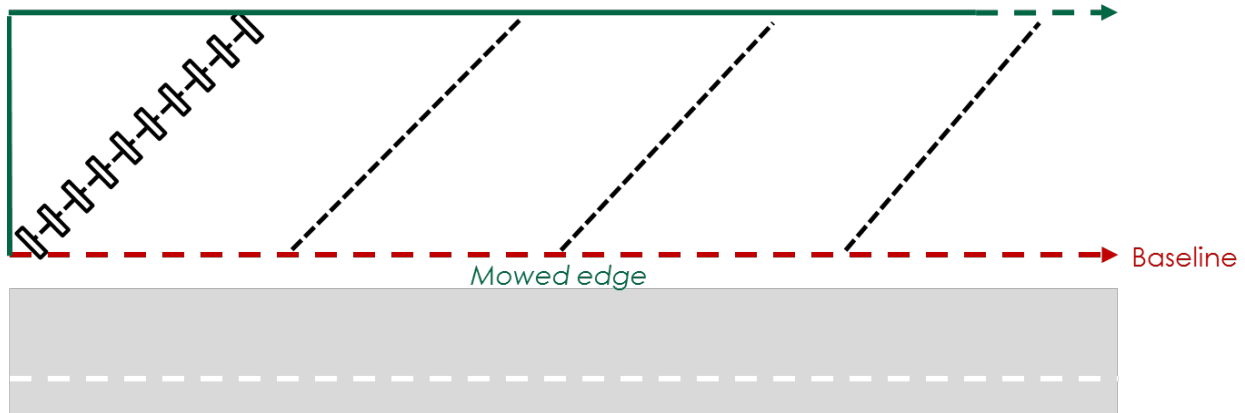


Figure 18. Baseline and transect layout for a roadside. A baseline is established along the mowed edge of the roadside. Transects are spaced at equal intervals offset from the baseline at an angle such that each transect reaches the end of the assessment area. For a right-of-way, baseline is established along the long edge of the right-of-way.

Transects will be located along the baseline at equal intervals, starting at the origin. If using pin flags, mark the location of the first transect and each additional transect along the baseline. Mark approximately 10 transects. Use the equation below to calculate transect spacing and place one pin flag at each interval.

$$\text{Transect Spacing} = (\text{Baseline Length}) / (\# \text{ of Transects} - 1)$$

REPEAT FOR EACH TRANSECT:

4. Lay out Transect

If using a transect tape, lay out a 25-meter transect using the 100-meter tape such that it reaches the opposite end of the Assessment Area. The angle of offset from the baseline for each transect can vary to ensure the transect reaches the opposite end. If the roadside or right-of-way is wider than 25-meters, use a longer transect. Take care to pull the transect taut and lay it over any shrubs along the transect. Anchor the transect on both ends.

Take a photo of the transect from the baseline, looking down the transect. Once the transect is established, collect the pin flag. **Record the length and bearing of the transect on the Transect datasheet.** Be sure to adjust the compass for declination. **If a handheld GPS unit is available, record the coordinates for the starting location of each transect.**

5. Collect 2m x 0.5m Plot Data

You will collect 10 plots along each transect. The first plot will be located at a random point along the transect between 1 and 5 meters (the first and last meter of the transect will not be sampled

because the sample frame would include areas outside of the Assessment Area boundary). Use a random number generator, or other means of selecting a random number, to pick the location of the first plot along the transect.

For a 25-meter transect, space plots at 2-meter intervals. If the transect is longer than 25 meters, use the equation below to calculate spacing between subsequent plots. **Record the starting location of the first plot and all subsequent plots on the Transect datasheet.**

$$\text{Plot Spacing} = (\text{Transect Length} - 6) / 9$$

Place the short side of the plot along and to the left of the transect with the lower corner of the plot located at the randomly-selected location of the first plot. See Figure 19. Drop the frame into the vegetation (or hold in place if the vegetation is tall). Adjust the vegetation so that only plants rooted within each subplot are recorded.

If a plot falls in a shrubby area or under the canopy of a tree, do not discard the plot. Collect the plot as usual, recording zeros for all species and milkweed if no forbs are present within the plot.

The 0.5 x 1.0-meter frame is divided into 2 subplots; the final (3rd) subplot results from flipping the subplot frame over.

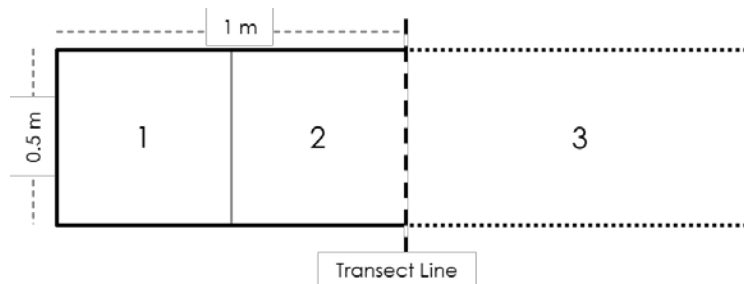


Figure 19. Plots are 1 square-meter in area, and consist of 3 nested subplots, the final of which is formed when the 0.5 x 1.0-meter frame is flipped.

a) Blooming Forb Availability

Starting with the smallest area in the measurement frame (Area 1 in Figure 19), **record all forb species with blooming flowers on the *Blooming Forb Availability* section of the Transect datasheet.** Using the species list created during the Timed Species Diversity Assessment, record the appropriate abbreviation. If a forb species is not listed on the species list, add it to the list now.

Only record each species in the smallest area in which it occurs, as follows: In the appropriate column for the given subplot, record a “1” for all species seen in area 1. Record a “2” for any new species seen in area 2. Then flip the subplot frame over the transect for area 3. Record any new species encountered in area 3. Thus each species is only recorded in the smallest area in which it is observed. If less than or more than 10 plots are located on the transect and some plots on the datasheet are not used, place an ‘X’ in the Plot Location box to indicate those plots were not collected.

Use a separate datasheet for each transect, listing all species encountered within subplots along the transect as they are encountered. Include species of milkweed with blooming flowers if present in the plot.

b) **Milkweed Density & Diversity**

For each 0.5 x 2m plot, **record the number of plants and stems of each milkweed species on the *Milkweed Density & Diversity* section of the Transect datasheet.** Only record information about stems rooted within the 2 m x 0.5 m subplot, even if the plant includes stems out of the plot. If a milkweed plant is blooming, you will record it on the *Blooming Forb Availability* section of the Transect datasheet, and again on the *Milkweed Density & Diversity* section of the Transect datasheet. In a sense, you are treating the nectar and hostplant functions of milkweed separately.

A milkweed plant is defined as all above-ground stems of milkweed originating from a visually-identifiable, common central point in the ground. A single milkweed plant may be composed of one or multiple stems depending on the species. For example, *A. viridis* (green antelopehorn milkweed) plants may grow multiple stems per plant, similar to *A. syriaca* (common milkweed) shown in Figure 19. Other frequently encountered species of milkweed that often grow multiple stems per plant are *A. tuberosa* (butterfly weed) and *A. incarnata* (swamp milkweed). If you encounter these plants, count each cluster of stems originating from the same central point as a single plant. Record data about both number of plants and number of stems per plant in the appropriate columns of *Milkweed Density & Diversity* section of the Transect datasheet. Stems of some species of milkweed may branch aboveground, but branches originating from a single stalk should be counted as one stem.

A single *A. syriaca* plant (common milkweed) may grow many ramets (above-ground as stalks) that are separated by small or large distances, but without excavating roots, it is impossible to tell if ramets are from the same or different plants (Figure 20). Record each individual stalk of *A. syriaca* as a plant in the “# of Plants” column on the *Milkweed Density & Diversity* section of the Transect datasheet.

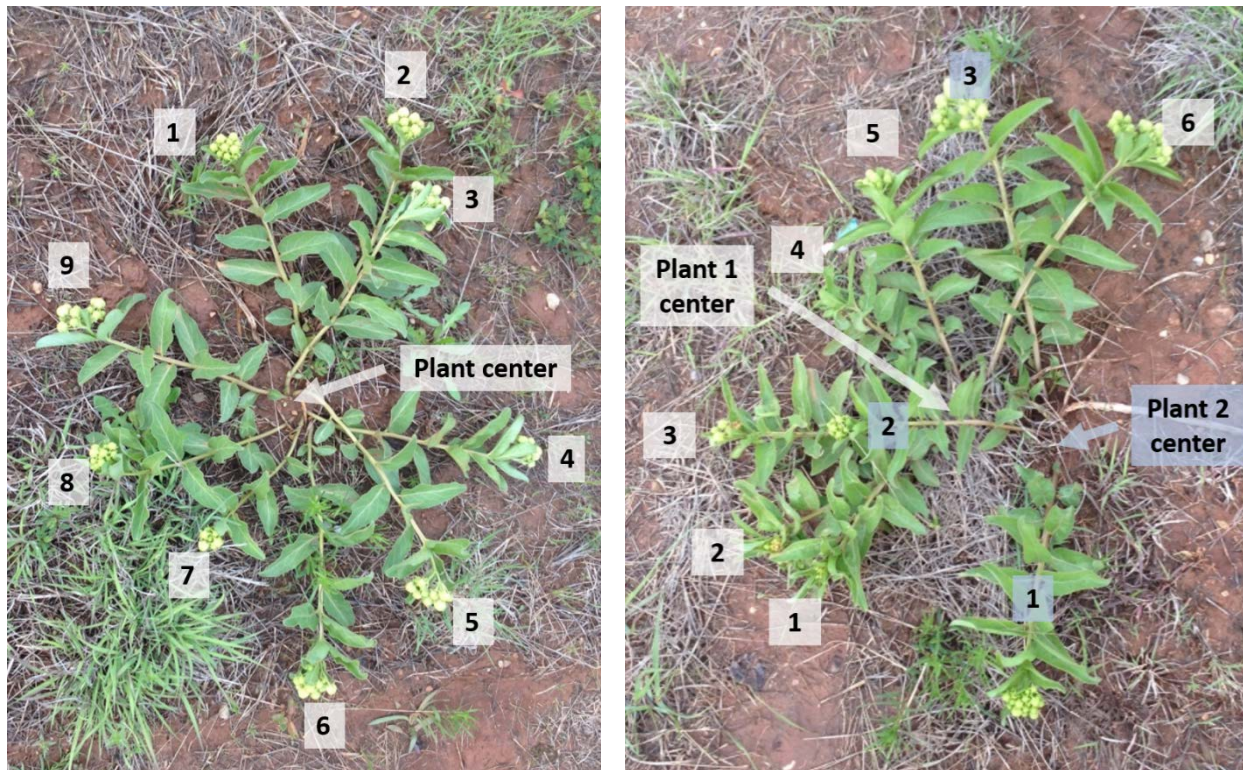


Figure 20. *A. syriaca* (common milkweed) plants. Each above-ground stalk (ramet) could be from different or the same plant. Count each stalk as an individual plant. (Photo courtesy of Kristen Baum).

6. Review Datasheets

Using a field temperature gauge, measure the temperature in the shade. **Record the temperature in the shade and the stop time on the Assessment Areas datasheet.**

Check datasheets for legibility and mistakes (exchanging sheets with someone that didn't record the data is a good technique) soon after you finish collecting data (e.g., during a lunch break or end of day).

ACKNOWLEDGEMENTS

Nectar plant monitoring procedures were adapted from the Prairie Reconstruction Initiative Retrospective Research protocol (Diane Larson, USGS). Milkweed monitoring procedures were adapted from the Monarch Larva Monitoring Protocol (2016). Additional protocol elements were modified from the MCSP Monarch Monitoring Trial Protocol (2016).

Monarch Butterfly Habitat Quantification Tool

FIELD DATA COLLECTION METHOD

III: Small Areas

1/30/2017

This field data collection method is typically used for sites less than 100 meters in width.

MATERIALS NEEDED

- 100-meter transect tape (optional)
- Pin flags (optional)
- 2 transect stakes (optional)
- Subplot frame (0.5 x 1.0-meter frame with nested subplots). The subplot frame can be constructed prior to the assessment, see *Appendix D* for guidance.
- Data sheets (Assessment Area datasheets; Transect datasheets)
- Clipboard & pencil/pen
- Plant list and identification guides for local area
- Watch or clock
- Camera
- Handheld GPS unit (optional)
- Duct Tape (optional but recommended in case subplot frame breaks)
- Calculator (optional)
- Thermometer
- Duct Tape (optional but recommended in case subplot frame breaks)
- Calculator (optional)

INSTRUCTIONS

Follow these instructions in each Assessment Area. Each Assessment Area should be assessed separately. Assessment Areas will be defined in *Step 1: Develop Project Base Map* of the User's Guide. If an Assessment Area has not been defined, you will define the Assessment Area in Step 1 below.

REPEAT FOR EACH ASSESSMENT AREA:

1. Confirm or Define Assessment Area Boundaries

Upon arrival at the site, field crews should walk together to define or confirm the boundaries of the Assessment Area. The Assessment Area should include the patch of milkweed and any associated blooming forb species. Assessment Area boundaries may be man-made (e.g., fence line) or natural (e.g., forest edge). Exclude any areas of open water or forest. If there are two

milkweed patches nearby, but a significant gap exists between them, consider those patches as two separate Assessment Areas. If a single Assessment Area will be subject to differing management regimes, it should be divided based on the expected management actions. If part of the Assessment Area will be subject to management actions that are inconsistent with monarch habitat, as defined in Appendix A: Best Management Practices, exclude that part of the Assessment Area. For example, a hayfield should be excluded from the Assessment Area unless haying of the field will not occur during sensitive times for monarchs in the region.

Mark or check the boundaries of the Assessment Area on the Project Base Map. Record the Site Name, Assessment Area, Recorder, Observers, Date, Start Time, and Field Data Collection Method used (III for the Small Areas method) on the Assessment Area datasheet.

2. Conduct Timed Species Diversity Assessment

While defining the Assessment Area, field crews should familiarize themselves with the species of milkweed and blooming forbs present in the Assessment Area. Use local plant identification guides and the relevant NRCS plant list for monarch butterflies⁴ for assistance in species identification. For each blooming forb species encountered, agree on a consistent abbreviation (first three letters of genus and first three letters of species) based on the [Integrated Taxonomic Information System](#) (ITIS). Note that in some cases, more than one species will have the same code (e.g., Asc vir could be either *Asclepias viridis* or *A. viridiflora*), so be particularly careful with such a species.

Record the name of all blooming forb species encountered in the Assessment Area based on the Integrated Taxonomic Information System (ITIS) on the *Blooming Forb Species* section of the Assessment Area datasheet. Stop searching for new blooming forb species if more than 2 minutes passes before encountering a new blooming forb species; however, add any blooming forb species encountered within the assessment area during the assessment.

Record only blooming forb species; non-blooming species should not be recorded. A forb species is considered blooming if it has any active flower parts. The status of a forb as a 'nectar' plant is not relevant for this assessment. An accurate count of the number of unique blooming forb species is more important than the accurate identification of each species. For any species that cannot be identified, capture a robust description, photograph, and/or sample of the species for later identification.

If additional blooming forb species are encountered during the remainder of the assessment, record the species name and an appropriate abbreviation on the Assessment Area datasheet. Confer with all members of the field crew in the Assessment Area for any new species encountered, as the other members of the field crew may have encountered the same species but identified it differently.

⁴ Important Plants of the Monarch Butterfly – Midwest; Important Plants of the Monarch Butterfly – Southern Great Plains.

3. Establish Baseline

Identify the longest bisection of the Assessment Area perpendicular to the shortest side. Establish a baseline along this line (see Figure 21). Using the 100-meter tape or by pacing, measure the length of the baseline. **Record the length and bearing of the baseline on the Assessment Area datasheet.**

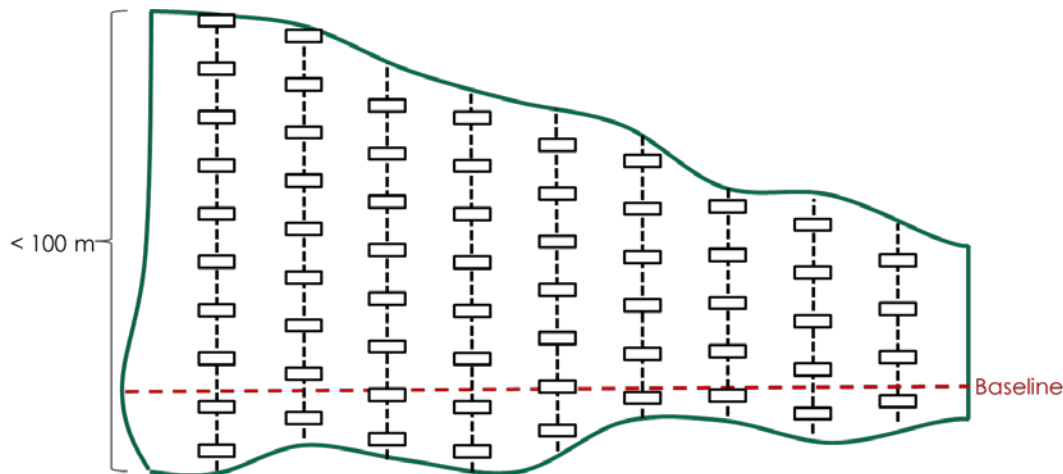


Figure 21. Baseline and transect layout for a small area (< 100 meters wide). A baseline is established perpendicular to the shortest end at the longest bisection of the assessment area. Transects are spaced at equal intervals perpendicular to the baseline, and laid out such that they reach each end of the assessment area.

Transects will be located perpendicular to the baseline at equal intervals. The first transect will be located at a random point along the baseline between 0 and 10 meters. Use a random number generator, or other means of selecting a random number, to pick the location of the first transect along the baseline. If using pin flags, mark the random starting location of the first transect along the baseline. If pacing, pace the random distance along the baseline to the first transect location.

Calculate transect spacing. We recommend using 10 transects per Assessment Area when practical. Use the equation below to estimate necessary transect spacing.

$$\text{Transect Spacing} = (\text{Baseline Length} - 10) / 9$$

If using pin flags, mark the location of all subsequent transects. If pacing, record the transect spacing and pace this distance parallel to the baseline at the end of each transect.

REPEAT FOR EACH TRANSECT:

4. Lay out Transect

If using a transect tape, lay out the transect tape perpendicular to the baseline using the 100-meter tape such that it reaches both ends of the Assessment Area and passes over the corresponding pin flag. Take care to pull the transect taut and lay it over any shrubs along the transect. Anchor the transect on both ends.

Take a photo of the transect from one end, looking down the transect. Once the transect is established, collect the pin flag.

Record the length and bearing of the transect on the Transect datasheet. Be sure to adjust the compass for declination. **If a handheld GPS unit is available, record the coordinates for the starting location of each transect.**

5. Collect 2m x 0.5m Plot Data

You should aim to collect at least 100 plots per Assessment Area. See *Step 3. Establish Baseline* for help calculating transect spacing to achieve this. The first plot will be located at a random point along the transect between 0 and 10 meters. Use a random number generator, or other means of selecting a random number, to pick the location of the first plot along the transect.

Subsequent plots should be located along each transect at equal intervals. To estimate plot spacing, first estimate the average width of the Assessment Area (e.g., average transect length). Then calculate plot spacing using the following equation.

$$\text{Plot Spacing} = (\text{Average Transect Length} - 10) / 9$$

Record the starting location of the first plot and all subsequent plots on the Transect datasheet (optional).

Place the short side of the plot along and to the left of the transect with the lower corner of the plot located at the randomly-selected location of the first plot (see Figure 22). Drop the frame into the vegetation (or hold in place if the vegetation is tall). Adjust the vegetation so that only plants rooted within each subplot are recorded.

If a plot falls in a shrubby area or under the canopy of a tree, do not discard the plot. Collect the plot as usual, recording zeros for all species and milkweed if no forbs are present within the plot.

The 0.5 x 1.0-meter frame is divided into 2 subplots; the final (3rd) subplot results from flipping the subplot frame over.

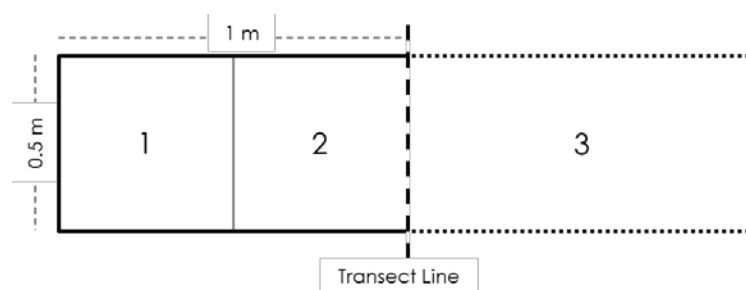


Figure 22. Plots are 1 square-meter in area, and consist of 3 nested subplots, the final of which is formed when the 0.5 x 1.0-meter frame is flipped.

a) Blooming Forb Availability

Starting with the smallest area in the measurement frame (Area 1 in Figure 22), **record all forb species with blooming flowers on the *Blooming Forb Availability* section of the Transect datasheet.** Using the species list created during the Timed Species Diversity Assessment, record the appropriate abbreviation. If a forb species is not listed on the species list, add it to the list now.

Only record each species in the smallest area in which it occurs, as follows: In the appropriate column for the given subplot, record a “1” for all species seen in area 1. Record a “2” for any new species seen in area 2. Then flip the subplot frame over the transect for area 3. Record any new species encountered in area 3. Thus each species is only recorded in the smallest area in which it is observed. If less than or more than 10 plots are located on the transect and some plots on the datasheet are not used, place an ‘X’ in the Plot Location box to indicate those plots were not collected.

Use a separate datasheet for each transect, listing all species encountered within subplots along the transect as they are encountered. Include species of milkweed with blooming flowers if present in the plot.

b) Milkweed Density & Diversity

For each 0.5 x 2m plot, **record the number of plants and stems of each milkweed species on the *Milkweed Density & Diversity* section of the Transect datasheet.** Only record information about stems rooted within the 2 m x 0.5 m subplot, even if the plant includes stems out of the plot. If a milkweed plant is blooming, you will record it on the *Blooming Forb Availability* section of the Transect datasheet, and again on the *Milkweed Density & Diversity* section of the Transect datasheet. In a sense, you are treating the nectar and hostplant functions of milkweed separately.

A milkweed plant is defined as all above-ground stems of milkweed originating from a visually-identifiable, common central point in the ground. A single milkweed plant may be composed of one or multiple stems depending on the species. For example, *A. viridis* (green antelopehorn milkweed) plants may grow multiple stems per plant, similar to *A. syriaca* (common milkweed) shown in Figure 22. Other frequently encountered species of milkweed that often grow multiple stems per plant are *A. tuberosa* (butterfly weed) and *A. incarnata* (swamp milkweed). If you encounter these plants, count each cluster of stems originating from the same central point as a single plant. Record data about both number of plants and number of stems per plant in the appropriate columns of *Milkweed Density & Diversity* section of the Transect datasheet. Stems of some species of milkweed may branch aboveground, but branches originating from a single stalk should be counted as one stem.

A single *A. syriaca* plant (common milkweed) may grow many ramets (above-ground as stalks) that are separated by small or large distances, but without excavating roots, it is impossible to tell if ramets are from the same or different plants (see Figure 23). Record each individual stalk of *A. syriaca* as a plant in the “# of Plants” column on the *Milkweed Density & Diversity* section of the Transect datasheet.

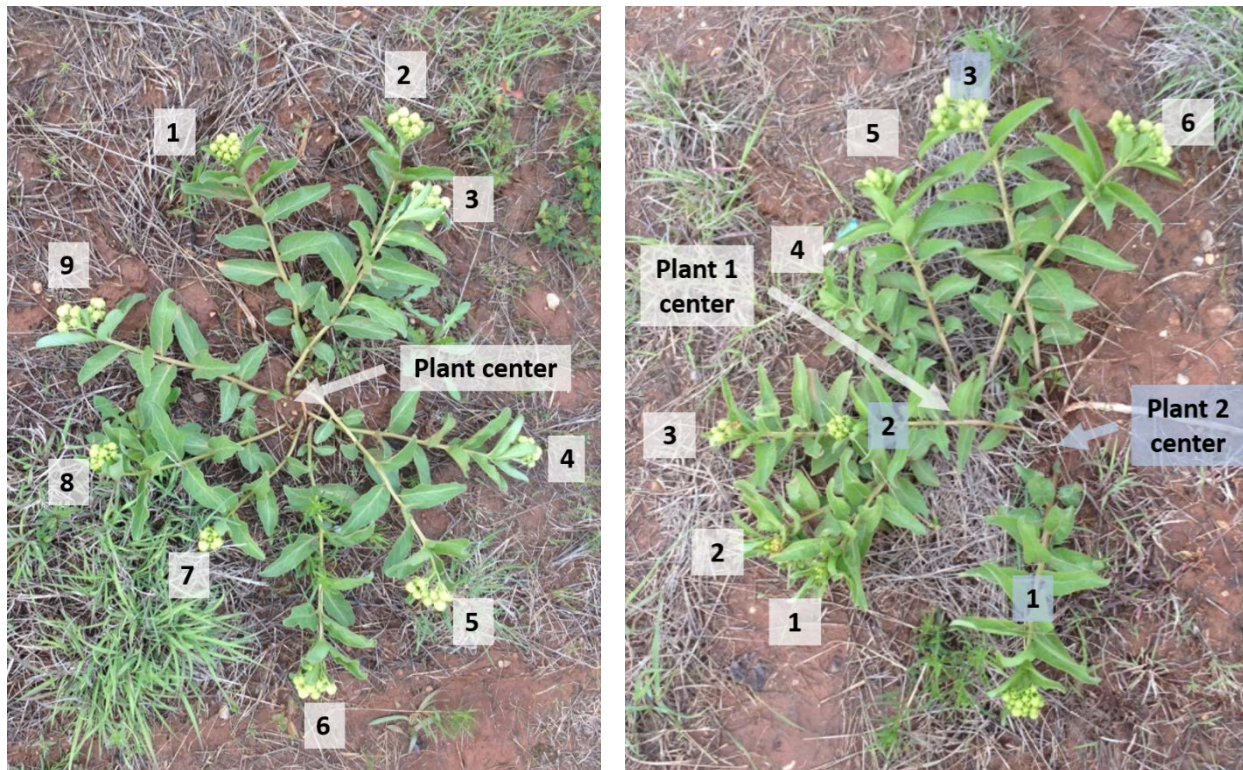


Figure 23. *A. syriaca* (common milkweed) plants. Each above-ground stalk (ramet) could be from different or the same plant. Count each stalk as an individual plant. (Photo courtesy of Kristen Baum).

Proceed to the next plot along the transect and repeat. Once the end of the transect (i.e., edge of the Assessment Area) is reached, proceed to the next transect. If using a transect tape, repeat Step 4. Lay out Transect. If pacing, pace off the transect length as calculated in *Step 3. Establish Baseline* and locate the first plot at a random location within 10 meters of the edge of the Assessment Area, then repeat *Step 5. Collect 2m x 0.5m Plot Data*.

6. Review Datasheets

Using a field temperature gauge, measure the temperature in the shade. **Record the temperature in the shade and the stop time on the Assessment Areas datasheet.**

Check datasheets for legibility and mistakes (exchanging sheets with someone that didn't record the data is a good technique) soon after you finish collecting data (e.g., during a lunch break or end of day).

ACKNOWLEDGEMENTS

Nectar plant monitoring procedures were adapted from the Prairie Reconstruction Initiative Retrospective Research protocol (Diane Larson, USGS). Milkweed monitoring procedures were adapted from the Monarch Larva Monitoring Protocol (2016). Additional protocol elements were modified from the MCSP Monarch Monitoring Trial Protocol (2016).

Monarch Butterfly Habitat Quantification Tool

FIELD DATA COLLECTION METHOD

IV: Large Areas

1/30/2017

This field data collection method is typically used for sites greater than 5 acres in size.

MATERIALS NEEDED

- 100-meter transect tape (optional)
- Pin flags (optional)
- 2 transect stakes (optional)
- Subplot frame (0.5 x 1.0-meter frame with nested subplots). The subplot frame can be constructed prior to the assessment, see *Appendix D* for guidance.
- Data sheets (Assessment Area datasheets; Transect datasheets)
- Clipboard & pencil/pen
- Plant list and identification guides for local area
- Watch or clock
- Camera
- Compass
- Handheld GPS unit
- Thermometer
- Duct Tape (optional but recommended in case subplot frame breaks)
- Calculator (optional)
- Duct Tape (optional but recommended in case subplot frame breaks)
- Calculator (optional)

INSTRUCTIONS

Follow these instructions in each Assessment Area. Each Assessment Area should be assessed separately. Assessment Areas will be defined in *Step 1: Develop Project Base Map* of the User's Guide. If an Assessment Area has not been defined, you will define the Assessment Area in Step 1 below.

REPEAT FOR EACH ASSESSMENT AREA:

1. Confirm or Define Assessment Area Boundaries

Upon arrival at the site, field crews should walk together to define or confirm the boundaries of the Assessment Area. Assessment Area boundaries may be man-made (e.g., fence line) or natural (e.g., forest edge). Exclude any areas of open water or forest. If a single Assessment Area will be

subject to differing management regimes, it should be divided based on the expected management actions. If part of the Assessment Area will be subject to management actions that are inconsistent with monarch habitat, as defined in Appendix A: Best Management Practices, exclude that part of the Assessment Area. For example, a hayfield should be excluded from the Assessment Area unless haying of the field will not occur during sensitive times for monarchs in the region.

Mark or check the boundaries of the Assessment Area on the Project Base Map. Record the Site Name, Assessment Area, Recorder, Observers, Date, Start Time, and Field Data Collection Method used (IV for the Large Areas method).

2. Conduct Timed Species Diversity Assessment

While defining the Assessment Area boundaries, field crews should familiarize themselves with the species of milkweed and blooming forbs present in the Assessment Area. Use local plant identification guides and the relevant NRCS plant list for monarch butterflies⁵ for assistance in species identification. For each blooming forb species encountered, agree on a consistent abbreviation (first three letters of genus and first three letters of species) based on the [Integrated Taxonomic Information System](#) (ITIS). Note that in some cases, more than one species will have the same code (e.g., *Asc vir* could be either *Asclepias viridis* or *A. viridiflora*), so be particularly careful with such a species.

Record the name of all blooming forb species encountered in the Assessment Area based on the Integrated Taxonomic Information System (ITIS) on the *Blooming Forb Species* section of the Assessment Area datasheet. Stop searching for new blooming forb species if more than 2 minutes passes before encountering a new blooming forb species; however, add any blooming forb species encountered within the assessment area during the assessment.

Record only blooming forb species; non-blooming species should not be recorded. A forb species is considered blooming if it has any active flower parts. The status of a forb as a 'nectar' plant is not relevant for this assessment. An accurate count of the number of unique blooming forb species is more important than the accurate identification of each species. For any species that cannot be identified, capture a robust description, photograph, and/or sample of the species for later identification.

If additional blooming forb species are encountered during the remainder of the assessment, record the species name and an appropriate abbreviation on the Assessment Area datasheet. Confer with all members of the field crew in the Assessment Area for any new species encountered, as the other members of the field crew may have encountered the same species but identified it differently.

⁵ Important Plants of the Monarch Butterfly – Midwest; Important Plants of the Monarch Butterfly – Southern Great Plains.

REPEAT FOR EACH TRANSECT:

3. Navigate to and Lay out Transect

Navigate to the start of the first transect location via a hand-held GPS unit. (Transect locations should have been randomly generated prior to the site visit). If using a transect tape, mark the transect start with a stake or flag. Lay out a 50-meter transect using the 100-meter tape along a random bearing, taking care to pull it taut and lay it over any shrubs along the transect. Anchor the tape on the far end.

Take a photo of the transect from the baseline, looking down the transect. Once the transect is established, collect the pin flag. **Record the length and bearing of the transect on the Transect datasheet.** Be sure to adjust the compass for declination. **Record the transect coordinates and bearing on the Transect datasheet.** Be sure to adjust the compass for declination.

If a transect will cross an assessment area boundary into another assessment area or outside of the project area, the transect will need to be reflected back into the assessment area by 90 degrees. Document the method used. Do not discard transects near map unit boundaries, as this would bias results.

4. Collect 2m x 0.5m Plot Data

You will collect 10 plots along each transect, beginning at the origin. For a 50-meter transect, space plots at 4.8 meter intervals. **Record the starting location of the first plot and all subsequent plots on the Transect datasheet.**

Place the short side of the plot along and to the left of the transect with the lower corner of the plot located at the randomly-selected location of the first plot (see Figure 24). Drop the frame into the vegetation (or hold in place if the vegetation is tall). Adjust the vegetation so that only plants rooted within each subplot are recorded.

If a plot falls in a shrubby area or under the canopy of a tree, do not discard the plot. Collect the plot as usual, recording zeros for all species and milkweed if no forbs are present within the plot.

The 0.5 x 1.0-meter frame is divided into 2 subplots; the final (3rd) subplot results from flipping the subplot frame over.

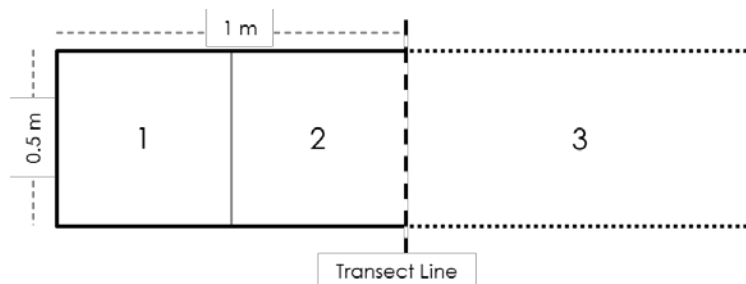


Figure 24. Plots are 1 square-meter in area, and consist of 3 nested subplots, the final of which is formed when the 0.5 x 1.0-meter frame is flipped.

a) Blooming Forb Availability

Starting with the smallest area in the measurement frame (Area 1 in Figure 24), **record all forb species with blooming flowers on the *Blooming Forb Availability* section of the Transect datasheet.** Using the species list created during the Timed Species Diversity Assessment, record the appropriate abbreviation. If a forb species is not listed on the species list, add it to the list now.

Only record each species in the smallest area in which it occurs, as follows: In the appropriate column for the given subplot, record a “1” for all species seen in area 1. Record a “2” for any new species seen in area 2. Then flip the subplot frame over the transect for area 3. Record any new species encountered in area 3. Record any new species encountered in area 5. Thus each species is only recorded in the smallest area in which it is observed. If less than or more than 10 plots are located on the transect and some plots on the datasheet are not used, place an ‘X’ in the Plot Location box to indicate those plots were not collected.

Use a separate datasheet for each transect, listing all species encountered within subplots along the transect as they are encountered. Include species of milkweed with blooming flowers if present in the plot.

b) Milkweed Density & Diversity

For each 0.5 x 2m plot, **record the number of plants and stems of each milkweed species on the *Milkweed Density & Diversity* section of the Transect datasheet.** Only record information about stems rooted within the 2 m x 0.5 m subplot, even if the plant includes stems out of the plot. If a milkweed plant is blooming, you will record it on the *Blooming Forb Availability* section of the Transect datasheet, and again on the *Milkweed Density & Diversity* section of the Transect datasheet. In a sense, you are treating the nectar and hostplant functions of milkweed separately.

A milkweed plant is defined as all above-ground stems of milkweed originating from a visually-identifiable, common central point in the ground. A single milkweed plant may be composed of one or multiple stems depending on the species. For example, *A. viridis* (green antelopehorn milkweed) plants may grow multiple stems per plant, similar to *A. syriaca* (common milkweed) shown in Figure 24. Other frequently encountered species of milkweed that often grow multiple stems per plant are *A. tuberosa* (butterfly weed) and *A. incarnata* (swamp milkweed). If you encounter these plants, count each cluster of stems originating from the same central point as a single plant. Record data about both number of plants and number of stems per plant in the appropriate columns of *Milkweed Density & Diversity* section of the Transect datasheet. Stems of some species of milkweed may branch aboveground, but branches originating from a single stalk should be counted as one stem.

A single *A. syriaca* plant (common milkweed) may grow many ramets (above-ground as stalks) that are separated by small or large distances, but without excavating roots, it is impossible to tell if ramets are from the same or different plants (Figure 25). Record each

individual stalk of *A. syriaca* as a plant in the “# of Plants” column on the *Milkweed Density & Diversity* section of the Transect datasheet.

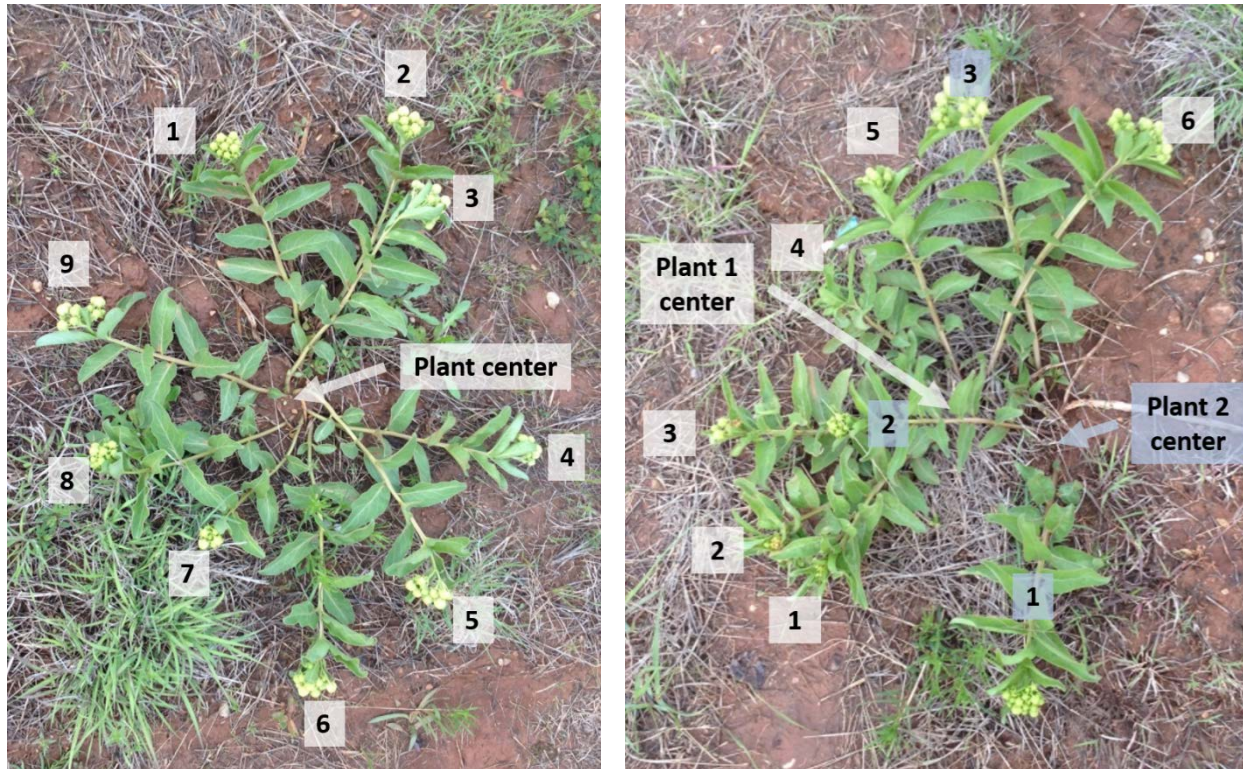


Figure 25. *A. syriaca* (common milkweed) plants. Each above-ground stalk (ramet) could be from different or the same plant. Count each stalk as an individual plant. (Photo courtesy of Kristen Baum).

5. Review Datasheets

Using a field temperature gauge, measure the temperature in the shade. **Record the temperature in the shade and the stop time on the Assessment Areas datasheet.**

Check datasheets for legibility and mistakes (exchanging sheets with someone that didn't record the data is a good technique) soon after you finish collecting data (e.g., during a lunch break or end of day).

ACKNOWLEDGEMENTS

Nectar plant monitoring procedures were adapted from the Prairie Reconstruction Initiative Retrospective Research protocol (Diane Larson, USGS). Milkweed monitoring procedures were adapted from the Monarch Larva Monitoring Protocol (2016). Additional protocol elements were modified from the MCSP Monarch Monitoring Trial Protocol (2016).

APPENDIX F: FIELD DATASHEETS

Site Name _____ Assessment Area _____

Recorder _____ Observers _____ Date _____

Start Time _____ Stop Time _____ Temp in Shade (°F) _____

Field Data Collection Method (circle one) **I:** Patch **II:** Small Area **III:** Roadside/ROW **IV:** Large Area

If Using Methods II or III, record: Baseline Length (m) _____ Baseline Bearing (°) _____

BLOOMING FORB SPECIES

Record the scientific name of all blooming forb species encountered in the Assessment Area based on the Integrated Taxonomic Information System (ITIS). For each species encountered, record a consistent abbreviation (first three letters of genus and first three letters of species). Use this abbreviation on the Transect datasheet. Stop searching for new blooming forb species if more than 2 minutes while searching for a new blooming forb species; however, add any blooming forb species encountered within the assessment area during the assessment.

Scientific Name	Abbreviation	Common Name (optional)	Notes

If Using Field Data Collection Method I, record the number of milkweed **plants** counted: _____ plants

Notes:

Site Name _____ Assessment Area _____

Provide a brief narrative description of the Assessment Area:

Describe any potential threats to monarch habitat nearby, especially conventional agricultural fields. If mitigating techniques are used (e.g., hedgerows), describe in detail:

Describe the current management regime of the Assessment Area and note any disturbances (mowing, haying, herbicide spraying, haying, etc.):

Note any observations of monarch butterflies, larvae, pupae, or eggs:

Additional Notes:

Site Name _____ Assessment Area _____ Recorder _____ Observers _____

Transect ID _____ UTM E _____ UTM N _____ Transect Length (m) _____ Transect Bearing _____

BLOOMING FORB AVAILABILITY

For each 2 m x 0.5 m plot along the transect, record the smallest subplot within which each species occurs (i.e., 1, 2, or 3). If no blooming forbs are present, record 0. Record only plants in flower, including milkweeds. If more than 10 plots are sampled for a transect, use a second datasheet.

2 m x 0.5 m plots

Plot Location (m):

Blooming Forb Species Abbreviation	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
All Blooming Forb Species ¹ :										

MILKWEED DENSITY & DIVERSITY

Record the number of milkweed plants and stems by species found in each 2 m x 0.5 m plot. Record the plot number in which the milkweed is found. Record all milkweeds encountered, including those on which you do not observe monarchs.

Milkweed Species Abbreviation	Plot #	# of Plants	# of Stems

¹Record the minimum value for each column. This represents the smallest subplot in which any blooming forb species was found.

Notes:

Site Name _____ Assessment Area _____ Recorder _____ Observers _____
 Transect ID _____ UTM E _____ UTM N _____ Transect Length (m) _____ Transect Bearing _____

BLOOMING FORB AVAILABILITY

For each 2 m x 0.5 m plot along the transect, record the smallest subplot within which each species occurs (i.e., 1, 2, or 3). If no blooming forbs are present, record 0. Record only plants in flower, including milkweeds. If more than 10 plots are sampled for a transect, use a second datasheet.

2 m x 0.5 m plots										
<i>Plot Location (m):</i>										
Blooming Forb Species Abbreviation	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
All Blooming Forb Species ¹ :										

MILKWEED DENSITY & DIVERSITY

Record the number of milkweed plants and stems by species found in each 2 m x 0.5 m plot. Record the plot number in which the milkweed is found. Record all milkweeds encountered, including those on which you do not observe monarchs.

Milkweed Species Abbreviation	Plot #	# of Plants	# of Stems

¹Record the minimum value for each column. This represents the smallest subplot in which any blooming forb species was found.

Notes: