



PLANNING FOR MONITORING ON SOLAR SITES GUIDANCE

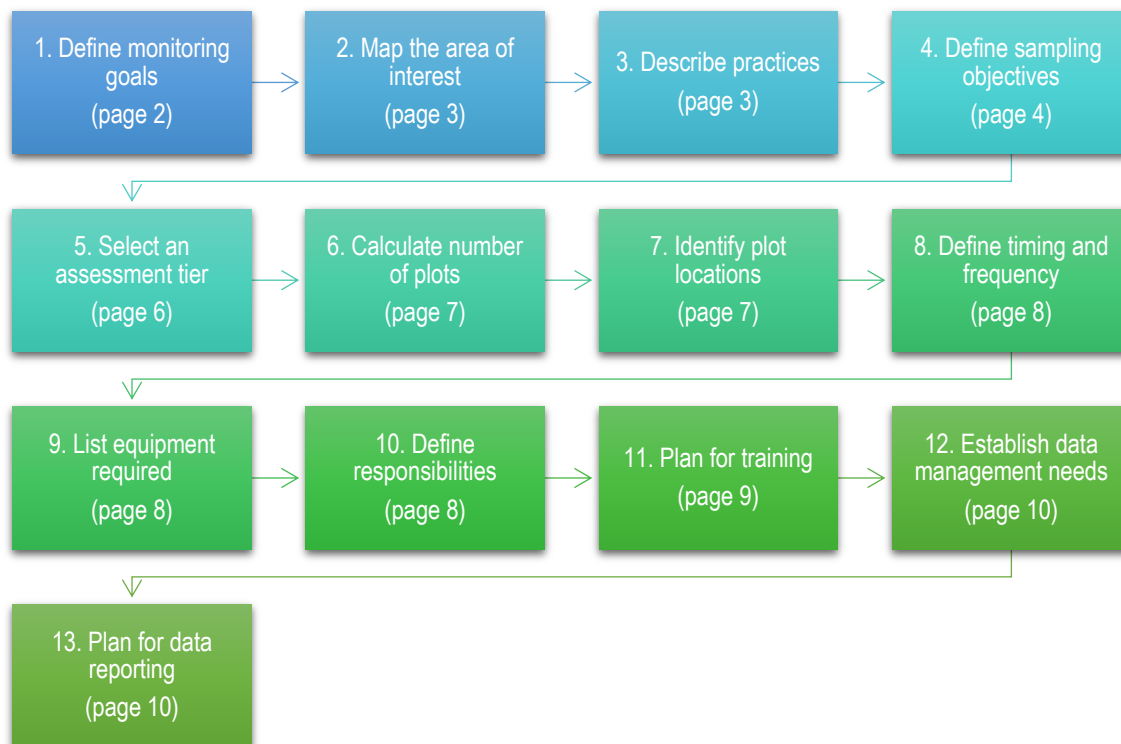
2023 EDITION



Step-by-Step Guidance

This step-by-step guidance developed for solar sites walks users through a comprehensive process for planning monitoring efforts that collect useful data that informs management decisions. Figure 1 illustrates the steps discussed within this guidance.

Figure 1. Steps for effective monitoring.



Helpful Resources

Several resources are noted throughout this guidance, which may help users with their vegetation or pollinator monitoring efforts.

User Guide: UIC previously published a [user guide](#) for the Rights-of-Way as Habitat Working Group’s Pollinator Habitat Scorecard. This guide provides a quick reference to the assessment tool for new users.

Example Monitoring Plan: Users may find the monitoring plan template helpful for preparing monitoring plans.

Geospatial Habitat Database: UIC, in partnership with The Field Museum, maintains the [Geospatial Habitat Database](#). This database is an online repository of habitat and monitoring data compiled by Rights-of-Way as Habitat Working Group partners.

Calculation Worksheet: Construct a Confidence Interval: This short guide introduces several methods for constructing a confidence interval used to communicate the uncertainty around parameter estimates from your data.

Calculation Worksheet: Number of Plots: This guide introduces several methods for determining the optimal number of sampling plots based on sampling objective(s).

Strategies to Reduce Monitoring Costs: While guidance provided can support a robust monitoring program, users may experience limitations in resources or abilities. This guidance helps solar sites identify ways to reduce monitoring costs by offering less time intensive or costly alternatives for amending monitoring plans.

Strategies for Distributing Plots: Determining where to sample in a way that reduces or eliminates bias is an important aspect of monitoring. This guidance presents several approaches to distributing plots across a site.

Quick Start Guide

This package of guidance documents contains many resources for monitoring on solar sites. Not all of these guidance documents may be necessary or feasible depending on needs, objectives, or limited time and resources. If time and resources are a limiting factor, users may still be able to use components highlighted in this “quick start” guide below, based on user interests. We recommend that you read through this document, **Planning for Monitoring on Solar Sites Guidance**, and scale information to your monitoring according to your needs and resources.

If You Are Interested In...	Then Refer To...
<i>Quickly characterizing your site’s vegetation?</i>	User Guide
<i>Developing a monitoring plan for repeatability?</i>	Example Monitoring Plan
<i>How to distribute monitoring plots?</i>	Strategies for Distributing Plots
<i>Using an online resource for archiving habitat and monitoring data?</i>	Geospatial Habitat Database
<i>Having a robust sample size determination for your monitoring effort?</i>	Calculation Worksheet: Number of Plots
<i>Reducing monitoring costs?</i>	Strategies to Reduce Monitoring Costs
<i>Communicating monitoring results for use in decision making?</i>	Calculation Worksheet: Construct a Confidence Interval

1. Define monitoring goals

Understanding why you want to monitor is the first step to developing a successful monitoring plan. Common questions monitoring can help address include:

- How is vegetation responding to different conditions or management approaches?
- Which non-native or invasive species of concern are present on the solar site?
- How is one seed mix performing compared to another?
- What local ordinances exist around vegetation? What management actions are needed to address them?
- Where does pollinator habitat exist on the solar site, and what habitat benefits does it support?
- What are desired conditions on the solar site?
- At what point should mitigation actions or adaptive management be implemented?
- What data can I collect to inform and communicate my organization's biodiversity contributions?
- Am I meeting the habitat targets of programs like the Monarch Butterfly Candidate Conservation Agreement with Assurances (CCAA)?

Questions being asked can help frame monitoring goals. Monitoring goals should be clearly identified and communicated to all team members prior to conducting monitoring. List your monitoring goals in Section 1 Monitoring Goals of the monitoring template.



CCAA Note

The monitoring goals outlined in the Monarch CCAA include:

1. Conduct monitoring in accordance with monitoring requirements outlined in Section 14.2 of the CCAA,
2. Verify that adopted acres are providing monarch habitat (milkweed and/or nectar plants), and
3. Inform adaptive management, when required



Follow Along Checklist

- Complete Section 1 *Monitoring Goals* of the monitoring template

2. Map or define the area of interest

The area of interest includes any geographic area that you hope to learn more about with your monitoring efforts. For a solar site, the area of interest may be a portion of a facility, an entire facility, or multiple facilities. The area of interest is not necessarily the same as the area in which you will be monitoring (more on that later). It may be important to delineate areas of interest that require different monitoring or management needs as well.

Ideally, use a geographic information system (GIS) (e.g., Esri ArcGIS) to delineate the boundaries of the area of interest. If you do not have access to a GIS, you can use a paper map or describe the area in a way that members of your organization can understand and replicate.



Tip

Upload your area of interest to the [ROWHWG Geospatial Database](#). The ROWHWG can help you store and review monitoring data. You can also upload special habitat sites and management areas (see Step 3, below) to track monitoring data by type of vegetation management.



Follow Along Checklist




- Describe the area of interest in Section 4a Area of Interest of the monitoring template
- Attach the map as Appendix A of the monitoring template

3. Describe vegetation management practices

Describe generally the vegetation management practices in use within the area of interest. This information will inform where and when you monitor, help you adapt management when needed, and provide context for monitoring data. Consider:

- Who is the main point of contact for vegetation management activities?
- Is there a set schedule for vegetation management activities and maintenance?
- What effects do you anticipate your vegetation management to have, and where?
- Where do you want to improve habitat with vegetation management?
- Where are habitats most at risk?
- Where are you most uncertain about the effects of vegetation management?
- Do you want to compare two or more differing approaches to management?
- Does management differ in any systematic way that might bias results depending on how plots are located?

If management differs across areas within the area of interest, describe each approach used. Update the map created in Step 2 with the boundaries of each management approach.

	<p>Tip If your monitoring goals include understanding how management is affecting vegetation, or comparing different management approaches, you will want to stratify your area of interest to delineate different management zones. More on stratification is provided in the accompanying Strategies for Reducing Monitoring Costs guidance. However, you do not need to stratify by management area.</p>
	<p>CCAA Note If participating in the Monarch CCAA, list any implemented conservation measures and describe where conservation measures are applied.</p>
	<p>Follow Along Checklist <input type="checkbox"/> Complete Section 2 <i>Management Overview</i> of the monitoring template</p>

4. Define management and sampling objectives

Management and sampling objectives are the heart of your monitoring plan. They deserve special consideration.

- Management objectives describe the desired state of the habitat.
- Define how monitoring data will be recorded and organized.
- Sampling objectives define how you know when you have met your management objective.

Management objectives may describe a trend (an increase or decrease in a specific measure of vegetation) or a threshold (meeting or exceeding a specific vegetation target). Management and sampling objectives are always specified in pairs. For example, consider the following management objective:

- *Increase blooming nectar plant cover 25% (absolute cover) by 2040.*

The sampling objective should describe how confident you want to be in detecting this change, what amount of change you want to detect, and how willing you are to be wrong. A sampling objective for the example management objective above might be:

- *Be 80% confident of detecting a 10% change in absolute cover of blooming nectar plants with a 20% chance of a false-change error.*



Check your understanding

Why detect a 10% change in cover when your management objective is a 25% change in cover? Being able to detect a smaller change will help you determine if you are making progress towards your objective over time.

The information you should provide in management objectives includes which component of the habitat you are targeting (e.g., nectar plant cover, milkweed abundance). Common vegetation characteristics include:

- **Target:** describe the target threshold or desired level of change
- **Geographic extent:** describe where the management objective applies (if applicable)
- **Target date:** describe when you want to see the change (if applicable)

For sampling objectives, include the metrics used to describe how confident you want to be in your results:

- **Confidence level:** subtract the confidence level from 100% to get the false-change error rate, which is the probability of determining you met your target when in fact you did not. The higher the confidence level, the more samples required.
- **Minimum detectable change (MDC):** the level of change that must occur for your monitoring efforts to detect the change. Small changes are harder to detect than large changes. For threshold objectives, this is equivalent to half of the confidence interval width (e.g., the MDC for a confidence interval width of 4 milkweed stems (+/- 2 milkweed stems) is 2). Always specify the MDC in the same value as the management target (e.g., if your target is specified as absolute cover, specify MDC in terms of absolute cover. Do not specify MDC as a percent of the true value or relative change from the true mean).
- **Missed-change error rate (trend objectives only):** the probability of not detecting a change that in fact did occur. Threshold objectives do not require a missed-change error rate.

List your management and sampling objectives in Section 3 of the monitoring template.



Tip

We recommend using 20% as both the false-change error rate and missed-change error rate. In vegetation management, falsely detecting a change when in fact there is no change (false-change error) and missing a change when there is a change (missed-change error) can both be equally hazardous. Thus, a balanced approach is warranted. A rate of 20% (rather than 5% as is commonly used in research studies) is reasonable for the purposes of informing vegetation management.



Tip

When specifying a minimum detectable change, consider what level of change is biologically significant. It is generally not worthwhile to detect a small change in vegetation when that change is typical due to natural variability.



CCAA Note

For those enrolled in the Monarch CCAA, we recommend the following management and sampling objectives for milkweed abundance:

- **Management Objective:** Maintain greater than (2 or 6, depending on region) milkweed stems per plot within adopted acres.
- **Sampling Objective:** Obtain estimates of milkweed stem abundance with 90% confidence intervals no wider than +/-2 milkweed stems per plot.

Consider the following objectives for nectar plant cover:

- **Management Objective:** Maintain greater than 10% cover of blooming nectar plant resources within adopted acres.
- **Sampling Objective:** Be 80% confident that estimates are within +/- 5% (absolute cover) of the true value with a 20% false-change error rate.



Follow Along Checklist

- Complete Section 3 Management & Sampling Objectives of the monitoring template




5. Select an assessment tier

The Pollinator Habitat Scorecard has multiple tiers to support differing monitoring needs. Your management and sampling objectives will inform which tier(s) you should use. The table below will help you select which tier is best for your monitoring needs. For more details on each tier, consult the [User's Guide](#).

Table 1. Overview of the multi-tiered approach of the Pollinator Habitat Scorecard

	Tier 1: Basic	Tier 2: Qualitative	Tier 3: Detailed
Information Gained	Is habitat for pollinators present?	What is the quality of pollinator habitat?	What is the composition of the pollinator habitat?
Metrics	<ul style="list-style-type: none"> ▪ Nectar plant cover ▪ Milkweed presence ▪ Pollinators observed 	<ul style="list-style-type: none"> ▪ Nectar plant cover ▪ Milkweed abundance ▪ List of blooming nectar plants ▪ Additional habitat resources ▪ Pollinators observed ▪ Threats and opportunities 	<ul style="list-style-type: none"> ▪ Nectar plant cover ▪ Milkweed abundance ▪ Richness of blooming nectar plants ▪ Additional habitat resources ▪ Invasive/noxious weed cover ▪ Pollinators observed ▪ Threats and opportunities
Level of Effort	5 – 10 minutes per plot	10 – 20 minutes per plot	20+ minutes per plot
Qualifications Needed	Some familiarity with pollinator habitat or minimal training (Untrailed field technicians and operators using iNaturalist or other tools)	Ability to distinguish nectar plants and count milkweed (trained Field technicians and operators)	Ability to identify plants to species level (Trained biologists and field technicians)
Outcome	“Yes/No” habitat determination	Qualitative rating of pollinator habitat and management score	Qualitative rating of pollinator habitat; list of species present and metrics of nectar plants, milkweed, and invasive/noxious weeds; and management score

Note which tiers you plan to use in Section 4b *Sampling Protocol* of the monitoring template. If using multiple tiers, specify when and under what conditions to use each tier. Also describe any changes or additions to the sampling protocol described in the User's Guide.

	<p>Tip You may choose to use multiple Pollinator Habitat Scorecard tiers. This strategy is discussed more in the supplemental Strategies for Reducing Monitoring Costs.</p>
	<p>CCAA Note We strongly recommend collecting the optional milkweed tally of the Tier 1 assessment or using a higher tiered assessment to meet the requirements of the CCAA. The optional milkweed tally allows you greater flexibility in achieving the 90% confidence interval adaptive management threshold.</p>
	<p>Follow Along Checklist</p> <p><input type="checkbox"/> Indicate which assessment tier(s) to use in Section 4b <i>Sampling Protocol</i> of the monitoring template</p>

6. Calculate the number of plots required

The number of plots required is determined by your sampling objectives. Some users may elect to only sample a small number of representative plots. Users wanting to implement a more rigorous monitoring program may use the Calculation Worksheet 1 to estimate the number of plots required to meet sampling objectives.

If the number of plots required exceeds what can be accomplished with available resources, you must either revise sampling objectives or consider strategies for reducing monitoring costs (described in the next section).



CCAA Note

Confirm that the number of plots meets or exceeds the requirements of the CCAA based on the adopted acres target (see Table 14-4 in the CCAA).



Follow Along Checklist

- Complete the Calculation Worksheet; provide a link to the worksheet in Section 4c of the template
- Indicate the number of plots to be collected in Section 4c Number of Plots of the monitoring template

7. Identify plot locations

A thoughtful strategy for distributing plots within your area of interest is critical to collecting useful data. Because each organization using the Pollinator Habitat Scorecard is unique, each organization's strategy for distributing plots will also be unique. There is no one-size-fits-all solution.

When developing your strategy for plot distribution, keep in mind these two considerations:

- **Reduce bias:** Bias is introduced when sampled plots do not reflect the true state of the habitat. To reduce bias: (1) ensure that all potential plots within your area of interest have an equal probability of being selected, (2) use randomization to select plot locations, and (3) select plots before seeing vegetation on site.
- **Maximize spatial balance:** Strive to maximize spatial balance in your plot distribution strategy. Because nearby vegetation tends to be similar, two plots close to each other will provide less insight than two plots in different areas. However, do not introduce bias simply to increase spatial balance!

Strategies for distributing plots are described in the Strategies for Distributing Plots guidance. Select one or more strategies and describe how you will distribute plots in Section 4c Plot Locations in the monitoring template. Update the map of the area of interest with plot locations (optional). Finally, make sure to communicate plot locations to field data collection staff.



Tip

Using permanent plots (i.e., plots that are revisited in subsequent years) is helpful when you want to measure change over time. This strategy is discussed more under Optional Strategies for Constraining Monitoring Costs.



Follow Along Checklist

- Describe the strategy for determining plot locations in Section 4d *Plot Locations* of the monitoring template
- Update the map attached as Appendix A with plot locations (optional)

8. Define timing and frequency of monitoring

Develop a plan for when you will collect plot data and how often you will revisit plots.

Timing

When using the Pollinator Habitat Scorecard, data should be collected during the valid field data collection window at or around peak bloom for your site. If vegetation in your area changes significantly over the seasons, you may want to sample an area multiple times in a year, however this is not required.

Ideally all plot data would be collected during the same season. This may not be practicable for all organizations. Keep in mind the impacts of seasonal variability in vegetation, especially when aggregating or comparing the data collected in different seasons.

Frequency

If using permanent plots, the plots should be revisited in subsequent years within a few weeks (before or after) the first date of data collection or as close as weather and site conditions allow (i.e., time after last frost, seed head emergence, etc.).

Other Timing Considerations

Describe when data should be reported to the data manager and any other important dates for the monitoring effort.



Tip

Pollinator habitat can change dramatically between seasons. When collecting data multiple times per year, it is often best to only compare data from subsequent years taken during the same season. Averaging data taken in different seasons of the same year can obscure some trends in vegetation conditions.



Tip

If available resources do not allow collecting all plots in the first year, you may divide data collection across multiple years. This strategy is discussed more in the supplement Strategies for Reducing Monitoring Costs.



Follow Along Checklist

- Complete Section 4e *Timing & Frequency* of the monitoring template

9. List equipment required

A list of required and recommended equipment is provided in Section 5 Equipment of the monitoring template. Ensure that all required equipment and recommended equipment you intend to use is available. List any additional equipment required.



Follow Along Checklist

- Complete Section 5 Equipment of the monitoring template

10. Define roles and responsible parties

Clearly describe the roles and responsibilities of team members involved in monitoring activities. These roles, fulfilled by either an individual or multiple team members, could include:

Survey Manager

The survey manager is responsible for making sure field surveys are conducted according to the Pollinator Habitat Scorecard protocol and that the data is in a format suitable for use in decision making and reporting. Responsibilities include:

- **Planning and Oversight**
 - Proper planning and resources are allocated in a timely manner
 - Survey technicians have all equipment, tools, and trainings required
 - Adherence to all organizational health, safety, and communications protocols
- **Quality Control**
 - Minimum required number of sample plots are collected
 - Pollinator Habitat Scorecard protocols were followed, including proper data collection
 - Data collected is accurate for the plot(s) sampled

Survey Technician

Survey technician(s) will conduct field surveys and keep track of all data collection. Responsibilities include:

- **Field Sampling**
 - Completing any training required by your organization to conduct sampling
 - Adherence to all organizational health, safety, and communications protocols
- **Quality Control**
 - All field sampling protocols were followed accurately
 - All data collected is stored in the proper format and location(s) required for annual reporting

Data Manager

The data manager is responsible for supporting the collection, storage, reporting, and archiving of all data that was collected, and providing it to the survey manager for annual reporting or other analysis.



Follow Along Checklist

- Complete Section 6 Monitoring Roles/Responsibilities of the monitoring template

11. Plan for training

Training is recommended for staff conducting field surveys to orient staff to the sampling protocols, ensure consistent field sampling, and teach milkweed and nectar plant identification. We recommend personnel using the Pollinator Habitat Scorecard to be trained at least once annually on:

1. The identification of both native and non-native species, particularly invasive and noxious weeds and milkweed and nectar plant resources for pollinators.
2. Estimation of percent cover (to improve consistency across surveyors).
3. Protocols and procedures expected of surveyors conducting field sampling. This may include any access communications, plus health and safety protocols.

**Follow Along Checklist**

- Complete Section 7 Training of the monitoring template

12. Establish data management needs

Organizations should develop a data management strategy to ensure that data collected in the field is properly stored for later use and review. This may include:

1. Once surveys are completed, verify sample plots are uploaded into the appropriate geospatial database.
2. Scan any hard copy completed data sheets and provide copies to the data manager.

**Follow Along Checklist**

- Complete Section 8 Data Management of the monitoring template

13. Plan for data reporting

After the surveys are complete, the data will need to be provided to the data manager and survey manager. Consistency in reporting the data will avoid complications that may arise from the multiple sampling events. Reporting protocols may include:

1. Notify the survey manager or data manager after each sampling event is conducted. This allows for optimal quality control verification.
2. After surveys are completed, provide the data to the data manager and survey manager. The data gathered will be used to inform monitoring goals and complete annual reporting.
3. Schedule annual vegetation management review of collected monitoring data and identifying adaptive management considerations when needed.

**Follow Along Checklist**

- Complete Section 9 Data Notification & Reporting of the monitoring template

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