

Monitoring Protocol Addendum 2: Use of Remote Sensing for Monarch CCAA Monitoring

June 2025

Document Purpose

This document guides the use of unmanned aerial vehicles (UAVs) and other remote sensing techniques that may support effectiveness monitoring by organizations enrolled in the *Nationwide Candidate Conservation Agreement with Assurances for Monarch Butterfly on Energy and Transportation Lands* (Monarch CCAA)¹. Organizations enrolled in the Monarch CCAA (“Partners”) conduct monitoring activities that are shared with the program administrator (University of Illinois Chicago, or UIC) and U.S. Fish and Wildlife Service (Service). This modification provides supplemental updates to the monitoring protocol described in the Monarch CCAA, Section 14.2.

Key Takeaways

- Remote sensing can be a cost-effective alternative to in-field sampling for Monarch CCAA monitoring.
- Remote sensing methods must satisfy the sampling requirements of the Monarch CCAA and demonstrate a minimum level of accuracy.
- If planning on using remote sensing methods, verify use with the Program Administrator before sampling.

Background

While not readily available or tested at the time of the Monarch CCAA development, remote sensing for milkweed and flowering plant data collection has recently become a reliable option available for assessing and monitoring plant communities. Studies have shown that species of milkweed and flowering plants can be accurately identified using available technology.^{2, 3, 4} Conversations with Monarch CCAA Partners has indicated that some have previously tested remote sensing technologies for their own Monarch CCAA monitoring purposes with accurate results.

Requirements

Monarch CCAA Monitoring Requirements

The Monarch CCAA sampling protocol outlined in Section 14 of the Monarch CCAA specifies the requirements for conducting monitoring as part of program compliance. A June 2021 [monitoring addendum](#) also provides additional clarity. Key considerations for the use of remote sensing include:

- Sampling should only occur in areas designated as adopted acres.
- Partners are expected to select sample sites across the full geographic extent where conservation measures are implemented (i.e., adopted acres).

¹ Online at: https://rightofway.erc.uic.edu/wp-content/uploads/Final-CCAA_Signed-4.7.20.pdf

² See Ozcan, K., A. Sharma, S. P. Bradbury, D. Schweitzer, T. Blader, and S. Blodgett. 2020. Milkweed (*Asclepias syriaca*) plant detection using mobile cameras. *Ecosphere* 11(1):e02992. 10.1002/ecs2.2992.

³ See <https://monarchjointventure.org/mjvprograms/science/remote-sensing>

⁴ See Lu, B. and Y He. 2017. Species classification using Unmanned Aerial Vehicle (UAV)-acquired high spatial resolution imagery in a heterogeneous grassland, *ISPRS Journal of Photogrammetry and Remote Sensing*, Volume 128. ISSN 0924-2716, <https://doi.org/10.1016/j.isprsjprs.2017.03.011>.

- Plot locations must be randomly selected to ensure data integrity and repeatability.
- Monitoring must be conducted during the growing season, preferably during peak bloom relative to the locale.
- Partners evaluate milkweed density and nectar plant coverage. These targets depend on the CCAA region where sampling occurs:
 - In the Midwest and Eastern U.S., 174 milkweed stems or more per adopted acre, or a minimum of 10 percent cover of potentially flowering nectar plant cover.

In the West and Southern U.S., 58 milkweed stems or more per adopted acre, or at least 10 percent nectar plant cover.

Remote Sensing Requirements for Monarch CCAA Monitoring

The Monarch CCAA sampling protocol intends to evaluate milkweed stems and the percent cover of potentially flowering nectar plants in the field. Monitoring options have expanded into the use of remote sensing. Remote sensing must reliably and repeatedly produce accurate measurements of milkweed stems and potentially flowering plants within sampled areas to ensure consistent monitoring results across different practices. Thus, the use of any remote sensing technique must:

- 1) All remote sensing used for Monarch CCAA monitoring must follow the steps noted under the Approach and Reporting Results sections described herein.
- 2) Demonstrate data collection and accuracy methods through prior research, field trials, or other validation records.
 - a) Ensure the sampling methods achieve 90% minimum accuracy in detecting individual milkweed stems.
 - b) Ensure area calculations represent the percent coverage for blooming and potentially blooming plants across the flight area's adopted acres.
 - c) Ensure accurate digital measurement of the data's geo-location within the adopted acres boundaries while excluding measurements outside those boundaries. Include a map depicting the flight area sampled.
 - d) Digital measurement tools must be capable of minimizing image overlap, ensuring that each area is represented by a single image to prevent multiple counts.
- 2) The minimum number of separate and distinct flight areas (e.g., not adjacent to each other) to be sampled is based on the on the full or regionalized extent of adopted acres and original number of plots required in Table 14-4 of the Monarch CCAA, as noted in table below.

Adopted Acres ⁵	Minimum Required Flight Area ⁶	Minimum Number of Separate and Distinct Areas
Fewer than 1,000	15,000 ft ² , or 0.34 acres	2
1,001 to 10,000	45,000 ft ² , or 1.03 acres	3
10,001 to 30,000	75,000 ft ² , or 1.72 acres	4
30,001 to 60,000	105,000 ft ² , or 2.4 acres	5
60,001 or more	More than 105,000 ft ² , or 2.4 acres, applied at a rate of one additional required area per every 15,000 ft ² .	6, plus one additional required area for every 15,000 ft ² added over 105,000 ft ² .

Approach

Partners using remote sensing in lieu of the standard in-field sampling method must do so using the following approach:

1. **Identify a data collection method.** Identify a method that aligns with the expectations outlined in this memorandum.
2. **Confirm with UIC.** Confirm the data collection method(s) and reporting requirements align with this addendum guidance with the Program Administrator prior to field sampling, including whether remote sensing only, or a hybrid data collection approach is planned.
3. **Prepare a monitoring plan.** Describe the sampling method and analysis used in the Partner's Monarch CCAA monitoring plan. If the Partner previously completed a monitoring plan as part of their implementation plan, then that monitoring plan may be revised to meet this requirement. A CCAA monitoring plan should include all the required elements from the template, plus additional detail on the accuracy validation used and the approach to sampling across the geographic extent of adopted acres.
4. **Conduct sampling.** Conduct sampling according to the approach described in the Partner's CCAA monitoring plan.
5. **Report Results.** In conjunction with Partner annual reporting, report sampling results to the Program Administrator using one of the two approaches noted below. The approach used will be clearly specified in reporting.

Hybrid Data Collection

Some Partners may choose to use a combination of in-field monitoring plots and remote sensing to fulfill their Monarch CCAA monitoring obligations. This hybrid data collection approach can be used to meet either the minimum monitoring requirements, or to provide supplemental monitoring:

- **For achieving minimum monitoring requirements,** Partners may use a combination of in-field plots and remote sensing to meet the minimum square footage, as outlined in the table under the [Remote Sensing Requirements](#). The number of in-field plots and/or distinct remote sensing areas must be consistent with the amount required for the square footage thresholds specified.

⁵ Based on Table 14-4 in the Monarch CCAA.

⁶ Minimum flight area is equivalent to the square footage required of standard monitoring plots per adopted acres as described in Table 14-4 of the Monarch CCAA. Each standard individual plot is 1,500 square feet. Thus, for Partners with fewer than 1,000 adopted acres, 10 plots are required; 1,500 square feet per plot equals 15,000 square feet total.

For example, if a Partner is required to sample 30 plots per Table 14-4 in the Monarch CCAA, and they opt to sample 30,000 ft² using remote sensing, then the remote sensing must cover at least two separate and distinct areas. Then, the remaining 15,000 ft² required for monitoring must be sampled across 10 in-field monitoring plots located outside the areas sampled by remote sensing. Collectively, this hybrid approach covers 45,000 ft², fulfilling the minimum monitoring requirement.

- **For exceeding minimum requirements to achieve a supplemental discount**, Partners may use a combination of in-field plots and remote sensing. The total area must meet or exceed 150% of the minimum square footage required, with at least 50% of that total assessed using remote sensing as indicated by the table under the [Remote Sensing Requirements](#). The number of in-field plots and separate and distinct remote sensing areas must be consistent with the amount required for the square footage sampled.

Reporting Results

Partners using remote sensing methods for CCAA monitoring can choose from two approaches for reporting results:

1. *Align remote sensing data with CCAA monitoring fields*

Under this approach, Partners conform the data collected to the standard monitoring reporting fields specified in Table 14-2 of the Monarch CCAA, including both required and optional data.

Within their CCAA monitoring plan, Partners will describe how they randomly select sampling plot locations:

- 1) Across the geographic extent of adopted acres, and
- 2) Within subsets of adopted acres annually sampled by remote sensing (if applicable).

Some Partner's adopted acres span large geographic areas covering multiple states or ecoregions. These Partners may choose to sample within a specific region or subset of adopted acres annually for cost-effectiveness and logistical reasons. If a regionalized approach is used, the Partner must describe their method and timeframe to achieve sampling across the full geographic extent of their adopted acres. Within regionalized sampling areas, Partners must also describe their method how they will randomly select plot locations.

Once sampling is conducted according to their monitoring plan, the Partner will compile results into the reporting format described in Table 14-2 on the Monarch CCAA and accompanying monitoring and reporting tools found within the Monarch CCAA Toolkit. The Program Administrator will summarize these results along with field data collected as part of annual Monarch CCAA program reporting.

2. *Share comprehensive sampling data and results, including CCAA monitoring fields.*

In this alternative approach, the Partner in lieu of additional analysis and constraints required, will summarize across the entirety of each separate and distinct flight area:

- Stems of milkweed, reported in stems per acre, and
- Percent cover of potentially flowering nectar plants, reported in percent cover across the sampled area.

As a supplement to these required data, include any other vegetation or habitat-related data collected through remote sensing. The Partner will provide data and analysis summaries as attachments to their CCAA annual reporting.

To ensure consistency in plot size and sampling results, the Program Administrator will summarize remote sensing data separately from data reported via standard monitoring fields. This separate reporting within the CCAA program annual report will allow for long-term comparison against field collected data to confirm whether any consistencies may exist across sampling methods.

The Program Administrator and Service will use the results of remote sensing shared by Partners to review for data consistency and reliability. This review may result in future modifications to this addendum, if necessary to ensure data quality or consistent use.

Application as a Supplemental Measure

Under either approach, Partners wishing to qualify for the “Additional pollinator habitat monitoring” supplemental measure discount must demonstrate data collection and report results on 50% or more of the minimum square footage required as outlined in the table under the [Remote Sensing Requirements](#). This requirement also applies to Partners implementing a hybrid data collection approach (i.e., a combination of remote sensing and standard in-field monitoring).

Adaptive Management

Adaptive management triggers still apply to the Partner and their remote sensing data results. Refer to Section 14.2.2 in the Monarch CCAA and the [July 2023 Adaptive Management Modification for Flowering Nectar Plants](#) addendum for CCAA region-specific requirements.