Citizen Science Toolkit Conference

June 20 - 23, 2007

the monarch larva monitoring project: educational and scientific goals and outcomes

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This presentation took place at the Citizen Science Toolkit Conference at the Cornell Lab of Ornithology in Ithaca, New York on June 20-23, 2007.

Note that this document did not originate as a formal paper. Rather, it combines an oral presentation with accompanying PowerPoint slides and reflects the more informal, idiosyncratic nature of a delivery prepared specifically for this live event.

Documentation of the conference is meant to serve as a resource for those who attended and for others in the field. It does not necessarily reflect the views of the Cornell Lab of Ornithology or individual symposium participants.

The following is one of three focus point presentations delivered as part of the session titled "Citizen Science Project Design" on day one of the Citizen Science Toolkit Conference

For complete documentation of conference proceedings and to learn more about citizen science and the Citizen Science Toolkit, or to join the ongoing citizen science community, go to:

http://www.citizenscience.org

This documentation is supported by the **National Science Foundation** under Grant ESI-0610363.

The Monarch Larva Monitoring Project:

Educational and Scientific Goals and Objectives

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Overview

I am going to talk about the Monarch Larva Monitoring Project (MLMP), and the focus is on developing a program that has very clear scientific and educational goals from the outset. A lot of times, particularly when citizen science was just beginning, there has been a perceived tension between educational and scientific goals. I think it is important to consider these two categories of goals as complementing each other and not competing with each other.

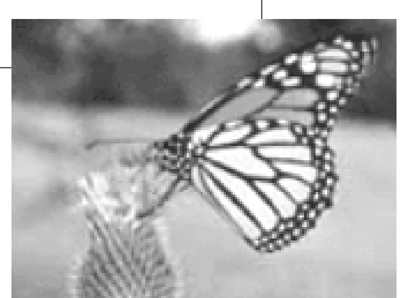
To set the context and offer an example, I will be talking a little bit about our project. Michelle Prysby developed this project as part of her master's thesis at the University of Minnesota back in the mid-1990s. She directed the project for the first couple of years and then I took over in 2001.

I will describe the project's goals and activities, and then talk about how we ensure that both educational and scientific outcomes are achieved. Because citizen science projects are often long-term projects that are going to evolve, it is important to both have the end in mind and be flexible and allow for end goals to change.

This project is probably different from many other projects represented at this workshop because we focus on a single organism, the monarch butterfly. We have the advantage of this being a very charismatic species, and it also has a lot of policy relevance. For example, next week I will speak to the ministers of the environment from Canada, Mexico and the United States about a new North American monarch conservation plan, and citizen monitoring is a huge part of this plan. We have the advantage that this is a species that people care about.

Outline

- MLMP goals, protocol and findings
- Ensuring that educational and scientific outcomes are achieved
- Emphasize flexibility and change—long projects that should evolve



MLMP Goals, Protocol and Findings

Scientific and Educational Objectives

Our overarching question is, how and why do monarch populations vary in time and space? Our focus for this question is on monarch distribution and abundance during the breeding season in North America. Additional questions, some of which have come up as a result of the observations that our volunteers made, relate to mortality rates in different life stages, female host plant choice, and habitat effects on recruitment.

Our overarching educational objective is to increase scientific literacy addressing three main categories: science content, science process and science applications.

MLMP Scientific Objectives

- How and why do monarch populations vary in time and space?
- Additional questions relate to mortality rates in different life stages, host plant choice, and habitat effects on recruitment

Photo by Mary Holland

MLMP Educational Objectives

To improve scientific literacy through increased understanding of:

- **Science Content:** Monarch/milkweed community biology and local ecology
- **Science process:** Data collection procedures, use of scientific equipment, scientific inquiry
- **Science applications:** Policy and conservation implications of data

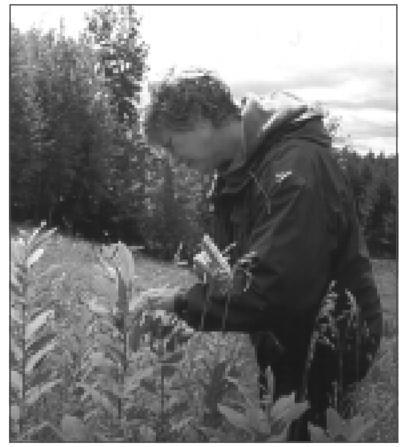
People learn a lot of science content by going out and observing monarchs on milkweed plants. They also learn a lot of important science process including data collection procedures, use of scientific equipment, and the process of scientific inquiry. Additionally, the project provides examples of how the data can be applied to policy and conservation decisions. We communicate often to our volunteers about applications of the data that they collect.

MLMP Protocol

- Volunteer, choose and describe a site
  - Gardens, parks, roadsides, prairies (need milkweed)
- Weekly Monitoring
  - Estimate monarch densities
  - Quantify milkweed quality (optional)
  - Estimate parasitism rates (optional)

Protocol

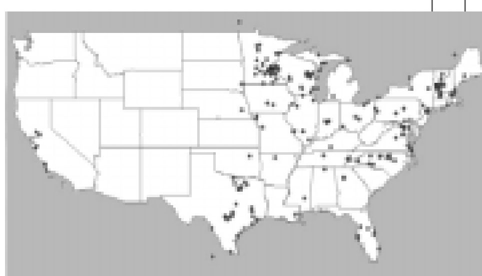
MLMP volunteers first decide that they are going to volunteer, then they choose and describe a site that will be monitored throughout the monarch breeding season. The only requirement for the site is that it contain milkweed, the monarch host plant, and volunteer sites range from backyard gardens to roadsides to national parks.



This is a fairly time consuming citizen science project. There is a lot of variation in what citizen science projects demand of participants. We all need to think about this; how much time do people spend on these projects? Our volunteers go out weekly and it takes them anywhere from an hour to three hours if they have a big site, depending on how much they want to do. All of them estimate monarch densities, and there are other optional activities from which they can select as well.

Volunteers

We have had over 1,000 participants since the inception of the program in 1997. Because we keep track of individual sites, it is hard for us to know exactly how many people monitor each of those sites, but we know we have well over 1,000 volunteers. Adults are the primary volunteers at sites, but we have learned from surveys that over fifty percent of them monitor with children, so there is a lot of opportunity for science education. Happily for us, from both an educational and a scientific perspective, most volunteers participate for more than one year. In fact, we have several who have participated every year of the project, and lots of people who have been going on for five, six, seven or eight years. Every year we acknowledge people who have been with us for over five years, so we have a good list regarding the amount of time they've been involved.



MLMP Volunteers

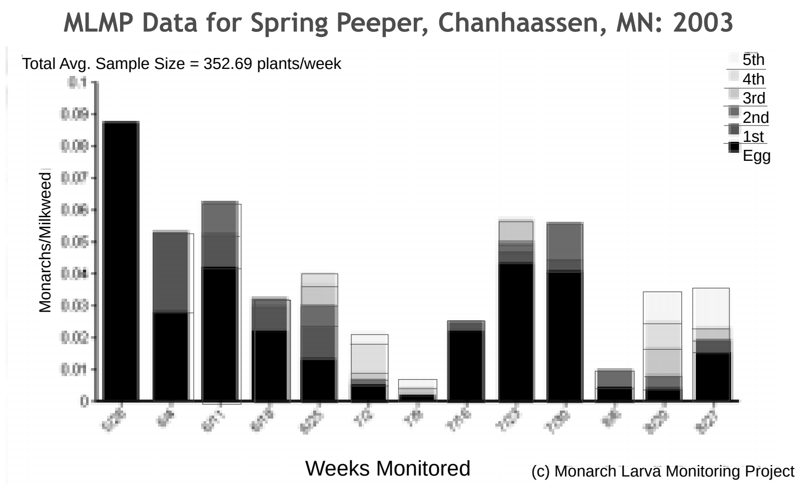
- 1000+ participants over 11 years
- Age range 20-85 (>50% monitor with children)
- Most participate > 1 year

Training

Training can take place in many ways. All of the directions are available on our Web site, mlmp.org. For four years we developed a network of trainers and a train-the-trainer structure with support from the National Science Foundation. We conducted train-the-trainer workshops throughout the U.S., and many of the people trained in those workshops have continued to train more people. All of the other education outreach programs in my research lab involve people in the MLMP whenever possible.

Data Entry and Feedback

The heart of the project is collecting data on weekly monarch densities. Here you can see data from a teacher and her students in Minnesota. The data are organized by dates, so we have both temporal and spatial referencing for the data. The bar graph shows the per-plant density of monarchs at this site, with the different shades on the bars representing either eggs or different larval instars of the monarch, so we have age and stage distribution as well as the time distribution of monarch numbers.



Data from Cindy Petersen and students, Chanhassen, MN

These data are all entered online and immediately accessible in either a site basis or a statewide basis. It's easy to find links on the Web site that you can click on to see data from your site or your entire state or any other state or site.

Ensuring that Educational and Scientific Outcomes are Achieved

Achieving Scientific Goals

There are several important things to think about in achieving your scientific goals. The first is to formulate questions that have important scientific merit, and then see that the data are relevant to your questions. A lot of citizen science projects don't think about this carefully enough. It is also important to use the data, both to answer scientific questions and to disseminate basic science literacy. And finally, there is something we all need to think about: maximizing data accuracy.

Achieving Scientific Goals

- Formulate questions with scientific merit
- **Ensure that data are relevant to the questions**
- Use the data (KEY)
  - To answer scientific questions
  - Dissemination (science and popular press)
- **Maximize data accuracy**

To save time, I'm only going to briefly talk about two of these areas, relevancy and accuracy. Data relevancy is an important part of the formative evaluation of citizen science projects in that the relevancy of the data requires constant reassessment. This is not a case in which you can just sit back and say you've developed a good project. You need to keep reassessing whether your data are relevant.

In some cases the questions may be answered, and there may not be any need for people to continue collecting data on these questions if they've already been answered. Sometimes we find that the data that we've asked people to collect really aren't that useful for answering our questions. There is a fine line between collecting data that might eventually prove interesting—we all have files and files of data that someday might be relevant—and wasting volunteers' time. That is a key thing to think about.

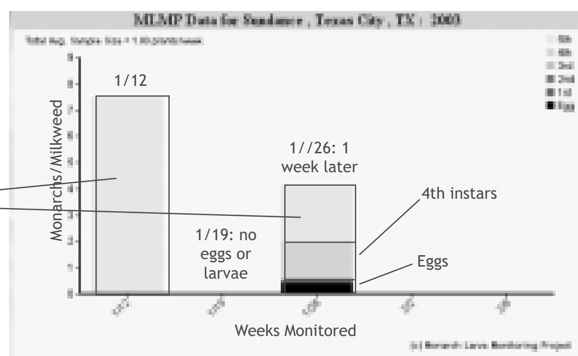
Data Accuracy

- Identify sources of error (also a formative process)
  - Detection Errors
  - Accuracy and Precision Errors
  - Sampling Errors
  - Failure to Report Negative Data

With data accuracy, it is important to think about all of the possible mistakes that volunteers can make. Again, that is a formative process. We learned a lot about how people could misinterpret our directives that seemed so clear to us. We've found that there are four important sources of error: detection errors (finding or not finding something that's there), accuracy and precision, sampling, and failing to report negative data. To save time I'm only going to talk about detection errors, but we have thought a lot about how to deal with other kinds of errors and I would be happy to share that with any of you later.

As an example, this is a bar graph from one of our volunteers in Texas whom I have gotten to know very well. I call her a lot because her data are completely unbelievable. This pale shade represents 5th instars, which are the largest monarch caterpillars. You can see that on 1/19 she went out and monitored and didn't see any eggs or larvae, and then a week later she went out and she found some 5th instars. That's biologically impossible, unless you believe in spontaneous regeneration. So we receive this dataset and we know that it's wrong, but she is enthusiastic and really loves doing this. We can spot this error easily, and simply not use her data for certain things. We can, however, use her data just for simple presence data.

Detection Error Example: No eggs, lots of larvae



- Observer doesn't see or recognize eggs
- Easy to catch

Solution

- Don't use data for survival analyses or egg absence

Another example is a little harder to verify. Some volunteers find too many monarch eggs, often mistaking the milkweed latex that gives milkweed its name for eggs.

In some cases we've interviewed volunteers to try to figure out what

Data Relevancy

- Requires constant reassessment (formative process)
  - Questions may be answered and not require further data collection
  - Data may not address questions
  - Fine line between collecting data that may eventually prove interesting and wasting volunteers' time

they're seeing, but we're very careful not to modify their data if they may be correct. We've discovered that sometimes they are more right than we are. This is a picture (*left*) of a milkweed plant with lots of eggs on it. A volunteer sent us this picture, teaching us that egg numbers can be very high. This knowledge comes from constant communication with our volunteers.

Detection Error Example: Too Many Eggs

- Observers mistake milkweed latex for eggs
- Hard to verify

Solutions

- Interview observers
- If data seem valid, do not modify or remove
- We know that egg numbers can be very high

We have found that, to avoid errors in our data, we need to have excellent training for people and continually reevaluate our instructions to ensure that they are clear to people. We interview volunteers with questionable datasets. And finally, we find that it is really valuable to go out with our volunteers in the field to anticipate the kind of errors that they might make. I don't want to make it sound like our volunteers aren't intelligent people. Usually mistakes happen because our instructions weren't clear enough. It's not their fault, it's usually ours.

General Solutions: Detection Errors

- Training
  - Train-the-trainer network
  - Easy-to-follow instructions
- Interview volunteers with questionable datasets
- Recognize normal patterns
- Watch volunteers in the field; anticipate common errors

I think it's also important to keep in mind that some mistakes are okay. If you're installing windows, you want your windows to be exactly the right size, so precision is important. But in a lot of cases it's not that important to be exactly precise. For example, in our project, presence data don't have to be as precise as survival data, so if we just want to know if monarchs are there and we don't care about how many, then we're okay with that with the data from that lady in Texas who can't recognize an egg.

Some mistakes are OK!

- For some of our scientific goals, quantitative precision is not important (e.g., presence data vs. survival)

Also (and I'm not going to talk about this at length), as others here have said, in many cases we really think that our volunteers are just as good as the people who are paid.

Who is the better data collector?

Undergrad paid $8/hour...

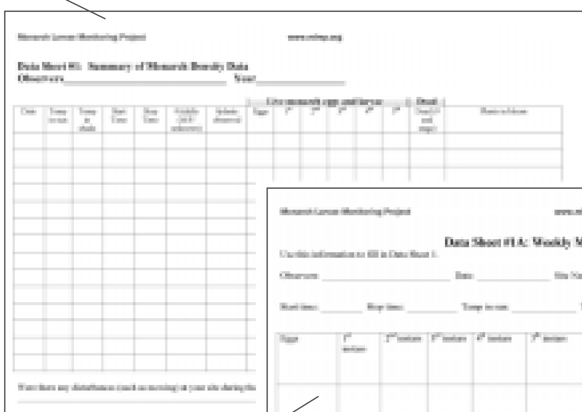
or unpaid volunteer?

Achieving Educational Goals

In achieving educational goals, it is important to think about situations in which adults monitor with children. For us, the child volunteers are really important. It is also important to encourage independent science inquiry and promote links between educational institutions.

What we have found in our program is that children are often involved with adults in three different contexts: with their families, neighbors and friends in a kind of very informal setting; with teachers in programs that go on throughout the center and throughout the summer; and with nature center programs. We have formulated appropriate data collection strategies, and we work with the adults monitoring those children to modify our data collection strategies so they are more appropriate for working with children.

Here is a simple example. This is the way our data sheet looked. Each one of the rows on this data sheet is a week of collecting data. If you're going out with a second grader, you'll find that most second graders can't fit their numbers into these little squares. We worked with a teacher to design a data sheet that looks like this, so that each week is a separate data sheet and the big huge numbers that kids write will fit into the squares on this data sheet. It's really simple, but it made it much more appropriate for kids working with adults to do this project.


Data Sheet #1: Summary of Monarch Density Data


Data Sheet #1A: Weekly Monarch Density

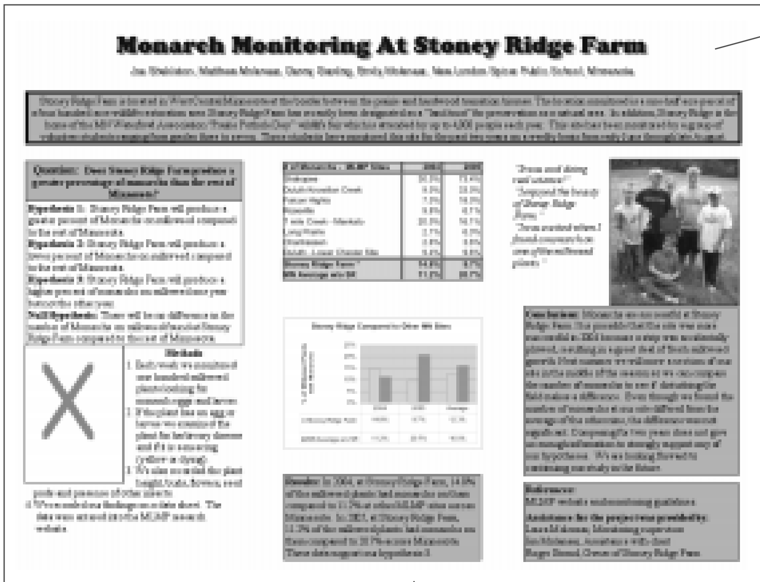
We are also trying to encourage volunteers to develop their own questions and protocols. This is something that is really exciting to me. We provide opportunities for a lot of our groups to give presentations to scientists and other individuals about the results.

Adult and Child Learners

- Defining circumstances under which children are involved
  - Family, neighbors, friends
  - Teachers
  - Nature center programs
- Formulate appropriate data collection strategies and support modifications
- Ensure that procedures teach science content and process

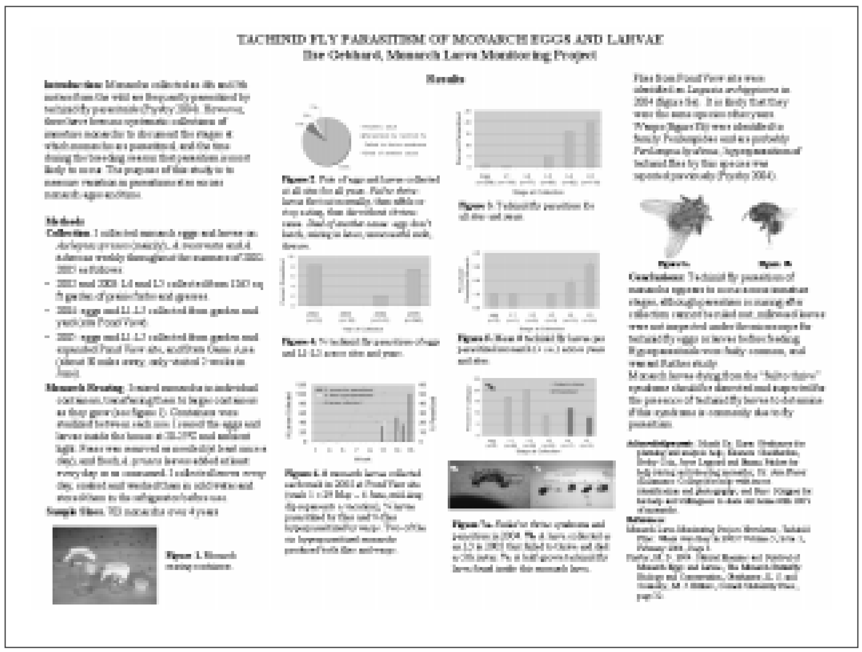
Independent Inquiry

- Flexibility to allow volunteers to develop new questions and protocols



You don't need to know the details about this graphic, but it is from a teacher working with a bunch of fourth-grade kids. The teacher came up with an independent project based on their monitoring. We try to support and encourage this.

One of these projects by an incredible woman, Ilse Gebhard, actually resulted in a published paper. She took one piece of a protocol and expanded it and we published a paper using her data and that of a couple of other of our volunteers to kind of go in a different direction.



K-12, ISE, Scientist Links

- Work with teachers
- Partner with ISE institutions (science museums, nature centers)
- Provide opportunities for student engagement with teachers

The other thing is to build links with K-12 institutions and ISEs. We've done a lot of work with teachers and ISE institutions and have, as much as we could, provided opportunities for students to engage with scientists in a lot of contexts.

Acknowledgments

- MLMP citizen scientists
- NSF, Xerces Society, Monarchs in the Classroom, USDA, UM Extension service
- University of Minnesota staff and students

Acknowledgments

I would like to end by acknowledging all of the MLMP citizen scientists who have worked with us. I would also like to acknowledge the funding from the National Science Foundation, the Xerces Society, Monarchs in the Classroom, the USDA, and UM Extension Service. And finally I would like to acknowledge the University of Minnesota staff and students involved with this project.