The Monarch Mission

Empowering Students to Improve Habitat for Monarchs, Grades 6-12

A Next Generation Science Standards-based curriculum

ECO-SCHOOLS USA
NATIONAL WILDLIFE FEDERATION
FOUNDATION FOR ENVIRONMENTAL EDUCATION

Green STEM
SCIENCE • TECHNOLOGY ENGINEERING • MATHEMATICS
Eco-Schools USA
NATIONAL WILDLIFE FEDERATION®

LEGO Community Fund U.S.

National Wildlife Federation

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The mission of the **National Wildlife Federation** is to inspire Americans to protect wildlife and natural resources for our children's future. The National Wildlife Federation has been a leader in developing high quality educational programming focused on the study and observation of nature, earth systems and wildlife to advance science learning for nearly 50 years. Combined, our K-12 programs reach 8,300 schools, approximately five million students and thousands of educators every year. For more about the National Wildlife Federation visit our website at www.nwf.org.

The LEGO Community Fund U.S. (LCFUS) mission is to inspire and develop the builders of tomorrow to reach their potential by supporting programs benefitting children 0-14, primarily in the areas of learning, creativity or creative problem solving. We will support programs in the U.S. communities where the LEGO Group operates, and will give preference to programs benefitting disadvantaged children.

A more advanced Citizen Science project suitable for secondary grade level students is the Monarch Larval Monitoring Project (MLMP). The MLMP is a program in which volunteer citizen scientists collect and report real scientific data on monarch egg and larval distribution and abundance from their monarch breeding habitat(s).
The project involves youth and adult volunteers from across the United States and Canada in monarch research. It was developed in 1997 by researchers at the University of Minnesota. Students can begin the project by viewing the online training video series and the instructions provided on the activity datasheets.

Citizen Science helps students to understand that science is a way of thinking about the world that involves observing, questioning, analyzing, revising and collaborating. It exposes students to learning opportunities relevant to the real world and allows integration of inquiry into the teaching of content. Children learn science by actually doing science.

National Wildlife Federation, Journey North and the Monarch Larval Monitoring Project are partners of the Monarch Joint Venture (MJV). The (MJV) is “a partnership of federal and state agencies, non-governmental organizations, and academic programs that are working together to support and coordinate efforts to protect the monarch migration across the lower 48 United States”. The MJV is committed to a science-based approach to monarch conservation work, guided by the North American Monarch Conservation Plan (2008).

Cathy Downs
Monarch Watch Conservation Specialist
Chair – Bring Back the Monarchs to Texas

Introduction to Citizen Science

What is Citizen Science?
Citizen Science is the collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists.

Goals and Objectives in the Classroom
The goal of Citizen Science in the classroom is to engage the student to not only learn about science but to be the scientist. Through discovering new things and increasing their own knowledge of the world students understand that science is not just memorizing a set of facts. By participating in Citizen Science they are now empowered to contribute to the ongoing process.

Students will make use of a number of skills such as collecting and analyzing data, interpreting results, making new discoveries, and developing and solving complex problems. According to the National Science Foundation, the constructs of citizen science are knowledge, engagement, skills, attitudes and behaviors. This creates a new science learning environment for students in the classroom.

Validity and Success
Citizen scientists collecting and reporting data to Monarch Butterfly projects provide information that contributes to the successful conservation of monarchs and their threatened migratory phenomenon.

For elementary grade level students Journey North's Monarch Butterfly Migration Project is a great place to start. According to its creators Journey North is "a global study of wildlife migration and seasonal change." Most students are familiar with this specie and the project is easy to participate in. With the appropriate building blocks even kindergartners can ask questions about data-another skill critical to building a scientific frame of mind. Students track the migration of the monarchs and learn about animal behavior and adaptations as well as the life cycle of the monarch butterfly representing key topics in life science. The project addresses content objectives through inquiry perspective which provides students with a way to build scientific skills and habits of mind.

One school in Brookshire, TX has taken their Citizen Science participation to new heights. With a new schoolyard Monarch Waystation garden in place they decided to embark on a sustained program where the students would be part of a world community. They would learn about science and conservation while helping the monarch population in their annual migration. They followed the suggested lessons from the Journey North website and shared their sightings of adult monarchs, eggs, chrysalides and caterpillars. Their students also participated in the Symbolic Migration and the school was plotted on the map of participating schools. One key element of their sustained inquiry was the Q/A with Dr. Karen Oberhauser where they learned important lessons about conservation and citizenship.

As lessons and activities were developed from the NGSS, we focused on three key components,

- **Project-Based Learning:** using Monarch Recovery Gardens as the focus for place- and project-based, learning experiences.
- **Green STEM:** Using the natural world as the lens in which to integrate:
    - science content,
    - technology via web-based applications and online digital publishing tools
    - engineering to create models, to demonstrate change over time and to solve design challenges to creating sustainable monarch habitat, and
    - Math to develop equations, measure plant growth, project progress, change over time and the rate of population growth/decline.
- **Interdisciplinary Instruction:** a scientifically literate student is able to communicate about topics in science and understand the historical value or nature of an issue and to use art to drive creativity and innovation.

Common Milkweed: Discovery Hill Austin
Photo Credit: Marya Fowler

Photo Credit: Avelino Mateas

Photo Credit: Harris Elementary

Plant milkweeds native to your region. Because they coevolved with your region's wildlife, native milkweeds are best. Sources of native milkweeds include Monarch Watch's Milkweed Market and the Xerces Society's Milkweed Seed Finder.

Cultivate native nectar plants. Nectar sources are especially important during spring and fall when monarchs migrate and need to fuel their flights, which can reach 2,000 miles during fall. Sources for native nectar plants include the Lady Bird Johnson Wildflower Center's Native Plant Database and regional planting guides published by the Pollinator Partnership.

Avoid pesticides use. In particular, steer clear of systemic insecticides such as neonicotinoids. These are taken up by plants' vascular systems, leaving caterpillars and butterflies that feed on leaves, nectar and pollen exposed to the poison long after it has been applied. A new study provides evidence that milkweed leaves treated with one neonicotinoid, Imidacloprid, kill monarch caterpillars that eat them.

Get your students involved in citizen science (see page the appendix, E-4). Biologists need volunteers to help study monarchs and students are great scientists. Programs such as Monarch Watch, the Monarch Larva Monitoring Project, and Journey North are great programs to involve your students in real science and support in helping monarchs.

About Monarch Mission

The lessons and activities that are part of ***The Monarch Mission, Empowering Students to Improve Monarch Habitat*** were created to complement your NWF Eco-Schools USA and Schoolyard Habitat® work and to accompany the construction of your school's Monarch Recovery Gardens and monarch observations.
The curriculum is only one component to the overall experience. The Monarch Recovery Gardens project is not a short-term learning project. It is a long-term learning experience that will allow students to:

1) Increase the available habitat needs of the monarch, subsequently leading to an increase in monarch numbers,
2) Provide a variety of field experiences for students, allowing them to apply new learning and practice critical science, engineering and 21st century skills, and
3) Build awareness in the community about a national environmental issue, while providing local solutions that can help bring them together, resulting in positive impacts for pollinator species, specifically the monarch butterfly.

Each of these lessons and activities were designed starting with the Next Generation Science Standards (NGSS) for the following grade bands, K-2, 3-5, 6-8 and 9-12.

What is the National Wildlife Federation and our Partners Doing to Help?

The National Wildlife Federation (NWF) recognizes the increased need for native milkweed to restore monarch habitat across large landscapes, suburban and urban gardens. Because, the lack of native milkweed is a limiting factor for the monarch butterfly, localized efforts to increase the supply of native milkweed is critical. This is especially important in Texas where the butterflies make their first stop after overwintering in Mexico before starting the annual migration north. Without sufficient habitat and milkweed in this region, the migration of the monarch stops. On a national level, NWF and U.S. Fish and Wildlife Service and many other partners have joined forces to help protect the monarch by working to bring back native milkweed and nectar producing plants that the species rely upon for breeding and feeding along its migratory route.

How Can Schools Help Monarch Butterflies?

As monarchs lose more and more habitat on agricultural lands, backyards have become increasingly important. As part of a larger effort to protect pollinators, NWF and the U.S. Fish and Wildlife Service recently signed an agreement, calling on citizens to help monarchs by cultivating milkweed and native nectar plants. With a long history of creating habitat for wildlife, National Wildlife Federation believes that individuals, schools and whole communities can play a key role in helping monarchs recover.

Studying pollinators and the monarch butterfly gives students the opportunity to become engaged in and empowered to help solve a current and tangible 'real-life' environmental problem. The monarch butterfly is a species that students can have a direct positive impact on; a species they see in their schoolyards, backyards and at their local parks. The study of the monarch butterfly also lends itself beautifully to project-based learning. Students learn the importance of pollinators, develop plans, and implement effective solutions—such as creating monarch gardens with native nectar and milkweed (host) plants—that can make a concrete difference for the species.

Here's how your schools can play a role in this nationwide monarch-recovery effort:

Create a NWF Schoolyard Habitat®

Now with 5,000 participating schools, is the single largest school garden program in America. It supports school and educator efforts to develop wildlife and ecosystem education programs directly on the school grounds and provides children with opportunities to learn in outdoor classrooms. Schools can also participate in **NWF's Eco-schools USA program** and explore the Schoolyard Habitat pathway earning additional recognition and awards for your work. (www.eco-schoolsusa.org)

Introduction: For many of us, one of our fondest memories of elementary school is observing monarch butterflies in the classroom and learning about metamorphosis as these remarkable creatures transformed from caterpillars to butterflies right in front of our eyes. As educators, many of you have probably used the monarch butterfly to teach about life cycles and migration. But this iconic species is in trouble and like many of our pollinator species is in decline.

These brilliant orange and black butterflies are among the most easily recognizable of the butterfly species. Their migration takes them as far north as Canada and, during the winter months, as far south as Mexico City. A single monarch can travel hundreds to thousands of miles. Monarchs are truly spectacular migrants, because the butterflies know the correct direction to migrate even though they have never made the journey before. They follow an internal "compass" that points them in the right direction each spring and fall. The monarch migration is one of the greatest natural phenomena in the insect world.

But it is this migration and the habitat the monarch depends upon during this journey that has resulted in the species decline. It was in 2014, when biologists and the US Fish and Wildlife Service became concerned about the monarch butterfly's population numbers. According to scientists, the continent's monarch population has declined by more than 80 percent from its average during the past two decades—and by more than 90 percent from its peak of nearly one billion butterflies in the mid-1990s.

Why is the Monarch Butterfly in Decline?

The U.S. Fish and Wildlife Service is currently studying the status of the species to determine if it should be listed as a threatened species under the Endangered Species Act. The reason for the precipitous decline is primarily due to the loss of the monarch's exclusive larval host plant and a critical food source – native milkweed. These plants have been eradicated and/or severely degraded in many areas across the U.S. due to the overuse of pesticides by commercial agriculture and conventional gardening practices in suburban and urban areas. The accelerated conversion of the continent's native short and tall grass prairie habitat to crop production has had an adverse impact on the monarch, and climate change has intensified weather events which may also be impacting their populations. It is estimated that one million acres of milkweed must be planted annually simply to keep pace with new losses. Creating all of the habitat that monarchs need will require a massive habitat restoration program.

THE MONARCH MISSION - MIDDLE SCHOOL

MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (food, light, space, water)
MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
ETS 1-1 Define the criteria and constraints of a design problem with sufficient precisions to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
ETS 1-2 Evaluate competing solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
ETS 1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solutions to better meet the criteria for success.
ETS 1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

THE MONARCH MISSION - HIGH SCHOOL

HS-LS2-6 Evaluate claims, evidence and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS2-7 Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-LS2-8 Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.
ETS 1-2 Design a solution to a complex real-world problem by breaking down into smaller, more manageable problems that can be solved through engineering.
ETS 1-3 Evaluate a solution to a complete real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
ETS 1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

The Monarch Mission

MIDDLE SCHOOL | 7-8 HOURS + | SCIENCE, MATH, READING, WRITING, TECHNOLOGY, ENGINEERING

BACKGROUND

The survival of individual species of animals and plants relies on the health of their habitat. Today, more than 1,000 types of plants and animals in North America have been designated as endangered. To prevent the extinction of these species and to conserve the amazing diversity of living things on this continent, people must work together to protect and restore habitat for wildlife. The Monarch Recovery Gardens provide the opportunity for students, teachers, and community volunteers to act as wildlife biologists and restoration ecologists as they work on a small scale habitat on their own school grounds.

Every living species has specific habitat requirements. Habitat is the arrangement of living and non-living things which together supply an organism's basic requirements for life. These essential components include sources of food, water, cover, and safe places to raise young.

Each species' habitat has a characteristic physical environment, including climate, and often a characteristic type of vegetation. Eastern temperate forests tend to have cold winters and wet, hot summers. Broadleaf trees like oak and maple live well in these conditions; Eastern forests are defined by the mix of oak, maple, birch, and other trees that grow there. These trees create a canopy that shades the forest floor and provides habitat for many creatures, such as gray squirrels, white- footed mice, white-tailed deer, blue jays, and more. Deserts, on the other hand, receive little rain throughout the year and can only support plants able to tolerate dry conditions such as cacti and sagebrush, which in turn characterize the habitat for many other plants and animals. In forests and all other habitat types, plants and animals living there are adapted to their environment (they have inherited characteristics that enable them to survive in that location). Most plants and animals have one kind of habitat that suits them best, although

they may be able to survive in several others. Other living things can survive in only one kind of habitat.

OBJECTIVES

Students will

- Use graphs and other visuals to better understand the present state of monarch butterflies.
- Propose solutions based on qualitative and quantitative evidence.
- Conduct field investigations for soil and water samples
- Compose and adopt a vision statement.
- Use the engineering design process to evaluate, create and construct a healthy native and sustainable Monarch Recovery Garden.

MATERIALS

- Science notebook
- Regionally specific field guides
- Soil thermometer or soil probe
- Infrared or digital thermometer
- Graph: Total Area Occupied by Monarch Colonies at Overwintering Sites in Mexico, p. 23
- V Model of Systems Engineering, p. 24
- Copies of the following:
  - Habitat Hunt, p.25
  - Science-Based Cooperative Group Task Cards, p. 26
  - Taking Earth's Vitals, p. 27
  - Monarch Recovery Garden Visioning Worksheet, p. 28
  - Habitat Team Planning Worksheet, p. 31
  - Eco-Action Plan, A-1

NOTE

When working with your students to create monarch habitat, please refer to the introduction for specific and detailed information. The needs of the monarch butterfly are specific. It is critical to their preservation to create and maintain a healthy and sustainable habitat using a diversity of native species that will meet the needs of the monarch.

GREEN STEM PROJECT DESIGN

PROJECT NAME: Monarch Recovery Garden(s)		**DURATION:** 7 class hours + building the recovery garden
SUBJECT/CLASS: Science	**TEACHER(S):**	**GRADE LEVEL(S):** 6-8

OTHER CORE OR ELECTIVE CLASSES TO BE INCLUDED, IF ANY:
Reading/ELA, Computer Science, Engineering, and/or Environmental Clubs

STRANDS:
6.A Scientific investigation and 6.E Organisms and environments
LEARNING STANDARDS:
6.1A and B | 6.2A-E | 6.3A-C | 6.4A and B
STRANDS:
7.A Scientific investigation, 7.B Matter and Energy and 7.E Organisms and environments
LEARNING STANDARDS:
7.1A and B | 7.2A-E | 7.3A-C | 7.4A and B | 7.10 A and B | 7.12A | 7.13A and B
STRANDS:
8.A Scientific investigation, 8.B Matter and Energy and 8.E Organisms and environments
LEARNING STANDARDS:
8.1A and B | 8.2A-E | 8.3A-C | 8.4A and B

LEARNING OUTCOMES:
Students will:

- Use graphs and other visuals to better understand the present state of monarch butterflies.
- Propose solutions based on qualitative and quantitative evidence.
- Conduct field investigations for soil and water samples
- Compose and adopt a vision statement.
- Use the engineering design process to evaluate, create and construct a healthy native and sustainable Monarch Recovery Garden.

21ST CENTURY COMPETENCIES (Model these skills. What will you need to teach and/or assess?)				
	collaboration	X	creativity and innovation	X
	communication	X	other	
	critical thinking	X		

PROJECT SUMMARY (include student role, issue, problem/challenge, action to be taken, and purpose/beneficiary)

Students will take on the role of citizen scientists. They will work together to increase monarch butterfly populations in their community. Students' goals are to inform and engage the community about the plight and solutions related to the monarch butterfly and design a monarch habitat that can be used to study the monarch, serving as a teaching and learning resource, to conduct citizen science around the monarch butterfly and to serve as a community resource; a model example of native and sustainable monarch habitat.

ENVIRONMENT-BASED DRIVING QUESTION – will my students understand it-find it interesting? Does it require in-depth inquiry and higher-level thinking to answer? Is it open-ended with multiple ways to reach the goal? To answer, will students need to learn the important content and skills I've targeted?
How can we, as citizen scientists:

- Inform the community about the importance of the monarch butterfly?
- Design a monarch habitat that can be used to conduct monarch investigations and increase our local monarch populations?
- Encourage the community to build monarch habitat throughout the city?

ENVIRONMENTAL ENTRY EVENT (what is your hook – how will you engage students making it meaningful to their lives)

Students will analyze a monarch population graph to determine trend over time. Next students will be asked why this insect is important; does it really matter if the population is threatened and eventually becomes extinct? Using information from the Butterfly Conservation, http://butterfly-conservation.org/, students will start to answer these questions.

GREEN STEM PROJECT DESIGN

STEM ELEMENTS	Science: ecosystem dynamics, populations, habitat, predator prey, human impact, limiting factors, fragmentation, habitat loss	Technology: graphic design, blogging, web design
	Engineering: design and construction of monarch habitat and outdoor learning/observation space	Mathematics: number operations, communicate mathematical ideas, reasoning and use tools to problem solve, proportionality, equations, measurement and data
PRODUCTS	**Individual:** science notebook, , Foldables, Thinking Maps, research questions, research summaries, self and group reflections	
	Team: oral presentation, infographic, participation in Young Reporters for the Environment, write a blog and use social media and school media to share, community engagement days (planning, building, maintaining, informing, etc.), and summary containing next steps and new inquiry questions	
PUBLIC AUDIENCE (experts, audiences, or product users students will engage with during/at end of project)	Students should plan to present to the: (this is only an example – have students decide who they need on their side) • City Council: As the result of their research, data collection, interviews, discussions, etc., what do students want the city council to consider or do? • School Board: As the result of their research, data collection, interviews, discussions, etc., what do students want the school board to consider or do? • Community Development and Planning Department of the city of residence: As the result of their research, data collection, interviews, discussions, etc., what do students want the department to consider or do?	
RESOURCES NEEDED	**Experts and/or Community Resources:** Who are the people in the community who can help teams answer questions, design, build and volunteer? Who are the groups with expertise in the areas teams need to learn about?	
	Space: Besides the classroom what other space is needed to carry out student learning? Science/Computer Lab, outdoor space for pollinator gardens, place to hold presentations, field trips, etc.	
	Materials: What materials are needed for each phase of student learning? What do students need to be successful?	

REFLECTION METHODS (individual, team, and/or whole class)	journal/notebooking		focus group	
	whole-class discussion		think/pair/share	
	survey		Other	

NOTES:

The Monarch Mission

HIGH SCHOOL | 7-8 HOURS + | SCIENCE, MATH, READING, WRITING, TECHNOLOGY, ENGINEERING

BACKGROUND

The survival of individual species of animals and plants relies on the health of their habitat. Today, more than 1,000 types of plants and animals in North America have been designated as endangered. To prevent the extinction of these species and to conserve the amazing diversity of living things on this continent, people must work together to protect and restore habitat for wildlife. The Monarch Recovery Gardens provide the opportunity for students, teachers, and community volunteers to act as wildlife biologists and restoration ecologists as they work on a small scale habitat on their own school grounds.

Every living species has specific habitat requirements. Habitat is the arrangement of living and non-living things which together supply an organism's basic requirements for life. These essential components include sources of food, water, cover, and safe places to raise young.

Each species' habitat has a characteristic physical environment, including climate, and often a characteristic type of vegetation. Eastern temperate forests tend to have cold winters and wet, hot summers. Broadleaf trees like oak and maple live well in these conditions; Eastern forests are defined by the mix of oak, maple, birch, and other trees that grow there. These trees create a canopy that shades the forest floor and provides habitat for many creatures, such as gray squirrels, white- footed mice, white-tailed deer, blue jays, and more. Deserts, on the other hand, receive little rain throughout the year and can only support plants able to tolerate dry conditions such as cacti and sagebrush, which in turn characterize the habitat for many other plants and animals. In forests and all other habitat types, plants and animals living there are adapted to their environment (they have inherited characteristics that enable them to survive in that location). Most plants and animals have one kind of habitat that suits them best, although

they may be able to survive in several others. Other living things can survive in only one kind of habitat.

Both teachers and students should read the blog and accompanying texts from National Wildlife Federation, Battle of the Butterflies, https://www.nwf.org/Magazines/National-Wildlife/2015/AprilMay/Conservation/Battle-for-Butterflies

OBJECTIVES

Students will

- Use a variety of peer reviewed primary and secondary sources.
- Construct graphs and other visuals to represent the present state of monarch butterfly populations.
- Propose solutions based on qualitative and quantitative evidence for the decline in migrating monarch butterfly populations.
- Conduct field investigations using the Monarch Larvae Monitoring Project, MLMP.
- Compose and adopt a vision statement.
- Use technological applications to show simulations of how your solutions will improve habitat and increase the number of migrating monarch sightings.
- Use engineering design to evaluate, create and construct healthy, native and sustainable Monarch Recovery Gardens.
- Develop and execute a plan to engage the community in on-going monarch recovery work.

MATERIALS

- Science notebook
- Regionally specific field guides
- Soil thermometer or soil probe
- Infrared or digital thermometer
- Graph: Total Area Occupied by Monarch Colonies at Overwintering Sites in Mexico, p. 23
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  - Monarch Recovery Garden Visioning Worksheet, p.28
  - Habitat Team Planning Worksheet, p. 31
  - Eco-Action Plan, A-1
  - Monarch Larvae Monitoring Project, MLMP documents, B-1

When working with your students to create monarch habitat, please refer to the introduction. The needs of the monarch butterfly are specific. It is critical to their preservation to create and maintain a healthy sustainable habitat using a diversity of native species that will meet their unique needs.

Go to, http://pollinator.org/guides or download the app for Android or iOS, titled BeeSmart® Pollinator Gardner and find your eco-region for a list of native pollinator plants. Search the list for milkweed and nectar plants and ensure they are incorporated into the school's garden(s).

SPONSORED BY:
LEGO Community Fund U.S.

GREEN STEM PROJECT DESIGN

PROJECT NAME: Monarch Mission: Empowering Students to Improve Monarch Populations through the creation of a Monarch Recovery Garden(s)		**DURATION:** 7-10 class and field investigation hours + building the recovery garden
SUBJECT/CLASS: Science	**TEACHER(S):**	**GRADE LEVEL(S):** 9-12
OTHER CORE OR ELECTIVE CLASSES TO BE INCLUDED, IF ANY: Reading/ELA, Computer Science, Engineering, and/or Environmental Clubs		

LEARNING STANDARDS:

Biology Knowledge and Skills
1A and B | 2E-H | 3A, D and E | 12A-D and F

Environmental Systems Knowledge and Skills
1A and B | 2E-K | 3A, D and E | 4E, G and H | 5E | 8A and B | 9A-C and E and F

LEARNING OUTCOMES:
Students will:

- Use a variety of primary and secondary sources, from peer-reviewed media.
- Construct graphs and other visuals to represent the present state of monarch butterfly populations.
- Propose solutions based on qualitative and quantitative evidence for the decline in migrating monarch butterfly populations.
- Conduct field investigations using the Monarch Larvae Monitoring Project, MLMP.
- Compose and adopt a vision statement.
- Use technological applications to show simulations of how your solutions will improve habitat and increase the number of migrating monarch sightings.
- Use the engineering design process to evaluate, create and construct a healthy, native and sustainable Monarch Recovery Garden.
- Develop and execute a plan to engage the community in on-going monarch recovery work.

21ST CENTURY COMPETENCIES (Model these skills. What will you need to teach and/or assess?)				
	collaboration	X	creativity and innovation	X
	communication	X	other	
	critical thinking	X		

<table>
<tr><td>PROJECT SUMMARY
(include student role, issue, problem/challenge, action to be taken, and purpose/beneficiary)</td><td colspan="2">Students will take on the role of citizen scientists. They will work together to improve monarch butterfly habitat at school and in locations within the community.

Along with their monarch monitoring, maintenance of their monarch habitat and outreach, students will participate in the Monarch Larva Monitoring Project that focuses on the health of the monarch butterfly during this life cycle stage through careful identification and observation.

Students' goals are to inform and engage the community about the plight and solutions related to the monarch butterfly and design a monarch habitat that can be used to study the monarch, serving as a teaching and learning resource, to conduct citizen science around the monarch butterfly and to serve as a community resource; a model example of native and sustainable monarch habitat.</td></tr>
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How can we, as citizen scientists:
Design a monarch habitat that can be used to conduct monarch larva and adult monarch monitoring investigations?
Inform the school and greater community about the important role the monarch butterfly plays in an ecosystem and what its decline means to overall ecosystem health?
Build an application that all members of the community can contribute to and is specific to our location and will share qualitative data over time?
Encourage the community to build monarch habitat throughout the city?</td></tr>
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GREEN STEM PROJECT DESIGN

PRODUCTS	**Individual:** science notebook, , graphic organizers, research questions, research summaries that include graphical representations of collected data, self and group reflections
	Team: research symposium, infographic, write a blog and use social media and school media to share meaningful work, community engagement days (planning, building, maintaining, informing, etc.), and summary containing next steps and new inquiry questions
PUBLIC AUDIENCE (experts, audiences, or product users students will engage with during/at end of project)	Students should plan to present to the: (this is only an example – have students decide who they need on their side) • City Council: As the result of their research, data collection, interviews, discussions, etc., what do students want the city council to consider or do? • School Board: As the result of their research, data collection, interviews, discussions, etc., what do students want the school board to consider or do? • Community Development and Planning Department of the city of residence: As the result of their research, data collection, interviews, discussions, etc., what do students want the department to consider or do? • Community leaders who are passionate about conservation, monarchs, education, STEM – can this person advocate for you and help with outreach strategies.
RESOURCES NEEDED	**Experts and/or Community Resources:** Who are the people in the community who can help teams answer questions, design, build and volunteer? Who are the groups with expertise in the areas teams need to learn about?
	Space: Besides the classroom what other space is needed to carry out student learning? Science/Computer Lab, outdoor space for pollinator gardens, place to hold presentations, field trips, etc.
	Materials: What materials are needed for each phase of student learning? What do students need to be successful?

REFLECTION METHODS (individual, team, and/or whole class)	journal/notebooking		focus group	
	whole-class discussion		think/pair/share	
	survey		Other	

NOTES:

The Monarch Mission

ACTIVITIES

Activity 1 – Entry Event
Activity 2 – Driving Questions
Activity 3 – Habitat Basics
Activity 4 – The Monarch Butterfly and Its Habitat Needs
Activity 5 – Soil and Water Health
Activity 6 – Visioning, Action Planning and Habitat Team Roles

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Activity 1 – Entry Event

WHAT TO DO

1. Watch: The Art of Movement – Monarch Migration, 3:03 http://www.cnn.com/video/data/2.0/video/world/2015/02/23/spc-art-of-movement-monarch-butterflies.cnn.html
2. Share graph with students, Total Area Occupied by Monarch Colonies at Overwintering Sites in Mexico.
3. Based on the data in the graph, ask pairs or small groups of students to come up with three possible reasons for the decline, three possible solutions and three investigable questions (questions whose results can be measured). Have students record their responses in their science notebook.
4. Have a class discussion around reasons, solutions and measurable investigations. Make a class chart and record the top five for each category agreed upon by the students. Ask students to record this final chart in their science notebook.

REASONS	SOULUTIONS	MEASURABLE INVESTIGATIONS

Activity 2 – Driving Questions

WHAT TO DO

1. Students will modify the driving questions below, customizing to meet their ideas and goals for the habitat. Present the driving questions to the class. There are three components to creating driving questions. Are students able to identify them from the sentence structure?

FRAMING WORDS	PERSON OR CAREER	ACTION OR CHALLENGE	AUDIENCE OR PURPOSE
How can…	I we	build… create… make…	real-world problem. Tto conserve native monarch habitat.
How do…	We as, [Roles] [Occupations]	design… plan…	for a public audience. For the city council.
Should…	[Town] [City] [County]	solve…	for a district.
Could…	[State] [Nation]	write…	for a community.
What…	[Community] [Organization]	propose… decide…	for an online audience.

Driving Questions, www.bie.org

- How can we, as citizen scientists, inform the community about the importance of the monarch butterfly, in an effort to increase monarch populations?
- How can we, as citizen scientist, design a monarch habitat to be used to conduct monarch investigations, leading to an increase in our local monarch populations?
- How can we, as conservationists, encourage the community to build monarch habitat throughout the city, in an effort to increase monarch populations?

2. Go outside for 5-10 minutes. Ask students to think about the Driving Questions presented in class and just make observations about the natural world around them.
3. Gather outside in a central location, such as the outdoor learning area, a garden, etc. Based on Activity 1 responses and the student's recent walk around the school grounds, are their changes students want to make to the driving questions? If yes, make changes and post the driving questions for all students to see. Also encourage students to make note of these driving questions in their science notebook.
4. Have students work in small groups to develop how each driving question will be measured. What will success look like? Come together as a class to finalize the measurements and post for all students to see.

Activity 3 – Habitat Basics

WHAT TO DO

1. What do wildlife need in order to survive? Have this discussion with students (This should be a review from elementary school). Here are a few examples, but you are welcome to supply examples based on wildlife in and around your location.
   - **Cedar Waxwing:** This sleek, brown, black-masked bird eats berries starting in late summer, and insects during the warmer months. They need a clean water sources, such as puddles that return with regularity, ponds, etc. Cedar Waxwings prefer the edge of a forest, and so find cover in thick undergrowth or amongst trees that grow along the edge. They often make their nests on the branches of cedar or maple trees.
   - **Fireflies:** For food, fireflies eat soft-bodied insects, snails, slugs and mites (only in the larval stage; many don't eat anything in the adult stage). Water is from the food they eat, rain puddles, dew or damp soil. Adult fireflies find cover in think grass, under leaves. They lay eggs in rotting wood or damp debris on the ground, and larvae spend the winter just under the soil (this could be considered a place to raise young).
2. Provide students with the handout, ***Habitat Hunt***. You may either provide students with an animal species or allow them to choose. For this exercise we are just talking about wildlife in general and not specific to any one species or type of species. Provide your expectations for being outside including how much time they have to complete the hunt and the boundaries in which to stay.
   - Optional: Divide students into groups of 2-4 and provide each group with a set of 4 utility flags. Each group would receive a different color.

Engineering Option: Give students the opportunity to design a habitat for the animal species they used for the ***Habitat Hunt*** activity. Their design should include the four habitat elements and maintain the characteristics of the ecosystem the species is found. Students should also refer to the ***V Model of Systems Engineering*** as they go through the design process.

Student Questions: Do you need to research species habitat in order to build a habitat? Will you be able to explain your species habitat needs and why it could or could not be found in and around your location?

Activity 4 – The Monarch Butterfly and Its Habitat Needs

WHAT TO DO

1. Just like the species in Habitat Hunt, the monarch butterfly requires food, water, cover and places to raise young. Go out into the schoolyard (into the gardens if you have any) and ask students to observe the insect populations, keeping in mind the four elements of habitat. In their science notebooks have them answer this question as best as they can and then Think-Pair- Share with a nearby partner.
2. Back inside, ask students to pair up. It's time for some friendly competition. Refer to the green box to the right for the competition prompts.

C1. What are the specific habitat needs of the monarch butterfly?

C2. Draw the life cycle of the monarch butterfly and describe the differences between the four generations.

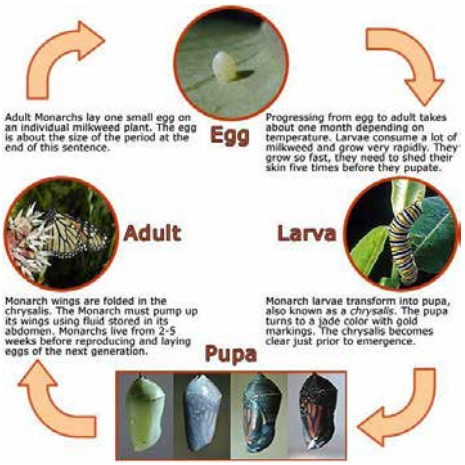
COMPETITION 1: Using their phones, tablets, laptop, etc. you want students to provide you with the four specific habitat needs for monarchs. What would allow them to successfully thrive at the school? No general answers, specifics.

If students need some search help provide them these keywords:
MJV | NWF | USFWS | Monarch Lab at UM | monarch butterfly | habitat conservation

MJV: Monarch Joint Venture
NWF: National Wildlife Federation
USFWS: US Fish and Wildlife Service

What you want students to find through their research –

Food: Milkweed and nectar plants (must have both) (native plants = extra points)
Water: Moist ground, areas or rocks where puddling of small amounts of water can collect.
Cover: trees or bushes
Places to Raise Young: milkweed (native milkweed = extra points)



COMPETITION 2: Sketch and label the life cycle of a monarch butterfly and describe the differences found between the generations as they migrate north and south.

Activity 5 – Soil and Water Health

PREPARATION

Whether you and your students will be designing, building, and maintaining your first Monarch Recovery Garden, have one on the school grounds already or are preparing to design and build somewhere in the community it is important students understand the health of the soil and water play a vital role in the success of a Monarch Recovery Garden. Test schoolyard soil at least three different areas. Test water from the sources that will be used, i.e. outside facets and/or rain barrels, etc.

If you are a GLOBE school, conduct the following protocols and submit your data by logging in to your account at www.GLOBE.gov.

- Soil pH, temperature, infiltration and fertility
- Water pH, temperature, alkalinity, conductivity and salinity

If you are not a GLOBE school, LaMotte soil and water testing kits are available for purchase through many of the large K12 science supply vendors.

Non GLOBE schools will collect soil and water temperature at three sites and record the *Taking the Earth's Vitals* data sheet.

WHAT TO DO

1. Divide your students into four groups and ask each group to elect task managers, see *Science-Based Cooperative Group Task Cards*. Grouping option:
   - Students work in one of three groups, either meteorologists, soil technicians or geologists and environmental quality technicians.
   - Each group will be responsible for one of three "vital signs" on the data sheet.
2. Distribute materials to the *Accountability Manager* (student in change of materials pick-up, safe and appropriate use and return of materials).
3. Each specialty group will answer the questions to the right, based on the data they have collected.
4. After each specialty group collects their data and answers the questions above, they will come back together as a group to discuss and analyze their findings as well as their answers to the questions.
5. One of the *Communications Managers* will be selected by the group to present a summary of their findings and explain how their data can support monarch butterfly conservation.

Q1. Over time, if we continue collecting data, what conclusions might we be able to draw related to wildlife and habitat conservation?

Q2. How can this type of data help efforts to increase monarch populations?

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Engineering Option: Soils perform vital functions. They can support plant life, regulate water and solute flow, filter, buffer, decompose and detoxify. Soils can story and cycle nutrients and provide support for structures. Soils can be engineered to serve a specific purpose. Provide students with a scenario, such as to engineer a soil that will support and outdoor learning center without harming the soil composition of the surrounding soils and that will be used for monarch recovery gardens. Students should refer to the *V Model of Systems Engineering* during the design process.

Student Questions: How are soils different (physical properties)? How does a soil's properties impact how they are used? What soils or combination of soils will help me solve this problem?

Activity 6 – Visioning, Action Planning and Habitat Team Roles

VISIONING STATEMENT

The first task of the Habitat Team is to define and set clear and attainable project goals. You can use an Eco-Schools Action Planning worksheet found on page 18 to support your planning. The construction of a Monarch Recovery Garden may seem daunting, but it won't be overwhelming if it's developed in phases. First, establish long-term goals; next, identify readily accomplished short-term goals to help move towards the larger vision. Fundraising, solicitation of materials, curriculum integration, etc. are all ongoing projects. With each phase of habitat development, important lessons are learned.

The overall long-term goal can be written as a vision statement. What does the school envision for this garden space? Take the time to develop this vision with as many different groups of people as possible, including students, teachers, administrators, parents, and community volunteers. This process will build support, enthusiasm, and ownership for the project. Keep in mind that the vision is not set in stone; it will probably need to be updated as the project progresses.

Use the Monarch Recovery Garden Visioning Worksheet to get the student's thoughts down on paper and to sketch out short and long-term goals as well as an overall vision statement. The worksheet, can be completed by older students and the Habitat Team. Younger students' thoughts and desires regarding the garden can be captured through brainstorming activities, discussions and drawings.

THE HABITAT TEAM

No one should undertake a Monarch Recovery Garden alone. Generally, **the more people involved and informed about the project, the more sustainable the project will be over time.** Of course, the greater the number of people actively engaged, the greater the numbers who will learn and reap the education, community and conservation benefits.

A dedicated team is necessary to tackle the planning, fundraising, publicizing, building, and planting involved in the development of a Monarch Recovery Garden. This conservation team is the working committee that acts as the driving force behind the development of the garden site. The habitat team is composed of members of the Eco-Action Team and should include teachers, students, parents,

maintenance personnel, administrators, and community volunteers. The diverse skills and support each member of the team brings to the project are invaluable to the habitats overall conception, construction, and maintenance. This team will have the important task of determining how to include students in the creation and implementation of the project. Members of the team will consider curriculum alignment with the goal of finding ways of using the Monarch Recovery Garden to assist in meeting the school's curriculum objectives.

Most teams find that regular meetings, clear delegation of responsibilities, and frequent communication both between team members, the Eco-Action Team and the wider school community, lead to effective progress.

THE HABITAT ROLES

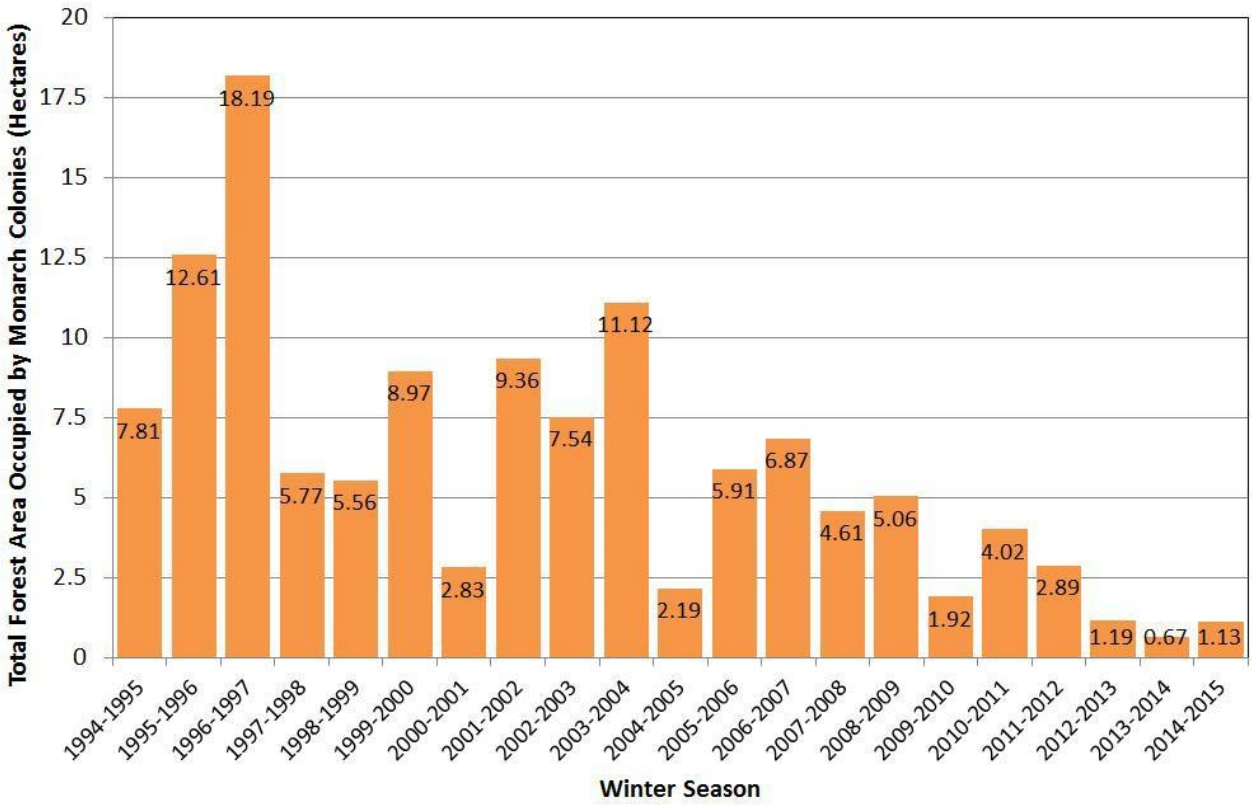
TEAM ROLE	IDEAL QUALITIES	RESPONSIBILITIES
Habitat Team Leader	Effective organizer, able to delegate responsibilities and communicate effectively	Oversee development of the habitat plan and coordinate other team members.
Budget Coordinator	Well organized; comfortable using online budgeting programs or software	Maintain receipts: keeping records of purchases, donations, etc. Research possible grants and sources of funding and donations.
Curriculum Coordinators	Leadership skills, knowledge of state based knowledge and skills required by state. At least on educator should be on this team, ideally one from each grade	Assist faculty to make effective use of the Monarch Recovery Garden site to meet academic standards. Compile resources and activities for staff use.
Historian	Creative. Research and explanation skills	Help with student research into historical uses of the school ground. Document project progress using the Eco-Schools Dashboard, the school website and by using a free online scrapbook or chronicling site.
Maintenance	Responsible; knowledgeable about the native plants and watering restrictions and needs	Coordinate on-going maintenance of site. Oversee delegation of tasks. Use online scheduler in order to maintain a regular schedule for the garden (Signup Genius).
Volunteer Coordinator	Good communication skills	Promotes volunteer involvement. Works with maintenance team to provide volunteers on a consistent basis. Send thank you notes to all who contribute.
Communications and Marketing	Writing and social media skills	Coordinates publicity and updates to local media and National Wildlife Federation's Eco- Schools USA. Contribute to the school newsletter. Report to the PTA and school staff. Provide continuous updates to the community on the project progress.
Student Liaison	Leadership skills and positive	Ensure ongoing involvement of student body.

1. Read the *Habitat Team Roles* above. Using the Habitat Team Planning Worksheet and work in groups or as a class to start making suggestions. Think about the skills of your peers and adults you know at school and in the community.
2. Make a master list of team members that can be kept and/or displayed for easy and quick access.

ACTION PLANNING

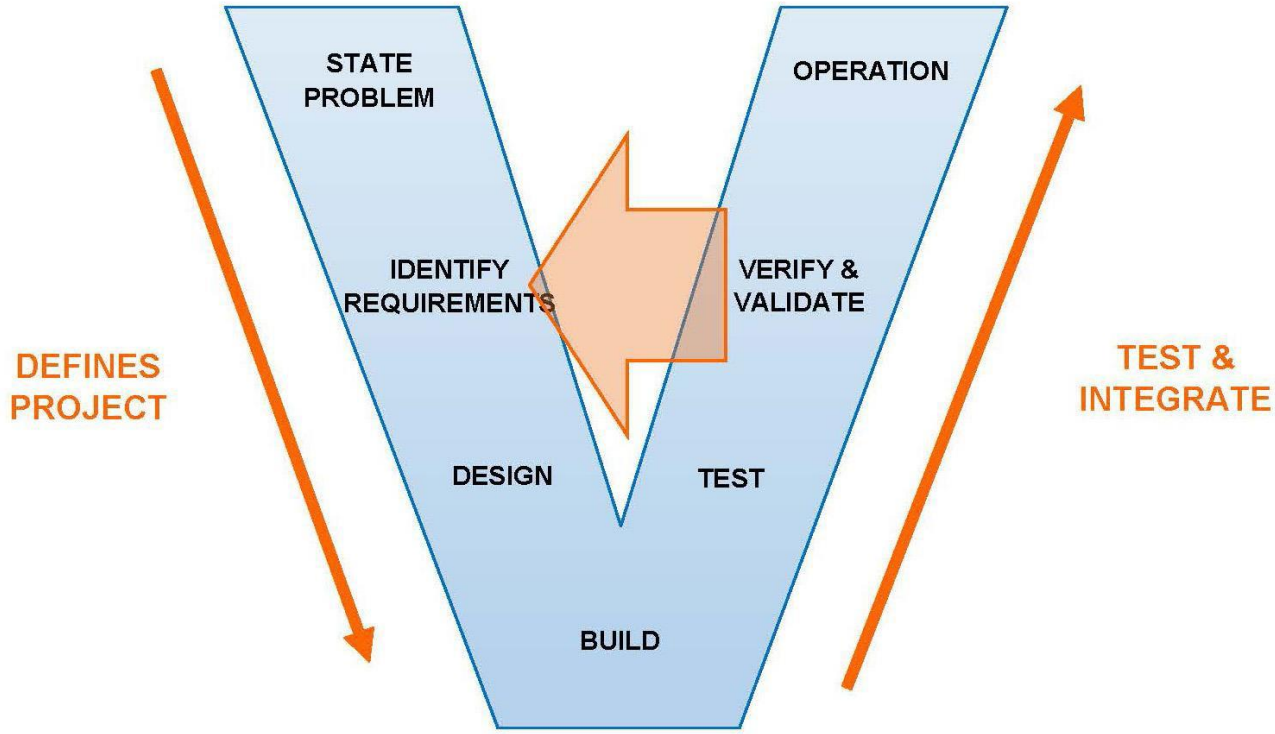
1. Gather results from the *Habitat Hunt* and *Taking Earth's Vitals*. Organize and summarize the findings in a way that will plan for the Monarch Recovery Garden.
2. Decide how you will measure success in achieving your objectives. For example, will you measure monarch larvae, number of monarch observations, numbers tagged, a combination, etc.
3. Negotiate a time frame for each action item. Is the target action to be achieved in the short, medium or long term?
4. Decide who is to be responsible for each action. Students should take as much responsibility as possible.
5. Include a section for monitoring any financial costs you may incur or save based on your activities.
6. **Make your *Eco-Action Plan* accessible** to the whole school community through your website or post it in a visible location, such as the school office or library. For examples of *Eco-Action Plans*, check out the sample plan included as part of each Eco-Schools USA Pathway. A blank Action Plan can be found at the end of the lesson.

Total Area Occupied by Monarch Colonies At Overwintering Sites in Mexico
1994/1995 - 2014/2015



data from 1994-2003 were collected by personnel of the Monarch Butterfly Biosphere Reserve (MBBR) of the National Commission of Protected Natural Areas (CONANP) in Mexico. Data from 2004-2015 were collected by the WWF-Telcel Alliance, in coordination with the Directorate of the MBBR. 2000-01 population number as reported by Garcia-Serrano et. al (The Monarch Butterfly : Biology and Conservation, 2004)

V MODEL OF SYSTEMS ENGINEERING



HABITAT HUNT

DATA SHEET

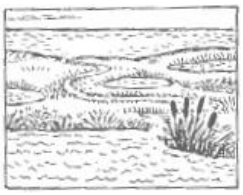
DIRECTIONS: You are a_____, and in order to survive you need food, water, cover and places to raise your young. Take a look around you. **Record the following information** and decide whether or not you will stay and set up home here.

Create a graph in your science notebook to determine the number of food and water sources, and areas of cover and places to raise young.

Once you have collected your data **answer the following questions** in your science notebook.

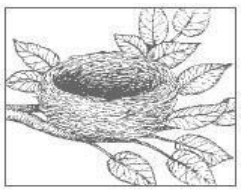
1. Will you stay and set up home here? Why or why not?
2. What other habitat elements would you like to see here?

Food Source



Water Source

Cover



Places to Raise Young

ACTION PLANNING

PRINCIPAL INVESTIGATOR • Reads all directions aloud for the group • Keeps the group on task • May clarify directions with other principal investigators or the project manager (teacher). • Comes up with new questions based on current data	LAB TECHNICIAN • Use equipment and materials safely and appropriately • Take accurate measurements • Validates measurements
ACCOUNTABILITY MANAGER • Picks up materials • Holds lab technicians responsible for safety and appropriate use of materials • Returns equipment and appropriately disposes of perishable materials	COMMUNICATIONS MANAGER • Records measurements • Keeps the questions and hypotheses fresh in the minds of the group. What are we trying to measure? Why? What's the purpose? • Summarize data and conclusions. • Presents findings to the class on behalf of the team.

TAKING EARTH'S VITAL SIGNS

WHAT TO DO: Use the appropriate thermometer to check the air, water and soil temperatures. Be gentle when pushing the thermometer into soils, sand or gravel.

SITE NAME: _____

VITAL SIGN: WEATHER

GPS COORDINATES	TIME	CLOUD COVER	TEMPERATURE	PRECIPITATION IN CENTIMETERS (cm)
N: **W:** **Feet:** **Meters:**			**F:** **C:**	

Coordinates: Provide North and West along with elevation in meters and feet

Time: A.M. or P.M. **Cloud Cover:** Full Sun, Partly Cloudy, Mostly Cloudy, Cloudy

Temperature: Provide degrees Fahrenheit and Celsius

VITAL SIGN: SOIL

TYPE OF SOIL (explain)	SOIL TEMPERATURE	SOIL pH
	5cm depth: **10cm depth:**	

Describe the soil using your senses, what does it feel like, smell like, look like? DO NOT TASTE SOIL.

VITAL SIGN: WATER

WATER SOURCE	WATER TEMPERATURE	WATER pH	NITRATES
	F: **C:**		

Where does the water source your testing originate?

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APPENDIX – RESOURCES

Who's Who in the Study of the Monarch Butterfly

Professor Dr. Lincoln Brower was an entomologist and research professor at Sweetbriar College in Virginia, who passed away in 2018 at the age of 86. He spent 6 decades studying the remarkable migratory lifecycle of the monarch butterfly and urging action to protect it. Dr. Brower's contributions include research on the overwintering, migration and conservation biology of the monarch butterfly. https://texasbutterflyranch.com/2015/02/16/q-a-dr-lincoln-brower-talks-ethics-endangered-species-milkweed-and-monarchs/

Chip Taylor, an insect ecologist, is Professor of Ecology and Evolutionary Biology at the University of Kansas and the Founder and Director of Monarch Watch, an outreach program focused on education, research and conservation relative to monarch butterflies. Watch this short documentary, **Saving the Migration** https://www.youtube.com/watch?v=maM2gl30cJc to learn more about his work and the plight of the Monarch.

Dr. Karen Oberhauser currently serves as the Director of the University of Wisconsin – Madison Arboretum. She also serves as an adjunct Professor, Department of Fisheries, Wildlife and Conservation Biology at the University of Minnesota. Previously, she worked as a director at the Monarch Lab at the University of Minnesota. Karen has been studying monarch butterflies since 1984. She has worked with teachers and pre-college students in Minnesota and throughout the United States using monarchs to teach about biology, conservation and the process of science. https://monarchjointventure.org/about-us/leadership-and-staff

Catalina Aguado Trail was a citizen scientist from the state of Michoacán in México, and part of the original team who discovered the monarch's over-wintering grounds. Under the guidance of Dr. Urquhart, Catalina and her husband Ken Brugger spent two years searching the mountains in Central México for the monarch's winter destination. Their discovery graced the cover of the National Geographic magazine in August 1976. http://texasbutterflyranch.com/2012/07/10/founder-of-the-monarch-butterfly-roosting-sites-in-mexico-lives-a-quiet-life-in-austin-texas

Xerces Society. The Xerces Society is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. For over 50 years, the Society has been at the forefront of invertebrate protection worldwide, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs. View or download their comprehensive report on the Conservation and Ecology of the Monarch Butterfly in the United States. http://www.xerces.org

U.S. Fish and Wildlife Service works to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. **USFWS** has

committed to work with its partners, including National Wildlife Federation to restore and enhance more than 200,000 acres of habit for monarch whole supporting over 750 schoolyard habitats and pollinator gardens. https://www.fws.gov/savethemonarch

National Wildlife Federation's Butterfly Heroes campaign is part of NWF's Garden for Wildlife program. Butterfly Heroes seeks to bring awareness to the declining population and connect gardeners, kids and families alike to help the monarch and other pollinators. To take the pledge and create new habitat for monarch butterflies submit your photo pledge and become a butterfly hero. https://www.nwf.org/butterflyheroes

Million Pollinators Garden Challenge: A campaign to register a million public and private gardens and landscapes to support pollinators. www.millionpollinatorgardens.org

Monarch Joint Venture. The **Monarch Joint Venture** (MJV) is a partnership of federal and state agencies, non-governmental organizations, and academic programs that are working together to support and coordinate efforts to protect the monarch migration across the lower 48 United States. The MJV is committed to a science-based approach to monarch conservation work, guided by the North American Monarch Conservation Plan (2008). http:/monarchjointventure.org/about-us

Resources for Developing your Monarch Garden

National Wildlife Federation How-To Guide for Schoolyard Habitats
Site selection is key to any successful gardening project. For a great class activity to help you choose the right site while engaging your students in meaningful science and math applications refer to the Site Inventory Activity in Part IV of the National Wildlife Federation How-To Guide for Schoolyard Habitats. https://www.nwf.org/schoolyard

Monarch Joint Venture Schoolyard Butterfly Gardens
For tips on designing and installing your garden refer to the Monarch Joint Venture Schoolyard Butterfly Gardens Fact sheet. You can download this fact sheet and many more wonderful resources from Monarch Joint Venture. http://monarchjointventure.org

Curriculum Resources

Monarchs and More (Grades K-2, 3-6 and Middle School)
Free lessons from the **Monarch Lab** at the University of Minnesota. The comprehensive curriculum guide includes lessons on monarch behavior, life cycle, a focus on features, adaptations, and migration. Full curriculum is also available for purchase at their Monarch Store. http://monarchlab.org/education-and-gardening/curricula

U.S. Fish and Wildlife Service
The U.S. Fish and Wildlife Service and Protección de la Fauna Mexicana A.C. (Profauna A.C.), a Mexican non-governmental organization, developed ***The Monarch Butterfly Manual, Royal Mail: A Manual for the Environmental Educator*.** This manual was developed for grades Pre-K through 12 and offers activities that promote conservation of the Monarch Butterfly. http://www.fs.fed.us/wildflowers/pollinators/Monarch_Butterfly/documents/royal_mail/monarch_pu b.pdf

Journey North
Categorized by season, and then by topics such as Citizen Science, Background, Conservation, migration, life cycle, video clips and food, **Journey North's** educational resources allows your study of the Monarch Butterfly to be relevant to the season you are in. (http://www.learner.org/jnorth/tm/monarch/indexSpring.html)

- Migration Rate Activities: https://journeynorth.org/tm/monarch/MigrationRateMathIntro.html

Journey North's Symbolic Migration
A terrific way to engage your students and help create cross-cultural connections is through Journey **North's Symbolic Migration**. Each year over 60,000 students in the United States and Canada create symbolic paper butterflies and send to them to Mexico for the winter. The children who live in Mexico beside the monarch's winter sanctuaries protect the butterflies and send them north in the spring. https://journeynorth.org/symbolic-migration

Rearing Monarchs in the Classroom
Rearing monarchs in the classroom can be a captivating and fun educational experience that can encourage conservation actions, but in order to avoid the spread of disease and harming the monarchs, it needs to be done responsibly. **Monarch Joint Venture** has a great fact sheet on rearing Monarchs responsibly.
http://monarchjointventure.org/images/uploads/documents/Monarch_Rearing_Instructions.pdf

Monarch Watch
Practical tips for rearing Monarchs in the classroom. http://monarchwatch.org/rear

Citizen Science Programs

Citizen science involves everyday people - just like you and your students - who volunteer to help scientists with their research. Using Citizen Science in your study of the monarch butterfly is a meaningful way to involve students in data collection. Students realize that their observations are contributing to real research that is being used to help scientists better understand the behavior, biology and migration of the monarch butterfly.

Journey North: Help scientists learn more about monarchs. Track the monarch migration each fall and spring. Record your observations on real time migration maps.

- Download the Journey North app for Android or iOS from Annenberg Learner.
- Live monarch updates throughout migration: https://maps.journeynorth.org/maps

Monarch Larva Monitoring Project: The Monarch Larva Monitoring Project, MLMP was developed by researchers at the University of Minnesota to collect long-term data on larval monarch populations and milkweed habitat. This citizen science program is run by Monarch Joint Venture. https://monarchjointventure.org/our-work/monarch-larva-monitoring-project-online-training

Monarch Watch – Migration and Tagging: Monarch Watch engages in research on monarch migration biology and monarch population dynamics to better understand how to conserve the monarch migration.

Funding your Garden

Funding your monarch garden can be a great way to connect to your larger school community and spread the word about the work you are doing on your campus to help the monarch butterfly while providing innovative learning opportunities for your students. Below are just a few organizations that provide funding for school gardens.

Monarch Watch – grants for milkweed plugs. https://monarchwatch.org/bring-back-the-monarchs/milkweed/free-milkweeds-for-restoration-projects/

Native Plant Societies - https://ahsgardening.org/gardening-resources/societies-clubs-organizations/native-plant-societies/

Kids Gardening.org - Youth Gardening Grants http://grants.kidsgardening.org

Keep America Beautiful - Check with your local Keep America Beautiful to see what grants they have to offer. https://www.kab.org/resources/beautify-communities

Lady Bird Johnson Wildflower Center - LBJWC has partnered with Native American Seed to provide **seed grants to schools in Texas.** http://www.wildflower.org/wildflowers

Whole Kids Foundation - School Garden Program - https://www.wholekidsfoundation.org/programs/school-gardens-grant

Annies - Grants for Gardens – https://www.annies.com/grants-for-gardens/

NSTA Position Statement

Environmental Education

Introduction

NSTA strongly supports environmental education as a way to instill environmental literacy in our nation's pre-K–16 students. It should be a part of the school curriculum because student knowledge of environmental concepts establishes a foundation for their future understandings and actions as citizens. Central to environmental literacy is the ability of students to master critical-thinking skills that will prepare them to evaluate issues and make informed decisions regarding stewardship of the planet. The environment also offers a relevant context for the learning and integration of core content knowledge, making it an essential component of a comprehensive science education program.

Declarations

- Environmental education programs should foster observation, investigation, experimentation, and innovation. Programs should be developed with grade-appropriate materials and should use a range of hands-on, minds-on instructional strategies that encourage active learning.

- Environmental education programs and curricula should address student outcomes as specified in the National Science Education Standards, be grounded in sound research, and reflect the most current information and understandings in the field.

- All learners are expected to achieve environmental literacy and an appreciation for and knowledge of a range of environmental issues, perspectives, and positions.

- All learners should be taught *how* to think through an issue using critical-thinking skills, while avoiding instructor or media bias regarding *what* to think about the issue.

- Environmental education should provide interdisciplinary, multicultural, and multi-perspective viewpoints to promote awareness and understanding of global environmental issues, potential solutions, and ways to prevent emerging environmental crises.

- Developers of environmental education programs should strive to present a balance of environmental, economic, and social perspectives.

- Appropriate technologies should be used to enhance environmental education learning experiences and investigations.

- Environmental education programs and activities should be fostered through both formal and informal learning experiences.

- Collaborations among schools, museums, zoos, aquaria, nature centers, government agencies, associations, foundations, and private industry should be encouraged to broaden the availability of educational resources, engage the community, provide diverse points of view about the management of natural resources, and offer a variety of learning experiences and career education opportunities.

Adopted by the
NSTA Board of Directors
February 2003

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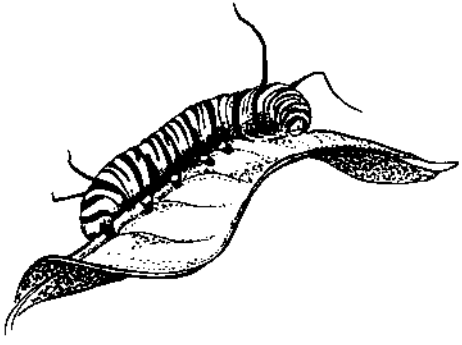
A Field Guide to Monarch Caterpillars (*Danaus plexippus)*



Karen Oberhauser and Kristen Kuda
Illustrations by Kristen Kuda

Produced with the support of the National Science Foundation. Opinions expressed are those of the authors and not necessarily those of the Foundation.

INTRODUCTION

This guide will aid in recognizing eggs and distinguishing larval (caterpillar) instars of monarch butterflies (*Danaus plexippus*) in the field. We assume that readers have some familiarity with monarch larvae already, and will recognize their bold yellow, white and black stripes on or near their host plants.

Several clues will help you find monarch eggs and larvae. Look for them on plants in the genus *Asclepias* (milkweeds), or on the closely-related *Cynanchum laeve* (Sand Vine) found in the central U.S. Females usually lay eggs on the underside of young milkweed plants, and this is often a productive location to search. A characteristic sign of a new larva is a minute hole in the middle of a leaf, while older larvae tend to eat on the margins of leaves. Learning to recognize "monarch-eaten" leaves will increase your success at finding larvae. They can also be located by the presence of their frass, or fecal matter. If you see adult monarchs (butterflies) in an area with milkweed, there is a good chance you'll find eggs or larvae as well.

Before going into the field to look at monarchs, we recommend reading the anatomy, molting, and distinguishing instars sections of this field guide. After these sections, there are detailed descriptions and drawings of eggs and each of the five instars.

Happy monarch hunting!

ANATOMY

The diagram below shows a generic butterfly larva, with three parts to its body—the *head*, *thorax* and *abdomen*. The thorax and abdomen each have several segments, which are numbered in the diagram. Many of these segments contain small holes called *spiracles*. The spiracles are connected to a network of airtubes called *tracheae*, which carry oxygen throughout the larva's body. Monarch larvae have two sets of *tentacles* or *filaments* (front and back); these are not antennae, and are not found on all butterfly larvae. They function as sense organs. The thoracic segments each have a pair of jointed *true legs*, and there are five pairs of false legs, or *prolegs*, on the abdomen.

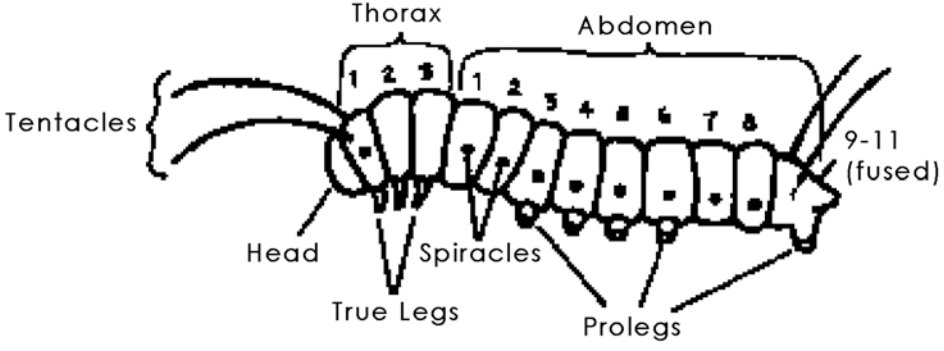


Figure 1. Larva anatomy

The head has a pair of short *antennae*, mouthparts, and six pairs of very simple eyes, called *ocelli*. The *spinneret* produces silk that small larvae use when they drop off a leaf and hang suspended in the air. Larvae in all instars use the silk to anchor themselves during molting, and fifth instar larvae make a "silk button" to which the pupa is attached. The *maxillary palps* are sensory, and also help direct food into the jaws. These features can be seen with the aid of a hand lens, but are difficult to see with the naked eye.

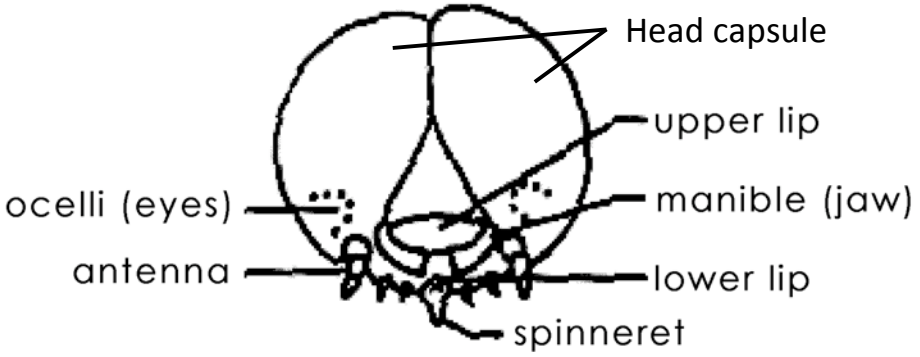


Figure 2. Butterfly Larva head

MOLTING

Monarchs have five larval *instars*, or stages between shedding their *cuticle* (outer layer of skin). The cuticle is made of long protein chains and chitin. It is rigid and hard, and serves to support and protect monarchs and other arthropods. It also restricts water loss. However, the cuticle limits growth and must thus be replaced periodically. The process of replacing the old cuticle is called *molting*. Molting is controlled by a hormone called *ecdysone* produced in glands in the thorax. It actually involves a whole sequence of events, beginning with the separation of the old cuticle from the epidermal (skin) cells that underlie it, a process called *apolysis*, and ending with the shedding of the old cuticle, a process called *ecdysis*. The old cuticle is partially broken down by enzymes, and some of its constituents recycled. When it is first secreted, the new cuticle is protected from these enzymes by a layer of wax. The new cuticle is soft and flexible, thus permitting expansion before it undergoes *sclerotization*, or hardening.

Table 1. Sequence of events in molting

1. apolysis (separation of old cuticle)
2. new cuticle production
3. wax secretion (protects new cuticle)
4. activation of molting enzymes
5. ecdysis (shedding of old cuticle)
6. expansion of the new cuticle
7. sclerotization (hardening of new cuticle)

Monarch larvae remain very still during all the steps of molting, the older instars often move off the milkweed at this time. The first thing that you will notice, besides their motionlessness, is the separation of the part of the cuticle that covers their head from the rest of the cuticle. This *head capsule* is the first part of the old cuticle to be shed, and the larva then crawls out of the rest of the skin. The shed skin is called the *exuvia.* After molting, monarch larvae (and the larvae of many other insects) usually eat the exuvia, thus recycling useful nutrients that it still contains.

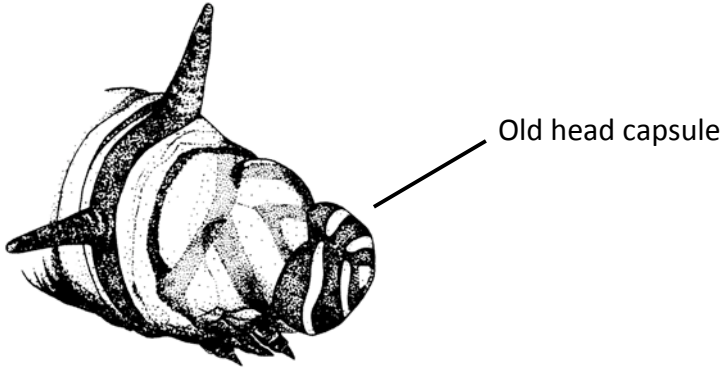


Figure 3. Third instar larva about to shed its head capsule.

DISTINGUISHING INSTARS

While most of the cuticle is quite hard, larvae still grow quite a bit within each instar. This is possible because of the flexibility of the new cuticle, and because parts of the cuticle contain a rubber-like protein which permits it to stretch. Therefore, distinguishing instars by size is not very accurate. Look at the drawings of a first instar larva, all drawn to the same scale, to see how much it changed in size within an instar!

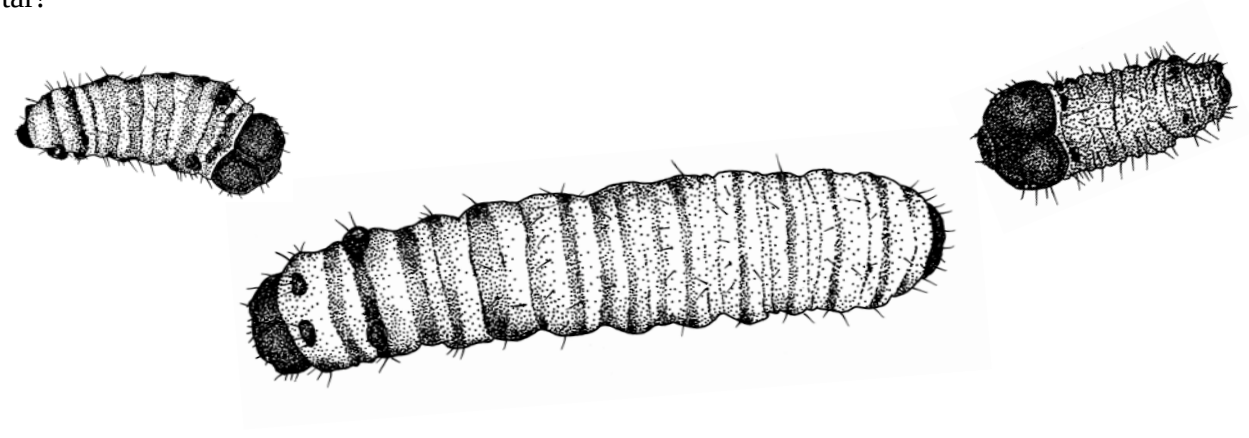


Figure 4. Three drawings of the same first instar larva over a period of 2 days (x25).

The easiest way to distinguish larval instars is by head capsule and tentacle size, since these do not grow during an instar. For example, the front tentacles on a fourth instar larva are about half the length of those on a fifth instar. Also, the size of the tentacles relative to the head capsule and the rest of the body increases with later instars. We have included estimates of the sizes of head capsules and tentacles for each instar in the table on the next page. However, individual monarchs vary in size just like humans do, so the larvae you find may not be exactly the sizes given.

The drawings below compare head capsule sizes in the five instars. Of course, real larvae have much smaller heads! The lines above each drawing give the actual measurement of the real heads. We measured several larvae with a calipers accurate to 0.1 mm, then took the average size, to get these measurements. Note that the head capsules increase in size by a factor of from 1.3 to 1.6 between each instar.

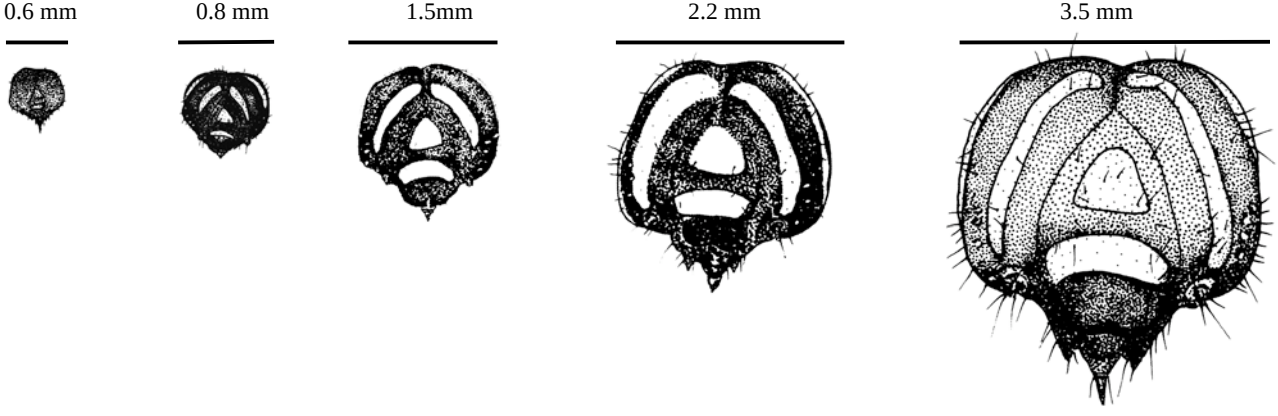


Figure 5. Head capsules, of the five larval instars (all drawn to the same scale, x12.5).

A note on measurement. We report the sizes of monarch eggs and larvae in millimeters (mm). There are 10 mm in a centimeter, so when something is 13 mm long, it is also 1.3 cm long. Sizes of body parts are most useful in distinguishing third and higher instars, since it is difficult to distinguish 0.6 from 0.8 mm (the sizes of head capsules on first and second instars) with the naked eye. It is best to use other characteristics described in the guide for the younger instars. The lines on the table below show the actual head widths and tentacle lengths for each instar. Whenever we show a drawing of a larva, we tell you how many times it has been magnified. For example, the heads shown on the previous page are 12.5 times larger than actual heads; we noted this by putting x12.5 in the figure caption.

Table 2. Comparison of head and tentacle sizes from the five instars. Lines show the actual length of these body parts, and numbers show how long the lines are (in mm). Starred spaces for the tentacles mean that these are too short to measure accurately.

	Instar				
	1	2	3	4	5
Head	(0.6)	(0.8)	(1.5)	(2.2)	(3.5)
Front tentacle	*	(0.3)	(1.7)	(5.0)	(11.0)
Back tentacle	*	*	(0.9)	(2.0)	(4.0)

EGG

Height: 1.2 mm

Width: 0.9 mm

Appearance: Monarch eggs are usually attached to the underside of young milkweed leaves. They are laid singly, and it is uncommon (though not unheard of) to find more than one on a single plant. The eggs look off-white or yellow, and are marked with a series of longitudinal ridges. The hard outer shell, or *chorion*, protects the developing larva.

Figure 6. Scanning electron microscope (SEM) image of a monarch egg

FIRST INSTAR

Body Length: 2 to 6 mm

Body Width: 0.5 to 1.5 mm

Front Tentacles: Small bumps

Back Tentacles: Barely visible

Head Capsule: 0.6 mm in diameter

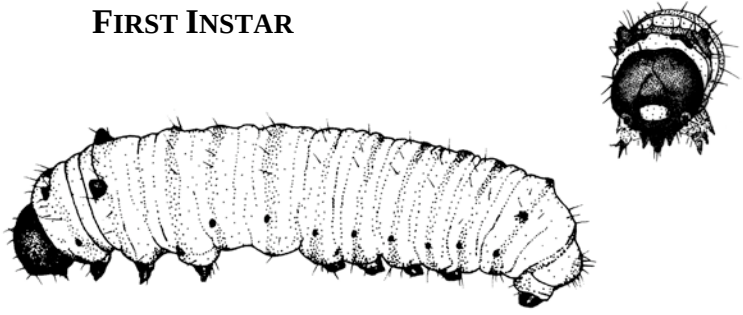


Figure 7. Body and head of first instar (x20)

Appearance: A newly-hatched monarch larva is pale green or grayish-white, shiny and almost translucent. It has no stripes or other markings. The head looks black, with lighter spots around the antennae and below the mouthparts, and may be wider than the body. There is a pair of dark triangular patches between the head and front tentacles which contain setae, or hairs. The body is covered with sparse setae. Older first instar larvae have dark stripes on a greenish background.

After hatching, the larva eats its eggshell (chorion). It then eats clusters of fine hairs on the bottom of the milkweed leaf before starting in on the leaf itself. It feeds in a circular motion, often leaving a characteristic, arc-shaped hole in the leaf. First (and second) instar larvae often respond to disturbance by dropping off the leaf on a silk thread, and hang suspended in the air.

SECOND INSTAR

Body Length: 6 mm to 9 mm

Body Width: 1 to 2 mm

Front Tentacles: 0.3 mm

Back Tentacles: Small knobs

Head Capsule: 0.8 mm diameter

Figure 8. Body and head of second instar (x12.5)

Appearance: Second instar larvae have a clear pattern of black (or dark brown), yellow and white bands, and the body no longer looks transparent and shiny. An excellent characteristic to use in distinguishing first and second instar larvae is a yellow triangle on the head and two sets of yellow bands around this central triangle. The triangular spots behind the head do not have the long setae present in the spots on the first instar larvae. The setae on the body are more abundant, and look shorter and more stubble-like than those on first instar larvae.

THIRD INSTAR

Body Length: 10 to 14 mm

Body Width: 2 to 3.5 mm

Front Tentacles: 1.7 mm

Back tentacles: 0.9 mm

Head Capsule: 1.5 mm in diameter

Figure 9. Body and head of third instar (x6)

Appearance: The black and yellow bands on the abdomen of a third instar larva are darker and more distinct than those of the second instar, but the bands on the thorax are still indistinct. The triangular patches behind the head are gone, and have become thin lines that extend below the spiracle. The yellow triangle on the head is larger, and the yellow stripes are more visible. The first set of thoracic legs are smaller than the other two, and are closer to the head.

Third instar larvae usually feed using a distinct cutting motion on leaf edges. Unlike first and second instar larvae, third (and later) instars respond to disturbance by dropping off the leaf and curling into a tight ball. Monarch biologist Fred Urquhart called this behavior "playing possum."

FOURTH INSTAR

Body Length: 13 to 25 mm

Body Width: 2.5 to 5 mm

Front Tentacles: 5 mm

Back Tentacles: 2 mm

Head Capsule: 2.2 mm in diameter

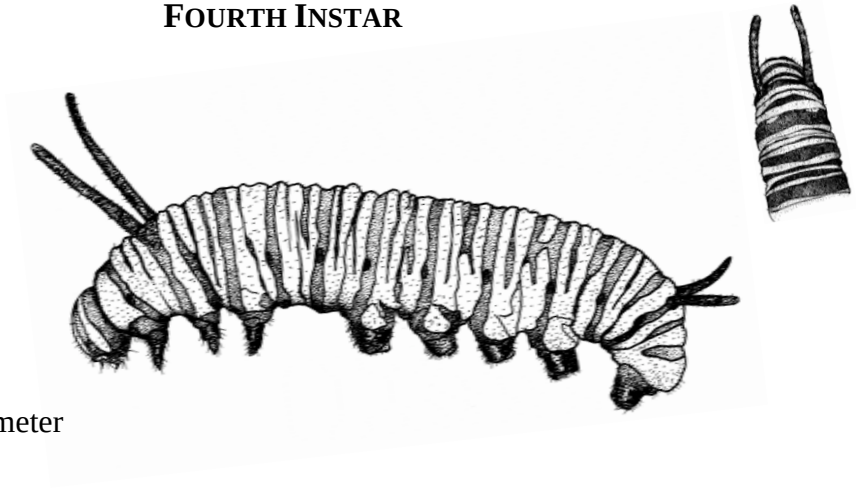


Figure 10. Body and head of fourth instar (x5)

Appearance: There is a distinct banding pattern on the thorax which is not present in the third instar larvae. The first pair of legs is even closer to the head, and there are white spots on the prolegs that were less conspicuous in the third instar.

FIFTH INSTAR

Body Length: 25 to 45 mm

Body Width: 5 to 8 mm

Front Tentacles: 11 mm

Back Tentacles: 4 mm

Head Capsule: 3.5 mm in diameter

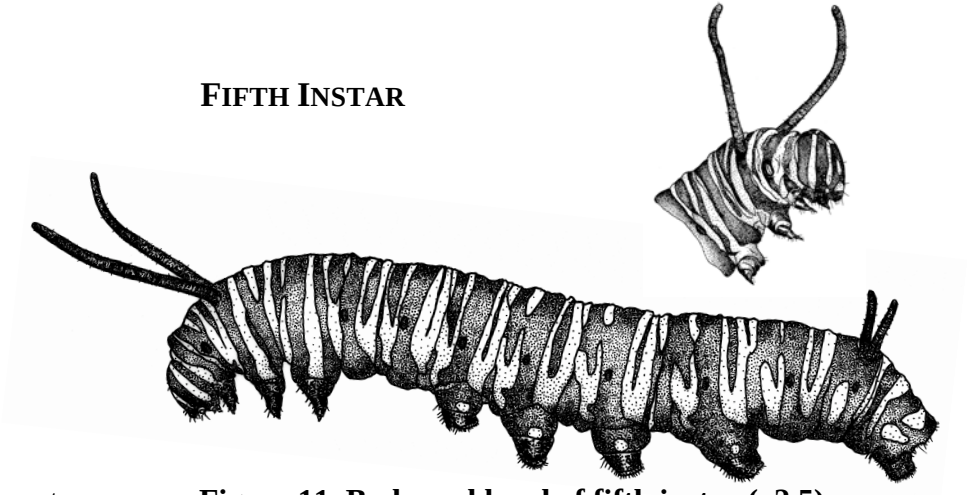


Figure 11. Body and head of fifth instar (x2.5)

Appearance: The body pattern and colors are even more vivid that they were in the fourth instar, and the black bands look wider and almost velvety. The front legs look much smaller than the other two pairs, and are even closer to the head. There are distinct white dots on the prolegs, and the body looks quite plump, especially just prior to pupating.

Fifth instar monarch larvae often chew a shallow notch in the petiole of the leaf they are eating, which causes the leaf to fall into a vertical position. They move much farther and faster than other instars, and are often found far from milkweed plants as they seek a site for pupating.

Schoolyard Habitats Action Plan

What is the issue?	What action will we take?	Who will do it?	When will it be done?	How will we monitor progress?	How will we know if we succeeded?	What will it cost?
K-2 Example We don't see many birds in our schoolyard.	We will find what the habitat needs of our local birds are and work with older grades to create the right habitat.	- Eco-Action Team - Master Naturalist - Master Gardeners - Interested school and volunteers	- Research in the fall and winter. - Take Junior Master Naturalist program in Winter - Bed prep in the spring - Build and plant in spring	We will use our Eco-Action Team meetings to learn, brainstorm and find ways to share our work with the school, our families and the community.	We will see an increase in the types and kinds of birds we see in our schoolyard.	We will look for donations of time and materials for the build of the garden. - student garden tools, plants/trees/shrubs, compost, feeders/seed, approx - $300-$500
3-5 Example We study a lot about ecosystems and we want to install a garden and plant trees and bushes so we can study ecosystems outside.	We will plan a garden and learning area using native plants and trees and natural elements.	- Eco-Action Team - Master Naturalist - Master Gardeners - City Parks Dept. - School/Community volunteers	- Research local flora and fauna in the fall - Secure approval for garden site in the fall - Take Junior Master Naturalist program in Winter. - Plant in the spring	We will use our Eco-Action Team meetings to check progress on our goals and create a project plant to help us stay on track.	Our school's students will be able to use the school gardens for learning no less than twice a year.	We will look for donations of time and materials for the build of the gardens. - student garden tools, plants, trees, shrubs, compost, field investigation tools - approx - $500
6-12 Example The principal at the CTE building has asked us to install gardens that their cullinary arts and horticulture program students can use.	We will develop a se ries of gardens that students can use for learning and as a way to engage the community in the education programs offered by the school district.	- Eco-Action Team - Master Gardeners - University/College horticulture dept. - Local chefs	- Schedule meetings early fall with stake-holders - secure approval for garden sites in winter - Bed prep in spring - Plant in the spring	We will rely on our Eco-Action Team meetings to check in on committee progress and our project plan timeline toward our goals.	Culinary and horticulture students will be able to use the gardens to deepen their learning by providing authentic learning experiences.	We will look for donations of time and materials for the guild of the gardens. - garden tools, plants, amendments and compost, building materials - $800

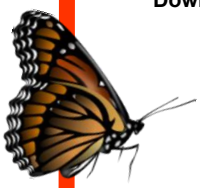
Remember these are just examples. Your Eco-Action Team may have one issue or you may have three. You may have one issue and three solutions. There is not a required number of issues to address or solutions to be completed. It is only required that the action plan be measurable and realistic.

Questions? **eco-schoolsusa@nwf.org**

Monarch Recovery Garden Action Plan

What is the issue?	What action will we take?	Who will do it?	When will it be done?	How will we monitor progress?	How will we know if we succeeded?	What will it cost?

Questions? **eco-schoolsusa@nwf.org**



Journey North Data Entry

1. Enter the number of monarch butterfly observed. _____
2. Comments. Here's what information is needed.
    a. Where are you? (Park, Schoolyard Habitat, Backyard, Walking Home)

    b. What time is it?

    c. What's the weather like? (Cloudy, Full Sun, In the high 90's)

3. Optional: If you have access, take a photo and use the photo editor to add the date and time.
4. What is the date for your observation? _____
5. What is the location of your sighting?
    a. Country: _____
    b. State: _____
    c. City: _____
    d. Latitude: _____ (round to the nearest hundredth)
    e. Longitude: _____ (round to the nearest hundredth)

    To find your current latitude and longitude use your phone's compass or go to http://mynasadata.larc.nasa.gov/latitudelongitude-finder/ and insert your school's full address, including zip code.
6. What is your first name? _____
7. What is your last name? _____
8. If instructed, go to the Journey North app, login and enter and submit your data.

MONARCH RECOVERY VISIONING WORKSHEET

Group members and their role in the project:

Please respond briefly.

1. Describe how your schoolyard currently looks. Take pictures and attach to this page.

2. How is the schoolyard currently used?

3. Describe your ideal schoolyard – what would it look like? Sound like? How would it be use?

In working towards creating a wildlife habitat(s) on the school grounds, consider these questions.

4. Where on the schools grounds will the habitat be located and what evidence do you have to support this location?

5. What should the size and shape of the garden site be?

6. What will this habitat provide for the monarch butterfly?

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7. What type of ecosystem are you restoring or recreating?

8. What will the source of water be in your habitat?

9. How will students be involved in the design and development of the habitat site?

10. How will classes use the completed site? What special features will the site need to accommodate these uses?

11. Which community members, businesses and organizations might be of assistance, labor or financial, with this project?

12. Sketch how the site will look after it is constructed. In the summer. In the winter. After a year.

IMMEDIATELY AFTER PLANTING	IN THE SUMMER
IN THE WINTER	AFTER ONE YEAR

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13. Use the above ideas and information to form a vision statement for the Monarch Recovery Garden. This statement should include:
    - Wildlife for which the garden(s) is designed
    - Location and reason for selecting the area
    - Size of the habitat project
    - Other details that will help the school and community understand and "see" the project better

MONARCH RECOVERY GARDEN VISION

School _____Date _____

Our Monarch Recovery Garden Vision is:

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HABITAT TEAM PLANNING WORKSHEET

This form lists the members of our Monarch Recovery Garden Team. Each participant recognizes their role as a member of this team. Many others will be involved in the project, but those listed below take responsibility for the specific project areas listed below.

NAME	HABITAT TEAM	EMAIL
1. 2. 3.	**Habitat Team Leaders**	1. 2. 3.
1. 2. 3.	**Budget Coordinators**	1. 2. 3.
1. 2. 3.	**Curriculum Coordinators**	1. 2. 3.
1. 2. 3.	**Historians**	1. 2. 3.

HABITAT TEAM PLANNING WORKSHEET

1. 2. 3.	**Maintenance**	1. 2. 3.
1. 2. 3.	**Volunteer Coordinators**	1. 2. 3.
1. 2. 3.	**Communications and Marketing**	1. 2. 3.
1. 2. 3.	**Student Liaisons**	1. 2. 3.

I acknowledge and support the creation of the Monarch Recovery Garden, which will help guide the project along the way.

Principal/Director Signature _____Date_____

Habitat team Leaders

_____Date_____

_____Date_____

_____Date_____

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Monarch Larva Monitoring Project

PERSONAL INFORMATION

Name of Participant(s):

Primary Mailing Address:

Secondary Mailing Address:

E-mail Address, if available:

How many years have you collected data for the Monarch Larval Monitoring Project?

When was the last year you participated?

Are you participating as part of an organization (school, nature center, etc.)? If so, what organization?

Will anyone (family, friends, etc.) be helping you with the monitoring? If so, please list their names (and ages if they are students/children).

We like to know a little about our volunteers. If you would like, tell us about your profession, other interesting information about you, whether you have helpers while you monitor, or anything else you think we would like to know.

SITE INFORMATION

Information on your monitoring site will help scientists understand how the environment in and around your site influences monarch presence and abundance. If you cannot answer a question, it is okay to skip it.

1. If you have collected MLMP data in the past, is this the same site you monitored in previous years? If not, why not?

2. Where is your site located?
   City or Township: _____ County: _____ State: _____
   Geographical Coordinates, if known: _____

3. What type of site is it (only one):
   - CRP land (Conservation Reserve Program)
   - Other "old field" (not currently used for crops)
   - Pasture
   - Restored prairie
   - Natural prairie
   - Nature preserve
   - Roadside (ditch or strip next to a road)
   - Garden (planted milkweeds that are watered and maintained)
   - Agricultural area (cornfield, soybean field)
   - Other

4. On what date this year did the milkweed emerge? _____

5. We would like to know the size of your site. This means the entire contiguous area in which milkweed is growing, not just where you monitor. You may either give us the area, dimensions, or estimate the area. Please answer a or b.

   a. What is the area of your site? _____ (Indicate units – square meters, acres, hectares, etc. Measure the length and width of the site and multiply them, or use a quantity that you already know, such as 40 acres.)

   b. Estimate the size by choosing one of the following: (only one)
      - Very small: 0-10 sq. meters (100 sq feet) – e.g. a small garden
      - Small: 11-100 sq meters (1000 sq feet) – up to the size of half a tennis court
      - Medium: 101-1000 sq meters (10000 sq feet)– a little smaller than a football field
      - Large: 1001-10,000 sq meters (2.5 acres)
      - Very large: Over 10,000 sq meters (large fields and bigger)

6. Please list all milkweed species at the site.

7. Was this milkweed planted by humans, or did it grow naturally?

8. Please check any forms of management that occur on your site:
    - ☐ Mowed 1-2 times per year
    - ☐ Mowed more than 2 times per year
    - ☐ Fertilized 1 or more times per year
    - ☐ Weeded
    - ☐ Planted with an agricultural crop (milkweed is a "weed" in this site)
    - ☐ Burned every year
    - ☐ Burned every 2-3 years
    - ☐ Burned with a frequency of less than once every 3 years

9. Which of the following are found within your site? This includes the entire contiguous area that contains milkweed, not just the part of it that you monitor.
    - ☐ Flowering plants
    - ☐ Native grass
    - ☐ Lawn grass
    - ☐ Shrubs (less than 3 m tall)
    - ☐ Trees (more than 3 m tall)
    - ☐ Natural body of water (pond, lake, or river)
    - ☐ Human-provided water (birdbath, pond, etc.)

10. Which of the following border your site? This includes the entire contiguous area that contains milkweed, not just the part of it that you monitor.
    - ☐ Lawns
    - ☐ Agricultural fields
    - ☐ Residential buildings
    - ☐ Industrial or commercial buildings
    - ☐ Roads
    - ☐ Body of water (lake, pond, river)
    - ☐ Deciduous woods
    - ☐ Evergreen woods
    - ☐ Schoolyard
    - ☐ Park
    - ☐ Other

11. How would you describe most of the area immediately surrounding your site? (only one)
    - Undisturbed (forest, prairie, or other natural vegetation)
    - Rural agricultural
    - Small town
    - Suburban
    - Urban

12. If your site is in a city, suburb, or town, what is the population?
    - Less than 5,000
    - 5,001 – 25,000
    - 25,001 – 100,000
    - Over 100,000

13. Is either of the following within 1 km (0.6 miles) of your site?
    - Another small to medium area with milkweed (0-1000 sq meters)
    - Another large to very large area with milkweed (over 1000 sq meters)

14. What is the elevation of your site?
    - 0-750 m (0-2500 ft)
    - 751-1500 m (2501-5000 ft)
    - 1501-2250 m (5001-7500 ft)
    - 2251-3000 m (7501-10000 ft)
    - Over 3000 m (over 10000 ft)

15. Do you ever release adult monarchs at this site? If so, how often and how many?
    - Yes
    - No

    If yes, how often? (only one)
    - Once
    - 2-3 times
    - More than 3 times

    And how many? (only one)
    - 1-5
    - 6-10
    - More than 10

16. Do you collect monarchs at this site? If so, what stages and approximately how many?

Stage	Check if this stage is collected	Check how often A few	Every once in a while	Most or all that I see
Egg		☐ A few	☐ Every once in a while	☐ Most or all that I see
L1		☐ A few	☐ Every once in a while	☐ Most or all that I see
L2		☐ A few	☐ Every once in a while	☐ Most or all that I see
L3		☐ A few	☐ Every once in a while	☐ Most or all that I see
L4		☐ A few	☐ Every once in a while	☐ Most or all that I see
L5		☐ A few	☐ Every once in a while	☐ Most or all that I see
Pupa		☐ A few	☐ Every once in a while	☐ Most or all that I see
Adult		☐ A few	☐ Every once in a while	☐ Most or all that I see

Monarch Larva Monitoring Project

MEASURING MILKWEED DENSITY

TIMING

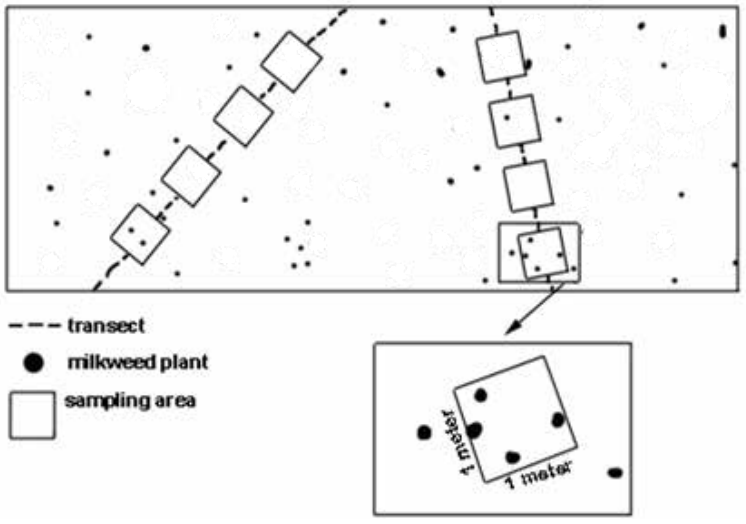
Complete the "Milkweed Density Datasheet" once per year. Since the milkweed may not all be above ground at the beginning of the season, wait to do the density measurements until the middle of the season.

PROCEDURE

If you can easily count all of the milkweed plants at your site, record the actual number of milkweeds at the site and the size of your site.

If your site is too large to easily count all of the milkweed plants, you will randomly sample points to obtain plant density data, counting the number of milkweed plants in several 1 meter squares. Follow these steps:

1. Start at any side of your site, randomly choose a direction, and walk one or more transects, or paths, through the site. On a transect, stop every 5-10 paces, and use a meter stick to delineate a square that is 1 meter on each side. The appropriate number of paces will vary with the size of your site (more paces for larger sites), but must be consistent for all of your samples. Use a consistent method for delineating each meter square plot, i.e. the square is always directly to the right and in front of your right foot when you stop.
2. Count all of the milkweed plants within that 1 meter square, and record the data on the Datasheet.
3. When you reach the edge of your site while walking a transect, randomly choose a new direction that takes you back into the site, and continue walking and recording data from the 1 square meter plots. It is possible that some transects will cross each other, but very unlikely that actual sampling plots will overlap, so don't worry about intersecting transects.
4. Continue with this method until you have sampled up to 100 squares (the more squares you sample the more accurate your density estimate will be, but more than 100 is not necessary).



Sampling transects. Note that the sampling plots will be farther apart than shown here.

Tip: A good way to randomly select a direction is by throwing a pencil or ruler into the air. Walk in the direction that it is pointing. The goal is to sample randomly and obtain data that are representative of the whole site. It is important not to let the presence or absence of milkweed influence your choice of samples.

MILKWEED DENSITY DATASHEET

Year: _____ **Observers:** _____ **Site Name:** _____ **City, State:** _____

You only need to do this activity once during the season (at middle of season)

If you can count all of the milkweed plants at your site, record the number of milkweed plants and area of your site (you can record the area in square meters, square feet, or acres).

Number of milkweed plants: _____ **Area of site:** _____

If your site has too many milkweed plants to count, use the sampling procedure described above and complete the table below.

Point #	# of milkweed plants in 1x1 meter square	Point #	# of milkweed plants in 1x1 meter square	Point #	# of milkweed plants in 1x1 meter square	Point #	# of milkweed plants in 1x1 meter square
1		26		51		76	
2		27		52		77	
3		28		53		78	
4		29		54		79	
5		30		55		80	
6		31		56		81	
7		32		57		82	
8		33		58		83	
9		34		59		84	
10		35		60		85	
11		36		61		86	
12		37		62		87	
13		38		63		88	
14		39		64		89	
15		40		65		90	
16		41		66		91	
17		42		67		92	
18		43		68		93	
19		44		69		94	
20		45		70		95	
21		46		71		96	
22		47		72		97	
23		48		73		98	
24		49		74		99	
25		50		75		100	

Monarch Larva Monitoring Project

ACTIVITY #1: MEASURING MONARCH DENSITY

Objective: Obtain a count of monarch eggs and larvae at the site by examining a recorded number of milkweed plants. The result will be a per plant density measurement of the monarch population at the site. We use this measurement to see how densities vary within a year, between years, and among different sites and locations.

You can choose one of three different datasheets to record your monarch density data for Activity 1.

- **Datasheet #1A – (BASIC):** this datasheet asks for the total numbers of plants and monarchs you observe at the site—for example, 4 eggs on a total of 100 plants observed. If you use this datasheet, you will need to print a new copy each time you monitor your site. It is the simplest datasheet for recording and is great for new volunteers or working with kids.
- **Datasheet #1B – (For combining full season summary in one place)** Like Datasheet #1A, this sheet asks for the total number of plants monitored and monarchs seen. However, you can record data from multiple monitoring events, and will only need one or two sheets for the entire monitoring season (although you will be more limited for writing space). You can use this to record data in the field if you write small, or can use it to combine all your weekly data in one place.
- **Datasheet #1C – (ADVANCED):** this datasheet asks you to keep track of the number of monarchs you observe on each individual plant you observe, instead of just reporting the total numbers of plants and monarchs that you observe. For example, with Datasheet #1C, you could record seeing 2 eggs on 1 plant, 1 larva on another, and zero monarchs on a third. This information will be useful in understanding potential impacts of crowding on monarch survival. Because you will also record the milkweed species, we'll be able to assess how female monarchs make egg-laying decisions when they have more than one milkweed species in a single site. Your data will be added to overall monarch densities, but will also be analyzed separately.

Method: Regardless of what datasheet you use, the basic monitoring method remains the same. You will examine as many milkweed plants as possible, keeping track of the number of plants examined, and recording the number of monarch eggs and larvae of each instar that you find. Follow the specific instructions below: Try to monitor on the same day and at about the same time each week, throughout the time that milkweed is growing in your area. It is okay if your timing is slightly off from one week to the next, or if you have to miss weeks.

1. **Record the required basic monitoring event details**. Record the date you monitored, the temperature in the shade (indicate Fahrenheit or Celsius), start and stop times, etc.
2. Always record the number of milkweed plants that you examine. The result will be a weekly estimate of monarch density at your site, measured as a proportion of milkweed plants with monarchs.
3. Examine as many plants as possible. **If you can monitor every milkweed plant at your site, please do so**. If there are too many for you to monitor all of them, randomly select plants to monitor during each monitoring session (it does not need to be the same subset of plants each week). It is important to monitor an unbiased sample of milkweed plants. In other words, you should not just look at the milkweed plants that you think are most likely to have monarchs on them because you will overestimate the monarch density at your site. You can avoid bias by following the directions below.

- For large sites where milkweed is more evenly distributed, **walk one or more random, straight-line transects, or paths, through your site.** First, choose a random direction to walk. You can do this by tossing a pencil or stick, and walking in the direction it points, or using some other random sampling method. After choosing a direction, hold your arms out to your sides as you walk. Stop and examine every milkweed plant that falls along your path between your fingertips. As you examine these plants, **keep track of the number of plants you look at**, whether they have monarchs or not. Record the total number of plants on one of the Activity 1 datasheets. When you reach the perimeter of your site, you can generate another random direction to conduct the next transect, or simply turn 90 degrees back into your site and continue monitoring. Continue running these transects through the site until you feel you have adequately sub-sampled the site, or have run out of time.
- For sites where milkweed density is patchy, a systematic approach to sub-sampling may be easier. To do this, estimate the total number of milkweed plants at the site, and determine how many you are capable of observing each week. You can use this number to calculate your sub-sampling method. For example, if your site has 900 milkweed plants, and you have time to monitor 300 of them each week, your method would be to observe and record every third milkweed plant that you observe. Again, be sure not to bias your sample by choosing plants you feel are more likely to have monarchs present.

Note: you do not need to use the transect method if you are able to examine all of the milkweed plants at your site.

4. **Search for monarch eggs and larvae on each plant that you examine.** Remember that monarch eggs and larvae can be hard to find! To examine a milkweed plant, look carefully at all parts of the plant, including the bottoms of the leaves, the area within the very small leaves at the top of the plant, and buds and flowers if they are present. Keep an eye out for caterpillar clues, such as chew marks on the leaves or frass. Handle the plants carefully, to avoid knocking any larvae off the plant. Remember, not all eggs and caterpillars that you find on milkweed are monarchs; use the pictures of each instar below and our Field Guide to Monarch Caterpillars to help you distinguish monarchs from other insects.

Note: Sometimes it is difficult to distinguish one "plant" from another; many species of milkweed have different growth forms. A rule of thumb is that if stems are separated by dirt, you can call them separate plants. We know that they might not be separate plants; common milkweed stems all over a field might actually be from the same "plant" and all be connected underground, and the stems in a clump of swamp milkweed (which is one plant) are often separated by dirt. If there are uncertainties, please email us first for clarification. Always write what you are doing in the notes section of your site information page, and be consistent from year to year.

5. **Keep track of the number of milkweeds, monarch eggs, and larvae that you find, and the instar of each monarch larva.** Use one of the Activity 1 datasheets to record your observations of eggs, larvae, and milkweed. Be sure to identify the larvae to instar (see photos below, MLMP Life Cycle cards, Field Guide to Monarch Larvae, or illustrations on MLMP clipboard). Note that you can record the number and stage of any dead monarch eggs or larvae that you see.
6. **Scan for adult monarchs.** Note any adult monarchs you observe, and their sex, if known. To avoid counting individuals more than once, count the maximum number of adults that you observe at any one time by scanning the entire site when you see an adult. Record this number on the datasheet, indicating how many are males, females, or unknown.
7. **Note what plants are blooming each week.** This information will help us learn about the diversity of blooming plants at your site and tell us if there were any nectar plants there to attract and feed adult monarchs. You do not need to record how many of each kind of blooming plant, just the species.
8. **Note any disturbances at the site.** Record the date and type of disturbance, which might include mowing, herbicide spraying, haying, or anything else that might affect the milkweed plants or monarchs.

9. **Note *Aphis nerii* presence or absence (optional)**. Note if you saw any of the bright yellow Oleander Aphids (*Aphis nerii*) while you were monitoring. You don't need to record numbers of aphids or plants with aphids, just whether they were there or not. If you didn't look, just check "didn't look".

ADULT MONARCHS

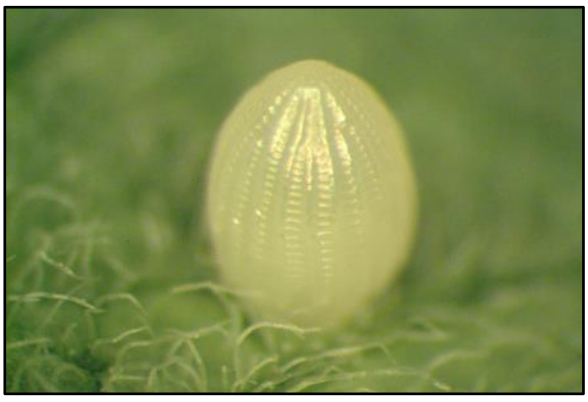
Male and female monarchs can be distinguished easily. Males have a black spot (indicated by a red arrow) on a vein on each hind wing that is not present on the female. The ends of the abdomens are also shaped differently in males and females, and females often look darker than males and have wider veins on their wings.

Male Monarch Butterfly
(photo courtesty of Michelle Solensky)

Female Monarch Butterfly
(photo courtesy of Barbara Powers)

EGGS AND CATERPILLARS

Monarch egg on milkweed leaf — The egg is a little more than 1 millimeter tall.
(Photo courtesy of Lynda Andrews)



Close-up of monarch egg — Note the pointed shape, the glossy color, and the vertical striping.
(Photo courtesy of Michelle Solensky)

Monarch egg (left) and latex drop (right)
(Photo courtesy of Anurag Agrawal)

Live monarch egg about to hatch
(Photo courtesy of Valerie Evanson)

Dead monarch egg – Note the "puddle" of dead larva in the bottom of the egg.
(Photo courtesy of Valerie Evanson)

Monarch first instar consuming eggshell — Note the dull greenish-grey color, and the size (not much bigger than the egg).
(Photo courtesy of Mary Holland)

First instar feeding damage — This circular feeding pattern is an indication that a monarch first instar was on the plant at some point.
(Photo courtesy of Tom Collins)

Monarch second instar — Second instar larvae have a distinct pattern of black, white, and yellow band, and the body no longer appears transparent and shiny.
(Photo courtesy of Monarch Lab)

Monarch third instar — This third instar monarch has just molted. As monarch larvae develop, they increase in size and their stripes become more distinct. Third instar larvae usually feed using a unique cutting motion on leaf edges.
(Photo courtesy of Monarch Lab)

Monarch fourth instar — Fourth instar monarchs front tentacles extend beyond the tip of the head. Internal changes, including the development of reproductive structure, begins to occur in late instar monarchs.
(Photo courtesy of Monarch Lab)

Monarch fifth instar — Older monarch larvae have bright yellow, black and white striping and 2 pairs of tentacles (on front and back ends).
(Photo courtesy of Richard Hicks)

Monarch instars — The entire larval stage in monarchs lasts from 9-14 days under normal summer temperatures. The speed of monarch development is temperature dependent.
(Photo courtesy of Monarch Lab)

APHIS NERII (APHID)

Aphis nerii – the only bright yellow aphid found on milkweed.
(photo courtesy of Anurag Agrawal)

Aphis nerii – hundreds of aphids on one milkweed plant.
(Photo courtesy of Grant Bowers)

DATASHEET #1A: MONARCH DENSITY (WEEKLY SUMMARY)

Use this information to fill in **Datasheet #1B Season Summary of Monarch Density**.

Date: _____ **Observers:** _____ **Site Name:** _____ **City, State:** _____

Start Time: _____ **Stop Time:** _____ **Temp in Shade:** _____

Eggs	1st Instars	2nd Instars	3rd Instars	4th Instars	5th Instars	# of Adults (F = female M = male U = unknown)	# Dead (egg or larval stage)	# of Milkweed Plants Observed (use tick marks to represent 1, 5, 10, or 20 plants and record total at end of session)

Plants in bloom at site (species, not numbers of plants!):

_____

_____

Note any disturbances that occurred at the site over the past week (mowing, herbicide spraying, haying, etc.):

_____

_____

Did you see any *Aphis nerii* at your site this week? Circle one: Yes No Didn't look

Other Notes:

DATASHEET #1B: MONARCH DENSITY (SEASON SUMMARY)

Year: _____ **Observers:** _____ **Site Name:** _____ **City, State:** _____

Date	Temp in Shade	Start Time	Stop Time	Live Monarch Eggs & Larvae						# Dead (& larval stage)	# of Adults (F = female M = male U = unknown)	# of Milkweed Plants Observed	Plants in Bloom	*Aphis nerii*? (Yes / No / Didn't Look)
				Eggs	1st	2nd	3rd	4th	5th					

Were there any disturbances (such as mowing) at your site during the monitoring period? Please describe the kind and timing of any disturbance.

ACTIVITY #1C: MONARCH DENSITY (WEEKLY DENSITY PER MILKWEED PLANT)

Objective: Activity #1C, like the simpler Activity #1A, results in an estimate of monarch density at your site. The difference is that you will keep track of the number of monarchs you observe on individual plants, instead of just reporting the total numbers of plants and monarchs that you observe. Whereas in the simpler activity you would report seeing, for example, 4 eggs on a total of 100 plants observed, this protocol will allow you to report if these eggs were on 4 separate plants, or if they were all on the same plant. This information will be useful in understanding potential impacts of crowding on monarch survival. Because you will also be recording the milkweed species, we'll be able to assess how female monarchs make egg-laying decisions when they have more than one milkweed species in a single site. Your data will be added to overall monarch densities, but will also be analyzed separately.

Method: Follow the directions for Activity #1A, with these modifications. When you look at a plant with no monarchs, place a tick mark in the box labeled "0 monarchs/plant." When you see one monarch on a plant, write "e," "1st," "2nd," "3rd," "4th," or "5th" (depending on whether you see an egg or a first, second, etc. instar) in one of the boxes under the words "1 monarch/plant." When you see 2 monarchs on a plant, write "e,e" or "e,1st," or "1st,1st," etc., depending on the stage of the two monarchs you see. Do the same in the boxes under the words "3 monarchs/plant," "4 monarchs/plant," and ">4 monarchs/plant" as needed. Note if an individual is dead; for example, if you see a dead first instar and a live first instar on a plant, you would note "dead 1^{st}, 1^{st}". At the end of the session, add up the total number of plants (including those with and without monarchs), eggs, and larvae you observed, and tally this in the appropriate section in the summary below the table.

If you have only one species of milkweed on your site, you'll use one table per monitoring session. If you have more than one milkweed species, you should keep a separate table for each species you observe. There are two tables per sheet.

DATASHEET #1C: MONARCH DENSITY (WEEKLY DENSITY PER MILKWEED PLANT) PLEASE SEE INSTRUCTIONS ABOVE

Year: _____ **Observers:** _____ **Site Name:** _____ **City, State:** _____

Key: e = egg | 1 or 1st = 1st instar | 2 or 2nd =2nd instar | 3 or 3rd = 3rd instar | 4 or 4th = 4th instar | 5 or 5th = 5th instar | p = pupae

Milkweed Species: _____ **Date:** _____ **Start Time:**_____ **Stop Time:**_____ **Temp in Shade:** _____

0 monarchs/plant	1 monarch/plant					2 monarchs/plant		3 monarchs/plant	4 monarchs/plant	> 4 monarchs/plant

Total plants:_____ **Total Eggs:**_____**Total 1st s:**_____**Total 2nd s:**_____**Total 3rd s:**_____**Total 4th s:**_____**Total 5th s:**_____

Total Pupae:_____ **Dead (list stages):** _____ **Adults:** _____males, _____ females, _____ unknown

Milkweed Species: _____ **Date:** _____ **Start Time:**_____ **Stop Time:**_____ **Temp in Shade:** _____

0 monarchs/plant	1 monarch/plant					2 monarchs/plant		3 monarchs/plant	4 monarchs/plant	> 4 monarchs/plant

Total plants:_____ **Total Eggs:**_____**Total 1st s:**_____**Total 2nd s:**_____**Total 3rd s:**_____**Total 4th s:**_____**Total 5th s:**_____

Total Pupae:_____ **Dead (list stages):** _____ **Adults:** _____males, _____ females, _____ unknown

Plant species blooming: _____

_____

_____

(Disturbance and Aphis nerii *data collected on next page.)*

Note any disturbances at your site this week:

Did you see any *Aphis nerii* at your site this week? Circle one: Yes No Didn't look

Other notes or observations:

Monarch Larva Monitoring Project

ACTIVITY #2: RAINFALL DATA

Objective: Obtain measurements of weekly or daily rainfall at the site.

Method: Mount a rain gauge at or near the site and record rainfall amounts.

We are interested in following the weather patterns at your site, especially rainfall. If possible, buy an inexpensive rain gauge and mount it at your site. Check the gauge regularly and record rainfall amounts on **Datasheet #2 – Rainfall Data**. Make sure to empty the gauge so it is ready to collect precipitation during the next rain event.

DATASHEET #2: RAINFALL DATA

Year: _____ **Observers:** _____ **Site Name:** _____

City: _____ **State:** _____

Date Emptied	Rainfall	Date Emptied	Rainfall	Date Emptied	Rainfall

Monarch Larva Monitoring Project

ACTIVITY #3: ESTIMATING MONARCH SURVIVAL

We are interested in learning about the natural enemies that may affect monarchs. Some of these enemies are parasitoids, organisms whose young develop inside the monarch larvae, eventually killing them. This activity will help us learn how common this kind of parasitism is at your site. Here, we provide information on how to collect data on parasitoids and a protozoan parasite called Oe (*Ophryocystis elektroschirrha)*. If you choose to participate in the Oe study, you'll need to contact the coordinators at the University of Georgia to obtain a sampling kit (see instructions below).

Objective: Obtain an estimate of survival in monarch larvae collected at your site. These data will help us measure the importance of mortality factors in populations of different densities and at different times and locations.

Summary of Method: Collect any 4th or 5th instars each week as you complete **Activity #1 Monarch Density**. If you would like to collect earlier instars as well, you can do this; just be sure to note that you are collecting earlier instars on the online **Site Information** form. You may collect larvae from your monitoring site or other locations. If you collect them from your site, enter their information under your monitoring site profile; if you collect them from other locations, use the data entry form under the "Enter/Edit Data on Monarchs You Rear from Other Locations" section. Rear larvae indoors and record whether they survive to adulthood, and, if not, what caused their death (parasitized by flies, parasitized by wasps, dead for an unknown reason, etc.). If you choose to test butterflies for the Oe parasite, do this before releasing them back at the site. Additionally, we would like to identify parasitoids that you rear from monarchs (or other butterflies or moths); please see #8 below for information on how to send the adult parasitoids to us.

DETAILED INSTRUCTIONS FOR REARING LARVAE TO ESTIMATE SURVIVAL

1. Larvae can be kept in an aquarium, large jar, ice cream bucket, or another container. The container should be easy to open, since you need to clean it every day. It should have a screen covering or holes for air flow and should allow you to see the larva inside. Unless you plan to move the pupae, the cage should be large enough for the adult to expand its wings when it emerges. Keep the cage out of the sun or other hot places (like a car in summer). High temperatures can kill the larvae. It is best if you keep only one larva in each container, as this will help combat disease and allow you to track individual larvae accurately, since you'll want to know the stage at which they were collected.

Example of rearing set-up. Photo by Ilse Gebhard.

2. Cages must be cleaned daily. Empty out the caterpillar frass (poop) and old milkweed. Wash your container frequently (at a minimum every time a new larva is introduced) using a 20% bleach-water solution.
3. Give larvae fresh milkweed daily. You can pick several days' worth of milkweed, wash it, and keep it in a plastic bag in a refrigerator. It stays fresher if you put a damp piece of paper towel on the bottom of your container.

4. The 4th and 5th instars that you collect will likely pupate within a week. When they are ready to pupate, they'll crawl to the top of their cage and form a pre-pupal "J" before shedding their skin for the last time. You can tell that they will shed their larval skin soon (within minutes) when their tentacles hang very limply and their bodies straighten out a little. Be careful to not jostle the container while larvae are pupating.

5. The pupa stage lasts nine to fourteen days. Pupae turn darker the day before butterflies emerge, and look black on the day they emerge. At this point, the wings are visible. The butterflies usually emerge in the morning. Their wings will be soft, flexible, and wet when they emerge, but they'll be ready to fly in about 4 hours. If they fall, carefully pick them up by holding the thorax, and hold their legs next to the top or side of the cage. They need to hang with their wings pointed down. A pupa that has been very dark for more than a few days is almost always dead. Within a day of an adult butterfly emerging, release it back at the site from which it was collected after recording information on the Activity 3 datasheet.

Above: Monarch pupae with silk-like thread from tachinid fly parasitoids. Photo by Sonia Altizer

6. Larvae that have been parasitized by flies will often not pupate successfully, but will hang limply and die, although some flies emerge from the pupa. Fly maggots come out of the host larva or pupa on a silk-like thread, and pupate on the bottom of the container. The adult flies emerge about 7-10 days later. Wasps emerge as adults from their host pupa. In both cases, be sure to remove the wasps or fly pupae if there are living monarch larvae in your rearing container; they may mate and parasitize new hosts. Please consider sending the specimens to us to identify after the adults have emerged (see #8).

Above: Parasitized monarch larva with three tachinid larvae (maggots). Below: Soon after emerging, the flies pupate, turning reddish-brown. Above by Jaap de Roode, below by Sonia Altizer.

7. Remove diseased larvae from any container with other larvae to avoid spreading the disease.

8. Please send us adult parasitoid flies or wasps that come from monarchs you rear. After the adult flies emerge from their pupae (7-10 days after they emerge from the monarch), put them in small containers (e.g. pill bottles, small boxes, Ziploc-style plastic storage containers), with a cotton ball or tissue to prevent them bouncing around. Each container should hold all of the parasitoids that emerged from ONE monarch. Put them in a freezer until you have several or until the end of the season. Label each container so we can determine the date of collection of the monarch, the stage at which the monarch was collected, the milkweed species on which the monarch was collected, the location of collection, and anything else you think is relevant. If you want, you can number the containers, and write this information on a separate table that you send with the containers. Contact info@monarchlab.org if you need assistance shipping the flies to us, and notify us when a package of flies should be expected. Send the specimens to:

Right: Adult tachinid fly. MonarchLab photo.
Below: Example container label with fields needed.

Monarch Larva Monitoring Project
University of Minnesota
Dept of FWCB
2003 Upper Buford Circle, 135 Skok Hall
St. Paul MN 55108

Location collected: _____
Date collected: _____
Instar collected as: _____
Date and # flies emerged: _____
Date adult flies: _____

DATASHEET #3: ESTIMATING PARASITISM RATES

Year: _____ **Observers:** _____ **Site Name:** _____ **City:** _____ **State:** _____

Larva ID #	Location of Collection (if different from site)	Date of Collection	Larval Instar at Collection	Adult Monarch		Date of Sampling for OE (if applicable) and result (if known)		Result: parasitized by fly, parasitized by wasp, dead from another cause (accidental or disease), adult monarch	Number of parasitoids - date emerged from monarch		Notes (e.g. cause of monarch death - accidental, disease or unknown; did adult flies emerge from fly pupae; other observations)
				Date Emerged	Male Female	Date	infected (yes/no)		#	Date	

DATASHEET #3: ESTIMATING PARASITISM RATES

INSTRUCTIONS FOR TESTING ADULTS FOR OE (OPTIONAL)

1. Obtain a sampling kit from Project MonarchHealth (see address below). You will send the sampling card plus a copy of your data sheet to the University of Georgia. You will still enter your data on the MLMP website for the monarch larvae you collected, and whether they died for an unknown reason, turned into monarchs, flies, or wasps.
2. Butterflies should not be handled for the first four or five hours after they emerge, and can be kept in the cage until the next day. To sample adult monarchs for the Oe parasite, wear gloves to prevent contamination. While the parasite is not harmful to humans, it is easily spread from one monarch to another.
3. Remove the butterfly from its rearing container. Hold firmly as shown in the picture below, using a gloved hand. Be sure not to use your other hand to touch the butterfly because that hand will be used to hold the tape sticker and sample for Oe spores. **It is critical that your bare hand NOT touch the butterfly!**

4. Pick up a piece of transparent tape or sticker with your other hand. Gently, but firmly place the sticky side of the piece of tape to the abdomen of the monarch. Press down so that it wraps around and sticks to the sides of the abdomen.
5. Gently peel the tape off and stick it to the index card. You will remove scales in the process, but it will not harm the monarch. Label the tape sample with a number that corresponds to the datasheet entry.

6. Sanitize your working surface with bleach solution. Thoroughly sterilize container with 20% bleach solution and clean all supplies and tools with bleach before rearing another wild monarch.
7. After you've entered your MLMP data, send a copy of the MLMP Activity 3 datasheet and the index card to:

Project Monarch Health
c/o Sonia Altizer
Odum School of Ecology
University of Georgia
Athens, GA 30602

Monarch Larva Monitoring Project

ACTIVITY #4: COMPARING PLANTS OCCUPIED BY MONARCHS TO RANDOM PLANTS

Objective: To assess whether female monarchs choose milkweed plants randomly within a site, or if there are characteristics of milkweed plants that make some more likely to be chosen as sites for oviposition. This will help us to understand what characteristics make milkweed "good" host plants for monarchs.

Methods: Measure and compare the same characteristics (height, reproductive status, age, herbivore damage, and the presence or absence of invertebrates) of plants with monarchs and randomly-selected plants. You will measure all (or a subset if you find over 30 plants with monarchs) of the plants you observe with monarchs and a random set of 30 plants at your site.

You will fill out **Datasheets 4A and 4B** every week if you do this activity. Complete datasheet 4A (milkweeds with monarchs) while you are doing your weekly Activity 1 monitoring (Measuring Monarch Density). If you find more than 30 plants with monarchs, you can stop recording when you get to 30 to save time.

Since it will be hard to record characteristics of random plants simultaneously, use one of the methods described below AFTER you have completed your weekly monitoring activities to complete the 4B datasheet (random milkweed plants).

It works well to copy the two datasheets below on two sides of one paper.

DIRECTIONS FOR FILLING IN PLANT CHARACTERISTICS ON BOTH DATASHEETS (4A AND 4B):

1. For datasheet 4A, record the stage of monarch(s) on the plant, then fill out the other characteristics as described below. If monarch densities are very high at your site, you can stop recording plant characteristics after the first 30 occupied plants. Keep looking for monarchs for Activity 1 (Measuring Monarch Density) and recording the number of monarchs you observe and the total number of milkweeds examined. For datasheet 4B, most plants probably won't have monarchs, but it's okay if they do (as long as they are selected randomly).
2. Look at the plant to determine what, if any monarchs or other invertebrates are on it, and record what you see on the datasheet. It is important to do this first, since your presence and plant manipulation will disturb some of the invertebrates. The Milkweed, Monarchs, and More Field Guide (available at: http://monarchlab.org/store) is helpful for identifying invertebrates you are likely to encounter.
3. Record the species of milkweed. Here is a helpful webpage courtesy of the Monarch Joint Venture (see Milkweed Resources category): http://www.monarchjointventure.org/resources/downloads-and-links/
4. Measure the plant height in cm to the top of the top set of leaves; if the plant is not standing straight, or if it is a recumbent species (growing horizontally along the ground), measure its length. If it has several branches, measure the height of the tallest branch (see photo).

Photo courtesy of Janet Allen

5. Note the presence/absence of buds, flowers, and seed pods.
6. Evaluate the percentage of leaf material that is yellowed and senescing (growing old). This is a subjective measurement, but use the categories provided on the datasheet for percentages.
7. Evaluate the percentage of leaf material that is eaten by herbivores or infected by a disease or air pollution. Use the categories provided on the datasheets for percentages.
8. For each milkweed plant you record, measure out a one meter square with that plant directly in the center of the plot. Count the number of other milkweed plants inside the one meter square plot and record this on the datasheet.

IF YOU HAVE A BIG FIELD WITH LOTS OF PLANTS YOU WILL NEED TO SAMPLE PLANTS RANDOMLY TO FILL IN DATASHEET 4B:

Once you are done monitoring for monarchs, choose another random transect(s), and measure the characteristics of 30 random plants. This can be done by standing at some point in the site or on the edge and tossing your ruler, butterfly net, or pencil up into the air and walking in the direction it points. It is important to do this randomly so that you don't subconsciously start walking in a direction with good-looking or otherwise nonrandom plants. Random milkweed plants that you record can have monarch eggs or larvae on them; the point is that they are a random sample of the plants in your site.

Walk 10 paces (or 5 if your site is small) in your randomly selected direction, and follow steps 2-8 above for the closest milkweed plant to your feet. Be sure to look for plants of all sizes, including very small plants, and not to measure a more noticeable plant if an inconspicuous one is closer to your feet. Walk 10 (or 5) more paces and repeat this process. Continue until you have measured up to 30 random plants (in addition to the ones you've already recorded on Datasheet 4A). If you reach the edge of the field before you have measured 30 plants, then randomly choose another direction and begin again, or simply turn 90 degrees back into your site and walk another transect in that direction.

IF YOU HAVE A SMALL AREA FIELD WITH FEWER THAN 30 PLANTS, YOU SHOULD MEASURE ALL OF THE PLANTS:

All of the milkweeds at your site should be measured if you have fewer than 30. In this case, your plants that are occupied with monarchs will be part of the "random plant" survey, since you will measure all plants. You should record the data on these plants on both datasheets – you don't have to actually write the data down twice, but enter them onto the web site for both 4A and 4B. We will then be able to determine if your "occupied" plants are a non-random subset of all of the plants.

DATASHEET #4A: CHARACTERISTICS OF MILKWEED PLANTS WITH MONARCHS

Date: _____ **Observers:** _____ **Site Name:** _____

City: _____ **State:** _____

#/stage of egg/larva on plant	Other invertebrates on plant	Plant Height (cm)	Buds (Y/N)	Flowers (Y/N)	Seed Pods (Y/N)	Condition (1 = <5%, 2 = 5-40%, 3 = 41-80%, 4 = 81-100% yellowed or dying)	Herbivory/Disease (1 = 0%, 2 = <5%, 3 = 5-25%, 4 = >25% damaged)	# other milkweeds within 1 m^2	Milkweed Species
Example: 1egg, 1 4th	*Aphids, spider, tussock moth caterpillars*	*52*	*Y*	*N*	*N*	*1*	*2*	*1*	*Asclepias syriaca*

DATASHEET #4B: CHARACTERISTICS OF RANDOM MILKWEED PLANTS

Date: _____ **Observers:** _____ **Site Name**: _____

City: _____ **State:** _____

Plant #	Invertebrates on Plant	Plant Height (cm)	Buds (Y/N)	Flowers (Y/N)	Seed Pods (Y/N)	Condition (1 = <5% 2 = 5-40% 3 = 41-80% 4 = 81-100% yellowed or dying)	Herbivory/ Disease (1 = 0% 2 = <5% 3 = 5-25% 4 = >25% damaged)	# other milkweeds within 1 m^2	Milkweed Species
Ex:	*Monarch egg, lacewing egg, earwigs*	*30*	*N*	*N*	*N*	*1*	*1*	*12*	*Asclepias syriaca*
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
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Monarch Larva Monitoring Project

ACTIVITY #5: MONITORING MILKWEED FOR APHIDS

Objectives: We use data from this activity to document the seasonal and geographical spread of aphids and to test hypotheses about factors that affect aphid population growth, the extent to which they damage plants, and the ways the different aphids affect each other. There are three objectives associated with this activity. You may choose to record data for any or all of them.

Objective 1) For each species of milkweed at your site, identify the number of plants that support aphid populations of different species and sizes each week.

Objective 2) Record the number of plants of each species that are severely damaged due to aphids.

Objective 3) Estimate the number of mummies, ants, and insect predators found on each species of milkweed.

Methods: This activity is designed to complement **Activity 1 (Monarch Density)**, so you may use the same sampling scheme and monitor the same plants at the same time. As with monarchs, please record both the presence and absence of aphids on the plants. Aphids feed on stems, on top of and especially underneath leaves, and on the new leaves at the very tips of the plants. You can identify the aphids present in your site using the aphid identification cards. Three types of aphids are commonly found on milkweeds: the bright yellow aphid called *Aphis nerii*, the greenish/brownish aphid called *Aphis asclepiadis*, and the translucent or orange-striped aphid called *Myzocallis asclepiadis*. If you find a species of aphid that is not listed here, that's great! Please record as many observations as you can about this aphid species to share with us. If you can take a picture, we would also love to see that. The aphid identification cards also include pictures of some aphid predators, plants that are significantly damaged due to aphids (to help with objective 2) and parasitized aphid mummies (to help with objective 3).

DIRECTIONS FOR FILLING OUT DATASHEET #5

Write the name of the observers and site location at the top of your sheet. You will complete one column for each milkweed species at your site on each date. (So if you have only one milkweed species, you may use a single data sheet for 5 weeks, but if you have more than 5 milkweed species at your site, you will need more than one data sheet each week). At the top of the column, record the date and the temperature in the shade. In the next row, record the name of each milkweed species at your site, and the number of plants of that species that you observe at your site on that date. For each plant you observe, identify which species of milkweed it is, and record your data in the appropriate column.

Objective 1. Make one tally mark for every milkweed plant you observe. If there are no aphids on the plant, put a tally mark in the "0 aphids" box on the data sheet. If there are aphids on the plant, identify the aphid species and estimate the total number of living aphids. Do not count aphid exoskeletons, which are dry and gray or clear. Place a tally mark in the box with the appropriate range of aphid numbers on your data sheet. If there are more than one species of aphids on a single plant, write down the species names and abundance of each in the

"combinations" row of the data table. For example, a plant with 10-100 *Aphis nerii* and 1-10 *Aphis asclepiadis* would be recorded as "An 10-100+Aa 1-10". If you have multiple plants with the same combination of aphid species, use tally marks to identify the number of plants with each aphid combination.

Objective 2. Make a tally mark if the plant is significantly damaged because of the aphids. A plant can be identified as significantly damaged because of aphids if there is shiny honeydew or mildew on at least 2/3 of the leaves, and if the plant appears to be wilting or losing leaves as a result of this damage.

Objective 3. Keep an eye out for aphid mummies, ants, and potential predators on the plants. Parasitized aphid mummies look like swollen, brown or tan, shiny aphids. If you observe any mummies on a plant, please estimate the number and record that number in the box on the data sheet. Some ants will "tend" aphids, meaning they eat the sweet honeydew that aphids produce and, in exchange, protect the aphids from predators. If you observe any ants directly on the plants tending the aphids, please estimate the number of ants and record that number in the box on the data sheet. Many insects eat aphids, including ladybeetles and lacewings. If you observe any predators on the plant eating aphids, please estimate the number of predators and record that number in the box on the data sheet. If you can identify the predators, please include their names in your list of observations at the bottom of the data sheet.

Record any interesting observations at the bottom of the data table. Observations may include the identity of any of the predators, other herbivore species you observe on the plants, descriptions of plant quality, or aphid behavior. When aphids get crowded, they often develop wings, so this is something interesting to look for. Finally, if you take any action to remove aphids from your plants, such as using a stream of water to disperse them or killing them, please record that information as well.

Thank you for contributing to the aphid monitoring effort!

DATASHEET #5: MONITORING MILKWEED FOR APHIDS

Observers: _____ Site: _____

Codes: An=*Aphis nerii*; Aa=*Aphis asclepiadis*; Ma=*Myzocallis asclepiadis*.

	Date/Temp					
	Plant Species (#)					
Objective 1	1) 0 aphids					
	1) An 1-10					
	1) An 11-100					
	1) An 101-1000					
	1) An >1000					
	1) Aa 1-10					
	1) Aa 11-100					
	1) Aa 101-1000					
	1) Aa >1000					
	1) Ma 1-10					
	1) Ma 11-100					
	1) Ma 101-1000					
	1) Ma >1000					
	1) Combinations (list both aphid species and abundance for each)					
Obj. 2	2) Plants with aphid damage					
Obj. 3	3) Mummies					
	3) Ants					
	3) Predators					

On which dates, if any, did you first find aphids of this species with wings: An? Aa?
(Ma adults always have wings)

On which dates, if any, did you take action to control aphids at your site?

Observations (use back if necessary):

Three aphid species are commonly found on milkweed: A) the milkweed aphid *(Aphis asclepiadis)*, B) the oleander aphid *(Aphis nerii)*, and C) a light green aphid with no common name *(Myzocallis asclepiadis)*. *A. asclepiadis* is greenish-brown in color and often tended by ants. The ants consume the sugary honeydew that aphids secrete. *A. nerii* is bright yellow to warn predators that it has sequestered toxins from the milkweed. *M. asclepiadis* is almost translucent and sometimes has orange spots. All *M. asclepiadis* adults (but not the smaller nymphs) are winged, in contrast to the other aphid species where winged adults are rare. While *A. nerii* and *A. asclepiadis* tend to clump together, *M. asclepiadis* tend to spread out across a leaf. *A. asclepiadis* and *M. asclepiadis* are thought to be native to North America, but *A. nerii* was introduced from Europe, along with its other host, oleanders. Oleanders and milkweeds are in the same family. *Photos by K. Mooney and A. Agrawal.*

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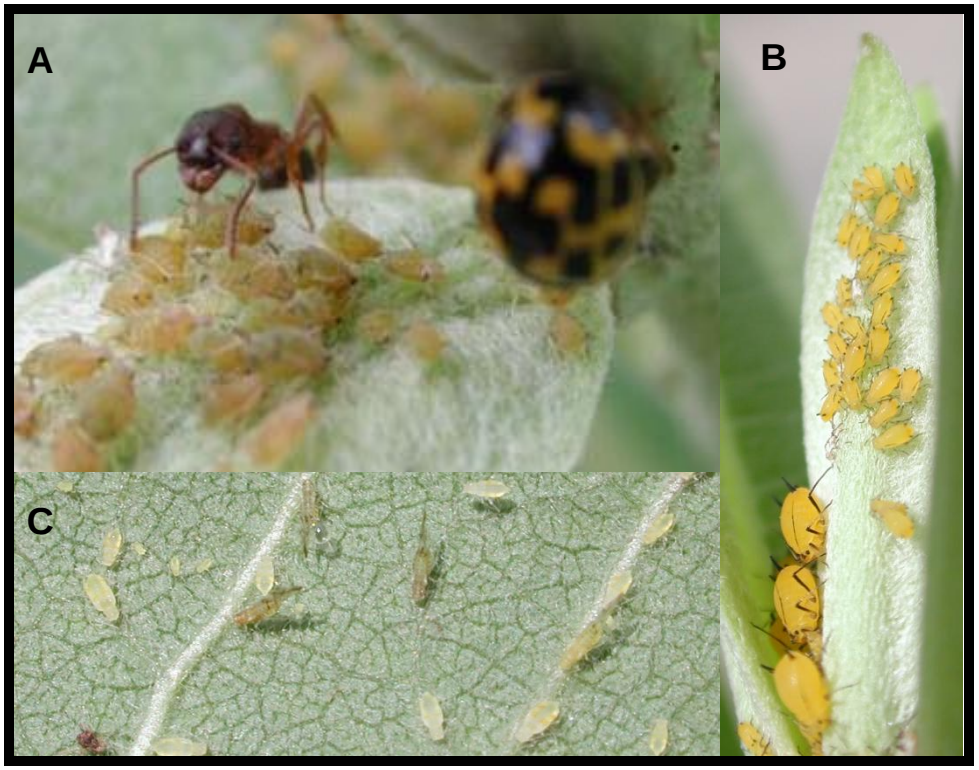

A) In most aphid species, adults are females that give birth to nymphs that are exact clones of themselves. This process is called parthenogenesis. In the fall, most aphids undergo a sexual reproductive phase, at which point they mate and lay eggs that overwinter. *A. nerii*, however, is an obligate parthenogen, so there are no males or eggs. B) Aphids molt 4 times between birth and their adult stage, leaving white exoskeletons behind on the leaf. This picture shows all 5 instars, or size classes, of aphids. C) As aphid nymphs mature, they must shed their old exoskeletons in a process called molting. This winged aphid emerges from its exoskeleton. D) Although all aphids have the genetic instructions for making wings, most adults do not have wings and stay on their original plant. When the population is overcrowded or the plant is stressed, more aphids develop with wings, allowing them to escape stressful conditions and colonize new plants. *Photos by E. Mohl.*

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The native wasp parasitoid *Lysiphlebus testaceipes* is one of the most common natural enemies of *Aphis nerii* and many other aphids. A) A female parasitoid forages on the bottom side of a milkweed leaf for aphids to attack. B) A female "stings" an aphid by inserting her ovipositor into its body. She lays one egg inside each aphid she stings. *Photos by E. Mohl.*

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A) Over the course of about a week, the aphid's body swells up as the parasitoid wasp larva develops inside. B) The aphid dies and turns into a brown or tan "mummy" as the parasitoid completes its development. C) The wasp emerges from the mummy through a round hole as an adult, usually about 10-14 days after the aphid was first stung. Pictured here is an empty soybean aphid mummy. The soybean aphid is another exotic host to *L. testaceipes*. *Photos by E. Mohl.*

Monarch Larva Monitoring Project

Aphis nerii reproduce prolifically, sometimes covering a plant. A) *A. nerii* prefer new plant growth and often colonize the tips of plants. Shown here near actual size, these two leaves host approximately 750 aphids. As the aphids grow through 5 instars, they molt, leaving white exoskeletons scattered on the leaf. B) As their populations grow, *A. nerii* also colonize plant stems and the undersides of leaves. *Photos by G. Bowers and E. Mohl.*

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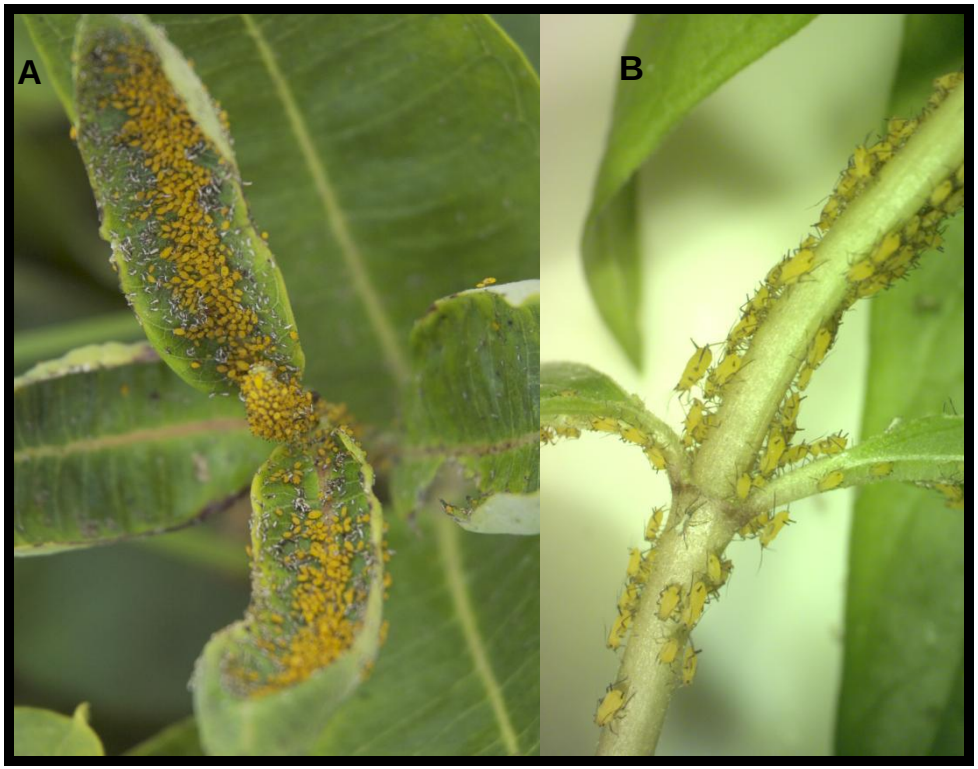

A) All aphids have mouth parts, called stylets, that allow them to feed on the sugars flowing through the vessels in the plant. B) Just as a mosquito is unlikely to do much harm to a person, a lone aphid will have little impact on a plant. However, when aphid populations grow, they can cover the leaves and stems and deplete the plant of important resources. Aphids can also transmit diseases between plants. C) Aphids do not need all of the sugar that they suck out of a plant, so much of it is secreted as sugary honeydew. Honeydew can cover leaves, making them very sticky. *Photos by E. Mohl.*

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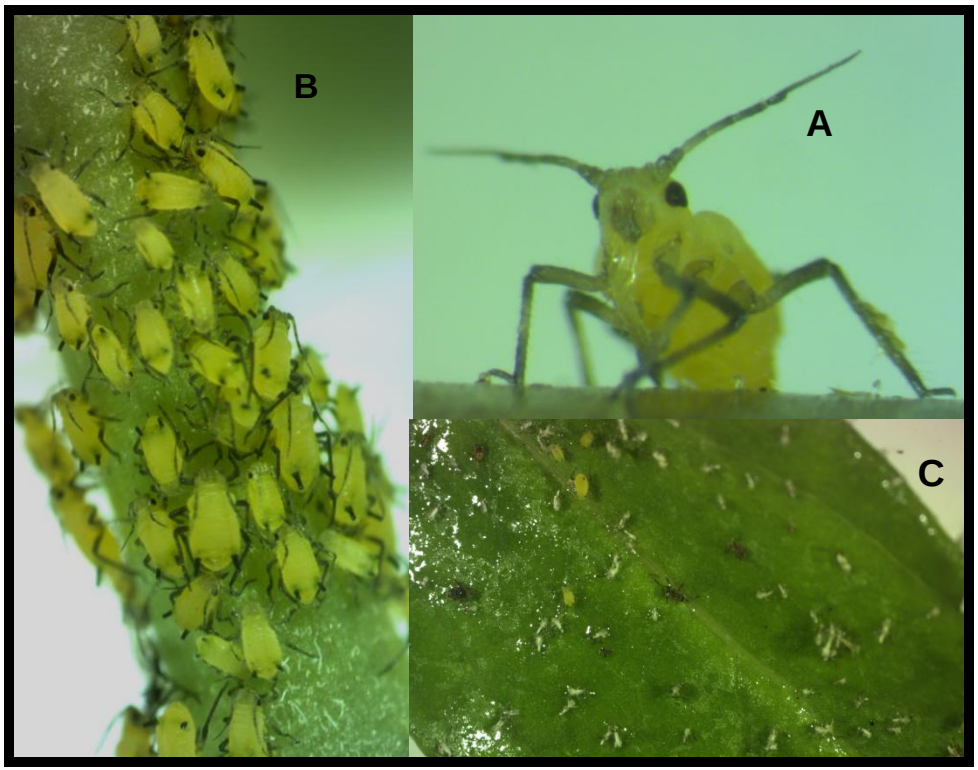
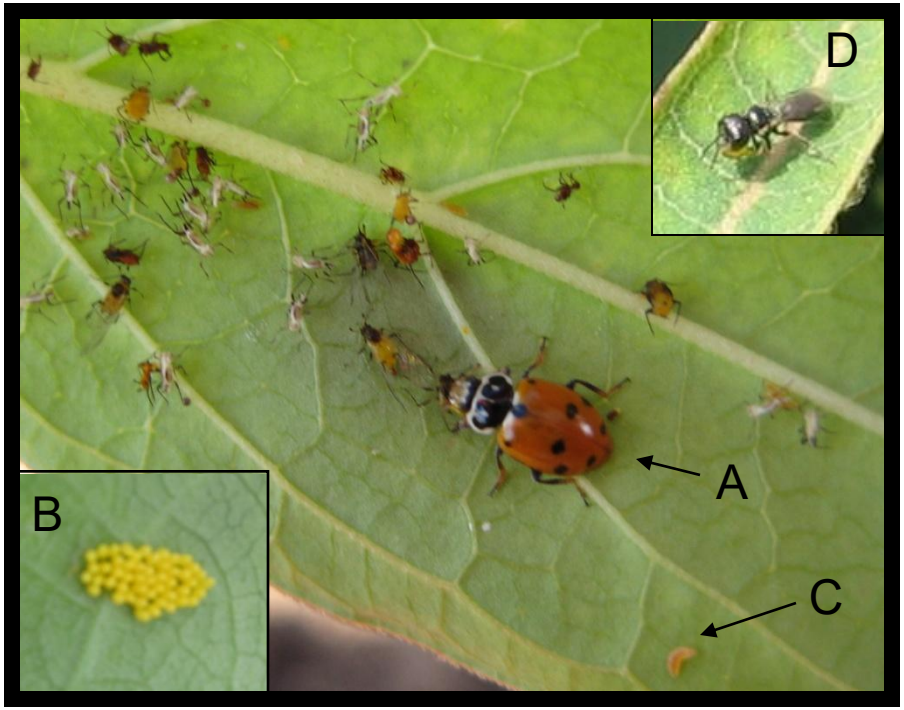


Many insect predators eat aphids. Some, like ladybeetles (A), consume the entire aphid. Ladybeetles often lay clusters of bright yellow eggs (B) on the underside of leaves on plants with aphids. Other predators, like fly larvae (C), pierce the aphids and suck out the juices. There are even some predators, like hunting wasps (D), that pick up aphids and carry them back to their nests to feed their young. *Photos by E. Mohl.*

Monarch Larva Monitoring Project



Aphids can significantly damage plants when they reach high densities. They suck the sugary fluid out of plants and excrete a sticky substance called honeydew. When enough aphids do this, the tops of leaves can become coated with the sticky honeydew and the plant starts to wilt (A). White or black mold can grow on the honeydew, preventing light from reaching the leaves. This can cause leaves to curl and become discolored (B). Ultimately, plants begin to lose their leaves as a result of aphid herbivory (C). Predators can benefit plants by consuming aphids, which often results in new plant growth. *Photos by E. Mohl.*

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