Introduction to the Unit:

In this unit, student groups compare two sets of habitats of milkweed bugs that were started at the same time. It is clear that reproduction has taken place in one set of habitats and not in the other. From this observation, students generate the question – "Why didn't the milkweed bugs in the second set of habitats reproduce?

Students then discuss their **own** experiences with populations that they raised at home or in school: mice, gerbils, goldfish, frogs, etc.. "Did these populations grow or stay the same size?" From this discussion the driving question of the unit is generated:

"What do I need to know in order to raise a population of any species at home?"

The rest of the unit concentrates on getting answers to that question. Parts of FOSS Investigations 1 (Milkweed Bugs) and 6 (Population Size) in the Populations and Ecosystems Course from the FOSS Middle School Program (2004, The Regents of California, p. 38 – 60;180 – 186) are utilized throughout the unit. Students observe milkweed bugs, make reproductive potential projections for a population of them and design their own investigations that determine the limiting factors that affect their population growth. The milkweed bug population investigations are linked to the students' world by asking students to identify what they learned that could help them raise a different species population at home.

Groups that were taught:
Two sections of 28 eighth graders

Unit Duration:
Eleven days of 50-minute class sessions, plus two weeks of 15-minute segments for observations.

Grades 5-8 National Science Education Standards addressed in this unit:
The Interdependence of Organisms – Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.

Grades 9-10 Massachusetts Science and Technology Curriculum Strands addressed in the unit:
Ecology 6.3 – Identify the factors in an ecosystem that influence fluctuations in population size.
NOTE: The curriculum in the school I was working specified that this strand be introduced in 8th grade.

Accredited Curriculum

- FOSS Populations and Ecosystems Course Investigation 1 Milkweed Bugs Part II
- FOSS Populations and Ecosystems Course Investigation 6:Population Size

Many **science processes** and **habits of mind** were emphasized in the unit. For that reason, they appear in each day's activity table rather than in this section.

The concepts **introduced** in this unit include:

- Population – all of the organisms of ONE species living in the same area at the same time.
- Population size – The number of organisms in a population
- Population growth – The change in a population's size
- Reproductive potential – Theoretical unlimited growth of a population; occurs under ideal environmental conditions.
- Limiting factors – biotic and abiotic factors in the environment that limit the size of a population.
- Insect diapauses – states of arrested development and/or reproduction that are induced by adverse environmental conditions.

Students should have prior knowledge of the following concepts BEFORE the unit begins:

- Taxonomy – a system for classifying organisms
- Species – the most specific level of taxonomy
- Insects – Arthropods with a head, thorax, abdomen, six legs, wings, antennae, compound eyes
- Habitat – the place where the organism lives that provides food and shelter for it.
- Abiotic – Non-living factors in an environment
- Biotic – Living or once-living factors in an environment
- Exponential growth – the larger a population gets, the faster it grows.

FOSS Materials used throughout the unit:

- FOSS Populations and Ecosystems Course Manual
- Investigation 1 Part I -Milkweed Bug Observation Sheets
- Investigation 6 -Milkweed Bug – Reproductive Potential Lab Notebook Page 27
- Investigation 6 – Transparency #13
- Investigation 1 Part II – "A Habitat for Milkweed Bugs", Lab Notebook p. 2-4

Instructor Preparation Before the Unit Begins:

The instructor should plan out students groups of four each, utilizing the "Factors to Consider when Forming Groups" in Table 6.1 of our textbook, "Teaching Science in Elementary and Middle School Classrooms" (2003, Krajcik/Czerniak/Berger, p. 213).

The materials prep work that is required BEFORE the unit begins is significant. The instructor will use the instructions from pages 47-55 in the FOSS Populations and Ecosystems Course (Investigation 1) to assemble and maintain two separate environments for milkweed bug "zip-bag" habitats for about two weeks prior to the start of the unit.

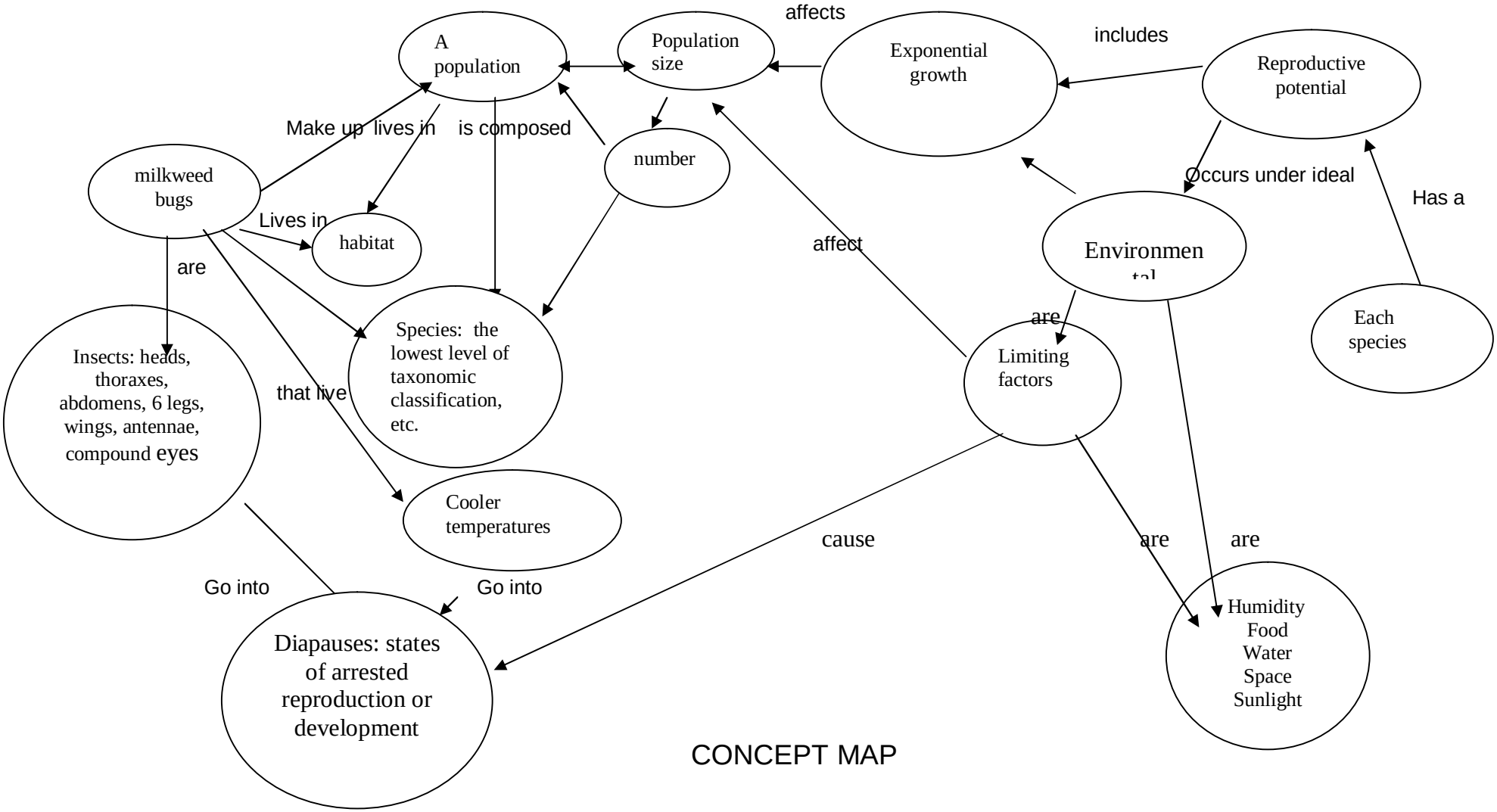
Each habitat will have one male and one female milkweed bug, a water wick fountain, shelled sunflower seeds, a piece of netting, a piece of polyester wool, and twigs.

One environment for half of the habitats (which will be called "Type A" habitats) will be kept at 68 to 75 degrees Fahrenheit temperature; it will be supportive for reproduction and population growth. The other environment for the second set of habitats ("Type B") will be kept at 50 - 60 degrees Fahrenheit and is not supportive for reproduction and population growth.

The materials for creating 16 zip-bag habitats (8 in each environment) and the two environments are:

- Sixteen 4 liter zip-bags
- Vials with caps
- Clear plastic tubes
- 10 cm x 10 cm pieces of paper towels
- Jumbo paper clips
- Unsalted sunflower seeds, raw, shelled
- Water
- 10 cm x 10 cm pieces of netting
- Rubber bands
- Polyester wool
- 20- 30 cm twigs
- Pushpins
- Pencils
- Washcloths
- Freezer packs
- Temperature probes
- Humidity probes
- Light probes
- Pieces of corrugated cardboard
- Thin curtain rods or sticks 1-2 feet long
- Aluminum foil
- Corrugated cardboard boxes
- Heat and/or light lamps

The instructions for the preparation of the habitats are on pages 47 – 53 (Investigation 1 Part II) of the FOSS Populations and Ecosystems Manual.


A population
Population size
affects
Exponential growth
includes
Reproductive potential
Make up
lives in
is composed
number
milkweed bugs
Occurs under ideal
Has a
Lives in
habitat
affect
Environmen tal
are
Each species
Insects: heads, thoraxes, abdomens, 6 legs, wings, antennae, compound eyes
Species: the lowest level of taxonomic classification, etc.
are
Limiting factors
that live
Cooler temperatures
cause
are
are
Go into
Go into
Humidity
Food
Water
Space
Sunlight
Diapauses: states of arrested reproduction or development

CONCEPT MAP

DAY ONE

Relationship of Lesson to the Unit:
Initial Exploratory Observation of Two Milkweed Bug Habitats

Curriculum Strands addressed:
The same strands that appear in the unit section at the front of this document.

Accredited Curriculum

- FOSS Populations and Ecosystems Course Investigation 1 Milkweed Bugs Part II

Science Processes

- Observation·
- Estimating·
- Collecting data·
- Inferring
- Communication

Habits of Mind

- Be curious, careful and accurate in observations.
- Be open-minded.

Concepts

- A habitat is a place where an organism lives that provides food and shelter for the organism
- A population is all of the individuals of one species that are living in the same area at the same time.
- "Population Size"is the number of one species living in an area.

Session Length:
50 minutes

Materials needed for the entire class

- A clothesline strung out across the front of the classroom.
- Posters, easels, markers

Materials needed for each group.

- Two banana hooks **OR** dowel stands (instructions for building dowel stands are on page 56 of the FOSS Populations and Ecosystems course.) that will display the habitats.
- One "Type A" milkweed bug zip-bag habitat that has been kept in the supportive environment. It will have a male and female adult milkweed bug, instars and/or eggs, a water wick fountain, twigs and shelled sunflower seeds.
- One "Type B" milkweed bug zip-bag habitat that has been kept in the non-supportive environment. It will have a male and female adult milkweed bug, instars and/or eggs, a water wick fountain, twigs and shelled sunflower seeds.
- Milkweed Bug Observation Data sheets

TIME	PROCEDURE	CONCEPT
Prep Work	Remove the milkweed bug habitats from their respective environments and hang them on the clothesline.	
9 to 9:20	The student groups will bring one "Type A" habitat and one "Type B" habitat back to their group table and hang them on the banana hooks (or dowel stands). Let the students "ooh" and "ahh" over their habitats for a few minutes, and then ask students to observe and diagram the bugs, to list the items in each habitat, to estimate the number of bugs and eggs in each habitat, and to write down questions. Explain that the observation/data sheets will be handed in at the end of the period. The teacher will circulate the room observing the students quality of participation.	PROCESS SKILLS • Observation • Communication HABIT of MIND • Be curious, careful and accurate in observations. • Be open-minded, listen to other's point of view

9:20 – 9:50	The ensuing entire-class discussion should give students an opportunity to present their observations and questions. These should be posted. The instructor can answer questions on what the species is (review species and taxonomy at the same time), which one is male/female, the eating and drinking, but should NOT answer questions about the environments that the habitats were kept in. The students will observe that the "Type A" habitats have babies and the "Type B" habitats have no babies. The question, "Why don't the "B" bags have any babies?" should be generated from the class; the instructor should not answer it. The students should present their own ideas on whether this is a problem and make inferences about the cause. The instructor should post these. During this discussion, the instructor should also introduce and clarify: • Habitat • Population • Population size Students will hand in their observation data sheets. HOMEWORK: Essay question: Compare the Type A and Type B habitats you observed today? What were their similarities and differences? Use the words species, habitat, population and population size in your answer.	PROCESS SKILLS • Communication • Inferring HABIT of MIND • Curiosity CONCEPTS: • A ***habitat*** is a place where an organism lives that provides food and shelter for the organism. • A ***population*** is all of the individuals of one species that are living in the same area at the same time. • ***Population Size*** is the number of organisms in a population. • *Taxonomy* – a system for classifying organisms • ***Species*** – a category of organisms at the most specific level of the Linnean taxonomy, • *Taxonomy* – a system for classifying organisms
	Put the zip-bag habitats back in their appropriate environments	

RUBRIC FOR OBSERVATION Period

PROCESS SKILL	Poor –0	Fair-1	Good-2	Excellent-4
Observation Engagement Is the student engaged in making observations?	Student is not participating	Student is intermittently engaged.	Student is engaged most of the time	Student is actively engaged for the duration of the observation period
HABITS OF MIND Be careful and accurate in observations				
a. Habitat Diagrams	No diagram	Diagram is not drawn accurately	Diagram is drawn accurately but not labeled	Diagram is drawn and labeled accurately
b. Habitat Content List	No content list	More than two items missing from the list	One or two items missing from the content list	Content list includes all items in each habitat
c. Behavior Observation	No behavior observation	---	----	A behavior observation is present
d. Estimate	No estimate		-	An estimate is present
Curiosity and Formulating Questions	No questions on the observation sheets	One descriptive question on the observation sheet	Two or more descriptive questions on the observation sheet	More than two questions on the observation sheets, at least one is a relational or cause and effect question

DISCUSSION PERIOD RUBRIC

PROCESS SKILL Communication Is the student participating in the discussion?	Student is inattentive and engages in off-task behavior for the majority of the discussion	Student attends to most of the discussion, engages in off task behavior for part of the discussion	Student attends to the entire discussion, but does not ask a question or respond to another student	Student either asks a question or responds to another student.
HABITS OF MIND Curiosity and Formulating Questions	No questions in the discussion	One descriptive question in the discussion.	Two or more descriptive questions in the discussion	More than two questions in the discussion; at least one is a relational or cause and effect question

HOMEWORK RUBRIC: Compare the Type A and Type B habitats you observed today? What were their similarities and differences? Use the words species, habitat, population and population size in your answer.

Analysis, Concepts (habitat, population, etc..), Clarity	No analysis, no concepts, unclear statements.	One similarity, one difference, one concept that is defined, and some clear statements	One similarity one difference, all five concepts, but they are merely defined.	At least one similarity and difference, all five concepts mentioned, at least one of the five concepts is explained.

DAY 2

Relationship of Lesson to the Unit:
Discussion of Exploratory Observation

Curriculum Strands addressed:
The same strands that appear in the unit section at the front of this document.

Accredited Curriculum
- FOSS Populations and Ecosystems Course Investigation 1 Milkweed Bugs Part II

Science Process Skills:
- Observation
- Communication

Science Habits of Mind
- Be curious, careful and accurate in observations.
- Be open-minded, willing to listen to other people's point of view.

Session Length:
50 minutes

Materials utilized by each group.

- Each group should have their Type "A" and Type "B" milkweed bug habitats at their tables
- Milkweed Bug Observation Sheets

TIME	PROCEDURE	CONCEPT, PROCESS SKILLS, HABITS OF MIND
PREP WORK	Remove the milkweed bug habitats from their storage environment and hang them on the clothesline.	
9 to 9:05	The groups should observe their habitats for a few minutes and take note of anything they did not observe the day before.	PROCESS SKILLS • Observation SCIENCE HABIT of MIND • Be curious, careful and accurate in observations.
9:05 – 9:50	DISCUSSION: • Talk about new observations for a minute or two. • Continue the previous day's discussion by restating, "Why don't the "Type B" habitats have any babies?" and the inference that "something is wrong with the "Type B" habitats." • What will happen if a population does not reproduce enough? What populations near your home are disappearing? How do you feel about that? • Do you know of a population that is near your home that there is too much of? How do you know that there is too much of that population? How do you feel about that? • Have you ever raised a population at home? What species? How many did you start with? How did you know what to do? Did they have any babies? Why/why not? **Guide this final question until the driving question of the unit is generated**: "**WHAT DO I NEED TO KNOW ABOUT A SPECIES IN ORDER TO RAISE A POPULATION OF THEM?"** Post the responses, and then ask, "Suppose you did everything you could to support your population. How much reproduction should you expect? What would your population size be in one year? Post these responses.	PROCESS SKILLS • Communication HABIT OF MIND • Be curious **DRIVING QUESTION** **"What do I need to know about a species in order to raise a population of them?** REVIEW CONCEPTS: • Habitat • Population • Population size
	Put the zip-bag habitats back in their appropriate environments IMMEDIATELY AFTER THE CLASS LEAVES.	

DAY 3

Relationship of Lesson to the Unit:
FOSS Benchmark Lesson/Inquiry on Reproductive Potential

Curriculum Strands addressed:
The same strands that appear in the unit section at the front of this document..

Accredited Curriculum
- FOSS Populations and Ecosystems Course Investigation 6: Population Size

Science Process Skills:
- Observation
- Communication
- Using numbers
- Predicting

Science Habits of Mind:
- Be curious, careful and accurate in observations.

Concepts:
- Reproductive Potential is the theoretical unlimited growth of a population over time that occurs under ideal conditions.

Session Length:
50 minutes

Other Subject Area Objectives:
Math - Exponential Growth

Materials Needed for the Teacher
- The FOSS Populations and Ecosystems Manual
- Overhead Projector
- Transparency #14 – Milkweed Bugs Reproductive Potential

Materials Needed for Each Group.
- The "Type A" and "Type B" habitats
- Milkweed Bug observations sheets
- Milkweed Bug: Reproductive Potential Activity Sheet (see Appendix A for a model of this).
- Calculators

TIME	PROCEDURE	PROCESS SKILLS, CONCEPTS, HABITS OF MIND
	The teacher should remove the milkweed bug habitats from their storage environment and hang them on the clothesline.	
9 to 9:05	The groups should observe their habitats for a few minutes and take note of any changes. Each student should have the Milkweed Bug Reproductive Potential worksheet Lab Page 27 (shown in Appendix A)	SCIENCE PROCESS SKILLS • Observation SCIENCE HABIT OF MIND • Be curious. Be careful and accurate in observations.
9:05to 9:50	**Benchmark Lesson –** FOSS Populations and Ecosystems Investigation 6: Population Size • Reread the posters created the day before with the driving question and the information needed to project the population for a species that students would like to raise at home. State that in today's lesson, students will project the population of milkweed bugs to learn the important factors that affect population growth for any species. • The instructor should start at Step 3 on page 180 – Introduce Reproductive Potential. • Students are introduced to Reproductive Potential and the factors needed to make a population projection for any species: o Life span o Mating age o Reproduction age o Number of offspring o M/F birth ratio • Students are told the population starts with one male and one female milkweed bug and then they **estimate** the population size after one year. • Students project the milkweed bug population at two-month intervals up to one year. **This is a difficult activity.** The FOSS curriculum gives the option of using a student-group format or a direct teaching format for this. If direct teaching is chosen, the instructor should utilize transparency #14. • Regardless of the chosen format, the instructor should **thoroughly** circulate the room to assist the students, and provide facilitating questions: o Do all of the milkweed bugs reproduce? (No, just the females). o How many times do they reproduce before they die? (once) o Additional facilitating questions • The instructor should assess the students by rating their level of engagement with the activity and their ability to communicate their need for assistance to the members of their group and/or the instructor.	SCIENCE PROCESS SKILLS • Using numbers • Communicating • Estimating • Predicting CONCEPTS: • Reproductive potential is the theoretical unlimited growth of a population under ideal conditions. • Life span • Mating age • Reproduction age • Number of offspring • M/F birth ratio

	HOMEWORK: Students should make a concept map showing how the following concepts are related: • Reproductive potential • Population • Population size • Life span • Mating age • Reproduction age • Number of offspring • M/F birth ratio	
	Put the zip-bag habitats back in their appropriate environments IMMEDIATELY AFTER THE CLASS LEAVES.	

BENCHMARK LESSON RUBRIC

PROCESS SKILL	Poor -0	Fair-1	Good-2
Communication Is the student effectively participating and/or collaborating in the activity? Does the student ask for help when stuck?	Student is not participating and/or collaborating and does not ask for help.	Student attends/participates for part of the lesson but gets stuck in certain areas and does not ask for help.	Student attends/participates for the entire lesson and asks the teacher or another student for help if he/she is not able to complete the work.

CONCEPT MAP RUBRIC

CONCEPTS	Poor -0	Fair-1	Good-2	Excellent
Are the relationships between the concepts correct? • Reproductive potential • Population • Population size • Life span • Mating age • Reproduction age • Number of offspring • M/F birth ratio	Student connected and labeled 20% of the relationships correctly	Student connected and labeled 40% of the relationships correctly	.Student connected and labeled 60% of the relationships correctly	Student connected and labeled 80% or more of the relationships correctly

DAY 4

Relationship of Lesson to the Unit:
Conclusion of Benchmark Lesson

Curriculum Strands addressed:
The same strands that appear in the unit section at the front of this document are addressed in this activity.

Accredited Curriculum
- FOSS Populations and Ecosystems Course Investigation 6: Population Size

Science Process Skills:
- Communication
- Interpreting data
- Inferencing
- Hypothesizing

Science Habit of Mind:
- Be curious. Be careful and accurate in observations.

Concepts:
- Reproductive potential is the theoretical unlimited growth of a population over time that occurs under ideal conditions.
- The reproductive potential for every species is different because the factors that determine reproductive potential have different values.

Other Subject Area Objectives:
Math - Exponential Growth

Materials for the class
- Laptop Computer
- LCD projector

Materials for each group.
- Observation recording sheets
- "Type A" and "Type B" habitats
- Milkweed bug activity sheets
- Calculators
- Graph Paper

Session Length:
50 minutes

Lesley University School of Education Activity Plan submitted by Avis A. Quint		
TIME	PROCEDURE	CONCEPT
PREP WORK	The laptop/LCD projector combo should be set up (but not displayed) at: http://www.otherwise.com/population . The type A and Type B milkweed bug habitats should beat the group tables.	

9:00 to 9:50	• Ask students to hand in the concept map that they did for homework. **INTERPRETING THE RESULTS OF FOSS BENCHMARK INQUIRY – Direct Teaching Activity** • Summarize the previous day's activities and state that they will help identify what you need to know to predict a population size for any species – goldfish, guinea pigs, etc..Restate the benchmark concepts identified on the previous day. • The instructor should point out that the reproductive potential population projection at one year shows a population of 32 million milkweed bugs. Put this in context by pointing out concrete examples of 32 million bugs. • Show that the reproductive growth rate is actually an exponential growth rate (The instructor will have to review exponential growth with various mathematical examples) • Students groups should collaborate graphing the reproductive potential growth rate for milkweed bugs. (One graph per group) • Turn on the laptop/LCD projector combo; it should be at http://www.otherwish.com/population. The simulation starts with one male and one female fish (M/F birth ratio is standard at 50%). Run the simulation. Compare the computer simulated projection graph with the 2-month point on the manual graph that students just created for the bugs (they should be identical), Point out that during exponential population growth, the slope of the "population growth line" is very steep because the population is growing at an explosive rate. • Ask the class to assume that the fish in the computer simulation are goldfish. Ask a student how many babies goldfish really have. Change the number of offspring in the simulation to the estimate and rerun the simulation. Students should observe/comment on the difference in the first and second projections. Assist the students with concluding that the reproductive potential is different for every species because IN THE REAL WORLD the factors that determine it have different values. Give examples of species with different life spans, number offspring etc.. and then ask the students to give some of their own examples. • Ask the students to compare **both** reproductive potential graphs to the milkweed bug zip-bag habitats sitting on the tables. Which habitats are "on track" for reproductive potential growth? What does that tell you about these populations and their habitats? **Populations growing at the reproductive potential growth rate are in habitats with ideal environmental conditions.** HOMEWORK: Answer the following questions: • The slope of the population growth line is very steep for a population growing at reproductive potential. Why? • Suppose you had to raise two different species at home and you found their reproductive potential population projections already graphed on the Internet. Why would the projections be different?	SCIENCE PROCESS SKILLS • Using numbers • Communicating • Predicting • Modeling • Graphing CONCEPTS: • Reproductive potential • Exponential growth • The reproductive potential for every species is different because IN THE REAL WORLD the factors that determine reproductive potential have different values. • Populations growing at the reproductive potential growth rate are in habitats with ideal environmental conditions. :
	Put the zip-bag habitats back in their appropriate environments	

BENCHMARK LESSON RUBRIC

PROCESS SKILL	Poor -0	Fair-1	Good-2
Communication Is the student effectively participating and/or collaborating in the activity?	Student is not participating and/or collaborating and does not ask students or the teacher for re-clarification of concepts.	Student attend/participates for part of the lesson but if off task for parts of the lesson and does not ask for re-clarification of concepts.	Student attends/participates for the entire lesson and asks the teacher or another student to re-clarify something.

HOMEWORK RUBRIC

- The slope of the population growth line is very steep for a population growing at reproductive potential. Why?

CONCEPT	Poor -0	Fair-1	Good-2	Excellent
A population growing at reproductive potential is experiencing exponential growth because the population is growing under ideal environmental conditions.	The student indicates that reproductive potential growth is "explosive" or "fast".	The student indicates that reproductive potential growth is fast or explosive, but does not say why.	The student indicates that reproductive potential growth is "fast" or "explosive" and states that conditions must be ideal for that species.	The student indicates that reproductive potential growth is exponential growth and can give a mathematical example of exponential growth. The student states that conditions are ideal for that species. The student explains some of the environmental conditions that might affect population growth.

- Suppose you had to raise two different species at home and you found their reproductive potential population projections already graphed on the Internet? How and why would the projection lines be different?

CONCEPT	Poor -0	Fair-1	Good-2	Excellent-3
The projection lines would have different slopes because the values of the factors that are used for the reproductive potential projections might be different (life span, number of offspring, etc.)	The student does not mention that different species might have different reproductive potentials.	The student states that reproductive potentials for two different species are different but does not explain what factors affect reproductive potential.	The student identifies and explains the factors that are included in reproductive potential projections and that they would have different values for different species.	The student identifies and explains the factors that are included in reproductive potential projections and that they would have different values for different species. The student explains that the slope of the line would be steeper for the species with the greater reproductive potential.

Day 5

Relationship of Lesson to the Unit: Students create investigation questions about environmental factors that affect population growth in milkweed bugs.

Curriculum Strands addressed:
The same strands that appear in the unit section of this document are addressed in this activity.

Science Process skills:
- Communication

Science Habit of Mind:
- Be curious, careful and accurate in observations.
- Open-mindedness, listening to other peoples points of view.

Concepts:
- A limiting factor is anything in the environment that limits the growth of a population.
- Cause and effect questions to be determined by the students.

Session Length:
50 minutes

Materials for the class
Discussion posters

9:00 – 9:40	Ask students to hand in the reproductive potential graph they did for homework. Hand back and review the concept map. DISCUSSION 1. Restate the driving question (What do I need to know in order to raise a species population?) We need to know the reproductive potential for the species: o Life span under ideal conditions o When they reproduce under ideal conditions o Litter size under ideal conditions o M/R offspring ratio under ideal conditions • We need to know the best environment conditions to raise them in (Food, water, habitat type, habitat size, temperature, humidity, etc..) 2. How do you determine which of the above environmental conditions affect reproduction and population growth? Introduce the concept of limiting factors. 3. What questions could you investigate that would tell you which conditions could be limiting factors? (Post these). 4. Assist the students with transforming the questions that they generated into cause and effect questions that they can investigate. For example: Student Question: What food is best for them? Final Cause and Effect question: "Does diet affect milkweed bug reproduction population growth? Student Response: We need to know the temperature that is best for them. Intermediate Relational Question: Do milkweed bugs like a warm or cold climate? Final Cause and Effect Question: " Does habitat temperature affect reproduction and population growth?" 5. Some of the cause and effect questions will not be feasible to investigate – i.e. "Can disease limit reproduction and population growth?" These should be eliminated from the list of possible investigations.	PROCESS SKILLS • Communication HABIT of Mind • Open-mindedness, listening to other peoples points of view. CONCEPT • A limiting factor is anything in the environment that limits the growth of a population.
9:40-9:50	Each student will select two of the cause and effect questions generated by the class to investigate (they should identify a first and second choice).	PROCESS SKILLS • Communication

Day 6

Relationship of Lesson to the Unit:
Students research their investigative questions.

Curriculum Strands addressed:
The same strands that appear in the unit section at the front of this document are addressed in this activity.

Science Process Skills:
- Communication

Science Habits of Mind:
- Buttress statements with facts found in outside sources, identify sources.
- Recognize that some comparisons may not be fair because some conditions are not kept the same.
- Question claims made on vague attributions or from unqualified sources.

Concepts:
- A limiting factor is anything in the environment that limits the growth of a population.
- Cause and effect questions to be determined by the students.

Pre-Class Instructor Preparation
The instructor needs to reorganize the investigation groups so that each student gets to investigate one of the cause and effect questions that he/she selected on Day 5. The factors listed in Table 6.1 on page 213 of our textbook, "Teaching Science in Elementary and Middle School Classrooms" (2003, Krajcik/Czerniak/Berger, p. 213) should be considered when reorganizing the groups.

Location
This session will take place in the library

Session Length:
50 minutes

Materials for Each Group.
- Field guides
- Internet work stations

Lesley University School of Education Activity Plan submitted by Avis A. Quint		
9:05 – 9:50	The instructor will announce the student groups for each investigative question. The students will come up with a team name and a motto for their group and then research their question in the library. Students can utilize: • Pre-printed web pages obtained from utilizing the SciLinks. • Internet web-searching • Field guides and other published resources. The instructor should circulate the rooms and assist the students in locating, utilizing and **EVALUATING** their resources.	PROCESS SKILLS • Communication HABIT of MIND • Buttress statements with facts found in outside sources, identify sources. • Recognize that some comparisons may not be fair because some conditions are not kept the same. • Question claims made on vague attributions or from unqualified sources.

DAYS 7, 8, 9

Relationship of Lesson to the Unit: Students will design and engage in their investigations.

Accredited Curriculum

- FOSS Populations and Ecosystems Course Investigation 1 Milkweed Bugs Part II

Curriculum Strands addressed:
The same strands that appear in the unit section at the front of this document are addressed in this activity.

Concepts:

- A limiting factor is anything in the environment that limits the growth of a population.
- Cause and effect questions to be determined by the students.

Materials to be utilized during the design process

- Investigation planning and design charts
- Investigation goal sheets
- "A Habitat for Milkweed Bugs" Instruction sheets from FOSS (Investigation 1:Part II)
- The "Type A" and "Type B" habitats

Materials on display that the students could use in their investigations

- Banana hooks/dowel stands
- Petri dishes with male adult milkweed bugs who have been kept in a supportive environment
- Petri dishes with female adult milkweed bugs who have been kept in a supportive environment
- A size variety of clear plastic zip bags, blanket bags, sheet bags, toy bags
- Vials with caps
- Clear plastic tubes
- 10 cm x 10 cm pieces of paper towels
- Jumbo paper clips
- Packages of unsalted sunflower seeds, raw, shelled
- Packages of salted sunflower seeds, shelled
- Bottled water
- Juice boxes of different types
- 10 cm x 10 cm pieces of netting
- Rubber bands
- Polyester wool
- 20 30 cm twigs
- Pushpins
- Pencils
- Washcloths
- Freezer packs
- Temperature probes/Palm Pilots
- Humidity probes/Palm Pilots

- Light probes/Palm Pilots
- Pieces of corrugated cardboard
- Thin curtain rods or sticks 1-2 feet long
- Heat and light lamps
- Aluminum foil
- Corrugated cardboard boxes of different sizes
- Markers

DESIGNING THE INVESTIGATION

TIME	PROCEDURE	CONCEPT
	The instructor should have the materials that the students will utilize in their investigations on a table at the center of the room. The instructor should remove the Type "A" and Type "B" milkweed bug habitats from their storage environment and hang them on the clothesline.	
9 to 9:15	• The instructor should explain that it is an investigation design day – students will not engage in their investigations until the following days. • Instruct the students to use the expanded goal sheets and planning/design charts for the planning phase. Students need to assign the following roles on the expanded goal sheets: o Getter – gets materials and puts them away o Encourager – is responsible for making sure each member of the group gets the necessary support (scaffolding) when needed o Task keeper/Timer – Makes sure members are on task and are aware of time limits. o Recorder – responsible for journaling ALL information on the planning and design charts, the investigation question, variables, hypothesis, roles, procedures, equipment list, investigation data, conclusions, evaluations etc. • Communicate to students that the group journal will be the primary assessment tool for the investigation and give them the journal rubric. • The instructor should show the students the "materials" table, and point out the FOSS instructions for building "zip-bag" habitats, but emphasize that students are not limited to "zip-bag" habitats or the materials on the table. They can ask for or bring in their own materials if they wish to build other types of habitats.	SCIENCE PROCESS SKILLS: • Communication • Defining variables operationally • Formulating a hypothesis • Predicting • Inferring SCIENCE HABITS OF MIND: • Open-mindedness, respect another's point of view. • Know why in science it is important to keep clear, honest and accurate records. • Recognize when some comparisons may not be fair because some conditions are not kept the same.

9:16 to 9:50	The groups will engage in the planning of their investigations. ' Students should collaborate effectively and provide scaffolding support to each other. The teacher will circulate the room to monitor and assess selected students' collaboration skills and to provide scaffolding support to groups who are not making progress with their plans.	PROCESS SKILLS: • Communicating • Identifying variables/defining operationally • Formulating a hypothesis • Predicting • Inferring HABITS OF MIND: • Open-mindedness, respect another's point of view. • Know why in science it is important to keep clear, honest and accurate records. • Recognize when some comparisons may not be fair because some conditions are not kept the same.

Rubric for Investigation Design Charts and Expanded Goal Sheets

PROCESS SKILLS	Poor -0	Fair - 1	2 -GOOD	EXCELLENT 4
Define variables operationally	Both independent and dependent variables not defined clearly. Students do not state the other variables that are controlled.	Either the independent or dependent variable not defined clearly. Students state the other variables that are controlled.	All variables designed clearly and the student states the other variables that are controlled.	
HABIT OF MIND Know why some comparisons may not be a fair test	More than one independent AND dependent variable	One independent OR one dependent variable.	One independent and one dependent variable	
HABIT OF MIND Know why it is important to keep clear honest and accurate records	Procedures not written up. Measurement and observation schedule not filled in. Equipment not identified. Student roles not defined.	30% not filled in	20% or less not filled i	100% complete

Engage in the investigation

TIME	PROCEDURE	CONCEPT
	The instructor should have all of the materials that the students will use on a table at the center of the room.	
9:15 to 9:50	Student groups will finish planning and then engage in their investigations. Students who are more capable in one particular can provide scaffolding support to students who need assistance. The instructor should circulate the room: • To monitor collaboration between the members of the group. • To provide scaffolding support to groups who are not making progress with their plans.	PROCESS SKILLS: • Communicating • Predicting • Controlling variables • Experimenting HABITS OF MIND: • Open-mindedness, respect another's point of view. • Recognize when some comparisons may not be fair because some conditions are not kept the same.
	Put the zip-bag habitats and the Petri dishes with the milkweed bugs back in their appropriate environments IMMEDIATELY AFTER THE CLASS LEAVES.	

COLLABORATION SKILLS RUBRIC

	Fair1	**Good 2**	**Excellent 3**
Habit of Mind - Open-minded ness, respect another's point of view	The student either does not listen to another student's point of view and/or tries to implement his suggestions without getting consent from the majority of the group **IN THE MAJORITY OF INSTANCES**.	The student either does not listen to another students point of view or tries to implement his suggestions without getting permission from the majority of the group **IN SOME INSTANCES**	The student listens to other student's point of view and does not try to implement his suggestions without the consent of the majority of the group.
Students communicate their need for assistance to each other and/or the instructor.	Student is off task for most of the time and has not requested help.	Student is off task some of the time and has not requested help.	Student is on task or has requested help from students and/or the instructor as needed.

2 WEEK OBSERVATION PERIOD

Curriculum Strands addressed:
The same strands that appear in the unit section of this document are addressed in this activity.

Accredited Curriculum
- FOSS Populations and Ecosystems Course Investigation 1: Milkweed Bugs

Materials needed for each group

- Digital Cameras
- Observation/Data sheets designed by the students.

TIME	PROCEDURE	CONCEPT
	During the two-week observation period, the groups will be given 15 minutes per day to maintain the habitats and record their observations and measurements, etc..	PROCESS SKILLS: • Communicating • Observations • Collecting data HABITS OF MIND • Be curious, careful and accurate in observations. • Know why in science it is important to keep clear accurate and honest records.

DAY 10

Relationship of Lesson to the Unit: In this lesson, students will interpret and transform their data from their investigations.

Curriculum Strands addressed:
The same strands that appear in the unit section of this document are addressed in this activity.

Process Skills:
- Using numbers
- Interpreting data
- Graphing
- Evaluate

Habits of Mind:
- Keep records of the investigation and not change them later.
- Look at a matter from many sides before drawing a conclusion.
- Be open-minded, willing to change your mind in the face of reliable evidence.
- Offer reasons for findings and consider reasons suggested by others.

Materials for each group
- Large poster board or freezer paper
- Markers
- All documentation materials pertaining to their investigations.

Session Length:
50 minutes

TIME	PROCEDURE	CONCEPT
9:00 to 9:50	• Student groups will transform the data by manually graphing the actual population growth for each habitat on one of the reproductive potential graphs that they created on Day 4. • Student groups will make a poster whose primary purpose is to communicate a summary of the investigation to the rest of the class. It should: o Restate the investigation question and the hypothesis o Summarize and document (photos) the investigation o States the conclusions that may be inferred from the data especially: ▪ The relationship between the independent variable and reproduction/population growth. ▪ Which habitat, (if any) achieved or came close to reproductive potential. The instructor will circulate the room: • To monitor progress and collaboration between the members of the group.	PROCESS SKILLS: • Using numbers • Interpreting data • Graphing • Evaluate HABITS OF MIND • Keep records of the investigation and not change them later. • Look at a matter from many sides before drawing a conclusion. • Be open-minded, willing to change your mind in the face of reliable evidence. • Offer reasons for findings and consider reasons suggested by others.

DAY 11

Relationship of Lesson to the Unit: Students will communicate their investigation data and conclusions to the class.

Curriculum Strands addressed:
The same strands that appear in the unit section of this document are addressed in this activity.

Science Process Skills:
- Communicating
- Interpreting Data

Science Habits of Mind:
- Be open-minded, willing to change your mind in the face of reliable evidence.
- Look at the matter from many sides before drawing a conclusion.
- Know that different explanations can be given for the same evidence and it is not always possible to tell which is correct.

Concepts:
- A limiting factor is anything in the environment that limits the growth of a population.
- Cause and effect questions to be determined by the students.

Session Length:
50 minutes

TIME	PROCEDURE	CONCEPT
9:00 to 9:50	1. Presentation of conclusions • One student group at a time will hang up their poster and present the information for the class. The instructor and the rest of the class will ask questions and assist clarification of conclusions. The students will take notes on each poster. • The poster and the presentation will be assessed as a communication tool (for clarity and completeness only); the validity of the information will not be assessed. The instructor will clarify the concept of insect diapauses – where development and/or reproduction are arrested under stressful conditions. Milkweed bugs go into diapauses when living in cool temperatures. There may be other environmental conditions that induce diapauses also. Student groups will submit the investigation journals to the teacher for further assessment. HOMEWORK (utilizing the notes taken in class). • According to the posters and presentations, what are the optimal environmental conditions for milkweed bugs? (Summarize each investigation conclusion). Are these the optimal conditions for a different species that you would raise at home? **THE INSTRUCTOR WILL HAVE TO SCHEDULE ADDITIONAL FEEDBACK TIME FOR EACH GROUP TO REVIEW THE JOURNAL ASSESSMENT.**	PROCESS SKILLS: • Communicating • Interpreting Data HABITS OF MIND • Be open-minded, willing to change your mind in the face of reliable evidence. • Look at the matter from many sides before drawing a conclusion. • Know that different explanations can be given for the same evidence and it is not always possible to tell which is correct. CONCEPT: • Insect diapauses are a state where growth and reproduction in insects is inhibited by stressful conditions – usually cooler temperatures.

JOURNAL RUBRIC

PROCESS SKILLS	**Poor 0**	**Fair 1**	**Good 2**	**Excellent 3**
GENERIC CRITERIA: Investigation question is a cause and effect question that is feasible and clearly stated	Investigation is not a cause and effect question.	Investigation is a cause and effect question but is difficult to test.	Investigation question is a cause and effect question that is feasible, but is not clearly stated.	Investigation question is a cause and effect question that is clearly stated.
GENERIC CRITERIA: Hypothesis is clear and testable	Hypothesis is neither clear nor testable	Hypothesis is testable but not clear.	Hypothesis is clear and testable.	

INVESTIGATION SPECIFIC CRITERIA: o The independent variable is the environmental factor. The dependent variable is population size at two weeks:	Students defined the independent variable as the dependent variable and vice versa.		Students defined the independent variable as the environmental factor and the dependent factor as the population size.	
INVESTIGATION SPECIFIC CRITERIA: The investigation design included at least three habitats	The investigation design included less than three habitats.		The investigation design included three or more habitats.	
GENERIC CRITERIA: Inferences and conclusions are consistent with the data collected	Inferences and conclusion are not consistent with the data.		Inferences and conclusions are consistent with the data.	
GENERIC CRITERIA: Was the investigation question answered?	The investigation question was not answered.		The investigation question is answered.	
INVESTIGATION SPECIFIC CRITERIA: Evaluate whether any of the populations came close to or reached reproductive potential?	The evaluation is not present	The evaluation is present but shows a poor understanding of reproductive potential.	The evaluation shows a good understanding of reproductive potential but the students didn't understand what to compare.	The evaluation shows a good understanding of reproductive potential and the students compared actual population size to reproductive potential at the first generation.

APPENDIX A

MILKWEED-BUG REPRODUCTIVE POTENTIAL
……

Question	Answer
How long do milkweed bugs live?	4 months
How old is a female when she mates?	2 months
How many eggs does a typical female lay in a lifetime	100
What is the ratio of males to females?	50/50

1. Guess the population size at the end of 1 year. _____

2. Calculate the population size after 2 months, 4 months…. up to a year.

Population reduction	Parents (male and female)	Offspring (male and female)	Total population	Total elapsed time
	M _____ F _____	M _____ F _____		
	M _____ F _____	M _____ F _____		
	M _____ F _____	M _____ F _____		
	M _____ F _____	M _____ F _____		
	M _____ F _____	M _____ F _____		
	M _____ F _____	M _____ F _____		

Reflections on teaching

When I implemented parts of this unit, I happened to be substituting for another teacher. I did not have a school budget or the means to purchase milkweed bugs, let alone the extensive list of supplies for building the habitats. So, I was forced to "make do" and implement parts of the unit, which follow:

1. Students discussed the possibility of raising goldfish at home.
2. Students generated the question of what they might need to know to raise a population of any species.
3. Students observed photos of milkweed bugs.
4. Students engaged in the benchmark lesson - FOSS Populations and Ecosystems Investigation 6: Milkweed Bugs Reproductive Potential Activity Sheet
5. Students graphed the reproductive potential growth rate for milkweed bugs
6. Students worked out the concept of "limiting factors" (abiotic and biotic), and then imagined their own limiting factors
7. Students calculated the loss in population due to the limiting factors that they created.
8. Students graphed the actual growth rate, which included the limiting factors on the same graph with the reproductive potential rate.

The lesson segments in the above list were implemented in the classroom over a period of 5 days.

I did not provide an exploratory experience at the beginning of the unit or a student designed inquiry investigation. The result was completely typical of what has been described all along. The students were very motivated when discussing raising goldfish at home, and then the lesson fell completely flat. I determined this by watching the students' level of engagement when doing the FOSS Investigation 6 benchmark lesson on the reproductive potential of milkweed bugs. Students were bored. Some copied their partner's work. Some did the calculations without understanding the concepts (I determined this by asking how the projections were made as I collected papers).

Upon reflection, I made the following resolutions and the appropriate changes in the unit plan:

1. Restate the driving question throughout the unit
2. Always begin the unit (and as many lessons as possible) with a "hands-on" exploration.
3. Do a student-designed investigation.
4. Reorganize the groups considering the factors that facilitate or interfere with effective collaboration.

IF I HAD TIME:

Milkweed bugs are not a species that are part of the students world. If I had time, I would have included a field trip after Day 2 and before Day 3 to a pond where a goldfish population is raised. This would really make a real-world connection for the concepts introduced later on in the unit.

.