It's (Not) Just a Bug Activity

Overview of Lesson Plan: In this lesson, students reflect on challenges that face farmers in cultivating crops, including insects. They then simulate how crops are affected by native and non-native insect populations and the options farmers have to protect their crops. Finally, they create an agricultural plan from the perspective of a farmer.

Authors:
Catherine Hutchings, The New York Times Learning Network
Bridget Anderson, The Bank Street College of Education in New York City JUNE 19, 2007 http://learning.blogs.nytimes.com/2007/06/19/its-not-just-a-bug/?_r=0

Suggested Time Allowance: 1 hour

Objectives:
1. Reflect on challenges facing produce farmers.
2. Learn about invasive species and how they affect the agricultural industry by reading and discussing the article "Tiny but Hungry, Moth May Peril California Crops."
3. Simulate and analyze different ecological scenarios related to invasive species and protection of crops.
4. Make decisions about which farming methods they would employ if they were farmers.

Resources / Materials:
Various fruits and vegetables
Pens/pencils
Classroom board
Paper for making "leaves" (10 sheets per student playing a plant)
Copies (one per student) of the article "Tiny but Hungry, Moth May Peril California Crops," **found on pgs. 9 & 10 of this document** or online:
http://www.nytimes.com/learning/teachers/featured_articles/20070619tuesday.html

Activities / Procedures:

DO-NOW:
- Bring in a variety of fruits and vegetables found in the grocery store and display them at the front of the room.
- Write the following on the class board
  - Where did this produce come from, and what did it "go through" to get to the local supermarket?
  - How did the farmer ensure the healthiest possible crop?
  - What challenges and threats might have faced these crops?

- How might the farmer have tried to protect the crops from these threats?

Student journaling activity: Students journal for five minutes on the questions you wrote on the board.

After five minutes: have students each read one phrase or sentence from their journals without comment from other students and record them on the board. Then allow students to briefly discuss and comment on all of the statements on the board.

Pass out copies of the article on pgs. 9-10 of this document and read-
Focusing on the following questions:
a. Where does the light brown apple moth come from? How long does it live?
b. Why is the light brown apple moth nicknamed the "light brown everything moth"?
c. What steps have been taken in California to eradicate the apple moth?
d. Why can small insects like the light brown apple moth and the Mediterranean fruit fly "set off alarm bells" and "prompt a statewide panic" in California?
e. What is a quarantine?
f. Why is the invasive moth raising concerns in Mexico and Canada?
g. Why do A.G. Kawamura and Senator Dianne Feinstein believe that agricultural border inspections should be moved back to the Department of Agriculture?
h. Considering the life cycle of the moths, why would it be difficult to inspect each and every plant brought into the country for invasive species?
i. What does James R. Carey mean when he compares the infestation of invasive insects with cancer?

Simulation Exercise: Explain to students that they will now simulate the effects of an invasive species on a plant population. (This simulation requires ample space for students to spread out and move around.) In the simulation, students will represent plants, insects and predators, such as birds, in several different rounds.

Draw the following chart on the board: You will record the number of plants in each of these category after each round.

Round	**7-10 Leaves** (Healthy)	**4-6 Leaves** (Moderate)	**1-3 Leaves** (Severe Damage)	**0 Leaves** (Dead)
1				
2				
3				
4				
5				

6				

RULES:
Insects can only take one leaf from a plant at a time and then must move to a different plant. They may not stay at one plant and eat all of its leaves.

When tagged by a predator, insects must sit.
Plants must remain stationary and give up their leaves, one at a time.
Dead plants can play plants the next round.
Predators can become insects in rounds with no predators.

ROUND ONE: Normal Populations of Native Species
Two-thirds of the class will act as plants

- Give each plant 10 pieces of paper

Three-fourths of the remaining students will act as native insects.
The remaining students are predators that eat the insects.

The insects have 1 min. to gather as many leaves as they can. If tagged by a predator the insect must sit and is out of that round.

At the end of 1 min. each plant tallies the number of remaining leaves it has and you record the data on the board.

ROUND TWO: Invasive Insects
Two-thirds of the class are plants

- Give each plant 10 pieces of paper

Remaining students are invasive insects

- Predators from Round One are insects this round.
    - Explain that invasive insects often do not have a natural predator, so they are able to reproduce in greater numbers.

There are no predators in this round.

The insects have 1 min. to gather as many leaves as they can.

At the end of 1 min. each plant tallies the number of remaining leaves it has and you record the data on the board.

ROUND THREE: Use of Pesticides
Two-thirds of the class are plants.

- Give each plant 10 pieces of paper
- Each plant should mark the underside of half of their leaves (chosen at random) with an X to denote the presence of pesticides. Since the underside of leaves is

not visible, the "insects" will not know if they are choosing a leaf marked with a pesticide or not.

Remaining students are invasive insects.

The insects have 1 min. to gather as many leaves as they can.

If an insect selects a leaf with an X on the underside they must sit and are out for the round (because it contained pesticide).
At the end of 1 min. each plant tallies the number of remaining leaves it has and you record the data on the board.

ROUND FOUR: Quarantine

Two-thirds of the class are plants.

- Give each plant 10 NEW pieces of paper (without X marked on them)

All other students are insects

Designate a section of the room as an insect quarantine area. Mark the area so it is clear where the boundaries are.

Put some of the plants in the area and some outside the area.

Insects have 1 min. to collect as many plants as possible. **Insects can't leave the quarantine area boundaries.**

At the end of 1 min. each plant tallies the number of remaining leaves it has and you record the data on the board.

ROUND FIVE: Diversification of Plants

Two-thirds of the class are plants.

- Give each plant 10 pieces of blank paper
- Instead of plants all being the same species, plants mark their leaves with shapes or letters to show the "type" of plant they are.

  Choose three shapes, such as square, circle and triangle and assign roughly equal numbers of each to the plants.

  Plants mark the top of their leaves with their shape.

Assign roughly equal numbers of insects with specific shapes (so they can only each leaves with those shapes on them).

Insects have 1 min. to collect as many plants as possible. **Insects can only eat the leaves with their assigned shape.**

At the end of 1 min. each plant tallies the number of remaining leaves it has and you record the data on the board.

Tell the class this round illustrates why invasive species are especially devastating to farmers with one type of crop vs. having diverse crops types on their farms.

ROUND Six: Class makes up their own round

After five rounds, encourage students to think of additional variations on the game. For example, they may choose to play a round that includes predators and pesticides, combining rounds one and three.

Another idea is to introduce a natural method of controlling the invasive species, such as bacteria that infects the larvae of the caterpillars.

A third idea is to expand on round four by having "insects" trying to sneak out of quarantine and making some students act as "inspection officials." Be sure to have students write down the conditions and the results of each round on their chart.

At End of Game: Have a class discussion with the following questions**:**

Which scenario yielded the greatest number of healthy plants? The least healthy plants? Why are invasive species most dangerous to farmers? How might diversification of plants help farmers? Why might large-scale farms be resistant to trying this?

How did pesticides affect the pest populations? How did they help the plants? What is the downside to using pesticides exclusively?

What is the benefit of quarantine? What is the downside to farmers trying to sell their product?

In your opinion, what other solutions should be used to control invasive species and protect crops?

To explore further, or for extra credit, have students read and analyze the Latest Situation Report on the light brown apple moth (LBAM), published by the California Department of Food and Agriculture (http://www.cdfa.ca.gov/phpps/pdep/lbam_main.htm). Students should use the trapping data to map the California counties most heavily affected by the LBAM and compare them to the quarantine zones mentioned in the article. Students should use the report to find out what treatment methods besides quarantine are being used in California and how successful they are at preventing the spread of the LBAM.

WRAP-UP/HOMEWORK: Individually, students imagine they are farmers in California and, using what they learned in the article and the simulation as well as additional information on the light brown apple moth (http://www.cdfa.ca.gov/phpps/pdep/lbam_main.htm), they write an agricultural plan for their farms that answers the following questions:

-What crop or crops do you grow?

-What pests affect these crops?

-How do you plan to protect your plants against pests? Would you choose to use pesticides, organic pesticides or another method? Why?
-Do you feel that quarantine is necessary to protect your crops from invasive pests? Why or why not?
Provide time for students to discuss and debate their plans in a later class period.

Further Questions for Discussion:
-Why can invasive species cause greater destruction than native species of moths?
-How has agriculture changed in the past 100 years? How do these changes make problems like those in California into global problems?
-What invasive species are problems in the region where you live?

Evaluation / Assessment:
Students will be evaluated based on participation in the opening exercise, thoughtful participation and discussion of the article, participation in and analysis of the simulation and thoughtful completion of the homework.

Vocabulary:
omnivorous, entomologists, native, fluttering, agricultural, specimen, pest, infestation, invasive, aerial, threatening, citrus, infested, decisively, organic, pesticides, wholesale, nurseries, safeguard, flora, port, quarantines, inspections, evocative, devastating, welts, immigrant, province, expertise, disputed, eradication, fruitless, subdetection, boom, climatic, microevolution

Extension Activities:
1. Research an invasive species in your region. What is it? How was it introduced? How does it affect agriculture in your state? What other businesses or industries does it affect? What are the monetary costs expected to be caused by the invasive species? What is being done to combat it? Make a community awareness poster or an educational pamphlet telling the public about the species and what they can do to help prevent it.
2. Research more on the life cycle of the LBAM and make a diagram showing the different stages and host plants.
3. Compare and contrast organic farming methods with conventional methods. What are the advantages and disadvantages of each? How does each one control pests? How is each labeled and sold? Make a persuasive speech to the class advocating for one method or the other.
4. Interview a local farmer about what he or she grows and the methods he or she uses to produce and sell crops. Talk about his or her experiences with pests, both native and exotic.
5. What are the laws and regulations surrounding the importation of plants and animals into the United States? Who should have this responsibility, the Department of Agriculture or the Department of Homeland Security? Talk to a customs official at the local airport to find out more about these laws.

6. Make an insect trap on the grounds near the school and use an entomology book to identify the insects you find. More about making these traps can be found online athttp://www.ento.csiro.au/ecowatch/Traps.htm.

Interdisciplinary Connections:
Geography -Trace the path of food from its source to where it is sold. What foods come from which parts of the world? Make a map showing what you learned.
Trace the path of an invasive species as it spreads across the globe. Journalism -Create a photojournalism exhibit on the devastation that can be caused by invasive plants and insects. Present solutions to the problem. Present your exhibit to the class.
Teaching with The Times – Read the Science Times section of The Times every week for one month. At the end of the month, write a summary of the main agricultural issues that arise.

References: Related Times Articles: "South Africa Puts the Unemployed to Work Restoring Land and Water" by Amanda Hawn, and the related lesson plan, "Invasive Species," can be found online athttp://www.nytimes.com/learning/teachers/lessons/20050726tuesday.html?searchpv=learning_lessons.
"Zebra Mussels Star in Hudson's Ecological Melodrama" by William K. Stevens and the related lesson plan, "The Mighty Hudson Stretches its Mussels," can be found online athttp://www.nytimes.com/learning/teachers/lessons/20000404tuesday.html?searchpv=learning_lessons.

Other Information on the Web:
Information and articles on invasive species can be found online athttp://www.invasive.org/.
The California Department of Food and Agriculture's Web site ishttp://www.cdfa.ca.gov/.
More information on what California is doing to combat the light brown apple moth can be found online athttp://www.cdfa.ca.gov/phpps/pdep/lbam_main.htm.

Academic Content Standards:
Grades 6-8 Science Standard 7- Understands how species depend on one another and on the environment for survival. Benchmarks: Knows ways in which species interact and depend on one another in an ecosystem; Knows that all individuals of a species that occur together at a given place and time make up a population, and all populations living together and the physical factors with which they interact compose an ecosystem; Knows factors that affect the number and types of organisms an ecosystem can support; Knows relationships that exist among organisms in food chains and food webs
Science Standard 8- Understands the cycling of matter and flow of energy through the living environment. Benchmarks: Knows how energy is transferred through food webs in an ecosystem; Knows how matter is recycled within ecosystems
Geography Standard 8- Understands the characteristics of ecosystems on Earth's

surface. Benchmarks: Understands the distribution of ecosystems from local to global scales; Understands the functions and dynamics of ecosystems; Understands ecosystems in terms of their characteristics and ability to withstand stress caused by physical events; Knows changes that have occurred over time in ecosystems in the local region; Knows the potential impact of human activities within a given ecosystem on the carbon, nitrogen, and oxygen cycles
Geography Standard 14- Understands how human actions modify the physical environment. Benchmarks: Understands the environmental consequences of people changing the physical environment; Understands the ways in which human-induced changes in the physical environment in one place can cause changes in other places
Geography Standard 18- Understands global development and environmental issues. Benchmark: Understands how the interaction between physical and human systems affects current conditions on Earth

Grades 9-12
Science Standard 7- Understands how species depend on one another and on the environment for survival. Benchmarks: Knows how the interrelationships and interdependencies among organisms generate stable ecosystems that fluctuate around a state of rough equilibrium for hundreds or thousands of years; Knows ways in which humans can modify ecosystems and cause irreversible effects
Science Standard 8- Understands the cycling of matter and flow of energy through the living environment. Benchmarks: Knows that as matter and energy flow through different levels of organization in living systems and between living systems and the physical environment, chemical elements (e.g., carbon, nitrogen) are recombined in different ways; Knows how the amount of life an environment can support is limited by the availability of matter and energy and the ability of the ecosystem to recycle materials
Geography Standard 8- Understands the characteristics of ecosystems on Earth's surface. Benchmarks: Understands how relationships between soil, climate, and plant and animal life affect the distribution of ecosystems; Knows ecosystems in terms of their biodiversity and productivity and their potential value to all living things; Knows the effects of biological magnification in ecosystems; Knows the effects of both physical and human changes in ecosystems
Geography Standard 14- Understands how human actions modify the physical environment. Benchmark: Understands the global impacts of human changes in the physical environment
Geography Standard 18- Understands global development and environmental issues. Benchmark: Understands contemporary issues in terms of Earth's physical and human systems*This lesson plan may be used to address the academic standards listed above. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education; 3rd and 4th Editions and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.*

Give each student a copy of this Article:

Tiny but Hungry, Moth May Peril California Crops

By: Jesse McKinley

SAN FRANCISCO, June 15 — Full grown, the light brown apple moth is roughly the size of a nickel: a little dirt-colored insect with an adult life span shorter than the average summer vacation.
But oh, what an eater. As a caterpillar, the moth feeds on flowers, fruits and firs, a diet that can include corn and tomatoes for dinner and cherries, peaches and plums for dessert. So omnivorous is the moth that some entomologists call it the "light brown everything moth."

It is exactly that appetite that has state and federal officials in California worried. A native of Australia, the moth had never been seen in the continental United States before February, when a retired entomologist discovered one in a trap behind his house in Berkeley, just across the bay from here and within fluttering distance of one of the nation's most important agricultural regions.

The moth has since been found in nine California counties, including Napa, where the discovery of a single specimen set off alarm bells for winemakers and farmers up and down the grape-happy region.

"It is a significant pest of wine grapes and because that's what we grow, that's what caught our attention," said Greg Clark, the assistant agricultural commissioner in Napa County. "And if we have an infestation here, it's likely it could move into other agricultural regions."

Over the years, California has faced a number of threats to its agriculture. Perhaps the most famous invasive pest was the Mediterranean fruit fly, or medfly, which prompted a statewide panic — and aerial spraying — in the early 1980s, when it appeared to be threatening the state's billion-dollar citrus industry. The National Guard was called out to bury tons of infested fruit, and highway checkpoints were installed.

No one is predicting that kind of response this time. But, then again, no one is taking the chance. "People want to see this pest dealt with quickly and decisively," Mr. Clark said. "Because there's always another pest over the horizon."

Spraying began this week in Oakley, a Bay Area suburb where masked workers went bush-to-bush with organic pesticides, with additional treatments planned for Monday in Napa, thought to be the northernmost border of the moth invasion.

The problem seems even more serious to the south in Santa Cruz County, where nearly 3,500 moths have been discovered and where farmers and agricultural officials have set thousands of traps in wholesale nurseries to try to safeguard the county's $73 million industry in shrubs, trees and other ornamental flora. Statewide, agricultural officials say California could lose more than $100 million because of increased production control and pest control.

Officials also fret that California may be just the port of entry for the moth.

Chief among growers' concerns is the possibility that foreign markets will begin to reject California crops. To that end, the federal Department of Agriculture and the California Department of Food and Agriculture have declared quarantines for the affected counties, barring the transportation of crops or plants around the state without inspections. That comes even as Mexican and Canadian officials have traveled to California to inspect their progress fighting the moth.

Like many states, California is already dealing with a variety of other invasive pests and diseases, each with a more evocative name than the last, like the glassy-winged sharpshooter (which can be devastating to citrus groves and vineyards) and the red imported fire ant, a nasty little insect whose bites can result in pain and welts.

Officials say they do not know how the moth got here, but that it may have come via a host plant brought by a homesick immigrant. "California is a popular place, and people come and bring their favorite plant along," said A. G. Kawamura, California's secretary of food and agriculture.

The moth infestation has also renewed cries from officials like Mr. Kawamura who believe that agricultural border inspections should be returned to the province of federal agricultural officials. The job is currently performed by the Department of Homeland Security, which some critics say does not have the expertise to spot incoming pests like the moth. Senator Dianne Feinstein, Democrat of California, has recently introduced a bill in Congress to move inspections back to the Department of Agriculture.

Russ Knocke, a Homeland Security Department spokesman, disputed the notion that the federal agriculture agency would do a better job. "If someone in this department said everything is working properly and everything is perfect, that person should be removed," Mr. Knocke said. "But for someone to express that rearranging the deck chairs — again — is going to be the solution, I'm going to flatly reject it."

Regardless of its method of entry or which agency ultimately takes the lead, getting rid of the moth is going to be a challenge. James R. Carey, a professor of entomology at the University of California, Davis, said eradication efforts can be fruitless, particularly when large numbers of insects have been found.

"These pests can be there at subdetection levels for years if not decades," said Mr. Carey, who worked on the medfly infestation. "They operate — cancer is a good analogy — they operate in little pockets and then boom, the conditions come together, both climatic and in microevolution, and then they appear."

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