MICHIGAN STATE UNIVERSITY | W.K. Kellogg Biological Station

K-12 Partnership Lesson Plan

Invasion: Total Take-Over!

Exploring invasive species and the methods to control them

Overview

Invasive species are non-native, introduced species that have a negative impact on the habitats they invade. Invasive species can be plants, animals, or microorganisms, and the damage they can cause to native ecosystems can be devastating. What is it about these species that allow them to successfully invade different habitats? Does the environment itself also play a role in how likely it is that an invasion will take place? In this lesson plan students will explore what it means to be an invasive species. They will learn what traits make a good invader as well as what environmental conditions favor invasion. Students will also get a chance to observe and interpret graphs and figures from real world research on invasive species. Finally, students will have the opportunity to play a game that simulates an invasive species spreading through Michigan, and students have to implement different methods to control its spread.

Objectives

At the conclusion of the lesson, students will be able to:

- Explain what an invasive species is and provide several local examples of invasive species
- Understand what traits help invasive species spread
- Understand what environmental factors facilitate invasion
- Interpret graphs and figures of real world data from several invasive species
- Understand the different methods that have been used to control the spread of invasive species

Length of Lesson

50 minutes (10 min for background presentation, 10 min for graph interpretation worksheet, 30 min for game) – Can be extended for multiple game plays.

Grade Levels

Grades 6-12

Standards covered

Interdependence of living systems

L3.p3 Factors Influencing Ecosystems
L3.p4 Human Impact on Ecosystems
B3.4 Changes in Ecosystems
B3.4x Human Impact
B3.5x Environmental Factors

Materials

- Data interpretation worksheet
- Michigan Monsters game board and control cards
- Michigan Monsters rule sheet
- 3 dice per game board used
- Pencils and erasers (it is important to have erasers for the game)

Background

One of the most challenging foes in the struggle to preserve natural ecosystems is invasive species. Invasive species are non-native, introduced species that have a negative impact on the habitats that they invade. They can be plants or animals, and once they have invaded the consequences for the native ecosystem can be disastrous. Invasive species can outcompete native species for limited resources such as food, light, or space. Invaders may also directly reduce native populations through predation or herbivory. Furthermore, if the invasive species happens to be toxic it may kill any native animals that try to consume the invader. On a broader scale, invasive species can alter the function of an ecosystem by changing important properties such as the fire regime or nutrient cycling.

Considering these negative impacts it is important to understand what makes a good invader. Invasive species tend to have several traits in common that help them successfully invade and spread through a habitat. Invasive species typically grow fast, reproduce at a high rate, and disperse very effectively. These traits allow the invader to spread very rapidly through a habitat. Additionally, invasive species tend to have a generalist diet, and flexible behaviors, so they can tolerate a wide range of environmental conditions. This allows the species to invade many different habitats.

In addition to traits directly possessed by the invasive species, several environmental factors can also play a role in determining how successful an invasion attempt will be. Habitats that have unused resources are more likely to be invaded by species that can exploit those resources. Habitats that are disturbed either through natural (e.g. fire) or human (e.g. construction) causes are easier to invade. Finally, if a habitat lacks natural predators or herbivores that can feed on the invasive species, it will be much easier for that species to spread.

In an effort to limit the damage caused by invasive species, scientists have developed a wide variety of methods and tactics used to control or eradicate invasive species. Invasive species may be actively killed using chemicals, predators, or direct human hunting/trapping. A different approach seeks to interfere with the invasive species! reproductive cycle by releasing sterilized males into the population or manipulating reproductive pheromones. Other control methods try to actively block the spread of the invaders by constructing physical (walls) or non-physical (electric fields) barriers. It is rare that a single method is completely effective at stopping an invasive species, often the best control strategies are those that combine a variety of different tactics to slow or eradicate the invasive species.

In this lesson, students will have the opportunity to observe and interpret real world data on invasive species and the control methods used to stop them. Additionally, students will step into the shoes of a conservation biologist when they play the Michigan Monsters game. In this game students, will have to use a variety of different techniques to try to stop the spread of an invasive species before it moves through all of Michigan.

Activities of the session

1) Use the invasive species powerpoint presentation to introduce students to invasive species, traits that make an organism a good invader, and methods that can be used to control the spread of invasive species.
2) Go over several examples of local invasive species, and invasives found around the world. An animated example of the rate of spread of zebra mussels over 24 years can be found here: http://nationalatlas.gov/dynamic/dyn_zm.html#
3) Hand out the data interpretation worksheet, have students look over the graphs and try to interpret the data they see.
4) Have students play through the Michigan Monsters game (see instructions below).

Resources

- Data interpretation worksheet and Michigan Monsters game
- **Dynamic map of zebra mussel spread**: http://nationalatlas.gov/dynamic/dyn_zm.html#
- http://www.invasivespeciesinfo.gov/aquatics/controlplans.shtml#ac
- http://asiancarp.org/faq.asp#30
- http://nationalatlas.gov/articles/biology/a_zm.html
- http://www.mnr.gov.on.ca/en/Business/Biodiversity/2ColumnSubPage/STDPROD_068705.html
- http://en.wikipedia.org/wiki/Biological_pest_control#Biological_control_with_micro-organisms
- **Purple loosestrife information**:
  http://www.npwrc.usgs.gov/resource/plants/loosstrf/index.htm
  http://www.miseagrant.umich.edu/downloads/ais/fs-97-501_purple_loosestrife.pdf
- **Emerald ash borer information**: http://www.stopthebeetle.info/

Extensions and Modifications

1. Instead of using pencils, small tokens could be used to indicate invaded counties. Then game boards can be re-used.
2. If computers are available (1 per student pair), the digital version of the Michigan Monsters map can be opened using MS Paint or a similar program. Students can use the fill tool to color invaded counties, or uncolor them if the species is removed. This is easier than erasing.
3. The game can be expanded to include adaptation and evolution. For example, native predators could evolve to begin feeding upon the invasive species or the invasive species could evolve resistance to different control methods.

Assessment

Students will be assessed with thought questions, discussion and graphical interpretation.

Michigan Monsters Rule Sheet

Number of players: 2
Materials: Game board, control cards, pencil, eraser
Overview:

In this game players go head to head in a struggle for control of Michigan's ecosystems. One player takes on the role of an invasive species that has been introduced to Michigan. As an invasive species, it is that player's goal to spread through Michigan as rapidly as possible. The second player plays the part of a scientist who has been put in charge of controlling the spread of the invasive species.

Roles:

Invasive species: The invasive species tries to spread as fast and as far as possible. To invade counties the player rolls a dice pool of three six-sided dice. Look at all the counties that share a border with any invaded territory. If any of these counties have a value less than or equal to the sum of the players dice throw the invasive species spreads into that county. To mark invaded counties on the game map draw a circle in pencil around the number printed in that county.

Scientist: Using "control cards," the scientist tries to control the spread of the invasive species and, if possible, completely remove it from Michigan. These control cards all have unique instructions printed on them that the scientist must follow. Most of these cards will help the scientist, but a few will actually help the invasive species. Some control cards allow the scientist to remove the invasive species from an area, make some counties completely immune to invasion, or change the values assigned to different counties. Use an eraser to remove the invaders circle mark (see above) whenever you get to remove the invasive species from a county. If you get the chance to make some counties immune to invasion, mark those counties on the map by drawing an X in that county. If the control cards change the values assigned to any of the counties, simply write in the new values on the map.

Rules:

1) Before you begin the game, make sure the control cards are thoroughly shuffled. Also, at this point you should choose what role you want to play; you can either be the invasive species, or the scientist.

2) The game begins with the invasive species choosing where to start its invasion. To do this, the invasive rolls its dice pool and selects a county on the Michigan border with a value less than or equal to the sum of the dice to invade.

3) After this initial invasion, the invasive species gets three more dice throws to establish itself in Michigan. After each throw, the invasive spreads into any neighboring counties that have a value less than or equal to the sum of the dice.

4) After the third dice throw, the scientist gets to pick up a control card and follow the instructions printed on the card.

5) After the scientist has used the control card, the game continues in an alternating pattern of dice throws and control cards. The invasive species throws its dice pool, followed by the scientist using another control card, followed by another dice throw from the invasive, etc….

6) The game continues until 15 control cards have been played. At that point, the game is over, tally up how many counties are invaded and how many are un-invaded to see how much the invasive species was able to spread and how effective the scientist was at controlling the invader.

Michigan Monsters Name: _____
Follow-up questions

1. How successful was the invasive species when you played the game?

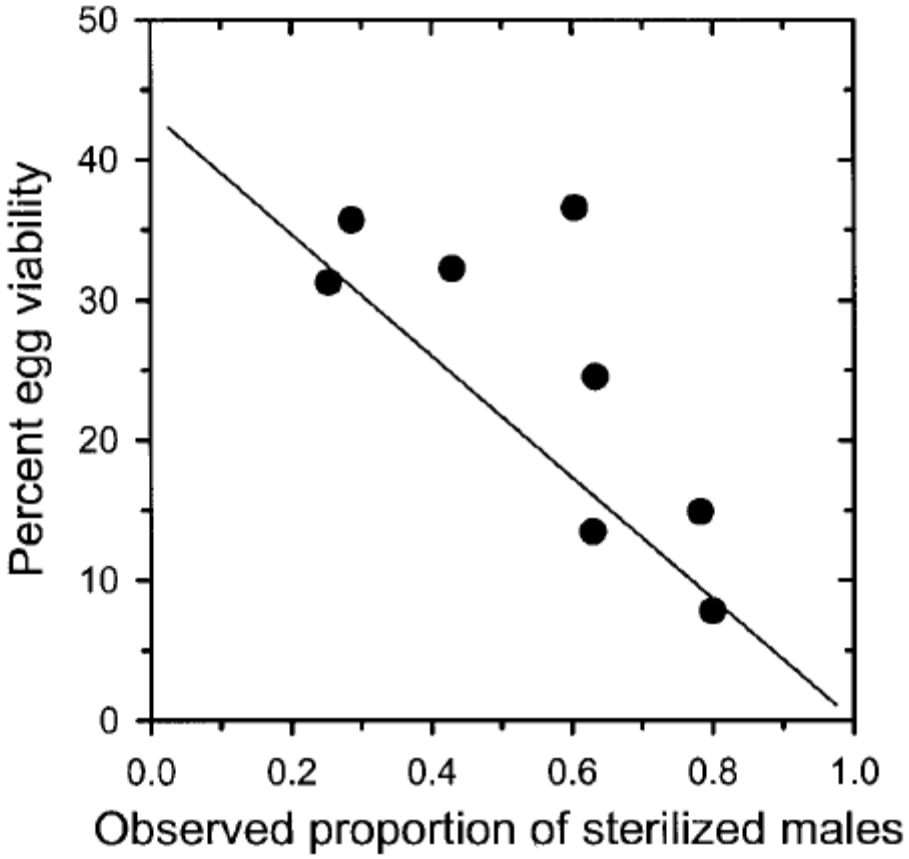
2. How successful were the human control efforts?

3. Did you notice any patterns in how the invasive species spread? Were there any areas on the map that were harder to get to?

4. Which control methods were most effective at stopping or slowing down the spread of the invasive species?

Invasion: Total takeover Name:_____
Data interpretation exercise

Sterilization of male sea lampreys is one method being used to try to reduce their populations. Sterile male lampreys still mate normally with females, causing the females to waste their eggs. The graph below shows how the chance of an egg hatching (Y-axis) changes depending on how many sterile males (X-axis) were seen at the nest site.



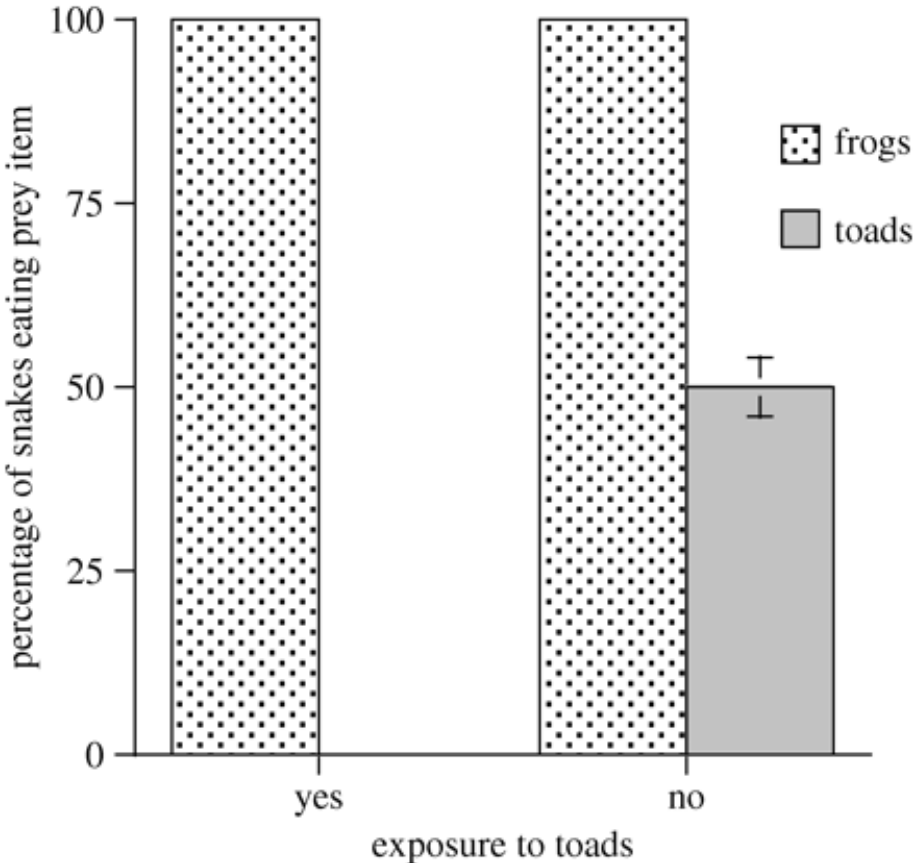
1. Based on this graph, what effect does sterilization have on egg hatching success?

2. If half of the male lampreys in a population are sterilized, about what percent of the eggs in that population would hatch?

3. What are the chances that lamprey eggs will hatch when humans aren't sterilizing any males in the population?

4. What are the chances that eggs will hatch when all of the males are sterilized

The Australian black snake feeds on native frogs. After the introduction of the invasive cane toad, Australian black snake populations suffered, because the cane toad is lethally toxic. Some black snake populations have never been exposed to cane toads. Scientists compared feeding behavior between snakes from populations that had been exposed to cane toads, and snakes from populations that were never exposed to cane toads. Snakes from each group were offered meals of native frogs and cane toads. The data below show the percent of time that snakes from each group ate frogs vs. toads.



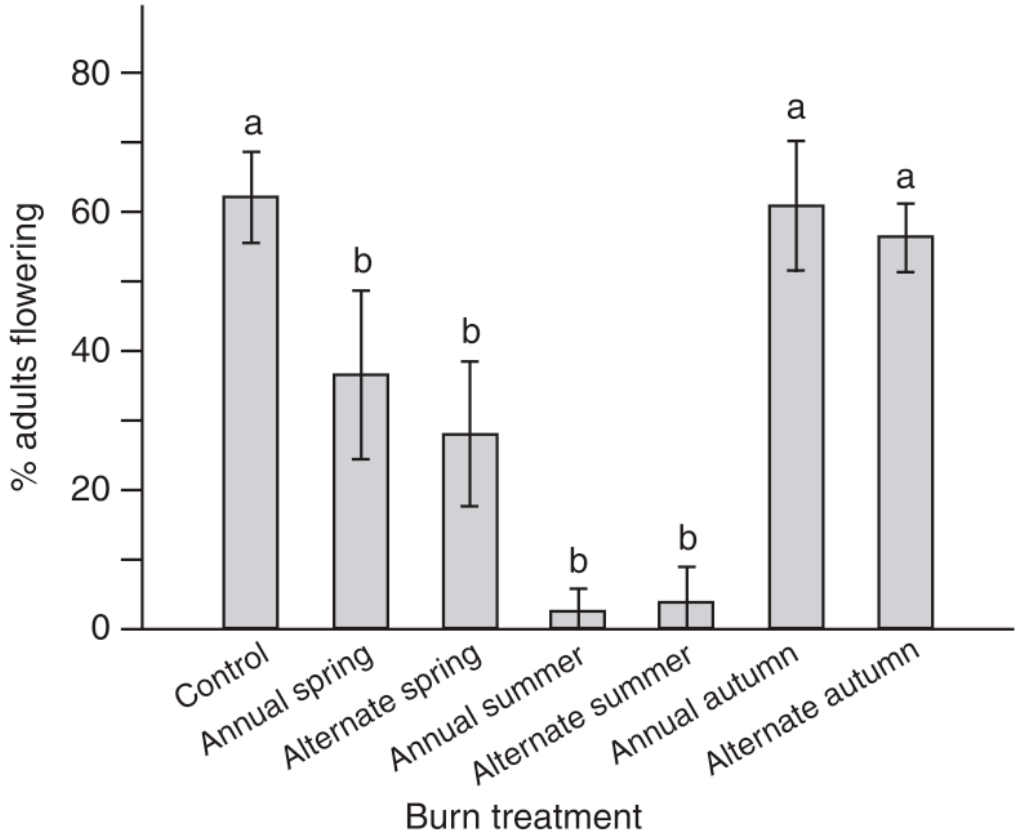
5. What effect does exposure to cane toads have on feeding preferences in Australian black snake populations?

6. How many of the snakes that were from toad-exposed populations ate the cane toads?

7. If a snake has never been exposed to cane toads, what are the chances that it would eat one, if offered?

8. What process might have caused the toad-exposed snakes to avoid eating cane toads

Burning is one method that has been used to control spotted knapweed, an invasive in Michigan's prairie ecosystem. The data below show the effects of burning every year (annual) and every 2 years (alternate) at different times of the year. Scientists measured the percentage of adults flowering as an indicator of how successful the knapweed was after a burning treatment.

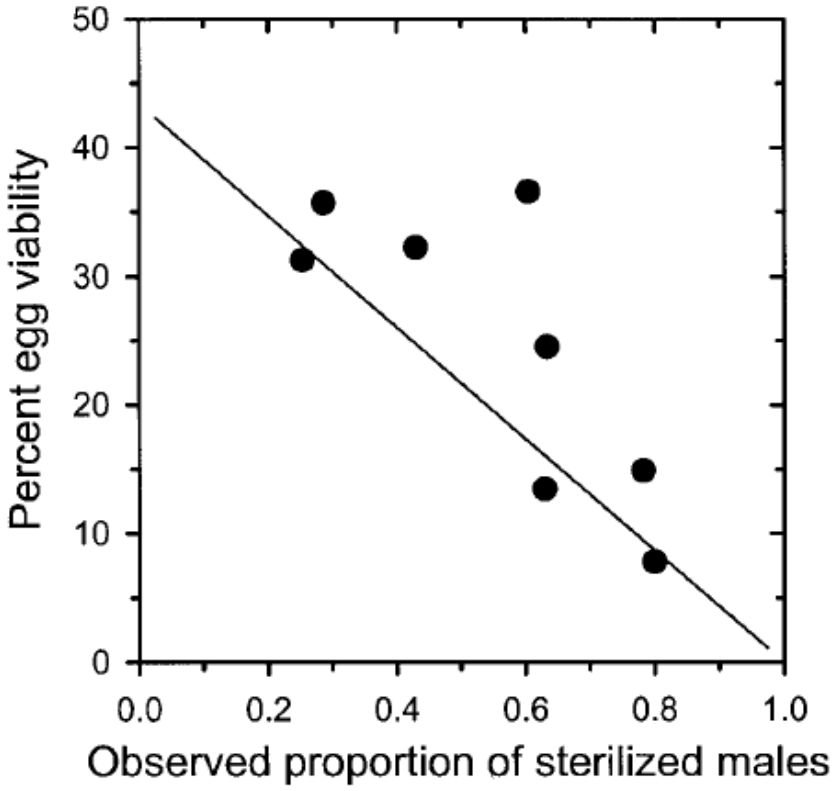


9. Based on this graph, if you had to choose just one season to burn knapweed populations, which season would you choose?

10. Do you think there is any difference between burning every year (annually) versus burning every 2 years (alternately)?

Invasion: Total takeover **KEY**
Data interpretation exercise

Sterilization of male sea lampreys is one method being used to try to reduce their populations. Sterile male lampreys still mate normally with females, causing the females to waste their eggs. The graph below shows how the chance of an egg hatching (Y-axis) changes depending on how many sterile males (X-axis) were seen at the nest site.



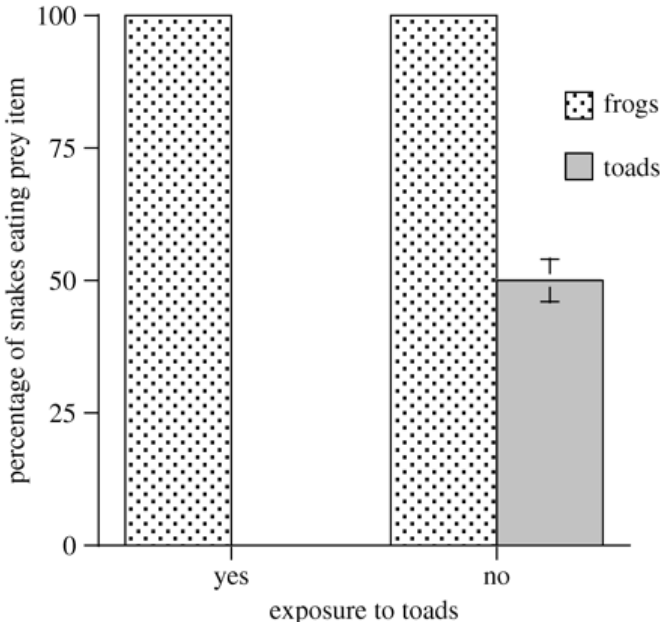
1. Based on this graph, what effect does sterilization have on egg hatching success?
    a. **Sterilization causes a decrease in number of eggs hatching**

2. If half of the male lampreys in a population are sterilized, *about* what percent of the eggs in that population would hatch?
    a. **Answers may vary. Between 20-35%.**

3. What are the chances that lamprey eggs will hatch when humans aren't sterilizing any males in the population?
    a. **Approximately 40%**

4. What are the chances that eggs will hatch when all of the males are sterilized?
    a. **0%**

The Australian black snake feeds on native frogs. After the introduction of the invasive cane toad, Australian black snake populations suffered, because the cane toad is lethally toxic. Some black snake populations have never been exposed to cane toads. Scientists compared feeding behavior between snakes from populations that had been exposed to cane toads, and snakes from populations that were never exposed to cane toads. Snakes from each group were offered meals of native frogs and cane toads. The data below show the percent of time that snakes from each group ate frogs vs. toads.



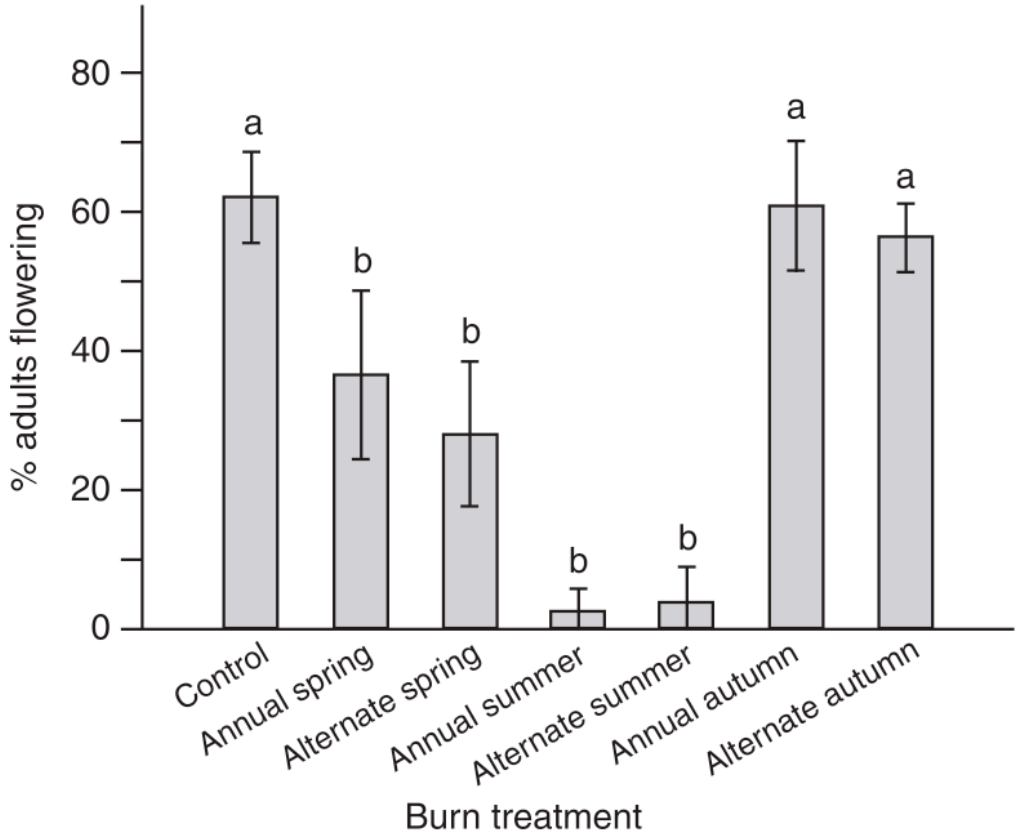
5. What effect does exposure to cane toads have on feeding preferences in Australian black snake populations?
    a. **Exposure to cane toads causes Australian black snakes to develop an aversion and not eat cane toads.**

6. How many of the snakes that were from toad-exposed populations ate the cane toads?
    a. **0%**

7. If a snake has never been exposed to cane toads, what are the chances that it would eat one, if offered?
    a. **About 50%**

8. What process might have caused the toad-exposed snakes to avoid eating cane toads
    a. **Answers may vary. Students may say it was a learned aversion. More advanced students may say the population evolved to include only toad-avoiding snakes (Remember that the cane toad is lethal).**

Burning is one method that has been used to control spotted knapweed, an invasive in Michigan's prairie ecosystem. The data below show the effects of burning every year (annual) and every 2 years (alternate) at different times of the year. Scientists measured the percentage of adults flowering as an indicator of how successful the knapweed was after a burning treatment.



9. Based on this graph, if you had to choose just one season to burn knapweed populations, which season would you choose?
    a. **Summer. Burning during summer has the strongest effect on reducing flowering success.**

10. Do you think there is any difference between burning every year (annually) versus burning every 2 years (alternately)?
    a. **Answers may vary. Within seasons, there is not a huge difference between annual vs. alternate burnings, and in some cases, alternate burnings seemed to have a stronger effect than annual burnings, so it would make the most sense to just burn every other year.**
    b. **This may be a good opportunity to discuss statistical significance with more advanced students. Error bars show 95% confidence that the true value for % flowering falls within that range, so when error bars overlap, there is no significant difference between the two values.**