ECOS Inquiry Template

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2. Name of Inquiry: Where is Knapweed successful?

3. Goals and Objectives:

a. Inquiry Questions: What abiotic variables contribute to the success of the invasive species Spotted Knapweed (*Centaurea maculosa***)**

b. Ecological Theme(s): Adaptation, invasive species, microhabitats

c. General Goal: Learn how microhabitats contribute to plant success in the context of invasive species

d. Specific Objectives: Learning to collect data, use scientific instruments, making and testing hypothesis, data presentation

e. Grade Level: 5+

f. Duration/Time Required: 1 week

→ **Prep time** 1 day

→ **Implementing Exercise During Class** 4 hour field trip

→ **Assessment-** Data analysis, presentation, and discussion

4. Ecological and Science Context:

a. Background (for Teachers):

Invasive weed species are a ubiquitous problem of the Missoula valley. Of the numerous species of weeds, spotted knapweed (*Centaurea maculosa*) is the most economically and ecologically significant. This weed displaces native vegetation and reduces forage quality. There are many reasons that this weed is a successful invader: growth, rapid dispersal, and chemical inhibition of competitors. However, when you walk across the surrounding mountains, knapweed is not ever present. Patches of knapweed exist in abundance, but some locations have much less than others, and some not at all. Despite its rapids growth and dispersal, knapweed will not be successful if site conditions are not appropriate. The available sunlight, moisture, and soil strongly determine the success of any plant. This investigation is designed to determine what environmental variables are best for knapweed growth and reproduction. A half day of fieldwork is required for data collection, but students will ultimately learn how to use scientific instruments, take measurements, compile and present their findings. This lesson teaches both basic biology and anatomy of plants as well as larger ecological questions of how plants interact with their environment.

b. Background (to present to Students):

When you go outside, why do you see the particular plants you see? Why are these plants here rather than other plants? Why aren't there bananas in Montana? The plant community, or collection of species in a location, is a product of plant adaptations, interactions with the biotic and abiotic environment, and some random chance. The plants that grow in Montana are well adapted to the abiotic environment (cold winters, harsh winds, rocky soils, high summer sunlight, and fire) and the biotic environment (insects that pollinate them, herbivores that graze them, parasites that attack them).

Spotted knapweed is an invasive species from Europe that is not native to Montana, but has been very successful in growing throughout the western half of the state. Why is knapweed so successful? It's well adapted to Montana's climate and lacks many of the herbivores and

parasites that attack it in Europe. With ideal climate and few negative biotic interactions, it has spread wildly through much of the western states.

Is knapweed for everywhere? No, it grows very well in some locations and not as well in others. For instance, do you see knapweed when you're in a dense forest? How about in an open prairie or school yard? These differences are largely a result of difference in microhabitats. While the climate in Montana maybe generally good for knapweed, not all locations are. We are going to conduct a field study like real plant ecologists, and try to determine why knapweed is successful in certain areas and not in others.

How can we determine a plant's health? Height, number of flowers, number of seeds produced, stem thickness, number of leaves. We are going to explore three different patches of knapweed and measure many of these plants to determine how well they are growing. Additionally, we will measure abiotic variables of: temperature, humidity, amount of sunlight, soil pH, soil moisture. Together, we'll use these data to try and determine what conditions are ideal for the growth of knapweed.

Let's start with some predictions:

Where do you think knap weed grows best, in what environment?

What abiotic variable do you think is most important to knapweed growth?

Where would knapweed grow poorly? Why?

5. Motivation and Incentive for Learning:

This is a half day activity outdoors, so the students are excited to go on a field trip to begin with. The students will enjoy exploring the different microhabitats. The group size is small enough, and provided enough volunteers, students get more personal attention than in a classroom setting. Finally, the students are introduced to a series of scientific instruments they likely have never seen before, and it's very exciting for them to take the measurements. Finally, the activity is intensive with little down time for the students to get bored.

6. Vocabulary:

- **Biodiversity** = the number of different species of plants and animals found in one particular location.
- **Ecosystem** = a single unit consisting of all of the organisms in one region together with their environment
- **Habitat** = the place or environment where a plant or animal naturally or normally lives and grows
- **Humidity =** a measurement of the water vapor in the air
- **Invasive specie**s= An invasive species is a species of plant, animal, or other organism that was introduced (usually by man) to a non-native ecosystem, where it became harmful to the natural environment or to human health
- **Microhabitat =** the physical habitat factors immediately surrounding an individual plant or animal
- **Organism** = a living thing
- **Observation** = a record of something noted or seen

- **Photosynthetic active radiation (PAR) meter=** A sensor that measures the amount of sunlight that plants can use for photosynthesis. The units presented as µmol $m^{-2}s^{-1}$ (micromoles of photons per square meter per second)

- **pH =** a measurement of acidity

- **Soil moisture =** a measurement of the amount of water available to plant roots and other organisms in the soil

- **Species** = a group of organisms that resemble one another closely and are genetically related

7. Safety Information:

Spotted knapweed is prickly and can cause skin irritation in some people if the living plant is handled too much. If the exercise is conducted during the growing season, make sure students wear gloves when handling the plants, or wash their hands frequently. Conversely, the inquiry can be completed in the fall, after the plants have stopped growing.

8. Materials List (including any handouts or transparency masters):

Measuring Tape
Rulers
Calipers to measure stem thickness
Thermometers
Soil thermometer
Soil pH meter
Soil moisture meter
Air Humidity meter
P.A.R meter
Data sheets (attached to inquiry)

9. Methods/Procedure for students:

a. Pre-investigation work:

The instructor should identify three distinct locations where knapweed is growing to serve as the field sites. The sites should be distinct in the abiotic variables we choose to measure: sunlight, moisture, soil. For our exercise, we chose a rough transect running away from the river. The first site was on the river bank, the second farther at the base of a hill near a forested area, and the final site on the hillside in open prairie. We randomly selected 7 knapweed plants (as we anticipate 7 groups) to be measured and marked them with numbered ribbon. Before the fieldtrip, we procured volunteers to aid the students in measurement. Additionally, we brought all out measuring tool in a large backpack to the site before the investigation began.

b. Investigation work:

1) What evidence (data, samples) do students collect?

The order in which you visit the sites is not important, but as this is a time consuming exercise, its best to end on the site closest to the departure location. Moreover, as the first site severs as a training ground for measurements, its best to start on a level, easily accessible location, not a hillside. Worksheets of data to be collected are provided. Each group is assigned a number and responsible for taking all the data from that site and plant. Students first write a general

description of the site and surrounding vegetation and move on to measure: temperature, humidity, sunlight, soil moisture, soil pH, plant height, number of seed heads or flowers, and stem thickness.

2) How do students present the evidence (data)?

Before the follow up class, it's best for the instructor to compile the data from each site into a table format (i.e. 7 replicates for each variable per site). Students will work in the groups they worked in on the field trip. The students should calculate the averages for each measurement. Its best for the teacher to assign each group to graph and present a single variable, conversely, each group could graph all variable and present on just one. The graphed data is collected and posted on the front board.

3) What conclusions are drawn from the evidence students collect?

Following presentation by each group, the instructor and students will have a discussion about which site had the most successful knapweed (based on seed heads or height) and what variables made that site unique. For instance, our group found that the biggest knapweed with the most seed heads was found near the river. While this site was not as sunny as the hillside, it did have the highest soil moisture. We hypothesized based on these observations that soil moisture is a strong contributor to knapweed reproductive success. Following this, we led a discussion on how to experimentally test this hypothesis in a greenhouse (or classroom setting).

4) Include examples of data sheets.

Worksheets attached

10. Assessment:

Here comprehension was measured by the graphs presented and the conclusions that were made during the discussion. Teachers may choose to extend this lesson to more formal presentations and a research project.

11. Extension Ideas:

The perfect extension for this activity is a classroom experiment on the growth of a species of plant under varying abiotic conditions. We choose to investigate the growth of beans with varying light, moisture, and soil conditions. The students will compare if beans have similar limiting factors as knapweed. The complexity of these follow up experiments is limited only by time and classroom space. Students could even grow a variety of plant, and test how different species react to changing environmental variables.

Extensions in the field are numerous as well. In addition to measuring abiotic parameters, more advanced students could document insects, neighboring plant species, or even soil insects to investigate these variables on the growth of knapweed. The students could be required to identify the surrounding insects in plants. Finally, abiotic variables like moisture and sunlight could be manipulated in the field given time and access to test the conclusion made during the observation portion of the exercise.

12. Scalability:

These exercises could easily be scaled up in complexity to higher grades. For instance, students may be required to calculate statistics on the data and run correlation analyses. Variables could be recorded for each site over time and the effects of seasonality could be explored. Students and teachers may want to explore the effects of these micro habitat parameters on more than one plant species found at each site, which would lead to discussions of plant communities and population ecology.

13. Science Standards Accomplished:

Content Standard A: Science as inquiry

- Abilities necessary to do scientific inquiry
- Understanding scientific inquiry

Content Standard C: Life Science

- Structure and function
- Reproduction
- Regulation of growth
- Population and ecosystems
- Diversity and adaptation

Content Standard E: Science and Technology

- Science and technology are reciprocal

Content Standard F: Science from a social perspective

- Resources and populations
- Natural hazards, risks and benefits
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Content Standard G: Nature of Science

- Observation and hypothesis formation
- Evaluation of data and methods

14. References:

National Research Council 2003. National Science Educations Standards, National Academy Press, Washington, DC

15. List of Experts and Consultants:

http://www.invasivespeciesinfo.gov/plants/spotknapweed.shtml

http://mtwow.org/Weed-ID.html

http://mtwow.org/

16. Evaluation/Reflection by Fellows and Teachers of how it went:

This was a great inquiry. The students, despite being on a field trip and outside, were very engaged and on task. They particularly enjoyed taking measurements with the scientific equipment. The follow up discussions and presentations of data revealed terrific insight of many students into plant and ecosystem ecology. Our teacher agreed.

In what habitat is knapweed most successful?

Data Collection Worksheet

Habitat 1.
Describe the location (where on campus? near river? near a trail? etc)-

General characteristics-
Climate (sunny? Shady? Cold? Moist? Hot? etc.)

Soil characters (rocky? Sandy? Muddy? Lots of leaves? etc.)

Surrounding vegetation (grasses? trees? Lots of knapweed? Number of plants? etc.)

Habitat Measurements

1) Temperature (degrees Celsius)-

2) Humidity (percent)-

3) Sunlight-

4) Soil Moisture (percent)-

5) Soil pH-

Knapweed measurements

1) Plant Number _____

2) Height your plant

_____

3) Number of seed heads your plant

_____

4) Stem thickness of your plant

_____

Habitat 2.
Describe the location (where on campus? near river? near a trail? etc)-

General climate characteristics-
Climate (sunny? Shady? Cold? Moist? Hot? etc.)

Soil characters (rocky? Sandy? Muddy? Lots of leaves? etc.)

Surrounding vegetation (grasses? trees? Lots of knapweed? no plants? etc.)

Habitat Measurements

1) Temperature (degrees celcius)-

2) Humidity (percent)-

3) Sunlight-

4) Soil Moisture (percent)-

5) Soil pH-

Knapweed measurements

1) Plant Number _____

2) Height your plant

_____

3) Number of seed heads your plant

_____

4) Stem thickness of your plant

_____

Habitat 3.
Describe the location (where on campus? near river? near a trail? etc)-

General climate characteristics-
Climate (sunny? Shady? Cold? Moist? Hot? etc.)

Soil characters (rocky? Sandy? Muddy? Lots of leaves? etc.)

Surrounding vegetation (grasses? trees? Lots of knapweed? no plants? etc.)

Habitat Measurements

1) Temperature (degrees celcius)-

2) Humidity (percent)-

3) Sunlight-

4) Soil Moisture (percent)-

5) Soil pH-

Knapweed measurements

1) Plant Number _____

2) Height your plant

_____

3) Number of seed heads your plant

_____

4) Stem thickness of your plant

_____