ECOS Inquiry

1. Contributor's Name: Joss McKinnon

2. Name of Inquiry: Beneficial Burns?

3. Goals and Objectives:

a. Inquiry Questions: Are fires always a bad thing? What are some of the potential benefits of fires in ponderosa pine-Douglas-fir forest ecosystems?

b. Ecological Theme(s): Fire ecology, intermediate disturbance hypothesis.

c. General Goal: To introduce the students to the concept of disturbance events as important drivers of ecosystem health (diversity).

d. Specific Objectives: To illustrate the importance of wildfires in the ponderosa pine-Douglas-fir forest ecosystem in western Montana.

e. Grade Level: 4-8 (Scaled up through 12)

f. Duration/Time Required:

→ **Prep time** 30 minutes.

→ **Implementing Exercise During Class** 45 minutes.

→ **Assessment** 10 minutes.

4. Ecological and Science Context:

a. Background (for Teachers):

Disturbance events, such as floods, landslides and fires play a key role in promoting diversity within an ecosystem. They act to remove some of the fiercest competitors in an area, opening it up to colonization by other species. Following disturbance, the secondary succession of the species within an ecosystem generally follows a particular pattern. Initially resource availability (light, soil nutrients, rooting space, etc.) is high because of little or no competition. Because of this, the first plant species to move in are typically fast growing and quick to reproduce, but not the best competitors. As time progresses, other species that can out-compete these early colonizers will begin to take over. Depending on the type of ecosystem there will be various stages of succession, with each community eventually being beaten out by another, until the "Climax Community" is established. At that point only a new disturbance event can open up an area to colonization by the early successional communities.

The intermediate disturbance hypothesis suggests that the overall diversity of an ecosystem is increased with periodic disturbances. If disturbances are frequent, only the early successional communities have a chance to establish themselves before the next disturbance hits. If disturbances are very rare, the entire ecosystem will only be made up of the climax community, and none of the species from the other successional stages will be present. When disturbances occur at an intermediate timescale, there will be sufficient time for later successional species to colonize the area, but not enough time for the climax community to take over completely. The pattern of disturbance plays an important role as well. Most times there will be areas that are affected to a greater degree and others that are affected very little. This will result in different stages of secondary succession in each area, and an overall increase in diversity within the ecosystem as a

whole. This pattern of disturbance distribution is sometimes referred to as a heterogeneous mosaic, meaning that communities are not exactly the same throughout the entire ecosystem.

Specifically, this inquiry will focus on wildfire as the disturbance event promoting this increase in diversity, and will highlight some of the other benefits of a burn. In the absence of fire, the forest ecosystem in western Montana proceeds to a climax community of shade tolerant Douglas-fir, which will eventually block the majority of sunlight from reaching to forest floor, making it impossible for ponderosa pine seedlings to survive and grow to adulthood. In addition, dead trees, branches, shrubs, and other woody debris accumulate and interfere with other species growth. Finally, as the p. pine and Doug-fir grow, they take nutrients up from the soil, and use them to produce new needles and new woody tissue. These needles are very recalcitrant, meaning they decompose very slowly once they have been dropped. This means that nutrients are being held within the thick layer of litter, not being returned to the soil as rapidly as they are being taken up. This can lead to nutrient limitation in the soil, making growth impossible for many of the early successional species from this ecosystem. Fire disturbance events will not only kill back many of the Douglas-fir trees, opening up areas to colonization by other species, but they also remove the majority of woody debris, and consume the litter layer, releasing some of the nutrients held within. Additionally, the random movement and severity of a fire often results in the creation of a heterogeneous mosaic landscape, further increasing the diversity within the ecosystem.

b. Background (to present to Students):

A general introduction to the concept of disturbances as drivers of ecosystem diversity would help students comprehend the specific goal presented within this investigation. In addition, perhaps looking at a series of photographs taken from the same location over time would help the students fully comprehend the concept of succession, and begin asking questions about the state of a climax community and why other plant species might have a difficult time growing in these conditions.

5. Motivation and Incentive for Learning:

Wildfires are something that these students have grown up with, yet it is likely that they have never been exposed to the beneficial side of such disturbance events. Additionally this investigation will allow the children to *escape* the classroom and get outside, and the game-like nature of the investigation should ensure their interest.

6. Vocabulary:

Climax Community: A community that occurs late in succession whose populations remain stable until disrupted by disturbance.
Community: An association of interacting species living in a particular area.
Disturbance: A temporary change in average environmental conditions that causes a pronounced change in ecosystem structure that lasts longer than the change in the environment. Ecosystem changes include altered populations or physiological behavior of difference species as they respond to the stressful conditions imposed by the disturbance.

Diversity: Describes the structure of ecological communities, not only the number of species, but also the number of individuals of each species.
Heterogeneous: Something (an object or system) consisting of a diverse range of different items.
Litter Layer: The layer of fallen twigs, needles, and leaves.
Pioneer Community: The first community, in a successional sequence of communities, to be established following a disturbance.
Recalcitrant: Material that decomposes very slowly.
Secondary Succession: Succession where disturbance has destroyed a community without destroying the soil; for instance, forest succession following a forest fire or logging.

7. Safety Information:

Nothing to Note.

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

Deck of Cards
Tokens (**If scaled up to 9-12**) (roughly 300?)
Plant type name tags
Rule sheets
Record sheets

9. Methods/Procedure for students:

a. Pre-investigation work:

Think about the succession photographs you were shown earlier, which year of succession looked like it had the most different types of species present, which year looked like it had the most individual plants regardless of species? Do you think any one year of succession looks like it is the healthiest forest? Given what you have learned about the intermediate disturbance hypothesis and heterogeneous mosaic landscapes, what kind of fire disturbance (how often, how severe, how widespread) do you think will lead to the overall healthiest ecosystem?

b. Investigation work:

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

Students will play the full version of the game "Beneficial Burns?", which will illustrate the concept of succession, competition for resources, and the potential benefits of wildfires to a forest community.

Rules of the Game:

1) An area of the playground will be divided into a number of zones, with each zone having 6 potential growth areas. These zones will be characterized by differing

frequency of disturbance, and each will follow a different set of rules based on that. Students will play the part of plants attempting to colonize each zone.

Scaled up to 9-12: Each zone will have three bins full of tokens which will represent the nutrients present in the soil, in the needle litter, and in the non-needle litter.

2) At the beginning of each turn students will select the zone that they will attempt to colonize, and select a card at random from the deck. The card that they select will determine the type of plant that they are (pioneer species, understory species, ponderosa pine, Douglas fir). The species present in a zone at the end of the previous turn will determine the cards that correspond to each plant type. The attached rule sheets provide the specific card values that correspond to each plant type in each successional stage.

3) (**Scaled up to 9-12 only)** When they colonize a particular zone, students will take up a specified number of nutrient tokens from the soil nutrient pool (pioneer species:1, understory species:2, ponderosa pine:5, Douglas fir:5)

4) Pioneer species and understory species die at the end of each turn, while pine and Douglas-fir individuals survive for two full turns before being removed.

Scaled up to 9-12: Pioneer species and understory species die at the end of each turn, and all of their nutrient tokens are placed in the non-needle litter bin. 90% of these tokens (rounded down) are then returned to the soil nutrient bin. Ponderosa pines and Douglas-firs must take up nutrient tokens from the soil nutrient bin at the end of each turn (Douglas-fir:2, ponderosa pine:3, Douglas-fir take them up first), and place the same number of tokens into the needle litter bin. 10% of these tokens (rounded up) are then returned to the soil nutrient bin. If there are not enough tokens left in the soil nutrient bin the plants that did not get enough nutrients must still discard the standard number of tokens, and if a tree runs out of tokens it dies, but continues to occupy its location until a disturbance occurs.

5) During a disturbance all of the plants in a zone are removed, and all tokens from both litter bins are returned to the soil nutrient bin, and the successional process begins again.

6) For each zone the identity of each species will be recorded at the end of each turn on the record sheet provided, and compiled for presentation at the end of the game. The game will continue for as many turns as time permits.

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

As a class students will compile the data gathered from each zone into a standard line graph, with turn number on the x axis and number of individuals on the Y axis, and a different colored line for each species type.

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

Once the graphs have been constructed, students will asses them for differences in species composition and diversity based on the disturbance regime.

4) Include examples of data sheets.

Included below.

10. Assessment:

A discussion of the patterns presented in the graphs will provide teachers with an opportunity to asses the students understanding of the concepts of disturbance frequency and the resulting affect on species composition and diversity.

11. Extension Ideas:

Students should be told to look closely at their local ecosystem and try to determine the difference between areas the have experienced a recent disturbance and those that have not.

12. Scalability:

This inquiry can easily be scaled up to apply to high-school students by introducing the nutrient tokens discussed within the rules above.

13. Science Standards Accomplished:

Grade 4:

Unifying Concepts and Processes: Systems, order, and organization; Constancy, change, and measurement.

Science as Inquiry: Abilities necessary to do scientific inquiry; Understandings about scientific inquiry.

Life Sciences: The characteristics of organisms; Organisms and environments.

Science in Personal and Social Perspectives: Characteristics and changes in populations; Types of resources; Changes in environments.

Grade 5:

Unifying Concepts and Processes: Systems, order, and organization; Constancy, change, and measurement.

Science as Inquiry: Abilities necessary to do scientific inquiry, Understandings about scientific inquiry.

Life Sciences: Structure and function in living systems; Populations and ecosystems; Diversity and adaptations of organisms.

Science in Personal and Social Perspectives: Populations, resources, and environments.

History and Nature of Science: Nature of science.

14. References:

Molles, M.C. Jr. 1999. Ecology: concepts and Applications. WCB McGraw-Hill, New York NY.

15. List of Experts and Consultants:

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

Rules Page
Few Disturbances

If nothing is present
All cards equal pioneer species

If only pioneer species were present
2-5 equals pioneer species
6-King equals understory species
Ace equal pine

If only understory species were present
2 equals pioneer species
3-8 equals understory species
9-King equals pine
Ace equal Douglas fir

If pines are present
2-6 equals understory species
7-Queen equals pine
King-Ace equals Douglas-fir

If one Douglas-fir is present
2-5 equals understory species
6-9 equals pine
10-Ace equals Douglas-fir
Ace of Diamonds equals disturbance

If two Douglas-firs are present
2-5 equals understory species
6 equals pine
7-King equals Douglas-fir
Red Ace equals disturbance

If three or more Douglas-firs are present
2-5 equals understory species
6-King equals Douglas-fir
Ace equals disturbance

Rules Page
Intermediate Disturbances

If nothing is present
All cards equal pioneer species

If only pioneer species were present
2-5 equals pioneer species
6-King equals understory species
Ace equal pine

If only understory species were present
2 equals pioneer species
3-8 equals understory species
9-King equals pine
Ace equal Douglas fir
Ace of Diamonds equals disturbance

If pines are present
2-6 equals understory species
7-Queen equals pine
King-Ace equals Douglas-fir
Red Ace equals disturbance

If one Douglas-fir is present
2-5 equals understory species
6-9 equals pine
10-Ace equals Douglas-fir
Ace equals disturbance

If two Douglas-firs are present
2-5 equals understory species
6 equals pine
7-Queen equals Douglas-fir
King-Ace equals disturbance

If three or more Douglas-firs are present
2-5 equals understory species
6-Jack equals Douglas-fir
Queen-Ace equals disturbance

Rules Page
Frequent Disturbances

If nothing is present
All cards equal pioneer species

If only pioneer species were present
2-5 equals pioneer species
6-King equals understory species
Ace equal pine
Ace of Diamonds equals disturbance

If only understory species were present
2 equals pioneer species
3-8 equals understory species
9-King equals pine
Ace equal Douglas fir
Red Ace equals disturbance

If pines are present
2-6 equals understory species
7-Jack equals pine
Queen-King equals Douglas-fir
Ace equals disturbance

If one Douglas-fir is present
2-5 equals understory species
6-7 equals pine
8-Jack equals Douglas-fir
Queen-Ace equals disturbance

If two Douglas-firs are present
2-4 equals understory species
5 equals pine
6-10 equals Douglas-fir
Jack-Ace equals disturbance

If three or more Douglas-firs are present
2-4 equals understory species
5-8 equals Douglas-fir
9-Ace equals disturbance

Record Sheet

Disturbance Regime_____

Turn #	Pioneer	Understory	Pine	Doug-fir
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				